TROPICAL AGRICULTURIST

AGRICULTURAL JOURNAL OF SRI LANKA

VOLUME CXXIX, NUMBERS 3 & 4

JULY – DECEMBER, 1973

PUBLISHED BY

THE DEPARTMENT OF AGRICULTURE, SRI LANKA (CEYLON)

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VOLUME CXXIX NUMBERS 3 & 4 JULY-DEC., 1973

TROPICAL AGRICULTURIST

Agricultural Journal of Sri Lanka

CONTENTS

PUBLISHED BY

THE DEPARTMENT OF AGRICULTURE, SRI LANKA

ISSUED BY

THE AGRICULTURAL INFORMATION DIVISION, 102, UNION PLACE, COLOMBO 2, SRI LANKA. (P.O. BOX 636)

PRINTED AT THE DEPARTMENT OF GOVERNMENT PRINTING, SRI LANKA (CEYLON)
2 A 00364—762 (7/73)

Studies on pasture improvement in the hill country dry zone patanas of Sri Lanka*

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(Received July, 1973)

I—EFFECT OF PIONEER CROPPING ON PASTURE ESTABLISHMENT

SUMMARY

IN an experiment carried out on heavily eroded infertile land to study the effects of one year of pioneer cropping on subsequent pasture establishment, the vigour of growth of the establishing pasture during the first six months was increased four-fold by pioneer cropping. This difference in growth vigour disappeared six months later but the swards established following a pioneer crop phase were characterised by a much lower incidence of weeds. The use of a higher level of lime, phosphate and sulphur the pioneer crop resulted in higher yields of forage, but there were on significant differences beween the different pioneer cropping treatments in their effects on subsequent pasture establishment.

INTRODUCTION

Natural grasslands (popularly referied to as the "dry patanas") occur in the hill country dry zone of Sri Lanka on steep to moderate slopes, at elevations ranging from 3,000 ft. to over 4,000 ft. The area is characterised by relatively mild temperatures throughout the year, with daily maximum, minimum and average temperatures around 76° F, 60° F and 68° F respectively. The total annual rainfall (average 66 inches) is bimodally distributed resulting in a 14 to 16 week wet season from around late September to mid-January, a second but shorter wet spell from mid-March to early-May, and a pronounced dry period of at least 16 weeks from late May to late-September.

The native pastures are of extremely low productivity, due largely to the very low level of soil fertility caused by sheet erosion over the past several decades. The generally steep topography of the land precludes the development of arable cropping but climatic conditions favour the introduction of high yielding Pastures. The main limitation to the development of such improved pastures in the region would appear to lie in the very low level of physical as well as chemical fertility.

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*Based on a thesis presented for the degree of Master of Science (Agriculture), of the University of Sri Lanka.

The interpo'ation of a brief, fertility rebuilding, pioneer crop phase between the ploughing up of the native grassland and the establishment of superior pasture, constitutes a possible method for circumventing the otherwise slow rate of establishment that occurs when superior pastures are seeded directly into ploughed up land. A two year experiment was therefore initiated to study the effects of different one-year pioneer cropping systems on the establishment and first year productivity of subsequently introduced permanent pasture.

EXPERIMENTAL

Six pioneer cropp ng treatments and a 'no pioneer cropping' control were included in an experiment based on a Latin Square design. The size of plot was 20 ft × 20 ft. The treatments are summarised below :—

T1 No pioneer cropping prior to pasture establishment 'High' level of Ca, P and S applied at the time of pasture establishment.

T2 Forage sorghum (October to January) followed by a ratoon crop (April to June) in the year preceding pasture establishment.
'Moderate' level of Ca, P and S applied to the sorghum crop.

T3 Forage sorghum (October to January) followed by sunnhemp (April to June) in the year preceding pasture establishment. 'Moderate' level of Ca, P and S applied to the sorghum crop.

T4 Forage sorghum (October to January) followed by a ratoon crop (April to June) in the year preceding pasture establishment. 'High' level of Ca, P and S applied to the sorghum crop.

T5 Forage sorghum (October to January) followed by sunnhemp (April to June) in the year preceding pasture establishment. 'High' level of Ca, P and S applied to the sorghum crop.

T6 Forage sorghum (October to January) follwed by a ratoon crop (April to June) in the year preceding pasture establishment. 'High' level of Ca, P and S applied in two equal split doses to the main sorghum crop and at the time of pasture establishment respectively.

T7 Forage sorghum (October to January) followed by sunnhemp (April to June) in the year preceding pasture establishment. 'High' level of Ca, P and S applied in two equal split doses to the main sorghum crop and at the time of pasture establishment respectively.

'High' Level ..	20 cwts. dolomitic limestone, 10 cwts. of ordinary superphosphate and 5 cwts. of gypsum per acre.
'Moderate' Level ..	10 cwts. of do'omitic limestone, 5 cwts. of ordinary superphosphate and 2.5. cwts. of gypsum per acre.

The experimental area, which was sited on typical native grassland was ploug-ed in mid-July 1969. Ca P and S fertilisers were applied to the plots carrying treatments 2,3,6, and 7 at the 'modeiate' level and to the plots carrying treatments 4 and 5 at the 'high' level. The pioneer sorghum crop was sown in early October with the first rains using the local variety known as 'Maradankadawala'. A seed rate of 15 lb per acre was adopted and the seed was sown in rows 1 ft. apart. A top dressing of 60 lb N and 50 lb K_20 per acre was applied to all plots during the growth of the crop, which was harvested at 14 weeks. The harvested sorghum was fed to livestock and the animal manure (dung and urine) returned to the individual plots in proportion to the yield of haivested herbage.

With the onset of the short wet season in late-March 1970, the plots carrying tieatments 3, 5 and 7 were ploughed up and sownwith sunnhemp at 30 lb. per acre. The plots caırying treatments 2,4, and 6 received 40 lb N at this stage to stimulate the growth of the ratoon crop. Both the sunnhemp and ratoon sor-ghum crops were harvested 11 weeks later. The former was ploughed back as green manure while the sorghum forage was fed to livestock and animal manure returned, as before, to the respective plots in proportion to yield.

At this stage the entire experimental area was ploughed. Ca, P and S fertiliseıs were applied to plots carrying treatment 1 at the ' high ' level and to the plots carrying treatments 6 and 7 at the ' moderate ' level. With the commencement of the main wet season in early October, 1970, the entire experi-mental area was uniformly planted up with Kikuyu cuttings spaced 1 ft. apart. All the plots were uniformly fertilised at 40 lb P_20_5 and 50 lb K_20 per acre while during the next two months nitrogen was applied at 60 lb per acre, in two split dressings. Two defoliations were carried out on the establishing sward in mid-January and early-April.

At the commencement of the shoıt wet season in April, 1970, all plots again received 40 lb N per acre and a third defoliation was effected at the end of May. A sample of the yield of each plot was dried to determine the dry matter content of the harvested grass.

RESULTS

A. *Pioneer Crop Yields*

The yields of the pioneer crops in the different pioneer cropping systems are presented in Table 1.

Application of the ' high ' level of Ca, P and S at the commencement of the pioneer cropping phase resulted in a significant increase in the yield of the main sorghum crop, relative to the ' moderate ' level of application. The yields of the following sorghum ratoon crop or sunnhemp crop however showed no response—indicating the absence of any residual fertiliser effects. Yields of the ratoon sorghum crop were almost 90 per cent of the main crop, while sunn-hemp yields were only about 10 per cent less than that of the ratoon sorghum crop.

B. *Pasture Establishment*

The yields of Kikuyu herbage harvested in the different treatments at the three defoliations effected during the establishment year are summarised in Table 2.

The data recorded at the first two defoliations clearly indicate a very marked effect of pioneer cropping in securing the vigorous growth of subsequently established pasture. The vigour of pasture establishment following pioneer cropping was approximately four times greater than in the treatment where no pioneer cropping was practised. No significant differences were however evident between the six pioneer cropping treatments tested, in regard to their effects on subsequent pasture establishment. The different levels and strategies of lime, phosphate and sulphur application, and the two different types of cropping practised during the short wet season therefore do not influence the effect of pioneer cropping on the vigour of subsequent pasture establishment.

At the third defoliation which was effected in late-May (after the growth made during the short wet season), herbage yields in the swards established following pioneer cropping were no longer superior to the yields of the swards established without prior pioneer cropping. Yields of herbage at this defoliation were also about 50 per cent greater than the total yield obtained at the two previous defoliations in the swards established following pioneer cropping.

DISCUSSION AND CONCLUSIONS

The pioneer cropping treatments tested in the experiment provide a comparison on two pioneer cropping systems. Sorghum grown during the main wet season is followed, during the short wet spell, by a ratoon sorghum crop in one cropping system and by sunnhemp in the other. A comparison is also provided of four different fertiliser strategies viz. a moderate level of Ca, P and S applied exclusively to the main sorghum crop, a ' high ' level similarly applied, a high level applied in equal split doses to the main sorghum crop as well as to the subsequently established pasture, and finally the ' high ' level applied exclusively to the establishing pasture.

The results of the experiment indicated no significant difference between the two cropping systems, either in regard to the yield of forage produced during the pioneer cropping phase or the early vigour of growth of the subsequently established pasture. Since the operational costs of seeding the sunnhemp crop are greater than the cost of the nitrogen fertilizer applied to stimulate the growth of the ratoon sorghum crop, it would appear that the cropping system involving the ratoon crop is to be preferred.

In regard to the fertiliser strategies, a 20 percent higher yield of forage was obtained where the higher level of Ca, P and S fertiliser was used exclusively on the main sorghum crop. This difference in pioneer crop productivity however failed to produce any significant corresponding effect on the vigour of subsequent pasture establishment, relative to the treatment where the 'moderate' level of these fertilisers was used. Application of the 'high' level of these fertilisers in equal split doses to the pioneer crop as well as to the establishing pasture did not produce any significant increase in the vigour of pasture establishment—relative to the treatment where a 'moderate' level of fertilisers was applied exclusively to the main sorghum crop—the choice being determined by the relative costs of the fertilisers on the one hand and the value of the milk yield or live weight gain returns (obtained by feeding the increased quantity of forage) on the other.

The high level of Ca, P and S fertiliser was applied exclusively to the establishing pasture in treatment 1 where no pioneer cropping was practised. The distinctly lower herbage yields at the first two defoliations (relative to the swards established following pioneer cropping) therefore suggest that poor soil physical conditions, rather than nutrient deficiencies, constitute the main limitations to vigorous pasture establishment where no pioneer cropping is practised. The growth of sorghum in the pioneer cropping treatments not only results in a large quantity of organic matter which, under the conditions of the experiment, was returned to the land as animal manure, but the decay of the extensive root system of the sorghum crop may also be expected to contribute greatly to opening up the soil and to an increase in its permeability, water holding capacity and organic matter content. Such amelioration of soil physical conditions was lacking in the absence of a pioneer cropping phase.

The pronounced effect of pioneer cropping on the early growth of establishing pasture—as demonstrated in this experiment—is of particular interest since the yield of forage produced in the pioneer cropping phase did not exceed 8 tons per acre, largely due to the low seed rate used (15 lb. per acre).

