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இலங்கை விஞ்ஞான முன்னேற்றச் சங்கம்

Ceylon Association for the Advancement of Science

වර්තමාන විද්‍යාත්මක පර්යේෂණ හා ඒවා ශ්‍රී ලංකාවේ සංවර්ධනයට අදාළවන අයුරු පිළිබඳ සම්මේලන වාරය

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SYMPOSIA ON CURRENT SCIENTIFIC RESEARCH AND ITS RELEVANCE TO THE DEVELOPMENT OF SRI LANKA

1973 ජූලි/අගෝස්තු

1973 யூலை/ஓகஸ்ற்

July/August 1973

කොළඹ 7, වාරිමාර්ග දෙපාර්තමේන්තුවේ රැස්වීම් ශාලාවේ දී

கொழும்பு 7, நீர்ப்பாசன இலாகாவின் மண்டபத்தில்

at Irrigation Department Auditorium, Colombo 7

C. A. A. S.
281/50, Bauddhaloka Mawatha,
Colombo 7.

G.A.S. SYMPOSIA

CURRENT SCIENTIFIC RESEARCH AND ITS RELEVANCE TO THE DEVELOPMENT OF SRI LANKA

INDUSTRIAL RESEARCH

FRIDAY 6th JULY 1973

2-00 P.M. TO 7-00 P.M.

AT

IRRIGATION DEPARTMENT AUDITORIUM

CHAIRMAN: Dr. S. GNANALINGAM

SECRETARY: Dr. K. G. DHARMAWARDENA

PRICE: ONE RUPEE.

PROGRAMME

3.00	Opening Address	..	Dr W.D.Ratnavale, General President, C.A.A.S.
3.10	Introduction by Chairman	..	Dr S.Gnanalingam, C.I.S.I.R.
3.20	Industrial Research and Development - Retrospect and Prospect	..	Mr S.F.Laurentius, C.I.S.I.R.
4.00	Research Investigations in the Salt-based Industries of Sri Lanka	..	Mr D.C.Munasinghe, National Salt Corporation
4.25 - 4.40	INTERVAL FOR TEA		
4.40	Industrial Research on Minor Export Crops	..	Dr R.O.B.Wijesekera, C.I.S.I.R.
5.05	Research and Development in the Cement and Steel Industries	..	Dr V.Perampalam, Ceylon Cement Corporation
5.25	Aspects for Research in the Oil Refinery, Sapugaskanda	..	Mr S.Weerasekera, Ceylon Petroleum Corporation
5.45	Research and Development in the Paper, Leather and Textile Industries of Sri Lanka	..	Mr E.B.Dissanaike, Government Analyst's Department
6.10	Research in Food Science and Technology	..	Mr L.A.C.Alles, Marketing Department
6.30	Summing up	..	The Chairman

INDUSTRIAL RESEARCH AND DEVELOPMENT

RETROSPECT AND PROSPECT

S.F. Laurentius

Deputy Director (Research)
Ceylon Institute of Scientific & Industrial Research

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While the past two decades have seen scores of industries springing up both in the public and private sectors, one must not assume that industrialisation in Ceylon is a recent phenomenon. If an industrial payroll is taken as an indicator of the size of the industrial sector, then Sri Lanka has had a sizable industrial sector for well over seventy-five years. Industry certainly is not of recent origin. What is new is industrial diversification with its concomitant social upheavals.

Another misconcept that may be current is that Applied Scientific Research is new. This is also not so. The first organised attempt to carry out applied research came from the Tea plantation sector with the setting up of the Tea Research Institute in 1926, followed soon after with the Rubber and Coconut Research Institutes. As the country's major income was derived from these exports there was a perceived need for research and development in these fields for maintaining and improving yields and quality of the export products, as well as for keeping costs of production in line. It bears stressing that those engaged in these industries were aware of this need and the research institutes came into being to satisfy this need.

One may well pose the question -Are industrial research and applied science intimately linked to industrialisation leading on to economic development, or can one exist independently of the other? There are many of us here today who know all too well - and ruefully at that - that under a certain set of circumstances, industry can be set up in a country without any reference to indigenous science. We have seen it happen. Foreign technology and know-how is the base for most of our industrial ventures. The continuation of these industries on a viable footing therefore requires continuous dependence on the foreign source, but where foreign exchange is in short supply as today, these industries, especially the science based industries, have to fall back on local science, at times merely to keep in operation - let alone grow. While industry can be started without the existence of a local applied science base, indigenous industrial research and development can make no contribution to economic development unless a viable industrial sector exists which is receptive to development, innovation or changes in techniques originating from local industrial research institutes. This was so in the plantation sector where a perceived need for research and development took the form of a commercial demand. Unless this environment exists, much of the efforts of any research institute would be fruitless.

Being traditionally an agricultural country and exporter of processed or semi-processed raw materials to the industrialised countries, one may have presumed that the 1914/18 war-time scarcities arising from our total dependence on imports of manufacture for both capital and consumer goods would have spurred us on to some semblance of industrial activity. However, this did not happen. Perhaps being part of a colonial empire there were no stirrings at any level on this question of industrialisation. With the introduction of the Donoughmore Constitution in 1931, industrial development, for the first time, became a function of government under an elected minister. Even so, progress in the field was painfully slow and the only tangible outcome was the proposal mooted for the establishment of a coir yarn factory both to serve as a model and to appraise the public of the possibilities of industrial development.

The establishment of a separate department of Commerce and Industries in 1938 marks the first concrete step towards the industrial development of this country. The functions of the department were listed under the following heads:

1) the establishment, maintenance and supervision of factories
2) the establishment, maintenance and supervision of industrial centres, workshops and schools
3) the maintenance of industrial investigation and research
4) sales development and accounting in respect of the department's factories and industrial centres.

With the outbreak of the Second World War in 1939, a sense of urgency was imparted into the need for industrialisation and following on the report of Mr. Guha who served as Ceylon's Technical Adviser on Industries during 1934/39, steps were taken to draw up plans for the manufacture of plywood, glass, leather, acetic acid, drugs, paper and cement.

March 1940 brought our first contact with the late Mr. D.H. Balfour, Director of Commerce and Industries as well as our initial exposure to applied scientific investigation. We were offered employment as temporary research assistants on Rs.3/- per day and asked to report for work at the Old Railway Workshop, Maradana.

Three of us reported there for work one Monday morning. It was an old dilapidated metal-clad building, gloomy, with metal scrap lying about on an unpaved dirt floor. The building was about 100 feet in length and at the further end there was a long table on which were some glass beakers, burettes and pipettes, and odd reagent bottles. There was a group of about 6 workmen who, I suppose, were wondering what we were up to. We were in this place close to about an year and here we were told more about the production of acetic acid from coconut shells by the Industrial Chemist. It was our first close look at a retort for destructive distillation and a fractionating column.

The facilities for experimental work were limited and the available literature was meagre. With these limited resources we set to work on a continuous stream of ideas which kept flowing from Mr. Balfour covering a wide range of investigations. One of the officers was assigned work on the hydrolysis of Manna grass for recovery of glucose. The hydrolysis was carried out in an autoclave and the resulting liquor had to be tested for its glucose content. This had to be taken to Muttiah Road where a laboratory had been set up by the Department.

Among the investigations carried out at the Old Railway Workshop premises were the separation and rectification of acetic acid from pyroligneous acid obtained from the dry distillation of coconut shells, rapid pulping for the manufacture of paper and fire proofing of cadjans. In regard to the rapid pulping process, representatives from the Dalmia Paper Mills, in India visited Ceylon for a study of the process.

Towards the end of this period, all the applied scientific activities of the Department of Industries at the Old Railway Workshop were wound up and were transferred to the laboratory at Muttiah Road. We really had the conventional laboratory benches to work on and tables and chairs as well as stools to sit on. The resources provided for work were glassware and chemicals with hardly any instruments - remembering the instrumentation 30 years ago - and very little literature. We also had workshop facilities for fabricating equipment. What was amazing, looking back on those years, were the variety of investigations undertaken by the staff which had gradually been strengthened to about ten.

Studies on peat, production of white cement from refined kaolin, furfuraldehyde from agricultural waste residues, rubber seed oil, ilmenite fusion, retting of coir fibre, nutmeg oil and nutmeg butter, caffeine from tea waste, glues for plywood, condensed coconut milk, activated carbon from coconut shells, electrolysis of ammoniacal sodium chloride using

zinc and iron electrodes, distillation of essential oil, were all taken up for investigation at various times. Unfortunately almost all of the reports and records of this era have been destroyed or misplaced.

May I dilate further on one particular investigation with which I was closely associated - the production of acetic acid from coconut shells. A small scale process had been tried out and the results obtained were encouraging. The steps in the process as worked out then were:

a) Dry distillation of coconut shells and condensation of pyroligneous acid vapour

b) Separation of liquor and settled tar

c) Salting out of the pyroligneous liquor with $MgSO_4$. This threw down the dissolved tar together with the acetic acid in the pyroligneous liquor

d) Fractional distillation of the tar for concentration of acetic acid.

If not for the exigencies of the war, it may be that more laboratory studies would have been carried out, as well as pilot plant trials before proceeding to commercial production. As it was, a decision was taken to fabricate a plant for the distillation of 10 tons a day of coconut shell together with the necessary condensers and distillation column for production of pyroligneous acid and recovery of acetic acid.

The erection of this plant was a remarkable feat of ingenuity for every item of equipment had to be fabricated locally or bought at second hand. In spite of all these handicaps, the plant was commissioned and within a few weeks, wer ran into trouble. We found that the salting out process had a number of in-built limitations which had not been taken into account when it was first considered as a process for separation of acetic acid from pyroligneous liquor. We were compelled to make a closer study of the relation between concentration of the $Mg\ SO_4$ solution and the degree of salting out. A further problem arose in that the heating system of the distillation column was fouled within a short period of operation with consequent drop in heat input into the system.

Despite all these problems and by repeated changes in the operations, acetic acid of 60% concentration was produced and sold to the rubber producers and the project contrived to keep its head above water financially. With the end of the war, however, the price structure changed considerably with the free import of acid and the losses started to mount until in late 1953 the decision was taken to abandon this project.

While this manufacture limped along to its close, the Industrial Research Laboratory was a hive of activity. The investigations referred to earlier were being worked on with Mr. Balfour as the chief motivating force behind all the activities. We, in the laboratory were in a way, the elite of the department at that time, for the Director was as much in the laboratory as in the office.

The Minister for Lab. Industry and Commerce in the 1940/41 budget speech on industrial policy made reference to the need for training "It was necessary that suitable persons should be selected for training abroad in certain specialised inudstries. For this purpose provision had been made for industrial scholarships". It was not until the end of the war that this proposal was put into operation. Commencing September 1945, officers from the Industrial Research Laboratory were sent abroad on training to various universities both in the United Kingdom and the United States.

Despite all the enthusiasm and drive of Mr. Balfour which struck a responsive chord in the officers, the I.R.L. really was able to make little impact on industrial development. The operational facilities were very limited and the work was more on the basis of "let's try it" rather than on a planned approach based on specialised knowledge. Its relationship with the private industrial sector was almost non-existent and the government plans for industrial development had little immediate reference to the programme of work of the laboratory or vice-versa. Admittedly, the staff was fresh out from university with no experience of industry or its requirements, and at that period of time, little or no assistance of industrial significance could have been forthcoming from the laboratory for immediate application. Even if significant results of practical value did materialise, there was no organised mechanism available to take any of the results beyond the laboratory bench.

Extracts from the estimates of the Department of Industries for the years 1943/44, 1944/45 and 1945/46 are indicative of the support forthcoming from government for industrial research and investigation.

ESTIMATES

COMMERCE & INDUSTRY 1944-46
Head - 103

Description	1943/44	1944/45	1945/46
Expenditure on Ind. Research - sub-head 13	37 169.	40,000.	70.000.
Investigations & Research sub-head 14	108,546.	170,000.	460,750.
Commerce & Technical Books & Periodicals	1,606.	2,400.	8,000.
Commerce & Industrial Scholarships	5,211.	26,000.	35,000.
Personnel Emoluments			
Principal Research Off.			24,000.
Metallurgist			24,000.
Specialist on activated carbon			18,000.
Industrial Engineer			7,410.
Asst. Industrial Eng.			4,045.
Industrial Chemist			6,000.
Senior Res. Officers			3,940.
Research Assistants			3,040.
Assistant Chemists - 13			44,140.
Daily paid Research Chemists - temporary			30,000.

Besides the experts we already had on quinine and leather, other experts were coming in to report on the setting up of various industries. Mr. Balfour retired from the post of Director of Industries and something went out of the I.R.L. But by now facilities had improved, permanent staff was available, including a head for the laboratory, and planned work was being undertaken, but the IRL was just another government activity outside of its industrial development plans. As and when the IRL officers returned to the country after completion of their programme of study, they were drafted to the Planning Division of the Department till a situation arose where the IRL was functioning with a head, some three chemists and four laboratory assistants.

This situation really presaged the beginning of the end. The obituary of the IRL was written by the IBRD Team who visited Ceylon in 1952 to report on the economic development of Ceylon. "Some years ago the government attempted to initiate a form of applied research for the development of industries and the activity was officially recognised in the name of the Ministry of Industries, Industrial Research and Fisheries. Laboratories were opened in Colombo under the supervision of this ministry and are still operating. Unhappily, they conduct no research, but are occupied with routine analytical matters. The laboratories are handicapped by all the problems inherent in bureaucratic control". They therefore made the following recommendation: "Ceylon needs an effective organisation for applied technical research - nothing of the sort exists now. We have seen that such laboratories as are operated by the government serve other valuable ends but are not suited to the conduct of original investigation. For Ceylon's purpose, what is required is a special type of institution enjoying government co-operation, but free of outright governmental control". Following on, the Mission put forward the proposal to set up the Ceylon Institute of Scientific and Industrial Research as an autonomous institute governed by a Board of Directors, financed partly from government funds and from fees earned by selling its services to clients. The government accepted this recommendation and introduced legislation to set up the Ceylon Institute of Scientific and Industrial Research. The Institute was formally set up on 1st May 1955 in rented premises with a staff of 8 research officers, all drawn from the staff of the Industrial Research Laboratory, one Chief Research Officer, 4 research assistants and 8 workshop staff.

The Institute is now in its eighteenth year, with a total staff of 192, of which 95 are on the technical side. It has an excellent scientific staff, a well stocked and up-to-date library, fairly well equipped laboratories and workshops with a floor space of 43,700 sq.ft. and its current operational budget is Rs. 3,506,500/-. We have in one location a collection of skills and expertise that would be difficult to duplicate or locate anywhere else in Ceylon. Our programme of work is largely based on investigations into the use of local raw materials, improvement of existing technology for processing of our raw materials, finding alternate local raw materials for imported raw materials, testing of a variety of industrial raw materials and finished products, providing advice and information to industry on a wide range of topics and also providing training facilities, albeit limited, at post-graduate and other intermediate levels.

Some of our investigations have resulted in commercial application. Among the earliest of such investigations resulted in the development of a process for the bottling of coconut toddy. There are now a number of brands of bottled toddy all using the same CISIR process and this has been extended to palmyrah toddy as well. The existence of the various centres for conversion of palmyrah juice into jaggery and sakkarai is the result of the work done by CISIR on the production of sugar from coconut toddy.

CISIR in collaboration with the Dry Zone Research Station at Maha Illuppallama has brought into commercial production and acceptance, another essential oil - Lemon Grass Oil. We have set up two prototype stills for the distillation of essential oils from the grasses with financial assistance from the Ministry of Plantation Industries. These are more efficient, costs of fabrication are lower than the conventional stills, and do not depend on the availability of large quantities of water for efficient condensation.

The work done by CISIR for Paranthan Chemicals has made it possible for Paranthan to plan for expansion today. It was given a new lease of life through the work of CISIR. In addition, a process for the manufacture of potassium chlorate using part of the available chlorine was also worked out for Paranthan by CISIR.

For the first time in Sri Lanka, mill scale trials on pulping of rubber wood were carried out at the Paper Corporation mills at Valaichenai. Rubber wood pulp has been a topic of discussion for a number of years, and these series of experiments demonstrated that paper could be produced from one hundred percent rubber wood pulp. Much work has yet to be done to solve the technological problems which were encountered, before it can be brought into commercial use, but it has been shown by our work that this merits further investigation.

The manufacture and sale of carbonated tea by a process developed at CISIR is under licence from us. We have also licensed a local manufacturer to exploit a CISIR patent for the manufacture of rubber latex emulsion paints. Likewise we have sold to the Steel Corporation, our process for the production of wire drawing lubricant, which would substitute for the imported product, while a locally prepared stamp pad ink for the use of the Postal Department also substitutes for the imported material. We have also compounded a finger print powder which the CID now uses instead of the imported product.

In the pipe line, needing further work for commercial exploitation or awaiting commercial exploitation, is production of sodium alginate and agar from locally available sea weeds, welding electrodes, coconut cream, glucose and other products from cassava. Investigations under way are on the use of composite flours for bread, production of road paints, aromatic derivatives from locally produced essential oils, refined papain and upgrading of graphite.

This by no means covers our work in its entirety, but it does give you an idea of the priorities we have st up in formulating our programme of work. We make no claim that our programme of work is totally relevant to the planned industrial development of the country and that our priorities have been correctly set up. This is difficult to ensure in as much as we do not have full and complete dialogue with the Planners.

A problem which has loomed large is the difficulty of quickly and economically accomplishing the transition from science to technology and from technical feasibility to economic feasibility. This is the problem of the interface. The transition from research to engineering is one of the most difficult problems and we have as yet no satisfactory solution to this.

We have however had our fair share of problems and the full potential of this National Applied Research Institute has yet to be developed. During the first five years of its existence, the philisophy underlying the operation of the institute was essentially materialistic. The institute had no overall research programme formulated in terms of national development. At the commencement the Institute did take over from the Department of Industries six uncompleted projects in various stages of development:

i) New vegetable oil sources

ii) Improved desiccation of coconut

iii) Manufacture of hardboard from coir waste

iv) Improved yields from citronella and cinnamon

v) Rubber compounding

vi) Factice from rubber seed oil

but the emphasis was on projects which had possibilities of process or product development for recovery of costs. The main objective was financial self-support.

I It became evident that such a policy was self-defeating and was also not compatible with that of a national organisation. The narrow view of self-support and independence had to give way to broader objectives and the assumption of heavier responsibilities in keeping with the image of the Institute as a national organisation. As the only industrial research organisation in the country, it is incumbent on us to undertake a programme of research and development having a bearing on the needs of a nation rather than concentrating on the needs of individual entrepreneurs or private sector interests.

Unfortunately, after the first five year period during which government made an annual grant of Rs. 1 million to the Institute, this source of funds dried up. The consequences of this can be imagined. Everything slowed down or came to a halt in an atmosphere of uncertainty. The morale of the staff was affected and once the rot sets in, it is a long haul to get back the feeling of security. In 1960/61, the Institute was not provided any financial support from government, nor in 1961/62, For the next four years the grant ran at Rs. 750,000/- per year i.e. from 1962/63 to 1965/66. This year the grant amounts to Rs. 3,521,000/-.

Various policy decisions of the government - two in particular - the first being the transfer of the Institute from the Ministry of Industries and Fisheries to the Ministry of Housing and Scientific Research weakened the relationship between industry, both in the private and public sectors, and the Institute. We have now gone back to the Ministry of Industries and Scientific Affairs. The second policy decision created a new organisation "the Industrial Development Board" functioning under the Ministry of Industries, which further weakened the position of the Institute vis-a-vis industry - small industry in particular. While it was intended that the Industrial Development Board and the Institute should work in close co-operation, in reality the co-operation was of a tennous nature - made more so by reason of the fact that the two organisations both charged with assisting industry were under separate ministeries.

There has moreover been a continual change in the emphasis given by successive governments to the Institute as a component of the infra-structure for industrialisation. This continual shift in emphasis cannot make for stability with clear cut objectives and the direct consequence of this has been the lack of long term planning in respect of staffing, staff trainin and renewal of facilities. Industrial research institutes must of necessity be staffed with the best qualified staff at all levels, for an institute cannot function successfully with staff inferior to that of the organisation it expects to advice. In order to be reasonably relevant to thesociety in which it exists, a national research institute must constantly renew its facilities both of men and equipment .

With increasing support from government, we now have the means to embark on a planned programme of recruitment of staff. Training facilities are not all what we need nor is renewal of facilities. These requirements have been severely curtailed due to outside constraints. The same outside constraints however have made industry more amenable to the proposition that an Institute engaged in industrial research can be of value. In other words, industry now is aware of a perceived relation between indigenous science and technology and the development of industry. This need is now felt by industry, especially by science based industry, despite the dependence of local industry both in the public and private sectors, on imported technology and know-how. Just as in the case of the plantation industry which recognised the need for applied science to maintain and improve the quality of thier products, and maintain their competitive position in the world markets, so it is now with our other industrial enterprises who have come nearer to accepting that local science and technology can provide them with the means of solving some of their immediate problems and of even ensuring their long term viability. For only a genuinely viable industrial sector can make a useful contribution to economic development, and applied research is one of the inputs without which the contribution of industry to economic development would at best be marginal.

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Colombo
6th July, 1973

SFL/cmw

3rd July, 1973.

RESEARCH INVESTIGATIONS IN THE SALT BASED INDUSTRIES OF SRI LANKA

When I was invited to speak on research in the salt and salt-based industries of Sri Lanka, I was very diffident about it since no basic research had ever been carried out, to my knowledge, in this field in Sri Lanka. However, a fair quantity of ad hoc applied research has been executed over the past three decades under somewhat trying conditions and in rather sporadic fashion, and I feel it may be interesting to mention very briefly the main items of such work.

In the field of salt itself, there is hardly any published literature of real value and, apparently, we are expected to purchase know-how from abroad. It is small wonder therefore that we were compelled to carry out our own investigations duplicating researches carried out elsewhere as was discovered much later on. The following items of work, singled out here as worthy of mention, should be noted in this context. Also, since my time is very limited, I am unable to give any details here.

a) The beneficiation of saltern gypsum including use of flotation, and the manufacture of plaster of Paris from such gypsum including autoclaving methods.

b) The manufacture of black-board school chalk both white and coloured, Ceylon Patent No. 3587 on 'the manufacture of uniformly coloured casts of plaster of Paris or of other dehydration product of gypsum' was taken out on the results of this work.

c) Investigations were also carried out on the strengthening of plaster casts using resins, particularly water-soluble resins.

d) The recovery of magnesia from sea brines and bitterns. The magnesia precipitates out as a slimy highly hydrated flocculent precipitate that is difficult (and expensive) to filter and wash to an acceptable purity. This piece of work discovered that if the magnesia was sedimented to a thick slimy sludge and this sludge was frozen solid, subsequent thawing resulted in the magnesia being converted to a comparatively coarsely crystalline and easily filterable condition.

e) The manufacture of magnesium carbonate from sea bitterns. The basic process is very elementary but the snag lies in obtaining a product conforming to required specifications especially B.P. standards.

f) The manufacture of magnesium sulphate from sea bitterns. The basic process consists of concentrating the bitterns in seperate ponds and then chilling the concentrate when a very crude magnesium sulphate deposit forms. It is fairly simple to obtain a fertilizer grade of magnesium sulphate from this crude deposit. It is not so easy however to obtain B.P. grade material. Re-crystallisation and the use of 60% ethyl alcohol can achieve this end.

g) The manufacture of gypsum, potassium chloride, magnesia, magnesium chloride, calcium, chloride from bitterns in an integrated process. The bitterns after removal of sulphate as gypsum by addition of calcium chloride, can be

processed further to obtain deposits of carnallite (and thence potassium chloride) and the residual magnesium chloride reacted with lime to obtain magnesia and calcium chloride. The basic chemistry is simple essentially, but various difficulties are encountered in practice. Thus, the addition of the theoratical quantity of calcium chloride results in only 80% of the sulphate in the bitterns precipitating out as gypsum. Again the gypsum precipitates in a very fine, almost slimy, condition which creates difficulties in filtration and washing.

h) The desulphation of sea-water itself using calcium chloride was investigated, along with the effect of concentration of the desulphated sea water. Here again, the increased solubility of calcium sulphate cropped up.

Although these investigations into the manufacture of by-products were carried out, it became clear that successful commercial manufacture depended on the scale of manufacture, and could be considered seriously only in the case of large salterns with a capacity of at least 100,000 tons per annum.

i) In order to arrive ar a correlation between absorption of solar radiation, wind speed and the evaporation rates of brines of verying densities, the viscosities and yapour pressure of the different brines were determined, at different temperatures.

j) The use of submerged combustion in the production of refined salt was investigated and it was found that this process could be used with advantage for small-scale

manufacture, say, less than 10 tons/day. The use of submerged combustion is now being investigated for the evaporation of bitterns and the simultaneous production of a grade of refined salt. We are also investigating the use of this process combined with wetted wall evaporation, again for production of evaporated salt.

k) Since solar evaporation of brines depends on absorption of solar radiation, it would be logical to attempt to increase the absorption effect by the addition of dyes. A suitable dye was found to be Nephthol Green B as had been tried out by Dr. Bloch in Israel for the manufacture of potash from Dead Sea brines. Trials have been conducted at our salterns using this dye, and the method has been adopted as standard practice. Now nigrosine-based dyes are being tried out.

l) Normal solar salt entrains a substantial amount of mother liquor due to the 'hopper' shape of the salt crystals formed under conditions of normal solar evaporation. Modification of crystal habit using mangenous sulphate was tried out and gave very good results. This procedure too is now being adopted whenever a purer or drier salt is desired.

m) A curious phenomenon was observed at some of the private salterns, particularly at Nachchikalt Saltern, in the Puttalam district, in 1968. Salt apparently did not form in the salt pans and appeared to be hindered in some manner by a jelly like substance in the pans. At our request, Dr. N.N.De Silva, then of the Dept. of Biological Sciences, at Vidyodaya University, investigated this problem.

In some salt pans at Nachchikali, the entire bottom and sides of the bed were covered with a pale brownish red jelly-like substance to a thickness of ¼ to ½ inch. Microscopic examination showed that small almost perfect crystals of salt had formed in the jelly. The investigations pointed to the conclusion that the saltern brines had been contaminated by some microorganisms introduced through the continuing influx of fresh water. The microorganisms responsible for the jelly formation was a flagellate belonging to the group Englenodinae probably to the genus Phacus. It will appear that the flagellates carried out active photosynthesis and some of the carbohydrate so formed leached out of the cells into the brine. Further, there were also associated some halophilic bacteria which acted by transforming these substances into a complex polysaccharide slime. Although the motile form of the flagellates was green coloured, the spores were reddish-brown in colour and imparted a brownish-red colour to the slime. Some of the halophiles also, when cultured, formed large mucoid colonies, colourless or pale whitish-brown, and exhibited marked surface growth.

n) It is of the highest importance to the solar salt industry to be able to forecast the weather pattern of the year. To this end, and hoping against hope, we are keeping track of sunspot data (both past and projected) supplied by the World Data Centre A for Solar-Terrestrial Physics at Boulder, Colorado, U.S.A., and rainfall data at salterns. Our saltern area rainfall records do not extend very far

back - for Elephant Pass from 1896 onwards, for Hambantota and Puttalam Met. station from 1869 onwards.

The only substantial salt-based industry in Sri Lanka at present is the manufacture of caustic soda and chlorine at Paranthan. The Paranthan venture has had a very chequered career. To obtain an idea of what research work has been carried out at Paranthan, and why, a very brief historical introduction is necessary.

The Govt. in 1951 decided to set up a plant for the daily manufacture of 5 tons of caustic soda with the co-production of 4.5 tons of chlorine along with 50,000 cu.ft. of hydrogen. For the disposal of the chlorine, advantage was to be taken of an offer of a DDT plant from UNICEF/WHO for the annual manufacture of 700 tons DDT. A factory for 3000 tons per annum of sulphuric acid was also to be established since 1300 tons of sulphuric acid was required for the DDT plant annually.

Contracts were placed in 1953 for the supply and installation of the caustic soda/chlorine and sulphuric acid plants with a firm in Switzerland. The consultants for the project were M/s. L.H. Manderstam & Partners Ltd., London. The plant and equipment arrived in Ceylon by the end of 1954. The Govt. also decided not to accept the DDT plant. Then again, on second thoughts, the Govt. decided that a smaller DDT plant should be accepted. For some reason or other, this decision was not implemented, and this has had grave far-reaching effects on the industry.

The manufacturers were requested to undertake the work of erecting and commissioning the plant but they declined, saying that their legal obligations under the earlier contract had expired. They also pointed out that they were doubtful about the technical and economic feasibility of the project in view of the abandonment of DDT manufacture.

The Corporation then obtained the services of a local engineering firm and the consultancy services of an Indian firm to instal the plant. The plant was erected by the end of 1957, but could not be put into any semblance of regular production for various technical reasons including explosions. It was then that the Corporation obtained the services of Dr. S. Gnanalingam of the C.I.S.I.R. and also entered into a six months technical management contract with the Indian firm.

The researches carried out by Dr. Gnanalingam enabled various modifications to the electrolytic cells and the plant process to be implemented and the plant was put into regular production. Early in 1961, the Indian consultants reported that the plant could not produce more than 3.75 tons of caustic soda per day at full production and returned to India, Dr. Gnanalingam continued his work there and established that the plant could produce nearly 5 tons per day of Caustic Soda. i.e. almost the rated production. Unfortunately, it has been found difficult to maintain this output steadily.

Dr. de Nora of Italy who had designed the electrolytic cell has stated that this design was only experimental and that the installation here was the only commercial plant of its type in the whole world.

Steady efforts have been made over the years to find suitable disphragms and modifications of operational procedure in order to increase the yield and reduce the chlorate content of the caustic.

The first by-product to be made was table salt from the evaporator salt. Then came potassium chlorate and calcium chloride. Here a C.I.S.I.R. team headed by Dr. Devanathan carried out investigations and was able to pave the way for the establishment of a small unit producing potassium chlorate and calcium chloride, using sniff gas and milk of lime.

A Krebs-Berlin hydrochloric acid unit was installed for the production of hydrochloric acid originally meant for use with sniff gas and cell hydrogen. The use of sniff gas was far too dangerous and the unit first operated with dry chlorine gas and now with wet chlorine gas.

After various trials, ferric chloride in the form of a 40% solution is now manufactured at Paranthan using scrap iron and sniff gas.

Similarly zinc chloride is manufactured in the form of a 50 - 60% solution from scrap zinc and sniff gas.

General purpose laboratory reagent grade sodium chloride is also being made on a small scale.

Successful trials have been carried out on the manufacture of zinc sulphate utilising zinc and waste sulphuric acid. Similarly, scrap aluminium has given aluminium sulphate.

D.C. MUNASINGHE.

-/rf-3-7-73.

INDUSTRIAL RESEARCH ON MINOR EXPORT CROPS

by

R.O.B.Wijesekera

Minor export crops is a term coined by the Ministry of Plantation Industries and defined as representing a range of export-oriented crops which have been cultivated in Sri Lanka for centuries. These crops have remained in the background of the general export scene which has been dominated by major export crops such as tea, rubber and coconut. The minor export crops include the following:

> Cocoa, cashew, coffee, mulberry (for silk), oil palm, papaw (for papain), cinnamon, cardamom, clove, nutmeg, pepper, citronella and lemon grass.

These crops and their products have received very little attention in the form of research hitherto; now the Government considers that attention to such crops would be a vital aspect of its development strategy. Accordingly, a Department of Minor Export Crops has been created and the Director, Dr E.Jayanetti, will talk about their development programmes in Part II of this Seminar. My task is to outline some of the C.I.S.I.R's own research efforts in the direction of finding uses for these crops and the development of export oriented products from them. Our work has been mainly confined to the spices and aromatic grasses. It could be divided into three main areas.

(1) Studies on the methods of extraction of aromatic oils from essential oil bearing plants and spices.

(2) Studies on the chemical constituents of these spices and the development of analytical techniques for the assessment of their quality.

(3) Further processing of essential oils into industrially important chemicals and preparations of new products from spices.

Our programme of studies on the methods of improving the technology in relation to spices and essential oil bearing plants received welcome sponsorship from the Ministry of Plantation Industries and the Ministry of Planning. In this area we have first of all made thorough studies of the existing methods and techniques in the production of essential oils that have been traditionally produced in Sri Lanka, such as cinnamon leaf and bark oil and citronella oil. The C.I.S.I.R., I must mention, had previously taken the initiative in the introduction of lemon grass oil as an export product in Sri Lanka. In the case of citronella oil we had noted that due to the inadequacy of the supply of water during the drought season no distillations were carried out. Large quantities of water are necessary for distillations in order to effect satisfactory condensation of the steam distillate mixture containing oil and water. Accordingly, a team from the C.I.S.I.R. designed a new still (MANAKOKA) which had the following features.

> The still used a new type of air cooled condenser in conjunction with an efficient latent heat exchanger. This novel condenser system reduced the water requirement to a mere 400 gallons. Unlike the conventional still which has a typical goose-neck to convey the hot vapour to the condenser the new still does away with this thus making it more facile for charging and discharging. The condenser tubes are made out of alluminium. It is preferable to the traditionally used copper tubes. The cost of this still is also far less

than one of traditional design. This still has now been patented and its designs are made available to the public. Already this type of still is in service at Walasmulla for the distillation of citronella oil, at Karandeniya for the distillation of cinnamon leaf oil. Within the next two months, two more are expected to go into service one at Ohiyo for the distillation of eucalyptus oil and another at Matara for citronella oil. Several other requests for this still are also pending.

Besides the above mentioned still, several other designs for specific spices have been completed. Their proto-types are being constructed at the C.I.S.I.R. and at other places in Sri Lanka. The ideas on which some of these stills are based have evolved from our studies during the last few years.

The second still the SPICA has now completed its tests. It was found to be extremely efficient in the distillation of such spices which contain a comparatively large proportion of fixed oils. These are nutmeg, pepper, clove and cardamom. This still again is based on a new idea where the steam pathway is through a flat wide bed of material and the distillate vapours pass into the condenser that is centrally placed along the axis of the circular bed of material. This arrangement overcomes the detrimental effects caused by material that tends to cake during distillation. Two other stills of the CISIRILL family have passed the designing stage. One the CISIRILL MEDPEE as a pressure distillation unit for oils that are difficult to remove from the plant material by steam distillation at atmospheric pressure. Examples of this type are vetiver and curry leaf. The next type of still the CISIRILL JALASULI is designed to handle such spices which require water distillation, that is distillation by boiling in mater itself and condensing the vapours. This type of distillation is more suited to certain spices such as cinnamon bark and ginger.

The second aspect of our research has been the studies of the chemistry of these spices and essential oils. This has been made possible by the fact that a few years back the basic minimum instrumentation was made available to the C.I.S.I.R. Namely, gas liquid chromatography and IR spectroscopy. We have used these instruments to carry out systematic studies on the type of chemical constituents that are present in cardamom oil, citronella oil, cinnamon leaf oil, cinnamon bark oil, cinnamon root oil, clove oil, fennel oil and lemon grass oil. Based on our findings, we are now able to estimate far more accurately and far more reliably than it was possible by the usual wet chemical techniques the major constituents of these oils. These instrumental techniques often enable us to get an idea of the minor constituents present in the oils which are not possible to even detect by other methods. Accordingly we have now with us expertise in techniques that are both modern and efficient and can be used for the assessment of quality in essential oils. We have also been able to monitor the performance of our industrial clients now producing these oils for export, on methods of improving their own products to reach export standards. We feel the increase in the export quantum of essential oils 0.7 million to 2.5 million rupees is substantially due to better quality standards achieved as a result of this work.

The third aspect of our research has been the upgrading of essential oils and the production of aromatic flavour chemicals from them. If I were to take one example from the work we have done, we have been able to prepare a variety of aromatic chemicals from the major constituents of cinnamon leaf oil namely eugenol. Some of these compounds are:

Acetyl eugenol, benzyl eugenol, benzoyl eugenol,
acetyl iso eugenol, benzyl isoeugenol,
benzoyl iso eugenol.

All these compounds have been made on a laboratory scale. Further work is needed to upgrade these laboratory preparations to a pilot plant basis. We have also been able to fractionate citronella oil into isolates that are enriched in the more important products, such as citronellal and geraniol and to prepare derivatives of these compounds that are used in flavour and perfumery work. There are a variety of other products of spices and essential oils which could be made here in Sri Lanka given time and opportunity for the necessary preliminary research. Products such as Oleoresins, [illegible] (the total solvent extracti[illegible] of a spice) and Dispersed Spices, are now coming into popularity in the industrialised countries. It is possible that we in Sri Lanka could think in terms of manufacturing these products here, for the purpose of export. Our research on spices and essential oils is geared to this end. It is our endeavour to provide the research base in the country for both developing new products and ensurement of their quality.

Our efforts have been greatly helped by sponsorship from the Ministry of Plantation Industries and the National Science Council of Sri Lanka.

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2nd July, 1973.

THE OUTLINES OF AREAS OF RESEARCH IN THE DEVELOPMENT OF CEMENT & CONCRETE

Research is the backbone of the development of any industry and tends to grow with the growth of the industry. Without research no industry can hope to compete, survive, grow or diversify. Up to now there has been a conspicuous absence of intensive, well co-ordinated and planned research effort in the Cement and Steel industries both at the national as well as industry levels.

It is therefore, necessary to establish Institutions for the maximum utilization of available research resources and for the co-ordination of dispersed individual efforts. The Cement Industry for it s development and growth requires research in specific areas. These can be conveniently classified into -

A Studies on Physical and Chemical properties of Raw Materials, Fuels etc.

B. Research on Cement

C. Research on Cement Production - Technology

D. Research on Concrete

E Structural Research

F Soils and Paving Research

A. Physical and Chemical Properties of Raw Materials

Scope of Work:

Physical and Chemical properties of raw materials used in the manufacture of cement and concrete, development of general laboratory procedures including petrography, mineralogy, spectroscopy, microscopy, electron microscopy; X'ray diffraction, differential thermal analysis etc.

Subjects for Research under "A"

(i) Petrographic and microscopic and other physical methods of examination raw materials used in the manufacture of Cement and Concrete.

(ii) Studies in the development of Laboratory procedures for the determination of the properties of raw materials, fuel, water etc and cement and concrete (both chemical and physical)

B. Research on Cement

Scope of Research

Studies relating to the properties of clinker, cements and cement pastes; Studies on the individual clinker constituents, their hydration and hydration products; development of new cements, cement paints etc.

Subjects for Research

1. Variations in the properties of clinker resulting from the variation in chemical composition, burning conditions; rate of cooling of clinker including phase equilibrium studies.

ii. Hydration of cement compounds i.e. the rate of hydration and heat evolved and the influence of these factors in mass concreting and other uses of cement.

Contd...../2

iii. Studies on the optimum levels of compounds such as free lime, magnesium oxide in Portland Cement.

iv. Studies on the influence of fineness and particle size distribution of cements on physical properties such as water requirements, workability, setting and hardening times, strengths, soundness etc.

v. Investigations on the manufacture and properties of cements such as high early strength cement, sulphate resisting cement, oil well cements, high alumina cements etc.

vi. Development of coloured cements and cement paints.

vii. Studies on the possibilities of utilising low grade and dolomitic limestones for the production of cement.

viii. Feasibility studies on the utilization of blast furnace slages; fly ashes etc as argillaceous materials in cement manufacture.

ix. Fundamental studies on the nature and function of water proofers, air entrainers, plasticizers etc.

C. PRODUCTION RESEARCH

Scope

Investigations in the area of the technology of cement manufacture to increase production, improve quality of cement and to achieve maximum manufacturing economy and efficiency. The uses of special techniques and equipment in the quarrying of raw materials; the preparation and homogenisation of raw material mixtures; Burning process; Reactions associated with kiln gases; grinding clinker and storage of cement; measuring and proportioning devices; automation etc.

Subjects for Research

i. Technology and economics of quarrying, handling and haulage of raw materials by different systems and equipments.

ii. Studies on the benefication of low grade material by screening; by floation for wet process cement manufacture or by electrostatic separation for dry process.

iii. Studies on the influence of trace elements on cement production.

iv. Studies on grindability of cement materials and grinding efficiency of different types of equipment.

v. Studies on the use and efficiency of low grade fuels in cement clinker production.

vi. Studies on the use of fluxes for improving the burnability of certain types of raw materials.

vii. Studies on the efficient utilization of fuels.

viii. Studies on the use of different types of refractories in the different zones of the kiln.

ix. Investigations of the factors which are responsible for the formation of mud rings; ash rings; clinker rings and the remedial measures to be taken to minimize such formation.

Contd...../3

x. Studies on the removal and collection of dust in the cement industry.

xi. Studies on the development and use of instruments required for the process control and automation.

xii. Studies on general maintenance of both the mechanical and electrical equipment used in the Cement industry.

xiii. Studies on the safety, productivity and efficiency of employees in the cement industry.

xiv. Studies on cost economies in cement plants with a veiw to reducing production costs.

D. Research on Concrete

Scope

Concrete materials; concrete mix design, placing and curing methods; deformation and other properties; heat resistance; alkali aggregate reaction, cracking; influence of aggressive waters; asbestos cement; light weight concrete, corrosion problems etc.

Subjects for Research

i. Study on the mix design for different types of aggregates and cements including assessment of the influence of moisture in the aggregate on the strength of concrete.

ii. Studies on the use of different types of admixtures such as plasticers, air entraining agents; retarders, accelerators etc. in concrete.

iii. Evaluation of the strength and deformational properties of concrete under different types of loading.

iv. Cracking of concrete.

v. Studies on alkali - aggregate reaction.

vi. Studies on light weight concrete and their properties.

vii. Concrete in acidic, alkaline and saline environment.

viii. Behaviour of concrete under very high temperatures and fire resistance properties.

ix. Corrosion of reinforcements in concrete including stress corrosion.

x. Influence of humid tropical conditions on the growth of fungi; moss etc on exposed concrete surfaces.

E. Structural Research

Scope

Studies on concrete in structures on the different structural elements made of plain, reinforced, prestressed concrete and constructions subjected to dynamic or repetitive loads; development of rational and economical design procedures; pre-casting and prefabrication; use of materials other than steel as reinforcements; cost and time studies of different methods of construction.

Subjects for Research

i. Experimental studies on different structural elements of various types of concrete structures.

ii. Development of rational and economical design procedures for concrete structures.

iii. Studies on the development of pre-casting techniques for casting structural elements such as lintols, wall panels, beams, columns, slabs etc.

iv. Studies on problems associated with tall concrete, constructions such as multi-storey buildings, cooling towers, chimneys etc.

v. Studies on liquid retaining concrete structures.

vi. Studies on concrete structures for the storage of food grains; cement etc.

vii. Studies on the design and manufacture of railway sleepers, pipes of all shapes, poles etc. in reinforced and pre-stressed concrete.

viii. Studies on the use of materials such as fibre-glass, plastics etc as alternative to steel reinforcement.

ix. Strength and deformation of structural elements when subjected to dynamic or fatigue loading causing tension, compression flexure, shear, torsion or a combination of any of these.

F. SOILS AND PAVING RESEARCH

Scope

Studies on concrete as a paving material, soil cement and its use in road and building construction; in slope protection of earth dams; in canal lining etc. Concrete reinforced concrete and pre-stressed concrete pavements - their analysis and design; cracking of pavements etc.

Subjects for Research

i. Soil-cement investigations of different soil types; development of design procedures for soil cement pavements; use of satisfactory soil cements for use in building construction in rural areas.

ii. Stablilization of slopes of earth - dams, cutting and canals by using cement.

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iii. Design of concrete and reinforced concrete pavements

iv. Pre-stressed concrete pavements for high ways and air-ports - their analysis and design.

v. Studies on wear-resistance and skid resistance of concrete pavements

vi Studies of specially heavy duty and alkali and acid resistance floors.

PRIORITIES IN RESEARCH - CEMENT INDUSTRY

1. At the present time, the cement industry is using high grade limestone for the manufacture of cement. High grade limestone is required for the blast furnace in the Iron and Steel industry when it materialises. It is therefore, essential to plan in advance to use low grade limestones including magnesia limestone in the cement industry by benefication. A research programme must be drawn up, at an early date, to examine methods suitable for the benefication of the low grade limestone taking into consideration the types of impurities and admistures present in this grade of limestone. Limestone is a very valuable industrial raw material. At the present time, it is used extensively for construction of buildings, roads etc. Alternative building materials should be found to replace limestone and thereby conserving limestone for industrial use at a later date.

2. Gypsum is imported and used as a retarder in the grinding of clinkerinto cement. The annual value of the imports will be in the region of Rs. 3 million in foreign exchange. Investigations are necessary for the full or partial substitution of gypsum by blast furnace slag. This material will be available in Sri Lanka when the final phase of the expansion of steel industry is implemented. A certain amount of work has been done in this direction in other Countries.

3. Investigations are also called for with regard to manufacturing special cements such as masonry cement, pozzalanic cement etc. using low grade limestone in the case of masonry cement; an adding calcined clays in the case of pozzalanic cements. Coloured cements and paints also require early investigation.

4. The cement rotary kiln incorporating the most modern advances in the cement technology is still only 50% efficient thermally. Fuel constitutes about 30% of the cost of production of cement. Investigations are, therefore, necessary to improve the thermal efficiency of the rotary kiln.

5. Studies relating to the use of Cement in Concrete

Immediate attention should be directed towards the following problems: -

a. Design of concrete mixes

b. Studies on the corrosion of steel reinforcement

c. Studies on the strength of concrete under combined stresses.

d. Studies on the methods of accelerated curing of concrete.

RESEARCH IN THE PRODUCTION OF IRON & STEEL

The production of Iron and Steel can be divided into three aspects: -

A. Production of Iron

B. Production of Steel

C Steel Works, Fuels, Furnaces, Refractories and Instruments.

A. Research in Iron Production

Scope:

Preparation and beneficiation of ores and their use in the blast furnace. Blast furnace fuels and furnace reactions. Blast furnace fuels and furnace reactions. Blast furnace slags and their uses. Blast furnace design plants and equipment. Blast furnace operation. Other methods of pig iron and alloy cast iron production.

B. Research on Steel Production

Scope

Blister, Shear and crucible steel. The Bessemer Process acidic and basic. Oxygen enrichment of blast and the use of pure oxygen, acid and basic open hearth process. Electric furnaces. Modifications of steel making processes. The manufacture of special steels.

C. Steel Works, Fuels, Furnaces, Refractories and Instruments

The uses of different fuels; oxygen enrichment, Furnace design and plant layout etc. Instruments for combustion control, pressure control, automat ic control etc. Selection of refractories withstand high temperatures abrasion, thermal shock, chemical attack and gases by slags, insulation etc. to prolong furnace life.

Dr. V. Perampalam
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VP/ka.

Aspects for Research in the Oil Refinery, Sapugaskanda

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The Oil Refinery at Sapugaskanda was erected in 1967 - 1969, and embodies fairly advanced know-how in refining technology and equipment design. Before outlining aspects for research I would like to briefly give the organisation structure, in order to show that upto a certain extent, provision for investigation and study of operating problems, whether in regard to processing or equipment has been already provided. However, there is indeed room for further outside assistance. We have three main departments; 1) Operations 2) Engineering 3)Administration. In the Operations Department, in addition to those in charge of Process operations there are advising Technologists. Their function is to keep a close watch on the various operations, and advise on maximising product output, and also to see that quality requirements are met. They analyse unit performance, and predict when regeneration of catalyst, or when steam-air decoking of furnaces are necessary. Trouble shooting is an important aspect of their work. In Engineering Department we have a full-time Inspection Department, whose main function is to advise on the repair methods to be adopted, and also maintain a continuous monitor on critical equipment, using available on-stream inspection tools such as X-radiography, Ultrasonic flaw detectors, in order to establish corrosion wear patterns, and advise on timely replacement of equipment before failure occurs. The Refinery operates continuously round the clock for two years, at the end of which 2 - 3 week shutdown is carried out both for the purpose of inspection and resetting of relief/valves, as well as for cleaning out of equipment which is required for operational reasons.

Now research in the Refinery, must fall within the objectives of the Refinery which can be stated as :-

1) To refine crude oil in order to produce refined products of the correct quality and required quantum, according to current product demand.

2) To carry out the above safely and within the equipment design limits, and the lowest possible maintenance and processing costs, and maximising foreign exchange savings.

To meet objective 1) we have to run the Refinery at maximum possible capacity, which at present is 10% above design capacity (5200 tons/day) and to meet objective 2), and to produce maximum foreign exchange savings we must maximise middle distillate production.

Now what are the problems we face? These can be classified as (a) Plant metallurgical problems mainly in connection with minimising of corrosion, and also equipment performance. (b) Process operating and utility operating problems. I will now outline some problems, beginning with (a)

Protection of overhead of Crude Distiller :

All crude oils contain varying amounts of salt, and electric desalters are installed to reduce the salt content. These are not 100% effective, and a certain amount of salt enters the crude distillation unit. The phenomenon of corrosion due to salts in crude has been the subject of much research, and can be said to be fairly well understood. Unfortunately, the control of corrosion is a complex matter. Briefly, it is the magnesium/calcium chlorides which are most harmful, as in the charge heater at temperatures over 120°C, hydrolysis takes place, producing Hcl.

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Hcl in its dry state is innocuous, but in contact with water it is extremely corrosive. In the atmospheric distillation column, the top regions are around water condensing temperatures, and it is these regions that corrosion is most severe. In the crude distillation column itself, the top four trays, as well as the column lining in this area, are of Monel, which is highly resistant to Hcl attack, and this is an approach by appropriate metallurgy to reduce corrosion. From the column we proceed to the overhead condensers, whose function is to condense overhead gases. In our Refinery, these comprise air cooled tubular exchangers, with tubes of carbon steel, and a water cooled exchanger with tubes of aluminium bronze.

The carbon steel tubes in these air exchangers are prone to severe attack unless measures are taken to prevent corrosion. Following methods are used :-

1) Injection of caustic soda: The injection of caustic into the crude stream neutralises Hcl formed in the heater. Generally, if properly applied about 95% of the Hcl can be neutralised in this way. The balance 5% finds its way into the overhead system.

2) Injection of Ammonia/Kontol Inhibitor : Gaseous Ammonia is injected to the overhead system to control the overhead pH at 6 - 7, so that Kontol type amine film inhibitor, which is also injected can be effective. The above control system has not been entirely effective, as evidenced by the corrosion in tubes of the air exchangers measured in 1973 January shutdown, when it was anticipated that a further life of 1 - 2 years may be obtained. These exchangers can cost above Rs. 70,000/= each, but more expensive is the downtime of the Crude Distillation Unit to install the new units, at nearly Rs. 100,000/= per day.

In crude H2S, is present and has a strong influence on corrosion in the overhead system. Here the most important parameter is the partial pressure of H2S, as this influences the stability of the protective iron sulphide film.

We are studying methods to improve this by :-

1) Alternative methods of corrosion control, and a proposal has been made by Central Service Organisation of Indian Oil Corporation. This envisages the injection of caustic plus Ammonia into the crude, instead of caustic only.

2) By the installation of corrosion probes and using a corrosometer to actually measure the corrosion level, (an acceptable is 5 mil/year). The present controls are empirical viz. 50 - 100 ppm on chlorides in the water condensate from overhead accumulator, and pH at 6 - 7.

Hence, we can summarise further work needed as ;

1) Modified injection of caustic and ammonia.

2) Installation of corrosion probes, or other means so that on-stream measurement of corrosion rate and rather than the current once in 2 years, thereby enabling a positive continuous control.

Failure of first stage blading on steam turbines :

The Refinery has two 5.5 MW steam turbo sets for generating its entire power requirements. In December of 1971, No. 2 set developed governor instability, which could not be resolved, and a manufacturer's representative was summoned. Whilst he was attempting to correct this the turbine developed high vibrations, requiring the removing of turbine covers for further

(Contd. 3/-)

investigation. It was then found that the first stage blade shrouding in one section had become detached, and there was general incipient failure. As no spares were available (these are never kept, incidentally as a 20 year life is normal), the shrouding was removed, and the rivets ground-off, the rotor was balanced at the C.G.R. Ratmalana shops, and the unit was satisfactorily commissioned. A similar inspection was made of No. 1 turbine, and here too the same pattern of failure was evident, though in a less advanced state, and the same remedy was adopted. We made a claim on the manufacturer on the basis that they supplied equipment with inherent defects, although the guaranteed period of 1 year was over. We had in fact operated for 3 years. The matter was referred by the manufacturers, who sent samples of the failed parts, to an Independent Laboratory, who said the failure was due to intergranular corrosive attack by chlorides present in the steam, on carbide precipitated on grain boundaries, in the chrome/nickel steel alloy blades rivets/shrouds. They concluded that the carbide precipitation may have occurred before or after manufacture, and in view of this vagueness, the manufacturer disclaimed liability. We in turn referred it to our consultants at the time, Shell International Petroleum Co. Ltd., in the Hague. They studied the matter and came out with the view, that the findings of the Independent Laboratory were correct, but disagreed with their conclusions. They pointed out whilst it is correct that carbide precipitation had occurred, this could have occurred only before manufacture, as certain minimum temperatures were required for this to happen, and these temperatures were not reached during operation in view of steam conditions. They said carbide precipitation most probably occurred during the heat treatment of the blades. Unfortunately, it is not easy to convince manufacturers of their errors, and this dispute is still unresolved.

As in the above case, there is a requirement for metallurgical analysis of failed parts, as by discovering the under-lying causes of corrosion, a repetition can be avoided either by altering operating conditions or improving the metallurgy of the failed part.

Steam Boilers :

The Refinery has 3 x 60,000 lbs/hr. boilers, steam at 560 psig/750°F, for driving steam turbosets for power generation and also to provide steam for process operations. Steam generation is therefore, a vital requirement, and 100% reliability is essential. Right from the start-up of the Refinery, this was one of our weakest areas, and many emergency shutdowns of Refinery had to be faced due to steam and consequent power failure. One of the reasons for the failure was the malfunctioning economisers. Economisers, are installed to remove heat from the flue gases, via the feed water to the boiler, and there is an improvement of about 4-5% in thermal efficiency. The main problems faced in the economisers was dramatic loss of wall thickness in the tubes especially at the water inlet regions, leading to rupture during operation. The problem was common to all three boilers. At first it was considered that the mechanism of failure was due to erosion from soot blowers, and from wet steam, combined with the effects of Sulphur tri-oxide in the flue gas. Although modifications were made these did not improve the situation, and further investigation revealed that the under-lying causes as mainly being due to low temperature dew-point corrosion. Now, the acid dew-point of flue gas is much higher than the water dewpoint, and can be as high 140°C. This means that if metal temperatures are lower than 140°C, then acid condensation will take place. In the economiser it was found that water inlet temperatures were lower than 140°C, and indicated that corrosion was primarily due to acid (H_2SO_3) deposition. A claim was made on the manufacturers for supplying an undersized preheater which was intended to heat the water above the acid dew-point, and they upheld the claim and provided 3 units free of charge. However, numerous boiler failures were being experienced,

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and since reliability is more important in this instance than economy, all economisers were removed, with the plan that they will be installed with thicker wall thickness tubes in the susceptible areas and with increased pre-heat capacity.

Here too, it was only after a proper metallurgical analysis that the real cause of failure was established.

The above are some of the problems we have encountered mainly on metallurgical aspects. I would like to consider, some work we have done on the operational side.

In relation to plant operations I would first deal with some development work rather than problems.

Production of L.P.G./S.B.P. Spirits/Aviation Turbine Fuel :

The Sapugaskanda Refinery, as built did not contain a provision for L.P.G. production. However, it was soon realised that the manufacturing of this product even to satisfy the rather small existing market would be worthwhile. The Refinery operates a thermal cracker (Visbreaker), which amongst other products makes cracked Naphtha. In order to render this product suitable as a gasoline component, it was necessary to stabilise it and also Merox treat (caustic treatment with merox catalyst) in order to remove sulphur compounds, mainly mercaptans. We also operate a Naphtha hydro-desulphuriser, for which the feedstock is stabilised straight-run naphtha. Since this unit had spare capacity, the cracked naphtha was fed after stabilisation in main S.R. Naphtha stabiliser, and treated in combined stream in the Naphtha Hydro-desulphuriser. This scheme released a whole train of equipment such as distillation columns, vessel, heatexchangers, pumps, which could be adapted for LPG production. The feedstock for LPG is from the catalytic reformer stabiliser tops, which is fractionated to yield mainly commercial Butane, which is caustic treated, to make a marketable product. The entire Island's requirement was supplied, and current plans are to produce this eventually from about 160 tons/year to about 10,000 tons a year, thus reducing the demand on Kerosene which we are facing increasing difficulty in fully meeting.

S.B.P. Spirits Production :

Several Special Boiling Point Spirits of Petroleum origin, are used in Ceylon of CIF value of about Rs. 2.5 million (in 1971). The feedstock for this is light Naphtha, already produced in the Refinery. By using one of the columns released from the Visbreaker Unit, it was possible to fractionate the cracked naphtha to yield SBP 62/82, 60/140. Low Aromatic White Spirits was also produced in the Kerosene Hydro-desulphuriser. All imports of these materials have been stopped.

The above descriptions have been extremely brief, and indicate the development work possible to maximise profits, i.e. by converting relatively inexpensive products, to valuable special products.

The production of Aviation Turbine Fuel is also worthy of mention, as it was undertaken only relatively recently. Here extremely stringent specifications must be met, and requires a reliable steady operation to produce on-grade product.

I would like to consider some development which we would like to develop in the future.

(Contd. 5/-)

BTX Production :

In the Refinery we have a catalytic reformer, which is used for high octane gasoline production. The reformate is high in aromatic content, and this can be further increased by special processing for BTX (Benzene, Toluene, Xylene) production. The main problem is to separate the reformate into Benzene, Toluene, Zylene. Local market demand is too low to allow a proper commercial design for which many licensed processes exist. There is scope for a pilot plant to achieve this objective, which can also if successful meet local market demand. BTX are essential components especially for the paint industry, and sizeable foreign exchange savings can be made.

Lubricating Oil Production :

Here again the size of the local market precludes a commercial unit. Unless a sizable export market is assured a lubricating oil plant making high viscosity index products is not commercially viable. At present the Refinery operates a Vacuum distillation column, the streams from which are light spindle oil or gas oil, and a heavy short residue, which is the starting point for Bitumen making. It may be possible, to obtain draw-off stream of low grade lubricating oils, to meet local demand for axle oils/heavy gear oils.

Corrosive Sulphur in Gasolines :

The storage tanks for gasolines, have floating roofs mainly to reduce breathing losses. Unfortunately, due to failure of hoses, the roof drains in some of these tank roofs have been out of action, with the result that rain water enters the tank. It has been found that under certain conditions the tank contents are rendered off-specification in respect of copper strip corrosion. In the dry weather, this problem is not experienced, and the problem is associated with the entry of water, and it is considered that sulphate reducing bacteria which thrives in water bottoms was the cause. However, attempts to eliminate the problem by treatment with biocides, and also altering the pH of the water, was not entirely successful.

As in the case of Aviation Turbine fuels, this would be a completely un-acceptable problem, in view of the need for strict conformity specifications, a clear analysis of the problem is desirable.

It is known that several factors influence the copper strip corrosion susceptibility i.e. the nature of various sulphur compounds, singly and together, and there is evidence that there is a synergist action.