More optimal seed rates in the region of 30 to 40 lb per acre—such as are generally used for forage production—may be expected to result in considerably higher returns of organic matter to the soil and, therefore, in a corresponding increase in the vigour of establishment.

The disappearance of any difference in productivity between the sward established with, and without, pioneer cropping at the third defoliation effected 7 months from the date of pasture establishment may be partly related to the application of the high level of Ca, P and S as a single dose to the sward established without pioneer cropping —in contrast to the other treatments where the fertiliser was applied wholly or partly to the preceding pioneer crop. An important effect of pioneer cropping—and of a long term nature—is however seen in regard to the incidence of weeds in the sward. The weed population in swards established without pioneer cropping was approximately four to five times greater than in the swards established following pioneer cropping. Weeding costs are therefore greatly reduced. Left unweeded, the higher weed incidence in pastures established without pioneer cropping may be expected to result in a reduction in the productivity and longevity of the pasture.

II—PERFORMANCE OF IMPROVED PASTURE ON RECONDITIONED PATANA LANDS

SUMMARY

FOUR experiments conducted on the reconditioned patana lands of the hill country dry zone of Ceylon indicated that tropical and sub-tropical grasses like *Setaria sphacelata*, *Panicum maximum* and paspalum species could be expected to sustain a high level of herbage production when adequately fertilised with nitrogen both in the year of establishment and in the second year. But when grown in admixture with sub-tropical legumes like *Desmodium uncinatum*, *Glycine javanica* and *Phaseolus atropurpureus* (Siratro) the productivity of the grasses was much lower, and the legume component of the sward either completely disappeared or reduced considerably by the second year. Further in order to obtain maximum herbage of satisfactory feeding value, these species had to be both adequately fertilised and defoliated once in four to five weeks.

INTRODUCTION

Several improved tropical and sub-tropical pasture species could be expected to grow well in the hill country dry zone (patanas) of Ceylon, once the soil has been ameliorated by a one-year programme of pioneer cropping described in the earlier paper (Sivasupiramaniam et al, 1973). Suitable species should, in particular, be able to withstand the three to four months drought that prevails during the period June to September. An evaluation of the most promising grasses under these conditions grown both in pure stands as well as in admixture with legumes therefore becomes necessary. Under temperate conditions the virtues of including a legume component in a pasture sward are well understood ; but their role in tropical environments is yet inconclusive (Vincent, 1965). In a drying soil, however, legumes on account of their deeper root systems can be expected to tap water resources lower down in the soil profile. Generally however, tropical and sub-tropical grass species lose their feeding value much more rapidly than their temperate counterparts. Therefore it would be necessary to defoliate these species at the correct stage of growth if maximum dry matter of satisfactory feeding value is to be realized.

The four experiments described in this paper were therefore designed to obtain some basic information on the suitability, yield potential, and cutting or grazing management of certain promising grasses, and also the feasibility of growing legumes in admixture with them.

EXPERIMENTAL

Experiment I

This was designed to compare the performance of twelve tropical and sub-tropical grasses in pure stands, on patana lands that had been previously pioneer cropped.

The following twelve varieties used for the sudy were established in plots 20′ × 10′ in a simple randomized block design with three replicates :

(1) Paspalum dilatatum poir. (Dallis grass)

(2) Paspalum plicatulum Michx. (Sweet grass)

(3) Paspalum commersonii Lem. (Scrobic)

(4) Chloris gayana Kunth. (Rhodes)

(5) Setaria sphacelata (Schumach) Stapf and Hubbard (Nandi Setaria) Var. Nandi

(6) Setaria sphacelata (Schumach) Stapf and Hubbard (Kazungula Setaria) Var. Kazungula

(7) Panicum maximum Jacq. Var. Green panic (Green panic)

(8) Panicum maximum Jacq. Var. Gatton panic (Gatton panic)

(9) Panicum maximum Jacq. Var. Guinea (Guinea)

(10) Digitaria decumbens Stent. (Pangola)

(11) Phalaris tuberosa L. (Phalaris)

(12) Pennisetum clandestinum Hochst. (Kikuyu)

All the grasses except pangola and kikuyu were established by seed. The experiment commenced in *Maha* (N.E. Monsoon season) 1968. During the seeding year 140 lb. nitrogen as sulphate of ammonia, 80 lb. P_2O_5 as ordinary superphosphate and 50 lb. K_2O as muriate of potash per acre was applied. The application of fertilizers was timed to coincide with the spells of wet weather and defoliations were based on visual observations of growth. On this basis a total of four cuts were made during the first of the seeding year and a total of five cuts in the second year. In the second year nitrogen was increased from 140 to 300 lb. per acre while P and K remained the same.

Results

Mean total yields of fresh herbage during the seeding year as well as in the second year are presented in Table 3. The varieties are ranked in order of productivity and yields are also expressed as a percentage of the outstanding variety Kazungula setaria whose yield is taken as 100 per cent. both in the seeding year as well as in the second year in the respective columns.

On the whole, scrobic and the two setarias were the most productive grasses during the seeding year with phalaris grass being the poorest ; whereas in the second year Kazungula setaria retained its superiority and was distinctly the best grass under study, closely followed by the panicum varieties and Nandi setaria.

Experiment II

This was designed to assess the productivity of the same twelve grasses grown in admixture with legumes and without any fertilizer nitrogen.

The layout of the experiment and the plot sizes was similar to Experiment I, but the legumes were planted in admixture with the grasses. Seeds of the legume mixture comprising equal parts by weight of *Desmodium uncinatum*, *Glycine javanica* and *Phaseolus atropurpureus* (siratro) were sown att he rate of 2 lb. per acre on 11.10.68 after innoculating with the appropriate rhizobial strains from imported peat cultures. The grasses were seeded one week later at right angles to the legume rows, in order to get a more uniform stand of legumes and grasses in the sward. Fertilizer applications were the same as in Experiment I, except that in the present trial no nitrogen fertilizer was applied. Defoliation treatments were also similar to Experiment I, and were carried out on the same dates. At each defoliation, yield samples from each plot were hand-separated into the component grasses and legumes and their freeh weights determined. The experiment was terminated at the end of the second *Maha* as the legume component had almost disappeared from the sward by then.

Results

As in the earlier experiment, during the seeding year the highest yields of grass in the mixed swards were from the more vigorous species such as scrobic and the two setarias while the lowest yields were produced by the less vigorous species such as Pangola, Rhodes, Sweet, and Dallis grasses. The legume component of the swards based on the more vigorous grasses varied from 5 to15 per cent. while in the case of the swards based on the weaker grasses it exceeded 25 per cent. Herbage yields of the grass and legume components are presented in Table 4, which represent both the seeding year as well as the second year *Maha* season. In general there was an inverse relation between the vigour of the grass and the associated legumes.

The decrease in the legume component was most marked in the swards based on the setarias and the panicums. Productivity of the mixed sward appeared to be directly related to the aggressiveness of the grass species. There was very little difference in the grass herbage productivity in the seeding year between pure swards and mixed swards. In the succeeding year however mixed swards showed a reduction in yield indicating that nitrogen was in short supply compared to the pure swards to which nitrogen fertilizer had been applied. At the end of the second year *Maha* the legume component had completely disappeared in the case of the swards based on the setarias, panicums and kikuyu. Indeed in all the swards tested, there was virtual disappearance of the legumes almost twelve months after seeding.

Experiment III

A further unreplicated preliminary trial was initiated in the *Maha* 1968/69 season to study the effects of legumes versus inorganic nitrogen on the productivity of swards based on six tropical and subtropical grasses.

The six grass species namely *Brachiaria brizantha*, *Pennisitum clandestinum* *Phalaris tuberosa*, *Setaria sphacelata*, *Digitaria decumbens* and *Paspalum dilatatum* were established in five different sward types as follows —

(*a*) Grass with *Desmodium uncinatum*

(*b*) Grass with *Glycine javanica*

(*c*) Grass with *Phaseolus atropurpureus* var. siratro

(*d*) Grass with the mixture of above three legumes.

(*e*) Grass in pure stand with nitrogen fertilization.

Each sward type was established on an area 60 ft. by 60 ft. The fertilizer treatments during the establishment year included P and K at the rate of 80 lb. P_20_5 and 50 lb.K_2 O per acre applied in two split applications. At the commencement of the secnd *Maha* (1969/70) an additional application of P and K at the rate of 60 lb. $P_2 0$ and 50 lb. K_2O per acre was made. In addition, the pure grass sward received 80 lb. nitrogen per acre in three split dressings in the seeding year and 120 lb. nitrogen in the second year *Maha* in two split dressings ; and in the following *Yala* (S.W. Monsoon season) 1970, all the swards received 40 lb. P_2O_5 per acre and 50 lb. K_2O per acre but the pure swards in addition received 60 lb. nitrogen per acre. The swards were defoliated three times in the first year and four times in the second year providing two months of recovery growth between each cut . At each defoliation plot yields were recorded as fresh herbage while composite samples were botanically analysed.

The data on the botanical composition of the different sward types (Table5) indicates that there was a general decrease in the legume component, more marked in siratro and particularly when setaria was the associated grass.

From the total herbage yields obtained from the different sward types in the two years of trial (Table 6) it is evident that the first year yields are higher in the mixed swards than the nitrogen fertilised pure swards, but in the second year, however, the nitrogen fertilised swards produced more than the mixed swards except in the case of phalaris grass.

Experiment IV

This experiment was designed to provide some information in regard to the cutting or grazing management of nitrogen fertilized pure swards of grass species listed in experiment I (except phalaris and pangola) in order to obtain optimum herbage of satisfactory feeding value.

The ten pasture swards which were three years old at the beginning of this experiment were defoliated on the same day with the onset of the rainy season in October, 1970 (N. E. Monsoon season) and 60 lb. nitrogen as urea, 60 lb. P_2O_5 as ordinary superphosphate and 25 lb. K_2O as muriate of potash per acre were applied. Eighteen days after the initial defoliation the first sample was taken at two places, each of 2 ft. by 2 ft. area, randomly selected in the sward. Thereafter samples were taken regularly on 24th, 30th, 36th, 42nd, 48th, 54th, 66th and 78th day and everytime from predetermined fresh areas in a similar fashion. The samples were dried at 98°C for 24 hrs. for determination of dry matter, and the dried samples ground and a representative sub-sample used for protein determination.

Results

The dry matter yields in lb. per acre and percentage crude protein are represented graphically in figure 1.

Dry Matter Yields

In the first 18 days the dry matter production of *Paspalum dilatatum* was over 1,000 lb. per acre while in all the other species it was less than 900 lb. per acre. In the next 6 days the growth rates were observed to be extremely high ; the increase in growth was in the region of 50-70 per cent. in terms of the growth recorded over the first 18 days. From the 30th day onwards the growth was more or less uniform upto 54th day after which there was a reduction in the yield due to senescence.

Crude Protein

In contrast to dry matter yields which increased, the crude protein content of all the grass species decreased with the advance in maturity. When the grasses were young the crude protein content of all the grasses exceeded 17 per cent. and in green panic, gatton panic and kikuyu it was as high as 25 per cent. when cut on the 18th day. But during the next six days there were a rapid decline particularly in green and gatton panics but Kikuyu showed a comparatively smaller depression. The decrease in crude protein content continued at a reduced rate up to the 78th day when their values were less than 10 per cent. except in the case of Kikuyu which was over 11 per cent. (See figure).

DISCUSSION AND CONCLUSIONS

Suitable Grass Species

The comparison of the relative performance of a number of tropical and sub-tropical grasses in nitrogen fertilized pure swards clearly established the superiority of the setarias, panicums and paspalums as the best adapted species for the dry patana environment. Setaria varieties produced almost 45 tons of fresh matter in the seeding year and over 50 tons in the second year. Their high vigour of establishment and the level of first year production are distinctly advantageous characteristics. The panicum varieties showed distinctly less vigorous establishment than the setarias ; the most productive variety (viz. Guinea) recording yields of less than 35 tons per acre in the seeding year, but in the second year, however, all the panicum varieties tested produced yields of herbage as high as those recorded by the setarias.

Of the paspalum varieties tested *P. commersonii* was the highest yielder over the two-year period—production in both the seeding year as well as in the second year exceeded 45 tons per acre. This species was very similar to the setarias in regard to the vigour of establishment and the continued vigour of growth in the second year. *P. plicatulum* was similar to the panicums, but the growth was not as vigorous in the seeding year, though there was a marked improvement in productivity in the second year. *P. dilatatum* is unique in that among these high-yielding varieties, it is the only pasture type exhibiting a low and spreading type of growth. It's productivity is, however, distinctly lower. Yields in the seeding year was as low as 20 tons of fresh matter per acre while in the second year yields did not exceed 35 tons per acre. Even so, its distinct advantage, is that it can be directly utilized by grazing stock without any serious effects on its persistency on account of its tendency to form a dense sod. The latter feature makes it ideally suited for the steeper slopes which constitute a fairly appreciable proportion of the total dry patana area. The very rapid recovery of this species after defoliation—despite its low productivity is another interesting feature which suggests that it could be grazed frequently at a fairly high stage of nutritive value without affecting its persistency.

None of the other grasses tested showed much promise. *Digitaria decumbens* and *Phalaris tuberosa* are, in fact, clearly unsuited to this environment. Kikuyu though low yielding because of its high crude protein content and its sod forming ability is of some use in the dry patana environment of Ceylon.

Role of Legumes

The cheapest method by which pasture could be supplied with the required nitrogen for its growth is by growing it in association with legumes. But it was evident that even the best adapted legumes namely *Desmodium uncinatum, Glycine javanica* and Siratro, which grow extremely well when grown in pure sward failed to persist beyond the second year when grown in association with grasses such as the setarias, panicums and paspalums.

Since it is well known that tropical and sub tropical legumes cannot stand the frequency of defoliation suited for optimum performance of tropical and sub-tropical grasses it is likely that the frequency of defoliation adopted in experiment II could have been too severe for legume persistency. This explanation receives some support from the experiment III where the frequency of defoliation was much less and there the legume species persisted successfully into the third year.

While the adverse effect on legume persistence resulting from defoliation frequencies optional for grass performance may be one of the main reasons for the poor performance of sub-tropical legumes grown in admixture with grass, it is likely that nitrogen fixation by sub-tropical legumes is also greatly inferior to that observed in the case of temperate legumes. The short day environment, high soil temperatures and alternation of wet and dry soil conditions are some of the factors which may be responsible for such restriction of nitrogen fixation, since they retard the growth, functioning and survival of the root nodule bacteria (Vincent, 1965). No reliable data are yet available on the extent of nitrogen fixation by legumes in the dry patana environment. Until such time the role of legumes in pasture is fully investigated in all its aspects, pasture production on the dry patanas of Ceylon has to be based on inorganic nitrogen fertilization.

Defoliation Management of Pure Grass Swards

Since the present investigation (Experiment IV) confirmed the inverse relationship between dry matter production and feeding value, the choice of the optimal stage of defoliation would involve a compromise between the two factors. A late defoliation would result in a higher dry matter production but low feeding value, while the reverse could be true for early defoliation.

Figure 1 indicates the relationship between dry matter yields and the crude protein content of the various species tested. In all these cases the point of intersection occurs between 28–35 days of growth when the crude protein was well above 15 per cent. Therefore a defoliation frequency of 28 to 35 days would appear to be the most advantageous for the species tested under the fertilizer regimes employed in this experiment.

REFERENCES

VINCENT, J. M., 1965—Environmental factors in the fixation of nitrogen by the legumes *Soil nitrogen, Agron., 10,* 384.

TABLE 1

Mean Yields of Forage and Green Manure in First Year

Treatment	*Main Sorghum Crop*	*Ratoon Sorghum Crop*	*Sunnhemp*
	(expressed in lb. per plot)		
1	—	—	—
2	80·0	81·6	—
3	97·0	—	79·9
4	127·4	102·1	—
5	121·7	—	89·6
6	104·3	95·9	—
7	101·4	—	84·6

TABLE 2

Effect of Pioneer Cropping on Growth of Establishing Pasture

Mean Yield of Herbage Dry Matter (lb. per plot)

Treatment	*First Cut*	*Second Cut*	*Third Cut*	*Total*
1	2·2	2·4	22·7	27·3
2	7·2	8·1	21·5	36·8
3	6·5	7·8	21·3	35·6
5	7·2	8·7	21·9	37·8
5	7·5	8·1	22·1	37·7
6	6·4	7·5	23·1	37·5
7	7·2	8·1	22·5	37·8

C. V. = 11·05%

L. S. D. to compare any two (total) treatment means = 5·8 lb. per plot.

TABLE 3

Mean Yields of Fresh Herbage

Grass Species	First Year				Second Year			
	Lb/plot	*Cwt/Acre*	*Ranking*	*Percentage*	*Lb/Plot*	*Cwt/Acre*	*Ronking*	*Percentage*
1. Paspalum plicatulum	337	653	5	68	473	917	7	75
2. Paspalum dilatatum	212	411	10	43	395	766	9	61
3. Paspalum commersonii	478	926	2	97	503	975	6	79
4. Chloris gayana	195	377	11	39	399	773	8	62
5. Panicum maximum (Green panic)	290	562	7	58	594	1,151	2	94
6. Panicum maximum (Gatton panic)	284	570	6	59	543	1,043	5	85
7. Panicum maximum (Guinea)	363	703	4	74	585	1,125	3	91
8. Digitaria decumbens	224	436	9	45	219	414	12	34
9. Setaria sphacelata (Nandi)	462	896	3	93	549	1,062	4	85
10. Setaria sphacelata (Kazungula)	494	957	1	100	642	1,245	1	100
11. Phalaris tuberosa	146	282	12	29	259	501	11	40
12. Pennisetum clandestinum	270	523	8	57	329	632	10	51

* Taking Kazungula Setaria as 100 per cent.

1st Year : C. V.—3·88%

L. S. D. at 1%—27·80 lb./plot

2nd Year : C. V.85%—

L.S.D. at 1%—51·49 lb/plot.

TABLE 4

Mean Yields of Fresh Herbage in lb. per Plot

Grass Species	*First Year*					*Second Year*			
	Grass	*Legume*	*Total*	*Ranking of grass*	*% Legume*	*Grass*	*Legume*	*Total*	*% Legume*
1. Paspalum dilatatum	107	51	158	10	32	126	9	135	7
2. Paspalum plicatulum	101	50	151	11	33	131	10	141	7
3. Paspalum commersonii	302	37	339	3	11	231	6	237	2
4. Chloris gayana	108	63	171	9	37	199	6	205	3
5. Panicum maximum (Green panic)	207	36	243	7	15	229	1	230	∠1
6. Panicum maximum (Gatton panic)	246	31	277	6	11	208	1	209	∠1
7. Panicum maximum (Green panic)	280	32	312	4	10	323	1	324	∠1
8. Digitaria decumbens	120	41	161	8	25	135	7	142	5
9. Setaria sphacelata (Nandi)	349	26	375	2	7	269	0	269	0
10. Setaria sphacelata (Kazungula)	392	22	414	1	5	268	1	269	∠1
11. Phalaris tuberosa	98	42	140	12	30	102	5	107	5
12. Peninsetum Clandestinum	250	31	281	5	11	117	1	118	∠1

TABLE 5

Legume Percentage in Different Sward Types

Legume Grass	*Desmodium*		*Glycine*		*Mixture*		*Siratro*	
	1st year	*2nd year*	*1st year*	*2nd year*	*1st year*	*2nd year*	*1st year*	*2nd year*
1. Pennisetum Clandestinum	26	17	28	20	34	17	14	4
2. Paspalum dilatatum	72	16	76	26	78	19	28	5
3. Brachiaria brizantha	66	7	57	12	67	11	33	7
4. Digitaria decumbens	48	16	59	22	78	30	40	14
5. Setaria sphacelata (Nandi)	15	3	12	5	15	3	3	2
6. Phalaris tuberosa	53	27	37	30	63	35	18	4