Indigeneous Development of Spares :

The import of spare parts constitutes an ever-increasing drain on our foreign exchange. There is considerable room for application of known technology to produce spares. We have begun this, an in future shafts, wear-rings for pumps will not be imported, except for the more complex equipment.

25th June, 1973.

SW/SN

CORROSION IN THE WATER TUBE BOILERS OF THE PETROLEUM REFINERY

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I. Introduction :

The Petroleum Refinery is provided with three Ruths steam boilers to generate 60,000 lbs/hr. of superheated steam per boiler at 580 psig and 760°F. The boiler incorporates a feed water economiser preheater system and it is fired with forced draught. The steam produced in the boilers is used for the generation of the total power requirements of the Refinery, drives of some of the pumps and compressors, and also as process stripping steam in fractionators and for other general uses.

Since the start-up of these boilers in July 1970 the leakage in the economisers in the three boilers has resulted in numerous sparodic shutdowns of the Refinery. Further severe localised pitting corrosion has been experienced in the superheater tubes. In order to arrest the above failures a detail study was made on the corrosion in water side and fire side of water tube boilers.

II. Discussion :

1. Mechanism of boiler Protection against corrosion :

Water in contact with mild steel (or low alloy steel) in the boiler, even if oxygen has been properly removed will cause corrosion according to the following equations.

Below 50°C : $Fe + 2H_2O \rightarrow Fe(OH)_2 + H_2$

A non-protective layer of iron hydroxide is formed on the steel, which at a higher temperature will be converted into a protective Fe_3O_4 film.

Above 50°C : $3\ Fe(OH)_2 \rightarrow Fe_3O_4 + 2H_2O + H_2$

at higher temperatures e.g. in the range from 220° to 570°C,

Fe_3O_4 (magnatite) is formed directly by the reaction.

$3\ Fe + 4\ H_2O \rightleftharpoons Fe_3O_4 + 4\ H_2$

Provided the condition in the boiler are adequate, this film of magnetite will adhere well to the mild steel substrate and after obtaining the required thickness, will protect the steel from further attack. Keeping this Fe_3O_4 film in good order is the main reason for the elaborate control of water-side boiler conditions.

The formation of protective Fe_3O_4 films is accelerated by increased temperature and higher alkalinity.

This is one of the reasons for maintaining the pH of the above boilers between 10 - 11. Another reason for high pH is that the Fe_3O_4 film is easily removed from the steel under flow conditions at lower pH values.

2. Causes of boiler corrosion :

Corrosion in boilers will take place.

a) If the formation of a protective magnatite film is prevented.

b) If the protective Fe_3O_4 film is damaged or attacked during operation.

a) Inadequate film formation :

If the water-side walls of the boiler are not clean, the effective formation of uninterrupted Fe_3O_4 film is impossible. Before start-up of the boiler foreign matter oil and grease are removed by an alkaline boil-out. In the case of the Refinery boilers Tri-Sodium Phosphate is used for boiling out. It is

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strongly advised to clean high pressure boilers with acid in order to dissolve rust and to loosen and remove mill scale. In this way a steel surface is obtained on which an uninterrupted protective magnetite film will grow during the initial stages of operation.

b) Damage to or attack of the magnetite film :

1. By Oxygen :

If the oxygen levels in the boiler water are too high either as a result of the entrance of air during shutdowns or as a result of improper deaeration of the boiler feed water, steel exposed to the water on spots where the Fe_3O_4 film is damaged will react as follows :-

$$4\ Fe + 2n.\ H_2O + 3O_2 \rightarrow 2\ (Fe_2O_3.\ nH_2O)$$

The powdery hydrated ferric oxide thus formed is non-protective and promotes pitting corrosion of the steel underneath by differential aeration (galvanic action). This is the main cause for the severe localised pitting experienced in the superheater tubes of the refinery boilers. To prevent this every effort is being made to prevent mal-operation of deaerator and it is proposed to inject catalysed (activated) sodium sulphite instead of the normal sodium sulphite used at present to remove residual oxygen.

2. By high Alkalinity :

The corrosion rate is low at a pH of 11.5, however, at increasing concentration of caustic the corrosion rates increases rapidly and at a caustic concentration of 40% catastrophic pitting corrosion would be experienced. These high caustic concentration would be formed by high heat transfer through tube wall or low water circulation in tubes giving rise to intermittent film of wet steam on the tube wall. The high concentration of caustic attacks the protective Fe_3O_4 film as follows :-

$$Fe_3O_4 + 4\ NaOH \rightarrow 2\ NaFeO_2 + Na_2FeO_2 + 2H_2O$$

The sodium ferrite and sodium hypoferrite thus formed are both soluble in hot concentrated caustic and in this way the steel is open to direct rapid attack by NaOH as follows :-

$$Fe + 2\ NaOH \rightarrow Na_2FeO_2 + H_2$$

This type of attack has been recorded in the target wall header of the boiler in the Refinery. Attack of caustic can also occur in superheaters by carry-over of a mist of concentrated boiler water from the steam drum. With the evaporation a concentrated caustic solution is left behind.

3. Caustic Embrittlement :

This is particularly a problem when riveted drums or boilers are used. At points of steam leakage, caustic concentrates and at locations of high stress, stress corrosion occurs leading to cracking and leakage.

(Contd. 3/-)

4. By Acidity :

If the pH of boiler water decreases, the growth of the protective Fe_3O_4 film is retarded, at an even lower pH, the Fe_3O_4 film is removed.

Low PH is caused by :-

i. CO_2 dissolved in the boiler feed water.

ii. CO_2 formed by the decomposition of sodium carbonate in the boiler.

$$Na_2Co_3 + H_2O \rightarrow CO_2 + 2\ NaOH$$

The above situation was never experienced in our boiler since adequate boiler water treatment facilities has been provided.

5. Corrosion fatigue and other effects of Mechanical Stress :

During operation the protective Fe_3O_4 film may be damaged as a result of mechanical stresses, the vibration of the boiler tubes giving rise to cracking of the film and corrosion of the bare steel. The cyclic stresses will crack each new Fe_3O_4 film forming on the bare area and fatigue cracks grow in the steel tube wall. Thermal stresses, which are found in tube areas where cyclic heating and cooling takes place may also damage the Fe_3O_4 film and cause corrosion fatigue cracking. The vibration of superheater, heater tubes of the Refinery boilers could have occurred due to burn-out of the support plates and thermal stresses could have also taken place due to the numerous shut-down and start-up.

3. Fire Side Corrosion :

a. High Temperature Corrosion :

Corrosion on the fire side of boilers especially of boiler tubes and superheater tubes, could be experienced depending on the temperatures and compounds present in the fuel used for firing.

If the heat transfer of steam-generating tubes is insufficient the tube wall temperature increases and oxidation and possible tube failure takes place. The same holds if combustion control is inadequate and flame impingement occurs.

In superheaters, deposition from entrained boiler water may lead to the overheating, oxidation and creep failure of the tubes.

Severe corrosion of external tube walls will be found in residual oil-fired boilers if the fly ash deposits contain considerable amounts of Sodium and Vanadium and wall temperatures, exceeds 1150°F. In fly ash deposits Sodium Vanadates and iron Sodium Sulphates are the main corrosive compounds.

The high temperature corrosion has not been noticed in Refinery boilers.

b. Low Temperature Corrosion :

Various compounds are present in flue gas. In residual fuel oil fired boilers the following compounds may be found in the fuel gas.

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H_2O 10%; CO_2 15%; SO_2 0.1 - 0.3%; SO_3 up to 0.01%

Hcl up to 10 ppm (Vol.)

Upon cooling, the following corrosive acids are deposited from the flue gas on metal and refractory surfaces.

∠ 300°F H_2SO_4

∠ 210°F H_2SO_3, H_2CO_3

∠ 140°F HCL

Below 300°F corrosion on exposed metal surface is severe and at lower temperatures corrosion becomes more and more catastrophic. This type of corrosion has been experienced in economizer tubes with too low boiler feed water temperature, soot blower lines, and during down time. The numerous economizer failure experienced in the Refinery was mainly due to the acid dew-point corrosion since the temperature of feed water was around 250°F and further corrosion could have taken place during the down time. Detail analyses of the design of preheater economiser system showed by increasing the capacity of preheater by 100% the feed water temperature could be increased to the required level. The extent of corrosion in the economiser were so severe that we were forced to operate the boiler without the economiser and the operation with the preheater of higher capacity was not possible due to the mechanical reliability of the economisers which has already severely corroded. However, this operation will be carried out after replacement of most of the tubes in the economiser. Modification to soot blower of economisers has been also made to improve feed water temperature by improving the heat pick up. Reduction of down-time corrosion is achieved by injecting NH_3 into combustion chamber to neturalise acid during shut-down and also by washing down the economiser while it is hot.

III. Conclusions :

The type of corrosion experienced in the Refinery boilers are :-

1. Severe localised pitting in the superheater tubes. This may have been mainly due to oxygen attack.
2. Pitting corrosion due to high caustic concentration in the target wall header.
3. Damage to the Fe_3O_4 film due to vibration of the superheater tubes and also due to thermal stresses by the numerous shutdown and start-up causing corrosion fatigue.
4. Fire-side corrosion on economiser due to acid dew point caused by the lower inlet-water temperature to the economiser.
5. Acid dew point corrosion in soot-blower lines and flue gas side corrosion during down-time.

The above type of corrosion were established by making use of the Inspection and Laboratory results with the limited available equipment. However, detail analyses of the samples obtained should give better results and C.P.C. would welcome any research carried out by Universities and Research Institutions with specialised equipment.

The following steps are taken to control corrosion in the Petroleum Refinery boilers :-

1. The boiler water pH is maintained between 10 - 11 to promote the formation of protective Fe_3O_4 film on the steel surface.

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2. Silica in boiler water is kept below 10 ppm to prevent carry over into superheater coils and also to power generating turbines.

3. Phosphate in boiler water is maintained between 20 - 40 ppm by injecting tri sodium phosphate to prevent scaling due to residual hardness of the feed water. The phosphate reacts with calcium to form the calcium phosphate, a rather flocculant precipitate, which remains in suspension without adhering strongly to the tube walls.

4. Sodium sulphite is injected into feed water after deareation to remove the residual oxygen. Due to the severe oxygen attack experienced it has been proposed to improve the activity by injecting catalysed sodium sulphite.

5. Strict control on the quality of boiler feed water is maintained to prevent caustic injection. Demineralizer is operated to produce neutral water with silica$\angle$1 ppm condensate return water is maintained at oil content$\angle$2 ppm and silica$\angle$1ppm.

6. During shut-down NH_3 is injected into combustion chamber to neutralize acid deposits and the economizer is also washed down with water. Further during down-time the boiler is filled with condensate inhibited with oxygen scavanger to prevent internal corrosion.

7. It has been proposed to increase the capacity of feed water pre-heater by 100% in order to improve economiser inlet water temperature to acceptable level to prevent acid dew point corrosion.

8. Modification to economiser soot blowers had been proposed to improve the heat pick up in order to eliminate acid dew point corrosion.

25th June, 1973

SS/SN

Research and Development in Paper, Leather and Textile Industries of Sri Lanka

Paper, Leather and Textiles are all fibrous in character.

Paper

Paper as we know today is a laminated sheet of vegetable fibres suitably processed to serve the purpose of writing, printing, wrapping etc. Fibres of wood are, generally, the source of raw materials for the manufacture of paper, although non-woody fibres like grass, esparto, straw, hemps, etc. are also used. The Eastern Paper Mills is an integrated pulp and paper mill, which now produces Bond paper, Writing paper, Printing paper, Duplicating paper and Wrapping paper. Paper board is also being produced since last year. Straw forms the main raw material for the above products.

The history of paper making may be told in terms of its search for newer raw materials. There is, however, a new problem which has come into focus today - the large amount of solid waste, which has to be disposed. The present desire to recover more secondary fibres is due more to problems of ecology and the need to solve the solid waste disposal problem. The industry's demand for fibres during the next two decades will depend on the economy of the country and the relative use of paper and paper board within that economy.

There is an urgent need to minimise the problems of solid waste disposal and an increase in research on separating processes for the use of waste paper as a paper making raw material. At the same time other considerations such as the desire to preserve the forests than denude them may bring the problem of fibre availability more crucial.

In 1975 the total demand for paper and paper board is estimated as 87,000 tons. The consumption in 1971 was 30,000 tons - this will necessitate an increase in production of 57,000 tons. New projects planned to meet this increased production will produce 109,500 tons giving a surplus of 22,500 tons for export.

The present factory is at Valaichchenai and the two new mills will be at Embilipitiya and Rajangana near Tambuttegama. The Valaichchenai factory will then produce (a) Special grades of paper and (b) Paper board. The Embilipitiya mill will produce fine grades of paper such as writing paper and tissue paper. The Rajangana mill will produce (a) Newsprint (b) Medium course grades (c) Kraft and (d) Low grades of printing papers.

The above projects will require extra pulping capacities in the respective pulping mills for the following reasons:-
(1) To give flexibility in the use of different indigenous raw materials.
(2) To use as much as possible of the long fibre substituents, as it gradually becomes available locally to replace ultimately all the imported long fibres.

Research studies carried out in the laboratories of the Eastern Paper Mills Corporation

1. Tropical long fibre substituents.

Since rice straw pulp consists of short fibres, only a certain percentage of long fibred imported wood pulp have to be used for blending depending on the grades of paper to be produced. Investigations show that plants like Kenaf, Sunn Hemp and Bamboo are good substitutes for long fibres. Mill trials carried out using 100% Sunn Hemp pulp in the furnish and 76% Sunn hemp pulp with 24% of waste paper in the furnish were successful. Kenaf a fast growing annual plant was also subjected to study and found to be a very good substitute. Kenaf is used in the U.S.A. for the manufacture of Newsprint and is thus a distinct possibility for the same purpose in this country.

Banana is another agricultural waste, Laboratory tests of Banana stems indicated that it is a good source of long fibre pulp for paper making. Bamboo is widely used in India and is not a new material for paper making. Experiments have shown favourable results.

2. Tropical Mixed Hardwoods.

Laboratory investigations were carried out with match wood waste and the pulp was found to be suitable to be blended with long fibred pulp for producing certain grades of paper. The use of these hardwood pulp is a good short term measure and as clearing of these wood is carried out, afforestation of these areas may be made with Bamboo and conifers. Eucalyptus is a short fibred plant. It has been used widely in Australia in the manufacture of Newsprint by a semi-chemical pulping process. A similar process is to be used in Sri Lanka. Other plants which have been tried out include Bagasse, which is being tried out for the making of newsprint.

It may also be mentioned that quick growing conifers are being tried out in the Upcountry areas for newsprint. Textile mill waste could be used for high grade quality paper and saw mill waste from the Plywoods Corporation could be used for making low grades of paper.

The Corporation has also indicated to the General Research Committee of the C.A.A.S. the areas where research is necessary. They are
(1) Removal of Silica and the recovery of chemicals.
(2) Determining the suitability of the use of pulp and paper mill effluent for irrigation purposes.
(3) The most economic method for the removal of algae for use as process water in pulp and paper mills.
(4) Improving the brightness of paper using the locally produced kaolin.
(5) Problems connected with the development of fibrous raw material for paper manufacture.

The picture will not be complete without mention of some of the converting industries such as Multiwall sacks, Envelopes, corrugated boxes, rigid boxes, folding boxes, Paper cans and tubes, coated paper and paperboard and disposable tissue. Only a few of the above are manufactured locally but there is a good demand for the others.

Leather.

Skin is a complex tissue containing a variety of proteins, cellular substances, salts, carbohydrates and fat. The main fibrous component of hide and skin is Collagen. The degree of utilisation of hide proteins in the Leather industry is very low. The amount of collagen protein that is found in the final product, i.e. shoes, is only 28-32% of the protein contained in the raw hides. This means that about 70% of Hide matter is wasted at different stages of manufacture of leather and leather products. There is a wastage at trimming of leather (6-8%) and in the shoe factory clicking room (15-20%).

These figures show that the extent of hide protein waste is very high. In the tanneries and shoe factories there is a possibility of reducing the recoverable losses, but at the present stage of development of the industry in this country does not permit the reduction of unrecoverable losses which accounts for 50% of the total. In these circumstances the trend should be to manufacture various by-products from these valuable wastes. The reasons for this being:-
(1) To reduce the world lack of proteins.
(2) To improve the economic efficiency of the Leather Industry.
(3) To solve the problems of disposing of waste in the tanneries and shoe factories and so diminish pollution.

The more important by-products are Leather board which is made locally, Animal food, production of artificial casings (for sausages, salami, etc.) and the production of semi-synthetic calloagenous poromeric also called Plastic Collagen Leather (PKK). The last three items are not as yet made locally but are certainly necessary for development of the industry in this country.

Dr Z.Kotazek of the State Leather Research Institute, Gottwaldov, Czechoslovakia, who was with the Ceylon Leather Products Corporation until recently stressed the need for development of the leather industry here with emphasis on the utilisation of waste hide proteins. The need for such development, he said, was based on the following facts:-

(1) Per capita production of footwear in Sri Lanka is 0.6 pairs per year which is lower than the world average. The average for industrially developed countries is about 4 pairs per year. He said that attempts should be made to increase our figure to one pair per head by 1975 when the projected world average would be 0.95.

(2) The percentage of leather footwear is only 10.7% compared to 40% for developed countries. He said that our target for 1975 should be at least 20%.

(3) He said that although no livestock population figures were available, considering the very favourable climatic conditions, steps should be taken to at least double the present production. This would solve not only the problem of the leather industry but also solve the more important problems of food production and employment.

(4) Attempts should be made to minimise faults such as branding, bad flaying and inadequate preservation of the raw hide.

Under the Research and Development programme the Corporation has given priorities for import substitution work and has been successful in developing several substitutes for imported materials.

1. Application of Natural Rubber Latex in the finishing of Leather.

A leather binder with similar properties to imported synthetic binders, has been developed by grafting methyl methacrylate monomer to natural rubber latex. Approximately 20% of the binders imported for finishing embossed and lining leather have been substituted by this newly developed binder. The manufacture of the binder is a rather simple process and is carried out at the tannery.

2. Utilisation of the bark of indigenous Wattle plant for tanning leather.

Approximately a million rupees worth of solid wattle extract is imported annually for the leather industry. Experiments carried out at the Corporation in extracting tannins from locally available Wattle Bark have proved highly successful and plans are now being made to construct a pilot extraction plant at the Corporation's Tannery with the assistance of the C.I.S.I.R. The harvesting and the supply of bark will be organised by the District Development Councils at Nuwara Eliya District. The project has bee planned to operate in phases, firstly to supply the Corporation's Tannery its requirements of wattle extracts and, then progressively supply the other private tanneries too. This will not only help to substitute imported solid Wattle Extract but also create new employment opportunities for a number of villages in the Nuwara Eliya area.

3. Utilisation of Tea-Waste and Coconut Husks in the Tanning of Leather.

Experiments conducted have shown that tea-waste and coconut husk contain appreciable amount of tannins and it can be a potential source of tanning material for the leather industry.

4. Use of Casein in Finishing Leather.

Casein, which is a by-product of the milk industry, could be used in place of certain imported synthetic protein binders in the finishing of leather. The National Milk Board has already indicated to the Corporation that skimmed milk, to prepare Casein to meet the entire requirements of protein binders, which is more than two and a half tons a year, could be produced by them.

5. Shark Liver Oil as a tanning agent.

Shark liver oil was found to be a good tanning agent for leather. The Corporation produces fairly large quantities of Chamois leather with oil supplied by the Ceylon Fisheries Corporation. But due to other domestic demands the Ceylon Fisheries Corporation is unable to supply the necessary quantities of the oil for commercial production.

6. Leather buffing dust as a substitute for high-styrene resins in Rubber Industry.

Leather buffing dust, which is a waste product of the tannery, is finding a valuable use in the rubber industry. Research work carried out in co-operation with the Rubber Research Institute revealed that the high styrene resins imported for the rubber industry can be completely replaced by leather buffing dust. A leading manufacturer of rubber goods is using leather dust in commercial production in place of imported resins.

Besides the above developments in leather chemicals and auxiliaries, vast improvements have been recorded in product developments as well. About a hundred and twenty types of leathers are now being produced by the Corporation's Tannery and over 70% of the production goes to export markets.

Among new developments Batik leather takes a prominent place and is exported to various parts of the world including U.K. and Italy.

Textiles

Textiles are manufactured from fibres, filaments, or yarns, natural or man-made, obtained by weaving, knitting, felting, bonding, and tufting. It is said that when Prince Vijaya landed in Sri Lanka he found Kuveni engaged in hand spinning cotton yarn. The first major industrial venture, the Wellawatte Spinning and Weaving Mills, was established in 1888, but the Textile Industry showed any development only in recent years.

In the foreword of the book on the five year plan the Prime Minister Mrs, Sirimavo Bandaranaike wrote " We import our cloth while our factories and powerlooms and handlooms remain unused, and what is worse, we do all this on credit which future generations have to pay".

The Textile Industry today has nearly 250,000 spindles with possible expansion tomore than 300,000 spindles. The weaving capacity consists of 10,000 power looms and 90,000 handlooms, both in the public sector and and private sector. The looms belonging to the Department of Small Industries are only worked for two shifts, whilst the rest are worked for three shifts. If yarn is available and all looms are activated ie they are worked for three shifts, there will then be an excess of woven cloth, since there are no finishing facilities and there will be no local demand at a figure of 11yards per head. We will then have to find an export market for this excess Grey Cloth.

Whilst spinning weaving and finishing have more or less achieved self-sufficiency, it is unfortunate that the industry has to depend on imported raw material and know-how. The units at present are capable of producing over 30 million pounds of yarn per annum. It has to depend for its cotton enterely on imports, the locally grown cotton which amounted to less than 2% affew years back now amounts to about 10% of the requirements. The earlier variety of cottongrown was H.C. 101 and this has now been replaced by a B.P. variety. The cotton is now grown in the Walawe and Mahaveli basins and in terms of the five year plan it is expected that 24,000 acres of cotton will be grown under the Walawe Scheme This acreage being capable of giving 25% of of our cotton requirements. Although the local conditions may not permit the growing of all our cotton varieties if we extend our cotton growing areasto regions other than the Walawe and Mahaveli basins a major portions of our cotton requirements will be met. This variety of cotton now grown is of medium staple and yarns of counts 30's to 40's could be spun from them.

It is proposed to establish a polyamide plant for the manufacture of Nylon, if this materialises Sri Lanka will soon have its first synthetic fibre extrusion plant.

The employment potential indicates that the Textile Industry is one of the leading Industries in SriLanka. Under the Five Year Plan this industry plays a major role providing employment for an additio nal 40,000 persons and has a growth rate of 19 per cent per annum.

I will now attempto point out areas where Research and Development are necessary for the progress of the Industry.

L. Fibres Cotton is grown now as a as a primary crop in the Yala season in the Walawe region. A cotton research station has been established at Suriyawewa in Embilipitiya. Its main objectives being to improvethe yield of cotton per acre under irrigated and rain fed conditions and to improve the spinning value of the strains. U.N. assistance has been obtain edto finance the laboratories. The adoption of early early sowing and the development of early maturing varieties have been found useful in reducing serious losses, which could be encountered in later stages of growth.

Experiments have been conducted on a scale in growing and extracting bast fibre such as hemp, banana pineapple etc but so far it has not proved a commercial success, although in other countries vegetable fibres are used.

Sericulture is being given a new life under the five year plan and silk farms are being established in the Kundasale region and also on some estates.

2. Chemicals. Soaps are satisfactory substitutes for detergences but further work is necessary to improve their effectiveness.

Turkey Red Oil can be prepared from Castor oil but there are insufficient quantities of Castor seed in Sri Lanka

Mutton Tallow is a very suitable Softener but available in very small quantities

Binders could be made from latex as in the leather industry to conserve our foreign exchange.

Thickeners such as Sodium Alginate are necessary, the latter has been obtained from local sea weeds, but so far no large scale manufacture has been undertaken.

The C.I.S.I.R. is presently doing work on enzymes. Firms like Lever Bros have also carried out work extracting enzymes from Kurakkan, Paddy and other cereals.

Tapioca Starch is being developed here and, the I.D.B. has set up a plant (pilot project) at Hanwella. In this connection atthe request of the I.D.B. the chemistry department of the University of Sri Lanka at peradeniya has evolved a thin boiling starch from manioc which is said to have the same features as the imported corn starch.

The C.I.C. has established a factory for local formulation of resins based on imported chemicals.

3. Machines and Accessories Although no machines have been turned out anumbe of machine spares, mostly wooden, are been made locally.

4. Technology No attempts have been made to undertake fundamental, applied and operationalresearch or developing methods to compare labour and machine productivity and to judge spinning performance. This is probably due to the absence of a Textile Research Association in Sri Lanka. Textile Research Associations in other countries are sponsored by the Textile Industry and supported the Institutes of Industrial and Scientific Research in that country.

5. Man Made Fibres No work has been carried out to identify a local wood for cellulose pulp and ultimate conversion into Viscose Rayon. Cotton linters could be used in the manufacture of cellulose Acetate Rayon.

I have only very briefly outlined the Research and development in the three industries. I have to acknowledge my sincere thanks to the Factory manager Mr Sabideen and Mr. Wickremasinghe of the Ceylon Leather Products Corporation, Mr P. Manokeran of the Eastern Paper Mills Corporation and Mr E. Palarajasinghe without whose help I could not have been able to present this paper today.

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RESEARCH IN FOOD SCIENCE AND TECHNOLOGY.

BY

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Department for the Development of Marketing

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In this contributionto the symposium, it is not my intention to cover the research work done in the various aspects of food and the associated technologies. It would be presumptious on my part to claim to know the details of all the research activities done by the different scientists and technologists in their respective organizations. In any case reports and summaries of such research are more appropriately and more interestingly presented by the researchers themselves. What I would attempt to do is to indicate the general trends in some areas of food processing and later to deal at some length on the context and organisztion of food research in our country.

The rapid changes in the economic conditions and in the food situation during the last two decades have drastically altered the scope and emphasis of food research. The conditions are in fact changing so fast that the aims and objectives of food research are being revised, even during a period of a few months, to cope with new problems that emerge, as it were, over night. A succession of crises in the food situation caused by the scarcity of some variety of food - potatoes, onions, chillies, sugar, flour etc., was highlighted a corresponding scene in food research. Food research if is to be of maximum benefit must be dictated not by the circumstances as they are now, but by the demands and problems as they will arise in the future - next month, next year, or even five or ten years hence. It is this anticipation that will enable the countryto cope with the problems before they assume gigantic propostions and it will also enable export industries to remain competitive in the world markets. Food science has been termed "S O S" i.e. the Science of Survival and it is difficult to find a more fitting description considering the role it plays in Sri Lanka today.

Ad hoc crash programmes of research cannot be worked out and carried through with any degree of thoroughness, deploying the best suited people and equipment on the job. They are often much more expensive than projects thought out well in advance of the eleventh hour.

Let us now look at the general trends in food research in some areas of food. Considering the staple diet, in the form of cereals, we find that researh has been entirely on agricultural aspects rather than on processing. The recent creation of the Paddy Marketing Board which is responsible for the entire purchase of surplus paddy, intermediate processing by parboiling, hulling, polishing etc., and the final distribution and sale of the processed rice, has placed the problems associated with paddy and rice on one single organisation. The problems which are now being investigated by the Paddy Marketing Board are the optimum moisture content in paddy at harvest time - a factor which affectsboth the price paid to the farmers for the paddy purchased as well as the milling characteristics-conditions of paddy storage in silos instead of in the traditional gunny bags which involve foreign exchange and therefore

now increasingly unavailable, deterioration due to fungal and insect attack, conditions of parboiling and hulling in relation to the more popular high yielding short term varities, and better packaging of cleaned rice in ratail polythene packs. On account of the large quantity of paddy and rice handled a slight improvement in any of the processes e.g. in hulling efficiency, reflects significantly on the economy.

In the case of wheat milling at the State Flour Milling Corporation, while no research as such appears to be in progress certain problems connected with the utilisation of mill byproducts such as wheat germ and wheat bran have been identified, and it is considered that human and animal foods valued at 5 - 10 million rupees are realisable from these by-products.

Finally while on the subject of cereals it is necessary to mention the attempts to supplement rice and wheat with manioc in the fresh form or as flour or as starch. This topic has had full coverage in a recent symposium under the Institute of Chemistry.

With regard to milk which is perhaps the next in importance as a food, the problems are of inadequate volume of production- the present per capita consumption being 2 ounces as against a recommended daily intake of 5 ½ ounces. Research on processing is minimal and the main burden of the scientific and technical officers in the milk processing industry is quality control. However temporary problems such as ahortage of bottles or tinplate cans for packaging call for investigations on stop gap remedial measures.

Taking fish and fish products next and including in this category dry fish, prawns and lobster, it is relevant to mention that this contributes the main animal protein fraction in the rural diet, - in the form of dry fish. The research input as regards processing is low. The main problems are once again inadequate quantities and high prices and the efforts have been mostly on increasing the catch by expanding the fishing fleet and by mechanization of fishing vessels. The recent development of the exports of frozen prawns and lobster necessitated research investigations on the development of micro flora in the frozen products at low temperatures. Progress in the manufacture of canned fish is limited by the supply of canning varieties of fish Kumbalawa and Salaya rather than by research and know how. The production of fish protein concentrate from abundant cheap varieties of fish, in which field research is needed has not been taken up as a major item of research.

With regard to meat (beef, pork and poultry) again the problems are in production, governed principallyby the availability of animal feed materials and to a lesser extent by the control of bovine and avian diseases. The limited production of cured meat products by a few private sector firms has been accomplished applying well known techniques.

Coming to the last main category viz : fruits and vegetables, preservation industries established for programmes of import substitution or for export have been based partly on adaptation of existing methods to raw materials and conditions obtained locally and partly on research on processing techniques. developed here. The extension of the technical know how to the entrepreneurs was a key factor in the development of the fruit preservation industries. The potentially large export earnings realizable from this industry are once again, not limited by scientific or technological research but by the agricultural production of the main raw materials required to feed the factories.

Therefore in general it would appear that the growth of the food industries has had the requisite minimal support from food research, so as not to be limited by technical knowhow. However what I would like to emphasize here is that while the giving of minmal support, absolves in a sense the scientists from having been found wanting at any stage, the positive contribution that a more purposeful programme of food research could have made and can make to a more rapid development of the food industries cannot be underestimated. Food research has always to be ahead of the needs of the industries and of the population, and we should at least have tentative solutions today for the possible problems of the tomorrow.

This leads me to the second part of my talk where in the available time I would like to comment on the organization of food research in our country. This is a subject which has been considered by several experts both foreign and local, during the last two decades and apparaently no finality has been reached. I do not of course speak as an expert but as one directly involved in it and deeply concerned about it. In a re-consideration of this question one has to take into account the present circumstances and needs and to see whether the earlier recommendations of many years ago under different circumstances, are in fact the best in the new context.

As indicated earlier food research is diverse in kind; short term in relation to ad hoc problems or long term in relation to more perspective needs; they may be chemical, microbiological,nutritional, physiological or they may pertain to engineering problems or market research aspects. Again one may classify them in relationto the two type of equipment - laboratory scale pilot plant scale or actual factory scale and of course the type of investigator would vary with the type of investigation. This diversity necessitates specialisation and it may not be possible to do all types of investigations under one roof.

The first major study of the topic and concrete contribution on the subject was made as far back as 1952 by Dr.Kertesz. He advocated a food research institute comprising five main divisions

Food Analysis
Food Biochemistry and Nutrition
Food Technology
Food Microbiology Sanitation and Storage
& Home Economics and Dietetics.

with a staff of thirteen research officers excluding the Director and Deputy. The objectives were very broadly stated to encompass all types of investigations. However some topical and typical problems for investigations were indicated, and among them interestingly enough, large scale utilisation of manioc, grain storage studies and recovery of nutrients from rice bran. This was in 1952.

For several resa the recommendations of Dr.Kertesz remained un-implemented. In 1966 another FAO food scientist Dr.E.C.Bate-smith examined the problem from a narrower angle in relation to the development of the fruit processing industries and recommended a specific research unit concerned with fruit processing and fruit storage studied particularly in relation to export developments. In the years between these two recommendations Sri Lanka's food position, food industries and food research had undergone considerable changes. Investigations relating to food are now being done in several institutes or organisations

Ceylon Institute of Scientific & Industrial Research
Medical Research Institute
Central Agricultural Research Institute
Tea Research Institute
Fruit & Vegetable Utilisation Laboratory
in organizations
Central Milk Board
Ceylon Fisheries Corporation
Flour Milling Corporation
Coconut Development Authority and the Boards under it
Sri Lanka Sugar Corporation
National Salt Corporation
Paddy Marketing Board
Co-operative Wholesale Establishment
Industrial Development Board
Cashew Board and the
Oil and Fats Corporation.

The contribution to food research by the private sector has also to be included.

During the last two or three years the National Science Council which is concerned with overall scientific research in Sri Lanka has arranged for the enhancement of research at the universities and other centres.

In spite of the fact that a considerable volume of food research is being done in the various units in relation to their specific needs, there are areas which do not come within the scope of the existing institutions. For example : examination of fresh and processed foods for pesticide contamination, though a matter of great importance and urgency is not he burdenof any of the organizations mentioned earlier. Similarly the testing of manufacturers' samples of food products an an advisory or quality control service or the quality testing of samples of food drawn from export consignments for purposes of issuing export licences are not undertaken by any organization. These are examples of service which need to be renderedimmediately and the simplest proceedure would be to extend the facilities of the most relevant laboratories.

It is argued that a single large food research institute as suggested by Dr.Kertesz, but now obviously on a much larger scalethan recommended by him,will be able to undertakeall types of food research problems. Considerationg the number of organisations now carrying out researchpertaining to the foods that they handle, and considering the growing demands of the food processing industries, this conclusion, is very risky. The trend in food research institutions in other parts of the world has been thereverse. Usually branch laboratories are established with respect to different foods or even on a regional basis. Knowing with some familiarity the research problems of the fruit processing industry, I can visualize the problems easily falling into two categories, those could be tackledin a central food research laboratoryand those that have to be solved in special pilot plant laboratories or even in the processing factories themselves. I believe the same is true of other food industries. Secondly, a central food research laboratory is not directly committed to a particular industry and the priority and enthusiasm it gives to problems will be much less than a research unit more intimately connected with that industry.

On the other hand decentralised food research as existing now lacks co-ordination as well as communication between scientists engaged on similar investigations. Dr.Bate-smith proposed a Food Research Steering Committee to guide the research programmes by the Fruit and Vegetable Utilisation Laboratory. An extention of this idea to cover all food research can exercise the required co-ordination without interfering with the distinctive character or the authority of the separate institutions.

The National Science Council would perhaps be the appropriate body to arrange such a steering committee.

C.A.A.S. SYMPOSIA

CURRENT SCIENTIFIC RESEARCH AND ITS RELEVANCE
- TO THE DEVELOPMENT OF SRI LANKA -

RESEARCH IN EARTH SCIENCES FORESTRY & FISHERIES

FRIDAY 20th JULY 1973

3·00 P.M TO 7·00 P.M

AT

IRRIGATION DEPARTMENT AUDITORIUM

CHAIRMAN: MR. L.J.D. FERNANDO

SECRETARY: MR. L.K. SENEVIRATNE

P R O G R A M M E

3.00	Introduction by Chairman	..	Mr L.J.D.Fernando
3.10	Current Scientific Research in the Earth Sciences and its relevance to the Development of Sri Lanka	..	Mr D.B.Pattiaratchi, Geological Survey Department
3.50	Heavy Mineral Sands	..	Mr L.J.D.Fernando, Mineral Sands Corporation
4.30 - 4.50	INTERVAL FOR TEA		
4.50	Forestry Research	..	Mr A.E.K.Tisseverasinghe, Forest Department
5.30	Fisheries	..	Dr P.Canagaratnam, Fisheries Research Station
6.10	Ground Water Hydrology	..	Mr M.W.P.Wijesinghe, Department of Irrigation
6.50	Closing remarks	..	The Chairman

Current Scientific Research in the Earth Sciences and its relevance to the Development of Sri Lanka

by

D. B. Pattiaratchi

Director, Geological Survey.

(Summary of Paper presented at the C.A.A.S. Symposium on 20th July, 1973).

Research activities in the earth sciences commenced in the Island over 70 years ago and over the last two decades considerable advances have been made both in advancing the knowledge of that part of the earth's crust underlying the Island and its continental shelf, as well as in the discovery of new minerals of economic value and their beneficiation for industrial use. Although the title of this summary paper is on current scientific research, I would have to go back to earlier research in that particular field carried out over the years as research in the earth sciences is a continuing activity and achieving a particular objective needs sustained and continuing work.

It would be appropriate to to describe first the advances made in geological mapping and although reconnaissance mapping of the Island commenced over 50 years ago, systematic geological mapping on the 1 inch = 1 mile scale commenced in 1953 and over the last 20 years nearly 70 percent of the Island has been mapped on these two scales and the area now remaining is largely confined to parts of the country North of Anuradhapura. The uses of a geological map are manifold and apart from locating target areas for mineral exploration it is a valuable tool for ground water exploration, location of dams, tunnels and highways. A geological map is also essential for interpreting geological structure and one could interpret the structures at some miles below the ground surface from a good geological map. Within the next 5 years or so geological mapping on the 1" = 1 mile scale will be completed, but this would not mean that the 'geological survey is over'. Geological surveys as well as surveys for similar resources are those of a continuing nature and no country in the world has so far 'completed' its geological survey. Geological surveys will not only be continuing

/activities all over

activities all over the world but will also have to be expanded to meet the challenge of the demands of an increasing population and improvement of living standards.

In the field of mineral exploration, I hope to describe in particular the work carried out for graphite, iron ores, phosphates, mica clays and ground water.

Graphite -

The mining of graphite has gone for over 120 years and during peak mining periods which coincided with the two World wars, over 2,000 workings including pits, shallow and deep, were worked particularly in the South-western and North-western parts of the country. Up to recently the discovery of graphite veins was largely by 'hit and miss' methods where a thin vein was found by accident in a road cutting or other excavation which was then followed to depth and the chances of finding a vein that could be worked economically was purely based on chance. A few years ago a geophysical technique was evolved by the Geological Survey for the location of near surface graphite veins and the first success was at Siyambalawela where after geophysical survey and diamond drilling a promising vein was proved and at which location the State Graphite Corporation has commenced a trial adit. Similar surveys for graphite have been carried out at a number of sites after the study of the detailed geology and structure followed by geophysical work and diamond drilling and the most promising prospects now under study are at Katuwana and Mahagama. Similar detailed surveys would be carried out at other sites over the next few years and commencement of small scale mining or even deeper mines at some of the proved sites will contribute to an increase in graphite production and perhaps at a lower cost as the mining will be at shallow depths.

Iron ores -

Up to two years ago the only iron ores known of some economic importance were the limonitic ores of the South-western part of the country and banded magnetite ores of Panirendawa area. Since then a promising iron ore deposit has been found in the Seruwila area and

/from the work

from the work so far carried out it appears to be of the banded iron ore type interbedded with the country rocks. The iron ore band has an outcrop width of 30 - 40 feet and has been traced over a mile or more with ground magnetometric work. The Fe content of the iron ore is around 67 to 68 percent; TiO_2 is less than 1 percent with only traces of P & S. The immediate objective is to prove at least 5 million tons of iron ore that could be mined by open cast methods.

There is good evidence that widespread smelting of iron ores was carried out in the Seruwila area during ancient times and further an actual mining site has also been discovered where the ancients mined this iron ore for the manufacture of iron and steel.

If the required quantity of iron ore is found an Iron and Steel plant would be a feasible project as the finished products or even the pig iron ingots could be transported out from Koddiyar Bay which is only about 10 to 12 miles from the belt of country where these iron ores are found.

Phosphates -

The discovery of the Eppawela phosphate deposit nearly two years ago was a topical find when one considers the importance of this mineral raw material not only for fertilizer but also for the manufacture of phosphate chemicals and by products such as crude gypsum. Mineral exploration of this deposit is still under way and from the data so far available it is estimated that over 25 million tons of phosphate rock are available but it is quite possible that the reserves may be much more as initial drillings indicate that the deposits continue to 500 feet below ground level. Apart from apatite which is the most common mineral in the 'leached' zone of this deposit it is expected that various rare earth minerals would be found, and recently during the study of the heavy minerals in the crushed rock, monazite has been identified which is both a radioactive and a rare earth mineral, and will be a valuable by-product mineral which will be available during large scale processing of phosphate rock.

/The initial

The initial development of this deposit would be to substitute for nearly 50,000 tons of rock phosphate imported into the country from the Middle East annually at a cost of Rs. 13 million and already samples of the local rock phosphate are with our Research Institutesfor laboratory studies and field trials. It is clear from the initial results that the local ground rock phosphate could be utilised for some of the perennial crops. The next stage of development of this deposit would be for the manufacture of phosphate fertilizers and in order to decide on the particular phosphate fertiliser to be manufactured a market survey of the phosphate fertiliser requirements in neighbouring South-east Asian countries would have to be carried out as the products have a sizeable export potential. The phosphate Working Committee of the Ministry of Industries and Scientific Affairs is studying these aspects and recommendation has been made that in the first instance a Crushing and Grinding Plant of 25,000 ton capacity on one shift working be established as early as possible to substitute for the imported material.

Mica -

Mining of this mineral has gone on in the country now and again since 1896 or so, but it was only recently that systematic prospecting has been carried out. Over 30 promising prospects have been located by the Geological Survey Department and some of the more promising ones are now being investigated in detail. The most important mica in Sri Lanka is phlogopite or amber mica for which there is a good demand at present even for the scrap grade. Under the Indo-Ceylon Cooperation Programme, mica will be a mineral commodity on which Sri Lanka would obtain help from India in curing and grading of mica for export together with training of local personnel both in India and Sri Lanka. There are a number of industrial uses of mica particularly for insulation and it is predicted that this mineral would be an important mineral commodity of Sri Lanka in the next few years.

/Clays -

Clays -

A systematic study of the geology, mineralogy and ceramic properties of the clays of Sri Lanka has been carried out and the results of this work will be published shortly in an Economic Bulletin of the Geological Survey. Some of the fundamental data and conclusions will be of use to scientists in related disciplines; in particular the concept of 'Clay Mineral Provinces'. The results will also be important to those involved with the improvement and expansion of the Ceramic Industry of the Island as the industrial potentialities of the various clays have been dealt with in detail.

Ground-water Exploration -

The Geological Survey over the years has carried out a large number of investigations to prove ground water both in quantity and of quality suitable for domestic and industrial use. The more recent investigations have been on the coastal belt of Sri Lanka particularly in areas where there are no perennial rivers. The main problem in such areas even if water is available in quantity is the aspect of quality. In order to make a meaningful forecast of the ground water re-charged each year in such areas statistical analysis of the rain-fall records at one of the sites in the South-east have been carried out by Mr. I.D.T. de Mel in the Department of Meteorology and the results of this work will be published shortly. One aspect of this work is that particularly in areas where the average rainfall is less than 70" per annum the increment from annual rains is variable and this information when available for other areas would be invaluable in working out the minimum recharge from rainfall and amount of water that could be extracted safely each year even in periods of drought.

A further research activity that is now under way is the study of the quality of water in two selected river basins namely the Kalu Ganga and Kala oya for irrigation, industrial and domestic use.

/Other Research Projects

Other Research Projects -

The research projects that are summarised below are those which have no immediate impact for development and could be termed as basic research although this distinction may not be valid in the Earth sciences.

(i) Gravity survey of Sri Lanka - A gravity survey of the Island was carried out during 1971-72 with the Geophysics Division, Dept. of Scientific and Industrial Research, New Zealand with a view to investigating the use of the gravity method in studying the geology of Sri Lanka. The survey was initially carried out in the Jaffna Peninsula after which the survey was extended to other parts of the Island. 1,170 observations of gravity were made during this survey and a publication incorporating these results has already been issued together with a 1 : 506,880 Bouguer anomaly map. The detailed interpretation of these results is now being made. This work apart from bringing Sri Lanka to the world gravity network would enable us to find the location of buried sedimentary basins, rift valleys and deep fractures and other crustal features.

(ii) Origin of Graphite - A joint project with the scientists of the University of Maryland, U.S.A. is now under way to find out whether graphite in Sri Lanka is of organic or inorganic origin. Earlier work done on the isotopic distribution of carbon in Sri Lanka graphite, as well as trace elements work did not give a conclusive answer and it is hoped that with modern chemical methods that more light would be thrown on this problem.

The occurrence of carbon in Precambrian rocks is known from many shield areas where these rocks occur. Recent work in other parts of the world has enabled geochemists to separate out organic compounds (such as porphyrins and chlorins) from Precambrian sedimentary rocks. In Sri Lanka too the graphic veins are found in Precambrian rocks which were metamorphosed initially over 2,000 million years ago. The occurrence of crystalline carbon (graphite) even as late veins in such rocks is difficult to explain as being of direct organic origin and the results of this work would be most helpful in working out the origin.

/(iii) Joint Project

(iii) Joint project with the State Graphite Corporation - A joint project with the C.I.S.I.R. and the State Graphite Corporation is now under way to work out economic methods for beneficiating low-grade graphite (carrying under 50% carbon) to a product with a carbon content of over 98%. Preliminary laboratory work using flotation methods has enabled the production of high-grade graphite and if this could be successfully done we will not only have a valuable export market but will also be utilising material now termed 'waste'.

(iv) Joint project with the Rubber Research Institute - A joint project to determine the percentages of calcium and magnesium in 5,000 samples of (rubber) soil and leaf extracts is now under way and already nearly 900 samples have been analysed by atomic absorption spectrophotometry.

(v) Offshore survey - Plans for an offshore survey of the continental shelf of the Island for minerals and other natural resources is being planned by an Interdepartmental Committee convened by the Ministry of Industries and Scientific Affairs, and priority would be given to the offshore survey of the strip of continental shelf adjoining the Pulmoddai beach sand deposit to ascertain whether exploitable deposits of heavy mineral sands exist, after which this survey will be continued over other parts of the shelf to locate useful minerals and also buried sedimentary basins on the continental shelf which may have a potential for oil and gas exploration outside the areas now being explored.

(vi) Metamorphic facies research - Over 90 % of the Island is occupied by high grade metamorphic rocks and already a number of fundamental contributions relevant to the classification of the Granulite facies have been made. This work is continuing in addition to major and trace element studies of the pyroxenes, amphiboles, micas and felspars of the Highland and Vijayan rocks in selected areas of the Island which would enable a better understanding of the stability of minerals such as biotite and hornblende in the Granulite facies.

/Contribution to Development

Contribution to Development -

The eventual yardstick to determine the contribution of earth science research to development would be the quantities and value of mineral production. The value in 1971 was Rs. 38.8 million which increased to 47 million in 1972 indicating an increase equivalent to 21 percent. It is expected that with the coming into operation of the new Mines and Minerals Law of 1973 that there would be a rationalisiation of mining and increased mineral production with more revenue to the State from mining rents and royalties. The implementation of this Law would also aid the conservation of the Island's mineral wealth and also initiate mining activities for the benefit of the nation as a whole.

Geological Survey Department,
Colombo 2,
18th July, 1973.
-/ss.

HEAVY MINERAL SANDS

L. J. D. FERNANDO

INTRODUCTION

Detrital minerals or heavy mineral sands are those with specific gravities greater than minerals such as quartz and felspar, and as commonly understood, are minerals with a specific gravity greater than 2.8. They are essentially mineral species which are marked by their chemical persistence and strong resistance to abrasion by virtue of their hardness. Due to their chemical stability they do not undergo change during the normal processes of rock alteration, and due to their hardness.and physical stability, they withstand abrasion during transport by streams, rivers and ocean currents. Most of these heavy minerals are present as accessory minerals in a large variety of crystalline rocks and it is the weathering of these source rocks which sets them free. Thereafter by the action of water they eventually make their way to the sea where they are concentrated by the natural sorting action of the waves. Minerals commonly found as sand deposits are principally ilmenite, rutile, zircon, monazite and garnet. Invariably ilmenite is the predominant constituent of these sands, which are often referred to as 'blank sands'.

The earliest reference to the occurence of heavy mineral sands in the Island are contained in the reports of the former Mineral Survey, and more particularly in the reports of Wayland and Coates in the second decade of this century. But beyond recording the presence of these minerals and a few salient features of the deposits, no detailed studies were made and their potential economic importance was not fully realised at the time.

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MINERAL DRESSING LABORATORY

At an early stage in my career in the Geological Survey the heavy mineral sands which nature has endowed us interested me greatly in view of their potential importance and as they constituted an important natural resource. It was my belief that their exploitation on scientific lines could generate substantial revenue by the export of the mineral products. At this time the only mining industry was graphite. There was no industry based on mineral sands, despite the fact that our neighbour India was producing 90 per cent. of the world's requirements of ilmenite in the period immediately before the outbreak of the Second World War. Unfortunately no meaningful work could be carried out without a laboratory for applied work, and in particular for pilot plant studies on these deposits, and in common with other scientific departments of the Government, the Geological Survey was starved of funds and its provision for research was woefully inadequate and niggardly. In such a situation, I looked for assistance elsewhere and through the generosity and kindness of an old friend of mine the late General Sir Geoffrey Howard, who was at the time Managing Director of Hopkin and Williams (Travancore) Ltd., one of the firms engaged in the production of ilmenite and other by-products from the Kerala mineral sands, an Exolon induced-roll separator and a Wind Table were obtained on loan. The equipment was shipped to Colombo at his own expense, and our only obligation was that he should have first choice on any monazite that was produced at ruling market prices.

The Wind Table consisted essentially of a wooden frame supported by a set of springs and connected to an eccentric motion by means of a shaft. A perforated wooden top is bolted on to the frame covering a wind chamber or wind box, and a closely woven cloth is tautly stretched and nailed on to the top. A blower

Contd.. 3/-

at the end of the table blows air into the Chamber and the eccentric provides a jig like motion to the table. The sands are fed on the cloth covered top end of the table, and as the sands move from the feed end to the discharge end, a distance of about twelve feet, the lighter sands are forced to the surface by the motion and the current of air and move faster, while the heavier sands remain below and move at a much slower rate. It is thus possible to get an effective separation of minerals of different densities and a complete spectrum of the sand. The whole process of separation is helped by table men using short handle fibre brushes. A significant factor which controls the effectiveness of a Wind Table is the colour of the individual minerals. This was an important consideration with relatively untrained labour, who soon acquired the means of identification by colour, and effectively assist in cutting off the various concentrates at the appropriate time.

The equipment was installed in a small building in the premises of the former Rubber Research Laboratory at Katukurunda in 1951 and this was the begining of the present Mineral Dressing laboratory of the Geological Survey. It also marked the commencement of an important series of researches by my colleagues and I in the Geological Survey. Despite the lack of adequate equipment, funds, personnel and other facilities, we were all inspired by the thought that our researches would lead to the establishment of a sound mineral processing industry based on our indigenous raw materials. At about the sametime, when the money voted for the establishment of a mineral processing complex based on the Pulmoddai sands was frozen on the advice of the I.B.R.D. Mission, a Humboldt cross-belt magnetic separator, which had been purchased earlier for trials in connection with the Pulmoddai project, was handed over to the Mineral Dressing Laboratory. This was a valuable addition and enabled us to extend the scope of our

Contd.. 4/-

pilot studies on the heavy mineral sands.

WEST COAST DEPOSITS

My earlier studies had proved the presence of heavy mineral sands at a number of points along the west, south west and southern coasts extending from Kudremalai in the north west of the Island to Kirinda in the south, a distance of nearly 300 miles of coast line. Such deposits include Kudremalai bay; Palluqaturai, west of the Wilpattu National Park; Vellaimundel, north of the Kala Oya; the stretch of coast north of the Kelani ganga from Hendala to Pamunugama; north of the Kalu Ganga; Polkotuwa, near Beruwela; Kaikawela, bear Induruwa; Kaluwella, near Galle; at Devinuwara: and at several points between Tangalle and Kirinda. Whereas most of these deposits are black due to the predominance of ilmenite, the deposits in the Tangalle-Kirinda area are red as garnet is the principal constituent of these deposits. Some of these deposits had been recorded earlier by the Mineral Survey but others were new.

The deposits at Polkotuwa and Kaikawela were studied in great detail and worked for monazite and other mineral by-products, while some limited investigations were carried out on the deposit at Devinuwara. The research programme had three main objectives -

(a) the mechanism of the formation of the west coast deposits;
(b) the mineralogy of the deposits; and
(c) the development of flow-sheets for the recovery of the mineral.

The most significant observation was that the concentrates were seasonal except for some minor deposits protected in small coves and bays, the formation of the concentrates marking the on-set of the south west monsoon. There is no doubt that the heavy minerals are derived from the igneous and metamorphic rocks which form

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the Precambrian complex, are transported by rivers, and finally discharged into the sea and deposited on the sea floor. Every river carries its quota of heavy minerals and almost everyone of these west coast deposits can be related to an important drainage channel. When the monsoon breaks the combined action of wave turbulence, currents, strong winds and the littoral drift result in a continuous piling up of the mineral sands on the gentle slopes of the coast line. As the waves break the heavy minerals settle while the light minerals, principally quartz, are carried away by the retreating waves, leaving clean mineral concentrates of a remarkable degree of purity. If the beach is left undisturbed, the process of building goes on until a state of equilibrium is reached when no further deposition takes place. The extent of the deposition will vary with the slope and profile of the beach but actual measurements at Kaikawela and Beruwela have shown that concentrates of ten to fifteen inches may be formed. On the other hand, if the mineral sand concentrates are scrapped up, fresh concentrates are formed and it is thus possible to harvest several crops of concentrates with rest periods in between allowing adequate time for their formation. You will appreciate from what has been described that the mineral sands are formed on the surface of the beach but abnormally seams may be preserved intact by burial under barren sands.

Detailed studies were also made of the mineralogy of these sands and with the exdeption of the southernmost deposits in which garnet predominates, ilmenite is the principal constituent generally ranging from 60 to 70 per cent, although concentrations of over 80 per cent. have been recorded occasionally at Pallugaturai, Vellaimundel and Hendala. The broad mineral assemblage is invariably the same ilmenite being followed by zircon, garnet, monazite, sillimanite and rutile more or less in that order. The interest of the west coast deposits is in their more varied mineralogy which reflects minor differences in the hinterland

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geology, and the discovery of a number of other rare minerals, though only in traces, which had not been recorded previously. These included the discovery of the radioactive mineral thorianite in the Kaikawela and Polkotuwa sands; baddeleyite (the oxide of zirconium) in the Polkotuwa and Dondra deposits and cassiterite in the Polkotuwa sands. The thorianite at Kaikawela and Polkotuwa is even grained and extremely fine in texture suggesting an origin different from the thorianites recorded from the gravels of the Western, Sabaragamuwa and Southern provinces. Some of the west coast deposits are also rich in monazite, particularly those at Kudremalai, Polkotuwa and Kaikawela, the average monazite content of the Polkotuwa sands being consistently of the order of 6-8 per cent. over several seasons, while local streaks and patches may attain 15-20 per cent. Concentrates from Kaikawela and Polkotuwa collected over a period of years and processed in the Mineral Dressing Laboratory of the Geological Survey have yielded over 700 tons of a high grade monazite product. But the exhaustion of the small but rich Kaikawela deposit emphasises the fact that the West Coast deposits can only support a very limited development.

The third and most important line of research was the development of flow-sheets for the processing and the recovery of the heavy minerals in these deposits. In this work no attempt was made to work out any new methods of processing but rather we used the conventional methods of magnetic, electrostatic, high tension, screening and gravity separation, and adapted these processes to suit the dictates of local conditions. For instance we avoided the use of wet methods as they require substantial quantities of water, and where water is used the sands have to be dewatered and dried before further processing can take place and drying costs are high. Using two magnetic separators of different design - a Humboldt cross-belt and an Exolon induced roll separator combined with an air float table, we were successful in producing an extremely pure monazite satisfying the rigid specifications for classification.

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as nuclear purity grade. The screened concentrates were fed into a Humboldt cross-belt separator for the removal of ilmenite and the non-magnetics from this were fed into an Exolon induced-roll separator with three rotors. The residual ilmenite in the non magnetics was removed in the first rotor and the product from the middle rotor was fed to an air float table with six chutes. The final monazite product from chute six assayed plus 99% purity. The middling product from the air table from chutes four and five was re-circulated. At the Sixth International Mineral Processing Congress at Cannes in 1963 Egyptian workers, based on their studies on the black sands of the Nile delta, reported that nuclear purity monazite could only be obtained by flotation and in an oral communication the author indicated that it was possible to obtain monazite of this purity purely by dry methods of separation.

The next significant contribution from these pilot studies was the development of a flow-sheet for the rare mineral baddeleyite. Once again the conventional methods of processing were used and by a judicious combination of magnetic separation using cross-belt and induced-roll magnetic separators with an air float table we were successful in producing a baddeleyite of high purity, where we were able to guarantee plus 95 per cent zirconia (ZrO_2) compared with the 68 percent. ZrO_2 for the Brazilian product. The main impurity in the final baddeleyite product was cassiterite, the oxide of tin, which has a similar specific gravity. However, it must be emphasised that the flow-sheets for monazite and baddeleyite developed at the Mineral Dressing Laboratory apply only to sand deposits which are similar to the west coast sands on which we worked. Variations in mineralogy are not critical and the flow-sheets have a certain flexibility as regards mineralogy, but the particle size is critcal as all processes of separation are subject to size effects which can cause overlapping and affect the final purity of the finished mineral products.

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For instance, the flow-sheet for the west coast monazite cannot be used effectively for the recovery of the Pulmoddai monazite, primarily because of the fine particle size of the latter compared with the west coast mineral.

THE PULMODDAI DEPOSIT

An adequate discussion of the geology and mineralogy of Pulmoddai deposit would far exceed the bounds of this paper, and the best that can be done is to present a few facts from recent studies which will throw some light on the origin of this remarkable deposit. How did this mineral sand deposit originate ?. Reference has been made to the fact that nearly all the seasonal deposits of the west coast can be related to important drainage channels but in the neighbourhood of Pulmoddai there are no substantial drainage channels to account for this concentration of heavy minerals, and even if there were it would be extremely difficult to account for a deposit of this magnitude. An explanation has to be sought elsewhere and it is necessary to discuss some geological detail briefly.

Apart from the Precambrian which consists of a complex of granites, gneisses and meta-sediments, the other geological formations represented in the Island include isolated areas of Jurassic sediments preserved in faulted basins, the Miocene of the north west of the Island and the more recent Pleistocene. The last consists of a lower gravel formation with prominent quartz gravel and an upper layer termed the 'Red Earth' which extends as a broad but discontinuous band from Puttalam to the Jaffna peninsula and in places may attain a thickness of hundred feet and over. The role of the 'Red Earth' has been recognised recently as an intermediate host in the formation of the detrital mineral sands. Although the 'Red Earth' was believed to be absent from the east coast, careful examination in recent years has shown the presence of relic patches of this formation in Pulmoddai and in Kokkilai. Whereas the 'Red Earth' is exposed in cuttings

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and excavations in the Pulmoddai village and in small estuaries between Pulmoddai and Kokkilai, immediately north of Kokkilai the 'Red Earth' forms a minor but recognisable feature rising to a height of twenty two feet running in a more or less north west - south east direction. These areas correspond to the red and yellow latosols of Panabokke shown in his soil map of the Island.