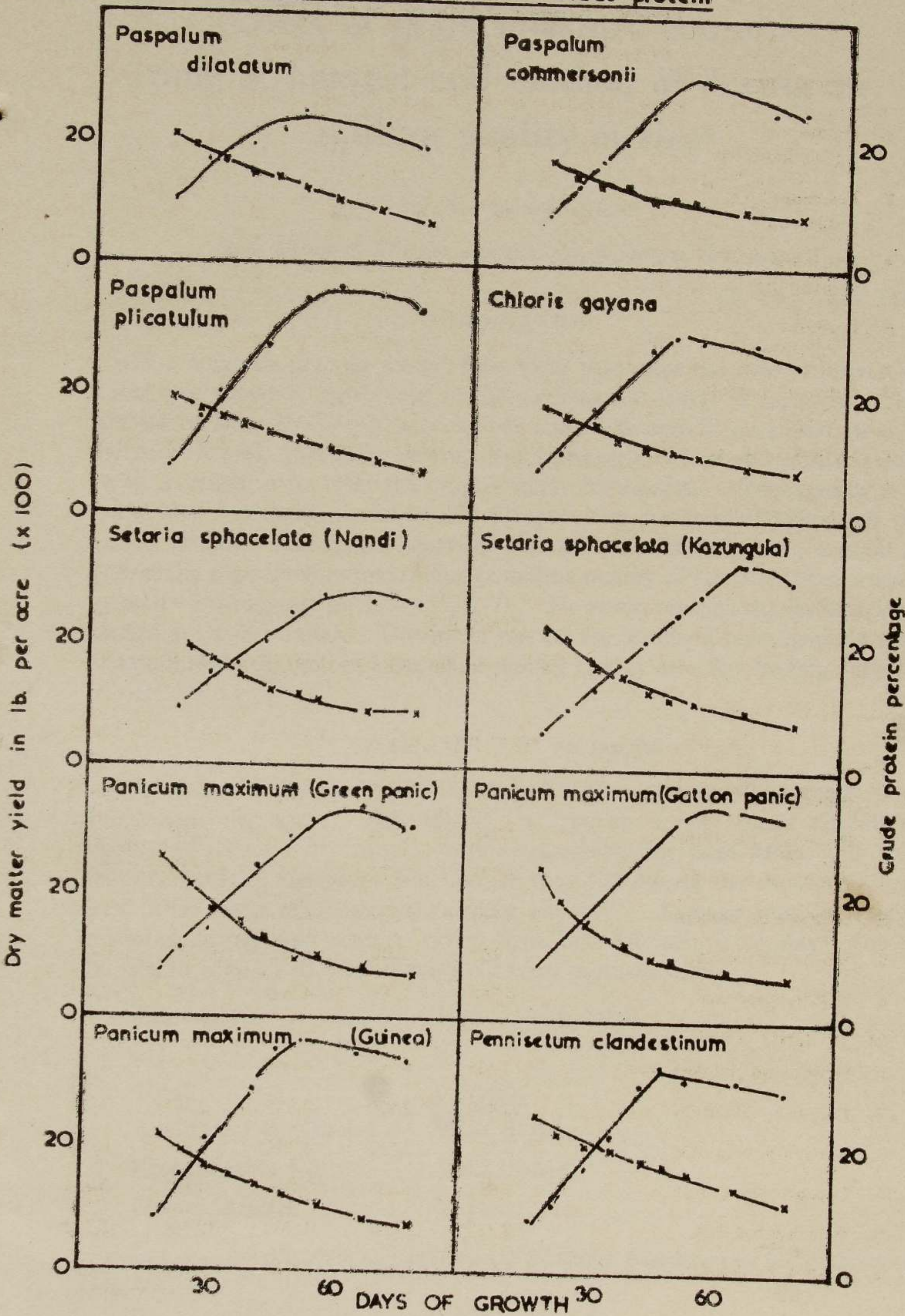
TABLE 6

Total Herbage Yields from the Different Sward Types (in lb.)

Legume / *Grass*	*Desmodium*	*Glycine*	*Mixture*	*Siratro*	*N-fertilized Sward*
(A) FIRST YEAR					
1. Pennisetum clandestinum	3,049	3,325	3,294	3,597	2,763
2. Paspalum dilatatum	2,848	2,694	2,795	2,169	1,722
3. Brachiaria brizantha	2,493	3,077	2,802	2,758	2,610
4. Digitaria decumbens	2,440	2,520	2,412	2,761	1,795
5. Setaria sphacelata	9,980	9,208	9,016	10,304	8,632
6. Phalaris tuberosa	4,268	3,996	4,960	3,136	2,132
(B) SECOND YEAR					
1. Pennisetum clandestinum	5,465	4,962	5,090	4,803	6,397
2. Paspalum dilatatum	3,469	2,839	2,923	2,367	3,475
3. Brachiaria brizantha	5,377	5,552	4,799	4,495	9,345
4. Digitaria decumbens	5,031	4,228	3,016	4,510	5,261
5. Setaria sphacelata	9,738	8,860	10,632	10,300	11,772
6. Phalaris tuberosa	5,852	6,468	5,940	5,936	5,684

Figure 1

Relationship between the Dry matter and Crude protein



Effect of grain moisture content, time of harvest and method of drying on milling quality of rice*

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(Received April, 1973)

INTRODUCTION

It is a common practice among farmers to determine the time of harvest of a rice crop based on the colour of the panicles and leaves at maturity. This method of determining maturity is very unreliable and is particularly true in the new varieties that have delayed leaf senescence, where the plants remain green in colour even after the crop is ready for harvest. Consequently it is found that harvesting is invariably delayed with resultant ill-effects on the quality of rice. The time of harvest, moisture content at harvest, method of drying and other factors that influence milling quality of rice have been studied by many investigators (1, 2, 3, 4, 5, 6, 7). However, no such studies have been carried out in Sri Lanka. This paper reports the results of investigations done at Bombuwala on factors influencing milling quality of a few leading varieties of rice.

MATERIALS AND METHODS

This study was done in Maha 70–71 and Yala 71 at the Rice Research Station, Bombuwela, Kalutara. This station receives an annual mean rainfall of about 115 inches fairly equally distributed during the both Maha and Yala seasons. Mean maximum temperature recorded during the experiment was 31°C while mean minimum temperature was 23°C. Average sunshine energy recorded during both seasons varied from 350–450 cal./sq.cm./day. Soil at the test locations had the following chemical characteristics.

Texture	Humic sandy loam
pH	5.2
Total Nitrogen	0.4786%
Available P_2O_5 (Olsen's)	75.81 lb/Ac.
Exchangeable K_2O	169.2 lbs/Ac.
Organic Matter	11.21%

* Paper presented at the 28th Annual Session of the Ceylon Association for the Advancement of Science.

The test varieties were Kahatawee, Pachchaiperumal 2462/11, and H-4 of the tall indica type, and IR-8, BG-11p11 and LD-66 of dwarf to intermediate type. The crop was transplanted and standard practices of management were adopted. The test was carried out at a fertilizer application level of 100 lbs per acre each of N, P_2O_5 and K_2O. Nitrogen was split applied in the ratio of 1 : 1 : 2 at planting, 4 weeks and 8 weeks after transplanting except in the case of Pachchaiperumal 2462/11 where it was given at planting, 3 weeks and 8 weeks after transplanting. Phosphorus was given as a basal application only while, potash was split applied $\frac{1}{2}$ at sowing and $\frac{1}{2}$ at the 9th week after transplanting.

Each variety was replicated four times in the field. The treatments consisted of harvesting 3 rows (approximately 4 lbs of paddy) from each variety in each replicate. Harvesting was done at 4 day intervals commencing from the 12th day and continued on the 20th, 24th, 28th, 32nd, 36th, 40th and 44th day after 50 per cent. flowering. Harvesting time was fixed between 10 to 11 a.m. and harvesting was done irrespective of the prevailing climatic conditions. Harvested paddy was threshed immediately and grain moisture per cent. was determined using a Steinlite Electronic moisture tester. Grains from each replicate were then divided into two sub-samples one of which was sun-dried the other was shade-dried at room temperature to a moisture level of 13 to 14 per cent. At this stage grain weight was determined after separating the chaff. Shade-dried and sun-dried samples from each replicate were then bulked and stored in cloth bags for three months.

Milling tests were conducted using three 100 gms samples from both the shade-dried and sun-dried grains.

Hulling was done using a Mc Gill Huller and polishing was done in a Mc Gill Miller, under constant pressure for one minute. Head rice and broken rice were hand separated and weighed.

RESULTS AND DISCUSSION : MOISTURE CONTENT OF GRAINS AT HARVEST

It was observed that the moisture content of grains in early harvested samples was in the region of 31 to 33 per cent. (Table 1). Also the percentage moisture content of grains at each harvest was more or less same for all varieties tested. Seasonal variations did not seem to influence the grain moisture content indicating that the rate of ripening during Yala and Maha seasons was the same.

The rate of moisture loss in sun-dried and shade-dried samples was determined by using grain samples harvested at about 23 per cent. moisture. It was found that the rate of moisture loss in sun-dried samples was about 20 to 25 per cent. as compared to 5 to 7 per cent. per day in shade-dried samples. (Data not given).

GRAIN YIELD IN RELATION TO TIME OF HARVEST

In the first sampling almost all grains were green in colour and in the majority of these the kernels were half-filled while in others they were empty. Grain weight increased very rapidly from 12 to 24 days and 12 to 28 days after 50 per cent. flowering in Maha 70–71 and Yala 71, respectively (fig. 1 and 2). During these periods, the yield increase was linear for all varieties (Table 2 and Figs. 1 and 2). In all varieties the major contribution to yield was during the first 20 to 24 days after 50 per cent. flowering. Yield increases after the 24th day were very slight. Varietal differences were observed in the rate of yield increase during the 12 day period from 50 per cent. flowering. The average rate of increase in grain yield in IR-8 during this period was about 4 bushels per acre per day as compared to 1.6 in LD-66, 2.0 in BG-11–11, 2.0 in H-4 and 1.3 in Pachchaiperumal. Also in IR-8 the maximum yield was attained much earlier than in other varieties. This character is possibly associated with high photosynthetic and translocation activity and may be considered a highly desirable physiological trait of this variety.

From grain yield data it is evident that delayed harvesting gave reduced yields in tall, lodging and shattering susceptible varieties like Pachchaiperumal unlike in lodging resistant medium height varieties. Considering both Maha and Yala seasons, varieties tended to reach a maximum yield level between 28th day to 36th day after 50 per cent. flowering. During Maha 70–71 H-4 had lodged partly at flowering, and the low yield recorded (4.9 Bushels/Acre) during first sampling is possibly due to this reason.

MILLING OUT-TURN IN RELATION TO TIME OF HARVEST

Milling out-turn of early harvested samples was very low (Table 3). This is understandable as in early harvested samples grains were still green and half-filled. In general, however the yield of total milled rice increased with time of harvest. Similar results have been recorded in India (1). Increase in weight of grains (100 grain weight) followed a trend similar to milling out-turn (Data not given). In all varieties tested, milling out-turn generally reached a maximum when grains were harvested during 28th to 36th day after 50 per cent. flowering.

HEAD RICE RECOVERY AND BREAKAGE IN RELATION TO MOISTURE CONTENT AND TIME OF HARVEST

The method of drying and time of harvest had a very significant effect on head rice recovery (Table 4 and 4A and 4B). Shade-dried samples gave more head rice than sun-dried samples. Breakages were a minimum irrespective of the method of drying in samples harvested between 28th day and 36th day after 50 per cent. flowering, while in general early or late harvesting resulted in high breakages (Table 5). The difference of head rice recovery between shade-dried samples was higher in early as well as late harvested samples, than in those harvested between 28th to 36th days from 50 per cent. flowering.

The samples harvested at higher moisture levels when sun-dried lose moisture at a rapid rate causing sun cracks in the grains, which enhance breakages in milling. Late harvested samples which have been left in the field to over-mature, and dry to a mo sture level below 18 per cent. tend to absorb moisture from the air, dew or rain. In clear weather these samples lose moisture again. This process of intermient wetting and drying causes sun cracks to form in the grain, a phenomenon reported to be the primary cause for breakages for in milling. Henderson (3) reported that the development of sun cracks begins at the centre of the kernel and progresses towards the circumsfernce and that dew induces cracking. He further observed that the highest head rice yield was obtained when the lowest air drying temperature was used to dry paddy. Uneven expansion of the kernel due to intermittent drying and wetting was attributed to cause cracks in the grain, resulting in breakages at milling.

Striking varietal differences were noticed in respect of percentage breakages of grain. IR-8 gave the highest breakages while LD-66 gave the lowest (Table 5). Compared with other varieties, LD-66 had the least amount of breakages even under sun-dried conditions and in general the difference between sun-dried and shade-dried samples was least in this variety. In IR-8, sun-dried samples on an average gave about 12 per cent. more broken rice than shade-dried samples, whereas in LD-66 sun-dried samples gave about 3 per cent. more broken rice than shade-dried samples. Varieties like BG-11-11 and Pachchaiperumal too gave comparatively low percentages of broken rice.