While the 'Red Earth' consists predominantly of heavily stained quartz grains with a fine ferruginous clay, it is known to contain heavy minerals principally ilmenite with minor amounts of other minerals such as zircon, rutile, sillimanite and monazite. Samples of the 'Red Earth' collected from Arakalu in the Puttalam North district during investigations for raw materials for cement manufacture showed a heavy mineral content varying from 6 to 8 per cent. Further north, 'Red Earth' samples collected from Pallugaturai and Kudremalai Point also showed 4 to 7 per cent. heavy minerals. In all these samples ilmenite is the predominant constituent accounting for over 80 per cent. of the heavy minerals. Streaks of heavy minerals consisting mainly of ilmenite with other heavies resembling the mineral assemblage in the Pulmoddai placer are seen to be washed out of the 'Red Earth' in the vicinity of Pulmoddai and Kokkilai, and it is therefore believed that much of the 'Red Earth' which stretched down to Pulmoddai on the north east coast has been eroded away giving rise to the Pulmoddai placer.

The mechanism of the formation of the seasonal heavy mineral sands of the west coast has been briefly outlined. If a similar mechanism operated on the east coast and there were minor changes in the relative levels between the land and the sea, one can easily visualise the formation of deposits of mineral sands several feet in thickness instead of a few inches as on the west coast. Erosion of the Pleistocene formations of an emergent coast line would have led to reconcentration of the stable

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minerals by wave action and their accumulation as high grade concentrations of heavy minerals, and their subsequent deposition under monsoon conditions during an interval of submergence. Subsequent uplift gave rise to the Pulmoddai placer which consists of an active beach area or foreshore between low water and high water and a scrub covered backshore area 6-8 feet above sea level. It is in the backshore area that rounded fragments and cobbles are found scattered in the mineral sands; these consist of crystalline rocks, Miocene limestone and Pleistocene gravel. The overall net uplift of the north east coast is proved by the presence of raised shell and coral beds and by the Recent sandsone which is well exposed north of Kokkilai.

The role of the Arisimalai promontory in the formation and preservation of the Pulmoddai placer should also be recognised. This is a prominent but narrow, rocky headland built up of banded gneisses and granites with relict caps of isolated Pleistocene gravels extending for almost a mile into the sea. It marks the southern limit of the mineral sand deposit. Accross the headland and over to the south no mineral sands are to be seen except for a little garnet derived from the weathering of the local gneisses and the beach is quite barren. There is no doubt that this rocky headland has acted as a trap and prevented the dispersal of the mineral sands along the north east coast. It is true to say that but for Arisimalai, there would be no Pulmoddai deposit.

The origin of the Pulmoddai placer is not a matter of mere academic interest. If this theory is correct, and the evidence is overwhelming in support of such a view, there is a vast potential for the development of the mineral sand industry by the exploitation of the Red Earth deposits on the west coast. Their exploitation will require techniques of mining and processing rather different from those which are now in use in view of the

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low grade of these sands. A preliminary wet stage of pre-concentration will be required before the sands can be processed in a magnetic installation or Dry Mill. However, before their exploitation can be undertaken detailed studies including pilot tests will be required on the extent of the Red Earth deposits. Without such studies, an estimate of the tonnages of heavy minerals present cannot be furnished, but from the nature and extent of these deposits there is little doubt that the tonnages available will exceed by far the Pulmoddai mineral sand deposit.

As mining proceeds we will have to fall back on leaner grade ores but the Red Earth deposits because of their extent and depth can provide the basis of a viable mining industry in the future long after the exhaustion of the Pulmoddai sands. The successful development of the low grade deposits will depend on a high degree of mechanisation, improved flow sheets which will ensure high recovery rates and the successful marketing of all the finished products and not merely the low value minerals such as ilmenite.

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FORESTRY RESEARCH

A.E.K.TISSEVERASINGHE

In common with most other Forest Departments in other parts of the world, the early research efforts of our Forest Officers were directed towards the study of natural regeneration of forests. At that time, the Dry Zone was considered to be the more valuable forest since the best and most acceptable species such as Satin, Palu, Ebony, Milla, Hulanhik and Wewarana were Dry Zone species. Hence the research effort was concentrated in the Dry Zone. Unfortunately most of this effort was wasted because the Dry Zone forest could not be made to regenerate naturally using the usual techniques. It took a long time for forest officers to accept defeat in this field, but even now we are asked why we do not regenerate or plant the naturally occurring species instead of planting exotics such as Teak and Eucalyptus.

Teak was introduced into this country some three hundred years ago but all planting of Teak at that time was in the Wet Zone.

About a hundred years ago one or two dedicated foresters decided to try out Teak planting in the Dry Zone. The work of this early planting was dohe at no cost to the Government. In one of these areas the Teak planting was combined with chena cultivation so that this system not only produced a valuable plantation but also mitigated the evils of chena cultivation. This valuable work enabled us to realise the forestry potential of the dry zone which is otherwise clothed in a poor, low productive forest. Today we are planting as much as 10,000 acres of Teak per year - all of it grown in association with chena cultivation so that we are not only growing trees but also food crops to the value of nearly Rs.6 million annually.

Just as in the dry zone, it was found that the montane zone forests also could not be regenerated naturally. Certain exotic trees such as species of Eucalyptus, Cypressus and Acacia however thrived if planted in this zone. Fairly large extents of plantation were thus created in this zone. Not much attention was paid however, to the utilisation of the timber of these species and we still have certain difficulties in this field.

In the intermediate zone Jak and Mahogany were planted and here of course we have no problems of utilisation since these are both well known and acceptable timbers.

The Wet Zone forests were comparatively neglected in the early days of forestry because only a few of the species growing in these forests were known and even these were only locally used.

Up to about the nineteen thirties forestry research was relatively unorganised and depended on the enthusiasm of individuals. In the nineteen thirties a special officer was appointed to attend to Silvicultural research and another for timber utilisation. For the first time a programme was initiated for the systematic investigation of the silvicultural properties of our local tree species. Utilisation research could not be started on a systematic basis because of the lack of laboratory facilities. The value of this sort of work is however demonstrated by the example of Hora (Dipterocarpus zeylanicus). This is a species that could not be used in the past (except for certain special purposes) because it was prone to decay when exposed to the weather. In the nineteen thirties this timber was sent to England for testing since no facilities were available locally. The tests proved satisfactory and in about 1952 an impregnation plant was installed to treat non-durable timbers with preservatives. Hora was the timber most used and up to very recently more than half the railway sleeper requirements and almost all the transmission pole requirements were met from Hora. A few figures may be relevant to illustrate the financial return from

this type of work. From 1948 - 1956 a total of nearly Rs.28 million of foreign exchange was spent on the import of sleepers. In 1957, as a result of producing the full sleeper requirements of the country locally, the saving in foreign exchange amounted to approximately Rs.3 million (Administration Report of the C.F. - 1957). In contrast to this the cost of the plant was about Rs.600,000 (it is in fact still in operation) and the annual cost of creosote and furnace oil is negligible. Today we are using many more species for use as transmission poles e.g. Alstonia macrophylla and Eucalyptus saligna none of which would have been possible had not the early work on Hora been followed up by a commercial scale plant.

From 1952 a Timber Utilisation Research Laboratory was set up with FAO aid and from that time systematic investigation of the properties of Ceylon species of timber became possible. The only snag was that although the equipment was available, the staff provided was grossly inadequate. I do not expect a country like Ceylon to have a Forest Products Institute staffed on the scale of say India with a professional research staff of 115, Malaya with a professional and technical staff of 149 or the Phillipines with 40 different research sections (it was too tedious to count the staff !), but when you consider that our research staff consisted of one Senior Asst. Conservator who had other duties as well, and only one full time Research Officer, I am sure you will agree that much output could not have been expected. Even today the position is not much better. The staff consists of one Senior Asst. Conservator, 2 Research Officers and 3 Technical Assistants. Neither of the Research Officers has been trained in any of the fields of Timber Utilisation Research. Despite these limitations we provide the sole advisory service on all matters connected with timber. We have to identify samples of timber sent by Government Departments all over the Island - several hundred per year, advise on seasoning and preservation, identify agencies of destruction and advise on control measures, provide information on properties of timber to engineers and architects, issue certificates of conformity with specifications to exporters of timber and timber products and various other matters. Many of these matters are the business of specialists but we have to be jacks of all trades. In the field of Silvicultural research similarly, we have only one Research Officer. I hope this will be borne in mind when our research efforts are evaluated.

I have so far given a brief sketch of the background to our work. I shall now attempt an exercise, the object of which is, starting from a datum, to proceed step by step and ultimately to derive our research priorities. This may seem somewhat ambitious but you may judge how far I have succeeded.

The point from which I am starting is what I call a Universal Forest Policy, in the sense that its unexceptionable aims are applicable to any country. This, stated briefly, is as follows:-

1. Conservation of soil and water, and the furtherance of scientific and cultural aims.
2. Optimum economic return from land under forest in relation to the needs of the country in a manner consistent with the above.

The next step is to expand the term "Needs of the country" in relation to ourselves. These are fuel, wood for construction and furniture, Railway sleepers and transmission poles and timber for industrial use. Forest products other than timber which are needed in the country are, to name only a few, resins, gums, fibres, oil seeds, and so on. In the present day, exports are a vital need and hence this is also included.

Now we consider how the two objectives, conservation of forests and optimum economic return from forests can be achieved in relation to our needs.

We formulate a strategy as follows:-

1. Retain the Wet Zone forests while increasing its productivity but without clear felling.
2. Create plantations in the Dry and Montane Zones since the forests in these zones are of poor quality and difficult to regenerate.

The problems encountered in dealing with natural forests are different to those of plantations. Hence we divide our tasks broadly into these two categories. As far as Timber Utilisation research is concerned the problems are common. In regard to the Natural Forest category the strategic areas for investigation are -

1. Conservation aspects. Here the problems are the effect of clearing and the effect of selective felling.
2. Availability of timber. This can only be known by continuous inventory.
3. Growth potential. In order to find this out studies of increment and felling cycles have to be carried out.
4. Improvement of Natural Forests. Before this can be attempted, ecological and silvicultural studies including the natural regeneration aspect have to be carried out. The effect of cultural operations on increasing productivity has to be determined. The question of enrichment planting also needs investigation.

In regard to the man-made forest category, the areas for investigation are:-

1. Growing stock. As in the case of natural forests here also we need continuous inventory. In addition, site quality studies have to be made and volume and yield tables constructed.
2. Choice of species. Trials have to be made not only with new species but with different provenances of these species. Trials are also necessary to determine the best species to suit particular climatic and soil conditions.
3. Improvement of growth potential -
   This area is divided into two:
   (i) protective measures which include protection against weeds, fire, insects, fungi and other agencies which reduce productivity and
   (ii) cultural measures in respect of which studies have to be made of Nursery practice, espacement, thinning, tree improvement and fertilizers.
4. Economic aspects. I have included here only two items of immediate relevance - evaluation of economics of planting of different species and cultural operations and market studies.

I have left one area - utilisation potential - to the last, not because I consider it to be the least important, but because it is common to natural forests and plantations. Here the research tasks are in the following fields, timber testing, wood structure, seasoning, preservation, forest products other than timber, prevention of degrade of timber by physical and biological agencies, designs of timber structures and industrial uses.

So far I have only listed areas for investigation and I have not suggested any priorities. What criteria are to be taken into account in deciding on priorities? Priorities cannot be decided on a purely scientific and abstract basis. If this were done all our research efforts will have to be concentrated on the natural forest because it is logical that we must first know the resource which we are managing. Another criterion to decide priorities would be the amount of money being spent in the area of work. If we use this criterion, our research effort must be concentrated on the plantations because most of our expenditure is on plantations. Still another criterion would be the economic return expected from the research. This criterion is a little more difficult to apply as opinions can vary as to which area of investigation is likely to bring in more economic returns. Some foresters advocate a policy of use before replacement.

This means that the research effort must be concentrated on getting to know more about the species we have with a view to using them. Others advocate the policy of planting the species of tree which we know to be acceptable or required for industrial purposes.

In Sri Lanka we are attempting, with our limited research staff, to do both these things. Timber Utilisation research is directed towards knowing more about the existing species of timber while the silvicultural research is concentrated on plantation forestry. Up to about 15 years ago this was not so. Silvicultural research was concerned almost entirely with natural forests. Many years of this sort of research did yield results, in the sense that we knew much more about our natural forest species but the economic return from this was negligible.

At the present time we are making efforts to provide the needs of industry by raising plantations e.g. Pines for the paper industry and Albizzia for the match and packaging industries. This creates more problems for research. Thus in terms of the areas of investigation described earlier the silvicultural research effort is concentrated on choice of species and improvement of growth potential of plantations. Considering our present circumstances, particularly the staff limitation, this is inevitable. I have tried in this paper to describe our research effort in broad terms only, no attempt has been made to describe individual research projects because these are available in other documents such as Administration Reports. I will however mention just a few which are considered to have contributed to development in this country. In the field of silvicultural research we have provided new fibre resources for the paper industry by growing Pines and Bamboo. We are also growing Beedi wrapper leaf which is presently imported into this country at an annual cost of Rs.8 million. In the field of Timber Utilisation research we have created a new resource by evolving a method of treating rubber wood. Already several million rupees worth of furniture has been manufactured from treated rubber wood and treated rubber wood panelling is being now exported to various European countries.

UNIVERSAL FOREST POLICY

1. Conservation of soil and water; scientific and cultural aims.
2. Optimum economic return from land under forest in relation to the needs of the country in a manner consistent with above.

NEEDS OF THE COUNTRY

1. Needs of the country are - (a) Fuel; (b) Construction timber; (c) Railway Sleepers; (d) Transmission Poles and (e) Raw material for wood based industries (Plywood, Particle board, Paper and Paper pulp, matches and packaging).
2. Export
3. Forest products other than timber.

STRATEGIC OBJECTIVES

1. Retention of wet zone natural forests while increasing their productivity without clear felling.
2. Since 4/5th of the forest area in Ceylon consists of dry and montane forests which are of poor quality it is inevitable that man-made forests must be created.
3. While retaining the forest cover in the wet zone at all times, attempts must be made to increase its productivity.

NATURAL FORESTS ..... MAN-MADE FORESTS

STRATEGIC AREAS FOR INVESTIGATION

CONSERVATION ASPECTS

1. Effect of clearing
2. Effect of selective felling.

GROWING STOCK

1. Continuous inventory (area of volume)
2. Site quality determination.
3. Construction of volume & yield tables.

AVAILABILITY OF TIMBER

Continuous inventory (area and volume)

CHOICE OF SPECIES

1. Trial with new species and races.
2. Trial under different climatic & soil conditions.

GROWTH POTENTIAL

1. Increment studies.
2. Felling cycles.

IMPROVEMENT OF GROWTH POTENTIAL

PROTECTIVE	CULTURAL
1. Weeds	1. Nursery practice.
2. Fire	2. Espacement trials.
3. Insect	3. Thinning trials.
4. Fungi	4. Tree improvement
5. Others	5. Fertilizer trials

IMPROVEMENT OF NATURAL FORESTS

1. Silviculture studies including Natural regeneration studies.
2. Enrichment planting
3. Cultural operations.

ECONOMIC ASPECTS

1. Evaluation of economics of planting of different species & effect of cultural operations.
2. Market studies.

UTILIZATION POTENTIAL

1. Routine testing of timber
2. Wood structure studies
3. Seasoning methods
4. Wood preservative methods
5. Forest products other than timber.
6. Study on the prevention of degrade in timber by physical & biological means.
7. Design of timber structure from small size timber.
8. Industrial uses.

UTILIZATION POTENTIAL

CURRENT SCIENTIFIC RESEARCH AND ITS RELEVANCE TO THE DEVELOPMENT OF SRI LANKA FISHERIES

by

P. Canagaratnam

(Research Officer, Dept. of Fisheries)

Introduction.

The subject "Fisheries" has been discussed some years ago at meetings of the Natural Sciences section of our Association and at many meetings within the Department of Fisheries. These discussions were largely on the assessment of resources and development programs. The present symposium "current scientific research in fisheries and its relevance to the development of Sri Lanka", organised by the council of the CAAS has given an opportunity to all interested persons to participate.

Research in the various fields of fisheries had been conducted prior to the setting up of the Fisheries Research Station. Naturalists attached to the National Museum carried out work on types of fishing and their gear, pearl fisheries, trawling, and some oceanographic work. Research work for improvement of the existing fisheries was contemplated about 1920 and the present research station was built only in 1934 but research staff was not recruited until 1949.

Trawler Fishery.

I would like to begin with the trawler fishery, though not a significant contributor to our total marine fish landings, because considerable work had been done in the early part of this century as well as recently.

The earliest recorded attempt at trawl fishing was in 1902 and this was carried out on an experimental scale off the Pearl Banks. Five years later exploratory surveys of our trawlable grounds - Wadge Bank (approx. 3000 sq.miles) and Pedro Bank (approx. 1800 sq.miles) - were carried out but trawling operations on a commercial scale were begun only in 1928 by a private company. The quantity of fish taken per day's trawling in both Banks were sufficient to make it a profitable venture but this company could only proceed with its operations till 1935 owing to difficulty in marketing the fish.

Again in 1945 trawling was commenced by Government with one trawler. In 1951 the second trawler was purchased but an year later the first trawler was found to be uneconomical to operate. By mid 1953 two trawlers were fishing on the Wadge Bank. Some private companies too tried trawling operations in 1947 - 48, 1961 and 1962 - 63.

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The surveys carried out during the period 1949 - 57 indicated that the year to year variations in the catch per unit of fishing effort did not in any way suggest that trawling affected the abundance of the Wadge Bank fishes. It was therefore suggested that fishing pressure could be increased considerably by adding more vessels to the existing fleet. Since seasonal variation showed a maximum during the April - October period it was recommended that maximum fishing effort be exerted during this season to get better returns. It was at about this time that the cold storage plant and fishery harbour at Mutual were completed with Canadian aid and hence an opportune time to begin the expansion of this fishery. However, it was not until further studies were conducted during the period 1958 - 63 that the need to increase the trawler fleet with stern trawlers to exploit the entire fishable area of the Wadge Bank and also the Pedro Bank was considered.

From the latter part of 1964 to mid 1966 the trawler fleet was strengthened with the addition of five 238 G.T. stern trawlers. Presently only the stern trawlers are in operation as the earlier ones were not operable.

The trawler operations off the Wadge and Pedro Banks, handled by the Fisheries Corporation, accounts for about 5% of the Island's total fish production. With an exploitable area of nearly 4800 sq. miles it is reasonable to expect an annual catch of about five times the present production of marketable fish i.e. 10,000 tons. This estimate has been worked out on catch rates for several years.

Wadge Bank catch analysis has shown that during the south west monsoon the average catch was almost twice that of the other seasons. The species composition too changes during the S.W.moonsoon period as a result of migrant species moving onto the Bank. These migrant species supplement the regular catch of resident species which constitute the year round mainstay of the trawler fishery.

With our present research effort of merely analysing past and current records we will not be able to get adequate information about what factors cause migration and hence learn to predict their extent and time of occurrence. Therefore, to obtain the maximum benefit of this phenomenon it was suggested as far back as 1957 that a long term research program be initiated. We have not been able to get this program started for reasons such as lack of staff and justifying the expenditure on a fishery that is a poor contributor to the total production.

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Even now it seems worthwhile considering expending a little research effort to understand the recruitment to these fishing grounds as it is important to the success of the trawl fishery. An understanding of the migration phenomenon will certainly be a boon to the trawler fishery and the existing fleet itself would suffice to bring in five to six times the present landings from the Wadge Bank alone.

Coastal Fisheries.

The coastal fisheries accounts for nearly 90% of the total fish catches. This is because the number of units involved is relatively very high. There is the beach seine fishery which is still the biggest single contributor (25%), non-mechanized traditional craft, mechanized traditional crafts and mechanized boats all using a variety of gear such as drift nets, set nets, handlining, longlining, trolling etc., A glance at the estimated annual production from the coastal fishery, as given in the administration reports of the Director of Fisheries, shows that production has increased almost five times since 1953.

What were the factors that enabled the stagnant coastal fishery to reach the present level of production. There were many and among them mechanization was the most important. In 1953 the first experiments towards mechanization were tried out with FAO assistance in the northern area. Various types of engines were tried out on indigenous craft as well as on other boats designed to suit our needs. Along with this different types of gear such as float longline, bottom longline, nylon gill-nets and the purse seine were tried out with FAO and C-Plan Canadian Aid. These experiments were successful and paved the way for organising a scheme to develop the coastal fishery through mechanization.

Among the most successful was the 26' boat with an inboard diesel engine referred to as the $3\frac{1}{2}$ - tonner. These boats with the required gear have been issued to fishermen on a hire purchase scheme. Since 1959 the Department of Fisheries has issued over 2000 mechanized boats. The mechanization of traditional craft such as teppams with outboard engines was also a success and since 1962 over 1800 outboard engines too were issued to fishermen on a hire purchase scheme.

These two development schemes increased the fishing effort and beach seine fishery which in the fifties contributed over 2/5 th of the total landings is presently contributing only about $\frac{1}{4}$th of the total production (though its fish landings have not dropped).

Besides fish the coastal region produces fair quantities of prawns, lobsters, holothurians, or sea - cucumbers and algae.

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The species of prawns and their distribution have been studied. Trials with small trawl nets suitable for operation from 3½ - tonners are being conducted to test the efficiency of this gear in deeper coastal waters. The prawn fishery has been intensified owing to the high prices paid by exporters. Further development of this fishery will depend on the discovery of new grounds and for this surveys have to be conducted. A programme for this survey has been postponed for want of personnel and funds.

In our waters we have several species of spiny lobsters and their distribution is known. Several trials with traps were tried out but these were not very successful. Lobster fishing begun by skin divers has developed rapidly owing to the export market. Lobster fishermen are now using set-nets and lobsters of all sizes are taken. It has been observed that the average size of the lobster taken now is much smaller and this is an indication that overfishing is taking place.

The research division informed the Department about the rapid decline in the length frequency distribution of the various species of lobsters captured and requested that this fishery should be managed. The Ministry of Fisheries will introduce legislation shortly to prohibit the taking of undersized lobsters, and to reserve certain areas as conservation zones. Further studies will be carried out in these zones to determine growth rates and recovery of depleted stocks. This information will be useful to develop the lobster fishery to produce sustained yields.

The holothurian or sea - cucumber is processed and exported as 'Beche - de - mer'. Stocks of various species of holothurians are being assessed along the western and northern coasts. Improved techniques for processing of the raw product have been introduced and the processed product is being sold at higher prices. This has encouraged the fishermen to intensify their efforts and production is being increased.

Marine algae are plants and there are a number of species that could be utilized and among them are cert in species commonly referred to as seaweeds.

A survey of the seaweed resources was carried out in the early fifties and it was found that two species of red seaweed or 'Ceylon Moss ' belonging to the genera Gracilaria were available in commercially exploitable quantities particularly in the Puttalam, Mannar and Trincomalee areas. This seaweed yields agar which is a jelly used in the preparation of confectionery, canning fish and as a media for growth of bacteria. This commodity was exported in 1961 but the export trade feel as there was no check on the quality of the exported product. The preparation of agar has been tried out and the IDB is now carrying out further tests in our laboratory with a view to setting up a small agar plant.

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A brown seaweed called Sargassum is available in large quantities and from this alginic acid could be prepared and its calcium and sodium salts are used in the manufacture of many goods, especially textiles. The extraction process for alginic acid is being tried out to ascertain whether this product will suit the needs of our expanding textile industries.

Off Shore Fishery.

This fishery is confined to the area beyond the continental shelf and within 100 miles from shore (i.e. 15 - 100 miles). Species commonly taken from this region are the yellowfin tuna (kelawalla), skipjack (balaya) and the smaller tuna like species. Skipjack and other tuna like species are also taken in coastal waters with gill - nets, troll lines and occasionally with the pole - and - line method. The float longline method was introduced in the late fifties to catch the yellowfin tuna but the fishermen using their 3½ ton boat could proceed only to areas up to 20 or 25 miles from shore where this fishery is not well established. It has been recommended that 38' - 40' vessels could be introduced to exploit the 15 - 50 mile zone and 50' - 60' vessels to fish the 50 - 100 mile zone. Much work has to be done to develop the tuna longline fishery as well as the pole - and - line method for skipjack. The biggest problem in these two methods of fishing is the supply of bait.

The first step in developing these tuna fisheries is to establish a bait fishery for the longline method and live bait for the pole - and - line method. Since the estimated exploitable resources of skipjack are high and the prospects of finding export markets for this fish are good top priority has been given for its development. Technical assistance and funds from FAO have been obtained for an U N D P skipjack project combined with resources survey for pelagic fishes of the coastal waters. The latter part of the project is essentially the bait fish survey to feed the skipjack fishery. This project is now underway and will be carried out during the next three years.

An U S S R - Sri Lanka fishery survey was conducted last year to assess deep sea lobsters and prawn stocks and other marketable species of fish on the continental edge and slope. This zone is outside our territorial waters and is usually over 150 meters deep. A spiny lobster (Puerulus sewelli) and many species of prawns were located in several patches but their concentrations were not sufficient to warrant investment in a deep sea trawler fishery.

contd. 6

Inland Fisheries (brackish waters and freshwaters)

The extent of brackish waters is about 300,000 acres and this includes shallow lagoons, tidal flats, mangrove swamps and estuaries. These water bodies occur around the coastal belt and are fished by marine fishermen on a part time basis when they cannot go out to sea. Only a few do full time fishing in lagoons. Besides the crabs, and prawns a few economically important fish are also caught. The production figures from these waters are included in the coastal fishery landings. An average production of 20 lbs/ acre/ year has been estimated for these waters.

There is one research station for brackish water fisheries at Pitipana. Here experiments are conducted to demonstrate fish culture methods. This centre is at present used to culture prawns, crabs and milk fish (Chanos). It could also be used to culture the grey mullet which has been successfully developed in Isreal and Taiwan. The production from pond culture could be as much as ten to twenty times as that of a comparable area in the natural environment. Some private companies and several residents around lagoons have started brackish water fish farming.

Freshwaters include irrigation reservoirs, hydro - electric reservoirs, small village tanks and flood lakes or 'villus'. Almost all these standing water bodies are man made. Besides these there are sixteen major rivers and the total extent of all freshwater bodies is about 200,000 acres.

Fish production from freshwaters was negligible about fifteen years ago. In a survey conducted in 1958 it was found that the average production of fish from an estimated area of 150,000 acres was less than 7 lbs/ acre/year or a total production of 446 tons. With the opening up of new reservoirs the area of freshwaters increased to 200,000 acres in 1962 and the total production estimated was 3350 tons. Last year's figure of 8000 tons brings the average production to about 90 lbs/acre/year. This increase was mainly due to the systematic stocking of fish fingerlings and of these Tilapia mossambica introduced from Singapore in 1951 was the most successful. Today Tilapia contributes about 90% of the commercial catches in some reservoirs. With the establishment of this species fishing effort increased in all water bodies that were stocked.

Investigations connected with hatching and rearing of carp, giant gouramy and monosex culture of Tilapia are being carried out at the freshwater stations in Polonnaruwa and Udawalawe. At these two stations about 200,000 fingerlings are produced annually for distribution among fish farmers and stocking open waters. A third station will be opened this year in the mid country (Ambagamuwa) to culture species which are suitable for stocking water bodies at higher elevations.

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To step up production a scheme has been drawn to introduce pond fish culture in the centr l and south west regions. Each pond will be about ⅛ acre to an acre in extent and the total pond area, according to this scheme, will be about 2500 acres. This is expected to be completed by the end of the 5 year period and the anticipated fish production is 400 tons. Likewise 2000 acres of brackish waters around lagoons will be converted into ponds for fish and prawn culture. Here too the expected production is 400 tons.

Pollution.

Protection of our freshwaters, lagoons and the coastal belt from pollution is likely to become a very serious problem in the near future if remedial measures are not taken at the initi l stages. Reports have been received that the lagoon at Valaichenai is polluted by the effluents discharged into it from the Paper Factory. Investigations c rried out at Valaichenai revealed that the lagoon is polluted and the oxygen level is too low to sustain organic growth, particularly fish and prawns. This problem of pollution is now receiving attention from several ministries concerned with the protection of our environment.

Our reefs are endangered by the rapid increase of the 'Crown of Thorns' star fish - Acanthaster planci. This 'pollution of our reefs' can cause much damage to beaches, reef fauna and flora. Presently the Department of Fisheries has launched a physic l attack in the most infected area Trincomalee. These reefs have been surveyed and the areas that have been described as having the 'Crown of thorns' starfish in plague proportions are being 'cleared' by divers under the supervision of the research division.

Conclusion.

Our objective in carrying out investigations or research projects is to develop the fishing industry to meet our requirements of aquatic products - mainly fish. This must be produced in sufficient quantities and in good condition to raise our per capita consumption of a good source of protein. Presently the per c pita consumption is around 35 lbs.(without imports this would be about 18 lbs) and this is about a third of Japan's Can we aim at increasing our per capita consumption to that of Jap If we do, then we should produce nearly 600,000 tons of fish annually. This is impossible. We should aim at increasing our catches to an optimum level of our estimated exploitable resources. This will be in the region of an annual production of about 300,000 tons. With this production we could raise our per capita consumption to about 52 lbs. provided our population will remain at the present level.

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To raise our fish production to provide a per capita consumption of 52 lbs. we need much more research effort, both applied and basic. What has held us back all these years ? There are several factors and among them are the following :-

(i) Lack of qualified or trained personnel caused by the very poor remuneration paid to scientists.

(ii) Sufficient funds are not allocated for long term projects and important basic studies.

The research worker must be regarded as a gambler who 'donates' his winnings to his organisation. He must be regarded as a partner in all development projects in which he is involved. Finally, the research worker must feel 'wanted' and, not treated as 'second grade' to get the best out of his or her talents.

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Ground Water Hydrology

by

M.W.P.Wijesinghe, M.Sc.(Geology) Durham, M.I.C.E.(Lon.) C.Eng.

INTRODUCTION

Water circulates in various forms around and near the surface of the Globe. The Science dealing with this ever-changing migration of atmospheric, surface and ground water as a complex inter-dependent system, is known as Hydrology. Occurrence of these phenomena may be collectively recognised as the Hydrologic Cycle, all aspects of which must be understood, at least in a general way before an accurate picture of the subsurface position of the cycle can be achieved.

With the occurrence of precipitation on the land surface a part of it is led away by rivers and glaciers to the sea and some part infiltrates under ground. The remaining part is partly lost by evaporation and sublimation before or after arriving on the surface of the earth. The ground water moves towards a valley, a lake or a depression and joins the surface water to be carried to the ocean. It joins directly to sea water in coastal regions.

Ground water and its movement is always observed under ground, in and through soils and rocks. The science of ground water treats, hydrologic relations underground and occurrance and movement of ground water. The paper outlines the pertinent features essentially of the subsurface portion of the hydrologic cycle, influenced by the distribution of surface water regime, resulting from precipitation of varying intensities. Kinds of soils and rocks and their distribution as well as geologic structure are different in area and thickness. The underground hydrological phenomena are influenced by these factors. Ground water investigations of a few extensive aquifers in Sri Lanka have revealed characteristic paths along which ground water circulates at great depths influenced by various geological features. To analyse the water balance of any given ground water basin for a certain period, a break down of the total precipitation in terms of evapo-transpiration infiltration and direct surface flow or surface runoff should be fully apprehended.

HYDROLOGIC CYCLE

The oceans are the immense reservoirs representing the "Hydrosphere" from which water originates by evaporation and to which it gathers, precipitating on the ocean itself or on the land surface. Not only sea water but surface land water which is kept temporarily in lakes, ponds, swamps, rivers, canals and depressions is lost by evaporation. Vegetation accounts for the water losses through transpiration. In countries of cold climate a part of snow deposits and glaciers is lost likewise by evaporation after melting and yet another part, directly by sublimation i.e. direct transference from the solid state to gaseous state. The total amount of water entering the atmosphere is very large. The depth of water lost annually from the ocean surface varies from about 0.5 metre (19.7 inches) in the polar regions to 1.5 meters (49.1") in the tropical regions. The average evaporation for all the oceans is roughtly 1 metre (39.4 inches). On the other hand rates of evaporation as high as 320 cms (126 inches) and transpiration in the order of 228 cms (90 inches) have been observed.

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Despite the large volume of water constantly entering the atmosphere, most of it is precipitated again on the ocean and land surfaces. A part of the precipitation on the land surface is carried away by rivers and glaciers to the ocean and some part infiltrates underground. The ground water moves towards a valley, a lake, a depression or sea, straining through soils and rocks of various types and hydrogeologic characteristics. All these processes are called hydrologic phenomena and such circulation of water is called the hydrologic cycle.

SURFACE WATER

The surface water is fresh and comprises rivers, canals, lakes, ponds, swamps, reservoirs and depressions on the land surface. It is distinguished in scale and salinity from sea water in the ocean. The run off is considered synonymous with stream flow and is the sum of the surface run off and ground water flow that reaches the streams. Surface run off equals precipitation minus surface retention and infiltration; The passage or movement of water through the surface and the soil infiltration is to be distinguished from ground water flow. Part of the water that infiltrates into the soil will continue to flow laterally as interflow at shallow depths owing to the presence of relatively impervious horizons just below the soil surface and will reach the stream channel in this capacity. Another part will percolate to the ground water table and eventually will reach the stream channel to provide the base flow of the stream, and still a third part will remain above the water table in the zone of the saturated flow.

When a drainage basin of a perennial stream is hit by a storm in the dry season, the hydrograph of the stream, will be disturbed from its smoothly levelling off curve and may assume various shapes, according to the relative magnitudes of rainfall intensity, rate of infiltration, volume of infiltrated water, soil moisture deficiency and other characteristics of the storm and the basin. The most relevant parameters and their influence on the four components of run off (surface run off, interflow, ground water flow and channel precipitation) are briefly discussed under the fllowing situations.

In the situation where the rainfall intensity is less than the rate of infiltration and the volume of the infiltrated water is not greater than the soil moisture deficiency, only an addition to the stream flow takes place, resulting in a slight increase of discharge. Surface run-off interflow or ground water flow never occur under these conditions.

In the second situation where rainfall intensity is less than the rate of infiltration and the volume of infiltrated water is greater than the soil-mosture deficiency, the moisture content of the soil would reach field capacity and the ground water flow accretion due to storm occurs in addition to the channel precipitation.

In situation 3 where rainfall intensity is greater than the rate of infiltration and the volume of infiltrated water less than the soil moisture deficiency, there are contributions from surface and channel precipitation but no additional ground water (i.e. owing to the storm) flow on top of the existing base flow sustained by the ground water basin of the river. (The river is called effluent.)

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In situation 4, rainfall intensity is greater than the rate of infiltration and the volume of the infiltrated water is also greater than the soil moisture deficiency. This is the normal case of a big storm. Now there is additional stream flow due to channel precipitation, surface run off, interflow and ground water flow, although the ground water flow contribution may be negative (i.e. When the river becomes influent recharging the ground water basin).

A hydrograph (Fig. 4) representing the normal case of a big storm shows the contributions of the various components.

(a) Surface Run off

(b) Interflow

(c) Ground water flow

(d) Channel precipitation

Channel precipitation ends with the storm.

In practice, the problem is not to compose a hydrograph, because the hydrograph is given by measurements in a gauging station but to separate its components. For simplicity channel precipitation and interflow are included in surface run-off to form a single item. The problem is to separate this from the ground water flow. A horizontal line through point A (fig. 4) where the rising limb starts to intersect the recession curve, may be considered as a first approximation to the boundary between direct run-off and base flow.

SUB-SURFACE WATER

A part of precipitation on the land surface seeps underground through the soil zone and is kept in a suspended state and moves downwards vertically. This water gives moisture to the soil and is called soil water or infiltrated water. A part of moisture is returned to the atmosphere directly by evaporation and the other part is absorbed by plants to return again to the atmosphere by transpiration. An excess of soil water goes downwards to be stored beneath to form an underground reservoir, dammed up on an underlying impermeable strata or compact rock mass. This is the shallow ground water and this water moves mainly in the horizontal direction, which is called percolation. It's upper limit is a free surface with same hydrostatic pressure as the atmospheric pressure on the ground and is called the water table, the gradient of which controls the ground water flow and obeys the laws of hydrodynamics. The infiltrated water or soil water which does not reach the ground water table but joins a surface water body is termed interflow.

The zone of free ground water or phreatic water merges at depth into a zone of dense rock with some water in pores, although the pores are not interconnected, so that water will not migrate. The depths to dense rocks vary with geologic environment

AQUIFERS

The water bearing zones which both transmit and store water are called aquifers. A rock which neither transmits nor stores water is called an aquifuge.

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Aquifers can be non indurated sedimentary deposits, fractured zones in dense plutonic rocks, porous sandstone beds, open cavernous in limestones and many other geologic features.

CONFINED AND UNCONFINED GROUND WATER

Water that is in direct contact vertically with the atmosphere through open spaces in permeable material is called unconfined or free ground water. When water flows through an aquifer situated between two layers of aquifuge or aquicludes above and below, separated from the atmosphere the ground water is called confined or artesian ground water. The terms semi-confined is used for the intermediate conditions. In many areas the first unconfined water encountered is above the general zone of phreatic water and is a more or less isolated body of water whose position is controlled by structure or stratigraphy. This is called perched water and the upper surface is called a perched water table.

When a confined aquifer is cut by some fault and water leaks out through this fissure or a hole drilled to this aquifer through and aquiclude (impervious bed) water rises under hydrostatic pressure existing in the aquifer. Water springs with pressure if this piezometric height is above the ground level and we get artesian flowing conditions.

MOVEMENT OF GROUND WATER

Phreatic or free ground water percolates in a horizontal direction towards a river valley, or some depression which is situated at a lower level. The velocity of this flow is controlled by the slope of the water table and affected by grain size and structure of the media.

Sediments such as gravels, sands and clays are composed of different size grains and show difference in effective porosity affected by their manner of sorting and arrangement. Some rocks are impervious to water but have many fissures, cracks or other openings and permit water easily through as seen very often in limestone and plutonic rocks.

Ground water percolates in most cases as a laminar flow with a very slow velocity, forming filtration tubes through space among grains of the medium. It is called a "Uniform flow" when the permanent or laminar flow has a constant velocity.

When ground water flows through cavities or cracks large enough in space, the flow is not permanent but turbulent and the movement of water molecules always changes its velocity and direction.

VELOCITY AND DISCHARGE OF GROUND WATER FLOW.

When ground water flow takes place through geologic formations under laminar or non turbulent conditions its velocity V, is proportional to the hydraulic gradient i and the coefficient of permeability k.

$$i.e. \quad V = ki$$

which is Daray's formula. It depends essentially on (1)the geometry of the pores i.e. their size and shape (2) mineral composition of soil particles or grains (3) the properties of the percolating fluid particularly its viscosity.

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For more or less accurate estimation of the velocity of flow, the coefficient of permeability should be determined experimentally preferably in the field. Laboratory methods using permeameters may also give some useful information on the value of the coefficient of permeability. This is expressed in cm/sec. in laboratory tests and in feet per day or year for practical engineering computations.

In geohydrological computations, the coefficient of permeability is expressed in terms of discharge and designated generally by capital letter K. It may be defined as the rate of flow of water in gals per day through a cross-sectional area of 1 sq.ft. under a unit (100 per cent) hydraulic gradient at a temperature of 60°F.

In the case of artesian aquifers, assuming that water flowing along is transmitted from section to section of the aquifer and no water is released from storage, another concept is used by geohydrologists. This takes into consideration the thickness of the aquifer D and the amount of water transmitted across a prism of unit square base area to the full thickness D_1 under the action of a unit hydraulic gradient (i = 1) i.e.

$$T = KD$$

T is the coefficient of Transmissibility or Transmissivity which shows the ability of the aquifer to transmit water. If the width of the aquifer is b ft. and the actual hydraulic gradient is i_o the amount of water transmitted from section to section is

$$Q = Tbi_o$$

The coefficient of permeability is expressed in gals per day and T is also expressed in gals per day per foot width of the aquifer.

The coefficient K and T are determined from pumping tests using c group of empirical formulae known as equilibrium formulae, under the assumption that the amount of water Q pumped during the day is constant. (i.e. steady state pumping). The other approach to the analysis of an aquifer was proposed by Theis, his formulae being known as the non-equilibrium formulae, in which the time factor t and the coefficient of storage S is introduced. For non-confined aquifers the coefficient S is equivalent to the specific yield of the material dewatered by pumping. In turn, the specific yield is the quantity of water yielded by gravity only, from saturated water bearing material and is expressed as a fraction of the volume of material drained. In the case of an artesian aquifer S is the ratio of the volume of water obtained from a prism of water bearing material with a base 1 ft. square and a height equal to the thickness of the aquifer D, per unit drop of hydraulic head, to the volume of that prism. The value of the coeff S, for instance, equal to 0.00032 means that 320 cu.ft of water would be released under an area of the aquifer 1000 ft square (1000 by 1000 ft.) as the average head declines 1 ft. Both T and S should be considered as empirical characteristics of a given artesian aquifer which can be determined from pumping tests.

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GROUND WATER OCCURRENCE AND AQUIFER CHARACTERISTICS IN SRI LANKA.

The crystalline rocks are at or near the surface in approx. 90% of the landmass of Sri Lanka and nearly two-thirds of this fall within the dry zone receiving a moderate seasonal rainfall averaging about 50" annually. The rest of the crystalline region is in the wet zone of the South West Sector, with rugged topography rising over 6000 ft. above M.S.L. having an annual rainfall averaging from 100" to 200". In spite of the abundant, the aquifers in crystalline terrain are limited in extent and thickness as a result of the shallow impervious hard rock strata which contain water in fissures, cracks and faults even at great depths. Main groups of aquifers consists of (1) coarse grained, loose sand and gravel surface deposits in isolated positions (2) lake deposits, wind deposits such as dunes or sandy varieties of loess (3) alluvial deposits in river valleys, flood plane formed of silts, sand and gravel deposits and (4) residual soils derived from in-situ weathering of rock. These aquifers consisting the overburden cover of the crystalline basement are generally less pervious and even otherwise due to the limitation in extent and thickness the yield into wells are poor which normally range from 5 to 10 gpm with exceptions upto about 30 gpm. Highly fissured or faultered zones of the crystalline basement may also be regarded as aquifers of limited yield capacities.

For this reason extensive ground water development for large water supplies for industries, irrigation or city use are not feasible in the hard rock regions. But for small scale industries and cultivations large diameter shallow dug wells are widely used, while often surface water resources from rivers, lakes etc. are being largely utilized for big scale development projects.

On the other hand, the remaining one-tenth of the island is underlain by the deep sedimentary rocks primarily of Miocene limestone and the sandstones, confined to the North and North Coastal Belt. The limestones are prominent sources of artesian and phreatic wells on account of their extensively cavernous (Karstic) nature caused by the solution of calcite, the primary constitute of limestone. Artesian and unconfined aquifers of depths ranging from 100 to 700 ft. or more are normally encountered in areas along the coastal belt from South of Puttalam upto Mullaitivu covering the whole of Jaffna Peninsula and its islands. The yield potentials in these karst aquifers are considerable, compared to these in the hard rock regions. The artesian tube wells yield ranging from 200 to 600 gpm per well and under phreatic conditions a well would yield around 200 gpm. However, due to sea water intrusion near coastal areas of phreatic aquifers may not give permissible levels in water quality compared to the moderately fresh water always encountered in the artesian basins.

A few examples are cited hereto briefly explain the hydrological phenomena of these deep aquifers as discovered by the investigations carried out by the Department of Irrigation during the past few years.

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Investigations in Palavi and Puttalam areas have revealed that a large artesian aquifer exists below an average depth of 200 ft. issuing water of good quality sometime freely flowing under pressure. A well of this aquifers constructed at the Railway Station of Puttalam flows freely at 4 gpm which has a safe pumping capacity of over 300 gpm and a quality level of 400 ppm of chlorides. A well in the same aquifer is being done at Palavi Saltern by the lagoon, which flows good quality water from more than one artesian zone. The flow is about 15 gpm. with water ranging from 200 to 700 ppm in chloride. These aquifers are recharged from direct rainfall and run off (influent rivers, streams and villus) and circulate water under great depth below aquicludes (impervious strata) which are extensive and deep seated often cuttings off direct incursion of sea water. Aquifers discharge through geologic structure zones in the form of springs and by diffusion. With the sea under phreatic conditions the shallow aquifers bear a limited depth in fresh water as a result of direct encroach of sea water if unintercepted by some geological structure barrier.

The well known Vanathavillu aquifers have been studied in detail and developed successfully for irrigation on account of deep circulation of water in kart limestone formations, situated 300 ft. or more below the ground surface. Recharge and circulation of water are as already discussed, but with the coastal upliftment resulted by faulting of geological strata have enabled to keep the large storage reasonably fresh cutting off direct intrusion of sea water. The artesian aquifer has been discharged naturally through many faulted structures but it may substantially discharge artificially through tube wells upto a safe annual recovery of 20000 Ac.ft. which could be developed for Agriculture.

A deeper artesian basin similar to that of Vanathavillu has been detected by systematic hydrogeological surveys in Puthukkudiyiruppu - Mullaitivu areas. Many investigation holes flow freely under hydrostatic head of over 500 ft. A remarkable circulation of fresh water extending beneath offshore could be expected in this area, compared to the often brackish phreatic aquifers near ground surface.

In areas of Mannar-Pooneryn including the Jaffna Peninsula, the limestone beds do not assume great depths (averaging to about 20 ft. below ground surface) often outcropping to the surface. On account of this deep artesian aquifers do not exist as in Vanathavillu or Puthukkudiyiruppu, circulating water at deeper levels and flushing the saline water. However, fresh water lenses are formed due to direct recharge from rainfall and flood runoff which keep back much of the sea water flow into the land discharging to the sea skipping over the saline water bodies. Investigations have detected fresh water basins in Murunkan and Mulankavil which could be developed by tube wells for extensive Agricultural development.

In Jaffna all fresh water lenses scattered over the Peninsula are limited in thickness recharged entirely by direct infiltration of rainfall. Here, the annual recharge of fresh water bodies has been estimated around 180,000 Ac.ft, 75% of which escapes into the sea on account of highly cavernous limestone formations. This volume of discharge, takes only two to three months, as a result of the conduit turbulent flow discharging through springs similar to those we find in Keerimalai, Urany, and many other places on the coast. Intensive investigations on a regional basis are now being done to study

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the flow paths through cavernous and other hydrogeological characteristics, in order to find possible solutions to arrest the present ground water discharge to waste.

HYDROLOGICAL DATA OF GENERAL INTEREST

The land area of Sri Lanka measuring 25332 sq.mls receives an average annual rainfall of 76.26 inches amounting to 89 x 10^6 Ac.ft. Nearly 40.5% of this has been estimated as total annual runoff i.e. 41.59 x 10^6 Ac.ft. The total annual flow escaping to the ocean, amounts to 27.00 x 10^6 Ac.ft. On this basis, assuming 50% of the difference between total runoff and the amount lost to sea, about 7.25 x 10^6 Ac.ft. could be assumed as the approx.annual recharge or flow of ground water through the aquifers, not taking into account the dead storage.

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C.A.A.S. SYMPOSIA

CURRENT SCIENTIFIC RESEARCH AND ITS RELEVANCE TO THE DEVELOPMENT OF SRI LANKA

RESEARCH IN ENGINEERING SCIENCES

FRIDAY 3RD AUGUST 1973

3.00 P.M TO 7.00 P.M

AT

IRRIGATION DEPARTMENT AUDITORIUM

CHAIRMAN : MR. T. WIJESINGHE.

SECRETARY: MR. G.M. YOGANANDAN.

C. A. A. S. SYMPOSIUM ON

"RESEARCH IN ENGINEERING SCIENCES"

3.8.73

PROGRAMME

3.00	Chairman's Introductory Address	..	Mr T.Wijesinghe
3.15	ROLE OF RESEARCH AND DEVELOPMENT IN MECHANICAL ENGINEERING	..	Dr B.Sivaprakasapillai, State Engineering Corporation
3.35	RESEARCH IN AGRICULTURAL ENGINEERING	..	Mr L.R.L.Perera, Government Factory
3.55	RESEARCH IN ELECTRICAL POWER ENGINEERING	..	Mr P.N.Fernando, Ceylon Electricity Board
4.15	RESEARCH AND DEVELOPMENT IN RURAL TECHNOLOGY	..	Mr D.L.O.Mendis, Ministry of Planning

(DISCUSSION)

- T E A -

5.00	RESEARCH IN IRRIGATION	..	Mr A.Maheswaran, Mahaweli Development Board
5.20	SCIENTIFIC RESEARCH IN HIGHWAY ENGINEERING	..	Dr T.Gunawardhana, Highways Department
5.40	RESEARCH IN STRUCTURAL ENGINEERING	..	Dr B.M.A.Balasooriya, State Engineering Corporation

(DISCUSSION)

6.45	Summing up by Chairman	..	Mr T.Wijesinghe

ROLE OF RESEARCH AND DEVELOPMENT IN MECHANICAL ENGINEERING

Dr. B. Sivaprakasapillai

Permit me to thank you, at the outset, for giving me the privilege of speaking to you today. I would like to say that I see this occasion largely in terms of an opportunity to tell you, clearly and unambiguously, my thoughts on the role of Research and Development in Mechanical Engineering and to then have you tell me what your reactions are to the views expressed by me. I am sure that all of you, like me, try from time to time, to view our own work as objectively as we can. I am also equally certain that we do not manage to be sufficiently objective and that we could all gain by listening to the frank opinions of our friends. It is in this spirit that I readily agreed to speak today when our Registrar told me that a very senior member of our profession, who was due to speak was unable to come along. I think you will now know whom to blame, should you feel you have wasted your evening by coming here!

Research and Development could possibly be looked on as an activity that is carried on largely in Research Laboratories and Universities. Mechanical Engineering on the other hand is always carried out in workshops and factories belonging to industrial undertakings. It is my view that there exists a symbiotic relationship between the research laboratory and industry. To say this in a simpler way, the research laboratory and industry cannot exist independently of each other. The respective roles of the laboratory and the workshop, and therefore the nature of their relationship, will be dictated by the needs and circumstances of the particular country in which they are located. If this view is accepted, it becomes axiomatic that the Research and Development activity must be consonnant with the technological capacities achievable in the country and these in turn must be related to the needs of the country.

Before we proceed further, it is advisable that we examine the meaning of the words Research and Development. The Oxford English Dictionary defines Research to be "endeavour to discover facts by scientific study of a subject". The word Development is defined to be "gradual unfolding, or, stage of advancement". It is worth remembering that even in the course of studying the published work of others, one indulges in a process of discovering for oneself what others have already discovered for themselves. This process of study is made easier if the original work is presented lucidly. To say that in large areas of mechanical engineering this kind of information is not available almost amounts to labouring the obvious.

Once the concept of a symbiotic relationship between the research laboratory and industry is accepted it is possible to define the role of the research laboratory. The proper function of an engineering research laboratory is to build up a reservoir of know-how to cater for both the short term and long term needs of the country and its industries. This in turn implies that, as a first step, the research laboratory must identify these areas where its efforts will lead to the setting up of nationally viable industries. In the case of a small country such as Sri Lanka, with an extremely limited home market, this means these industries that will use locally available raw material, or those industries that will manufacture items produced on a one-off basis or on a small batch basis. Thus research and development directed towards the needs of agro-based industries, ilmenite, ceramics, etc. could broadly be justified.

Let us consider, first of all, the short term problems. There are today a number of workshops that are unable to work to anywhere

near their full capacity. They are short of both orders and raw materials. As a country we have invested, over the years, monies in machine tools and in training personnel to man these workshops. On the other hand there are a large number of industrialists who are engaged in export oriented or other key industries who need equipment to permit them to either start of a new line of activity or to expand their present activity. A sizable part of this need of equipment could be met with advantage through local manufacture. This recourse to local manufacture cuts down the requirement of direct foreign exchange, often by as much as 60% - 70%. It is apparent then that the needs of the workshops and the needs of the industrialists could be satisfied simultaneously. Let us consider a few examples of this type of situation.

Consider first the case of the Paddy Marketing Board. This Organisat on is now the sole purchaser of paddy. It has made a case, which has been accepted, that Paddy must be stored in silos and not in gunny bags placed in stores. Four storage complexes are being set up at Inginiyagala, Polonnaruwa, Hasalaka and Galgamuwa, with a combined capacity of 22,000 tons of Paddy. The equipment needed consists of screw conveyors, belt conveyors, bucket elevators, scalper cleaners and mechanical dryers. The total cost of this equipment amounts to nearly Rs.5 Million and the foreign exchange needed amounts to Rs.5 lakhs. Agricultural Engineers attached to the P.M.B. specified the layout and the flow diagrams. Mechanical Engineers at S.E.C. studied manufacture catalogues and handbooks and produced a set of tentative designs before going to South India to see similar equipment. At the end of this visit it was possible to produce a set of designs. The manufacturers of the equipment are now in a position where they are able to produce the manufacturing drawings and proceed with the manufacture. This work is scheduled for completion in March, 1974.

A slightly different problem is the plan for the manufacture of equipment needed for rice mills. The principle items of equipment used in rice milling are Pre-cleaner, Rubber roller sheller, Separator, Polisher and Grader. This type of equipment is at present manufactured in this country according to a fairly old design. Thus the machinery now manufactured is unable to meet the quality requirements and is also wasteful. There is a consensus that we should go in for manufacturing more modern equipment. The way out would appear to be to study the catalogues of the better manufacturers, visit the modern mills in Sri Lanka and South India and to then produce a set of prototypes that will be evaluated by P.M.B. Once these prototypes are accepted, it will be possible to give the manufacturing drawings to the smaller industrialists for turning out the equipment.

A smilar strategy has been tried out in the case of the sugar cane crushers where the I.D.B., Nugaduwa and Browns' have produced prototypes that have been evaluated by the Sri Lanka Sugar Corporation. The two-wheel tractor is a further example of the type of developmental work that may be undertaken in Sri Lanka. The International Rice Research Institute in Manila, gave us free of any form of charge, a set of drawings relating to a two-wheel tractor powered by a 5-6 h.p. I.C. Engine. We then had to do a complete mechanical design of the tractor based on these drawings and produce a complete set of manufacturing drawings. This involved the choice of materials and alterations of some of the purely mechanical aspects to suit local conditions. For instance we have made the bearing housings in cast iron and have avoided fabricating these in steel. The steel and the welding electrodes needed for the bearing housings will be difficult to find locally. Again we replaced two of the anti-friction ball bearings by two journal bearings

for three reasons. First, these shafts were running at only 75 rpm. which is fairly low for anti-friction bearings. When the anti-friction bearings fail, a farmer may be put to severe hardship to find an imported replacement. Lastly the amount of foreign exchange immediately needed, for manufacture is cut down. We have plans for replacing two more anti-friction bearings by journal bearings. As part of the development effort we plan to modify the handle and handle adjustment, introduce a steering clutch and a rotary tiller. This notwithstanding the first prototypes are being tested by the Farm Machinery Research Centre at Maha Illuppalama. The prototype has been put through the dry ploughing and wet ploughing tests and is at present going through the endurance tests.

The expansion of the Flour Mill at Mutwal represents a situation similar to that obtaining with respect to the Paddy Marketing Board. Automatic weighing and Bagging machines, bag conveyors, Inclined belt conveyors, Screw conveyors, Bucket elevators, Battery cyclones and Centrifugal discharges are required. The value of this work amounts to around Rs.3 Lakhs with a foreign exchange commitment of Rs.40,000/-. Most of the spouting needed for this will be manufactured locally. A significant aspect of this project is that the process and the flow chart are being supplied by the original suppliers of the machinery. This being a modification to the existing mill, we have to abide by their decision that they will supply us with the centrifugal fans and the milling equipment. This is a clear case of a situation where our incomplete understanding of the process design has caused us to cut down on the items that could justifiably have been manufactured locally.

Another example of this type of situation has been the proposal that was put up around early 1972 for the setting up of an Ilmenite Plant. Here again there was a significant proportion of the equipment (120 tons/220 tons total in the Titanium Slag Production plant and 320 tons/664 tons total in the Titanium tetrachloride plant) could have been manufactured locally. We did not make much headway, at that time, because we did not have detailed specifications of the items of machinery.

On occasion we are fortunate in that the process know-how is available locally. An example of this is that of the Ball-Clay Plant for the Ceramics Corporation at Dediyawela. The process is very similar to that used in the Kaolin Plant at Boralesgamuwa. The process consists of feeding the mined ball clay into extruders and obtaining noodle shaped extrusions. These are carried on a stainless steel apron conveyor through an indirectly heated drier. The moisture content is less than 1% after the clay has been dried. The clay is then pulverised and classified (according to particle size) before it is weighed and bagged. The equipment needed consists of extruders, apron conveyors, dryer, bucket elevators, table feeders, attriter mills, shizzer type air classifiers, dust catchers and automatic weighing and bagging machines. The drier requires, in turn, oil burners and heat exchangers. The bulk of these items, except for the dryer, are of the same type as are found at Boralesgamuwa. Further, this type of equipment does not appear to have undergone any significant design changes since they were installed at Boralesgamuwa, about 15 years ago. The Kaolin plant has a throughput of 2.3 TPH as against a throughput of 5.5 TPH at Dediyawela. It was therefore reasonable to design the equipment for Dediyawela. It was therefore reasonable to design the equipment for Dediyawela by scaling up the equipment available at Boralesgamuwa. It was found that in the case of the attriter mill and the air-classifier, two of each of these units, found at

Boralesgamuwa, could be used at Dediyawela. This made them only marginally more expensive than if single units had been used, but it had compensating advantages in that these were of proven design and the supplying of spare parts to both Boralesgamuwa and Dediyawela could be solved simultaneously. This project will cost around Rs. Two Million and will require a foreign exchange commitment of about Rs.1.5 Lakhs.

A final example of this type of situation is the supplying of Air Ceylon with Passenger ramps, baggage loaders, pallet dollies, water bowsers, and toilet bowsers. A total of Rupees 4 Million worth of equipment will have to be supplied to Air Ceylon over the next twelve months or so. These are items that will have to be designed, fabricated and tested prior to being supplied to Air Ceylon.

In the examples I have cited, we see a Research and Development Unit functioning principally as a Design Office. This is the normal way that one should proceed if one wanted to establish a Research and Development Unit. I could buttress my arguement by citing the case of the National Engineering Laboratory in U.K. which started off as the Mechanical Engineering Drawing Office of the National Physical Laboratory. The rationale behind this approach is that once you undertake a design project you will be forced into acquiring a large amount of relevant information. This knowledge is then carefully built up and the experience that is acquired automatically leads them to find ways and means of improving their design from the standpoints of performance and cost.

Viewed from a different light the setting up of a design group with a view to eventually setting up a Research and Development Unit again makes sense. Anyone who has done a research degree or a design

project knows that the first step is to carry out a literature survey in the chosen field of study. The object of doing this is to get to know all that is published and after critical examination, identify the shortcomings with a view to finding ways and means of increasing the body of knowledge. By these arguments one could justify the design office activity as laying the foundation for later Research and Development activity. This design office activity could be justified for other reasons also. The value of the work undertaken for Paddy Marketing Board, Flour Milling Corporation, Ceramics Corporation and Air Ceylon amounts to just over Rs.12 Million and involves a foreign exchange requirement of Rs.1.2 Million. In all these cases the price paid by these institutions for the local product will be equal to or less than the FEEC's and duty paid price of the imported items. The country has to pay only about one-tenth of the total price in foreign currency and work has been given to local workshops.

On occasion we get a slightly different set of affairs taking place. For instance it is sometimes possible to go for the newer technologies. It is now possible to make Fluidic elements in this country. A consequence of this is that it is possible to make fluidic control circuits. This advantage was used to make an automatic weighing and bagging machines. Three of these machines were made for the Oils and Fats Corporation. It is likely that more of these will be supplied to the Flour Milling and Ceramics Corporations. If a modicum boasting may be forgiven, I will recount the inadvertent admission of a technologist from one of the most developed countries. We showed him this machine because he had wanted to know whether such machines could be made in Sri Lanka. The moment he got near the machine he became quite engrossed by it and shot off a series of questions. Half way through one of the local boys asked him whether they made this type of machine in his country. He replied

"not yet, but quite soon we will have a better machine!".

Again we found that we could not make the conventional type of traffic lights, so we went in for a system that used electronic circuitry. This we found led to a cheaper unit and it has worked quite satisfactorily for the last three years.

The country is now totally self sufficient in sewage treatment equipment. We make our own sewage pumps, rotory distributors, aerating cones, and paddle rotors for oxidation ditches. A complete plant has been installed at Mahiyangana and the Buildings Department is contemplating placing orders for equipment worth about Rs.5 Lakhs.

An example of how the constraints imposed by the manufacturing capacities available in a country could act as a stimulant is the cutter-suction dredger that was constructed about four years ago. Electric generators and motors and oil hydraulic pumps and motors are not manufactured in Sri Lanka. This meant that it was difficult to make dredgers, using either hydrostatic or electric drives, competitively in Sri Lanka. It was decided to explore the possibility of using a hydro-kinetic drive with a water pump driving turbines. Though the transmission efficiency of this type of drive is far less than that of the other two options, the actual operating costs would have been equal. This was the first time that a turbine this size, 40 hp. at 660 rpm., had been designed and built here. It turned out to be just as efficient, 74%, as the Turgo-Impulse turbines made by Gilbert-Gilkes and Gordon. The runner was around half the size of that of the U.K. Turbine, and the then costs were Rs.12,000/- for the local turbine as against Rs.77,000/- for the imported turbine. Another happy outcome of the dredger project was the use of rubber liners for the dredge pumps. It was found that under comparable conditions of dredging in the Kelani, the rubber liner had a life of 850 hours

vis-a-vis a rubber liner that would cost Rs.2,500/-. Rebuilding a Manganese steel casing would cost around Rs.10,000/- vis-a-vis Rs.250/- for the rubber liner. The rubber liner will be as good as new after rebuilding while the steel liner will have the characteristics of the hard facing electrodes used. The steel liner will also have rough wetted surfaces that will accelerate the wear. It takes around 3-4 weeks to rebuilt a steel casing but only two days to rebuild the rubber liner. All these advantages came about purely because we were not able to make electric drives, hydrostatic drives or cast manganese steel casings!

A completely different function of Research and Development may be to avoid unnecessary mechanical sophistication. This I am sure will sound a heretical way to end this talk. I refer to the proposal put to the Commissioner of Excise regarding an arrach bottling plant of 8000 bottles per hour capacity. In these proposals there has been a radical departure from the automatic type of bottling plants that are now in vogue throughout the world. The present proposals would virtually put the clock back at least fifty years. A manual plant has been suggested because it provides opportunities for the harnessing of local resources in the way of manpower and machinery to meet local requirements. The manual plant is commensurate with the present stage of technological development of the country. It requires a larger number of personnel of a type that is abundantly available today, and the skills that they require are of a kind that they require are of a kind that could be imparted easily and cheaply. The automatic plant, however, is too sophisticated for our present capabilities. This is because it employs a very limited number of relatively highly skilled operators, who have quite often, to be specially trained with difficulty and at considerable (foreign) cost. Again in the event of breakdown of sophisticated machinery, competent technical skills are not readily

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available as in the case of the washer at Kalutara Warehouse No.1. Valuable equipment would be forced to idle under compulsion. Finally the bottling of arrach must be viewed in the context of rural unemployment prevalent in Sri Lanka. Thus the decentralisation of employment opportunities, wherever it could economically be justified, must be persued. In particular the bottling of arrack could be undertaken either at the centres of production or at the centres of consumption. The proposals put before the Commissioner of Excise offer manual plant of sufficiently small size to permit this decentralisation. Further they are of a kind that would enable a rural cycle shop or car garage to undertake their repair and maintenance. Finally the manual plant is built up of a series of modules that would enable the capacity to be increased purely by adding extra modules. Ultimately the manual plant has been justified on pure economic grounds considering overall economic and National Economic Profitability. The foreign exchange component of the capital cost of the Automatic plant is Rs.790,000/- vis-a-vis Rs.182,000/- for the manual plant. The annual foreign exchange needed for the running costs are Rs.20,020/- and Rs.8,516/- respectively.

This example is a special case of a more general problem that needs attention quite urgently. All imports of machinery for existing projects and for new projects must be screened with the possibility of alternative ways and local manufacture in mind. It is only by doing this that the most appropriate solutions for our needs could be found.

29th June, 1973.

Bs/Nw.

C A A S

SYMPOSIA ON CURRENT SCIENTIFIC RESEARCH AND ITS RELEVANCE TO THE DEVELOPMENT OF SRI LANKA

- RESEARCH IN AGRICULTURAL ENGINEERING -

by L.R.L. Perera

Agriculture is one of the most (if not the most) important factors in the development of Sri Lanka. Under present conditions and standards Engineering plays such an important role in Agriculture that the development of Engineering Science in application to Agriculture bears a significant relevance to the development of Sri Lanka.

Machinery for Agriculture in Sri Lanka is known to have been introduced as far back as the late thirties. From that time machinery that were used has gone through constant modification and improvement. These modifications and improvements were the result of research and development work done in the countries of their origin and were oriented to suit their agriculture. We in Sri Lanka neither had the capacity nor the necessity to indulge in direct research for the improvement of machinery during the early stages because we had a vast range of machinery to import from to make-do the operations for which machinery was really sought at the time. Foreign Exchange appeared to be no problem or even if it was, nobody seemed to bother. However, with the influx to the country of a large range of machinery for the initial cultivation operations in agriculture to the final processing of the crops, we began to realize that the machinery that was flowing into this country was not all that suitable for our agriculture. Research did start both by scientists and farmers - not in up-to-date workshops and air conditioned designs offices, not in multistoried buildings, but in our farmers fields and the village smithies. It is unfortunate, however, that no worthwhile follow up and proper recording has been done of whatever little that had been done and proved or had been tried and appeared promising.

This Symposium seeks to review current scientific research and its relevance to the development of Sri Lanka. My assignment is to review the field of Agricultural Engineering and that with special reference to mechanization, since the subject of Irrigation will be dealt with separately by another speaker. I must repeat that it is unfortunate that records of some of the early works done have not been kept or they cannot be ~~traced since they had not been kept or they cannot be~~ traced since they had not been properly documented and published. After all most of the research and development in this field had been done by "goiyas" and "barbers" and not by learned doctors or post-graduate researchers.

From work done at Maha Illuppallama as early as 1944 it was realized that the great value of tractor drawn agricultural machinery lies in the speed with which agricultural operations for ploughing and sowing can be undertaken. Until the late forties tractor ploughing here was done either by the mould board plough or the disc plough. In the early fifteen Ratnatunge[1] manufactured a tine cultivator in the workshops of the Department of Agriculture in Gannoruwa which was then nothing more than a wayside garage and which had suffered the full impact of the 1947 floods. The imported tyne tiller was thereafter used and no attempt whatever was made until recently to manufacture these locally to meet our requirements. It is, however, being done now. Ratnatunge again had tried stellite to overcome the rapid wear of blades but this was not persued perhaps due to lack of facilities and proper know-how. how. It was found that hard-faced local plough shares costing less than half the price of imported shares did five times more work than the imported shares.

Imported machinery available were most suited for highland conditions. In 1946 trials were conducted at Hingurakgoda and Maha Illuppallama Government Farms in the dry sowing of paddy. Of 130 acres sown at Hingurakgoda 42 acres were sown dry by means of machinery and the rest of the extent puddled

and sown. The average yield in the dry sown areas was 24 bushels per acre compared with an average of 45½ bushels per acre in the puddled and sown area. At Maha Illuppallama too the same results were indicated.

The question as to whether mechanical ploughing has any bearing on yields was investigated by me along with Kanapathipillai[6] in 1956. Ploughing with mammoty and also with tine tiller, disc plough, disc harrow, and mould board plough on a four wheel tractor were done on random plots on a five acre block of land in Wagolla Farm in the Kegalle District with a crop of maize. The results showed that there was no significant difference in the yield by the different operations.

During the period 1950 - 51 Tractor trials were started to find out whether tractor cultivation ~~under proper management~~ is profitable in this Country. Four Pilot Tractor Units were established in Kilinochchi in the north, Karadian Aru in the East, Wirawila in the South and Nikaweratiya in the North-West. These trials undertaken with old machinery obtained from the Director of Land Development proved that under proper management tractor cultivation is profitable in Sri Lanka and renders a great service to farmers in areas where a shortage of buffaloes and labour exist. By the operation of Agricultural machinery pools during recent times in the Department of Agriculture, I can support the view that under proper management tractor cultivation and other agricultural operations with machinery is a profitable venture.

During this same period
Intercultivation with tractor driven spring tine Cultivators of crops such as Chilli, Cotton and Tobacco was tried out very successfully on farms. Transplanting of Chilli and Tobacco using tractor driven Robot Transplanters was also done satisfactorily. Besides reducing costs, mechanical transplanting produced very even growth and satisfactory stand of the crop. About 200 acres were transplanted with Chilli at Gal Oya using tractors with automatic Robot Transplanting machines.

During this same period a special 5 furrow power lift shallow plough for shallow ploughing in rice cultivation was fabricated for trial with a Ferguson Tractor. Also a portable, self energised electric coil salinity meter was developed for research investigations by the Division of Botany of the Department of Agriculture at Muthurajawela.

In late 1954 I tried the drilling of germinated paddy with modifications to a corn planter. This was done in the Karadiyaru Farm in the Eastern Province on a 1/4 acre plot. The main modification done was the replacement of the steel disc with a thicker wooden one. Besides the seeding itself being satisfactory a significant increase was observed in the tillering and thereby of the crop. It was felt that this was due to damage to the plumule during the drilling operations. The only follow up on this was by Johnpulle[2] who made the simple 4 row seed drill for germinated paddy on the lines of the Indian seed drill.

Much work has been done by many on seeders for paddy. A fair review of this has been made by Thambiayah[3] in the Tropical Agriculturist of December, 1958. The whole idea is to get the paddy in rows so that weeding could be done. However, spacing the plants on the row itself will reduce the seed rate per acre and allow for further tillering. Dibbling in rows therefore is resorted to. Two dibblers of significance is Manickavasagar's[4] Drum Dibbler (1966) and Dias's[5] Rice Seed Dibbler (1960). Dias improved his dibbler with simultaneous fertilizer attachment in 1969. Patents are pending on Manickavasagar's drum dibbler.

Dias's Dibbler was tried out very successfully to dibble rice in rows 10 inches apart with a spacing of 4 in. in the row. The Dibbler is about 10 lb. in weight and could be operated with ease by a child of 12 to 14 years. The seed rate about ½ to 1 bushel per acre depending on the size of the seed used. The average out put is about 1 acre in 8 hours of work. This method is cheaper than transplanting and mechanical control of weeds by using a rotary weeder could be done after about 2 to 3 weeks of

Dibbling. Many farmers who used this method with other improved techniques such correct doses of fertilizer etc. have obtained better yields than transplanting or broadcasting.

Following on the success of this Dibbler, Dias developed his prototype of the rice Seed Cum Fertilizer Dibbler, and was tried out successfully. In one operation pregerminated rice seed with a ring of compound pellet fertilizer placed round the seed at each hill could be dibbled. Rows are 10 inches apart with a spacing of 8 inches in the row. The weeds can be controlled by using the rotary weeder both ways between the rows. The out-put is about 1 acre in 8 hours of work.

Manickavasagar's dibbler is essentially for sowing paddy under dry conditions. 20 prototype models manufactured at the Department of Agriculture Factory at Welisara were distributed to farms and Agricultural Officers in the different districts for testing. Although some results have been collected by the Agricultural Designs & Testing Unit at Mahailluppallama and analysed there seems to be some resentment that a proper evaluation of this machine has not been done.

The Johnpulle seed drill is widely used by local farmers and is manufactured locally at the Department of Agriculture Factory in Welisara. The Dias Dibbler also is manufactured there and is gaining popularity. No large scale manufacture of the Manickavasagar Drum Dibbler has yet been started.

Along with his development work on the drum dibbler, Manickavasagar worked on transplanters and strip crushing Transplanting mechanically does not seem to gain popularity. Strip crushing is being condemned as wasting more seed over direct seeding or dibbling although there is a definite saving in the seed rate over broadcasting. Besides, the advantages obtained by row seeding over broadcasting are available in strip crushing.

Manickavasagar conducted his strip crushing using the Rotary weeder and two wheeled tractor. He concluded on his experiments that the technique gives a crop similar to a transplanted or row sown crop, at a much lower cost and eliminating the peak labour requirements at a time of transplanting.

The transplanter developed by Manickavasagar is a semi-mechanised one. 100 of these were produced at the Department of Agriculture Factory at Welisara and distributed to all ranges and Farms. Although the first model did not gain popularity several modifications and adjustments were subsequently done. The first model weighed 53 lbs. and had a draught of upto 30 lbs. By eliminating the base board with two skids and a metallic spring loaded leveller he managed to bring down the draught to less than 12 lbs. He finally produced a machine which had an efficiency of 92% and which could transplant 1/3 acre a day, three machines and six labourers being able to transplant an acre inclusive of the filling of vacancies.

Besides this Manickavasagar tested and also made several modifications on a transplanter sent here by the National Institute of Agricultural Engineering in Silsoe, U.K. This machine which was too be heavy and cumbersome to operate, was modified by reducing the weight from 73 lbs to 40 lbs and incorporating floats. He had also worked on several other transplanters which he had named M.I. 1 M.I. 2, M.W. 3. The present state of these are not known.

Transplanters are generally not popular because of the labour involved in working the machine itself or the preparation of plants for the machine. In 1970 I developed an automatic planter where plants from trays could be transferred to the field direct by a single operator. Patents are pending.

Quite an amount of work has been done on machinery for threshing and winnowing of paddy. The Agricultural Machinery Designs and Testing Unit at Mahailluppallama is known to have worked on a tractor mounted thresher cum winnower. This has not yet been fully

tested and accepted for production.

Sethansingho[7] designed a thresher cum winnower which he patented in 1957 - Dias[5] patented a Thresher cum winnower in 1956. Neither of them however went into production although I am aware that Sethansingho used his one and only model for custom work in his village.

A table model rubber drum thresher and a horizontal rubber drum thresher were designed by me in 1969. Patents are pending on both models. The table model which was tested in 1970 have given very encouraging results as far as breakage is concerned.

Quite an amount of work is done on threshers in most rice producing countries. The International Rice Research Institute in Manila developed a thresher which was brought here for testing but did not turn out to be satisfactory. IRRI is also working on a table model thresher.

Combine Harvesters have been tried and tested in Mahe Illuppallama farm as far back as 1948. Although this was abondoned soon after, with the development of short straw non lodging varieties of paddy experiments have been re-started with combine harvesters. Combining of rice and threshing and winnowing with mechanical threshers are becoming popular in areas like Minipe and Mahiyangane where labour is scarce.

In 1966 I developed at the Department of Agriculture workshops in Gannoruwa a tractor with large front wheels for working in muddy paddy fields. The modifications were really tried out on a discarded power tool bar. Later, the same machine was developed with a drive on to the front wheels so that a four wheel drive model with large front wheels was available. This tractor which was tried out in the Central Agricultural Research Station in Gannoruwa alongside other standard four wheel models showed definite advantages working in mud.

Experiments have also been tried with wooden bearings on the front wheels of standard four wheel tractors, since the cost of replacing bearings at the rate they do fail in mud is prohibitive and involve foreign exchange as well. Further studies on this are continuing. The four-wheel tractor described above with the large Front wheels had advantages in the saving of front wheel bearings from failure, since the chances of ingress of mud was less due to the height of axle from ground.

In recent times attempts have been made to manufacture locally a

two wheel tractor. Four institutions undertook to copy a prototype designed by the IRRI which was a simple machine. However, Kodituwakku[8] and Brlendran[9] developed this further by adding simple steering clutch mechanism and other modifications.

The IRRI design though simple in manufacture had many disadvantages. The sprokets were welded to shafts. In case of wear on the sprokets, the shafts too have to be replaced. All the housings were of mild steel. The transmission housings are bolted on to a box section, bent from sheets. The reduction box was not of sufficient strength. Handle was not rigid. Only two speeds were available and that is by changing the main drive V belts. No steering clutch system was available.

The improvements done so far involved the fixing of sprokets to shafts by keys, Cast Iron Alluminium alloy housings in view of low material cost and greater production capability, transmission housings box section fabricated out of angle Iron and sheets, thereby eliminating bending, modifications to handle to improve rigidity and manouverbility and the incorporation of a steering clutch system.

Further development is now being done on improvements to the steering clutch system and the incorporation of a gear box giving 4 forward speeds and 2 reverse speeds.

We have now begun to realize the importance of drying paddy. Fernando[10] worked on a simple machine for the drying of paddy (1970) and later developed it to a par boiler cum drier. Trials are still going on with the experimental model. A test run of 100 days is now in progress. Patents are pending for the Government in 22 countries which include both machinery manufacturing and rice producing countries.

Apart from all this we have developed in this country, machinery from puddling in muddy fields to special spray nozzles for paddy pest control work. Quite an amount of work has been done on stubble mulching, surface tillage practices, weed control, irrigation-sprinkler and otherwise. A multitude of other problems are being tackled currently by both engineers, scientists and farmers.

1. Retnatunga D.M.

   Then Superintending Agricultural Engineer, Dept.of Agriculture.

2. Johnpulle A.L.

   Then Agricultural Officer - Western Province.

3. Thambiah S.

   Then Agricultural Instructor.

4. Manickavasagar T.N.

   Then Agricultural Instructor (Machinery Research) Agricultural Research Station, Maha Illuppallama.

5. Dias G.R.W.

   Agricultural Officer (Farm Engineering, Dept. of Agriculture).

6. Kanapathipillai P.

   Then Statistician, Dept. of Agriculture.

7. Sethensingho

   Farmer from Horana.

8. Kodituwakku K.K.J.

   Then Acting Factory Engineer, Govt. Factory, Kolonnawa.

9. Balendran V.

   Engineer, Govt. Factory, Kolonnawa.

10. Fernando H.I.

    Agricultural Instructor

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CEYLON ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

CURRENT SCIENTIFIC RESEARCH AND ITS RELEVANCE TO THE DEVELOPMENT OF SRI LANKA

Electrical Power Engineering - Presented by P.N.Fernando

(1) Power System Planning for Developing Countries

- Mr P.N.Fernando under the supervision of Dr A.K.David at the University of Ceylon, Peradeniya.

The possible future development of the Sri Lanka electrical power system was used as a background in these studies. Given the probable feasible power system configurations arising with time from the development of multipurpose hydro schemes, thermal/nuclear plant, power and energy exchange with an independent power system and the associated transmission, an optimal planning approach has to be sought. This problem was formulated as a discrete multistage decision process, and the applicability of Dynamic Programming for its solution was shown. A computer program was developed for this purpose and applied to the background example power system considered, using an IBM 1130 Computer.

The possible configurations are considered feasible if amongst other requirements they show satisfactory performance with respect to voltage control and reliability. The optimal reactive power requirements for satisfactory voltage control were determined by a perturbation of the non-linear power system equations in conjunction with linear programming and a computer program was developed for this purpose. The reliability aspects of the power system configurations were also studied by considering the effects of power system component outages. Quantitative estimates of reliability were derived incorporating the probabilities associated with the exceedance of particular loads and component outage occurrence. Several transient stability studies were also performed on these configurations.

A computer program was also developed to study the performance of one of the power system configurations above, in conjunction with a simulation of the steady state operation of a High Voltage Direct Current Link between itself and an independent power system for power and energy exchange.

(2) Hydro Power Development Studies

- Messrs K.L.Ariyananda, S.V.A.Buddhadasa and other Engineers of the Engineering Studies Organisation (ESO), Mahaweli Development Board and Dr S.Sabanathan, University of Ceylon, Katubedde.

The major hydro power stations in Sri Lanka at present comprise a system where the outputs are electrically interconnected by the high voltage, grid system and the inputs hydraulically interconnected by the power waterways and the reservoirs of the Kehelgama and Maskeliya Complex. A prerequisite to the further development of hydro plant in other river basins was the study of the integration of their operation in conjunction with those existing. Such a study would involve simulations aimed at obtaining the parameters of the future schemes for optimal integrated operation. These studies were first attempted on a ICL 1900 computer for the economic justification of the Ukuwela Power Plant on the Mahaweli. Later a computer program developed by Messrs K.L.Ariyananda and S.V.A.Buddhadasa of the ESO for integrated operation of the several future plants in view with those existing, indicating also the optimal thermal back-up required of the system, bearing however a distinctive simplicity. This progam was used to prove the economic justification of the Bowatenna and Samanalawewa power plants and it will be extended to incorporate the Canyon and Kotmale power plants.

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Other computer programmes were developed for the following by the ESO -

(a) Calculation of penstock water hammer using dimensionless parameters - K.L.Ariyananda.
(b) Operation of a single reservoir - K.L.Ariyananda.
(c) Surges in an inclined surge chamber with a restricted orifice - Dr S.Sabanathan.

These were used for the Bowatenna power plant designs. The ESO is developing a program to evaluate the pressure and speed regulations of a Hydro-Electric System to determine in one study the optimal hydraulic, electrical and mechanical parameters that are interlinked in a hydro-electric power station. The ESO is also working to review available literature and current practices for application to economic power plant design. Some areas investigated are unit spacing of generations, optimum generating voltage, economic power station earthing systems.

(3) <u>High Voltage Tests on Pia Insulators and Wood Cross Arms</u>

- Messrs L.C.Aramatunga, P.N.Fernando, M.Tissera.

The electrical insulation of a power system gets stressed beyond the normal voltage of operation under the impact of over voltages caused by surges in the system. These are generally caused by direct and indirect lightning strokes, switching surges and unbalanced faults. In transmission system design, the insulation levels are decided on the basis of maximum probable switching surges while catering for the diversion of lightning surges, maintaining a suitable coordination of insulation levels of the different power system components. These princliples are applied in the selection of insulators for a given system, giving due consideration to environmental constraints. High voltage tests are performed to determine the surge voltage performance of insulators. Besides the voltage withstand limits, the creepage distance of an insulator is also of importance particularly in determining the performance under polluted conditions.

Owing to trouble experienced in polluted areas the CEB has adopted the use of 44 KV and 15 KV pian insulators on 33 KV and 11 KV lines respectively. The increased voltage withstand values and the higher creepage lengths thereby have proved satisfactory in overcoming flashover in heavily polluted areas. However this has led to an over rating of insulators in the moderately polluted and clean areas. The High Voltage Tests above, performed at the Engineering Faculty, Peradeniya, were aimed at obtaining the impulse withstand properties of high voltage insulators in conjunction with treated/untreated wood cross arms in polluted/non-polluted and wet/dry atmospheres.

The test results were to a great degree in agreement with those expected. The effect of the wood was to add approximately 50 KV of impulse withstand voltage per meter of it over and above the impulse value for the insulator alone in both dry and wet tests. Based on these results a table was drawn making engineering recommendations on the usage of insulators and wood cross arms for different parts of the country. The economic implication of these tests may be observed by noting that a standard set of wood cross arms are about one third the cost of steel cross arms, apart from the possibility of using lighter rated insulators.

(4) <u>Long Term Forecasts of Electric Power Demand in Sri Lanka</u>

- Mr T.V.Arumugam.

The various socio-economic and technical factors propagating the continuous and discrete increase of the electric power and energy demand are described in detail. The relative merits of the different methods available for load forecasting are also discussed. Load forecast trends

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for the recent past derived on the basis of one of these methods, namely direct extrapolation of past trends, is compared with realized values in practice and the close agreement of actual and predicted curves shown. The probable upper and lower limits for the future loads are also given on the above basis and compared with forecasts by other independent authorities.

(5) Studies on the Deviation of Reservoir Control Curves for the Castlereigh and Mousakelle Reservoirs

Contribution to these studies were made at various times by Messrs T.R.Cooray, K.Arumugam, K.A.S.Chandrasiri, P.N.Fernando of the Ceylon Electricity Board (CEB) in consultation with Prof. K.K.Y.W. Perera, University of Ceylon, Katubedde Campus.

The Sri Lanka electric power system is a mixed system consisting of both hydro and thermal plant. The hydro component, which is predominant depends largely on the inflow from rainfall realized in the catchment areas of Castlereigh and Mousakelle Reservoirs. In view of the fact that these inflows are probabilistic, the major function of the thermal plant is to back up the hydro system and enable a hydro-thermal coordination which would as far as possible minimize spilling on the one hand and avoid system energy shortages on the other, while meeting the constraints imposed by the demand, maintenance programs and operation of other plants.

The problem of hydro-thermal coordination in an optimal manner with the in-flows considered deterministic is well defined and realistic methods of solution are available. However, when the inflow is stockastic, this problem becomes very complicated and the solution approaches attempted have depended on a suitable processing of the historical spectrum of inflow records and an operational simulation on the system of main and control reservoirs, power waterways and machines installed etc. Briefly the method consists of working back from a realistic end point of the system under study, such as the commissioning date of a new hydro scheme, and working backwards to the present, simulating the effect of past inflow sequences over the relevant time span on the reservoirs and deriving a basic rule or minimum safe level curve.

Thermal energy is called for whenever the actual reservoir level is below that indicated by this curve. Modifications to this approach were also worked out and the practical reservoir control was based on a careful interpretation of these results. At the initial stages these tedious computations were done manually, but subsequently a computer program was written by Mr K.A.S.Chandrasiri for this purpose and the inflow figures from 1934 to 1972 were processed to obtain more comprehensive results.

CEYLON ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Symposium

on

Engineering Research in relation to Sri Lanka's Development

on 3rd August, 1973 3 - 7 p.m.

at Irrigation Auditorium

Some thoughts on Research and Development in rural technology in Sri Lanka -

by D. L. O. Mendis

PRIMITIVE MAN struggled against nature. To survive, he soon learnt to work in groups. This was the beginning of organised Society.

2. In rural Society in our country today, the individual's struggle with nature remains, but the group struggle is organised on a more systematic terms than in primitive Society. Consequently, there is a balance with nature which should not be upset in the process of development, especially technological development. To understand this is to appreciate the meaning of "Research and Development in Rural Technology".

3. Rural Society has an ancient traditional background. This background is essentially agricultural. The technological achievements that supported the ancient agricultural civilisations are evident in the form of ruins of the ancient irrigation systems that were built using locally available resources. If we are to use modern knowledge to achieve rapid development in the rural sector, we should develop technologies that will not on the one hand rudely disturb the existing balance with nature, but will, on the other hand, utilise locally available resources to the maximum.

4. It would be convenient to discuss this development and plan and conduct the necessary research in each of four sectors, viz. agriculture; industry; construction and transport. It would also be convenient to discuss certain important factors that are common to one or more of these sectors, viz. water, fertilizer, tools, machinery and implements and energy and power.

5. Water is stored on the surface of the earth or tapped from underground sources for irrigation of crops. With surface storage, considerable amounts of stored water are lost through evaporation and seepage. Indigenous research to reduce these losses can make use of modern knowledge that was probably not available in ancient times. For example, a mono-molecular layer of oil has been spread on large reservoirs to reduce evaporation losses.

6. To make use of potential energy available in storage water, we may undertake local research to develop water-wheels especially where there are falls in large canals.

7. To avoid seepage and evaporation losses in the conveyance system, we must develop cheap pipes. An example is available of a very light quality of polythene being used to make a pipe system totalling about 1 mile in length, which costs less than Rs. 50/- for the irrigation of paddy. Again, in certain areas of the country where clay is available and there is a tradition of pottery work, it may be possible to manufacture clay pipes on a commercial scale. For this purpose, the research would include development of suitable machinery.

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8. Where water has to be lifted using mechanical power, although wind power has been used in some places this has not been supported by adequate indigenous research. For the development of water pumps, some research has been done in the State Engineering Corporation and elsewhere, but commercial application is still far from complete and pumps continus to be imported, whilst local manufacture does not adeuately meet the demand. At present, a project to manufacture 2-wheel tractor with a water pump attanhed has been launched, based on ad hoc research done in a few public sector institutions. Such research can be effectively institutionalised if the N.E.R.D. Centre is started.

9. Another area of research for lifting water is the direct conversion of energy from the sun, on which some initial research was done several years ago in the faculty of Engineering. Unfortunately, that research was not applied to the solution of problems on the field in the rural areas.

10. For land preparation in agriculture we have used the buffalo and cattle since ancient times. But the 4-wheel tractor was introduced some years back without much thought for the future. Today, the capital cost of the 4 wheel tractor is prohibitive whereas the 2-wheel tractor is still within our reach. But it is not hard to anticipate the time when the capital cost of an imported 2-wheel tractor will also be prohibitive. This is a clear example of the consequence of the absence of research in rural technology. Even at this late stage, we must take steps not only to conserve the buffalo, but to manufacture the mechanical substitute for the buffalo in this country. Obviously, the 2-wheel tractor and not the 4-wheel tractor would be the next appropriate step in technological development and that is why the Ministry of Planning launched the local 2-wheel tractor project recently.

11. Not only the tractor, but all the tools, implements and machinery needed in agriculture must be systematically developed in this country. Unfortunately, successive governments had invested large sums of capital expenditure on such white elephants as the State Hardware Corporation instead of investing more wisely and conservatively on indigenous research to develop our agricultural machine technology. Such efforts as were made in the Ministry of Agriculture were not given adequate support from the industrial sector nor were such efforts properly co-ordinated within the agriculture sector. For example, the Agricultural Implements Factory at Welisara although set up to manufacture such implements locally, functions in a different section of the Department of Agriculture from the Farm Mechanisation Unit at Maha Illuppalama; and, of course, other organisations in the industrial sector such as the Hardware Corporation, the Government factory and various private workshops that have a potential for manufacturing agricultural hardware have no contact with these two organisations in the agricultural sector.

12. To remedy this situation, the Ministry of Planning is setting up Medium Scale Industrial Co-operatives in the Districts. The needs of the agricultural sector will be met by the production in the local Industrial Co-operative, and direct contact between the agricultural sector and the industrial sector at the District level will be effectively maintained. However, the need for research and development in this area of rural technology becomes all the more important.

13. If such research is financed; one can look forward to the development of the indigenous thresher and winnower and other small machines (both man-powered and power operated) as well as a combined harvester on the indigenous 2-wheel tractor, in the near future.

14. In regard to fertiliser, we have paid very little attention to research in the rural areas, on traditional methods of fertilising the land. Modern knowledge is available to us to study the growth of organic fertilisers, such as the nitrogen fixing bacteria. But we hear much more about the advantages of using chemical fertilisers that are imported into the

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country than about such organic fertilisers. Recently, a Scientist observed that the Dry Zone of this country had sustained agriculture for thousands of years probably on account of such organic fertilisers as produced by nitrogen fixing bacterial that thrive in the presence of sun light and in the presence of trees of phosphate. However, we have not heard of any organised research on these aspects. Meanwhile our Agricultural Scientists are well versed in the techniques developed in foreign countries and transferred here, which techniques depend on imported fertilisers, weedicides and pesticides, to say nothing of the seed. Agricultural Scientists bemoan the backwardness of the rural agricultural worker in adopting these"modern technology" whereas the rural agricultural worker finds that modern technology is being imposed on a traditional technology, which we knows well, without due regard to a more gradual transformation based on research in the rural technologies.

15. It is seen that in the industrial sector, much of the potential for development is intimately tied up with the agricultural sector. One may even define agriculture as an industry and invest in research for the development of the "agricultural industry" in the rural areas.

16. In regard to transport, we can mention transport on land and transport by water. Land transport will be revolutionised by the development of a strong light and cheap wheel in the country. One would yearn to see research directed to this problem resulting in the development of a pair of wheels costing less than Rs. 50/- weighing less than say 20 lbs. and able to carry on axle load of up to 1 ton on unsurfaced rural roads. This wheel should also be locally manufactured in the rural areas. What comes to mind is a bicycle type with rubber tyres and a steel axle.

17. With such a wheel it will be possible to utilise man-power to a much greater extent than at present for rural transport. This in itself will have a tremendous chain effect on national economic development.

18. Water transport may be possible on a systematic scale in large Colonisation Schemes, where main channels carry water continuously during the cultivation season. We have heard of an invention made by a rural technologist of an unsinkable boat, powered by wind, which would lend itself to such transport.

19. In the construction sector, a great deal of research and development is necessary for construction of earth works, both channels and bunds on such major projects as the Mahaweli Development Project, for example. To quote a well known example, the earth works in retraining the Dhun Oya below Ukkuwela Power Plant cost Rs. 35 lakhs of which as much as Rs. 12.5 lakhs is in foreign exchange. This is because we have merely handed over the job to a foreign contractor, who is doing it with modern technology imported from abroad, which is the easiest way for him. If we had used appropriate rural technology in this area, we would have given employment to a very large number of people and set up a permanent industrial centre near Matale, with the foreign exchange component of this work. In this Centre, we would have researched the appropriate technology and developed the appropriate machines for this job.

20. Very probably, this would have been small power units mounted on 2 or 4 wheels, hauling trains of earth-moving carriages also mounted on 2 or 4 wheels, which would have been loaded by labour using hand tools.

21. The earth itself could have been loosened by the use of mechanical power, for example with tillers. The equipment would have been manufactured locally, with only such items as engines and transmissions imported. At the end of the job, the district would have had a very valuable residual investment in technology for the future.

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22. Another area in which such practical research should be done is in rural housing. It is indeed a shame to see pottery workers who work with clay in the Murunkan area in Mannar District living in thatched hovels, which themselves have no clay walls! This is because there has not been any research in rural technology in this area which would have given these rural workers an opportunity for economic development. For example, if clay pipes can be made in this area to conserve water under the Giant's Tank Irrigation Scheme, there would be benefits to the farmers and indeed to the whole District as well.

23. In conclusion, I wish to mention a new institution which has already been tried and proved, through which research and development in rural technology may find practical application. I refer to the Dispersed Production Co-operatives set up by the Ministry of Planning, as Division Development Council projects all over the Island.

24. The first Dispersed Co-operative Divisional Development project was the Light Engineering Industrial (Blacksmiths) Co-operative at Kotmale. In this type of organisation, each member of the Co-op retains his identity and individuality in his own work place. A number of such individual members who practice a common profession or trade form a Special Co-operative and obtain for themselves certain benefits which may be broadly described as 'Inputs' and 'Outputs'. The Inputs are generally raw materials, tools and know-how and the Outputs are the markets for their products. Following the success of the Kotmale Project, Light Engineering Industrial Co-operatives have been set up in more than 50 Divisions in all parts of the Island. Thereafter, Medium Scale Industrial Co-operatives consisting of small machine shops, welding shops, foundries and repair garages are also being organised at the District level. The commercial production of the 2-wheel tractor and water pumps are being undertaken through these Co-operatives.

25. Dispersed Production Co-operatives have also been set up in the agricultural sector. For example, a Kitul Products Co-operative is manufacturing jaggery and honey, some of which have been exported to London. An Ayurvedic Producers Co-operative has also been set up. Indigenous research is necessary to develop the productivity of the Ayurvedic Co-operative.

Research in Engineering Sciences - Irrigation

by

A. Maheswaran

Introduction

We have inherited a vast network of irrigation tanks and channel systems from our forefathers. Most of these ancient irrigation works were in an abandoned state when the Government through the Irrigation Department undertook a programme of restoration during the late thirties. In order to achieve returns from the investment made on such irrigation projects, research work had to be undertaken so that the schemes could be properly designed with the minimum of cost to the country. A research division was set up in the Irrigation Department to carry out scientific study and research for the efficient utilisation of the land and water resources available to the country.

The main branches in which research was undertaken are Hydrology, Geology, Soil Mechanics and Hydraulics. A brief review of the work already carried out and the lines on which future studies may be carried out are discussed in this paper.

2. Hydrology

The Science of Hydrology deals with the origin, occurance and distribution of the waters of the earth. Its evolution as a science has been dependant upon supporting sciences such as physics, chemistry, fluid mechanics, metereology, geology, forestry, mathematics, statistics and more recently computer science.

Engineering hydrology deals with the science as applied to the design and operation of Engineering Works. Hydrology is not an exact science, but thanks to the efforts of modern day researches, it is fast moving towards an exact science, especially since the advent of the electric computer in the early 1950's.

Fortunately for us, researchers in other countries have carried out studies for our guidance in the development of hydrological data applicable to this country. LEROY SHERMAN (1932) introduced the theory of "Unit Hydrograph" whereby rainfall excess could be translated to run-off in the form of a hydrograph. This was followed by Horton (1933), who outlined a procedure for determining infiltration losses so as to enable the calculation of rainfall excess for a given storm to be made on a rational and scientific basis. In 1941 Gumbel introduced statistics into Hydrology by suggesting the use of extreme value distribution for hydrologic analysis.

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These advances in Engineering Hydrology and its scientific application, play an important part in the development of the Water Resources of the country. The work commences with hydrological data collection and thereafter involves the analysis and design utilising the data so gathered.

The Research Division of the Irrigation Department is responsible for the systematic collection of hydrological data and the analysis of such data. The Island is covered by a network of rainfall stations. The Department of Meteorology maintains about six hundred 24-hour gauges and 24 self recording continuous gauges. Surface run-offs are measured at gauging stations maintained by the Irrigation Department. Stream flows in about 100 potential reservoir sites have been gauged and a great deal of data relating to the surface flow at these sites are available. In addition, 24 free water surface evaporation stations are also maintained by the Irrigation Department to provide data for the preparation of iso-evaporation maps.

The cost of irrigation water is rising rapidly thereby necessitating the study of proper methods of conveyance, distribution and use of water. Several investigation and studies have been made on the seepage losses from channels and the planning of farm layouts. With the departure from the traditional rice irrigation system, studies have also become necessary on farm layouts for crops other than paddy. These studies have already been initiated so as to provide the designer with sifficient data applicable for conditions in Sri Lanka.

The study of availability of ground water and its exploitation also calls for scientific investigation. These studies have also been undertaken. The subject of Ground Water has already been discussed in great detail in a recent seminar organised by the CAAS under this programme.

Further studies and researches into seepage losses in Canals, siltation of reservoirs and canals, water management etc., have to be carried out urgently, if some of the major projects (e.g. Mahaweli Project) are to be dosigned on a rational basis.

3. Geology

Geology is a science of the structure and formation of the earth. It consists of several branches like Geomorphology, Petrology, Mineralogy, Historical Geology, Structural Geology etc. We, as Engineers, are concerned with some aspects of the above branches, chief of which are Structural Geology and Petrology.

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When a major irrigation project is undertaken, Geological investigations are conducted so as to enable a safe and economical design to be prepared. Initially detailed geological maps are prepared of the project area using the (i) available largest scale topographical map of the area, (ii) aerial photographs (usually 1:40,000 scale) and (iii) information gathered by site inspections. Data furnished in these geological maps are checked and confirmed or amended by core drilling at selected locations. Suspected weak zones are usually test checked by core drilling; at the time of core drilling, water pressure tests and punping tests are also carried out. In special cases, fluctuation of water table is also measured over a period of time. These investigations would provide sufficient data to prepare Engineering Geologic Sections for areas where Engineering structures are proposed. A preknowledge of the geology of an area would be necessary to evolve satisfactory designs for a project. Even during construction, geologic investigations and evaluations are necessary to determine the nature of foundations, need for lining of tunnels, extent of grouting to be carried out etc.

During recent years, extensive geologic investigations were carried out for the design of important projects like Polgolla & Bowatenna Complexes in the Mahaweli Development, Bowatenna Power Project, Samanalawewa Project etc.

4. Soil Mechanics

Soil mechanics is the application of the laws of mechanics and hydraulics to the engineering problems dealing with sediments and other accumulations of solid particles produced by the mechanical and chemical disintegration of rocks. This include the theories of behaviour of soils under stress, the investigation of physical properties of soils and the application of theoretical and empirical knowledge of the subject to practical problems. The benefits that have accrued to the country as a result of this early break-through from the traditional approach of earth dam design to a more rational and scientific method of design, have been twofold. While costs have been minimised by introducing economic designs, at the same time factors of safety available in the designs, have also been correspondingly increased.

The staff attached to the Irrigation Department's Soils and Materials Testing Laboratory is engaged on applied research in connection with the application of the principles of soil mechanics and concrete technology to the solution of problems affecting design and construction of dams and other hydraulic structures. This Laboratory which is believed to be among the earliest Soils Laboratory in Asia, was founded in 1942 for the purpose of applying principles of soil mechanics in the design of earth dams. Up to this time, the design of earth dams has been based on empirical formulae and precedent.

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We have passed through some of the stages in the evolution of the practice of earth dam design. It is a significant fact that over the years we have accumulated sufficient experience to handle with confidence the demands that face us now in the field of high dam design.

In the first stage our ancestors designed earch dams on the basis of precedent and probably on empirical thought processes.

In the second stage we passed on to the thumb rule stage - this is typical of the earth dam designs during the colonial ear. During this period the efforts of the department were mainly concentrated on the reconstruction of the ancient earth dams. Re-modelling of these old dams show only over fill to the newly augmented heights on very much the same pattern as what the ancient Ceylonese had done centuries ago. After varying periods of storage, these dams developed seepage at points along the downstream slopes and protective works had to be carried out in order to avoid failure. This type of empirical design and treatment has cost considerable sums of money. The stability of critical section of the Minneriya Dam under conditions then existing, showed a factor of safety of 1.35 on the upstream and 0.82 on the downstream (1948). Allowing a margin of error for high values of pore water pressure in this analysis, the fact remains that this dam nearly failed in early 1950's. The Eramudu Oya Gap or Parakrama Samudra was designed as a homogenous fill in 1938. The then practice was to assume a phreatic line on a steady 1 on 4 empirical gradient. This led to most inconvenient and unrealistic designs with very flat downstream slopes requiring extra quantities of fill material.

The third stage set in with the design and construction of projects such as Huruluwewa, Hulanda Oya, Padaviya and Gal Oya. These designs show improvements in techniques, chiefly in the adoption of zoned dam sections and internal filter arrangements to arrest seepage water. The slopes of these dams have been designed after careful study of the physical properties of the soils that were available at the sites for construction. The factors of safety available in the design had been evaluated and unnecessary flattening of the downstream slopes avoided thus saving a considerable amount of money by deviating from the thumb rule method of design of earth dams. The design and construction of the Gal Oya earth dam incorporating some of the latest design techniques, such as inclined downstream filters, marked the dawn of a new era of high dam design and construction.

In the fourth stage that is currently taking place, the Irrigation Department's Soils and Material Testing Laboratory is engaged on high dam design of projects such as Samanalawewa, Kotmale, Randenigala and Moragahakanda. The 350 ft. high Samanalawewa earth dam is in the design stage, while field investigations are in progress for the design of the

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Kotmale dam. Preliminary investigations and laboratory tests of representative soil samples have been completed for the Randenigala and Moragahakanda dams.

In the design of these high dams, it is of great importance to assure the stability of the dam. What is done in the name of development would turn out to be a catastrophic failure if the various factors that contribute towards stability of the dam are not correctly evaluated. The principal uncertainity in the determination of the factor of safety lies in the estimate of pore water pressures. This estimate has to be made for three separate sets of conditions - i.e. during construction, when the reservoir is full and during draw down of the reservoir. The initial estimate is based on laboratory tests of representative samples of soils obtained from the proposed sites, theoretical considerations and field observations of the geology of the site.

The evaluation of an economic factor of safety therefore implies that the parameters that contribute towards stability should be evaluated as accurately as possible by laboratory testing. The use of accurate and even elaborate methods of testing is resorted to in the Soils Laboratory as the reduction in construction costs fully justify this method. For instance in the design of the Samanalawewa dam, the original design for the earth dam proposed by Consultants, necessitated a fill volume of 8.3 million cubic yards. This design is presently being reviewed by the Engineering Studies Organization of the Mahaweli Development Board in collaboration with the Irrigation Department's Soils and Material Testing Laboratory in the light of additional data available from field investigation and laboratory test results. The design under study now would require a fill volume of only 5.8 million cubit yards.

5. Hydraulic Engineering

Hydraulic Engineering problems cannot always be solved by theoretical analysis. Model testing in hydraulic research laboratories usually provide the answers to many complex problems. All designs organizations undertaking work on Water Resources development are backed up by hydraulic research laboratories for checking the performance of structures on hydraulic models. Work done in hydraulic research laboratories have helped to evolve economical and efficient designs resulting in reduction of the cost of projects. Engineering Hydraulic Research therefore plays a vital and effective role in the implementation of development programmes.

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In 1938, a Hydraulic Research Laboratory was established at Jawatte Road by the Irrigation Department. In the first 20 years of its existance, this Laboratory had undertaken a number of hydraulic investigations and experimental work for the design of flood protection schemes for Nilwala Ganga, Gin Ganga, Kalu Ganga and Kelani Ganga. Though the flooding problems in these rivers were very complex, partial suggestions have been implemented with varying degrees of unsuccess.

Research work was also carried out in the field of Coastal Engineering. Sea outfalls at Maggona, Goiyapana and Wellawatte were studied in detail and partial success has been noted on the implementation of the findings of the researches. Model tests were also carried out on several important structures for Parakrama Samudra Scheme, Minneriya Scheme, Katupathoya Scheme, Huruluwewa Scheme, Ridiyagama Scheme etc.

During recent years several studies were carried out for determining the suitability of designs in several major projects. A brief description of the work done is given below :-

(a) Mahaweli Project

The construction of a barrage at Polgolla on a major river like the Mahaweli Ganga pauses several problems. The design call for a barrage with hook-type gates and the diversion of the river flows through a 19 feet diameter tunnel.

Model tests were carried out to study the backwater effects caused by the barrage, an operation pattern for the gates, siltation and sediment movement, flow conditions downstream of the barrage etc.

These studies helped to finalise the design of the structural features and perhaps saved money for the project.

(b) Samanalawewa Project

The desigh called for a chute spillway located on the left bank. The model tests revealed that the approach to the spillway could be modified so as to save over a million rupees in the construction of the approaches to the spillway.

(c) Ambawela Scheme

The problem of energy dissipation on the downstream of the chute spillway had to be solved as the rail track in the vicinity of the spill channel had to be safeguarded. The laboratory evolved a satisfactory chute spill with zig-zag baffles. The spillway based on the recommendations of the laboratory has been constructed and is functioning very satisfactorily.

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6. Conclusion

Research studies carried out in the various branches of the Irrigation Department have helped in the advancement of design of several complex structures and in the efficient development of water resources of the Island. As several major projects are scheduled for implementation in the next few years, it would be prudent to make additional investments for the development of research.

7. Acknowledgement

The willing and ready assistance rendered by the officers of the Research Branches of the Irrigation Department, in the preparation of this paper, is gratefully acknowledged.

CURRENT SCIENTIFIC RESEARCH IN HIGHWAY ENGINEERING AND ITS RELEVANCE TO THE DEVELOPMENT OF SRI LANKA

Paper presented by Tudor Gunawardhana on 3rd August 1973 at the C.A.A.S. Symposium on Current Scientific Research and its Relevance to the Development of Sri Lanka.

Role of Highways in National Development

Roads are of prime importance in national development. We need roads for land and agricultural development, exploitation of mineral and other natural resources, development of health and educational services, community and social development and for the development of tourism and internal trade and economy. Almost every aspect of national development requires the direct or collateral service provided by highways. A good highway system is a national asset and no substantial national development can take place without a corresponding development in a country's highway system.

Research and Development

With any form of development programme, research is an important factor in achieving progress and the development of highway planning, design, construction and maintenance is no exception.

Also if research is to make an immediate impact on development, research must be first directed at those areas where substantial results or economies can be expected without protracted delay.

Highway Research

In highway engineering the potential areas where fruitful results cam be expected early are the following.

i) Co-ordinated planning in relation to other development activities.

ii) Rational design to suit traffic demands and providing for stage construction

iii) Quality controlled construction using the least expensive material and the adoption of labour intensive techniques to produce an economic and efficient highway system.

The Highways Department has its Planning functions looked after by the Division of Traffic & Planning and the pavement design, materials and methods of construction research by the Division of Research and Development. This paper deals essentially with the work carried out by the latter, ie. the Division of Research and Development which is located at Ratmalana.

Research Policy

If the country's need and our objective is the obtaining of early results through research, it is clear that specially in the case of highway development the accent should be more on applied research than on basic or fundamental research. This has been the continued policy of the Highways Department, whereby it is expected that research activities shall be devoted to making realistic improvements to practical road building technology and also to finding solutions to actual field problems encountered.

In the field of highways we have been very fortunate that developed countries in reaching their advanced states of development, have given very careful attention to highway research. However it must be borne in mind that each country has its own characteristic conditions or problems of climate, geographical and geological features, availability and type of material resources, traffic demand and financial resources. These variable factors therefore require the modification and adjustment of the research findings worked out elsewhere before they can be adapted to suit another environment. Therefore, although we have the advantage of having research findings at our disposal without having to indulge in expensive and time consuming basic research these findings must be judiciously modified to suit our financial

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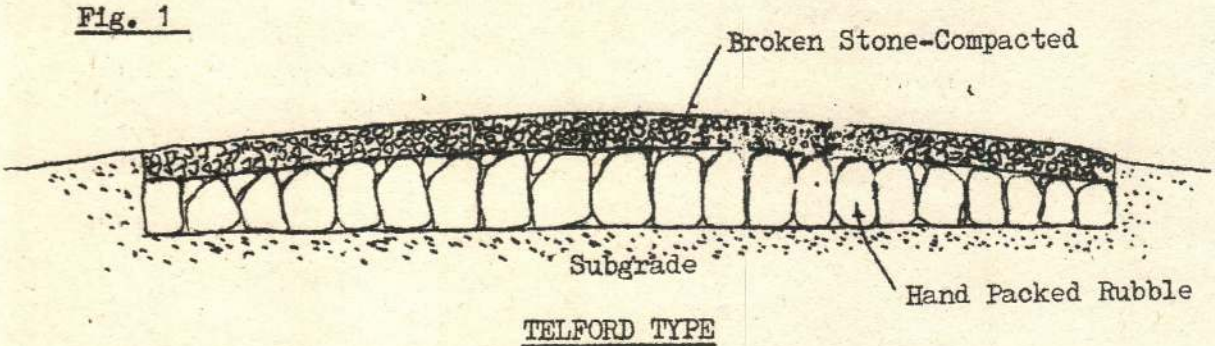
and environmental conditions and the labour intensive system which we must necessarily support. This persuit together with research on a series of characteristically indigenous problems directed towards the production of economic and quality controlled roads, along with the training of personnel to carry out this work have constituted our effort towards national development since the inception of the Office of Research and Development in 1967.

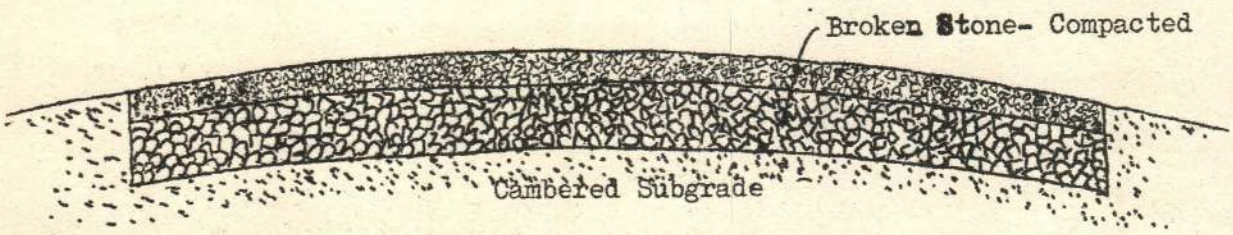
Practical Applications of Research

The road mileage which has grown since the beginning of the British Period of rule has essentially been of the Telford and Macadam Types as illustrated in Figure 1.

Fig. 1



TELFORD TYPE



McADAM TYPE

This type of construction was used irrespective of subgrade conditions. On a strong subgrade this led to waste of material, and on a weak subgrade, pavement distress was inevitable. Even if the pavement survived, surface undulations could not be prevented due to the rubble and single sized aggregate gradually sinking into the subgrade with repetition of traffic loading.

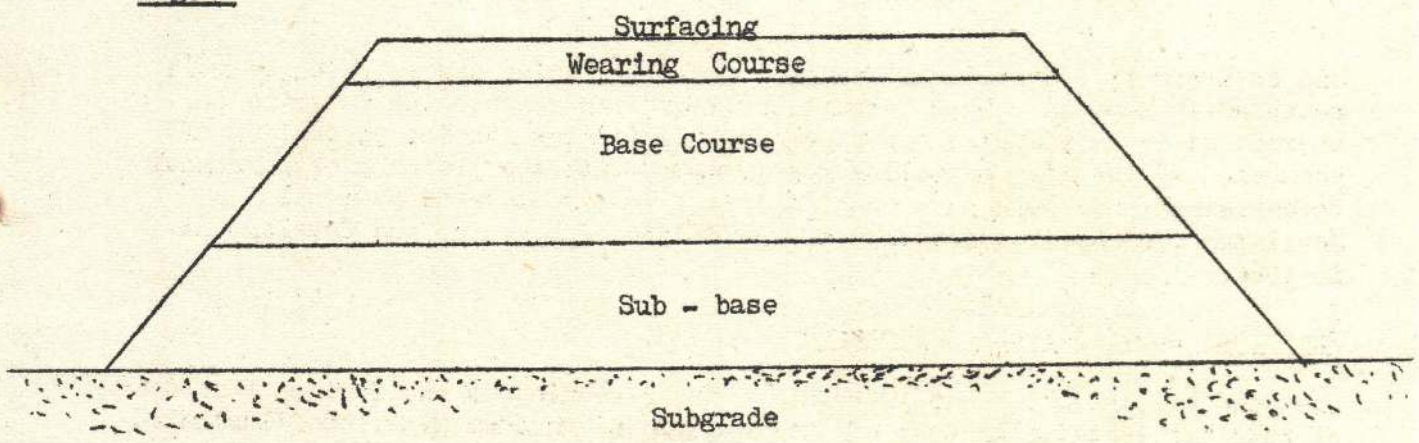
The eventual result of this was the build up of a considerable mileage of substandard road with poor riding qualities which we inherited as a legacy to begin our modern development era.

The problems that were inherent in this legacy could not be eliminated outright by the complete reconstruction of these roads on the lines established by modern research findings for new road construction. The first cost of such a venture would have been beyond our financial means at any time. Therefore the problems of this aniquated system have had to be continuously looked after as best as possible by improvements and maintenance.

In order to review the contribution made by applied research towards economic highway construction and maintenance, it is first necessary to discuss the basic highway pavement structure to bring to mind or identify the areas that can benefit from research. These components are indicated in Figure 2.

We shall take each of these components in turn and see the impact made by research in making its construction more economical and more effective in-service.

Fig. 2



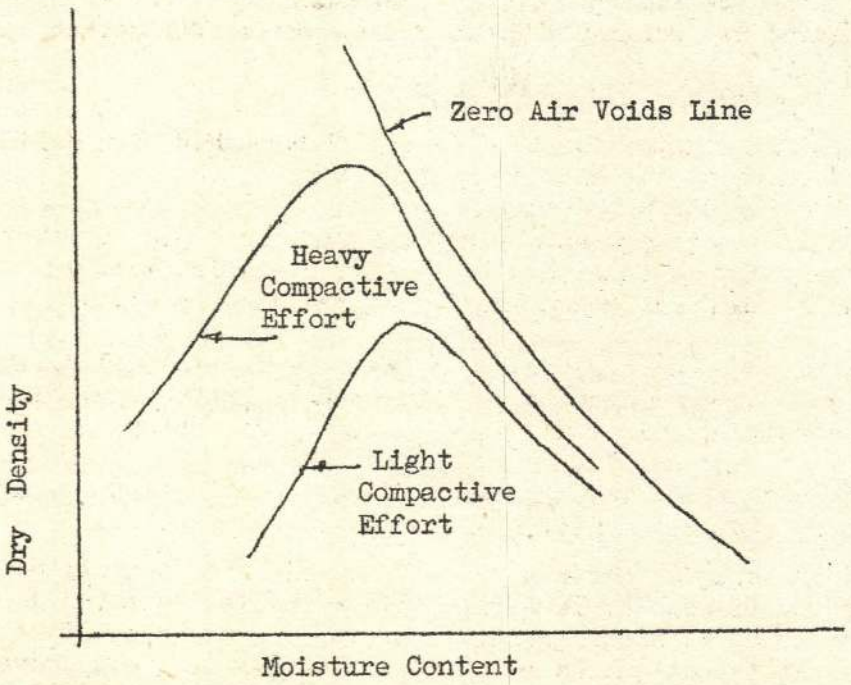
Definitions *

Subgrade :	The natural foundation or the fill which directly receives the loads from the pavement.
Sub base :	A layer of material placed between the foundation and the formation, usually for a special purpose, such as to get the road way above water level or to increase the depth of construction to reduce intensity of loading on subgrade.
Base Course :	That part of the pavement resting upon, and through which the load is transmitted to the sub-base, subgrade or supporting soil.
Wearing Course:	Abrasion resistant surface course on which traffic loads are applied.
Surfacing:	Final water proofing finish placed on wearing course or on a compacted base.
Optimum Moisture Content:	That moisture content at which a specified amount of compaction will produce the maximum dry density.
Maximum Dry Density:	The dry density of a soil obtained by a specified amount of compaction at optimum moisture content.
Compaction:	The process whereby the soil particles are constrained by rolling or other means, to pack more closely together, thus increasing the dry density of the soil.
Grading:	The distribution of particle size as determined by the percentages of the various grain sizes presented in a soil or aggregate.
Stabilized Soil:	Soil treated in such a manner as to render its properties less affected by water and to increase its load bearing capacity.
Pavement:	The whole of the artificial construction made to support traffic above the subgrade.
Cut back Bitumen:	Bitumen which has been rendered fluid at moderate temperatures by the addition of a suitable diluent such as kerosene.