The susceptibility to breakage in rice varieties is dependent on grain characteristics such as grain length, hardness and chalkiness. The variety BG 11-11 having a small type grain was less susceptible to breakages in milling. The grain of Pachchaiperumal which is a hard grain type was also less susceptible to breakages. The high degree of resistance to breakage in LD-66 (bold grain type) is possibly associated with superior physical characteristics of the grain.

DISCUSSION

The value of rice, the edible product from paddy is dependent to a great extent on the quality of the milled product. A high percentage of broken grains while leading to low head rice recovery results in a product of low market value.

From this study it was found that certain factors within the control of the farmer, influence the quality of milled product. It is evident from this study that time of harvest and method of drying can reduce head rice losses as much as 10 to 15 per cent. Results obtained indicate that delayed harvesting reduces grain yields due to lodging and shattering, where this effect is pronounced in varieties that are susceptible to lodging and shattering.

Moisture content of the grain was the major factor which determined the breakages in milling. Results showed that samples harvested at 20 to 24 per cent. moisture gave the highest head rice recovery. This moisture level was found in samples harvested between 28th day to 36th day after 50 per cent. flowering. Similar results have been obtained in India and Philippines (1,7). It was found that at this stage milling out-turn and grain yield also reached the maximum level for each variety.

This suggests that the moisture content of the grain can be used as a reliable criterion to decide the optimum time of harvest. It has been reported that re-wetting at moisture level of 18 per cent. or above has little effect on grains, while the breakages due to sun crack formation were higher when re-wetting occurred at moisture levels below 15 per cent. (4). It was also found that harvesting later than 36 days gave 1 to 2 per cent. more broken rice per day (Table 6). Similar results have been reported by other workers (1,2 , 6). Results also indicated that shade-drying of paddy immediately after threshing can yield more head rice than sun-drying.

CONCLUSIONS

The best time therefore to harvest a crop of rice is when the grain moisture is about 20 to 23 per cent. In all varieties tested this moisture level was found in samples harvested between 28th to 36th day after 50 per cent. flowering. Generally most of the popular varieties grown by farmers, come into complete flowering 2 to 3 days after 50 per cent. flowering. This means that the optimum time to harvest a rice crop is 30 to 34 days after complete flowering.

ACKNOWLEDGEMENTS

I am thankfull to Dr. J. W. L. Peiris Deputy Director (Research), Dr. D. V. W. Abegunawardena Assistant Director (Research) and Dr. I. Gunawardena Botanist for the valuable suggestions made and the keen interest shown in this study. My thanks are also to Dr. H. Weeraratna and D. Senadeera for the valuable help given in milling a large number of samples.

The author gratefully acknowledges the excellent assistance given by Mr. P. D. Hemadasa, Laboratory Assistant and other laboratory minor staff, both in the field and laboratory work.

REFERENCES

S. GOVINADASWAMI and A. H. GHOSE—Time of harvest and method of drying on milling qualities of rice—ORYZA, *Journal of the Association of Rice Research Workers*. Vol 6, (1969). No. 2 54–65.

HUYSMANS, A. A. C., 1965—Milling quality of paddy as influenced by timing of harvest, *I. R. C. News letter*, Nol. 14(3). 4–12.

HENDERSON, S. M., 1954—The cause and characteristics of rice cracking, *Rice Journal*, 57(5). 6P18.

RHIND, D., 1962—The breakages of Rice in milling review. *Top. Agric*. Vol. 39, No. 1 (January).

TEN HAVE, H., 1963—The testing of new promising varieties for their yield of total milled rice and breakages.

TEN HAVE, H., 1959—Effect of date of harvest on the quality of some rice varieties. *Rice Journal* 62 (1). 27–30.

D. NANGJU and S. K. DE DATTA—Effect of time of harvest and nitrogen level on yield and grain breakages in transplanted rice. *Agronomy Journal*, Vol. 62, July-August (1970). 468–474.

TABLE 1

Moisture Percentage at Time of Harvest

Time of harvest days after 50% flowering	KAHATAWEE		H-4		LD-66		BG-11-11		IR-8		PP			
	Maha 70–71	*Yala* 71†	*Maha* 70–71	*Yala* 71	*Maha* 70–71	*Yala* 71	*Maha* 70–71	*Yala* 71	*Maha* 70–71	*Yala* 71	*Maha* 70–71	*Yala* 71	*Maha* 70–71	*Yala* 71
12	32.35	—	32.56	31.07	32.94	32.93	31.88	30.79	28.68	32.68	32.77	33.16	31.86	32.12
16	29.60	—	29.92	28.70	31.75	31.44	28.96	28.58	28.52	28.67	32.40	32.31	30.19	29.94
20	28.42	—	29.92	27.83	30.05	29.27	26.31	25.37	25.07	25.08	31.06	32.15	28.47	27.94
24	26.80	—	27.53	27.05	28.39	27.66	26.10	25.46	23.91	23.42	27.23	29.31	26.66	26.58
28	25.20	—	28.02	23.29	25.79	26.05	22.39	24.43	20.28	22.46	25.06	27.75	24.45	24.79
32	21.20	—	24.59	25.08	25.75	25.19	21.94	19.56	22.15	20.32	25.16	30.25**	23.46	24.08
36	20.16	—	22.65	18.78	22.96	22.86	19.18	17.92	19.72	23.73**	24.31	33.38**	21.50	23.33
40	17.49	—	20.17	17.41	26.01	**22.43	21.51	17.61	16.75	17.82	23.12	31.94**	20.84	21.44
44	—	—	*	17.79	*	*	*	16.67	*	15.75	*	31.70	—	20.50

† During Yala 71 Kahatawee was not sampled.

* Not sampled due to floods.

** Increase in moisture content due to rainy weather.

TABLE 2

Effect of Time of Harvest on Grain Yield (Bushels/Acre)

Time of harvest days after 50% flowering	*KAHATAWEE*	*H-4*			*LD-66*			*BG-11-11*			*IR-8*			*PP*		
	Maha 70–71	*Maha* 70–71	*Yala* 71	*Mean*	*Maha* 70–71	*Yala* 71	*Mean*	*Maha* 70–71	*Yala* 71	*Mean*	*Maha* 70–71	*Yala* 71	*Mean*	*Maha* 70–71	*Yala* 71	*Mean*
12	13.0	4.9	42.9	23.9	20.2	17.5	18.8	17.1	31.4	24.2	54.1	54.5	54.3	16.5	13.9	15.2
16	33.4	36.0	55.1	45.6	39.0	48.7	43.8	35.8	47.7	41.8	64.5	70.2	67.4	21.3	28.4	24.8
20	42.4	56.7	75.0	65.8	59.3	60.2	59.8	55.9	69.0	62.4	82.7	78.3	80.6	25.5	36.9	31.2
24	55.1	61.1	80.6	70.8	63.9	74.1	69.0	64.5	80.9	72.7	84.9	90.2	87.6	35.8	38.4	37.1
28	51.3	72.0	84.3	78.2	62.9	84.3	73.6	76.4	90.0	83.2	89.6	95.6	92.6	35.0	40.8	37.9
32	52.5	88.4	84.5	86.4	88.6	90.2	89.4	84.4	93.4	88.9	90.2	90.6	90.4	32.6	42.9	37.8
36	58.3	80.8	78.7	79.8	91.2	92.8	92.0	86.0	94.0	90.0	94.2	88.8	91.5	25.2	35.0	30.2
40	55.5	89.0	76.8	82.9	95.5	91.0	93.2	88.4	89.2	88.8	84.4	84.5	84.4	25.5	35.8	30.6
44	†	†	83.2	83.2	†	95.2	95.2	†	90.4	90.4	†	82.3	82.3	†	29.4	29.4
Rate of yield 0–12	1.1	0.4	3.6	2.0	1.7	1.4	1.6	1.4	2.6	2.0	4.5	4.5	4.5	1.4	1.2	1.3
increase in 12–24	3.5	4.7	3.1	3.9	3.6	4.7	4.2	4.0	4.1	4.0	2.6	3.0	2.8	1.6	2.0	1.8
Bu/ac. perday 24–36	0.3	3.4	0.5	2.0	2.3	1.0	2.0	1.8	1.1	1.4	0.8	1.3	1.2	—	0.6	—

† Not sampled due to floods.

During Yala '71 Kahatawee was not sampled.

TABLE 3

Effect of Time of Harvest on Milling Out-turn Percentage

Time of harvest days after 50% flowering	*KAHATAWEE*		*H-4*		*LD-66*		*BG* 11–11		*IR-8*		*PP*	
	Sun	*Shade*	*Sun*	*Shade*	*Sun*	*Shade*	*Sun*	*Shade*	*Sun*	*Shade*	*Sun*	*Shade*
12	53.6	51.2	42.9	42.0	64.8	51.9	58.6	57.0	62.2	62.7	52.0	58.6
16	51.8	53.8	55.8	52.1	61.6	60.2	65.5	64.3	66.3	67.6	60.0	59.7
20	68.6	59.5	63.0	64.6	67.6	65.6	69.0	68.8	68.2	68.9	62.4	65.3
24	63.8	64.3	70.5	68.4	68.9	69.0	71.1	68.5	69.6	65.6	63.8	65.2
28	69.0	64.7	70.4	68.5	68.0	69.8	72.0	71.4	71.4	69.1	66.3	64.1
32	70.6	67.5	70.5	70.0	70.9	67.0	72.2	71.7	71.0	68.8	60.9	69.2
36	71.9	66.9	70.8	70.1	70.2	69.9	71.2	71.0	69.8	70.2	66.2	67.6
40	71.5	67.6	70.0	69.8	69.8	70.8	69.1	71.4	70.5	67.0	67.3	67.8
44	*	†	71.9	69.7	69.6	67.2	71.4	66.3	71.3	69.2	69.6	66.1

* Kahatawee data of 70–71 Maha only, but mean of two seasons data in other varieties.

† 44 days after 50 percent flowering—data of 71 Yala Only. (Maha 70–71 44 days after sampling not done due to floods.).