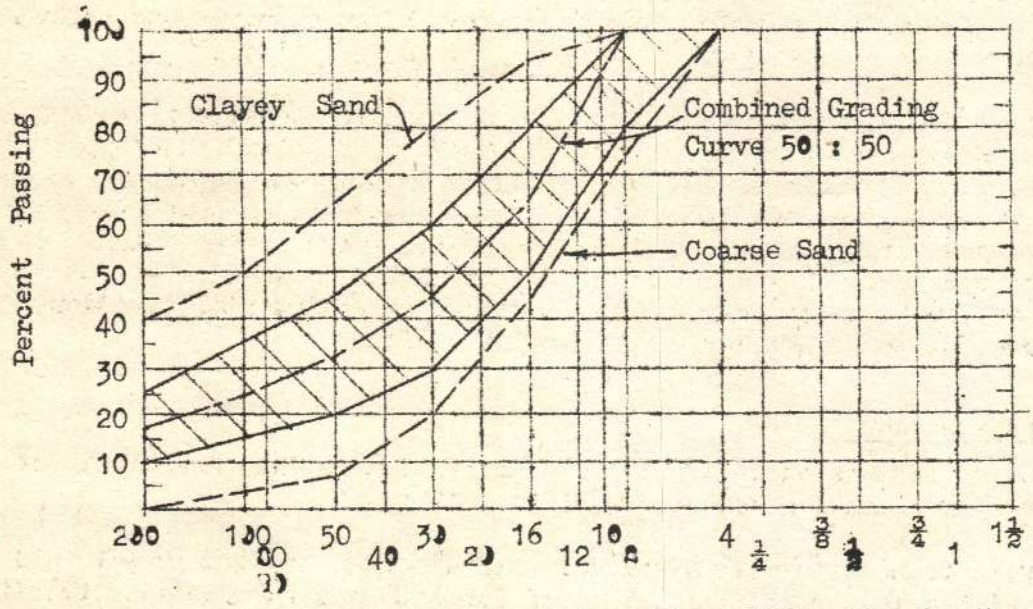
*Definitions: As per Soil Mechanics for Road Engineer - H.M.S.O.

Subgrade Treatment

The component that needed first attention was the subgrade. The basic treatment for strengthening a subgrade is compaction. Although this is not a very popular exercise with road builders we have been pressing hard to create an awareness of the importance of such characteristics as maximum density and optimum moisture content in subgrade compaction in the obtaining of stronger and more stable subgrades.



The road builder is next given the concept of maximum density gradings as an introduction to the techniques of mechanical or particle size stabilization. In this process the subgrade soil is analysed for particle size and it is blended with the appropriate percentage of a suitably graded burrow soil to adjust the particle size grading and provide sufficient binding material to yield higher density and stability on compaction.



The next stage of subgrade treatnent is soil stabilization by the use of chemical additives or bituminous binders.

In this field an extensive amount of research with indigenous soils has been carried out to establish the effectiveness of lime as a stabilizer. The performance of dolomitic limes and calcitic limes have been subjected to comparative study.

The potentialities of stabilizing soils by admixing with liquid bitumen or cut backs have also been investigated.

Cement though extremely useful as a stabilizing agent has not been recommended for use except in exceptional cases as in our present state of development, cement has to be put to the more urgent use of building houses and bridges.

Sub base Treatment

We next come to the treatment of the sub base. When a sub base is being used to build up the road platform, essentially the same treatment as used on strengthening the subgrade by compaction and stabilization can be adopted.

Base Course Treatment

It is in the treatment of the base course that it has been difficult to popularise the use of the results of research.

Single sized large aggregates are not suitable in a base as such material cannot be fully compacted with ease to form a stable platform. The problems inherent in the Telford System would continue to persist.

This deficiency can be corrected by using a binder and relatively smaller sized aggregate or by the use of a continuously graded aggregate conforming to maximum density requirements to form stable base courses.

The problem encountered here is the difficulty of obtaining suitably graded material in sufficient quantity for use on road bases.

In the hand breaking of metal a few uniform sizes of aggregate are produced with hardly any fines. It is mainly this situation that led to the drafting of specifications for single sized aggregate for use on road work and gave rise to some of the attendant problems. Attempts are being made to rectify this situation without diminishing the labour intensive nature of aggregate production by recommending suitable blending of aggregates with crusher dust and fine sands.

In the case of the Weerawila Aistrip which is presently under construction this method of blending to produce continuously graded aggregate in base construction is being followed.

When bitumen becomes more readily available, the problems of base construction can be reduced to a large extent by using bitumen bound construction where the effect of aggregate grading is not that critical.

In any case the use of crushed metal is an expensive construction process. Therefore where ever possible we have strived to substitute a cheaper but effective enough stabilized soil base course in new construction. A number of experimental stretches of stabilized road construction have been carried out as demonstrated and proving jobs in several parts of the island. As a result of our research studies with indigenous material and the test road experiences, we can now confidently recommend effective stabilization procedures for the construction of cheaper roads.

Stage Construction

An extension to this outlook on road construction is the possibility of providing for planned stage construction.

A good road foundation with a minimal surfacing can be quickly put into service with a lesser initial outlay of funds to cater to present traffic demands and a more substantial base placed upon this at a future date when it becomes necessary. By this means a road way can be progressively built up to yield a high quality facility without having to make a large capital investment at the very commencement.

Wearing Course and Surfacing

The traditional wearing course and surfacing have consisted of a layer of penetration macadam surfaced with a coat of bitumen blinded with sand. This is produced by consolidating a layer of 2 to 1½ inch metal with the interstices filled by a small quantity of ¾ inch metal and fines, and by grouting from, the surface downwards with hot bitumen. Hence the term 'penetration macadam'. The final surface is obtained by spraying bitumen and sand blinding.

This kind of wearing course is very vulnerable particularly if the underlying base is not strong enough. Also it is uneconomical practice to keep on renewing the surface by applications of bitumen and sand alone.

Improvements to the wearing course have been produced by the adoption of aggregate seal coats and eventually asphalt concrete.

An aggregate seal coat is produced by first spraying bitumen on the base and then spreading a single sized aggregate ½ or ¾ ins. thereupon, followed by light rolling. This produces a surface termed a 'single seal coat' and by laying a second application of bitumen and aggregate a 'double seal coat' is produced.

A seal coat is an extremely versatile surfacing that can even be used directly on a compacted soil base or be used to renew the surfacing over old pavements requiring maintenance.

When this technique was first introduced there was considerable septicism concerning the effective adherence of aggregate on to a surface by inverted penetration. Problems that arose by the use of wrong grades of bitumen and premature opening to traffic had also to be countered. Now this method has been accepted on an island wide scale as a standard practice and has ceased to require pushing by research persuasion. However work still remains to be done in carrying out improvements to the techniques adopted to obtain a high quality finish.

Asphalt concrete or premix is the highest type of wearing course cum surfacing available. A properly designed and laid asphalt concrete surfacing should give long years of maintenance free service. The success of asphalt concrete surfaces depends on several factors such as

i) Aggregate strength and grading
ii) Filler content
iii) Bitumen type and content
iv) Degree of compaction
v) Void content and size of voids

There is vast potential for research in the field of asphalt concrete and considerable work has been done by the Research and Development Division on evaluation of material and mix designs for the production of asphalt concrete.

Though asphalt concrete provides a very high type of surfacing, it is also very expensive. Therefore great caution must be excercised when asphalt concrete over lays are placed in upgrading old roads. The road foundation and existing structure must be carefully evaluated and strengthened if necessary before an expensive over lay is placed. This checking service is also available through the Research and Development Division, though rarely called into use.

So far we have discussed the contribution made by scientific research to each element of a highway pavement. In addition to the above there has been progress made on research activities which have an overall bearing on highway development. Some of this work is briefly described below.

Agricultural and Rural Roads

In instances where a high quality metal base is not warranted due to the low intensity of traffic several experimental stretches have been constructed to demonstrate the suitability of cut back surface dressing with sand blinding on compacted soil or stabilized soil bases.

In this method the compacted base is penetrated by a suitable grade of cut back bitumen (ie. bitumen mixed with kerosene oil) to water proof the base and provide a wearing surface.

These experiments have clearly demonstrated that the cost of road construction can be considerably reduced if the construction authorities gear themselves to adopt those methods on a wider scale.

Survey of Lime Resources

A comprehensive survey of the availability and production methods of lime to evaluate the lime producing potential of the island is in hand. One of the objects of this survey was to obtain information required for the co-ordination of work on the lime stabilization of rural and agricultural roads.

Use of Rubberized Bitumen

The use of rubber in bitumen to improve performance and durability has been tried out in several countries. It is now undisputed that all physical properties of bitumen relevant to highway performance and durability are significantly improved by the use of rubber as an additive.

The little additional cost incurred in the addition of rubber is more than offset by the increase of life span of the road way.

50 to 100% increase in durability or longevity has been reported for trials carried out in France and Russia respectively. Even on the modest expectation of 30 to 40% increase in longevity a substantial saving can be expected on the unit cost of construction and maintenance per annum.

Despite these advantages rubber in bitumen is not used as popularly as it should be due to the problem encountered in blending the rubber with bitumen and also in the handling of the product in the construction stage.

Research carried out in collaboration with the Rubber Research Institute of Sri Lanka on rubberizing of bitumen has yielded very promising results. Rubber in the form of stabilized field latex has been used and techniques evolved for the admixing of rubber, into heated bitumen. Several experimental stretches have been laid as way back as 1966 and have been observed to be performing very creditably.

A method has also been evolved for the addition of rubber into bitumen by diluting a highly concentrated rubber bitumen pre-blend in the heated bitumen in the field kettle.

The ultimate object of this project is to make arrangements for the rubber to be blended with bitumen at the refinery itself.

Road Failure Investigations

As was mentioned earlier we have inherited a large mileage of roads that have been built, without the benefit of scientific understanding and design. Furthermore these roads were never intended to carry the loading and intensity of traffic that have been imposed upon them, and our monsoonal weather conditions add to the problem. All these factors and on occasion poor workmanship add up to result in frequent road distress requiring heavy maintenance. The hasty filling up of a pot hole does not settle the problem. The cause of failure must be investigated and if necessary the pavement treated from the subgrade upwards if a permanent cure is to be effected.

The investigation of major road failures and the recommendation of suitable treatment is yet another function carried out by this Division.

Quality Control Assistance and Materials Testing

Another service provided by this Division is the providing of quality control assistance on construction jobs when requested.

A laboratory testing service for specification testing of soils, bitumen, cement, aggregates, concrete, steel, timber, bricks, precase products etc. is always available for Govt. Departments, Corporations and the Private Sector to make use of.

Airfield Pavement Design and Construction

Mention must also be made of the contribution made by our Division to the investigation, evaluation and structural design of airfield pavements.

The site investigations for the Bandaranaike International Airport and the quality control on the extension work, investigation and design of the Anuradhapura and Weerawila Airstrips and load testing of the K.K.S. Runway are works that were carried out during the last development decade.

Although outside the field of national development, I would like to record that the complete soil and material investigation and structural design for the Hululle Airport in the Republic of the Maldives was also handled by this Division.

Foundation Investigations for Bridges, Buildings and Housing

Another aspect of development where we have made a continued contribution is in the field of foundation investigations. On the average we have investigated about 8 to 12 bridge sites per year and over the past twelve years several building sites have also been investigated for the construction of high rise buildings and low cost housing schemes.

The results of these investigations should help to reduce the cost of bridge and building foundations by a substantial amount.

Conclusion

In concluding I have to emphatically state that research alone cannot give an up-to-date efficient and comfortable road system. In every item of work carried out it is workmanship that either makes or mars a job. In this regard the American Asphalt Institute says;

> "Regardless of the methods or materials of construction chosen, the most important single factor in producing just a good job **or** a superior job is workmanship. More problems arise from and poorer results are realized because of this reason than any other. The importance of attention to small details as well as proper procedures in construction cannot be over emphasized".

As a follow up to this, it must be stated that even the very best of construction jobs would soon decay if proper maintenance is not provided. A roadway certainly needs maintenance as it is constantly subject to wear and tear and it is not worth putting up an expensive construction unless maintenance would be forthcoming as maintenance intrinsically is investment protection.

Research can help to improve service and stretch funds further and keep a facility going over a longer period of time if intelligent use is made of research findings.

Very often people come to research only when they have encountered a difficulty or problem. Although this may serve some purpose this is not the manner in which the best advantage can be made of a research organization.

Planning, design and construction must be intimately associated with research if scientific and economical development is to result.

It is heartening to note that the interest shown in the application of highway research has been on the increase in recent times and this certainly is a move in the right direction towards national development. To give an added impetus to this response and also to cater to those who have been unable to call on us we have begun an Implementation Service, to which you are all welcome.

Acknowledgements

The author is thankful to the Director of Highways for permission granted to present this paper at the Symposium on Current Scientific Research and its relevance to the development of Sri Lanka.

The research contributions to development presented in this paper have been the work carried out over the past thirteen years at the Office of Research and Development of the Highways Department by the late Mr. A.A.D.O.P. Saparamado, former C.E. (R & D) and Research Staff, without whose efforts this review of work would not have been possible.

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CURRENT SCIENTIFIC RESEARCH AND ITS RELEVANCE TO THE DEVELOPMENT OF SRI LANKA

Research in Engineering Sciences

Structural Engineering

by

B.M.A. Balasooriya

SUMMARY

Looking back on say, the last 25 years of building industry in Sri Lanka one could make the following observations :-

(a) There certainly has been a marked development in the types of major buildings constructed and techniques of construction used.

(b) Heavy structural steel skeletons used in buildings and bridges in the olden days have been gradually replaced with reinforced concrete elements.

(c) Subsequently, techniques of prestressing concrete have been used to advantage in many structures.

(d) Local skills and talents have been developed so that now it is not necessary to depend on foreign consultants and contractors to carry out any of our building projects.

This is true of major building projects in the country. However, on the other hand, almost no development at all has taken place in the construction of small scale buildings and houses which are largely owner built or are in private hands, but which still form a major proportion of the total volume of building construction in Sri Lanka.

House building is still confined to traditional methods using traditional building materials. There is hardly any new techniques or new local building materials used for structural purposes. Apart from new materials, even the traditional local building materials like timber and clay brick continue to be wastefully used because no real attempt has been made to closely understand their behaviour and determine their strength properties.

This is so due to the fact that very little research, if any at all, has been done in this field. It wouldn't be wrong to say this, and it is probably so, because no institution had been established with the responsibility to fulfil this need. The University too was not geared to carry out any development work, at the time.

(Contd...)

With the establishment of the Research and Development Division of the S.E.C., several development projects were undertaken, and at the same time, the Peradeniya Campus of the University also commenced some projects to develop new building materials with local raw materials. Presently, a Building Research Institute is being established under the S.E.C., and several research projects have been planned, with the main objective of developing new building materials. Some of the building components produced by the S.E.C. and the University, with local raw materials, which are in various stages of development, include :-

i. purlins for roof work made of prestressed burnt clay blocks which have been found to be cheaper than the equivalent timber or steel purlins.

ii. ceiling boards, insultation material and accoustic tiles made of coconut fibre waste.

iii. clay tiles.

iv. bamboo reinforced concrete.

v. concrete made with no fine aggregate for load bearing walls, wall panels etc.

vi. several fishing boats have been developed using a modified form of ferro-cement with the patent name 'Wirecon'. These have been found to be cheaper than the equivalent timber or fibre-glass boats.

Development projects being planned to be undertaken by the new Building Research Institute include -

i. Further development of 'wire-con' boats

ii. Use of 'Wirecon' to produce building components and water tanks.

iii. Production of building blocks using lime stabilised sand

iv. Use of coconut waste, possibly with cement mortar for production of building components

v. Development of standard timber beams and trusses for low cost housing.

A start having been made, although in a small way, it is hoped that this work would enable to develop, and use, new and cheaper building materials and techniques of construction suited to the needs of Sri Lanka. At this period of the history of Sri Lanka, faced with a severe foreign exchange crisis, salavation lies in our ability to develop our own resources to meet the needs of our building industry, without undue dependence on imports.

C.A.A.S. SYMPOSIA

CURRENT SCIENTIFIC RESEARCH AND ITS RELEVANCE TO THE DEVELOPMENT OF SRI LANKA

RESEARCH IN MEDICAL AND SOCIAL SCIENCES

FRIDAY 10th AUGUST 1973

3·00 P.M. TO 7·00 P.M.

AT

IRRIGATION DEPARTMENT AUDITORIUM

CHAIRMAN: PROF. K.N.SENEVIRATNE

SECRETARY: Dr. T.PONNUDURAI

C. A. A. S. SYMPOSIUM ON

"RESEARCH IN MEDICAL AND SOCIAL SCIENCES"

10.8.73

P R O G R A M M E

3.00	Chairman's Introductory Address	..	Professor K.N.Seneviratne
3.10	EPIDEMIOLOGY	..	Dr.C.Sivagnanasunderam
3.50	FAMILY HEALTH	..	Professor B.A.Jayaweera

- T E A -

4.45 DISCUSSION

SOME ASPECTS OF EPIDEMIOLOGICAL RESEARCH IN MEDICAL AND SOCIAL SCIENCES, AND THEIR RELEVANCE TO THE DEVELOPMENT OF SRI LANKA

Dr C.Sivagnanasundram

The five year plan for 1972-1976 of the Government of Sri Lanka is based on social and economic objectives. The purpose of the plan is to organise the utilization of human and material resources of the country to the best advantage of the nation as a whole (Government of Ceylon, 1971).

Socio-economic development includes development in the field of health. Every sector of the economy has a health component of such importance that it cannot be disregarded in any major socio-economic development (W.H.O. 1973).

In Sri Lanka the changes in the pattern of diseases, and the effects caused by them, have shown an inter-relationship with the general socio-economic complex.

In the past endemic malaria played a prominent role in the history of Ceylon (Viswalingam, 1961). Up to its control in the forties, malaria had been a major hindrance to the efforts to resettle population in the dry zone, and make greater use of the Island's agricultural potential.

1. 1900-1950

1.1. MAJOR NOTIFIABLE DISEASES

At the beginning of this century, in addition to endemic malaria and its 3 - 5 year periodic epidemics, the country faced epidemics of cholera, small pox and plague. These epidemic diseases because of their devastating effects on social life and the loss of lives constituted the first priority in the investigation and control of diseases at that time. Kelaart (1952) states that cholera was responsible for the depopulation of villages in Anuradhapura and Mannar districts, outbreak of small pox were accepted as a matter of course with the arrival of each batch of immigrant labourers, and that plague had to be endured as a necessary evil, as long as the importation of rice was essential.

The annual average of cases of these three major communicable diseases in 10-year periods is shown in Table I. There had been no cases of plague since 1938, and in the 1950s cholera and small pox were absent except for an occasional imported case, usually due to illegal immigration from India. The successful eradication of these diseases is a positive achievement of public health work in Ceylon.

However, apart from the routine epidemiological investigations, reference to any research on these diseases is not available.

1.2. MALARIA

Early developments in the direction of scientific study was in the field of malaria, which remained a major problem. Tables II and III give figures for malaria morbidity and mortality respectively. The year 1946 marks the beginning of the control programme with D.D.T. and 1958 the start of the eradication programme. The lowering of morbidity and mortality during these periods is obvious. Incrimination of A.enlecifacies as the malaria vector in Ceylon by James and Gunasekera (1913), and the 'Report on Malaria and anopheline mosquitoes in Ceylon' by Carter (1927) are studies that were of great value in the control of malaria. In his report Carter brought for the first time entomological and

epidemiological data relating them to the trends of malaria incidence and endemecity over different parts of Ceylon.

The urgent need for a serious epidemiological study for control work was demonstrated in unmistakable termsby the epidemic in 1934-35, when there were about 50,000 deaths. A brilliant epidemiological study of this major epidemic by Briercliff (1935) is acclaimed a classic in descriptive epidemiology by malariologists. As an administrative consequence of this study, malaria control programme was brought under the General Health Scheme in 1937. In the control era with DDT i.e. after 1946, a notable epidemiological contribution was by Rajendram and Jayawickrema (1951).

1.3. ANKYLOSTOMIASIS AND MALNUTRITION

Ankylostomiasis and malnutrition were the next contributing factors to the general lowering of health and welfare in the community. During the period 1920 - 1950 the annual deaths due to ankylostomosis ranged from 900 - 2650. However, epidemiological surveys indicated very high morbidity rates due to H.W. infection (Table 4). The full impact of this infection on the community must have been considerable, with an adverse effect on the development of the country. Hookworm and malaria had been the chief causes of malnutrition and this triad response for high morbidity and mortality rates, especially among the vulnerable groups - mothers and children. A notable study during this period was that of Wickramasuriya (1937) who analysed the impact of malaria and ankylostomiasis in pregnant women.

The first dietary and nutrition surveys in this country were made by Nicholls in 1936 which was by using a questionnaire; More comprehensive food consumption studies of rural families were done by Nicholls and Nimalasuriya in 1941; by Bibile, Cullumbine and Wickramanayake in 1949, and by Gunasekera in 1958 (see references in Gunasekera, 1958). These surveys served to point out the deficiencies in the diet of the people which was mostly in calcium, vitamin A and riboflavin, and stress the role of the economic factor in the nutritive value of the diets consumed by the people. The lower the family income the more inadequate was the diet of the family. The studies on nutritional status of the community and the prevalence surveys of hookworm infestation, together with analysis of the vital rates, especially the maternal and infant mortality rates provided the 'intelligence' to the health administrator to recognise priorities for health care.

1.4. PERSONAL HEALTH SERVICES

Naturally the primary need for health care was in the field of maternal and child welfare, and this work started in the twenties was steadily improved and was consolidated throughout the country. The various factors that contributed to the improvement in the general health of the mother and infant, the fall in mortality rates of the different groups leading to a demographic revolution experienced in the mid-forties, and the new concepts of family health care have drawn the attention of medical men, demographers, sociologists and economists. The scope of research in this important field is the topic of another paper today (Jayaweera, 1973).

2. 1951-1973

At a time when epidemics of infectious diseases affected the health and wealth of the nations epidemiological studies were chiefly the analysis of these epidemics.

Epidemiology was a term confined to the description of these devastations upon the people. The scope of this term has, however, widened and in developed countries, epidemiology is now the study of heart diseases, of cancer, of accidents etc. and these form the 'new epidemics'. In Sri Lanka we are witnessing a period of transition - major infectious diseases are gone (malaria has come back again), other infectious diseases are endemic and flare up in small epidemics, malnutrition is still a problem, and chronic diseases have begun to show an increased incidence. Mental illness has come within the visible area of the spectrum of diseases, old age people, people living with physical and mental handicaps, and workers in our factories predict problems in the near future. Epidemiologically speaking we are in between a developed and developing country.

The pattern of morbidity and mortality in Sri Lanka during the present time is seen from Tables V - VII. Though the data presented are subject to errors inherent in the source from which they are obtained, they give a broad view of the health problems that we are faced by us today. Tables V & VI show the first ten causes of illness as seen in the hospital wards and in the consultation rooms of general practitioners respectively. The category of illness are almost identical in both situations; they constitute respiratory infections, alimentary infections and infestations, anaemias, asthma and skin infections. About 41% of our hospital discharges fall into these 5 - 6 broad categories; and on an average a G.P. sees 32 cases belonging to these diagnostic groups daily. The pattern is obviously that of a developing country, and could be changed by preventive measures. Table VII show the first ten cases of deaths in the country. Diseases of the heart, hemiplegia, cancers and accidents have moved into the picture. Arteriosclerotic and degenerative heart diseases when taken together with 'other diseases of the heart' come second only to diseases of infancy as our killer. The pattern seen in mortality is a mixed bag of the causes in developing and developed countries. In the future, with improvements in environmental sanitation, and more organised methods to combat malnutrition these diseases are likely to more to the forefront as our problem killers. In addition, diseases associated with the growth of industrial projects will add to the morbidity burden. Finding solutions to these problems naturally falls on the medical & social research worker, and one finds that already a large amount of work is in progress within the resources available. I have attempted to group some relevant work so that they could form the broad topics for discussion today. Selection has been entirely on the data I was able to collect within a short period, and I am aware that there could be important omissions. Further one cannot pretend to assemble all information in a short discourse on the broad topic of epidemiology. With this reservation I have grouped contemporary epidemiological research under the following headings: 1. Infectious diseases, 2. Nutrition, 3. Chronic Diseases, 4. Occupational diseases and 5. Operational research.

2.1. INFECTIOUS DISEASES

2.1.1. INFLUENZA

Influenza is the leading diagnosis among morbidity in country. Mendis and colleagues (1969) in documenting the influenza epidemic of 1969 have reviewed past outbreaks of influenza. Though under climatic conditions in our country, it is not a killing disease, economic loss to the country because of absenteeism from work could be considerable. Careful epidemiological studies on the incidence of influenza and attack rates under different social, economic conditions are likely to reveal useful information regards prevention.

2.1.2. BOWEL DISEASES

Diarrhoeal diseases are an epidemiological entity from the view of prevention. Gastro-enteritis and colitis and helminthiasis form important causes of morbidity and mortality. Studies and reviews on the epidemiological aspects of diarrhoeal diseases show the urgent necessity for a programme for prevention of diarrhoeal diseases and improvement of environmental sanitation (W.H.O., 1962; Mendis, 1970). Results of the studies on the prevalence of ascariasis were briefly shown earlier - Table IV. Two important epidemiological studies on the effects and eradication of ascariasis are being carried out at the Dept. of Preventive and Social Medicine, Peradeniya (Fernando, 1973 a, b). One of these is a study into the methods to eradicate ascariasis from the community - a prospective study which is in the 5th year. The other is a study of the influence of ascariasis on growth of children 2 - 10 years, using anthropometric and haematological methods. Results of these studies are likely to give a complete picture of the ill-effects of ascariasis in growth of children and also give indices for quantification of ascariasis infection and indicate levels of infection at which propagation of infection can be stopped.

Typhoid

Epidemiology of Typhoid fever in this country has been documented by Arumanayagam and Mendis (1970). It is one of the important public health problem but still the incidence of the disease could only be estimated due to poor reporting of cases - 100 - 200 per 100,000 population. Apart from studies into the failure of reporting of cases and detection of carriers of the disease, basic research on the vaccines used are indicated. Two such studies are by Velaudapillai and colleagues (1965) and by Maheswaran and colleagues (1971).

2.1.3. TUBERCULOSIS

Morbidity and mortality due to tuberculosis began to show a decrease in early fifties. However since 1956 the death rates per million population remain between 180 and 120. Further reduction in the figures would need the help of epidemiological research on drug resistance and antibiotic sensitivity of the bacilli, incidence of non tuberculous mycobacterium infections and its relevance to B.C.G., immunological reactions in mycobacterial infections etc. The work of Pinto and colleagues (see reference for selected papers) have contributed greatly to this basic knowledge and would be a source for further work leading to better understanding and control of this disease in Sri Lanka.

2.1.4. VIRAL HEPATITIS

Important research that is being carried out in the subject of viral hepatitis is finding the relationship of arbovirus infection to viral hepatitis (Vitarana et al, 1972 a,b), Vitarne et al (1972c) also showed an important use of epidemiology, namely the identification of syndromes. From the study of virus antibody patterns in children suffering from infectious hepatitis, these workers believe that there is a possibility of infectious hepatitis being a syndrome caused by different viruses.

2.2 NUTRITION

Anaemias and nutritional deficiencies are the cause of much ill-health among children and pregnant mothers, and possibly among the occupational groups in the lower income strata of our society. The Director of Health Services (1970)

points out in his administration report for the years 1966-67 that malnutrition is the chief cause of morbidity and mortality among pre-school children, and that anaemia in pregnancy is second only to haemorrhage of pregnancy and childbirth among the causes of maternal deaths. Further many of the neonatal deaths are due to poor nutrition of the pregnant mothers. Epidemiological studies have been undertaken recently to search the causes of anaemias and malnutrition in these vulnerable groups. B.V.de Mel (1965) investigated the problem of iron deficiency anaemias among mothers. The role of diet, iron absorption and parasites in the aetiology of anaemia was discussed, and a recommendation was made as to the iron allowances for adolescent girls and women. Later studies were done on mothers, unmarried young girls and children. (De Mel, 1972). The dietary surveys showed a correlation between iron intake and the anaemias. Fortification of food with iron was discussed by her. Seneviratne and co-workers (1973a) discussing the problems in the management of anaemias in the tea estates point out the failure of intake of iron tablets by the people and suggest fortification of wheat and manioc flour. Several studies of this nature are being undertaken by nutrition division of the M.R.I. to understand the epidemiology of nutritional anaemias. Studies into the acceptability and effect of a supplementary food (W.S.B.) on the growth of infants and pre-school children is another important research project of the M.R.I. (B.V.de Mel, Personal communications - see references) designed to find a solution to the problem of protein-calorie malnutrition. Abeyratne and others (1970) have studied the growth, nutritional status and feeding habits of infants and pre-school children at different socio-economic levels and under differing environmental conditions. They state that the growth curve of young children of the lower socio-economic groups fall well below that of upper and middle income groups from the age of 6 months and last up to 5th year. The effect of income on food habits in Ceylon has been commented upon by Perera and others (1973) in their analysis o the socio-economic survey of Ceylon in 1969/70 by the Dept. of Census and Statistics (1971). Gunaratna (Personal communications) and co-workers at the Faculty of Medicine, Peradeniya are engaged in establishing the norms for Hb. %, Packed cell volume, serum iron, iron binding capacity, serum B_{12} and serum folate in pregnant mothers and healthy children in the Kandy area. This is an inter-departmental project in which the Dept. of Obstetrics and Gynaecology would study the variation of these values in pre-eclampsia, twin pregnancy and absorptio placentae. The data would be of great value in t e study of nutritional anaemias which would be undertaken in this project. Two nutritional projects that give a base line data before starting major developmental projects were undertaken by the M.R.I. (Mahendra - Personal Communications). They are - (i) Diet and Nutrition surveys in Kandalama Colony, Kataragama (a remote village - 'Purana') and Ganthiriyagama (close to an assured water supply) in the N.C.P. before the diversion of the Mahaveli Ganga to these areas. 40 families in each area were studied.

(ii) Diet and nutrition surveys undertaken in collaboration with the F.A.O. and Dept. of Agriculture at Elahera, Hakwatuna Oya, Rajangana and Minipe before agricultural extension programmes. These base-line studies would be useful in assessing the impact of these developmental projects of the country. Studies on the capacity to work on the type of diets consumed by various categories of workers is of relevance in obtaining maximum benefit from labour. A study in this direction was carried out by Hettiarachchi (1973) on conjunction with M.R.I. in the Undugoda Farm in the Kegalle District among 9 families of agricultural workers. Relationship between energy intake and energy expenditure was studied, in order to ascertain the work load and capacity for increased output of work on present diet. Anaemia in two economically important communities in Ceylon, namely the workers in the Tea estate at Hantane and workers in the paddy fields at Madirigiriya (Polonnaruwa), was studied by Seneviratne and colleagues (1973 - personal communication), 36% of the tea workers

and 24% of the paddy workers suffered from anaemia. (Males: Hb 13.0 G %; females Hb 12.0 G % being classed as anaemia), 18% of the tea workers having Hb less than 8 G %. This team of workers are now engaged in epidemiological studies to find the aetiology of anaemia and the pathogenesis of rickets.

2.3. CHRONIC DISEASES AND 'MODERN EPIDEMICS'

In the near future chronic diseases, and diseases that top the morbidity and mortality lists in developed countries are likely to determine the pathological pattern in our country. In retrospect, therefore, it appears very relevant that it happened to be a pathologist - G.H.Cooray (1967), who highlighted the problems and prevention of chronic diseases in his presidential address before this learned audience (Ceylon Association for the Advancement of Science). Cardiovascular diseases, cancers, and disability and deaths due to accidents would form over 'epidemics' too, and diseases like diabetes, renal disease, mental diseases, arthritis and allied diseases, cataract and glaucoma etc. would come into prominence with the problems - health, social and economic - associated with them.

The role of heart diseases in causing deaths among Ceylonese, at the present time, has already been noted (Table VII). In terms of morbidity as seen from hospital discharges in 1966/67, the following figures show the distribution illness - Heart and circulatory system (D.H.S., 1970).

Other diseases of the heart	...	16,371
Other diseases of the circulatory system	...	11,925
Hypertension	...	9,792
Hypertension with heart disease	..	6,573
Arteriosclerotic and degenerative diseases	...	6,270
Chronic rheumatic heart disease	..	5,263

It is obvious that the aetiological factors for a substantial number of diseases of the heart are not known or proper diagnosis is not made. 16,000 cases have been classified as'other diseases of the heart' and reminds one of the infamous diagnosis of 'Pyrexia of unknown origin'.

It is likely that a good proportion of these cases would fall under cardiomyopathies. Nagaratnam (1972) chose the subject of cardiomyopathies for his Sir Marcus Fernando oration. In this, he had discussed the various possible aetiological factors of cardiomyopathies and the various entities that come under this term. He states that sufficient attention has not been paid to the possible roles of alcohol and infection in the causation of cardiomyopathies, and that prospective epidemiological studies are indicated in searching for cardiotrophic infective agents.

Of the known causes hypertension, and arteriosclerotic and degenerative diseases are next in importance. Ranasinghe and co-workers (1971) in an autopsy study of the aorta and coronary arteries reveal that the atherosclerotic process in the aorta has already commenced at 10 years of age. Nagaratnam and colleagues (1973) in a study of coronary heart disease in Ceylon adults under 45 years of age, discuss the possible roles of alcohol and of infection such as toxoplasmosis or filariasis as precipitating factors. Prospective studies have been undertaken involving several departments (Cardiology Unit, Colombo, University of Ceylon and M.R.I.) to study the risk factors in Ischaemic heart disease in an urban male population (Wallooppillai - personal communication, see references). This long term study (5 - 10 years) would survey a multitude of factors, viz. diets,

blood cholesterol and lipids etc. clinical examination, E.C.G., Blood pressure etc.

Similar in depth studies are indicated in other diseases that are to be future problems - diabetes (see Weerasinghe, 1967), renal disease, mental diseases (see Wickramasinghe et al, 1966), accidents (Fernando - pers. comm) and cancers.

2.4. OCCUPATIONAL HEALTH

It is the policy of the Government 'to take measures to regenerate rural society and to make it more attractive to the young by modernising agriculture, and by setting, agro-based industries in rural areas. Full and efficient utilization of existing industrial plants, expansion of selected industries and investments in new industrial projects on the basis of national priorities have been stated as one of the basic strategies in the 5 year plan (Government of Ceylon, 1971). Fulfilments of these objectives will move over process of industrialisation from infancy to the toddler stage, and carry with it a variety of socio-medical problems associated with this process, as was witnessed in industrialised countries - problems in housing, nutrition, general standards of living, occupational hazards etc.

The problems that are likely to be encountered by workers in this country will be influenced by our way of living and environmental conditions. The importance of serious research on the diseases of workers in this country has been highlighted by Uragoda (1972a) in his Cyril Fernando Memorial Lecture delivered at the Ceylon College of Physicians on the subject of occupational lung disease in Ceylon. We are fortunate that Uragoda himself has set a pace for epidemiological research of high quality in this field. As examples I wish to mention the epidemiological studies carried out by Uragoda, and his colleagues among chilli grinders (Uragoda, 1967), granite workers (Uragoda, 1968), workers in graphite mines (Ranasinghe and Uragoda, 1972; see also Uragoda, 1972 b & c) and workers in the ilmenite factory (Uragoda and Pinto, 1972).

Inquiry into the causes of morbidity and mortality among workers in the estates has been carried out by the Planters' Association Estates Health Scheme. The studies include study of maternal and child health on estates (Fernando, 1969), cancer deaths and accidental deaths, and respiratory disease on Ceylon plantations (Fernando, L.V.R - personal communication).

Another useful research into the hazards of tea industry was the work of Pinnagoda (1971), who carried out an epidemiological study into the health hazards from exposure to tea fluff in blending and packing industries.

2.5. OPERATIONAL RESEARCH

Operational research may be defined as the systematic study of the working of the health services with a view to their improvement (Morris, 1967). Morris states that one of the values of basing op. research on populations is that the idea of the people and their changing needs will not be forgotten. The concept of operational research in the modern sense, especially its application to the health services is of recent origin. But time and again evaluation of medical care as a basis for its improvement has been done in Ceylon, based on data from hospitals and the field, and from special reports. De Silva (1956) in his survey of the health progress in Ceylon summarises a mass of relevant data on health care up to 1956. E.A.Nugawela, who was the Hon. Minister of Health, in his forward to this publication, states that the report draws attention to the imperative need for organised research into the vast amount of clinical material and statistical data available in regard to morbidity and mortality

from some of the endemic diseases in this country. He points out that in addition to the development of the 'preventive' outlook in our health services, that the greatest efficiency and output should be secured from our existing personnel and institutions (See also Cumpston, 1950 and Hance, 1956).

At the present time, operational research using epidemiological methods has gained a momentum with the National Health Manpower study in this country. This research is conducted by the Ministry of Health with the assistance of the W.H.O. and is composed of the following eleven sub-studies:

'A' Demographic characteristics

'B' Health Needs and Demands

'C' Census of Doctors

'D' Census of nurses, midwives and dental nurses

'E' Medical Education

'F' Nursing and Midwifery Education

'G' Activities of the Health Personnel working in Rural areas.

'H' Utilization of doctors

'I' Staffing Pattern, Facilities and Cost of Health Services.

'J' Demand for medical care services, and

'K' Pattern of Ayurvedic Practice.

It is believed that the mass of information that would be collected from this research at a national level, would help in deciding future health and social policies of the government. However, efficient working of health services at lower administrative levels demand a continuous process of monitoring of the service and evaluation of the needs, demands of the people and utilization of the services by them at micro-levels.

The Department of Preventive and Social Medicine at Peradeniya is carrying out studies on the utilization of peripheral units and on the pattern of diseases in Western and Ayurvedic General Practices. The attitudes and practices of Ayurvedic physicians on maternal and child health is being investigated into, with the view of finding out to what extent their services could be utilized for this work in the general health organisation. (Sivagnanasundaram and Abeykoon, 1972; Sivagnanasundaram and Samarawickrema, 1972 a & b).

3. FUTURE RESEARCH

3.1 Epidemiologic hypothesis and interpretation rests on comparison with accepted 'norms' for the population under study. These include heights and weights, blood picture, blood pressures, E.C.G., oral temperature etc. Human physiological studies done in Ceylon up to 1969 have been documented by Basnayake (1971) where he refers to 63 papers. However further research and surveys are necessary to supply more informations on the 'norms' of our population.

3.2 Usefulness of an epidemiological finding depends on the validity of the data from which conclusions are drawn. Research into the sensitivity and specificity of diagnostic methods, methods of record keeping and analysis of records is necessary to improve the quality of our basic material. An extremely novel technique has been invented by Gunawardena (pers. comm) to detect duplication of medical records in his skin clinic at Kandy. He uses a 'pseudo-phonetic code' for the names of his patients, and it is

so programmed that a computer sorts out duplicates in a matter of minutes out of 15,000 case records. Unless a serious attempt is made to improve the quality of our hospital and clinic records, operational studies based on them will be futile.

3.3 Eradication programmes of communicable diseases require finer methods of detecting transmission of disease. For example, in the consolidation phase of the malaria eradication programmes the hitherto accepted case detection methods have been found to be inadequate. It is likely that sero-epidemiological surveys are necessary for early detection of transmission. Ponnudurai (pers. comm) believes that an upward rise in titre in fluorescent antibody tests, done in areas of high malariogenic potentials could be used for this purpose. Similar research methods will become necessary in the case of other diseases.

3.4 Socio-medical surveys are an urgent need in our country before the introduction of new health care measures. Traditional epidemiological and knowledge-attitude (K.A.P) studies have a place in knowing their wants and demands. One must plan services with the people and not just for them.

3.5 As discussed earlier, the pattern of diseases undergo changes. Continued epidemiological and operational research in the community, work place and hospitals is necessary to adapt health care to changing needs and wants.

It has been suggested by Mac Mahon that epidemiological research should be concerned with not only morbidity and mortality but also with the positive components of health implicit in the definition of the word as used by the W.H.O. Medical and social research workers should not lose sight of this ideal definition of health and well-being. But we have, of course, in our country a fair load of disease and infirmity to keep us busy for some time.

A C K N O W L E D G E M E N T S

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TABLE I

SRI LANKA: INCIDENCE OF CHOLERA, SMALL POX AND PLAGUE, 1871 - 1950

TEN YEAR PERIODS	ANNUAL AVERAGE OF CASES		
	CHOLERA	SMALL POX	PLAGUE
1871 - 80	3675	2031*	NIL
81 - 90	386	1162	NIL
91 - 1900	612	309	NIL
1901 - 10	171	351	NIL
11 - 20	110	175	244**
21 - 30	42	81	113
31 - 40	9	64	47***
41 - 50	24	156	NIL

SOURCE: Adapted from 3 tables in Kelaart (1952)

* on Figs for 4 years

** on Figs for 7 years

*** - do - 8 years.

TABLE II

SRI LANKA: MALARIA MORBIDITY PER 1000 POPULATION, 1934 - 1969

YEAR	MALARIA Attendance (Clinical) Median	MALARIA Attendance (Positive cases) + median
1934 - 1938	431*	?
1939 - 1943	522	116
1944 - 1948	259	46
1949 - 1953	57	3.6
1954 - 1958	0.7	-
1959 - 1963	-	0.02
1964 - 1966	-	0.05
1967 - 1969**		

* In 1935 983 clinical attendance/1000 popn.

\+ 1934 - 1958 Estimated positive cases

** In 1968-69 there were 522,704 positive cases

TABLE III

SRI LANKA: MALARIA MORTALITY, 1925 - 1969

YEAR	Number of deaths (median)	Rate per million population (median)
1925 - 1933	1,161	312
1934 - 1938*	4,778	820
1939 - 1943	7,132	1,180
1944 - 1948	5,604	888
1949 - 1953	1,599	206
1954 - 1958	144	16
1959 - 1963	43	4.2
1964 - 1969**		

* In 1935: 47,326 deaths, rate 8,439 per million

** In 1968-69: 26 deaths, rate 2.1 per million

TABLE IV

SRI LANKA: HOOKWORM AND ROUNDWORM SURVEYS

LOCATION	PERIOD	NUMBER EXAMINED	PERCENTAGE INFESTATION	
			Hookworm	Roundworm
1. Sri Lanka	1924-25	32,507 (all ages)	90.5	-
2. Colombo Rural	1953-55	804 (2-10- yrs)	72.5	49.7
3. Colombo and suburbs	1946 - 52	1,251 (all ages)	45.0	49.0
4. Horape	1962	458 (0 - 10 yrs)	30.1	46.7
5. Obeysekera Town (Colombo)	1962	423 (0 - 10 years)	7.6	48.9
6. Hindagala	1966-67	5,201 (all ages)	45.2	64.4

SOURCE: TABLE ADAPTED FROM FERNANDO, M.A. (1973a)

1. Sweet, W.C. reported by Chellappah (1938)
2. Jayawardena, L.G. (1957)
3. Sivalingam, V. (1961)
4 & 5. W.H.O. (1967)
6. Fernando, M.A. (1973a)

TABLE V

SRI LANKA: FIRST TEN CASES OF MORBIDITY, 1966/67
(HOSPITAL DISCHARGES)

DISEASE	NUMBER	PERCENTAGE OF TOTAL DISCHARGES *
1. INFLUENZA	107,547	7.12
2. ANAEMIAS (Including Anaemias of pregnancy)	99,597	6.59
3. BRONCHITIS	89,179	5.90
4. GASTRO-ENTERITIS	81,634	5.40
5. HELMINTHIASIS	62,218	4.12
6. ASTHMA & ALLERGIES	59,675	3.95
7. PNEUMONIAS	33,305	2.20
8. DYSENTERIES	32,232	2.13
9. UPPER RESPIRATORY INFECTIONS	28,407	1.88
10. AVITAMINOSIS	21,759	1.44
TOTAL	615,553	40.73

* TOTAL: 1,511,385.

* Does not include normal deliveries.

SOURCE: Administration Report of D.H.S. (1970) for the years 1966/67.

TABLE VI

SRI LANKA: FIRST TEN CAUSES OF MORBIDITY, 1972

(VISITS TO 132 GENERAL PRACTITIONERS)

DISEASE	RANK IN HOSPITAL MORBIDITY	AVERAGE NUMBER SEEN BY 132 G.P. PER DAY	AVERAGE NUMBER SEEN BY EACH G.P. PER DAY
1. COMMON COLD	-	744	5.6
2. INFLUENZA	1	707	5.4
3. ENTERITIS ETC.	4	538	4.1
4. HELMINTHIASIS	5	537	4.0
5. BRONCHITIS	3	433	3.3
6. SKIN INFECTIONS	-	330	2.5
7. ANAEMIAS	2	327	2.5
8. STREPTOCOCCAL SORE THROAT	-	222	1.7
9. ASTHMA	6	217	1.6
10. PYREXIA	-	216	1.6
		4,271	32.3

SOURCE: Sivagnanasundram and Samarawickrema (1973a)

TABLE VII

SRI LANKA: FIRST TEN CAUSES OF MORTALITY, 1965

DISEASE*	NUMBER	PERCENTAGE OF TOTAL DEATHS **
1. Ill-defined diseases of Infancy and Immaturity	8501	9.3
2. Gastro-enteritis and colitis	5155	5.6
3. Other diseases of heart (+)	5090	5.6
4. Hemiplegia and other paralysis	3948	4.3
5. Convulsions (inder 5 yrs)	3801	4.1
6. Accidents	3065	3.3
7. Malignant neoplasms	2840	3.1
8. Broncho-pneumonia	2533	2.8
9. Anaemias	2186	2.4
10. Arteriosclerotic and degenerative heart disease	2142	2.3
TOTAL	39261	42.8

* Excludes deaths due to senility and ill-defined and unknown causes.

** Total deaths: 91728.

(+) Excludes rheumatic, arteriosclerotic and degenerative heart disease.

SOURCE: Report of R.G. (1970) for the year 1965.

"Family Health in Ceylon"

Prof. B.A.Jayaweera
Prof. of Obstetrics & Gynaecology, and Dean of
the Faculty of Medicine, Peradeniya Campus,
University of Sri Lanka.

Introduction

I wish to thank the organizing committee of the Ceylon Association for the Advancement of Science for inviting me to give this address on Family Health in Ceylon.

The scope of the proposed symposium is to cover the principal areas of past research which has had a significant bearing on the development of the country; current research and their objectives; priorities in research in relation to the development of Sri Lanka and the role of basic research.

Since this is a vast subject I will not be able to cover all these aspects in the limited time. I hope you would bear with me if I concentrate on the priorities in research to be done and the role of basic research.

Family Health is a very encompassing field where workers in varying disciplines both medical and non-medical have to work together. The more I think of this subject the more I am convinced of the relative insignificance of the role played by us "specialist clinicians". We form but a small cog in the wheel of Family Health care. Greater responsibility, dependance, reliance and respect should be accorded to all the other categories of health workers who provide basic care, and more emphasis placed on the basic essentials for providing the necessities for such care.

Family Health

Family health is the concept of physical mental and social well being applied to the smallest operational unit that constitutes a community.

It is an ideal which all health workers hope to achieve, both in the developed and developing countries.

Family health is related to several factors such as -

1. Socio economic state of the country.
2. Socio economic level of the family unit.
3. Literacy and educational levels.
4. Occupation.
5. Cultural, racial, religious and political factors.
6. Planned parenthood.
7. Environment.
8. Health care delivery systems.

The provision of family health care is primarily the responsibility of the state, but active cooperation and participation of the recipient individual family and community is the key to success.

Though in any country, the Ministry of Health is primarily responsible for implementation, the active cooperation of all other Ministries is essential for providing total family care. Hence research in this field would need the collaboration of persons in these Departments also.

If a comprehensive research programme into family health is to be undertaken it is obvious that no single programme could cover the multitude of variables that encompass this subject. However, it is desirable if indices - short term and long term - for assessment of Family Health could be evolved.

Several publications on morbidity and mortality patterns, epidemiological surveys, maternity and child health, school health, nutrition and health education have been made each dealing with a particular facet of family care. The conclusions of these studies have been very valuable, highlighting certain aspects of problems, which may have a bearing on health care. As to whether the knowledge so gained has had a direct impact on decision makers or health care systems and the

consumer is questionable. Any research that has not taken into consideration the health care of the people, seems to me a waste of money in the context of this country; though certainly a useful academic exercise for the research worker.

The possible reasons for failure of utilization of the research done are -

1. The results and conclusions being unknown to the policy makers, and planners.
2. The subject chosen being of no immediate relevance to the problems confronting the policy makers, planners and implementers.
3. Conclusions being already known, established and implemented hence being of no real significance.
4. Failure of publication and communication.
5. Absence of an adequate system of central documentation and ready availability of data pertaining to local research.

With the limited resources available in this country, for research; as a general principle, it may be inadvisable to embark on

(a) Basic or pure research which could at this state of development be best left to the more developed countries.
(b) Repetition of research already done here or in other countries.

Research priorities should be related to the spectrum of problems and activities, ranging from identification of family health care objectives through health care systems to acceptance of health care measures by the family unit; and their evaluation.

These research measures should supplement the technical expertise that is now available in this country.

Method of identifying research fields

1. Specifying broad areas of research in terms of the immediate problems by a technical group.
2. By identification of individual problems within these broad areas.

It seems to me that the latter approach should take priority if financial and manpower constraints exist as in Sri Lanka.

These identified areas should aim at obtaining answers to specific and urgent problems confronting Family Health Care activity as contrasted to those where a broad area is specified and the research worker is left to choose a facet which may not be of immediate value. This is what I would refer to as 'specific goal orientated research'. For the successful implementation of such research, identification of the research potential of individuals and organizations is essential.

I am glad to note that constructive efforts in this context have been taken by the scientists of this country.

Broad areas in which further research is needed are -

1. Research into yet uninvestigated or incompletely investigated health problems that exist in this country, or of those which may occur from time to time; e.g. mental health, dental health, changing patterns of disease etc. being some of the examples.
2. Success or failure of hitherto accepted health care measures e.g. control of communicable diseases, of immunized campaigns, measures to improve nutrition, personal hygiene and environmental sanitation should be evaluated.
3. Operational research into health care delivery systems and administrative machinery and research into the quantity of care provided within the existing constraints.
4. Research into new health care problems, these may arise with new ventures e.g. industrialization, colonization campaigns etc.
5. Cost benefit analysis of the health care delivery system.
6. Research into manpower development and utilization with special emphasis on the review of existing role definitions - identification of new ones - task oriented training - in doctor/patient/public relationships.

7. Development of a system of record keeping which would enable periodic assessment of family health care levels with identification of the vital parameters by which the efficiency of the system is to be judged.
8. Behavioural studies.

It would be appreciated that in many of the above-mentioned areas there is a close relationship to behavioural aspects of the family unit in terms of the decision maker, extended family, cultural aspects, attitudes and beliefs, habits, religious taboos, administration and political considerations etc., variables that can have a direct bearing on the ultimate health of the family.

It would be extremely difficult to place these areas of broad research in any meaningful order of priority as they are so closely interrelated, but if I may suggest some order - perhaps they could be arranged as 2,3,5,8,4,1,6,7.

It may be observed that research in most of these broad areas which I have been considered could be undertaken by survey methods with a minimum of laboratory study. Most of these studies could be undertaken immediately with the facilities and resources that we now possess.

It is desirable that operational research activity be strengthened.

Taking the first broad area -

I. <u>Research into yet uninvestigated or imcompletely investigated health problems</u> -

i. The changing pattern of disease due to the change in the age pyramid, introduction of modern drugs and social factors like industrialization, colonization etc.
ii. Hazards from modern agricultural practices i.e. the large scale introduction of mechanization, the extensive use of pesticides, weedicides and fertilizers, and their impact on health.
iii. Hazards in industry with ita attendant risks of accidents, pollution and the preventive measures to be adopted.
iv. Mental health problems in relation to the rapidly changing social environment.
v. The strategy for prevention of dental caries and periodental disease.
vi. Safety of locally manufactured articles with proper indices of safety standards.
vii. Purity standards for locally prepared foods and food products.
viii. Economic and safe methods for handling, storage, preservation, distribution and marketing of foods.
ix. Nutrition - though much researhh has been done into this aspect, work on a balanced nutritions diet schedule in relation to parameters such as economic, religious and cultural factors, food habits and availability in the local market, need constant review to keep pace with rapidly changing agricultural and industrial developments.
x. Research into utilization of so-called "waste materials" as sources of food.
xi. Pollution of environment in terms of industrial waste, human and animal contamination, atmospheric pollution etc. to determine the levels of pollution which may be permissible and preventive and remedial measures that could be implemented within the existing constraints.
xii. Studies into the economic aspects of providing educational and recreational facilities to rural and urban groups viz. organized community centres.
xiii. Care of the mentally handicapped - e.g. working out indices for assessment of children in this country, epidemiological studies, health care systems etc.
xiv. Problems due to old age and dependance.
xv. Sex education - identification of the content of sex education in relation to this country.
xvi. Drug addiction - epidemiological studies, strategy for prevention.

II. Success or failure of hitherto accepted health measures -

This group of research concerns "acceptance factors" by the family unit. Many variables may come into play in this area such as those influencing knowledge and attitudes and the system of delivery of health care.

i. Research into the factors that retard or prevent acceptance of health care measures is urgently needed. Properly constructed sample surveys have to be done.

Since ours is a multiracial, multireligious and multicultural society, extrapolation of conclusions from one group to another may not be entirely satisfactory. If valid conclusions are to be drawn for the planning of strategy, sample surveys embracing these variables need to be done.

ii. Surveys to identify the appropriate method of communication and conviction of the family and studies on the psychological reaction of the recipients would be useful in planning. This type of research data would be most useful in planning the delivery of any programme be it Health education, immunization or planned parenthood.

The sociologist and psychologist should play a leading part in formulating these investigations. Much sociological research has already been done, which has an indirect and direct bearing on this but there is a lack of systematised research to identify all parameters, which would have an effective bearing on such a programme.

iii. Investigations into administrative structure in relation to this area - to identify lapses, and the antecedent factors which cause them.

iv. Regarding health education - programmes in schools, when such subjects as hygiene and health science are taught extensively it is my impression that the desired behavioural change in the student is not in proportion to the knowledge acquired or the teaching effort expended.

Research needs to be done in this field to evaluate the programme and also to develop more effective measures of producing the desired behavioural changes.

v. Strategy for health education of school "dropouts".

III. Operation research into health care delivery systems and administrative machinery and research into the quality of care within the existing constraints

This is an area where planned studies are very urgently needed -

i. Factors which determine the best utilization of institutions and manpower.

ii. Factors that determine the steady flow of expendable and non-expendables at service outlets to maintain continuing care of the family - I refer in particular to the logistics of distribution of drugs and material.

iii. Research to evolve effective yet economic comprehensive care of the family unit - with special reference to mother and child e.g. a system of care of the mother from conception to delivery and after care including family planning and for the child - from prenatal to beyond school age.

iv. Assessments of standards of care and operational researdh leading to measures for improving the quality of care in terms of prevention, treatment, follow up and rehabilitation.

IV. Research into new health care problems that may arise with new developmental projects.

Much could be learnt from the experience of developed and neighbouring countries; as regards health problems in relation to industrialization. However, investigations into those aspects that would have a bearing on Family Health in our local context needs to be emphasized.

The prevalence and the magnitude of these problems needs study to enable preventive measures to be adopted e.g. safety factors in prevention of accidents, handling of toxic agents, inhalation of noxious fumes, dust diseases and effects of industrial by-products and effluents.

V. Cost benefit analysis of health care delivery system

I am made to understand that several surveys are presently being done in this field by the planning unit of the Health Ministry.

It may be desirable to study the cost of health care to the individual family unit. The latter data would be of the greatest value to the health planners to identify whether health measures have failed due to the family

unit being incapable of meeting the cost of the prevailing health care system and whether it could be bettered by appropriate modification of the system.

This is topical in the light of the current tendency to change to a fee levying system - even though the fee is a token payment.

VI. Research into manpower development

With reference to this the W.H.O. has successfully completed its many faceted projects, the release of an official report is awaited. I am sure that this would shed valuable light on future planning.

There is a need for -

i. Review of the existing role definitions of the many categories of health workers.

ii. To identify the basic knowledge, skill and attitudes required to satisfy family health requirements in relation to the different groups that constitute the community.

iii. There is also a necessity to identify new roles which health workers would have to perform in terms of the changing patterns of health and social organization.

This data could be utilized in reviewing and modifying existing courses of study for all medical and auxiliary health personnel and may also shed light on the need for the creation of new categories of health workers, and reintroduction of categories such as the Assistant medical Practitioners.

VII. Development of a data collection system

Research into a simplified yet meaningful data collection and recording system for assessing family health is needed. The most useful parameters need to be identified so that assessment could be done on a sample survey basis or if feasible incorporated in the census data collection.

I am aware that such a venture has been undertaken by the Family Health Bureau.

VIII. Behavioural studies.

The behavioural aspects of the family unit, as mentioned earlier, is the key to success. Research surveys properly planned, taking into consideration, the variables mentioned earlier, are urgently needed.

Much research has been done by sociologists but what is most needed is research into strategies that have to be adopted to overcome identified barriers for the achievement of desired behavioural changes.

Most of these research aspects can be immediately undertaken by field studies, utilizing existing manpower, with relatively little expenditure of money.

Since most of the problems requiring investigations are concerned with the lesser educated, lower socio economic groups, a postal questionnaire method will have very limited value. The interview method may have to be used, with proper planning and training of interviewers and pretesting of the instrument chosen for use. An effective system of co-ordinating national research should be implemented, and the existing systems modified if necessary.

A documentation centre of research activities conducted in this country, should be established as a reference library, with abstracts and reprints being made readily available to interested scientists in view of the poor library facilities available throughout the country.

Identification of problems should be made by expert groups in terms of policies that are to be implemented.

Effort must be made to obtain funds from state and private sources or a "Consumer oriented programme" basis. I am sure international organizations would assist well planned research ventures of this kind.

This brief talk is not meant to be comprehensive but should rather serve to provoke a lively discussion of the various aspects I have raised by members of this distinguished audience.

C.A.A.S. SYMPOSIA

CURRENT SCIENTIFIC RESEARCH AND ITS RELEVANCE TO THE DEVELOPMENT OF SRI LANKA

RESEARCH IN AGRICULTURE and ANIMAL HUSBANDRY

FRIDAY 17th AUGUST 1973

8·30 A.M. TO 3·00 P.M.

AT

IRRIGATION DEPARTMENT AUDITORIUM

CHAIRMAN: Dr. M.A.P. Manthriratne

SECRETARY: Mr. M.A.T. de Silva

CEYLON ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Symposium on

" RESEARCH IN AGRICULTURE AND ANIMAL HUSBANDRY "

on Friday the 17th of August 1973 at the

IRRIGATION DEPARTMENT AUDITORIUM

Bauddhaloka Mawatha, Colombo 7

PROGRAMME

Morning

8.15 - 8.30 - Introduction, Dr M.A.P.Manthriratne, Session Chairman

8.30 - 9.00 - Rice - Dr J.W.L.Peiris

9.00 - 9.30 - Subsidiary Food Crops - Dr W.Fernando

9.30 - 10.00 - Minor Export Crops - Dr E.Jayanetti

10.00 - 10.20 - Discussion

TEA BREAK

10.30 - 11.00 - Tea - Dr M.A.V.Devanathan

11.00 - 11.30 - Rubber - Dr O.S.Peries

11.30 - 12.00 - Coconut - Dr W.R.N.Nathanael

12.00 - 12.20 - Discussion

LUNCH INTERVAL

Afternoon

2.00 - 2.30 - Animal Production and Health - Dr J.A.de S.Siriwardene

2.30 - 3.00 - Pasture Development - Prof. R.R.Appadurai

3.00 - 3.20 - Discussion

3.20 - Closing Address by General President, CAAS.

RICE RESEARCH AND ITS RELEVANCE TO THE DEVELOPMENT OF SRI LANKA

Dr. J.W.L. Peiris+

Department of Agriculture

In 1966, the Section B of the Ceylon Association for Advancement of Science organised a two-day symposium on "Research and Production of Rice in Ceylon". On this occasion the various phases of rice research in Rice Breeding, Soils and Fertilizers, Cultural Practices, Pests Diseases and Weeds, water management and Mechanisation were dealt with comprehensively and are now well documented. Within the short space of time at my command it is neither necessaryhor possible for me to refer to the progress made up to that time. I would content myself therefore by giving the highlights of the more recent developments in the wide field of Rice Research.

I speak against the backdrop of gloomy prospects for the immediate future in regard to the rice situation not only in Sri Lanka but also in the rest of the rice growing world. You are aware that the recent droughts have adversely affected the rice production of South East Asia and the price of rice has risen to nearly three times the world market price a year ago. The price of wheat and flour has also risen mainly due to heavy purchases by Russia and China from the U.S.A. and we have had now to get on to a war-footing to grow whatever we could as starch substitutes.

The rice and flour imports for the last few years are set out below.

Year	Rice in Tons	Cost in Rupees	Cost in U.S. $	Flour Million Rs.
1968	343,829	345,011,397	57,501,900	218.5
1969	260,187	211,385,780	35,230,963	229.9
1970	525,606#	352,758,254	58,793,042	225.3
1971	334,000	188,000,000	31,333,333	212.0 ?
1972	262,000	140,000,000	23,333,333	218,0 ?

Increased imports for the double ration given from 1970.

By 1975 with the increase in population, the demand is expected to reach 2,324,525 metric tons of paddy or 113.78 million bushels ~~when~~ we only produced 62.9 million bushels in 1971/72. We import considerable quantities of wheat flour as well. If we could produce an abundance of rice we would not only save the foreign exchange sent out in purchase of rice but also a considerable proportion of the price paid for flour.

+ Deputy Director Agriculture (Research) and Co-ordinator Rice Improvement Programme.

The foreign exchange thus saved could be liberated for economic development leading to the greater prosperity of the country and also provide a solution to the pressing problems of unemployment. There is no question of the fact that rice research and production has and continues to receive top priority in our domestic agriculture.

Soils and Fertilizers.

It is generally accepted that agricultural production is closely related to the intensification of fertilizer use. At the 1966 symposium several papers traced the development of soil and fertilizer studies from the days that only bone-meal was used to the completion of the all-island rice soil fertility survey in 1963 which enabled specific fertilizer recommendations for the 22 districts of the island in 1964.

Teething troubles of these recommendations began to show up as the recommendations were implemented. In 1966/67 conditions of stunted growth and poor tillering showed up in Pannaliya and Galgamuwa areas of the Kurunegala district. A number of experiments carried out here showed that this area was low in phosphorus and saphos phosphate prescribed was inadequate. Increase of yield by 78% was obtained by changing the saphos to concentrated superphosphate. Similar situations could arise in other areas where phosphate status is low.

Further studies on the direct, residual and cumulative effects of phosphorus fertilizer are continued together with the investigations on the use of recently discovered local phosphorus or ~~local~~ Eppawala apatite in rice nutrition as a substitute for imported phosphorus.

A tendency was observed for the farmers to use only the Nitrogen fertilizer without the Phosphorus and Potash because the effect of Nitrogen was evident within a few days whereas P & K were not immediately reflected in the growth of the plant. Therefore, in 1971 it was decided to issue the subsidised fertilizer in mixed form of a basal dressing of P, K and a little N and top dressing of K and N to ensure that all three ingradients are used.

Not only should fertilizer be used for obtaining high yields with the more efficient new high yielding varieties obtainable today, it is also necessary, in view of the fact that fertilizer involves foreign exchange, to use the most economic levels. During the last two years multi location tests have shown that 90 - 100 lb/ac. of nitrogen is the optimum in the dry and intermediate zones and in the well drained wet zone whereas 60 lb/acre was sufficient for the ill drained wet zone.

Plant Protection.

The role of plant protection - that is the protection of the rice plant from pests or diseases can be briefly summarised as follows:-

(a) The identifications of disease pathogens and pests, study of their life histories and evolution of chemical methods or alteration of cultural practices for their control. This involves continual screening of new chemicals to identity more efficient or more economic chemicals for control.

(b) Screening of varieties for identifying resistant donor parents that could be used by the breeder to build into the new rice varieties resistant to specific pests or diseases.

The second is by far the more acceptable to the farmer as the use of chemicals and spraying involves time, labour and money, but certainly it imposes heavy responsibilities on the rice breeder. The new high yielding varieties capable of taking in high doses of fertilizer can and has precipitated disease and pest problems as high nitrogen fertilizer renders plants susceptible.

Plant Pests.

Techniques have been developed in Sri Lanka for the laboratory rearing of the rice gall midge, a problem which evaded solution by rice entomologists in the past. It has now been demonstrated that some varieties have genetic resistance to gall midge. These varieties are now being used by breeders to incooperate gall midge resistance to the newer agronomically ideal high yielding varieties.

Similarly, certain varieties resistant to the brown leaf hopper have been observed and future work will include similar work on stem-borer, leaf rollers and thrips.

A comprehensive programme of study is under way on the parasites and predators of major rice pests with a view to initiating a programme of biological control by introduction of suitable parasites not found here.

The programme of chemical control is being developed on the lines of applying highly selective chemical control which will minimise parasite or predator destruction and permit of the concomitant use of biological control resulting in integrated pest control.

Plant Disease.

Perhaps the most important disease of rice is " Blast " caused by the fungus "Piricularia oryzae. Whereas in the past, reports

of this disease were common, today we hardly hear of it in spite of the increased use of fertilizer. The reason is that we have, for a long time built resistance into our new varieties. No variety is released to the farmer unless it has reasonable resistance to the blast disease. Moreover effective fungicides have been found which could control the disease should it assume serious proportions.

Bacterial Leaf Blight Xanthomonas oryzae is another important disease for which resistance has to be built up in our new varieties. The pattern of inheritance of resistance to this disease has been studied and sources of resistance identified.

In the wet ill-drained areas of the island sheath blight is an important problem attacking the dwarf varieties more severely than the taller ones. Most varieties are susceptible and it has been difficult to find varieties resistant to this disease. We have just obtained information from the International Rice Research Institute that K 8 - the sister line of H4 has in comparative tests shown resistance. It may therefore be possible to develop this line of investigation further.

The phenomenon of resistance to pests and diseases in plants is not a static one. Varieties that have been bred for resistance to a pest or disease may succumb to newer and more virulent strains of the pathogen which the pathogen can evolve as it is a living organism. Hence, the fight against pests and diseases is a continuing and dynamic one.

Weed Control.

The tall traditional local varieties with drooping leaves which existed earlier were capable of competing with weeds whereas in the modern hybrids these characteristics were eleminated for the sake of greater yielding efficiency and they are invariably dwarf with erect leaves. Efficient weed control therefore becomes imperative. For the Herbicidal control of weeds recommendations of various chemicals have been made earlier and they are sprayed on the crop. A significant break through in this area has been the development of granular herbicides for weed control in broadcast or transplanted rice which eliminates the use of a sprayer which is often not within the reach of most farmers. The granules are broadcast into the crop like fertilizers. Five new granular herbicides Machete, Linuron , Saturn etc. have been tested, optimum doses determined and recommended to the farmers.

RICE BREEDING

The most important gains in rice research made during the last few years have been secured in the field of rice improvement by breeding. At the last symposium we reported the objectives of the rice

breeding programme, the achievements made up to that time and our expectations for the future. Although ours is a small island, we need a number of different rice varieties for different situations. The objectives can be broadly classified as -

(A) Breeding varietiesfor specific areas to meet the demands of special conditions,

(B) Breeding varieties for general rice improvement and wide adapatability.

The rice breeding programme has during the last six years produced results which are far beyond our normal expectations.

A. Breeding varieties for specific areas to meet demands of special conditions.

1. Breeding Varieties for Cold Tolerance:

Above 2,000 feet elevation the cooler temperature causes varying degrees of sterility in varieties that perform normally at lower elevations. The local varieties that have been grown in these areas are Pa/nithi and Thatuwal. However, H4 quickly displaced these owing to its higher yield in spite of suffering from some sterility and its sister line K-8 was even better. Breeding for cold tolerance in rice varieties was carried out by Goonewardana at Experiment Station, Pussellawa and from a cross between H4 and Panduruwi, lines have emerged which could give increased yields between 2,000 to 4,000 feet.

Cold Tolerant Rice Varieties - Yield in Bu/ac.

Variety	Maha 70/71	Yala 1971	Maha 71/72	Maha 72/73
K-8	76.9	42.4	-	-
PL 6	83.1	51.4	55.4	65.7
PL 16	79.4	60.2	85.7	73.4

Apart from the traditional rice fields in this area a considerable amount of ill-drained land bordering the mountain streams could be profitably utilised now that we have a reasonably cold tolerent variety. There are indications from this programme that hybrids with even greater cold tolerance could be developed inthe future from ~~cold tolerant~~ germ plasm obtained from Assam. PL 16 has been released to the farmers this year and the reports are encouraging.

2. Breeding Varieties of 5½ Month Age Group.

An area of over 80,000 acres covering Colombo, Mirigama and Madampe tracts require a long aged variety of 5½ months owing to its peculiar rainfall pattern. PTB 16 and Podiwi are the traditional varieties grown here. Normally we breed varieties which are not

photosensitive, so that their age remains the same irrespective of the time of the year when planted. The variety required for this area has to be photosensitive i.e. it should allow planting any time from the middle of July to early September but flower into dry weather in mid December irrespective of the planting date. This was our most difficult assignment. The first release of H 9 brought out three years ago was high yielding, had excellent grain quality but was not sufficiently photosensitive. We have now produced Bg 3-5 which substantially conforms to the requirements for this area and gives higher yields over the presently grown PTB 16 or A-8. It also has lodging resistance superior to the tall PTB 16 or H 9. Comparative yields are as follows :-

Variety	Maha 1970/71	Maha 1971/72
Bg 3 - 5	102 Bu/ac.	117 Bu/ac.
H 9	100 "	110 "
PTB 16	85 "	64 "

3. Breeding Varieties for Salinity Resistance

While there are well defined areas where the occurence of Salinity has depressed the yields of paddy there appears to be substantial tracts where Salinity is beginning to develop especially due to the impedence of drainage. These areas should immediately received attention by way of proper drainage channels.

The variety that has been used for decades for growing under saline conditions is Pokkali. Although it has Saline tolerance, yields are generally low. It is also susceptible to bacterial leaf blight.

Our latest experiments in producing a variety to suit these conditions are very hopeful. Among the most promising are A-52 produced at Ambalantota (Goonetillake) and Bg 33-2 from Batalagoda (Weeraratne).

Variety Testing for Saline Tolerance

Variety	Yield Bu/ac.	Place of Origin
A 52-20-1-1 (IR 262 x SR 26B)	78	Ambalantota
Bg 33-2	76	Batalagoda
A 15-167	72	Ambalantota
Bg 34-8	62	Batalagoda
Pokkali	53	Local variety
IR-20	44	IRRI
A 12-86-2	41	Ambalantota
IR-8	25	IRRI
Bg 11-11	23	Batalagoda
H-4	10	Batalagoda

It will be seen that we can bring back most of our Saline areas to greater productivity with these varieties.

4. Resistance to Bronzing.

The phenomenon called bronzing is observed in certain ill-drained soils making the plants assume a bronzed appearance. While the actual cause of bronzing has not been definitely established and many explanations have been put forward, it is observed that different plants show differences in their reactions to this condition. A programme of screening of varieties to bronzing is continued at Bombuwela to identify those varieties that are resistant to this condition.

B. Rice Breeding for General Improvement.

At the last Symposium we discussed the early efforts of the Rice Breeding Programme for improvement of varieties that have to be used in the greater part of the Island. From the Central Rice Breeding Station, Batalagoda, Weeraratne contributed H 4 (4½ months), H 8 (4½ months) and H 7 (3½ months) which together with Pachchaiperumal - an old local selection in the 3 months age group - constituted the mainstay of our rice production programme till recently. H 4 established a land mark in our rice breeding programme. Its wide adaptability, response to fertilizer, comparatively higher yielding ability over the old varieties and disease resistance in due course made it assume the major role in rice production in Sri Lanka. Some have acclaimed it as the best traditional rice variety produced in South East Asia.

For the greater part of the Island we require varieties of 3, 3½ and 4 months duration. In the early stages the pace of rice breeding was far too slow as is seen from the fact that between 1958 - 1966 only three ~~month~~ new varieties have been forthcoming. Moreover it took nearly 5 - 6 years from the time of making a cross, for a promising variety to find its way to the farmer involving preliminary selections through five or six generations, station yield trials and subsequent testing in Government Farms. This process was far too slow and had to be accelerated.

The rice improvement programme was intensified and reorganised in 1968 in two ways:-

(A) By the intensification of the Rice Breeding Programme at the stations at Batalagoda, Maha Illuppallama and Bombuwela and the extension of the programme to three other experiment stations Ambalantota, Labuduwa and Karapincha.

(B) By the organisation of the Co-ordinated Rice Varietal Trial Programme as a quick and reliable method of testing the new and promising varieties over a range of agroclimatic conditions in the shortest possible time.

A. RICE BREEDING - STRATEGY FOR RICE IMPROVEMENT

In the past, the traditional varieties of rice which obtained in the rice bowl of Asia were tall types which have by natural selection become adapted to a low level of management i.e. without fertilizer and without weeding or pest and disease control. Owing to their tallness they invariably lodged (fell down) during the latter part of their growth. Addition of fertilizers generally caused these to lodge even earlier and yields were affected. Thus for example even with an inherent potential of 160 bushels per acre the yield of H 4 was unpredictable depending on whether it lodged sooner or later with the prevailing weather conditions. The concept of the new improved high efficiency dwarf plant type as illustrated by Taichung Native I from Taiwan and IR-8 from International Rice Research Institute set a new trend in rice breeding.

The dwarf character which made a rice variety resistant to lodging and erect leaves which prevented mutual shading, enabled this plant type to take in more fertilizer and give high yields hitherto unattainable with traditional varieties. These varieties were derived from the Taiwan dwarf varieties I-geo-tse and Dee-geo-woogen. However, TN 1 and IR-8 were tested in our research stations as far back as ~~far back as~~ 1965 and it was observed that inspite of their potential high yields there were certain deficiencies.

(1) They were mostly adapted to well drained soils unlike our traditional varieties.

(2) Their dwarf nature necessitated very efficient weed control which the average farmer could not easily provide. We require varieties of intermediate height.

(3) They were susceptible to various diseases such as Bacterial Leaf Blight, Sheath Blight and Insect Pests. (Gall fly, Leaf Roller, etc.) especially at the high levels of nitrogen necessary for attaining their potential yields. This necessiated a high efficiency in pest and disease control.

(4) The grain quality of these varieties especially of IR 8 was not quite satisfactory.

Thus, the progressive farmers growing these varieties in well drained soils were able to obtain high yields, but the generality of farmers were unable to extract the high potential of these varieties because it required high levels of management and inputs which were not immediately forthcoming from the marginal farmer.

The Rice Breeding Programme in Sri Lanka was directed to develop varieties which would give the average farmer at reasonable levels of management, higher yields than what he is presently obtaining with the traditional varieties, rather than varieties having a high maximum potential which could be extracted only with high inputs. The very important concept of non-lodging promulgated by IR-8 was fully accepted and adopted in our

programme. However, although IR-8 was selected in the Philippines for an ideal height of 100 cm., its height is much shorter in Sri Lanka excepting in rare cases of extremely well drained soils. Its resistance to pests, diseases and grain quality had also to be improved.

Proven local varieties with their adaptability to local conditions, better grain quality and some inherent resistance to pests and diseases were freely used in the making of our hybrids. These varieties were to form an intermediate stage in leading the average farmer to more sophisticated levels of management later. In other words the strategy was an agricultural evolution rather than an agricultural revolution.

The rice scientists in Sri Lanka worked on the following lines in developing varieties.

(1) Into the native germ-plasm which was already adapted to local conditions dwarfing genes were introduced from IR-8, TN 1, Deo-geo-woogen etc. and selections made for plants with intermediate height, reasonable resistance to pest and diseases, higher adaptability and better grain quality, e.g. Bg 34-8, Bg 33-2 etc.

(2) Natural dwarf mutants of proven high yielding local varieties such as K 8 (m), Panduruwi mutant were used in crossing to obtain non lodging varieties of good plant type e.g. A 11-40.

(3) Irradiation of proven high yielding local varieties to obtain non lodging mutants, e.g. Irradiation of H-4 to produce MI 273(m).

(4) Introduction of straw strength to proven high yielding local varieties and producing varieties of intermediate height, with greater resistance to lodging e.g. production of Bg 11-11 by crossing H-8 with Engkatek.

Table 6 presents the pedigree of the more promising varieties emanating from this programme and the breeders responsible for their selection.

B. THE CO-ORDINATED RICE VARIETAL TRIAL PROGRAMME

In this project the promising high yielding varieties emanating from our own breeding programme along with varieties, reported to be high yielding in other countries were tested in standard variety trials located in different parts of the Island representative of the main agroclimatic zones. For the first two seasons, testing was carried out at six stations and later the number of stations were increased to eight as follows:-

Dry Zone - Maha Illuppallama, Ambalantota, Paranthan and Karadian Aru.

Intermediate Zone - Batalagoda.

Wet Zone - Bombuwela, Karapincha and Labuduwa.

Agronomists at these stations are responsible for the conduct of these trials. Plant Pathologists and Entomologists evaluate disease and pest resistance of the varieties in the Co-ordinated Trials as well as in their own screening tests in the laboratory and field. The food Technologist supplies the information on milling outturn, grain quality, palatability etc. The soil scientists keep track of the nutritional status of the soil at the trial sites while Agro-meteorologists study the climatic factors in order to assist in the interpretation of the data coming from the different test locations. In addition to yield data various other varietal assessments such as height, ripening and growth duration, heading records, lodging assessments, tiller number, panicles per square foot, plant stand etc. are recorded and processed by the statistician and data processing unit.

The credit for identifying the most promising varieties as a result of the evaluation of 154 varieties in over 181 well conducted coordinated yield trials goes therefore to the whole community of rice researchers participating in the programme. The organisation, coordination and direction of the whole programme comes from the Co-ordinated Rice Varietal Trial Project which not only mobilised and coordinated the members of the various disciplines of Agricultural Science and promoted research communication between them towards the objective of producing improved rice varieties, but also evolved well organized and dependable testing machinery for highlighting the most promising varieties in the shortest possible time.

The Co-ordinated Rice Variety Trial Project is responsible for the identification of the new improved varieties for cultivation. The contribution of participants involved in testing and evaluation - The Entomologist, Pathologist, Food Technologist, Agronomists, Statisticians, etc. is just as important as those of the rice breeders who develop a variety which is now released as a recommended variety.

RESULTS

The data presented in the following pages are the results of the cocordinated rice variety testing programme. Although the data is in relation to the grain yield, as mentioned earlier, various other characgeristics are evaluated in the programme. These criteria are taken into consideration in the interpretation of the yield data and when the final recommendation of a variety is made. The results presented in this paper are in respect of the last 9 seasons - Yala 1968#, Maha 1968/69, Yala 1969, Maha 1969/70, Yala 1970, Maha 1970/71, Yala 1971, Maha 1971/72 and Yala 1972.

Maha - Wet season - October to February.

Yala - Dry season - April to August.

3 MONTHS AGE GROUP

High yielding varieties of 3 month duration have been rather rare in the past in South East Asia or for that matter in the Rice growing countries of the world. Even the International Rice Research Institute at the outset concentrated mainly on the development of varieties of the 4 month age group because it is well known - that this 120 day duration group is capable of the maximum potential. Nevertheless, for countries such as Sri Lanka and no doubt for many other countries in the world, varieties of a shorter duration are very relevant. These varieties come in useful where limitation of water in our tanks in the dry zone necessitate a short growing period. These are also useful when rainfall patterns postulate a $5\frac{1}{2}$ month variety in certain parts of the country so that the 2nd crop must of necessity be a short one. They also come in handy when a 4 month variety already planted out happens to be destroyed by floods. In the present context of the development of multiple cropping in combinatinn with other crops, a short aged high yielding variety of rice becomes extremely important, For these reasons we concentrated on the development of Good short aged varieties to replace the local selection Pachchaiperumal which has filled this role for well over 25 years inspite of its susceptibility to blight, blast and susceptibility to shattering.

Fig. 1. (Chart and Slide) presents in histogram form the overall mean yields of the varieties obtained from the co-ordinated trials for the last 7 seasons. It can be observed from this histogram that during even the first two seasons some of the new varieties tested gave yield increases over the standard variety Pachchaiperumal. (Standard variety depicted in black). With the introductionof newer varieties frm the breeding programme in subsequent seasons, possessing better plant characteristics such as lodging resistance, disease resistance etc. into the trials from Maha 1969/70 onwards, all the varieties tested gave substantial yield increases over Pachchaiperumal.

It will be also observed that the yield of the Standard variety Pachchaiperumal is higher in Yala than in Maha owing to the greater disease incidence in the Maha season and the susceptibility of Pachchaiperumal to Blast, Bacterial Leaf Blight and lodging.

The improved varieties, apart from their much higher yield give a much more stable performance without these fluctuations owing to their resistance in these respects.

The mean yield and yield increases of some of the new varieties over the standard variety Pachcheriperumal are given below:-

Table 1

Variety	Maha 1969/70 @Mean yield Bu/ac.	Yield Inc. over P.P# Bu/ac.	Yala 1970 Mean yield Bu/ac	Yield Inc. over P.P# Bu/ac.	Maha 1970/71 Mean yield Bu/ac	Yield Inc. over P.P# Bu/ac.	Yala 1971 Mean yield Bu/ac.	Yield Inc. over P.P# Bu/ac.
Bg 34-8	73.6	+37.9	107.0	+45.9	91.9	+56.1	99.5	+35.2
Bg 34-11	77.2	+41.5	100.6	+39.5	85.6	+49.8	96.2	+31.9
Bg 34-2	-	-	106.3	+45.2	91.8	+56.0	105.6	+41.3
Bg 33-2	-	-	-	-	84.4	+48.6	101.8	+37.5
# PP	35.7	-	61.1	-	35.8	-	64.3	-

Pachchaiperumal 2462/11

@ Mean of 8 locations.

NOTE: 1 Bushel per acre - 50.5 Kilogrammes per hectare.

It is clear from the above table that Bg 34-8, Bg 34-11, Bg 34-2, and Bg 33-2 have given yield increases ranging from 35.2. - 56.1 Bu/ac. 31.9 - 49.8 Bu/ac. 41.3 - 56.0 Bu/ac. and 37.5 - 48.6 Bu/ac. respectively, over the standard variety. The maximum grain yield obtained todate with these varieties in this series of experiments for Bg 34-2, Bg 34-8, Bg 34-11 and Bg 33-2 are 142.2, 140.4, 126.8 and 122.0 Bu/ac. respectively. When we consider that these are 90 day duration varieties, Bg 34-8 has produced - 1½ bushels per acre for each day of its existence in the field. It would be difficult to produce varieties giving a higher maximum potential in this age group than what has been reached by the varieties mentioned. These varieties are of intermediate height, approximately 58 cm. culm height vs. 80 cm. for Pachchaiperumal and are superior to Pachchaiperumal in resistance to lodging, Bacterial Leaf Blight disease. We have recently obtained reports from extension that Bg 34-8 shows tolerance to submergence by floods. This has been tested and confirmed by us. There have also been reports that it is drought resistant and also tolerant to Saline conditions. With a record potential of 140-150 Bu/ac for a 90 day variety Bg 34-8 is indeed a truly remarkable rice variety. The series of trials in the 3 months age group have been temporarily

suspended to enable the breeders to improve further the Rice Quality, lodging resistance etc. of this age group.

31 new varieties have been tested in the Co-ordinated Rice Varietal Trial Project for the last 7 seasons. The data obtained has enabled the recommendation of two varieties viz. Bg 34-8, and Bg 34-11 to replace Pachchaiperumal which has been the standard variety in this age group. These are only two of the varieties among the many that have been highlighted in the Co-ordinated Rice Varietal Trial Programme. Bg 34-2 and Bg 33-2 are the leading varieties during the last season. The histogram Fig. 1 - will show that there are many varieties which can outyield Pachchaiperumal by nearly 100%. Bg 34-8, Bg 34-11 have been already released to the farmers and has been eargerly accepted by them. Bg 33-2 is found to perform even better than Bg 34-8 in the boggy soils of the wet-zone, where bronzing could be a problem.

Considering the fact that the total acreage per annum under the 3 months age group is approximately 185,000 acres the increase in production that can be expected by growing the new varieties, assuming a yield increase of 20 bu/ac over Pachchaiperumal on a modest estimate, will be approximately 4 million bushels per annum. This acreage could no doubt be even increased when this short aged variety go into lands that have been so far left fallow for the 2nd season for want of a good short aged variety and also contribute extra harvests from the multiple cropping programme in the highlands.

3½ MONTHS AGE GROUP

The histogram (Fig. 2) (chart and slide) presents the mean grain yield data of varieties of this age class tested during the past 8 seasons. It can be seen that upto Yala 1969, many, among the new varieties tested, were superior, but a fair number were inferior in yield to H-7. (the Standard variety in black) - However, after the introduction of varieties of Improved Plant Type with better lodging resistance, pest and disease resistance, into the Co-ordinated Rice Varietal Trials, the standard variety H-7 has been almost the lowest yielder during the last four seasons.

The grain yields and yield increases of the leading varieties which have emerged from these trials are presented in the table given on page 14.

Table 2.

Variety	Maha 1969/70 @Mean Yield Bu/ac.	Inc. over H-7 Bu/ac.	Yala 1970 Mean yield Bu/ac	Inc. over H-7 Bu/ac.	Maha 1970/71 Mean yield Bu/ac.	Inc. over H-7 Bu/ac.	Yala 1971 Mean yield Bu/ac	Inc. over H-7 Bu/ac.	Maha 1971/72 Mean Yield Bu/ac	Inc. over H-7 Bu/ac.
IR 262	93.2	+39.0	106.2	+46.9	86.5	+29.8	117.2	+47.7	96.3	+35.1
Bg 34-6	87.2	+33.0	99.7	+40.4	83.5	+26.8	105.5	+36.0	101.7	+40.5
Bg 35-2	85.1	+30.9	95.2	+35.9	75.2	+18.5	101.7	+31.6	-	-
A 9-48	78.8	+24.6	86.6	+27.3	77.7	+21.0	107.6	+38.1	99.5	+38.3
H 7(Std.)	54.2	-	59.3	-	56.7	-	69.5	-	61.2	-

@ Mean of 8 locations.

NOTE: 1 Bushel per acre = 50.5 Kilogrammes per hectare.

The variety IR 262 from the International Rice Research Institute (IRRI) has been the leading variety from Maha 1968/69. Locally bred varieties Bg 34-6, A 9-48 and Bg 35-2 which were entered in the Co-ordinated Rice Varietal Trial for the first time in Maha 1969/70 also gave high yields only slightly inferior to IR 262.

The newer varieties viz. IR 262, Bg 34-6, etc. have given yield increases over H-7, ranging from 39.0 - 47.7 and 26.8 - 40.5 bu/ac. respectively. However, IR 262 though a very good x variety with fine rice quality, has one disadvantage in that it is too short. Its culm height is 47 cm. compared with 61 cm. for Bg 34-6 and 88 cm. for H-7. Although progressive farmers exercising good weed control could extract the high potential yields from this variety, it is observed that by an large the average farmer does not yet adopt a high standard in weed control, so that the high potential of IR 262 is not always realised. Bg 34-6 is intermediate in height and has found favour with most of the farmers who have used it in their fields. In this age class a total of 45 varieties have been tested and presently two varieties are recommended viz. IR 262 for farmers practising a high level of management and Bg 34-6 for others, to replace the standard variety H-7 in the 3½ month age class. A 9-48 is now ready for recommendation and it is more resistant to BLB than Bg 34-6.

Varieties of this age group are grown in the dry, intermediate and wet zone and cover an area of approximately 165,000 acres [illegible] per annum. The varieties IR 262 and Bg 34-6 have given 27 - 47 bushels per acre over H-7 in this series. Assuming that these varieties give a yield increase of 20 bu/ac., an increased potential of 3.3 million bushels of paddy per annum would be possible from the area covered by this age group.

4 - 4½ MONTHS AGE GROUP

This age group is the most important one in the island and covers nearly 1.25 million acres each year. For over 12 years the varieties H-4 and to a lesser period H-8, were the standard varieties that have been used as widely adaptible varieties. However, these varieties are far from ideal for wet zone conditions. For this reason, in addition to H-4 and H-8 many old local varieties are also being grown in this region. However, the spectacular increase in production obtained during the last few years (Fig. 4 - Slide and chart) is largely due to the response of these varieties H-4 and H-8 to better management practices. Both these varieties are tall and tend to lodge towards harvest or even shortly after heading, if they run into rainy weather. The yield is therefore largely dependent on the climatic conditions obtaining especially during the latter part of the growing period. Varieties with a more stable and higher yield ceiling should be available to make a substantial impact on Rice productionwith this most important age gruup.

Imported varieties such as Taichung Native 1 was found to be too susceptible to Bacterial Leaf Blight disease in Sri Lanka and never made an impression on our rice production. IR-8 on the other hand was superior to the above in many respects, but, as mentioned earlier does best only on well drained soils and under high levels of management, including high fertilization, pest, disease and weed control.

The objectives of breeding in this age group as well as in earlier mentiondd age groups were varieties of intermediate height with erect leaves having greater resistence to the commoner pests and diseases and good grain type. It is more difficult to produce absolutely non lodging types at intermediate height than dwarf types. We were prepared therefore, to even sacrifice some of the lodging resistance at this stage knowing very well that the average level of nitrogen still used in our fields is not very high.

The figure 3 (slide and chart) summarises the mean grain yields of the eight locations of the various varieties tested for the first 7 seasons. The tables 3 and 4 and Fig 7 show the yields of the more promising varieties during the last few seasons.

In Yala 1968 and Maha 1968/69, of the large number of new varieties tested along with the standard variety H-4, only a few showed yield superiority over H-4 (Fig 3 chart and slide). IR-8 was distinctly superior to H-4. This trend changed from Yala 1969 onwards with the influx, from the breeding programme, of high fertilizer responsive varieties with good plant type and resistance to lodging. In fact, during the 3 seasons viz. Yala 1970, Maha 1970/71 and Yala 1971 all the 15 varieties that were tested in the Co-ordinted Rice Varietal Trials were superior to the standard H-4 by very substantial margins.

Table 3 gives the overall mean yield data of the leading varieties obtained duringthe last 6 seasons The range of yield increases obtained with IR-8, Bg 11-11, MI 272(m), LD 66 and A 11-40 are 25.4 - 60.9, 18.2# - 36.9, 16.6 - 52.7, 24.0 - 38.2 and 22.8 - 54.5 bushels per acre respectively.

(# Low yield of Bg 11-11 due to over seeding.)

During the last two seasons Maha 1970/71, and Yala 1971 many new varieties viz. MI 273(m), A 11-40 have equalled or improved on the yield of IR-8 in their mean yields (Fig 3 Chart and slide). These varieties possess in addition, some or all other characteristics such as superior grain quality, greater resistance to diseases and pests and greater adapatability than IR-8 itself. As the trials are carried out at a highlevel of management, it can be assumed that the maximum potential of IR-8 has been equalled by these varieties with improvements in one or more characteristics over IR-8. Fertilizer levels for wet zone N:P:K 100:100:100 and for the Dry Zone - N:P:K - 120:100:100.

From Yala 1972 Bg 11-11 replaced H-4 as the standard variety and H-4 was deleted from the trials. From Maha 1971/72 even more promising varieties are identified such as Bg 66-1 and Bg 90-2.

PERFORMANCE OF 4½ MONTH VARIETIES IN THE WET ZONE

While most good varieties bred here or imported from abroad perform well in the Dry and Intermediate Zones, with their better sunshine hours, better drainage and growing conditions, the challenge of improving the yields in the wet zone has always been a more difficult one. Poor drainage and cloud cover, frequent rainfall and greater incidence of pests and diseases have contributed to hold back the high potential yield of the best varieties in this Agro Climate.

Table 4 gives the performance of the more promising varieties in the wet zone.

It will be observed that most of the new varieties which are more resistant to lodging are capable of giving substantial yield increases over H-4 even in the wet zone even though their yield levels are lower than those in the dry zone.

PERFORMANCE OF NEW VARIETIES IN EXTENSION FIELD TRIALS

Co-ordinated variety testing is limited to 8 locations in the Wet, Dry and Intermediate Zones, and it is necessary to find out the performance of these varieties under a wider spectrum of soil types and agro-climatic conditions, before a final recommendation could be made. Therefore, promising varieties from the Co-ordinated Variety Trials are passed on to the Extension Organization for testing in the cultivators' fields. By this means, the Extension staff as well as the farmers could

become familiar with the new varieties, find out the areas in which particular varieties are more suitable and gener ally transmit to research any deficiencies in these varieties.

Table 5 gives the data from 186 locations in 21 districts of Extension field trials carried out with the 4 - 4½ months varieties for Maha 1971/72. The trials were carried out at fertilizer levels of N:40 P:70 K:50 in the Dry & Intermediate zones and N:40 P:50 K:50 in the wet zone. It will be observed that some of the promising varieties like Bg 11-11 and LD 66 have given over 100 bushels per acre on an average. Even the other varieties have given quite acceptable yields with a mean yield of 95.3 bushels per acre for all varieties. However, although the data from all locations have been pooled and averaged for this purpose, if a study of individual districts were made, those which are more favourable for growth have given much higher yields than the averages. In some Districts, even at low levels of fertilizer yields of 140 - 150 bushels per acre have been recorded with Bg 11-11. Nevertheless, it would be apparent from this rough average that a potentiality of 90 - 100 bushels per acre is possible when till recently our national yields of varieties have been in the region of 51 bushels per acre.

THE PERFORMANCE OF NEW VARIETIES OVER LARGE AREAS

It is well known that Trials carried out in expermental plots of about 1/80th of an acre whether by Research Officers or Experimental Staff do not reflect the yields that would be obtained when rice is grown over large extents in farms or in small extents by the farmers. This is because over large areas it is not possible to give the same attention that is given to experimental plots and the management levels must necessarily be lower. However, it would be seen that through out this address what is stressed is not the absolute yields obtained with the new varieties but more the differences between the old and the new varieties at the same level of management. This is a truer comparison between the varieties.

There are however, figures available on the performance of these varieties when grown in large acreages and these are presented below.

Yala 1970 - Hingurakgoda Government Farm

Variety	Extent in acres	Yield Bu/ac
Bg 11-11	45	70
LD 66	5	88
H-4	50	50

Maha 1970/71 Hingurakgoda Government Farm

Variety	Extent in acres	Yield Bu/ac
MI 273(m)	12	105.4
Bg 11-11	146	91.7
IR-8	36	83.4
LD 66	35	70.8
H-4	186	52.0

Yala 1970 - Private Cultivators' Farm, Ambalantota

Variety	Extent in acres	Yield Bu/ac
Bg 11-11	5	120
IR - 8	5	90
H-4	5	75.

Many cultivators who have grown blocks of Bg 11-11 have realised average yields of 120 - 130 bu/ac whereas their normal yields with H-4 have never been over 80 - 90 bu/ac.

The foregoing data demonstrate the capability of new improved varieties to give yield increases of 30 - 35 bu/ac over the presently grown H-4 and H-8. If a modest increase of only 20 bu/ac were realised over the 1.25 million acres growing the 4½ month age group, these new varieties could increase rice production by around 25 million bushels per annum.

EFFECT OF HIGH YIELDING VARIETIES ON THE FUTURE OF RICE IN SRI LANKA.

For the increase of rice production in a country high yielding varieties are a sine qua non. All other efforts must necessarily prove to be of little avail if the varieties set a low limit of production. On the other hand, good varieties with high yielding potential cannot by themselves achieve much unless certain supporting services are available. Good varieties can spread to some extent on their own merit. Farmers have been paying higher than the standard price for seed of these new varieties in the early days of their release. However, for a quick and extensive impact on rice production and for the full exploitation of their potential the following are necessary:-

(a) A good extension service
(b) An efficient seed production programme.
(c) Easy availability of fertilizer at the right time to the farmer.
(d) Availability of credit without much difficulty.

Of these, the Department of Agriculture is responsible for Extension and seed production in addition to Research. The excellence of these varieties have been matched by a magnificnt extension effort, the like of which has been rarely seen in South East Asia. In the season Maha 1971/72 five thousand mini-kits comprising of four varieties ~~m~~ in each age group together with the required fertilizers, and agro-chemicals have been distributed throughout the country. In addition to this,100,000 production kits containing one pound of seed of a variety were sold to farmers. The results of these and the intensification of the seed production and certificatinn programme have been spectacular. The trends of spread of the new varieties of the second generation are shown in figure 8.

It has already been shown that in the 3, 3½ and 4½ months age groups, many varieties are available which are capable of yielding around 20 - 50 bushels per acre over the old varieties, Pachchaiperumal, H 4 and H 7. Even at a modest estimate of an increase of 20 bushels per acre, this would mean a potential of around 30 million bushels of extra paddy per annum valued around at Rs. 540 million. The chart (figure 4) shows the increase in paddy production in Sri Lanka during the last 12 years. The year 1964/65 registered a decline in our production owing to drought. Since that time, rice production has steadily improved in an ascending curve excepting for the year 1968/69 when again a drought prevailed. This was however made up in 1969/70 with an unprecedented 77.4 million bushels production. The total production dropped sharply in 1970/71 - the year of insurgent activity in Sri Lanka - which threw the facilities services out of gear. Following this, in Maha 1971/72 and Yala 1972 and even last season, Maha 1972/73, crops were badly affected by severe droughts.

The sharp increase in production from 1966/67 - 1969/70 was due to the increasing adoption of better cultural practices, fertilizer, weed and pest control and the organization of the Government machinery to assist farmers with better credit facilities, fertilizers and other supplies. Nevertheless the yield increase so achieved was through the old varieties, H4, H7, H8, Pachchaiperumal.

The dotted line from 1970 - 1971 represents the estimated total increase of production envisaged by the Draft Seven Year Plan of the Ministry of Agriculture. The estimated demand for rice according to projections on the increase of population is shown at the top of the graph. It will be seen that according to the plan, at the then rate of increase of production self sufficiency would be realised between 1975 - 1976. With the generation of an increased potential

of over 30 million bushels per annum with the second generation high yielding varieties, it is clear that this target could be reached much sooner. It is estimated that the new varieties could replace the older ones in the field in two or three seasons, and we could expect reaching our target even by the end of 1974, provided that the inputs such as fertilizer, credit are made to flow smoothly and ofcourse if adverse weather conditions are not encountered.

The improved varieties have been biologically tailored to suit local conditions at levels of management within the capacity of the average farmer. They represent a forward step in agricultural evolution towards higher levels of management for the future. There is little doubt, that even better varieties will emerge ffom the Rice Improvement Programme in the years to come.

These varieties are a gift to the farmers and people of this country by the whole community of rice scientists of the Research Division of the Department of Agriculture, that worked as a co-ordinated team with the objective of producing high yielding varieties for increased rice production. It is their hope that these varieties will receive the fullest support from the facilities services and that they will relieve the country of the heavy economic burden of importing rice for the people and bring about an era of prosperity for the farmers of the country.

++++++++++++++++++++

Table 3.

Variety	Maha 1969/70 @Mean grain yield Bu/ac	Yield Inc. over H-4 Bu/ac.	Yala 1970 Mean grain yield Bu/ac.	Yield Inc. over H-4 Bu/ac.	Maha 1970/71 Mean grain yield Bu/ac.	Yield Inc. over H-4 Bu/ac	Yala 1971 Mean grain yield Bu/ac	Yield Inc. over H-4 Bu/ac.	Maha 1971/72 Mean grain yield Bu/ac	Yield Inc. over. H-4 Bu/ac.	Yala 1972 Mean grain yield Bu/ac	Yield Inc. over H-4 Bu/ac.
IR-8	94.3	+30.9	112.1	+60.9	107.2	+36.2	125.7	+49.1	112.0	+25.4	118.9	
Bg 11-11	81.6#	+18.2	87.5	+36.3	107.9	+36.9	109.9	+32.3	106.4	+19.8	101.2	
MI 273(m)	-	-	103.9	+52.7	108.9	+37.9	121.3	+43.7	103.2	+16.6	-	
LD 66	87.4	+24.0	-	-	102.2	+31.2	115.8	+38.2	-	-	-	
A11-15) Sister lines	-	-	105.6	+54.4	-	-	-	-	-	-	-	
A11-40)	-	-	-	-	108.2	+37.0	132.1	+54.5	109.4	+22.8	121.3	
Bg 66-1	-	-	-	-	-	-	-	-	105.7	+19.1	122.3	
Bg 90-2	-	-	-	-	-	-	-	-	-	-	124.6	
H-4 (Std. Var.)	63.4	-	51.2	-	71.0	-	77.6	-	86.6	-	-	

@ Mean of 8 locations.

NOTE: 1. # Low yield of Bg 11-11 due to overseeding.

2. 1 Bushel per acre = 50.5 Kilogrammes per hectare.

Table 4.

Performance of Varieties in the Wet Zone

(Results obtained from Co-ordinated Rice Varietal Trial)

Variety	Maha 1969/70		Yala 1970		Maha 1970/71		Yala 1971		Maha 1971/72		Yala 1972	
	* Mean yield bu/ac.	Inc. over H-4 bu/ac.	Mean Yield bu/ac.	Inc. over H-4 bu/ac.	Mean yield bu/ac.	Inc. over H-4 bu/ac.	Mean Yield bu/ac.	Inc. over H-4 bu/ac.	Mean yield bu/ac.	Inc. over H-4 bu/ac.	Mean yield bu/ac.	Inc. over H-4 bu/ac.
A 11-40	-	-	-	-	89.6	+21.4	101.5	+59.8	94.4	+ 9.6	93.0	
MI 273(m)	-	-	84.6	+35.9	90.4	+22.2	90.2	+48.5	90.8	+ 6.0	-	
IR-8	35.1	+31.6	69.8	+21.1	85.7	+17.5	85.9	+44.2	91.1	+ 6.2	89.8	
LD 66	83.4	+29.9	-	-	86.8	+18.6	80.5	+38.8				
Bg 11-11	80.4 **	+26.9	72.2	+23.5	95.9	+27.7	70.6	+28.9	95.1	+10.3	63.5	
Bg 66-1	-	-	-	-	-	-	-	-	83.7	- 1.1	94.6	
Bg 90-2	-	-	-	-	-	-	-	-	-	-	103.7	
H-4(Std.var)	53.5	-	48.7	-	68.2	-	41.7	-	84.8	-	-	

NOTE: 1. * Mean of 3 Locations.

2. ** Low yield of Bg 11-11 due to overseeding.

3. 1 Bushel per acre = 50.5 Kilogrammes per hectare.

Table 5.

EXTENSION FIELD TRIALS - MAHA 1971/72

4 - 4½ MONTHS VARIETIES

Fertilizer Level N: P: K: 40: 7.0: 5.0	IR 661	IR-20	MI 273(m)	K8(m)	Bg 11-11	LD-66	Mean yield Varieties (Bu/ac)
Mean: Dry & Intermediate Zones 127 Trials in 16 Districts	93.1	94.3	93.0	97.9	109.9	101.1	98.2
Fert.Level: N:40 P: 50: K:50 Mean: Wet Zone 59 Trials in 10 Districts	84.5	81.8	87.1	94.7	105.3	102.0	92.5
186 Trials in 21 Districts Overall Mean	88.8	88.0	90.0	96.3	107.6	101.5	95.3

1 Bushel per acre = 50.5 Kilogrammes per Hectare.

Table 6

Origin of some Promising Varieties

Age Group	Variety	Pedigree	Bred or Selected by	State/Country Station/Country
1. 3 Months	Bg 34-2	IR 8-24-6 x (Pachchaiperumal x Mas) x H 501	Dr. H.Weeraratne and Mr. N.Vignarajah	Central Rice Breeding Station, Batalagoda, Ceylon.
	Bg 34-8	IR 8-24-6 x (Pachchaiperumal x Mas) x H 501	Dr. H.Weeraratne and Mr. N.Vignarajah	-do-
	Bg 34-11	IR 8-24-6 x (Pachchaiperumal x Mas) x H 501	Dr. H.Weeraratne and Mr. N.Vignarajah	-do-
	Bg 34-12	IR 8-24-6 x (Pachchaiperumal x Mas) x H 501	Dr. H.Weeraratne and Mr. N.Vignarajah	-do-
	Bg 33-2	IR 8-24-6 x H 10	Dr. H.Weeraratne and Mr. N.Vignarajah	-do-
2. 3½ Months	A 9-48	(PVM x H 7) x IR8	Dr. I.P.S.Dias and Mr. G.A.Gunatilake	Paddy Research Station, Ambalantota, Ceylon.
	Bg 34-6	IR 8-24-6 x (Pachchaiperumal x Mas) x H 501	Dr. H.Weeraratne and Mr. N.Vignarajah	Central Rice Breeding Station, Batalagoda, Ceylon.
	Bg 35-2	IR 8-24-6 x (M 307 x H 501)	Dr. H.Weeraratne and Mr. N.Vignarajah	-do-
	IR 262	IR 262 - Peta/3 x T (N)1	From the International Rice Research Institute, Philippines.	

Table 6 Contd...

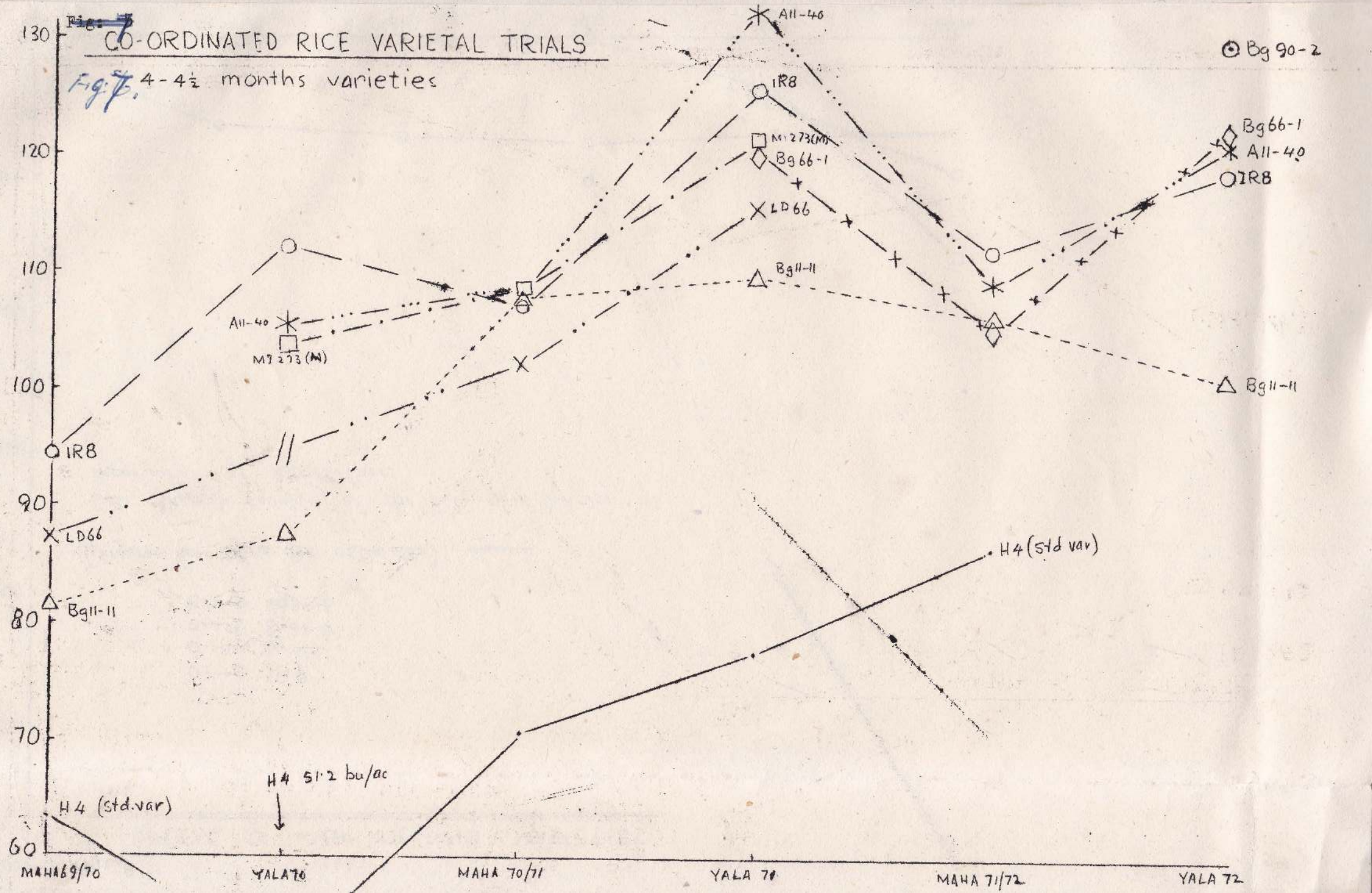
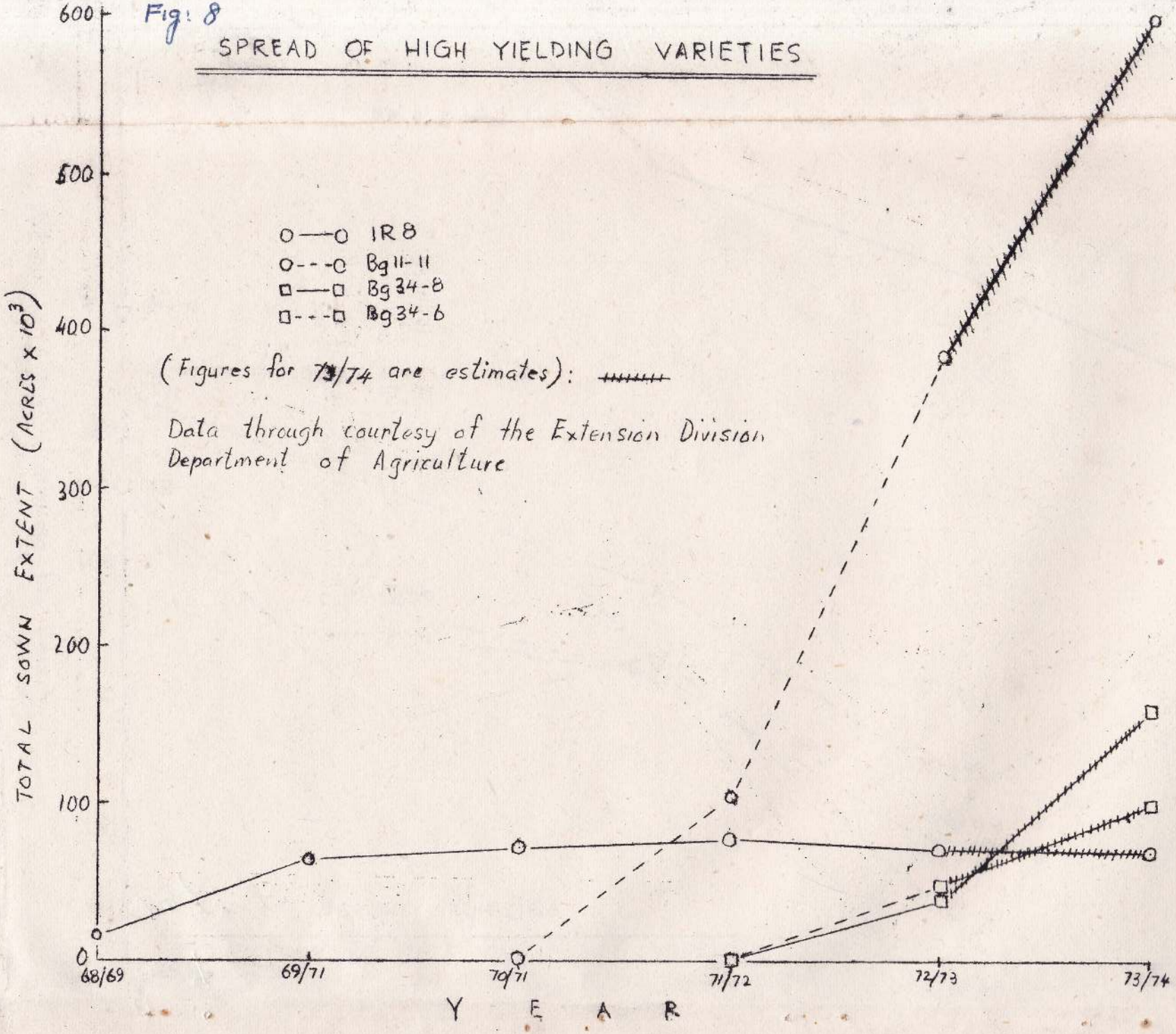

CO-ORDINATED RICE VARIETAL TRIALS
Fig: 7.
4-4½ months varieties
130
120
110
100
90
80
70
60
A11-40
IR8
M1 273(N)
Bg 66-1
LD 66
Bg11-11
Bg 90-2
H4 (std var)
H4 51·2 bu/ac
MAHA 69/70
YALA 70
MAHA 70/71
YALA 71
MAHA 71/72
YALA 72

Fig: 8

SPREAD OF HIGH YIELDING VARIETIES



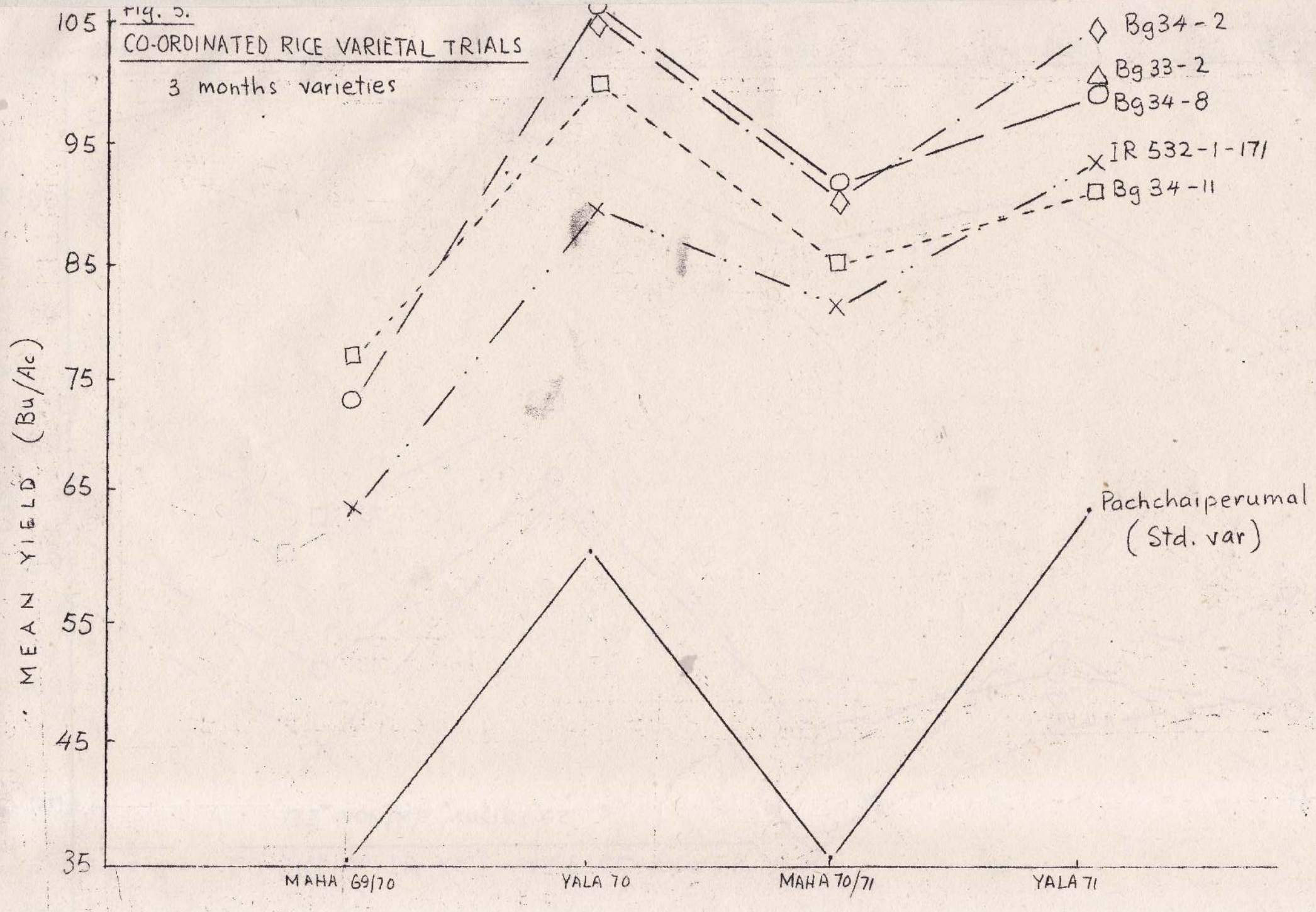
(Figures for 73/74 are estimates):

Data through courtesy of the Extension Division Department of Agriculture

Fig. 5.