TABLE 4 (a)

Time of Harvest and Method of Drying on Head Rice Recovery 1970–71 Maha

HEAD RICE RECOVERY PERCENTAGE

Time of harvest days after 50% flowering	*KAHATAWEE*			*H-4*			*LD-66*			*BG-11-11*			*IR-8*			*PP*		
	Sun	*Shade*	*Mean*	*Sun*	*Shade*	*Mean*	*Sun*	*Shade*	*Mean*	*Sun*	*Shade*	*Mean*	*Sun*	*Shade*	*Mean*	*Sun*	*Shade*	*Mean*
12	37.6	42.2	39.9	16.0	10.2	13.1	56.0	39.5	47.8	45.6	52.0	48.8	40.2	47.2	43.7	51.0	55.9	53.4
16	32.6	49.0	40.8	24.0	26.6	25.3	48.2	53.6	50.9	60.6	57.4	59.0	48.6	61.0	54.8	53.3	58.7	56.0
20	57.0	53.3	55.2	35.2	53.0	44.1	55.6	61.4	58.5	58.8	66.9	62.8	56.6	60.2	58.4	56.1	59.8	58.0
24	37.8	59.8	48.8	57.3	62.2	59.8	64.0	69.2	66.6	66.0	66.6	66.3	49.7	59.0	54.4	40.3	62.8	51.6
28	46.0	60.3	53.2	60.5	65.4	63.0	60.6	68.8	64.7	65.8	69.5	67.6	46.2	65.4	55.8	58.4	57.6	58.0
32	34.6	56.1	45.4	60.4	65.0	62.7	66.6	67.7	67.2	65.3	68.2	66.8	54.4	61.2	57.8	39.8	65.1	52.4
36	36.3	59.2	47.8	51.8	62.8	57.3	67.8	68.8	68.3	64.6	66.5	65.6	35.0	63.6	49.3	60.6	64.4	62.5
40	33.0	51.2	42.1	57.8	64.6	61.2	68.8	69.4	69.0	56.5	68.8	62.6	32.6	57.2	44.9	58.6	65.7	62.2
44†																		
Mean	39.4	53.9	46.6	45.4	51.2	48.3	57.4	62.3	59.8	60.4	64.5	62.4	45.4	59.2	52.3	52.3	61.3	56.8
Coefficient of Variation		2.67			4.66			3.99			3.75			3.95			4.21	
LSD (0.05) for drying techniques		—2.06			—3.68			—1.8			—1.8			—1.6			—1.8	
LSD (0.05) for time of harvest		2.69			—4.81			—3.6			—3.5			—3.1			—3.6	

† Not sampled due to floods.

TABLE 4 (b)

Time of Harvest and Method of Drying on Head Rice Recovery Yala 1971

Time of harvest days after 50% flowering	*HEAD RICE RECOVERY PERCENTAGE*														
	H-4			LD-66			*BG-11-11*			*IR-8*			*PP*		
	Sun	*Shade*	*Mean*	*Sun*	*Shade*	*Mean*	*Sun*	*Shade*	*Mean*	*Sun*	*Shade*	*Mean*	*Sun*	*Shade*	*Mean*
12	33.3	41.0	37.1	55.4	50.9	53.2	55.7	56.8	56.3	48.1	49.8	49.0	42.2	48.7	45.5
16	56.6	57.7	57.1	59.2	61.6	60.4	56.6	67.7	62.1	45.5	54.6	50.1	56.2	51.7	53.9
20	56.1	61.5	58.8	67.9	62.7	65.3	70.5	66.2	68.3	52.2	61.8	57.0	58.8	61.9	60.3
24	65.2	60.5	62.9	65.5	63.9	64.7	67.2	65.7	66.4	54.1	56.4	55.2	62.2	60.2	61.2
28	59.6	58.8	59.2	65.9	66.2	66.1	60.2	68.2	64.2	61.0	58.9	59.9	56.1	63.5	59.8
32	58.0	62.6	60.3	68.8	60.9	64.9	66.2	69.0	67.6	55.7	61.4	58.5	55.1	67.1	61.1
36	55.9	62.3	59.1	66.6	67.9	67.2	62.2	65.6	63.9	48.1	59.3	53.7	63.2	63.4	63.3
40	48.5	55.0	51.8	65.7	69.3	67.5	49.4	63.0	56.2	46.6	59.0	52.8	59.4	62.8	61.1
44	48.5	53.9	51.2	63.3	65.5	64.4	59.4	56.5	57.9	35.9	58.0	47.0	65.6	61.3	63.4
Mean	53.5	57.0	55.2	64.3	63.2	63.8	60.8	64.3	62.6	49.7	57.7	53.7	57.7	60.0	58.8
Coefficient of variation	5.39			3.08			3.51			4.83			5.67		
LSD (0.05) for drying techniques	—1.6			N.S.			—1.2			—1.4			—1.8		
LSD (0.05) for time of harvest	—3.5			—2.3			—2.6			—3.0			—3.9		

TABLE 5

Effect of Time of Harvest and Method of Drying on Breakage

Time of harvest days after 50% flowering	PERCENTAGE BROKEN RICE																	
	KAHATAWEE			*H-4*			*LD-66*			*BG-11-11*			*IR-8*			*PP*		
	Sun	*Shade*	*Mean*	*Sun*	*Shade*	*Mean*	*Sun*	*Shade*	*Mean*	*Sun*	*Shade*	*Mean*	*Sun*	*Shade*	*Mean*	*Sun*	*Shade*	*Mean*
12	16.0	9.0	12.5	18.8	15.4	17.1	9.0	6.7	7.8	8.0	2.6	5.3	18.1	14.2	16.2	5.4	5.3	5.4
16	19.2	4.8	12.0	15.5	10.0	12.8	7.8	2.6	5.2	7.0	1.8	4.4	19.2	9.8	14.5	5.2	4.5	4.8
20	11.6	6.2	8.9	17.4	7.4	12.4	5.8	3.6	4.7	4.4	2.4	3.4	13.8	7.9	10.8	5.0	4.4	4.7
24	26.0	4.5	15.2	9.2	7.0	8.1	4.0	2.4	3.2	4.5	2.4	3.4	17.8	7.8	12.8	12.6	3.6	8.17
28	23.0	4.4	13.7	10.4	6.4	8.4	4.8	2.3	3.6	9.0	2.5	5.8	17.8	7.0	12.4	9.0	3.6	6.3
32	36.0	11.4	23.7	11.3	6.2	8.8	3.2	2.6	2.9	6.4	3.1	4.8	16.0	7.6	11.8	13.4	3.2	8.3
36	35.6	7.7	21.6	17.0	7.6	12.3	3.0	1.6	2.3	7.8	5.0	6.4	28.2	8.7	18.4	4.3	3.6	4.0
40	38.5	16.4	27.5	16.8	10.0	13.4	2.6	1.5	2.0	16.2	5.4	10.8	30.9	9.0	20.0	8.3	3.5	5.9
44+				23.4	15.8	19.6	6.4	1.7	4.0	12.0	9.8	10.9	35.4	11.2	23.3	4.0	4.8	4.4

Kahatawee—Data of 70–71 yala only , but in other varieties mean of 70–71 Maha and 71 yala data.

+'71 yala data only.

TABLE 6

Time of Harvesting in Relation to moisture content milling out-turn Head Rice Recovery and Brokens

AVERAGE OF ALL THE VARIETIES TESTED

Time of harvest days after 50% flowering	*Moisture Content*			*Milling out-turn*			*Head Rice Recovery*			*Brokens*			*Yield in Bu/ac*		
	Maha 70–71	*Yala* 71	*Mean* —	*Maha* 70–71	*Yala* 71	*Mean* —	*Maha* 70–71	*Yala* 71	*Mean* —	*Maha* 70–71	*Yala* 71	*Mean* —	*Maha* 70–71	*Yala* 71	*Mean* —
12	31.9	32.1	32.0	51.7	58.7	55.2	41.1	48.2	44.6	10.6	10.5	10.6	21.0	32.0	26.5
16	30.2	29.9	30.1	56.9	64.8	60.8	47.6	56.7	52.2	9.3	8.1	8.7	38.3	50.3	44.2
20	28.5	27.9	28.2	64.5	68.1	66.3	56.2	61.9	59.0	8.3	6.2	7.2	54.4	63.8	59.1
24	26.7	26.6	26.6	67.4	68.0	67.7	57.9	62.1	60.0	9.5	5.9	7.7	60.9	72.8	66.8
28	24.5	24.8	24.6	69.1	68.7	68.9	60.4	61.8	61.1	8.7	6.9	7.8	64.5	79.0	71.8
32	23.5	24.1	23.8	69.7	68.6	69.2	58.7	62.5	60.6	11.0	6.1	8.6	72.8	80.3	76.6
36	21.5	23.3	22.4	70.0	68.2	68.6	58.4	61.5	60.0	11.6	5.7	8.6	72.6	77.8	75.2
40	20.8	21.4	21.1	71.2	68.7	70.0	57.0	57.9	57.4	14.2	10.8	12.5	73.0	75.5	74.2
44*	*	20.5	20.5	*	69.2	69.2	*	56.8	56.8	*	12.4	12.4	*	76.1	76.1

70–71 Maha—Average of six varieties

71 Yala—Average of five varieties

Maha 70–71*— 44th day not sampled due to floods

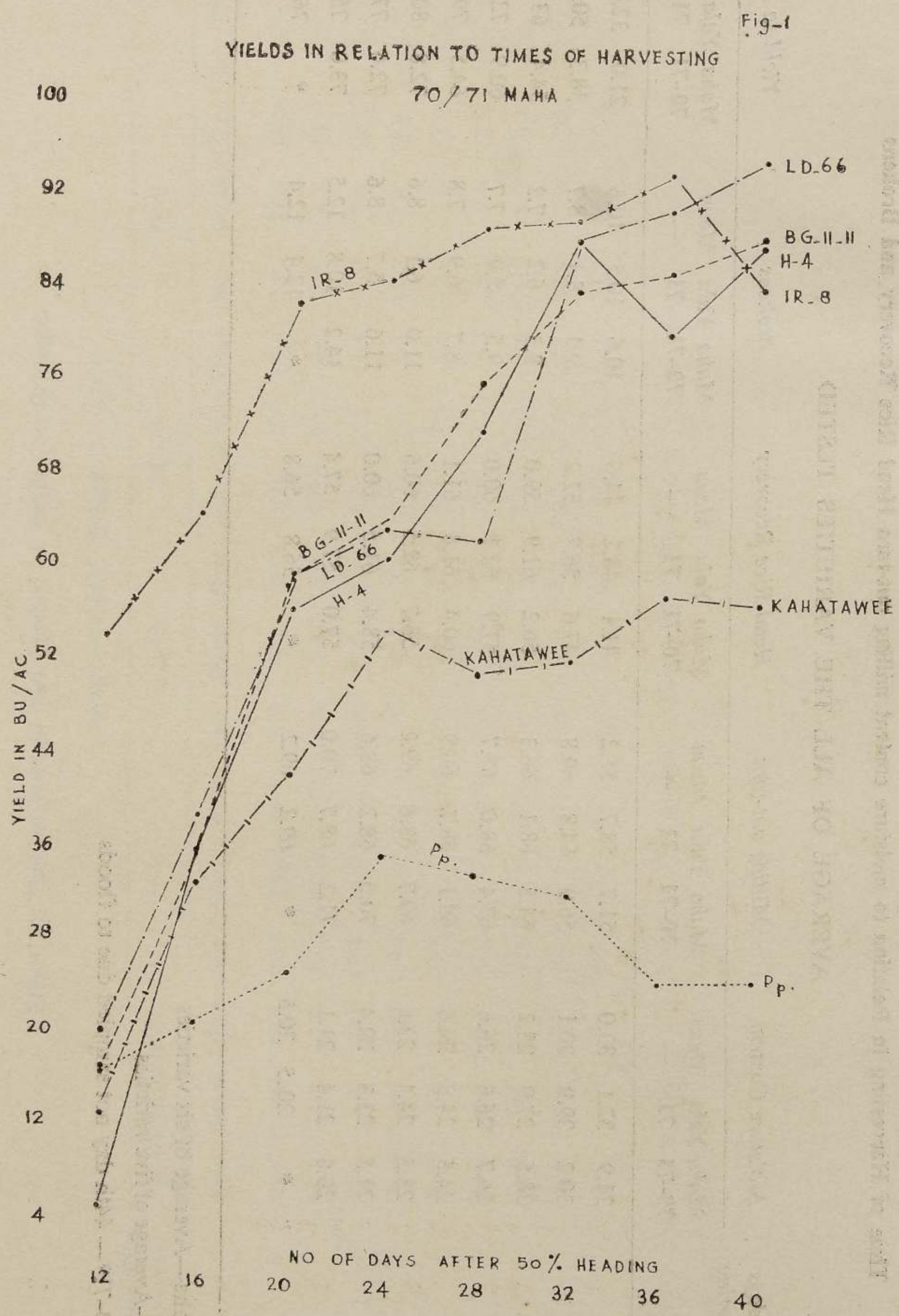


Fig-1
YIELDS IN RELATION TO TIMES OF HARVESTING
70/71 MAHA
100
92
84
76
68
60
52
44
36
28
20
12
4
YIELD IN BU/AC
LD-66
BG-11-11
H-4
IR-8
KAHATAWEE
Pp.
NO OF DAYS AFTER 50% HEADING
12
16
20
24
28
32
36
40