CO-ORDINATED RICE VARIETAL TRIALS

3 months varieties



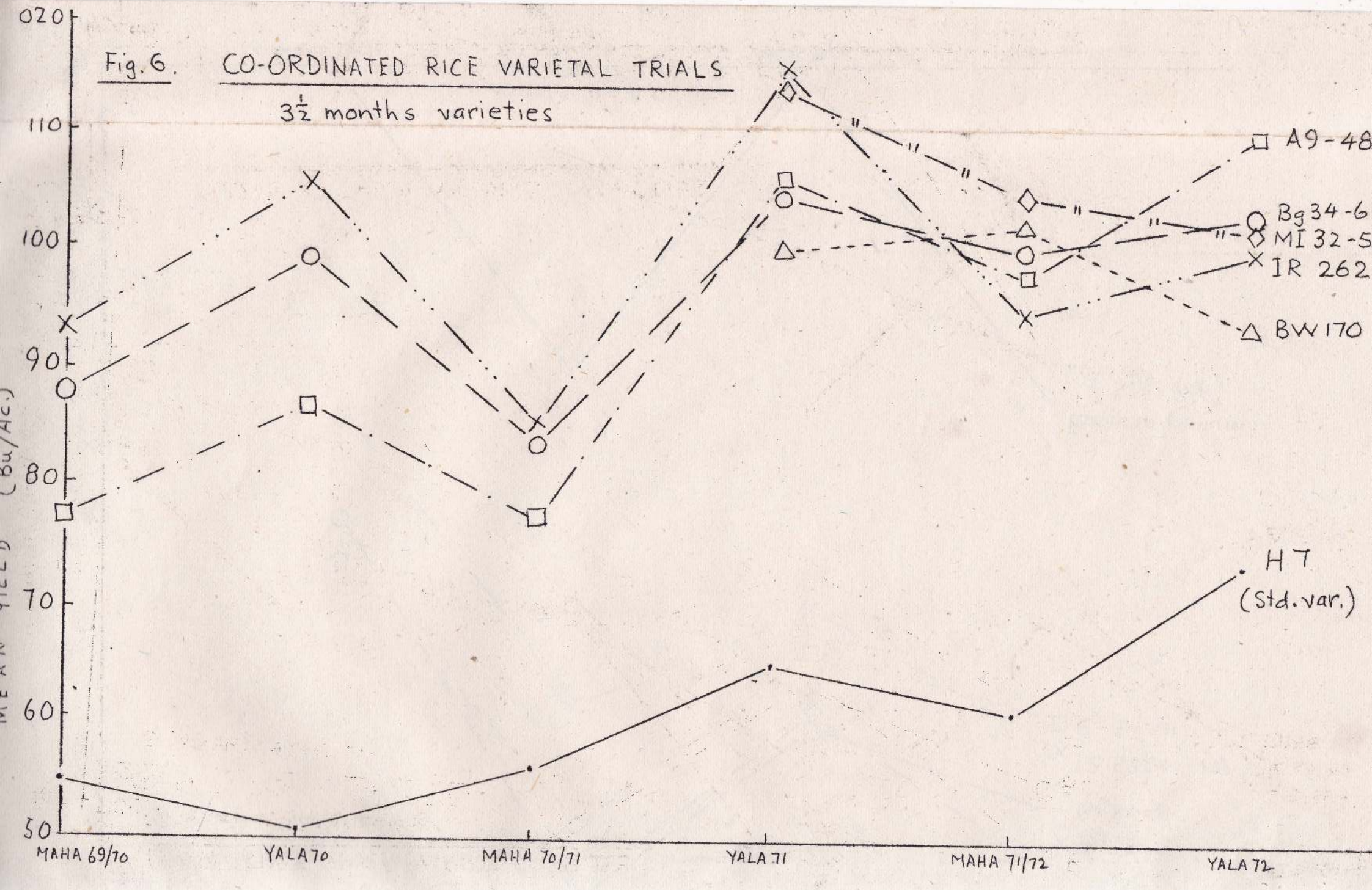


Fig. 6. CO-ORDINATED RICE VARIETAL TRIALS
3½ months varieties
020
110
100
90
80
70
60
50
MEAN YIELD (Bu/Ac.)
A9-48
Bg34-6
MI32-5
IR 262
BW170
HT
(Std. var.)
MAHA 69/70
YALA 70
MAHA 70/71
YALA 71
MAHA 71/72
YALA 72

FIG. 4. POTENTIAL FOR SELF-SUFFICIENCY IN RICE

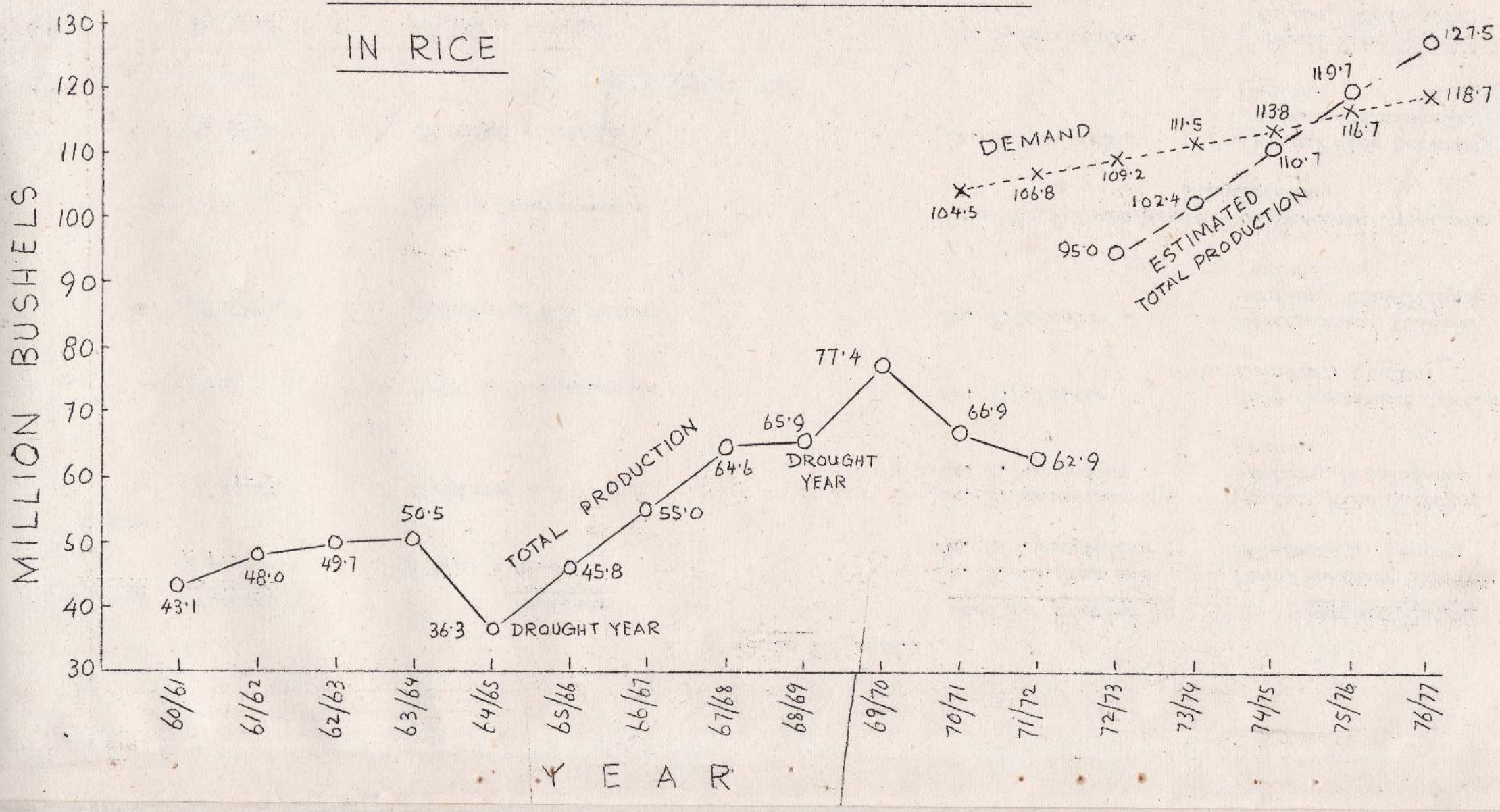


Table 6 (Contd..)

Age group	Variety	Pedigree	Bred or Selected by	Station/Country
3. 4-4½ Months	A 11-40	K 8(m) x 66-404	Dr. I.P.S.Dias and Mr. G.A.Gunatilake	Paddy Research Station, Ambalantota, Ceylon.
	Bg 11-11	(Engkatek x H 8) x H 8	Dr. H.Weeraratne and Mr. N.Vignarajah	Central Rice Breeding Station, Batalagoda, Ceylon.
	L9 66	H 501 x Deo-geo-wogen	Mr. P.E.Peiris	Rice Experiment Station, Labuduwa, Ceylon.
	MI 273(m)	Irradiated H 4 Mutant	Mr. P.Ganeshan	Agricultural Research Station, Maha-Illuppalla Ceylon.
	IR 8	Peta x Deo-geo-wogen	From the International Rice Research Institute, Philippines.	
	Bg 66-1	IR 8-246 x Remadja	Dr. H.Weeraratne	Central Rice Breeding Station, Batalagoda, Ceylon.
	Cy 90-2	IR 262 x Remadja	Dr. H.Weeraratne	Central Rice Breeding Station, Btalalgoda, Ceylon.

S U B S I D I A R Y F O O D C R O P S**

by

G. W. E. Fernando,
Agricultural Research Station
Maha - Illuppallama.

Sri Lanka's economy is founded on Agricultural Production with rice as the pre-eminent food crop and the basis for a large part of village agriculture. The plantation crops tea, rubber and coconuts provide the main overseas funds on which depend the imports of a great variety of manufactured products and of additional rice and other food stuffs.

Ironically enough, this country though primarily agrarian in economy and with all favourable natural resources for the production of a wide range of food crops, had to depend largely on imported food items which made many critics of our national economy predict a gloomy future. The present Five Year Plan emphasises that the two major constraints determining the possible rate of growth of the economy are the shortage of foreign exchange and the shortage of savings and to overcome the shortage of foreign exchange. The plan emphasises an export plan which embraces the traditional crops and a wide range of new crops on the agricultural side and a wide variety of industrial exports. The plan relies heavily on import-substitution in agriculture of which rice, chillies, onions andd pulses are obvious examples. The import figures of a few commodities for the period 1969 to 1971 are given in Table 1.

TABLE - 1

Value of Imported Commodities
Annual Average 1969-1971.

Commodities	Value in Million of Rupees
Rice	257
Sugar	176
Cotton	153
Pulses	62
Milk Products	51
Chillies	27
Onion	16

The average annual export earnings of the country for the 3 years from 1969 to 1971 amounted to Rs.2,200 million and value of imports into the country for the same period was Rs.2,400 million. Therefore, a considerable amount of the foreign exchange was expended on the imports of several commodities which can be produced in this country.

The foreign exchange crisis has hastened the arrival of the green revolution so much so that Sri Lanka is expected to achieve self-sufficiency in the near future and has achieved self-sufficiency in potatoes, chillies, onions and green-gram. The central figure in this great transformation will be or has been the farmer who had been erroneously called a conservative. The spurt in demand for high yielding varieties of rice in recent years has beli ed the concept of the cultivator as a traditionalist. In fact so good has been the response to the adoption of high yielding rice varieties by farmers, it is possible to achieve self-sufficiency in rice in a few years from now.

** Paper read at the C.A.A.S.Symposium on current Scientific Research and its relevance to the development of Sri Lanka on 17.8.73.

Areas of Production:

The development of plantation crops notably tea, rubber, coconut, coffee and cocoa in the Wet Zone has resulted in a change in the economy of Sri Lanka during the last century but the present trends in the world market indicate a gloomy picture for those plantations crops. Up to early 1960's, the greater part of the island's requirements of agricultural products were cheaply imported and this gave no incentive to the development of local agriculture. This is particularly true of the Dry Zone of Sri Lanka which remained under-developed and under-populated whilst in the Wet Zone, the population increases began to create increasing demands for land. As a result, agricultural expansion in the Wet Zone is limited and the greatest potential for the cultivation of annual crops, such as rice, maize, sorghum, chillies, onions, pulses, oil crops and industrial crops lies in the Dry Zone of Sri Lanka where a marked dry period exists for the ripening of various crops. It has been estimated that even with the maximum development of our irrigation potentialities, an extent of over 2.5 million acres will still remain unirrigable. The research station at Maha - Illuppallama is intensively engaged in developing systems of irrigated farming in anticipation of the Mahaweli Divsrsion project which will bring an additional 71000 acres of new land for the cultivation of rice and non-rice crops. Nevertheless, the need to continue research into problems of rainfed farming will remain because large areas of arable land in the dry zone which will not receive the Maha weli waters will have to be cultivated under rainfed conditions.

New Concepts in the Improvement of Plant Type:

The breeding work in Sri Lanka during the past two years has been greatly influenced by the concept of improved plant type, which has proved so very useful in the improvement of rice in India, Phillippines and Sri Lanka and Wheat in India. Rice and Wheat have been the two most intensively investigated crop plants but inspite of a long history of research, it was found necessary in recent years to give them a new form to improve their productivity. Based on those findings, the research workers have made a re-examination of the plant type in several other groups of crops such as maize, sorghum, chillies, pulses etc. A major reconstruction of the plant type in most crops has required a reduction of their spreading and tall growth habit so that more plants can be raised per unit area of land. Associated with this, there has been the improvement in their harvest index (weight of grain/total plant weight). Another major breeding objective in recent years in crops like pulses has been to cut down their excessive vegetative growth, and reduce their maturity duration. This latter attribute is most important as it helps to increase the per day productivity of the crops and makes it possible to fit them in more intensive cropping patterns. The influence of plant type on yield in a few selected crops is shown in Table 2.

TABLE - 2

Influence of Plant Type on yield (Lb. per acre)

	Improved Plant Type		Improved Plant Type	
	Variety	Yield	Variety	Yield
Rice	H4	3000	BG 11-11	5600
[illegible]	Pachchaperumal	1800	BG 34	5000
Chillies	Mahilay	700	MI Hybrid	1200
Sorghum	Thambagala	2000	IS 2941	4500
Toor Dhal	T 64	1700	MI 10	2500
Green Gram	MI 1	2900	MI 3	3400
Okra	H-10	12000	MI 5	18000
Cowpea	Arlington	1500	MI 35	1500

Within the time available to me, I shall be able only to touch on a few of the more important crops and to try to highlight some of the more important problems that exist in this connection.

Red Onions:

The five year plan estimates that the total demand of red and large onion in 1976 will be around 2,400,000 Cwt. According to the estimates of production, the country is almost Self-sufficient in the production of red onions and red onions have almost completely replaced the Bombay onion in the food habits of the people. However, due to the operation of certain factors, there are in fact two periods of scarcity, one in December, January and the other in June. The December, January scarcity has been attributed to the difficulties in growing the crop of red onion during October to December due to heavy Maha rains. The scarcity in June is attributed to the fact that Jaffna Peninsula does not grow this crop in May and June because the sowing seasons are March, April and July. The average yield of red onions is in the range of 5 tons per acre and the growth duration is about 60 to 70 days. There were no imports of red onions since 1968 and the prices have now stabilised between 60 cts. during peak production to about 1.50 during the off seasons.

Bombay Onion:

The cultivation of Bombay Onion has not spread as there are technological problems which are yet to be overcome. This crop has been grown successfully during the Yala Season (April to September) in the Dry Zone. Its cultivation during the Maha Season (October to March) is limited due to the incidence of a physiological disorder commonly referred to as "tip drying" at the nursary stage. Recent findings have shown that a night cover is effective in controlling this disorder during this season where heavy dew is experienced.

The recommended variety is Poona Red, an introduction from India. Other promising varieties are Tropicana Hybrid and Red Creole. The yield is around 5 to 6 tons per acre and the net income including labour is around Rs.8500/- per acre.

Chillies:

Sri Lanka imported 300,000 to 400,000 Cwt. of dry chillies at an average cost of about Rs.35 million. The local production was estimated to be about 150,000 Cwts. in 1971 and the anticipated demand in 1976 is around 600,000 Cwts. After the total ban on import of chillies and the establishment of a free market, the prices rose from Rs.20/- to Rs.30/- per pound. With increasing local production, the price has fallen to about Rs.5/- to Rs.10/- per pound. The increased prices have compelled the consumer to (i) reduce the level of consumption and (ii) to grow their own domestic requirements in chenas, fields and home gardens.

The variety popularly grown in Sri Lanka is Maha - Illuppallama Hybrid, a cross between Myliddy x Tuticorin. It is a variety with a very high yield potential and with all the desirable qualities for the production of dry chillies. The yields and net income which have been obtained by the cultivation of this variety from a few selected farmers from the Muthu-Iyan Kaddu Colonization Scheme are given in Table 4. It will be seen that very high yields have been realised by these farmers under ensured irrigation and good management conditions. On an average the yield is around 10 Cwts. per acre under irrigation and the net income is about Rs.6,600/-.

TABLE 4

Yields and Income from 10 Chillie Farmers at Muthu Iyan Kaddu.

Contd. on Page 4

Name of Farmer	Extent (acres)	Yield (Cwts.)	Net Income (in Rupees)
1. E. Kanagaratnam	1¼	23	11,700.00
2. S. Nadaraja	1	20	10,440.00
3. S. Mylvaganam	1½	25	12,300.00
4. T. Theivendram	1½	18	10,000.00
5. S. Tharmaraja	1	10	4,500.00
6. S. Suntharalingam	1½	21	14,400.00
7. S. Seevaratnam	1½	24	14,700.00
8. S. Kanagaratnam	2	34	16,450.00
9. R. Theivendram	1½	24	12,380.00
10. K. Kuddithamby	1¼	19	10,000.00

Recently another selection has been isolated from the variety MI Hybrid and this strain has been identified as MI-2. MI 2 is a dwarf plant with narrow leaves and long pods which are more pungent than MI Hybrid. The yield potential in both varieties is similar but the rate of spread of leaf curl-complex in MI 2 appears to be less than that of MI Hybrid.

Almost the entire acreage of chillies during the Maha season is grown in chenas under rainfed conditions and the average yields rarely exceed 4 to 5 cwts. per acre. The low yields can be attributed to the use of long age varieties which invariably suffer from water stress during the tail end of the Maha season. Thus a major objective in the chillie breeding programme under rainfed conditions is to evolve a short age variety (4 to 4½ months) which will fit into the rainfall pattern during the Maha season and which will minimize crop failure due to drought in late January and early February. A research programme on these lines is in progress and several promising lines have been isolated from the cross MI Hybrid x Santaka. It will not be long when several strains with diverse morphological characteristics will be available for cultivation under rainfed conditions.

The influence of plant population on the yield of chillies under rainfed and rainfed + supplementary irrigation is shown in Table 3.

TABLE 3

Influence of Spacing and Method of Irrigation on the yield of chillies (lb. dry chillies per acre)

Spacing	Rainfed	Rainfed + Supplementary Irrigation	Average
1½' x 1'	1063	1468	1265
2 ' x 1'	926	1236	1081
2 ' x 1½'	746	1188	967
2 ' x 2'	601	940	770
Average	834	1208	-

The results permit the following conclusions -

(1) Yields can be increased by increasing the plant population per acre.

(2) the provision of a few supplementary irrigations during periods of water stress can enhance yields considerably.

....(5)

Studies on the Direct Seeding of Chillies:

Chillies are normally transplanted in the country but the techniques of raising seedlings in nurseries present problems. Apart from a need to master the techniques of nursery management transplanting increases labour inputs and delays the establishment of nurseries due to shortage of water in some locations. On the other hand direct seeding has many advantages over transplanting. The main advantages are uniform germination and establishment, early flowering, high yields and low incidence of leaf curl. This problem has been studied at Maha Illuppallama for the last few seasons and successful crops by direct seeding have been established. The results are shown in Table 4.

TABLE 4

Influence of Seed Treatment on the Yield of Direct Sown and Transplanted Chillies.
(Cwt. per acre of dry chillies)

	Treated Seeds	Untreated Seeds	Average
Direct Sown	21.94	19.80	20.87
Transplanted	17.02	14.05	15.52
Average	19.48	16.92	-

The treatment of seeds by alternate wetting for periods varying from 24 to 48 hours followed by subsequent drying prior to seeding hastened germination. Untreated seeds often take 8 to 14 days to germinate but seedlings from pre-treated seeds will emerge in 4 to 5 days after seeding.

The direct seeded plots matured two to three weeks earlier and gave appreciably higher yields than the transplanted crop. In both transplanted and direct sown plots, higher yields were obtained when treated seeds were used.

Major problem that was limiting the yield of chillies and acting as a deterrent to the expansion of chillie cultivation was the occurance of disease which is commonly referred to as the "Leaf Curl Complex". The leaf curl complex is caused by thrips, mites, white flies and the incidence of virus at a later stage of the crop. Trials carried out in several locations have clearly indicated that the leaf curl component due to thrips, mites and white flies can be effectively controlled by the application of a number of insecticides. On the basis of this findings, Fenitrothion, an effective and economic insecticide with low mamalian texicity was recommended with a sulphur component. As seen in Table 3 these recommendations have produced excellent results.

Pulses:

The pulses include species belonging to the family Leguminosae which are cultivated for their edible seeds. Because they are high in protein, the pulses provide a major source of protein in the diet of the rural population. In the Five Year Plan (1972-1976) priority has been given to the cultivation of pulse crops since a high potential for growth exists in this hitherto neglected field.

Pulses form an important constituent of the daily diet. A large variety of pulses such as lentils, green gram, black gram, cowpea, toor dhal, horse gram and peas are consumed in the country. A study of the per capita availability of pulses in the country reveals that their average consumption over the 12 year period 1956-67 was 6,83 kgms. per annum. This availability is only about half of the per capita nutritional requirements of 12.77 kgms. per annum (or 35 gram per day).

....6

In many countries of the world, the enhancement of the quality of food through a shift to the plant - animal - man-food chain would not be easy in view of the scarcity of grains and rapidity of growth of the population. The animal food chain is too expensive in terms of energy conversion and it is here that there is an urgent need to develop varieties of grain legumes which are high in the content of essential amino acids.

With the exception of lentils and bengal gram, many of the traditional pulse crops such as green gram, black gram, horse-gram, toor dhal and cowpeas can be cultivated successfully in Sri Lanka. Work at Agricultural Research Station, Maha Illuppallama has shown that toor dhal, and a variety of cowpeas known as MI 35 can be used as direct substitutes for lentils. The question therefore is to formulate a policy which will encourage -

1. The development of these pulses which have been traditionally grown in the country.

2. The development of suitable substitutes which can be grown to replace lentils and chick pea.

Green Gram:

Green gram is the most popular pulse crop that is grown in Sri Lanka. It is traditionally grown in chenas, mixed often with cereals like Kurakkan and Maize. The current yields of green gram under field scale do not exceed 5 cwts. per acre and consequently to meet the current demand of 233 thousand Cwts. the total area required for this crop would be approximately 47,000 acres. It should however be emphasized that this yield is achieved under poor management conditions practiced in chena cultivation. If the crop is cultivated under settled and irrigated conditions the yields would be substantially greater.

The varieties recommended by Department of Agriculture are ML-1 and ML-2, and the demand for these varieties has been increasing. Several recent introductions from India have shown promise (Annex 1).

Toor Dhal:

Toor dhal is the second major import item in the pulse group. Toor dhal can be easily established with the early October showers during the Maha Season and the crop may be harvested in January or early February. Our investigations reveal, that in addition, two ratoon crops are possible from the same crop. The varieties T64 and T85 have been recommended by the Department of Agriculture for a long time but they never became popular with the cultivators and is barely grown at present in the country. The recommended varieties T64 and T85 grew to a height of over 10 feet and effective spraying of insecticides for the control of pod borers is not possible. The main limiting factor in extending the cultivation of this crop has been the occurrence of severe pod borer damage caused by a number of insect species.

The Agricultural Research Station, Maha-Illuppallama has now bred a dwarf variety of toor dhal which rarely attains a height of 4 feet. The dwarf dhal variety is a cross between varieties T64 x Trinidad. This new dwarf strain can be described as the "wonder drop of the dry zone". The outstanding characteristics of the dwarf variety are:-

1. It is an ideal crop to be grown in chenas of the dry zone under rainfed conditions.

2. It is very highly drought resistant and can withstand long periods of drought.

3. The crop can be ratooned at least twice, so that it is possible to obtain 3 harvests from the same crop.

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4. Grain yields ranging from 3000 to 4000 lbs.per acre per annum have been obtained under experimental conditions.

5. This crop can be grown during the first year, second year or in abandoned chenas.

6. This crop will aid farmers in developing settled systems of farming in chenas under rainfed conditions in the dry zone.

7. The dwarf habit of the plant permits effective and easy spraying for the control of pod borers.

8. The dwarf toor dhal can be a valuable source of fodder and a browse plant in pastures for dairy cattle.

The new strain has been released to the extension service last year and it has been readily accepted by the cultivators. In 17 demonstration plots in cultivators fields, yields ranging from 1000 to 1500 lbs. per acre have been recorded from the first harvest.

Toor dhal can be direct substitute for lentils and is widely consumed as a pulse crop throughout the island.

Ground Nuts:

Improvements in yields have been made through selection an several varieties have been recommended for cultivation. These include A.20, A.92, Uganda erect and Red Spanish. Recent investigations indicate that several new varieties have shown promise. (Annex 1). The results also indicate that the yields of ground nut can be raised by 100 percent when the crop is grown under irrigation The entire production of ground nuts is now utilized for direct human consumption.

Soyabean:

Very little attention has been given to the cultivation and utilization of soyabean as a pulse crop even though it is widely used as food crop in China, Japan, Taiwan and other adjacent countries. Although soyabean hasbeen cultivated on an experimental scale for a sufficiently long time in Sri Lanka, it did not gain pupularity as a crop for a number of reasons. These are -

1. Non-availability of varieties which are adapted to tropical areas.

2. Lack of technolo ical research in developing the industrial utilization of soyabean as an oil crop.

3. Performance for other pulses to the soyabean as a protennceous crop.

4. Lack of marketing facilities and price incentives.

It is only during the last three years that soyabean has assumed some importance in the cropping patterns of the Department of Agriculture. Many soyabean varieties which are suitable for tropical region have been bred and the recommended varieties at present are:-

TK No.5, Tainung (R1) and Hernon.

Sri Lanka imported Rs.50 million worth of milk products and the present 5 year plan (1972-1976) hopes to achieve self-sufficiency in milk products while meeting the demand for liquid milk at current levels of per capita consumption. One of the primary requirements for any successful animal husbandry programme is the availability of high quality food. Ceylon imports a large quantity of fish meal as a protein supplement for live stock. It is felt however, that soyabean cake left after the extraction of oil can

completely substitute fish meal when fortified with the addition of some amino-acids like methionine. According to the Five Year Plan, the animal food industry will need 4600 tons of fish meal in 1973 and this will increase up to 6500 tons in 1976. In terms of soyabean the quantities needed are approximately 6000 tons in 1973, increasing up to 8600 tons in 1976. On this basis, the acreage needed under soyabean will vary from 12000 acres in 1973 to 17000 acres in 1976 to meet the requirements of the animal industry. This target can be easily achieved if a reasonable price is fixed and marketing facilities to purchase the crop at the village level are established. With the phenomenal increase in the price of milk foods in the world market, soyabean was assumed special recognition as a direct source of protein in the diet. Much attention has also been focussed in recent years by various institutions on the production of soyamilk in Sri Lanka. Milk in unlimited quantities can be produced from soyabean. One pound of soyabean seed will yield 10 pounds of soya milk. On this basis an acre of irrigated soyabean will yield 20,000 lbs. of milk in three months. The corresponding milk yield for an acre of irrigated pasture for the same period would be around 3000 lbs. and 1500 lb. for European and Indian breeds of cows respectively. These figures are based on a stocking rate of two animals per acre. the European breeds giving 20 lb/cow/day and Indian breeds at 10 lb/cow/day. It is estimated that 10,000 acres cultivated annually will produce the short-fall in milk requirements.

Soyabean is the most important legume crop as raw material for industry. Soyabean is processed in a variety of ways to yield a wide range of edible and industrial uses. On account of the composition of its insaturaters, soya oil offers special usefulness for the manufacture of hydrogenated compositions eg. margarine and shortenings for bakery trade. Soyabean is widely used in the industrial production of antibiotics because it is a rich source of protein oil, calcium, phospharus, iron and several vitamins. The soyabean seeds are consumed green, dry or sprouted. The seeds are processed to give meat and milk-like products, curd, cheese or sauce.

Cowpeas:

Cowpea is an important leguminous crop which is grown widely as a grain and vegetable crop. Of the two departmental selections, Bombay Cowpea and Arlington which are used as grain crops, the latter has outstripped the former in popularity despite its lower yields. The variety Arlington has many of the desirable qualities of lentils and has been recommended as a dhal substitute But the search for better dhal substitutes led to the evolution of a new hybrid known as MI 35 or "Lanka Parippu".

The maturity of MI 35 is uniform and the entire crop can be harvested in one or two picks, within 60 days after planting. This is an ideal substitute for dhal and the palatability and cooking qualities are identical with that of masoor dhal or lentils. Under good management conditions, yields of 1500 to 2000 lbs. per acre can be obtained.

Maize:

For many years the recommended variety of Maize was T.48, a local open pollinated variety but this variety has been replaced with two promising varieties namely (1) Thai Composite and (2) Cupurico X Flint Campestro. The optimum plant population for these varieties should be about 20,000 plants per acre with a spacing of 2½' by 10". There is a good response to nitrogen upto about 80 lbs. N/acre but there has been no marked response to P & K.

Sorghum:

The variety which was recommended earlier was a tall variety known as Thambagalla. Recently we have identified

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a high yielding dwarf variety, IS 2941. This variety is becoming increasingly popular with the cultivators. Yields as high as 4,000 lbs. per acre from the main crop have been recorded. Another major advantage in this variety is that it lends itself to ratooning. Two to three ratoons can be obtained provided there is assured irrigation. The ratooned crop is also capable of giving similar yields as the main crop. At Trinity College Farm, under ideal conditions a yield of over 20,000 lbs. per acre per year has been recorded from the main crop and 3 ratoons. This is an ideal crop for the fallow rice fields during Yala provided one or two supplementary irrigation can be given. A major problem in extending the cultivation of maize and sorghum is bird and stem borer damage. Losses from the crop may be as high as 40 - 50 %. The stem borer has been successfully controlled with the application of Azodrin (Annex 4).

Irrigation of Subsidiary Food Crops:

Under the system of rainfed farming potential, yields of crops could not be realised since this was mainly governed by the total rainfall received during the growing season and its distribution. The crop yields may be adversely affected by the drought or excessive moisture conditions in the soil under rainfed conditions, but the cultivation of crops during the Yala season under irrigation would offer the greatest potential for agricultural production.

Study of plant responses in relation to their water supplies had indicated that as much as 50% enhanced yields can be obtained through irrigation. The studies also revealed that the low available water capacity of the reddishbrown earths and the shallow depths of the effective root zone of most crops, which seldom exceed a foot, impose some limitations to irrigation practices in the dry zone. This will imply that light application of irrigation water is required at more frequent intervals which make it difficult to realise high efficiency in irrigation practices. The low efficiencies of irrigation, together with rainfall would cause the build up of the water table in the lower areas and therefore the provision of drainage in these areas is essential for maximal production.

The growing of subsidiary food crops in the paddy fields particularly the legumes had been successfully demonstrated. The water requirements of these crops are less than half that required for paddy. This is because 50% or more of the water losses from a flooded paddy field is through deep percolation. Thus the cultivation of subsidiary crops in paddy fields can render larger extents to be brought under cultivation with limited supplies of irrigation waters.

More research work is needed for conslusive experimental evidence concerning the best management practices for high yields of subsidiary food crops grown in different agro-climatic zones under rainfed and irrigated conditions. A ~~concentrated and~~ comprehensive research programme on these crops is currently in hand at the Agricultural Research Station, Maha Illuppallama.

Incentives for Production of Subsidiary Food Crops:

(a) Credit Schemes:

Some of the crops dealt earlier are at present supported by credit schemes. These schemes should be maintained and the feasibility of extending the credit schemes to cover other crops not served by credit at present should be carefully evaluated. At the present time there are serious difficulties in formulating credit schemes to cover all these crops. For instance some of these crops are grown on a small scale and have no recognized marketing arrangements through recognized institutions to enable recovery of credit granted. It is not advisable to launch a

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credit scheme without safeguards for recovery. There is also the further difficulty that the cultivation of some of these crops in themselves at present levels of management may not bring adequate returns to enable farmers to repay the loans. This difficulty will gradually disappear when these crops are grown in a farming system and the per acre yields increase through the use of high yielding varieties and improved management. In real farming conditions, a farmer may need short term credit for a variety of farming operations. His ability to repay the credit will also depend on the success with which his manifold farming operations work together in his farm. A credit system must therefore aim at the total farm rather than on a single crop. Such a credit scheme can be evolved only when farm plans even of an elementary scale are used by the farmers.

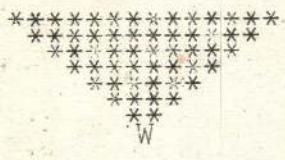
(b) Extension:

With the rapid changes that are taking place in agricultural technology, new needs for education among farming communities have now arisen. Short term training courses based on the most frequent needs received from farmers such as the cultivation of crops, training in the repair and maintenance of tractors and pumps must be organised for the benefit of the farmers. The optimum farm size that a family Unit could handle appears to be in the region of 2 to 3 acres and a land unit of this magnitude cannot be cultivated with hand implements without resorting to mechanization. The mechanization of agriculture must develop with momentum. The opportunities for rapid agricultural advance in Sri Lanka are indeed great. We have the technical know-how and the will to act.

(c) Organization for the Supply of Improved Seed Material:

There is no organized institution for the supply of improved varieties of crops with the exception rice and vegetables. Numerous requests are received from the members of the public for the supply of seed material of improved varieties. Therefore an organization for the distribution of improved seeds, similar to that of rice is necessary. The seed material should be multiplied in Departmental Farms which in turn should issue the seed to registered seed farmers for multiplication as in the case of rice.

Apart from the above, many other aspects of agricultural production need consideration. Among them are the small size farming facilities particularly of perishable farm products, transportation problems insecure markets and the entire problem of chanelling technical information to the farmers with a view to improving their farming systems.



Annex - 1

CROP RECOMMENDATIONS FROM AGRICULTURAL RESEARCH STATION MAHA ILLUPPALLAMA

Crop	Name of variety	Date of release	Source	Remarks
Chilli	MI Hybrid	1962	A selection from Mylidy x Tuticorin	
	MI 2	1973	A straight selection from MI Hybrid	
Bombay Onion	Poona Red	1962	Introduction from India.	
Maize	T. 48	Not known	Not known	
	Thai Composite	1973	Introduction from Thailand	
	Cupurico x Flint Compesto	1973	"	
Sorghum	Thambagalla	Not known	Not known	Tall variet
	IS 2941	1971	Introduction from Thailand	Dwarf type
Kurakkan	MI 301	1968	Not known	
	MI 302	1968	"	
Toor Dhal	T 64	Prior to 1960	Introduction from India	Tall variety 8'-10' in height.
	T 85	-do-	-do-	-do-
	MI 10	1969	A selection from T 64 x Trinidad	Dwarf 4'in height
Green Gram	MI 1	1960	Selection from an Indian variety.	
	MI 2	1960	Local selection	
	Type 51	1970	Introduction from India	2 months variety
	MI 3	1973	Selection from an Indian variety	
Black Gram	MI 1	1960	Local selection	
Gingelly	MI 1	1960	Selection from an Indian variety	
	MI 2	1960	-do-	
	MI 3	1960	-do-	

Annex 1 Contd.

Crop	Name of variety	Date of release	Source	Remarks
Ground Nuts	Red Spanish	1960	Introduction from New Guinea	
	Uganda Erect	1960	Introduction from Africa.	
	A 20	1960	Introduction from Congo.	
	A 92	1960	-do-	
	MI 1	1973	Selection from MI	
	MI 3	1973	A selection from an Indian variety.	
Cow Pea	Bombay Cowpea	1960	Introduction from India.	
	Arlington Cowpea	1960	-	Creeping type.
	MI 35 (Lanka Parippu)	1973	Selection from Avlingtob x Floricream.	60 days Bushy plant type
Soya Bean	Hernon	1969	Introduction from U. S. A.	110 to 120 days.
	Tainung (R1)	1970	Introduction from Taiwan	80 to 90 days.
	TK No.5	1970	-do-	-do-
Sweet Potatoes	Norin	1969	Introduction from Japan	60 day variety.
	Wariyapola	1969	Local selection	-do-
Okra	MI 5	To be released	A selection from H.10 x Jaffna local	Virus Tolerant s
	MI 7		-do-	
Kang Kung	MI Kangkung	To be released		Upland variety
Snake Gourd	MI 1	To be released		Short podded less fibrous variety

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Annex 2

FERTILIZER RECOMMENDATIONS FOR SUBSIDIARY FOOD CROPS

Crop	Portion analysed	Yield Kg/Ha	Nutrients removed Kg/Ha					Fertilizer recommendation Kg/Ha		
			N	P	K	Ca	Mg	N	P	K
Chillies	Pods	2500	51	5	69	3	3	143	33	31
Shallot Onion	Bulb	13000	42	5	26	3	2	52	22	31
B. Onion	Bulbs	25000	60	9	41	10	4	60	22	31
Soyabean	Seed	2800	164	16	55	9	6	26	22	31
Toor Dhal	Seed	1800	55	4	26	3	2	39	22	31
Green Gram	Seed	900	34	2	10	1	1	26	22	31
Black Gram	Seed	1600	59	4	18	2	3	26	22	31
Ground nut	Shelled nut	1350	67	4	9	1	2	26	22	31
Cow-pea	Seed	1500	62	4	21	3	3	26	22	
Maize	Grain	3900								
	Cob	1300	116	11	154	32	25	44	22	31
	Stiver									

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RECOMMENDATIONS FOR WEED CONTROL IN SOME SUBSIDIARY FOOD CROPS

Crop	Herbicide	Dose in lbs/ai. per acre ai=active ingradient	Quantity of commercial product per acre.	Time of application and volume of water per acre	Duration of weed control from time of spraying	Commercial names of Herbicides	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Maize (Rainfed or irrigated)	Simazine 50%	2	4 lbs.	Pre-emergence Mix in 40 gls. of water	1½ - 2½ Months	Gesatop 50	No effect on emerged weeds
	Ramrod 65%	4	6 lbs.	Pre-emergence mix in 40 gls. of water	4 - 5 weeks	Ramrod	Soil must be moist at the tim of spraying
Sorghum Rio Sorghum	Prometryme 50%	1	2 lbs.	Pre-emergence mix in 40 gls. of water	3 Weeks	Gesagard	No effects on emerged weeds
	Ramrod 65%	2	3 lbs.	-do-	3 Weeks	Ramrod	-do-
Ground Nut (Irrigated or Rainfed)	Linuron 50%	1	2 lbs.	Pre-emergence mix 40 gls. of water	2 - 3 Weeks	Lorox or Afalon	Soil should be moist at the tim of spraying.
	Amiben 20%	4	2 gls.	-do-	5 - 6 Weeks	Amiben	-do-
	Planavin 75%	2	2½ lbs.	-d-	4 - 5 weeks	Planavin	-do-
	Ramrod 65%	3	4½ lbs.	-do-	3 - 4 Weeks	Ramrod	-do-
Soyabeans (Rainfed or Irrigated)	Ramrod 65%	3	4½ lbs.	Pre-emergence mix in 40 gls. water	2 - 3 Weeks	Ramrod	Spray after firs shower of rain or Irrigation.
	Linuron 50%	1	2 lbs.	-do-	2 - 3 weeks	Lorox or Afalon	
Cowpea (Rainfed or Irrigated)	Amiben 20%	2	1 gal.	Pre-emergence 40 gls. of water	2 - 3 Weeks	Amiben	Spray after firs shower of rain or irrigation.
	Linuron 30%	½	1 lb.	-do-	2 - 3 Weeks	Lorox or Afalon.	

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bombay Onions (Irrigated)	Ramrod 65%	4	6 lbs.	One or two days after transplanting and before the weeds emerge mix well in 40 gals. of water.	2 - 4 Weeks	Ramrod	No effect on emerged weeds.
Shallots (Red Onions) Irrigated.	Ramrod 65%	4	6 lbs.	After planting the bulb mix in 40 gals of water.	3 - 4 Weeks	Ramrod	-do-
Chillies (Rainfed or Irrigated)	Lasso 40%	2-3	4-6 pints	1 to 14 days after transplanting on a clean seed bed mix 40 gls. of water.	5 Weeks	Lasso	No effect on emerged weeds. One or two hand weedings may be given at 6-8 weeks after spraying. No toxie effects on chillie.

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MINOR EXPORT CROPS

by

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Department of Minor Export Crops and
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Project

INTRODUCTION

In the Government's development plans major emphasis has been placed on the need for improving the country's foreign exchange position in the medium and long term projections. This is expected to be achieved by (a) reaching self-sufficiency in essential commodities which are presently being imported but could be produced locally, primarily rice and secondarily sugar, cotton and food crops, (b) by reducing the importation of non-essential items, (c) by increasing the exports of agricultural and other products.

Although the bulk of the foreign currency earnings will continue to accrue from the main export crops, tea, rubber and coconut, the increase in the export of agricultural products is however not likely to come from these crops and will have to come mainly from the perennial minor export crops.

This denomination in Sri Lanka applies to: Cocoa, Cashew, Mulberry (for silk), Cinnamon, Papaw (for papain), Cardamom, Coffee, Oil Palm, Pepper, Nutmeg, Clove, Citronella, Lemon Grass, and possibly Pyrethrum, Cinchona & Vanilla. This list is not limitative, other perennials of interest may be added in the future. These crops have been assigned to the newly formed Department of Minor Export Crops under the Ministry of Plantation Industry.

POSSIBILITIES AND PLANS

Studies done earlier by the Government and in 1971 with UNDP/FAO assistance under the Agricultural Diversification Project of the Ministry of Plantation Industry, have shown the potentialities of certain crops more clearly for the Government to formulate development proposals under the Five Year Plan.

Cocoa - Over the next 10-15 years the world cocoa production is expected to increase about 3.5% per annum close to the rate experienced in the past, at a price projection of 25 U.S. cents per lb. for cocoa beans. Sri Lanka's present production would only represent about 0.5% of projected world production and would therefore not be exposed to any demand constraint for a very large increasing output.

Cashew - The world consumption could expand in the next few years at a yearly rate of 10-12%. In fact, the estimated world supply shortfall of Cashew kernel by 1975, 25,000 to 50,000 metric tons is equivalent to the production of nearly 450,000 acres of Cashew trees in full bearing age.

Mulberry (silk) - It has been established that silk is a fibre with a future and that its demand cannot be fully met even if the world production were to double itself during the next decade or so. FAO studies clearly reveal that the threat of natural silk, if at all, will not be from synthetics but could be due to its own short supply in the world market. The threat of a gradual decline in production has been obvious in Japan which accounts for over 50% of world production on raw silk. This is to be expected as a natural consequence of the shift from agrarian to urban based industrial economy in a developed country like Japan.

Cinnamon - Sri Lanka produces 60% of the world supply of Cinnamon. The export of cinnamon in the traditional form of quills is not expected to increase substantially. The best prospects appear to be a demand for high quality oil from adulteration; Cinnamon Bark Oil is more valuable and is relatively free from the threat of synthetics.

Citronella - Production could at most be maintained at the level permitting export at the present level of 200 tons. The demand for Ceylon type Citronella oil has declined during the last decade while that for the Java type has increased but here again there has been a slackening as the result of the spreading use of synthetic substitute. The best prospects appear in producing an oil of high quality and also in fractioning of its more valuable constituents.

Clove - Although Clove prices are at present very high, longer term expansion should be considered in the context of more normal supply conditions of clove price of around 40 US cents per lb. Any production Expansion undertaken should be on a mixed crop basis to avoid dependancy of small holders on a single crop whose earnings may fluctuate considerably. However, the prospects for Sri Lanka clove is good because of its better quality. For cloves as well as other oil producing crops as Nutmeg, the best prospects are in the production of distillates and of oleo-resins.

Coffee - There is at present no excess production over demand. Expansion in coffee production seems to be reasonable since output in Sri Lanka will have no impact on the overall supply situation on the world market. With the collapse of the International Coffee Agreement Market access in importing countries has been broadened.

Pepper - The long term outlook for the world trade in Pepper is good caused in particular by declining supplies from disease attacked vines in Indonesia. In addition, the Pepper Community is expected to exert a dampening effect on the substantial fluctuations in annual supplies accompanied traditionally by subsequent fluctuation in prices.

Cardamoms - Prospects for the production of cardamoms are favourable since output in virus disease struck India is still considerably below former levels. Competition with Guatemala on the quality market in the Middle East, however, is anticipated to become stiffer.

Oil Palm - The present possibility of replacing coconut oil and imports of other oils and fats by palm oil in the home economy has been put at about 15,000 tons. This output is from 8000 to 10,000 acres. The substitution of coconut oil locally will enable the release of a large quantity of coconut oil to the export market, but should palm oil fetch better prices, its export could be equally easy and profitable.

Papaw (Papain) - Because of the uses of Papain in the meat and beer Industries and owing to the lack of large production programmes elsewhere, the prospect of papain are considered good.

For pyrethrum, Cinchona and Vanilla, the prospects for the natural products are reported very good as against the present synthetic substitutes.

Based on these studies and beeause of problems that the major export crops are facing, government now considers that the development of minor crops a vital aspect of its development strategy. The development of such crops will reduce the nation's dependance on tea, rubber and coconut for a large slice of its foreign exchange earnings. It is a form of insurance against the vicissitudes of international trade. Also, particularly in the context of development of high yielding strains of tea, rubber in the face of slow expanding world markets there will be some land freed from relatively uneconomic tea and rubber which in terms of land capability would be more suitable for these minor crops. The development of these crops could considerably increase rural incomes and generate new employment.

The Five Year Plan 1972-76

In this context the Government has adopted the following development programme of these crops as a part of the Five Year Plan. This programme envisages an increase of the area under crops as well as intensification of cultivation of the existing plantings, depending on the future production prospects:-

Crops	Acreage planned for			
	New planting	Re-planting	Rehabili-tation	Fertilizer application
Cocoa	10,000	4,500	1,500	10,000
Cashew	25,000	-	3,500	3,500
Coffee	10,000	-	-	-
Mulberry	10,000	-	-	-
Oil Palm	5,000	-	-	-
Papaw	2,500	-	-	-
Cinnamon	(4,000)	5,000	5,000	25,000
Cardamom	6,000	-	5,000	-
Cloves	5,000	-	2,000	-
Nutmeg	2,000	-	-	-
Pepper	10,000	-	6,400	1,500
Citronella	-	-	15,000	15,000
Lemon grass	2,500	-	-	-
	92,000	9,500	38,400	

Assistance Schemes

The Implementation targets for the crops mentioned are fulfilled through the following Assistance Schemses for the different crops, which are operated by the Department of Minor Export Crops:-

NEW PLANTING, REPLANTING, REHABILITATION AND MAINTENANCE

New Planting - for lands which are being cultivated for the first time with recommended crops.

Replanting - where existing crop is very poor due to senility but the conditions are good for planting the crop over again.

Rehabilitation - where there is some amount of good bearing plants but the poor plants need replacement.

Fertilizer Application in existing cultivations

The Assistance will be in cash or in kind

In Cash

(a) Subsidies or grants are payable in instalments by the Department of Minor Export Crops.

(B) Long-term loans payable in varying instalments by the Peoples' Bank and Rural Banks. Repayment is scheduled only from the year when the borrower earns an income from the cultivation. The loan is thereafter repayable in 5 annual instalments. The rate of interest is subsidised.

In Kind

(a) Free planting material, from government to government approved nurseries.

(b) Fertilizer at half cost.

(c) Free Agro-chemicals (Pesticides), where there is an outbreak of disease.

This assistance is available to persons who have applied for assistance and are permit holders of the Dept of Minor Export Crops.

In the case of installation of new units for extraction of essential oils and oleoresins and rehabilitation of existing plants, it is proposed to give financial assistance as grants after evaluation of each project. The Peoples' Bank will also consider grant of loans in these cases.

At present, this assistance applies to the crops mentioned in the above table. However, continuous studies are being made to identify other crops and hence the current list should not be considered as final.

RELEVANCE OF RESEARCH

In order to carry out a development programme of the magnitude proposed, it is essential to have sound research support by providing superior planting material, suitable fertilizer mixtures for the different crops, methods of pests and disease control and superior knowledge of the

culture of the crops and processing techniques and quality standards to meet the International Market requirements. It is very necessary to get optimum yield of crop in relation to resource inputs, at the lowest possible unit cost of production to enable to be competitive in the world market.

Past Research

Unfortunately, little research or experimental work has been performed locally on minor export crops in the past. In the 1930s and 1940s, the Dept of Agriculture carried out preliminary trials in introducing crops like Pyrethrum and cinchona, and also did studies on cultural aspects of Cocoa, fertilizer experiments on Citronells. But these were not carried to conclusion. In the 1960s introduction of improved coffee varieties (S-274 and S-795) and a number of varieties of Malayan and Upper Amazon Cocoas were done. It is surprising that even a crop like cinnamon which supplies 60% of the world requirements had not got any significant attention.

This meagre attention given to minor crops research was perhaps due to the reason that the emphasis, at that time, was on tea, rubber and coconut (and latterly on paddy). This is understandable on the basis of the economy of the country which was dependent on these crops and because of the paternalistic attitude of the government of the time for the main export crops.

However, the minor export crops have been grown in this country for many years. There is promising local material and some local experience to make a start with the programme.

Project on Research and Experimentation

Simultaneously with the initiation of the development programme it has however, become necessary to commence on a comprehensive Research Programme. We have therefore taken action, under the Ministry of Plantation Industry, to organise a separate "Project on Minor Export Crops Research & Experimentation" to ensure that the required programme of research and experimentation is carried out, on a priority basis.

Although it would appear desirable to create and support a full pledged Institute for working on these crops, we are not in a position, presently to do so. The Dept of Minor Export Crops is not staffed yet to undertake its own research and investigations. The solution adopted is to make the maximum use of all the facilities and personnel already available in the country, within the framework of a co-ordinated programme of work. This means that the existing Institutes such as the Central Agricultural Research Institute which is already handling most of the crops, the Tea Research Institute, the Rubber Research Institute, the Coconut Research Institute, the Ceylon Institute of Scientific and Industrial Research, the Faculty of Agriculture of the University of Sri Lanka and the Minor Export Crops Dept will take up part of the investigation on the crops and it is proposed that each body takes full responsibility on the execution of the Research and Experimentation Programme on the crops assigned to it. The Minor Export Crops will be shared between these Institutes, at present, as follows:-

TRI - cardamom, pyrethrum, cinchona; RRI - oil palm, ramie;
CRI - cashew; CARI - pepper, cloves, nutmeg, cinnamon, vanilla, citronella, papaw (papain); University of Peradeniya, Faculty of Agriculture - lemon grass; Minor Export Crops Dept - cocoa, coffee (arabica and robusta) including their processing.
CISIR - Research on the processing and/or analysis of the crops or raw products, with emphasis on essential oils and oleoresins. (At an earlier session of this Symposium Dr R.O.B.Wijesekera read a paper on the 'Industrial Uses on Minor Export Crops'. The work referred to in that paper is part of the activities that has been assigned to the CISIR under this programme).

In Mulberry (Sericulture), the programme of development and research warrants special attention. Therefore, a special project with UNDP/FAO assistance has been set up separately to fulfill these needs; it is functioning under the Dept of Minor Export Crops, with its Headquarters at Pallekelle.

UNDP/FAO Assistance

This Research and Experimentation project is supported by UNDP/FAO, which will provide foreign experts where local experience is lacking e.g. in cocoa, coffee and short term Consultants in other activities such as oil palm production and processing of minor export crops. In addition necessary equipment and material will be provided by the UNDP/FAO all costing $425,000. This UNDP assistance will be for 3 years.

The local personnel required will be recruited by the Dept of Minor Export Crops and will be lent to the Institutes as required. Financial provisions for the carrying out of the experiments will also be provided under the Dept of Minor Export Crops. A main research station (at Matale) and sub-stations in the different agro-climatic zones are being established by the Dept of Minor Export Crops where already land facilities for experimentation are not available with the Institutes at present. In the fields of Plant Pathology, Entomology and Soil Science, this Project will however rely heavily on the co-operating Institutes.

As mentioned earlier an UNDP/FAO supported Sericulture Project is functioning separately and providing the necessary experts and equipment for the Sericulture programme. The UNDP/FAO Sericulture Project is for two years and the financial assistance provided is US $275,000.

Standing Committee

The overall responsibility of the programme of research and experimentation on Minor Export Crops will be with the Standing Committee under the Ministry of Plantation Industry. The collaboration of the Institutes and other organisations as well as the allocation to them of specific activities and of crops is governed by this committee, the composition of which is as follows:-

Secretary, Ministry of Plantation Industry - Chairman
Director of the C.A.R.I. Dy.Director (Research) of Dept of Agriculture
Director of the T.R.I.
Director of the R.R.I.
Director of the C.R.I.
Director of Minor Export Crops
Dy. Director of Agriculture (Extension)
Representative of the Faculty of Agriculture, University of Sri Lanka
Chief Adviser of the Project and his Counterpart Project Director
as well as the
UNDP Resident Representative and
Senior Agricultural Advisor/FAO Country Representative are also represented on this committee which serves the purpose of the project Steering Committee.

The Senior Advisor of the Agricultural Diversification Project is also co-opted to this committee to liaise the activities of the Agricultural Diversification Project and the Minor Export Crops Research Programme.

Lines of Action

The Research and Experimentation project will undertake all the necessary investigation on minor export crops in order to define the proper cultivation and production techniques; carry out the selection work and produce improved planting material for higher yields and resistance to pests and diseases; recommend methods of controlling pests and diseases; establish proper processing techniques of the raw material and demonstrate them.

The importance of a system of cultivation, whether as a plantation or as a small holding in the form of a mixed garden, is relevant to this programme. These studies are being undertaken by the UNDP/FAO supported Agricultural Diversification Project for the replacement of uneconomic tea and rubber with more profitable crops.

The extention of the research findings will reach the farmers and estates through the field staff of the Dept of Minor Export Crops. Demonstration and experimentation in the growers fields will be carried out along with the extension programme so that the research findings could simultaneously be tested in the field.

Government intends to support the research and experimentation work on minor export crops continuously and it is hoped that in due course the nucleus that is now being set up with UNDP/FAO assistance will grow into a permanent 'Research Institute' on Minor Crops.

C.A.A.S. SYMPOSIUM ON CURRENT SCIENTIFIC RESEARCH AND ITS RELEVANCE TO DEVELOPMENT

"RESEARCH ON TEA"

by

M.A.V. Devanathan

Director, Tea Research Institute, St Coombs, Talawakele

The Tea Research Institute of Sri Lanka was founded in the year 1925 after a prolonged agitation by the Planters' Association for a research institute to service, train personnel and carry out research for the tea industry of Sri Lanka. At present the TRI is the premier research institute for the tea industry of the world.

The institute started off with a temporary laboratory at "Lynfield" at Scrubs Estate, Nuwara Eliya. In 1928 St Coombs Estate which now houses the main laboratories was acquired. In 1935 Gonakelle Station was established for entomological studies and in 1961 the Low Country Station was established. Since then a clonal testing station was opened at Kottawa in 1963 and in 1964 a Mid-Country Sub-Station was set up at Hantane, Kandy, and a second Uva Sub-Station was opened at Agratenne. In 1972 work was started on newer laboratory facilities at St Coombs. The TRI network of stations covers the main agro-climatic zones for tea in Sri Lanka, with St Coombs covering the Up Country, Hantane Station the Mid Country, St Joachim covering the Low Country with the Uva district being serviced by two Sub-Stations at Gonakelle and Agratenne.

It would be useful to summarise the achievements of the TRI todate. In the first instance the TRI developed the now famous TRI 2020 series clones which form the backbone of the tea replanting programme. Techniques of vegetative propagation of these clones were also perfected by the TRI enabling the large-scale commercial production of nursery plants with almost 100% success.

For the nutritional requirements of tea, the TRI has carried out extensive studies on the levels of Nitrogen, Phosphate and Potash required. In this connection it may be noted that the first statistically designed fertilizer experiment in the world was set up at St Coombs by Dr Eden in 1931 and this experiment is continuing to give useful results.

In the area of crop protection TRI's research work illustrates the many types of pest control techniques which are available. In the first instance Blister Blight, which could have wiped out plantations in the same way as Hemileia vastatrix destroyed the coffee plantations, was stemmed by chemical control. The ravages of the tortrix caterpillar were eliminated by the introduction of the parasite Macrocentrus homonae, a classic example of biological control. The infestation of tea with Shot-hole Borer particularly in the mid country is being managed by cultural control methods, and in the case of the low-country livewood termite both chemical and cultural control methods are being applied. The fungal disease Poria hypolateritia has been kept in check by techniques of soil fumigation developed by the TRI using D-D and Methyl bromide. For the control of nematodes both Methyl bromide and Chlorine gas has been found to be effective. The above examples show that the TRI is engaged in a continuous study of all aspects of diseases and pests and using a wide spectrum of techniques of control.

The original scientific divisions in the TRI were Plant Physiology, Plant Pathology, Entomology and Technology. The Technology division was expanded considerably in 1960 along with the establishment of the Biochemistry division. Although a new division, this has made significant contributions to the technology of tea not only in the intensive study of orthodox operations but also in the development of newer products and machinery. As an example of inter-institutional collaboration the TRI in collaboration with the CISIR developed a successful process for the preparation of hot-soluble instant tea, which process is now being exploited by CeyTea Limited. The latest achievements of the Technology division is the development of the fluidized bed dryer for tea. The main advantageous of this drier is that the capital cost is reduced from

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roughly Rs 125,000 per drier to something like Rs 70,000 for a drier with an output of 600 lb made tea/hour. Even more important is the economy in operating expenses. Thus whereas the conventional ECP drier would yield anything between 25-35 lb made tea/gallon of fuel the fluid bed drier can give as much as 60-65 lb made tea/gallon of fuel. The fluid bed drier with minor modifications can be adopted for the drying of desiccated coconut, spices, rice and even crumb rubber, where the economy achieved in drying costs may make a significant contribution to the competitive position of these products in the international markets. The Technology division in collaboration with the Biochemistry division is currently carrying out research on cold-soluble instant teas. It is also engaged in the study of CTC tea manufacture, green tea manufacture and the development of newer machinery.

The Biochemistry division is also studying by-products of tea such as tea seed oil, sapponins from tea seed, tea seed meal, caffeine from tea and food colours. This division carries out basic studies on the mechanisation of photosynthesis, translocation of fertilizer uptake and mechanization of fermentation, using modern analytical techniques including isotopic tracer techniques.

The research findings of the TRI are communicated to the planters and to the scientific community of the world in the form of books, monographs, bulletins, advisory circulars and the Tea Quarterly which has a record of 42 years of continuous publication.

It would be useful at this stage to discuss the benefits accruing to the industry in more quantitative terms. Since it is fashionable to talk of the cost benefit ratio of a project it seems to me appropriate to carry out a similar analysis for the TRI. Let me take one segment of the TRI research programme, that concerned with replanting by vegetative propagation techniques using the TRI 2020 golden clones. The tea replanting programme got off to a start only as late as 1960, and increasing rates of replanting are envisaged. By replacing the old seedling tea which averaged in yield around 1000 lb with the newer clones giving as much as 2000-6000 lb per acre, over the years since 1960 an extra 200 million pounds of tea has been made available for export. In other words this programme has given about Rs 400 million in foreign exchange to this country.

If we take the overall acreage in tea which approximates 600,000 we find that since the post war years the production has doubled on the same acreage due entirely to the fertilizer programme and other cultural practices recommended by the TRI. This has enabled Sri Lanka to become the world's biggest exporter of tea in 1965 overtaking India. This extra crop made available to the tea industry as a result of the fertilizer management practices has yielded almost 3500 million pounds of tea worth about Rs 7000 million in foreign exchange. The total expenditure incurred in running the TRI since its inception is a mere Rs 70 million. Thus an overall cost benefit ratio of 100 : 1 is I think a unique record as far as research institutions go. It is of course impossible to quantify the benefits accruing to other tea producing countries which closely follow and study the TRI's research publications.