Fig. 2

YIELDS IN RELATION TO TIMES OF HARVESTING

71 Yala

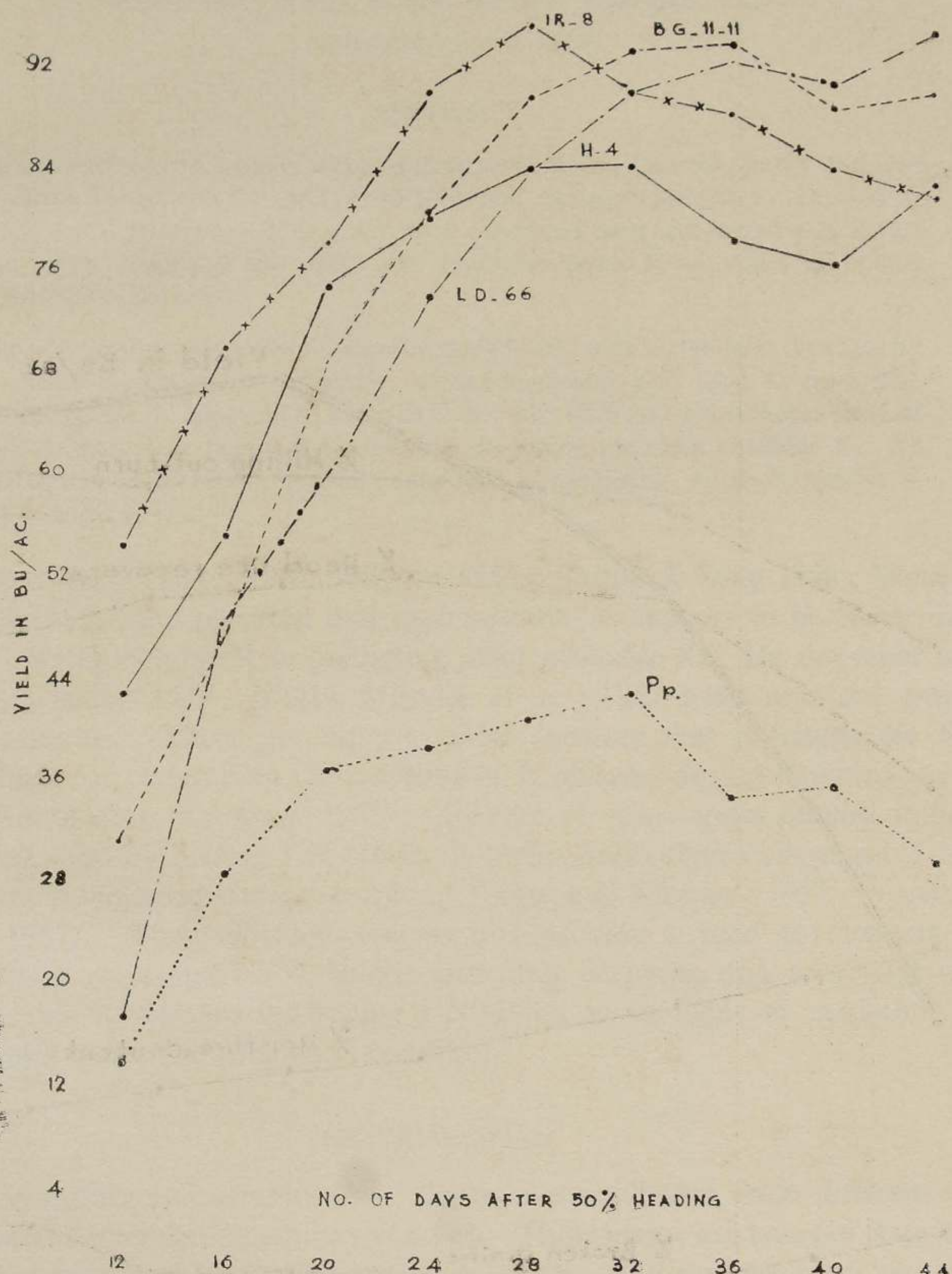
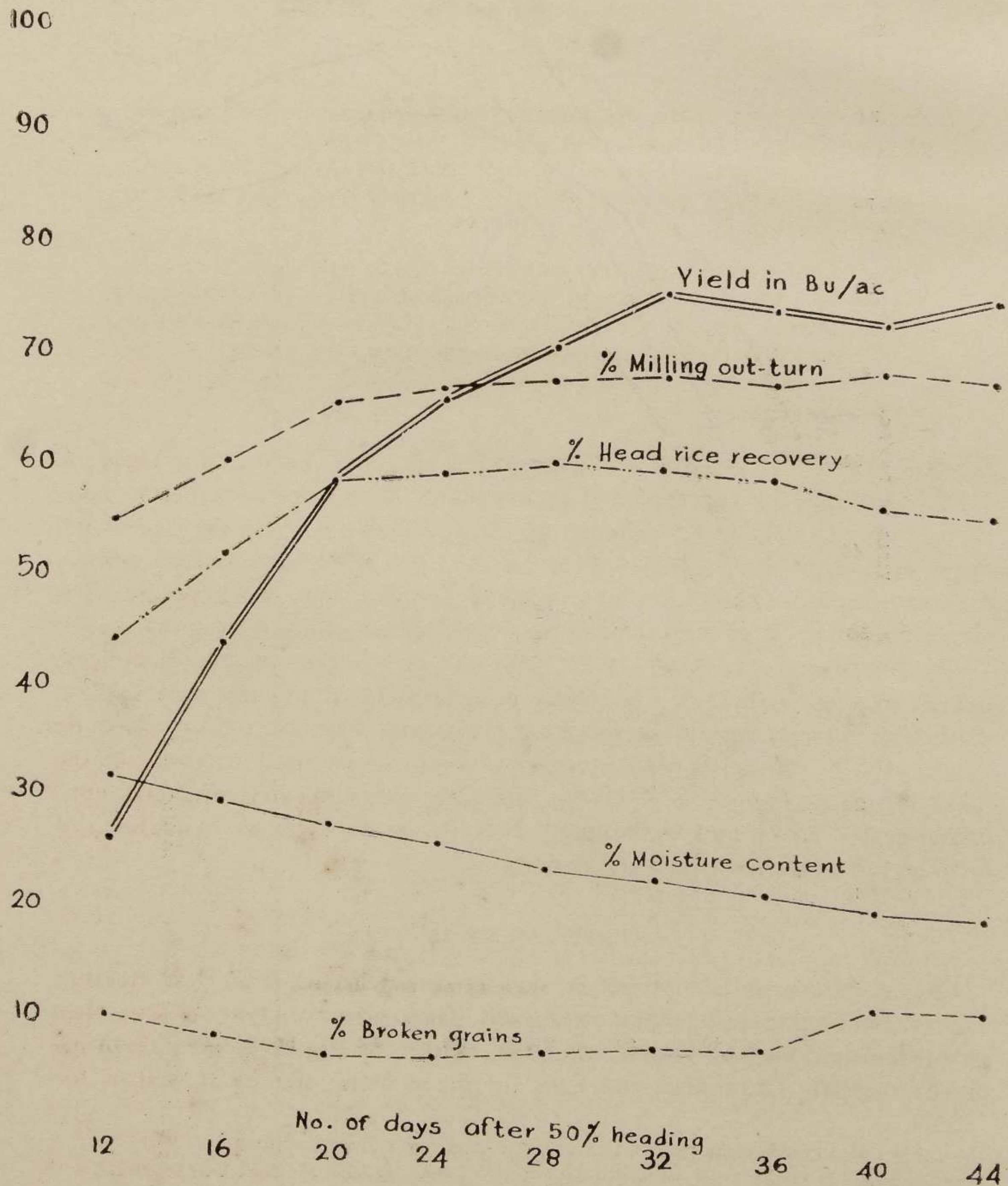


Fig-3

TIME OF HARVESTING IN RELATION TO MOISTURE CONTENT, MILLING OUT-TURN HEAD RICE RECOVERY AND BROKEN GRAINS



Potassium-supplying power of some Rajasthan soils

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(Received : April, 1973)

ABSTRACT

Fifteen surface soil samples were cropped with Maize, Cowpea, Jowar and Urd in Green House and the quantity of total and nonexchangeable K removed by crops was determined. This uptake was correlated with exchangeable K before and after cropping and total and nonexchangeable K extracted by boiling 1 N HNO in the soils.

The uptake of potassium by different crops indicates wide variation in the capacity of crops to remove exchangeable, nonexchangeable and total K from soil. Exchangeable K appeared to be better index than total and nonexchageable K of soils (extracted by boiling 1 N HNO) in describing the plant available K. All chemical measurements proved unreliable in predicting nonexchangeable K removed by Jowar.

SEVERAL workers (Eagel 1967 ; Nelson 1959 ; Sutton & Seay 1958 ; Weber & Caldwell 1965) have reported that exchangeable K appears to be better index than 1 N HNO_3 soluble K in predicting plant available K. On the other hand Pope & Cheney 1957 ; Marin Morales *et al.* 1967 have reported entirely different trends. There are reports which indicate that exchangeable K is significantly correlated with the amounts of K released during cropping (Ayes 1949 ; Smith and Matthews 1957). Results of some more studies indicate that K released by boiling 1 N HNO_3 is better index than exchangeable K in predicting K released during cropping (Pope and Cheney, 1957 ; Vasco da Gama, 1967). These contradictory results provide a need to evaluate the reliability of exchangeable K before and after cropping and total and non-exchangeable K released by boiling 1 N HNO_3 as an index of availability of K to plants under Rajasthan soil conditions.