The success of the TRI in giving advice of a practical nature to the tea planters is due largely to the very close contacts it has with the tea industry, permitting maximum feed back of information. This close link with the industry has naturally led to stressing of research on immediate pressing problems. The research strategy of the TRI has been therefore to resort to extensive field experimentation and in 1967 there were 400 statistically designed experiments laid out, of which 300 were located on its own stations, and a 100 in commercial estates. This strategy has been remarkably successful in enabling the TRI recommendations to be tailored to suit various agro-climatic zones and also to demonstrate to the planters in a practical way the benefits of following TRI recommendations. This type of short term field experimentation strategy did also suit very well the composition of the TRI staff which was manned at senior staff level largely if not entirely of expatriates with lower rungs of Ceylonese technicians and estate labour providing support. The middle level was probably conspicuous of its absence. The wide disparity in capabilities and powers of comprehension of the staff meant, that if the senior staff left the country on completion of their contract, there was no body of

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persons who would act as a repository for the knowledge gained during the period of the service of the expatriate expert. It was therefore imperative to Ceylonize the scientific staff at the research scientist level and upwards, in order that knowledge gained in this country continued to be available for the progress of subsequent research programmes. The Ceylonization move was initiated by Dr Joachim around 1960 and at present the TRI is manned 100 percent by Ceylonese staff consisting of 18 doctors, 6 masters, 26 bachelors and 19 technical assistants with a large labour force drawn from the estate from time to time. The Ceylonization of the staff permits study of problems in depth, since there is no necessity to produce results of a tangible nature to justify ones contract period. The research strategy which is now being adopted by the TRI is to place greater emphasis on laboratory and green house experiments because major break-throughs can come only from intensive laboratory studies. The new laboratories now nearing completion at St Coombs for these developments will comprise some 32,000 sq. ft of which 22,000 sq.ft will be reserved for new laboratories. This will augment the existing 18,000 sq.ft of laboratory space, exclusive of the Technology division space. Provision has been made in the new building for a Residue laboratory, a Flavour laboratory, Isotope and electronics laboratories, a biocontrol laboratory, a formulation plant, a green tea factory and a tea machinery testing and development laboratory.

The finances available for the pursuit of this programme is therefore a matter of paramount importance. The TRI is funded by a Cess from tea exports which stood at 0.1 cent in 1925. It has been subsequently raised to 0.3 cents in 1940, 0.55 in 1954 and stood at 1.00 in 1961. At this level it gets an income pf approximately Rs 4.5 million and an additional Rs 5 lakhs from the profits from its estates, sale of clonal cuttings and green leaf. These resources amounting to Rs 5 million per year would have been adequate for financial self-sufficiency some 10 years ago when the cess has been doubled from 0.55 cts to Rs1.00. Since then the cess has been static and in the last few years due to the severe drought experienced exports have declined. Simultaneously with increasing costs profits of the TRI's estates have also diminished and the increasing cost of supplies, fuel, motor vehicles and staff salaries have led to a very severe financial crisis. This has forced the TRI to prune drastically many items of expenditure, including expenditure on estate experiments. Unless substantial financial relief is forthcoming it will not be possible for the TRI to give the service it has given the tea industry since its inception. I believe the time is ripe for a doubling of the cess for research from 1 cent to 2 cents per pound of tea exported.

DEVELOPMENTS IN RUBBER RESEARCH

by

Dr O.S.Peries, Director, Rubber Research Institute

The work of the Rubber Research Institute can be conveniently divided into two sections: the Biological and Chemical Technology. The Biological research is geared to developing planting material i.e. high yielding, disease resistant and will grow in the various soil and climatic conditions available in the rubber growing districts of Sri Lanka. The research in Chemistry and Technology is mainly concerned in improving present methods of production of raw rubber, developing new uses for Natural Rubber (NR), developing technological know-how for the production of industrial goods, both for the home market and export.

There are 4 research Departments, namely Botany, Genetics & Plant Breeding, Plant Pathology and Soils Chemistry, dealing with the biological aspects of the crop. To state it very briefly the sum total of the achievements of these Departments from the inception of the Institute is the increase in the per-acre yield of rubber from the 3 - 4 hundred lbs. in the early days of rubber planting in this country to the level of about two thousand lbs. at present. We now have clones with a potential to yield upwards of about 3000 lbs. per acre. This has been made possible by the co-ordination of the research work of the four Biological Departments.

In the early days of the rubber industry, the development of high yielding clones depended entirely on selection of high yielding trees and multiplying from them by bud grafting methods. At present, carefully controlled hand-pollinations are carried out in high yielding disease resistant material of known potential. It has been established that both high yield and disease resistance are heritable characters in rubber. The recently developed RRIC clones of the 100 series e.g. RRIC 100, 102 and 103 have the potential to yield over 3000 lbs. per acre and/or are resistant to both Oidium leaf disease and Phytophthora diseases. There is a possibility that these clones, being high yielders, may be prone to Brown Bast, a disorder known in high yielding clones. This is where the Botany Department comes into the picture, with the adoption of the correct tapping systems for each clone. Apart from this the Botany Department is concerned with the development of correct nursery practices, selection of suitable stocks for bud grafting and determining the optimum management of field plantations.

The Plant Pathology Department of the Institute is concerned with the control of the diseases of the rubber tree. In this regard, the Department has made a significant contribution to research on plant disease control in this country. It is normal for Pathologists to control diseases by the use of fungicides. At the Rubber Research Institute we tackle the problem, first by a careful study of the biology of the causal fungii. We also study the mode of infection of the rubber tree by these fungi i.e. the type of organ that is infected, its stage of development, the weather conditions that are conducive to rapid infection. We found then that the former method of sulphur dusting for Oidium leaf disease control was not necessary on all clones and in all areas. We issued recommendations on this basis and at present the expenditure on Oidium control has been drastically reduced in this country. Likewise in the control of Phytophthoradiseases we found that the weather conditions prevalent in this country by themselves militated against the diseases with the result that no economic damage was done to the crop. On the basis of recommendations made on these studies, the control of Phytophthora leaf disease is not carried out in this country, at present, and as far as Bark Rot is concerned very little expenditure is incurred as fungicides are applied only in certain districts during certain specific periods of the year and general control is effected by ensuring that trees are not tapped when there is surface moisture on them. These innovations in disease control and those recommended for the control of other diseases of the rubber tree have reduced the expenditure on plant protection in rubber from about 5 cents per lb. to about 0.5 cents.

In the Soils Chemistry Department, our recent studies have been directed towards the development of techniques for the recommendation of fertilizers for rubber, based on soil and foliar analysis. We are hopeful that this method would result in significant savings for the industry, as we will be recommending fertilizer usage merely to bring the level of each

element in the leaf to a certain norm, which on the basis of a great deal of collected data we consider to be adequate for the tree to produce the amount of latex it does. We will be making a start on this method of fertilizer recommendation in 1973, on a modest scale and increasing the area for treatment in the next few years, to cover the whole of the rubber growing area in this country, in the next few years.

What does the future hold for research in biology for rubber? What is the type of work that we will emphasise in future? It is an economic fact of life that money in the hand today is much more profitable than money in the hand next year or twenty years hence. Therefore, the Institute will spend its efforts into producing early maturing clones which will reach peak yields rapidly and also to developing nursery practices that would enable plants to be transferred to the field at a semi-mature stage in the form of stumped buddings or poly-bag plants. These could come into tapping in three years from the time of planting in the field, which would mean that we are saving 3 - 4 years of the field life of the tree, before it comes into bearing. We have made careful studies on this subject and have concluded that the expenditure in maintaining plants in the nursery should be very much lower than in the field, so that the method is feasible under Sri Lanka conditions.

It is a characteristic of the rubber tree that it comes into bearing after about 6 - 7 years in the field, takes 3- 4 years to reach peak yields and that the yield declines after about 14 years of tapping. If we can jack up the yield at the point where the curve dips, then we should be on to something good. This is where Ethrel yield stimulation comes in. There has been a question mark over Ethrel for some time now, but we are in a position to make a firm recommendation for its use at this stage. Ethrel can increase yields by over 100 per cent and to expect it to yield at this high level over a long period of time is unreasonable. Our thinking on Ethrel has always been fraught with caution and we have felt that if we can get a 30 - 40% yield increase on a long term basis with stimulation, we should be doing well. Therefore, we were looking out for the correct methods of using Ethrel and we now agree with the results obtained with this material in Malaysia, that the correct method would be to combine its use with lower tapping intensities, around 67%. In my recent visit to the Rubber Research Institute of Malaysia, I found that they are using a new method of Ethrel application i.e. to apply the material on the tapping cut, after the removing of the panel scrap, with a small paint brush. The effect lasts for 2 - 3 weeks and is extremely economical on the use of Ethrel. We will be testing this method in the near future and making the necessary recommendations.

The study of the chemistry of raw rubber manufacture has been the forte of the Rubber Chemistry Department of the Institute over the years. Rubber Technology is a new trend for the Department. However, the Rubber Research Board decided a few years ago, and very correctly, that the Institute must give a lead to the industry in Rubber Technology. Therefore, with the assistance of Professor Gerald Scott of the University of Aston in Birmingham, we have revamped our Research Programmes for the Rubber Chemistry Department, since 1969, and we are now geared to carrying our a considerable amount of studies on Rubber Technology, with the intention of increasing the areas of the usage of rubber and assisting rubber based industries in technological processes.

The most significant change that has occurred in the rubber industry in the recent past has been in the production of Standard Natural Rubber or New Process Rubber. In the old days latex was taken out of the tree, coagulated by the addition of acid, pressed into sheets of one form or another, dried for 7- 8 days in hot air or natural air drying chambers, baled roughly, and exported, grading the material visually, without any regard to its technological properties. New Process Rubbers are different, in that the coagulated latex is broken up into small particles, like pebbles, dried rapidly in hot air produced by an oil fired or electrically operated burner, pressed into 70 lb. bales in a hydraulic press and sold to exacting technical specifications, so that the consumer knows the quality of the material he buys, and he could select the type of material he requires. I repeat that this is a significant innovation of the successful competition of Natural Rubber against Synthetic Rubber.

I know that everybody is interested in the price of rubber and it behoves me to say a few words about this aspect of the industry. Our research has revealed that the world would require about 17 million tons of elastomers by 1980. The Synthetic Rubber industry too has carried out a survey and concluded that ~~that~~ the world requirement of elastomers would be about 15 million tons in 1980. At present the share of NR in the total rubber market is about 33%. Here again NR research has established that our share of the market would be around 43% in 1980. Therefore, even if we accept the lower figure of the Synthetic industry, by 1980 the world would require about 6 million tons of NR. If the NR industry does not produce this, the gap will be filled by SR. When you consider that the world production of NR, at present, is a mere 3.6 million tons you can gauge the potential for NR in the future - the requirement is for us to double our present production.

Another important aspect of the rubber industry is the difficulties that the synthetic rubber industry is facing at present. The price of the monomer that goes to produce Synthetic rubber is increasing, because the monomer is a by-product of the petroleum industry and the price of petrol is rapidly increasing all over the world, thanks to the policies of the Governments of the Middle East. I also have had, on good authority, that the sources of petroleum are drying up all over the world. This will further increase the price of the monomer. The second factor that affects the Synthetic industry is the cost of machinery and spares. Many of the machinery in the Synthetic plants which were opened in the late 1940s are now either obsolete or require a great deal of repair. The cost of new machinery is prohibitive. The third factor is the cost of labour, which is so high in the Western countries and in Japan that they are moving over to areas where labour is cheaper. Finally, the problem of pollution has to be reckoned with. The Synthetic Rubber industry is a pollution producing industry, whereas the NR industry is one which purifies the air, as the rubber tree takes up carbon dioxide and gives out oxygen. It should also be noted that the latest innovations in the tyre industry, the radial ply tyre, uses 15 - 16% more NR than the original tyre. Therefore, all in all the future for the Natural Rubber industry is extremely bright and if at all the prices for natural rubber will be better in the 1980s than it is at present.

I should like to end this brief address by making a plea to the Government of this country to encourage rubber based industries in this country. I do not see why we should export the only industrial raw material we have in this country, to other parts of the world for them to make industrial goods and re-export them still to other countries. We should earn much more foreign exchange by doing it ourselves.

Thank you.

RESEARCH ON COCONUT

By

Dr. W.R. N. Nathanael
Director, Coconut Research Institute

(Paper presented at the C.A.A.S. Symposium - "Research in Agriculture and Animal Husbandry" (17th August, 1973).

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From the agricultural point of view the cultivation of the coconut palm has received considerable attention in the different countries where it is grown. Of these, the coconut industry of Sri Lanka can claim pride of place as being among the first in the world to establish an agricultural research institute for the prosecution of research for an industry comprised predominantly of small-holdings.

Being a highly ramified 'Agri-Industry' embracing the production and technology of a series of important products, the coconut industry is of major importance to our economy. It occupies about 1.15 million acres - the largest extent of the three main plantation crops. Of this, 705,000 acres consist of holdings less than 20 acres in extent and is an industry in which the indigenous people have the largest interest. In a way therefore, every improvement to the industry would permeate through the whole economy of Sri Lanka.

Though the industry has greatly expanded since its commercial inception, yet in terms of overall land use it yields the lowest returns. It is being plagued by stagnant production (combined with increasing local consumption), low quality of some of its products and inefficient market performance. These problems, if solved, could doubtless contribute substantially to the health of the industry and to the vigour of the economy. It is known that the older production areas suffer from excessive planting density which reduces productivity. Poor management practices have also contributed to the low productivity. Apart from the fact that external forces to a large extent determine many of the domestic marketing conditions, the lack of a production oriented policy combined with inadequate extension activity has probably retarded the efficient development of the industry.

In view of what has been adumbrated above, if research on coconut is to be responsive to the needs of the industry it is a sine qua non that it should be integrated effectively with appropriate extension techniques and farmer education.

Though it is a statutory requirement that the activities of the Institute should include technological research for by-product development, utilization and industrialization, it has been recognized

that for the industry to remain viable the twin problem of increasing productivity of coconut lands in terms of both yields and profits is the one that requires high priority.

A recent survey on Land Use has revealed that only about 50,000 acres out of the land yet available for future agricultural development would be suited for coconut culture. This fact serves to confirm the opinion that no substantial increase in the Island's coconut production could be achieved through the medium of planting new land under coconut. Obviously the only other way open for increasing production would be to adopt measures for maximising production per unit area of the existing lands. In this context the continuing research programme of the Institute aims at improving productivity, genetically and agronomically and increasing the income from coconut lands by associate cropping and livestock development.

Four broad objectives could be identified in the research programme of the Institute currently in progress. They are:-

I. Improving Crop yields and Quality through Hybridization and Selection techniques.

II. Improving Crop performance through Correct Nutrition and Management.

III. Maximising returns from Coconut lands through Associate Cropping and Livestock Development.

IV. Minimising crop losses through Control of Pests and Diseases.

I would mention that consequent on recent changes under the Coconut Development Act (No.46 of 1971) a certain degree of responsibility devolves upon the Coconut Processing Board for research on problems associated with coconut technology and utilization of coconut products.

I. <u>Improving Crop yields and Quality through Hybridization and Selection techniques</u>.

Plant breeding in relation to a perennial crop like coconut (with an economic life span of over 60 years), is long term research of tremendous importance to the industry. It is a field of research in which Sri Lanka leads and the possibilities are immense. In fact, the breeding of palms with uniformly high yields is a matter of equal importance to the industry as sound agronomical techniques.

The programme of breeding and selection that has been implemented hitherto at the CRI has embraced the following standard techniques:

(1) Mass Selection Consisting in systematically choosing a part of the population in which the desired qualities are most strongly developed and using the selected individuals for seed collection.

(2) Progeny testing to identify 'Pre-potency' Consisting in the identification of the progenies of high yielding mothers and picking out 'yield transmitters', which are used for propagation and for intercrossing with each other.

(3) Controlled Pollination leading to establishment of Isolated Seed Garden. Consisting in crossing phenotypically superior mother palms with pollen from pre-potent palms, and utilizing the high yielding material derived therefrom exclusively for the establishment of the Isolated Seed Garden.

(4) Hybridization between Varieties and Forms. Consisting in the production of high-yielding inter-varietal hybrids that are early bearing.

The hybridization programme utilizing the varieties and forms of coconut indigenous to Ceylon as well as the exotic San Ramon variety has been carried out since 1950. The C.R.I. has developed two high yielding strains (viz. CRIC 60 and CRIC 65), which are being released to the industry. WithCRI assistance the latter hybrids are also being produced by the private sector on a commercial scale.

An Isolated Seed Garden for the mass dissemination of elite seedlings was initiated in 1955. The Garden planted up almost exclusively with hand-pollinated material, is now being expanded so that the original capacity of 135 acres could be increased to about 250 acres.

Though in general the results of this work have been successfully and gainfully applied in industry the major constraint so far has been the limitation of the experimental work to the three indigenous varieties of coconut (typica, nana and aurantiaca) which include only thirteen eco-types.

For further genetic improvement of the crop with the practical object of improving the efficiency of the breeding process and shortening the breeding time it is considered that the development of future experimental work should embrace the following:-

(1) Inter-origin hybfidization using exotic germ-plasm. This would require the import of germ-plasm in the form of both pollen and seed taking adequate phyto-sanitary precautions.

(2) The establishment of a gene bank of variable germ-plasm in order to widen the genetic base of the future crop improvement programme, and the identification from this pool of superior individuals with useful specific characters for future experimental work.

(3) The introduction of drought tolerant dwarf strains to determine their suitability and those of hybrid offspring raised from them (by crossing with adapted local varieties) for the drier agricultural areas.

II. Improving Crop Performance through Correct Nutrition and Management.

Though empirical information of local value has been available for a fair length of time, the first series of modern field experiments on the manuring and cultivation of coconut are those that have been carried out since 1934 by the Institute.

Experiments on the manuring of young and mature plantations under various environmental conditions have also been laid down on a number of estates in different areas. The Soil Chemistry Division was one of the earliest to be established at the Institute and subsequently, its scope was extended to cover Soil Surveys and Classification. The addition in 1960 of a small laboratory for radio-isotope work has also proved a valuable adjunct to the Division particularly for fertilizer research.

The fact that fertilizer usage leads to increased yields and reduces costs of production is well recognized in agriculture. With regard to the coconut crop, it has been found that significant increases in production could be realised (within a relatively short period of time) by the proper application of fertilizers, provided that the other basic soil management practices are also maintained at proper levels. In this context, the field experimental results obtained have shown that correct fertilizer application could bring about yield increases of the order of 2,000 to 2,500 nuts per acre per annum.

Experiments carried out at the Institute have shown that coconut production in most coconut soils of Ceylon is limited by deficiencies of nitrogen, phosphorus and potassium. In certain areas - particularly in the wet zone, magnesium has also been found to be deficient. On the basis of research data obtained from these experiments the Institute has been making various recommendations over the years pertinent to fertilizer usage in different areas. Owing however, to adverse economic conditions and the inevitable time lag between fertilizer application and the realisation of its beneficial effects, the results of these researches found practical application on an appreciable scale, only after the Coconut Fertilizer Subsidy Scheme came into operation in 1956.

Prior to the introduction of the Subsidy Scheme, only about 100,000 acres (less than 10 % of the total coconut acreage) received fertilizers. Today, this acreage has increased to about 325,000 with a fertilizer consumption of about 60,000 tons as against 1,000 tons during the pre-war period.

Fertilizer problems are legion, and since the coconut crop is grown under a wide range of soil and climatic conditions, perhaps unequivocal solutions could not be found for some of them. Further, standard field experimental techniques adopted for studying such a problems depend on yield data. In the case of the coconut however, such experiments are laborious, time consuming and expensive, because quick results cannot be obtained within a single season's cropping. Owing to the inevitable time lag between yield responses and fertilizer application (complicated by climatic interactions) it generally takes 6 to 8 years before any conclusions can be drawn from a single field experiment on coconut. A further problem is that owing to population heterogeneity in yield characteristics, large extents of land (25 to 30 acres) are required for a single statistically designed experiment. In spite of these handicaps experiments have been laid down by the Institute to elicit information on fertilizer levels (for types and forms), time and frequency of fertilizer application, relative efficiencies of methods of application, and optimum methods of fertilizer placement. In other words, the main objective has been to obtain and disseminate information that would help to maximise the efficiency of fertilizer utilisation, thereby increasing profits and reducing costs of production.

Isotopic techniques constitute a useful tool for the solution of some of the problems that have been adumbrated above.

Using radio-active phosphorus (P^{32}) the relative placement efficiencies have been assessed for different methods of application. The results have conclusively demonstrated that the density of active roots is much higher in the area immediately surrounding the palms up to a distance of about 5.5 feet from the bole. In accordance with this, the results have shown that fertilizer applications in the entire area round the palm up to about 5.5 feet from the bole, lead to 100 % more efficient fertilizer utilization by the palm, than placements in centres of squares or in the traditional manure trenches. It has also been found that full circle applications are about 40 % more efficient than half-circles, and that broadcast applications are less efficient than placement round the palm.

On the recommendation of the Institute, the above findings are now being adopted generally in field practice.

The problems affecting the nutrition of the coconut palm are legion. In fact, for a long time the manuring of the palm has been done to a large extent purely on an arbitrary basis, based on practical farming experience more than on any fundamental knowledge pertaining to its nutritional requirements. It would appear that the principal disability that has hampered progress in the past, is the lack of fundamental knowledge pertaining to the uptake of nutrients, their pattern of distribution and how they drift with time and supply during the nursery phase, adolescence, maturity and senescence of the palm. In this context, facilities have now been provided for projecting intensive investigations on the fundamental aspects of coconut nutrition.

III. Maximising returns from Coconut Lands through Associate Cropping and Livestock Development.

In 1952 the CRI appointed an officer to study the possibilities of animal husbandry under coconut, and in 1955 with the aid of a Colombo Plan Expert established the Division of Agronomy. In 1958, this Division was redesignated Agrostology and the work and objectives were changed specifically to study:-

(1) the development and management of pastures that might be grown on coconut estates and used to provide meat and milk, without detriment to the coconut palm.

(2) The utilization of space on coconut lands for intercropping

(3) inter-relationships between livestock and coconut.

(4) the wider problem of maintaining and improving soil fertility in areas where the one crop has been and perhaps will be grown forhundreds of years.

In terms of nett income per acre, probably coconut lands give the lowest returns. The trend in commercial coconut growing in most countries has until very recently been to think almost exclusively in terms of monoculture. During the early growth stages of the coconut (in new plantings) however, a wide variety of crops are grown in order to obtain some income from the land until the coconut comes into production. This type of intercropping on new clearings is of course of wide application, and is generally practised with success. It is essential that 'catch-cropping' of this type on immature coconut holdings should be distinguished from "multi-cropping" or true intercropping which would constitute part of a mixed farming system on mature coconut plantations. In this context, apart from many kinds of crops (annual, semi-perennial and perennial) such as mangoes, plantains, cocoa, coffee, manioc, pineapples, maize etc., the maintenance of livestock cum pasture grasses is also not uncommon.

There is nevertheless, a section of experienced opinion in the coconut industry that stresses that any kind of mixed cropping, whether in agricultural crops or by animal husbandry, would be undesirable as the nett effect on coconut production would be reduction in crop yields.

Regarding the possibilities of intercropping, much attention has been focussed on the cultivation of pastures and fodder grasses under coconut. It has been found that in the Wet Zone these crops will not compete with coconut for soil moisture. On the other hand, they will require adequate manuring to eliminate competition for major plant nutrients such as nitrogen, phosphorus and potassium. It would therefore appear that where the rainfall is adequate and well distributed, any competitive effect of the crop associated with coconut is purely nutritional.

On the basis of this work CRI recommendations in respect of the establishment of pasture and fodder grasses on coconut lands are now being applied in industry.

Since the inception of the work on animal husbandry at the CRI, Sinhala cattle have been used for all experiments with pastures. Intensive work has also been carried out to study their lactation, weight and other characteristics. The data that have been consolidated confirm the view that the Sinhala animal is not a suitable dairy breed for the coconut triangle, even under optimum conditions of management. In view of this, studies on three-way rotational cross-breeding with the exotic strains - Jersey, Sindhi and Friesian have been initiated to up-grade the foundation Sinhala herd at the CRI. In this system there is evidence that any loss of hybrid vigour after the F_1 generation is overcome by introducing a different breed at the F_2 stage.

IV . Minimising Crop losses through Control of Pests and Diseases.-

Getting rid of pests and curing diseases could be very expensive procedures. Prevention is always better than cure and in the long run much cheaper.

Two features which characterize coconut cultivation in Ceylon influence methods of pest control to a considerable extent. Firstly coconut gives a low income per acre, which means that pest control measures must be cheap. The second feature is the low level of management. This generally means that cohtrol measures are not implemented effectively in certain areas; consequently pests spread from badly managed areas to well managed holdings. One way of getting over this situation is to utilise methods of control (such as biological control, sterile male technique etc.), which can be carried out by a comparatively few people working from co-ordinated centres. These methods may be cheaper than regular chemical treatment.

This has been amply demonstrated recently when the new leaf miner coconut pest Promecotheca cumingi, which threatened to jeopardise our coconut industry was brought under control and reduced to sub-economic levels entirely by biological means. Again, the coconut caterpillar, Nephantis serinopa, is regulated through the release of some its parasites. Current studies are giving very promising results with the predator Chilocorus nigritus (lady-bird beetle) in the control of the coconut scale - Aspidiotus destructor.

Judging from the volume of inquiries that are being received at present, it is obvious that there is increasing awareness of the usefulness of the service and advice rendered by the CRI in this sphere.

Regarding diseases of coconut, some advances have been made in elucidating the causes of 'Leaf Scorch Decline' of Coconut, a disorder that has been prevalent in the Southern Province of Ceylon, and a problem that remained elusive for a long time in spite of multi-pronged investigations in the past.

C O N C L U S I O N.

Research is an investment and an insurance against the future. Within the short compass of this paper, I have endeavoured to pin-point the progress of Coconut Research on all fronts in recent years. Yet, the Coconut Research Institute has many problems to overcome and many questions to answer. The good work done by the Institute has borne fruit in the past, and the coconut industry should not be allowed to become a declining asset in our economy at any stage in the future. More research is therefore needxd to make the coconut industry a high water-mark of efficient production. Many years of ever-expanding utility and activity lie before the Coconut Research Institute of Sri Lanka for the achievement of this goal.

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The Impact of Research on Development of the Animal Industry

by
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Until about four decades ago, very little organised Livestock farming was in evidence in Sri Lanka. During the early thirties, the Government established a cattle farm at Polonnaruwa with Scindhi animals imported from India. Later on, in 1946, further importations were made of temperate breeds of cattlefrom Europe. With the arrival of these animals, the Department of Agriculture established the two up-country farms at Ambewela and Bopatalawa. These imported stock were used by the Department for upgrading the indigenous Sinhala cattle through artificial insemination and by issue of bull calves through a bull calf exchange scheme. However, there was no organised development programme until the year 1958when the first National Development Plan came into existence. But development of animal husbandry did not receive high priority duringthis period. It was only with the implementation of the current 5-Year Plan that the highest priority was given to animal husbandry.

The place of animal protein and its importance in the human diet is very well known. Animal proteins assume much more importance in underdeveloped countries such as ours, because of the severe imbalance of protein to carbohydrate in the diet of the average citizen. The general objective of the efforts of the animal scientists is therefore to try to correct this imbalance by stepping up the pace of animal production.

Looking back over the years, one sees a change in the strategy for development of the animal industry. During the early period the biggest obstacle to development was the widespread prevalence of animal disease. Cattle disease such as Rinderpest, Haemorrhagic septicaemia, Anthrax, Black Quarter, and poultry disease such as Ranikhet and Fowl Pox, took a heavy toll of animal life. It was obvious at that time, that no animal development would be possible, on a national scale, in the face of such a major constraint.

The first task facing the Veterinarians was then, the control and possibly the elimination of these killer diseases. Research work was mainly directed towards the production of animal vaccines, testing their efficacy under field conditions, the study of immune responses and the improvement of diagnostic methods. The success of the disease control effort and the tremendous impact this programme had on the animal industry is widely acknowledged. The complete eradication of Rinderpest disease in the year 1946 was undoubtedly the crowning success of the efforts of the Veterinarians of that era. Sri Lanka has been free of this dreaded disease since that time. In general, the disease control measures adopted during that period and in subsequent years have proved very effective. Today, contagious diseases are no longer a problem in this country.

A complete range of animal vaccines are now produced locally, to meet the present requirements of the disease control programme. What remains to be done in this sphere of activity is to expand the programme to give complete coverage over the entire livestock population. Deaths resulting from contagious diseases have been brought down to insignificant levels. What this means in terms of our broader objectives of increased production is that relative disease-free conditions now prevail in the country, to make it possible for the animal industry to develop unhindered.

Current Research

I would now like to deal with the present situation and what the animal scientists are trying to achieve. As I remarked earlier, the strategy has changed and the emphasis has shifted from animal health research to animal production research. The current research programme is directed towards finding ways and means of accelerating the

pace of animal production. How can we achieve this objective? Increased production can only be effected by a coordinated effort on the part of research workers in all disciplines related to both animal health and animal production aspects. Figure 1 shows the different means by which production could be stepped up.

Animal Breeding

Genetic improvement of livestock may be effected in one of two ways. Firstly, by selection within a breed and secondly, by cross-breeding with a breed possessing high productive merit. The indigenous breeds of cattle, pigs and poultry genetically, have very low productive ability. Mahadevan (1952) working with Sinhala cattle estimated that it would take approximately 200 years to improve by selection, the mean yield of Sinhala cattle from the present level of 90 gals. per lactation to 300 gals. per lactation. It is obvious that the only means by which genetic improvement could be effected within a reasonable period of time was through a programme of cross-breeding. One other possibility exists, and that is the importation of large herds of high producing stock, an exercise which would involve a staggering expenditure of foreign exchange. Assuming that foreign resources are available for importation of stock, such a course of action would help only in a very limited way to step up dairy production in this country.

It is estimated that, at present, there are around 60,000 head of dairytype animals in Sri Lanka. Of this number, only a very small proportion are pure temperate breeds and their crosses. Thus the large majority of the existing stock are of the Zebu types. It is inevitable that any programme of cross-breeding would have to utilise the Sinhala and Zebu types as base animals. Research work involving Zebu types and temperate breeds have been carried out by the Department of Agriculture since the year 1953. Both Sinhala and Sindhi cows have been used as base animals in these experiments.

Table 1 - shows the results of Sinhala x Scindhi cross breeding experiments.

No hybrid vigour is evident at F_1 generation. It would not be possible to evolve a crossbred animal which would outdo the Scindhi type. Upgrading towards 100% Scindhi blood is the only means of genetic improvement possible.

Table II - shows the results of Sinhala x Jersey and Sinhala x Friesian cross-breeding experiments.

Further backcrossing of the F_1 generation to the temperate type results in a lowering of the productive ability of the progeny. Buvanendran (1973) is of the view that the best results could be achieved by crossing the F_1 generation interse. Here again their progeny would show a drop in production. The only means by which it may be possible to maintain hybrid vigour would be to use two or more tempedate breed in a rotational cross-breeding programme. This is a new technique which has been adapted by the Department of Agriculture. The results of the work will become available only from 1974 onwards.

With pigs and poultry however, cross-breeding of indigenous stock has no place, because thesespecies are capable of rapid multiplication, making it possible utilise pure bred stock to effect increased production. Genetic improvement of pure breeds involve the use of known techniques such as progeny testing and the use of proven sires. Such techniques are currently being used on Goveenment Farms.

Improvement through Better Nutrition

Livestock can be broadly classified into groups, from the nutritionist's point of view, namely, the ruminants and the non-ruminants. While non-ruminants or monogastric animals depend almost entirely on concentrate feeds, ruminants have the inherent ability to utilise relatively low quality feedstuffs much more efficiently than non-ruminants.

It is thus to our advantage to capitalise on this inherent characteristic of the ruminant. Much more use should be made of pasture grasses and fodder grasses in the feeding of dairy cattle. Unfortunately, the practice in our country has been to rely much too heavily on concentrate feeds in the feeding of dairy cattle. This practice perhaps originated at a time when good quality grasses were not readily available and when concentrate feeds were cheap and freely available. Generally, most farmers allow between 50 to 70 lbs. of grass per cow per day, supplementing this with concentrates on the basis of 5 lbs. per cow for maintenance and an additional allowance of ½ lb. per pint of milk produced. This means that pasture supplies only a part of the maintenance requirement of the cow. Viewed from a National standpoint, it would be disastrous to continue with such a feeding practice, particularly when the greater part of the compounded feeds are required for the poultry and pig industries. The task facing the research worker is therefore to provide high yielding pasture and fodder types of reasonably good quality and provide the know-how on techniques of pasture management and utilization. It has been demonstrated that with the feeding of improved types of pasture, it is possible to obtain a production level of 10 pints per cow per day without resorting to concentrate feeding. Already a considerable amount of research has been done in the field of pasture development. Since this subject will be dealt with at length by Prof. Appadurai, I will desist from entering into a discussion on the subject except to outline briefly some of the work done by us in the mid-country region. The work has been mainly directed towards providing improved pasture species that are capable of supplying both quality and quantity, both at high and moderate levels of management. Fifty species of grass were studied over a period of two years at Gannoruwa on the basis of observations made during this period, 14 species were selected from among this number for further study. The results of this study are presented in Table 3 - (Pathirana & Siriwardena 1973). Pusa Giant Napier, Panicum Maximum, commonly known as Guinea B proved to be the four best varieties, which recorded dry matter yields of - 33,385, 33,226 and 26,023 lbs. per acre respectively. The fertilizer levels used were N 125, P_2O_5 75 and K_2O 150 lbs. per acre per year respectively.

(Panicum maximum cv.Guinea, Brachiaria ruziziensis and a local variety of

Moving on the field of monogastric nutrition, theprovision of adequately balanced feeds in sufficiently large quantities to meet the increasing demands of the poultry industry has been the biggest problem in recent times. It would not be an exaggeration to state the success of the development programme hinges on the availability of adequate supplies of good quality feeds. All those involved in animal husbandry activities know how true this is. Today the country is faced with an acute shortage not only of human food, but also of animal feed. During the past few months the effects of feed shortages on the animal industry, particularly the poultry industry has been very severe indeed. Compounded poultry feeds need to be well balanced, providing energy protein, vitamins and minerals in amounts adequate to meet the requirements of the poultry. The energy source is generally maize, while the fish meal and meat meal supplies part of the protein requirements. These feedstuffs are at present imported to a large extent. The cost of these items have risen two to three fold in the world market. This together with the levy of FEECS has resulted in price hikes of poultry feeds. Figure 2 gives the requirements of cereal and fish meal with estimates of availability from local sources for the years 1973 and 1977.

Coconut poonac and rice bran generally constitute about 50% of the commercial poultry feeds. Both these ingredients have been in short supply for a considerable period of time. While these shortages may be passing phases, it nevertheless illustrates the need to find alternative feed resources which may service to buffer the effects of temporary shortages. The task of the nutritionist in the present situation is a very difficult one indeed. Priority in research has been given to the search for potential feed sources. Rubber seed meal is one of the recent finds resulting from thw work of nutritionists (Buvanendran and Siriwardene, 1970),(Siriwardena and Nugera, 1972) and (Rajaguru, 1973). Its feeding value is similar to coconut poonac, except that rubber seed meal has a little more protein. Other feedstuffs

that have engaged the attention of research workers are manioc meal, manioc waste, high protein leaf meals, polkudu poonac, sediment poonac and passion fruit peel.

Evaluation of feed potential has to take into consideration both the energy and protein components and the calorie/protein ratio in the diet. A complete assessment of the potential value of feed material on this basis cannot yet be handled due to lack of facilities. While work has been recently initiated to study the energy value of local feeds, evaluation of protein quality will require specialised equipment. It is expected that facilities will become available soon to enable us to study the amino acid composition of these feeds. The importance of the knowledge of the amino acid composition in feed formulation is illustrated in Figure 3 which indicates the amino acid requirements of the chick and the amino acid contribution from feeding of coconut poonac, fish meal, gingelly meal and soyabean meal at 20% level in the diet. The amino acid deficiencies in feedstuffs can sometimes be corrected by use of two or more protein feeds. For instance, gingelly meal is deficient in lysine while soyabean meal is deficient in methionine. The use of a 50 : 50 mixture of both helps to even out these defieiencies as illustrated in Figure 3. The importance of the estimation of amino acid composition of local feedstuffs is thus an extremely vital aspect of future research.

Control of Infectious Diseases

Priority in research on the animal health side has been given to problems connected with infertility and diseases responsible for lowered productivity particularly of dairy cattle. However the control of some of the contagious diseases - continues to receive the attention of the Veterinary scientists. For instance, work is continuing on improvement of foot and mouth disease vaccine. At present 800,000 doses of this vaccine are produced annually. This production level would be grossly inadequate if the entire cattle population were to be vaccinated. This is a disease that must be brought under effective control because production of affected animals, particularly of temperate breeds could be depressed for life. A Foot and Mouth Disease Vaccine Laboratory has been constructed at Polgolla with assistance from F.A.O. and when vaccine production commences at this laboratory, it is expected that the entire requirements of vaccine for an intensive control programme would be produced at this laboratory.

Research work is also proceeding on the improvement of Ranikhet vaccine. Although an effective vaccine has been in existence for some years, this disease is still prevalent in Sri Lanka, But most of the outbreaks seem to occur only in unvaccinated flocks. The failure to bring about more effective control has been largely due to lack of trained personnel to effect complete coverage of the poultry population. This vaccine has to be administered by I/M injection at or beyond three months of age. Birds below this age cannot be vaccinated with this vaccine because of the possibility of severe side-effects including paralysis. Research work is now proceeding on theproduction of a vaccine that would require no technical skill to administer and one which will confer immunity at a very young age. Some headway has already been made at the Veteeinary Rewearch Institute in producing a vaccine that could be administered in drinking water (Kulasegaram, 1973). The vaccine produces no ill-effects and may be administered within a few days of birth.

Improvement of Fertility

Reproductive diseases and nutritional deficiencies constitute two of the major factors causing infertility among dairy cattle. Priority in research has been given to reproductive diseases particularly to Brucellosis. This disease is prevalent in almost all breeds of livestock resulting in serious economic losses. Such losses are extremely difficult to assess, and estimates have not been made for Sri Lanka. However figures available for other countries would give us an idea of the magnitude of the problem. For instance, losses from Brucella infection have been estimated at 50 million dollars in the USA from loss of milk, $ 5 million

from calves lost and $ 32 million from depreciation in value of infected herds (Stableforth, 1959). The figure for France is estimated at 37,000 million francs per year Renoux (1953) and for U.K. at 1 million pounds sterling per year (Brown 1969). These figures speak volumes on the magnitude of the possible economic gains that would result from an effective Brucella control programme. The incidence of Brucellosis in some of the Government farms and the beneficial effects of an effective control programme at Polonnaruwa are indicated in Table 4 (Kumaraswamy, 1973).

Control measures involve the regular testing of herds to isolate infected animals. Two courses are open to us in the control of this disease. One is by slaughter of all positive animals. This is a very expensive method and therefore has limited application in this country. The other is by isolation and vaccination of infected herds and the progressive development of clean herds with non-infected animals and disease free calves from vaccinated herds. The latter scheme has been in operation at Polonnaruwa Farm since 1956.

The incidence of other diseases that cause infertility such as vibriosis and trichononiasis have not yet been investigated. It is expected that future research programmes will cover these disease conditions as well.

Control of Other Diseases causing Economic Losses.

I propose to touch on only a few of these diseases. The three conditions that are currently receiving the attention of research workers are mastitis, parasitism and foot and mouth disease.

Mastitis

Like Brucellosis this disease too causes heavy economic losses in dairy herds. Wanasinghe (1971) has attempted to assess the likely losses on the basis of results of a number of surveys into the incidence, the effects of the disease on production and the damage to the udder. This work has revealed that around 60% of the animals tested were positive for mastitis. Of this number, 20% showed clinical symptoms of the disease while in 15% of the cases either 1 or 2 quarters of the udder were completely lost. Low grade mastitis constitutes one of the major causes of lowered milk production. Economic losses from this disease result from (1) a decline in milk production (2)a decline in the content of milk constituents (3) damage to the udder (4) shortening of the productive life of the infected cow and (5) increased cost of the replacement value of the herd. The Veterinary Research Institute has formulated a comprehensive plan to bring this disease under control. This plan involves the periodic testing of dairy herds, introduction of dairy herds, introduction of dairy hygiene techniques, treatment of infected animals and the prophylactic treatment of dry cows in the herd. Lack of funds has prevented the Department of Agriculture from launching on such a programme.

Parasitism

Parasitism, as we all know, is widely prevalent in all tropical countries. Ours is no exception. The damage caused to livestock can be very extensive indeed. Parasites can be broadly classified into two groups, i.e. the Ectoparasites and the Endoparasites. Among the ectoparasite or external parasites that cause a lowering of production and even death in livestock, are the ticks and mites. Ticks cause damage in three ways: (1) direct damage by way of blood loss and injury to the skin (2) by injection of toxic substances and (3) by transmission of disease. Damage to skins can be extensive rendering the hides worthless. It is estimated that each tick could remove from 0.5-2.0 ml. of blood from its host. One could imagine then the extent of blood loss from an animal harbouring a few hundred ticks. The resultant anaemia results in a loss of production and a lowering of the resistance to disease. In Sri Lanka the cattle tick poses a big threat by transmitting the tick fever disease.

The disease is often fatal to pure bred and cross-bred temperate breeds of cattle. The zebu types on the other hand are resistant. The control measures now adopted include the application of insecticides, either by spraying, hand-dressing or by dipping. Prophylactic control is effected by premunising animals by injection of a strain of less virulent organism maintained in donor animals. Current research is directed towards the study of the life-cycles of the ticks, a knowledge of which will help to cut down the cost of insecticides used in tick control work.

Internal parasites cause similar economic losses. Control measures involve treatment on a regular basis, a practice which has proved to be expensive indeed. The efforts of research workers have been therefore directed towards finding ways and means of reducing the cost of worming, while maintaining effective control of worm infestation.

Work carried out at two locations, Kottukachchi and Melsiripura (Ranatunga 1973) have demonstrated this objective and in fact be achieved if the pattern of infestation and the life cycle of the parasite is known. A study of the life-cycle of the parasite in each particular location and the pattern of infestation in the herd throughout the year would help in making a judgement as to the most effective time of year when the animals should be treated.

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FIGURE - I

INCREASED ANIMAL PRODUCTION

IMPROVED FEEDING	IMPROVEMENT IN GENETIC POTENTIAL	IMPROVED MANAGEMENT	CONTROL OF CONTAGIOUS DISEASES	IMPROVED FERTILITY	CONTROL OF DISEASES CAUSING LOWERED PRODUCTIVITY
↓	↓	↓	↓	↓	↓
PASTURE	SELECTION	SANITATION	VACCINATION	EARLY BREEDING	BRUCELLOSIS
CONCENTRATE FEEDING	CROSS-BREEDING	HOUSING	VACCINE STABILITY	SHORTER CALVING INTERVALS	MASTITIS
			IMPROVED DIAGNOSTIC SERVICES	REDUCTION IN INTRA-UTERINE AND POST-NATAL DEATHS	PARASITISM
					FOOT AND MOUTH DISEASE

FIGURE - 2

FEED REQUIREMENTS AND AVAILABILITY
(1973 - 1977)

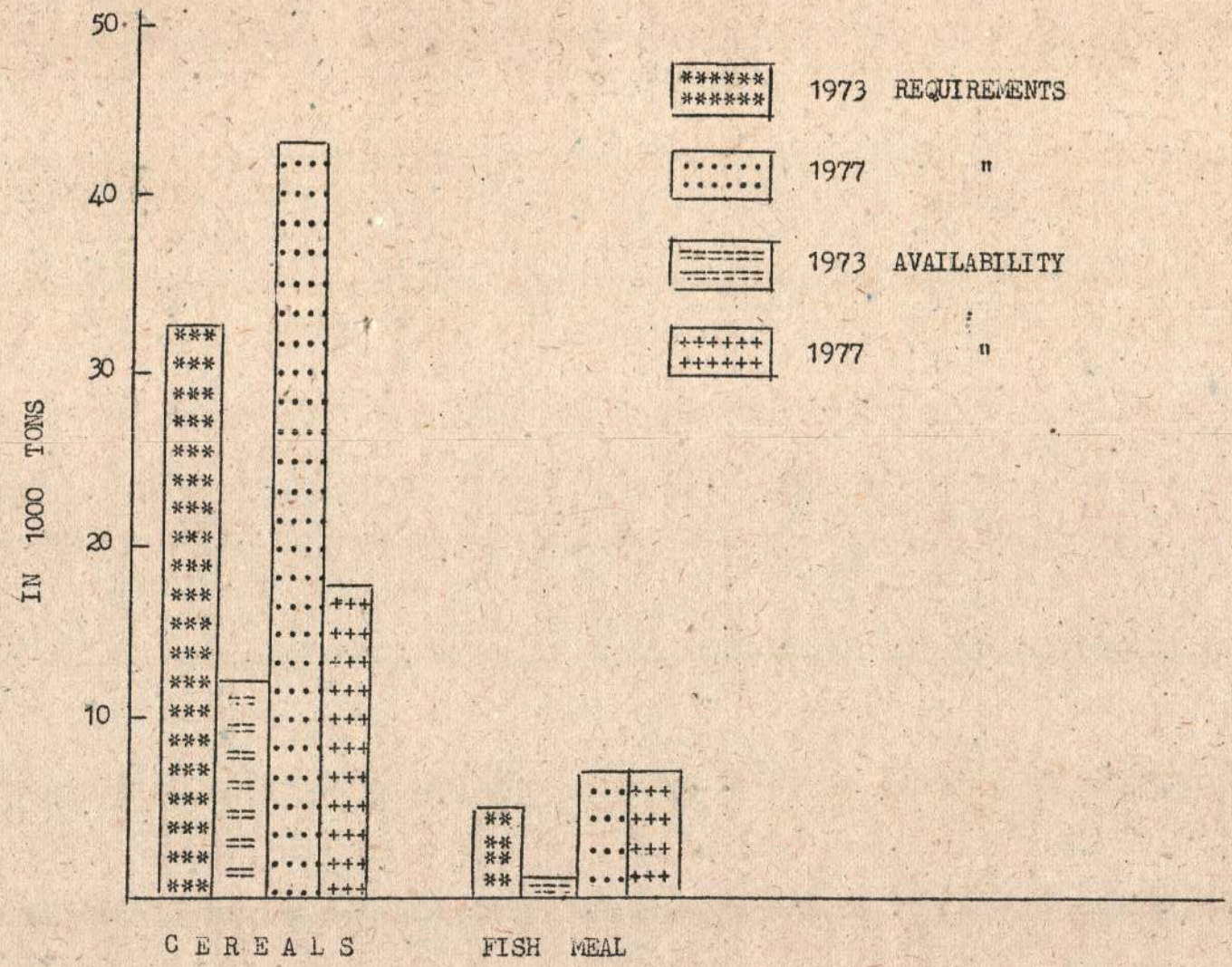

TABLE I

Performance of Sinhala and Crosses

Breed	% J/Fr Blood	Milk Yields (lbs. per lactation)
Sinhala	0	980
J/S F_1	50	2600
J/S F_2	50	1400
J/S B_1	75	2100
Fr/S F_1	50	3300
Fr/S F_2	50	2000

S indicates Sinhala, J - Jersey and Fr. - Friesian

TABLE II

Performance of Sinhala and Sinhala x Schindi Crosses

Breed	% Schindi Blood	Milk Yield (lbs. per lactation)
Sinhala	0	1000
Sc/S F_1	50	1700
Sc/S B_1	75	2300
Sc/S B_2	87.5	2380
Schindi	100	2380

TABLE 4

Location	Species	Incidence	Year
Polonnaruwa	Buffaloes	19%	1956
		12%	1968
		6%	1971
		3%	1973
Tamankaduwa	Zebu breeds and crosses	40%	1969
Nikeweratiya	Zebu cattle	35%	1969
		12%	1970
Welisara	Pigs	3%	1969
Kottukachchiya	Goats	4%	1968
		0%	1970

Pasture Research and its relevance to Animal Husbandry Development in Sri Lanka.

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Most of the development of grassland farming, so far, has in fact taken place in the temperate countries of the world. Here in Sri Lanka, pasture has never enjoyed a prominent place in our systems of land use. It is only in recent times that the importance of grassland farming has been seriously considered, and this has been largely due to the ever increasing import bill for milk and milk products, and the realization that profitability in dairying for example, is governed largely by the cost of the feed and its influence on milk yield. Even in countries with a long tradition of grassland farming the part played by research workers in developing new or improved techniques, and in helping the farmer to make use of the latest technical developments has been of considerable importance. Research is of even greater significance where grassland farming is a recent development and where there is no tradition based on long experience. It is against this background that we should try and assess the research efforts of the past twenty years, and consider their relevance to Animal Husbandry development in Sri Lanka.

A comprehensive programme of pasture research should cover the problems met with in the whole field of grassland farming. In the context of this country, at least four of these become immediately relevant.

1) Plant introductions, including methods of establishment and management of pure and mixed swards.
2) The assessment of the productivity, and feeding value of pastures and fodder crops, with particular reference to their concentrate saving value.
3) Systems and methods of conservation.
4) The development of balanced systems of farming based on pasture.

Ever since the introduction into Maha Illuppallama of a good grazing grass for the dry zone, namely Brachiaria brizantha in 1951, we have been literally combing the grasslands of the world, in order to find suitable introductions which could be established in the various agro-climatic regions. Today we have several promising new species, such as Brachiaria and Buffel for the dry zone, Cori and Pangola for the coconut triangle, Guinea and Ruzi for the mid-country wet zone, and Paspalum and Kikuyu for the hill country and so on.

Role of the legume:

Ceaseless efforts have also been made to develop mixed pastures inclusive of both grasses and legumes, in the hope that such mixed pastures, like their temperate counterparts would contribute to high pasture productivity and feeding value. Very often the practical difficulty has been one of incorporating, and sustaining legume components into pastures composed of highly aggressive tropical grasses. There are also certain environmental factors, among the more important of which are high soil temperatures, rapidly alternating wet and dry conditions, and the relatively short-day lengths, which tend to restrict the symbiotic value of pasture legumes, under tropical conditions such as ours. (Vincent 1965).

On the other hand, in other tropical and sub-tropical areas, such as Queensland for example, tropical legumes, capable of fixing around 100 lb of N per acre, and thereby contributing to greater productivity and higher quality of pasture herbage have been successfully developed. Some of these have been introduced, locally, and are under study at the present time. Of these Siratro (Phaseolus atropurpureus) appears to be particularly promising, though the Desmodiums, particularly Desmodium uncinatum, and Glycine javanica have also performed satisfactorily. They seem to combine better with fodder grasses such as Guinea and Setaria, than with grazing grasses. In the context of rising fertilizer costs, and shortage of foreign exchange, there can be no doubt that a full evaluation of the role of the legume in mixed pastures in Sri Lanka, should be an urgent research priority. We must find the most adaptable and productive forage legume species, for every agro-climatic region, but particularly for the dry zone, and then develop appropriate management practices for those species which combine well with the adapted grasses.

High Nitrogen Pastures:

For the more intensively farmed areas, particularly in the mid-country and low country wet zone, however, the differences between mixed pastures and pure grass stands, is insignificant in comparison with the yield increases that can be brought about by the application of Nitrogen. One of the most striking pieces of evidence that has come out of recent grassland research is that improved grasses have a high Nitrogen requirement, and indeed in the years to come, Nitrogen will become the most important single factor in pasture production. The results of several of our recent investigations, into the use of high levels of applied Nitrogen, in various agro-climatic zones, indicate that herbage yields were almost doubled by high N application. In every single instance the pattern of response was distinctly linear upto applications of about 300 lb N per acre per year. Nitrogen efficiency was found to be of the order of 1 : 29 for Brachiaria brizantha, 1 : 39 for Brachiaria ruziziensis; and 1 : 70 for the hybrid fodder Pusa Giant Napier.

High nitrogen application does not result in the maximization of herbage production alone. In every single instance, high N use is accompanied also by an enhancement of the feeding value of the herbage. Recent studies of herbage quality have clearly established that fodder grasses such as Pusa Giant Napier, and Guinea B for example have organic matter digestibilities of over 60 percent, when cut monthly and fertilized at 300 lb N per acre per year. Such good quality grasses, have high concentrate saving value, and this is of considerable importance in the context of rising prices for concentrates, particularly coconut poonac. With digestibilities of over 60 per cent, it should normally be possible to meet both maintenance and production requirements of cows producing around 1½ gallons of milk /day. Only at higher production levels, would there be a need for either concentrate feeding, or a corresponding increase in herbage digestibility.

Focus on Fodder:

With the emergence of such good quality herbage grasses, the new focus, particularly for the mid-country, a high priority area for Animal Husbandry development under the Five Year Plan, has been on fodder development. The marginal plantations in this area are mostly undulating or steeply sloping, so that in such a situation grazing grasses can have only a limited value. On the other hand, high tonnage fodder grasses with their high yield potential can be effectively utilized for feeding livestock under a zero-grazing management. From a series of experiments conducted in this region, three highly promising fodder grasses have emerged as being highly suitable for establishment. These are the hybrid fodder Pusa Giant Napier, Guinea B, a popular ecotype of Panicum maximum and the Nandi variety of Setaria sphacelata. The mean annual production of herbage dry matter, at a fertilizer application of 300lb N per acre per year, and under a cutting frequency of a month have been of the order of 38,824, 29,628, and 29,637 lb per acre/year for the three fodder grasses respectively. (Appadurai and Goonewardene 1971). These are all very high yields of herbage, and would be capable of supporting around 3 - 4 milking cows per acre. The animal production potential of these three grasses was estimated on the basis of a controlled feeding trial, with penned sheep. Mean liveweight gains per day of growing Bikaneri sheep fed artificially dried grass made from the monthly cut herbage, amounted to 147.5 g, 116.7 g, and 99.0 g for Pusa Giant Napier, Guinea, and Setaria respectively during an experimental period of 70 days. (Goonewardene and Appadurai 1972). The percentage organic matter digestibility (invitro) of the samples fed was 66.6% in Pusa Giant Napier, 62.3% in Guinea, and 53.7% in Setaria, and this rating was clearly reflected in the liveweight gains produced. Management practices suited to the maintenance of high feeding value have

high feeding value have also been established on the basis of research findings. The inverse relationship observed between herbage dry matter yield and its feeding value indicates that the maintenance of high feeding value will involve a compromise between yield and quality..(Goonewardene and Appadurai 1971). These fodder grasses can all be established most effectively on small holdings of 5 - 10 acres, in which not only the planting, replanting, fertilizing, and the maintenance of the fields, but also the daily routine of cutting and carting of the cut fodder to the stalled cattle, would in terms of labour intensiveness, be second only to tea on these lands.

Hill Country wet zone: For the Hill Country wet zone, the introduction of temperate type grasses and legumes has opened the possibility for developing ley farming practices, that could help to farm these lands intensively with both crops and livestock. The need for energy supplementation for milking cows fed on kikuyu grass, noted for its high protein content, but low percentage dry matter re-emphasises the need to integrate crop and animal production on these farms, so that the necessary feed, including crop by-products and residues could be used to correct imbalances due to pasture nutrition. Such integration will also result in better land use, enabling these lands to be used for raising both crops and livestock for long periods without loss of soil fertility.

Potential of the dry Patanas:

No better example of poor, and denuded soils can be found in this area than the patanas of the hill country dry zone covering nearly 150,000 acres. Of this extent nearly 38,000 acres consist of rolling or undulating land. Hitherto there has been no attempt at utilizing these lands for more productive purposes. The work of one of my research students at the Pattiyagedera dry zone Research Station has now conclusively demonstrated that through a programme of pioneer cropping using a short term crop such as fodder sorghum, it would be possible to recondition these lands for pasture establishment. These could thereafter be intensively farmed using high nitrogen pastures, consisting chiefly of the Panicums, Paspalums, and Setarias. The potential of such lands either for sheep or for cattle production has now been conclusively demonstrated on an experimental basis, and needs to be followed by farm trials which would also have a demonstration value. (Sivasupiramaniam 1971).

Conservati and the need for a feed Calendar:

Year round systems of feeding livestock from pasture must rely on efficient methods of conservation. This is obviously one of the major bottlenecks in pasture production. Pasture improvements for the future must be aimed at circumventing the limitations imposed on pasture production by climate. For the dry zone, irrigated pasture,

and livestock may provide a possible solution, but equally important would be the need to amalagamate both species and systems of management into one feeding system. The need for the development of a feed or fodder calendar in which pasture, fodder, and even tree fodders could be combined with systems of conservation should be examined carefully. Partial barn hay drying may be resorted to, to overcome the problems of high humidity during storage of hay. Heavy plastic or rubber sheeting could be used to carefully seal the surface of the mass during ensilage in pits, in order to reduce the losses due to spoilage by rain. Non-protein nitrogen supplements such as Molasses-Urea could be used to meet protein deficiencies in herbage particularly during the long period of dry weather during June to September. In the light of such developments increasing efforts should be made towards over-coming the problems, which have hitherto tended to restrict animal production during periods of feed shortage in the dry periods.

Farming systems:

Finally there is an urgent need to develop productive farming systems, embodying the synthetic, as opposed to the analytical appraoch to research, in our attempts to solve the farmers problems, connected with grassland farming. This is best illustrated with reference to the possibilities that exist for grassland farming in Coconut plantations. Nearly two decades of research at the Coconut Research Institute indicates that considerable possibilities exist for the successful exploitation of the space and growth factors existing under mature coconut plantations. There is also positive evidence available that grassland farming under coconuts is technically feasible and can be encouraged without detriment to the palms. What is now obviously necessary is to demonstrate the economic feasibility of inter-cropping in general and of grassland farming in particular, in order to develop a farming system for coconut lands, so as to increase the productivity of these hitherto unexploited areas. How can this be done? There is an urgent need at the present time for farm management studies which could shed some light not only on the economic feasibility of various farming systems, but which could also generate information which could be used to determine the economic size of holdings under coconut say for example in the wet zone. Such trials would also shed light on the likely problems in management, and the supporting systems that would be required to ensure the viability of such farm plans. There is a strong case, for example, for the development of dairying on these lands, since 32% of the national herd is located within the zone and the demand for liquid milk in Colombo, consequent to the diversion of the milk produced in the hill country to the two processing factories will have to come from within the coconut triangle. Equally there is a strong case also for

The question then is, is there a case for developing a farming system either for milk production or for beef production under coconuts, and what role must research play in the development of such systems of farming? The farm studies I have proposed will no doubt provide at least part of the answer.

Oraganization of Grassland Research:

It is clear then, that for the development of the ruminant industry in Sri Lanka, a primary requirement would be the reduction of our dependance on concentrate feeds, by the better utilization of pasture and fodder. Unfortunately the rate of progress in this most important sphere of development activity has been poor. As I pointed out at a recent seminar on the Five Year Plan, the extent of improved pasture at the present time works out to less than one acre for every 10 head of the productive bovine population in the country. (Appadurai 1972). It is clear also at least with regard to one of our major milk production projects that success would depend not so much on the location or on the breed or even the health of the dairy animals but on finding the thousands of acres on which to develop pasture in an area where holdings are small, and the farmers have no experience or interest in herbage production. Indeed a primary requirement for any milk production or dairy development project would be the working out of the type and quality of feed that has to be produced, and the adjustments in land use and farming practices that would be required to produce this feed.

Unfortunately no such organizations exists for grassland research in this country. There is an urgent need for a fully fledged Grasslands Division, in the Department of Agriculture, preferably under the direction of a separate Deputy Director, with regional units in the different agro-climatic regions, to undertake this work. The Grasslands Division should be staffed by qualified and competent officers, who should be entrusted with the work of introduction, evaluation, and propagation of planting material, and the responsibility for providing the research information required for the promotion of grassland farming, which is the most urgent need at the present time, if we are to achieve any kind of break through with respect to the ruminant livestock industry, in Sri Lanka.

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FIGURE - 2

FEED REQUIREMENTS AND AVAILABILITY
(1973 - 1977)