EXPERIMENTAL

Fifteen surface soil samples (0-9″ depth) were collected from different sites of Rajasthan representing major soil types. These major soil types of Rajasthan have been described by Pareek and Seth (1970). Soil samples were air dried, passed through 2 mm sieve and used for green house studies as well as for

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4—A 00364 (7/73)

laboratory analysis. Plants of four crops viz—Maize (*Zea mays*) ; Jowar (*Sorghum vulgare*) ; Cowpea (*Vigna sinesis*) and Urd (*Phaseolus mungo*) were grown in earthen pots containing 3 kg of sieved soil each with three replications. At the end of sixty-day growing period, plants were harvested by cutting stem at ground level. The tops were then dried and weighed. The plant material was digested in triacid mixture for estimating K content in the crops.

pH was determined in saturation extract (Richards 1954) of the soil. Mechanical analysis was done by international pipette method (Piper 1950). Estimation of calcium carbonate was done according to method of Hutchinson and Macleannan's as cited by Piper (1950). Theexchangeable potassium extraction was done by 1 N NH_4Ac method (Sutton & Sey 1958). The total 1 N HNO_3 soluble potassium was determined according to the method desciibed by Reitemeir *et al.* (1948). The total 1 N HNO_3 soluble K minus exchangeable was designated as release of nonexchangeable K by boiling 1 N HNO_3. Eshmation of potassium in plant and soil extracts was done on a Coleman Flame Photometer.

RESULTS AND DISCUSSION

The general characteristics of soils, amount of potassium removed by different chemical measurements and uptake of K by crops are shown in Table 1 and 2.

Changes in exchangeable K by cropping, K uptake and release of nonexhangeable K by cropping

The exchangeable K content of most of the soils decreased due to cropping by all the four crops studied except in two soils from Dungarpur and Kherwara where increase was recorded. The Gangrar soil has shown an increase in exchangeable K content by cropping with Cowpea, Jowar and Urd. The initial level of exchangable K was very low in these soils and as such insufficient to meet the crop requirements. During the process of crop growth, roots it appears solubilized some K from nonexchangeable form and the potassium left unutilised by crops possibly got into exchange sites and thus appeared as increased exchangeable K after cropping. Similar observations were also recorded by Sutton & Seay (1958) and Weber & Caldwell (1965).

A perusal of data in Table 2 reveals that number of soils have not brought about release of nonexchangeable K by cropping where as in some soils fixation (negative release of non exhangeable K by cropping) was observed. Smith & Matthews (1957) also observed negative release of nonexchangeable K in two soils after cropping with alfalfa upto two cuttings. This can be attributed to higher level of exchangeable potassium in soils (Wiklander 1954).

In all the crops, the total uptake of crop was not related to nonexchangeable K removed. Correlation coefficient values (r) between total uptake and nonexchangaeble K have been obtained for Maize (– 0,316), Cowpea, (– 0,058), Jowar, +(0.269) and Urd (−0.310) which are non significant. The data relating to nonexchangeable K released by cropping were subjected to statistical analysis (Table 3).

Results indicate that there is a variation in the capacity of soils to supply nonexchangealle K during cropping and the capaicty of crops to remove nonexchangeable K from the soils.

Potassium uptake and nonexchangeable K released on cropping compared with different chemical measurements

Correlation coefficients between amounts of potassium extracted by different chemical measurements and uptake and nonexchangeable K released on cropping by crops are given in Table 4. The data in Table 4 indicates that exchangeable K gives better prediction of uptake of potassium than total and nonexchangeable K removed by boiling 1 N HNO_3. This may be due to the fact that either nonexchaneable K does not make significant contribution towards K removed by plants or that equilibrium between exchangeable and nonexchangeable K is re-established rapidly during removal of exchangeable K by plants (Nelson 1959). Table 4 further reveals that all chemical measurements proved unreliable in predicting nonexchangeable K removed by cropping with Jowar. Overall comparison of different chemical measurements indicates that exchangeable K content before cropping appears to be better index in predicting nonexchangeable K removed by Maize, Cowpea and Urd.

REFERENCES

AYRES, A. S., 1949—Univ. of Hawaii Agric. Exp. Sta. Bull., 9.

EAGLE, D. J., 1967—Tech. Bull. Minist. Agric. Fish. Fd. 14, 49.

MARIN MORALES, G., MCCLUNG, A. & LUENGAS and VILLATE, A., 1967—*Agriculture Trop.* 23 88.

NELSON, L. E., 1959—*Proc. Soil. Sci. Soc. Amer.* 23, 313.

PAREEK, B. L. and SETH, S. P., 1970—Fertilizer News 15(3), 62

PIPER, C. S., 1950—Soil and Plant Analysis, Adelaide, Australia.

POPE, A. and CHENEY, H. B., (1957) - *Proc. Soc. Sci. Amer*, 21, 75.

REITEMEIR, R. F., HOLMES, R. S., BROWN, I. C., KLIPP, LORAINE, W. and PARKS, R. Q., (1948). *Proc. Soc. Soil Sci. Amer*, (1947) 12, 158.

RICHARDS, L. A. (Ed.), 1954—U. S. D. A. Hand Book, No. 60.

SMITH, J. A. and MATTHEWS, B. C., 1957—*Can. J. Soil Sci.* 37, 1.

SUTTON, P. and SEAY, W. A., 1958—*Proc. Soc. Soil Sci. Amer*, 22, 110.

VASCO DA GAMA, M., 1967—*Agronomia lusit* 29, 99.

WEBER, J. B. and CALDWELL, A. G., 1965—*Soil Sci.* 100, 34.

WIKLANDER, L., 1954—Potassium Symposium, 109.

TABLE 1

General Characteristics of soil, total and non-exchangeable K (removed by boiling 1 N H NO_3) and changes in exchangeable K by cropping

S.No. Soil (Location)	pH	$CaCO_3$ % 2	Boiling 1 N HNO_3 soluble (*m.e. per* 100*g soil*)		Exchangeable K (*m.e.* 100 *per g soil*)				
			Total	*Released Non-exchangeable*	*Before cropping*	*After cropping by Maize*	*After cropping by Cowpea*	*After cropping by Jowar*	*After cropping by Urd*
1. Chanderia (SL)*	7.55	1.50	3.06	2.41	0.65	0.45	0.57	0.59	0.64
2. Amate (LS)	8.05	2.75	8.82	7.87	0.95	0.65	0.70	0.79	0.77
3. Jodhpur (LS)	8.10	1.60	2.55	2.24	0.31	0.31	0.25	0.29	0.25
4. Udaipur (CL)	8.20	1.00	7.16	5.73	1.34	1.05	1.19	1.24	1.20
5. Kankroli (SCL)	7.65	1.00	4.47	3.78	0.69	0.52	0.60	0.66	0.61
6. Pali (SCL)	7.60	0.75	6.26	4.78	1.48	1.12	1.30	1.41	1.35
7. Chittor (LS)	8.30	0.50	5.24	3.63	1.61	1.06	1.21	1.21	1.16
8. Gangrar (SCL)	8.27	0.25	2.55	2.13	0.42	0.40	0.43	0.47	0.43
9. Nathdwara (LS)	8.60	0.54	4.60	4.15	0.45	0.38	0.43	0.43	0.42
10. Khumbalgarh (SCL)	8.80	0.51	14.57	12.22	2.35	1.87	2.02	2.30	2.17
11 Dnngarpur (SCL)	7.40	1.35	1.28	1.15	0.13	0.14	0.14	0.17	0.17
12. Dabok (LS)	7.90	0.35	4.73	4.33	0.40	0.28	0.31	0.35	0.35
13. Jaipur (LS)	7.65	1.00	2.55	2.25	0.30	0.19	0.27	0.27	0.29
14. Tonk (SCL)	8.00	1.18	3.45	3.00	0.45	0.33	0.36	0.41	0.44
15. Kehrwara (SL)	6.80	0.53	1.28	1.14	0.14	0.15	0.17	0.16	0.18

* Letters in parentheeis show textural class, S : Sandy ; C : Clay ; L : Loam.

TABLE 2

Uptake by various crops from Exchangeable and Non-exchangeable K of soils

(*m.e. per* 100*g soil*)

S.No.	Soil (Location)	Uptake of K by Maize			Uptake of K by Cowpea			Uptake of K by Jowar			Uptake of K Urd		
		Exchangeable	Non Exchangeable	Total	Exchangeable	Non-Exchangeable	Total	Exchangeable	Non-Exchangeable	Total	Exchangeable	Non-Exchangeable	Total
1.	Chanderia	+ 0.20	- 0.02	0.18	+ 0.08	+ 0.12	0.20	× 0.06	+ 0.05	0.11	+ 0.01	+ 0.10	0.11
2.	Amate	+ 0.30	- 0.11	0.11	+ 0.25	- 0.08	0.17	× 0.16	- 0.04	0.12	+ 0.18	- 0.08	0.10
3.	Jodhpur	+ 0.09	0.00	0.09	+ 0.06	- 0.01	0.05	× 0.02	+ 0.02	0.04	+ 0.06	- 0.03	0.03
4.	Udaipur	+ 0.38	- 0.05	0.33	+ 0.24	- 0.02	0.22	× 0.19	0.00	0.19	+ 0.23	- 0.12	0.11
5.	Kankroli	+ 0.17	+ 0.13	0.30	+ 0.09	+ 0.15	0.24	× 0.03	+ 0.18	0.21	+ 0.08	+ 0.07	0.15
6.	Pali	+ 0.36	- 0.15	0.21	+ 0.18	- 0.09	0.09	× 0.07	+ 0.04	0.11	+ 0.13	- 0.09	0.04
7.	Chittor	+ 0.55	- 0.35	0.20	+ 0.40	- 0.14	0.26	× 0.40	- 0.24	0.16	+ 0.45	- 0.45	0.20
8.	Gangrar	+ 0.02	+ 0.16	0.18	- 0.01	+ 0.15	0.14	— 0.05	+ 0.15	0.10	- 0.01	+ 0.09	0.08
9.	Nathdwara	+ 0.07	+ 0.15	0.22	+ 0.02	+ 0.16	0.18	+ 0.02	+ 0.16	0.18	+ 0.03	+ 0.08	0.11
10.	Khumbalgarh	+ 0.48	- 0.15	0.33	+ 0.33	- 0.08	0.25	+ 0.05	+ 0.25	0.30	+ 0.18	0.00	0.18
11.	Dungarpur	- 0.01	+ 0.06	0.05	- 0.01	- 0.03	0.02	- 0.04	+ 0.07	0.03	- 0.04	+ 0.05	0.01
12.	Dabok	+ 0.12	+ 0.08	0.20	+ 0.09	0.00	0.09	+ 0.05	+ 0.03	0.08	+ 0.05	+ 0.04	0.01
13.	Jaipur	+ 0.11	+ 0.10	0.21	+ 0.03	+ 0.11	0.14	+ 0.03	+ 0.02	0.05	+ 0.01	+ 0.05	0.06
14.	Tonk	+ 0.12	+ 0.06	0.18	+ 0.09	+ 0.09	0.18	+ 0.04	+ 0.09	0.13	+ 0.01	+ 0.05	0.06
15.	Kehrwara	- 0.01	+ 0.09	0.08	- 0.03	+ 0.06	0.03	- 0.02	+ 0.05	0.03	- 0.04	+ 0.05	0.01

Uptake from exchangeable form — (Exchangeable K before cropping—Exchangeable K after cropping.)

Uptake from Non-exchangeable form — Uptake by plants—(exchangeable K before cropping —Exchangeable K after cropping).

- Exchangeable uptake — Increase after cropping

+ Exchangeable uptake — Decrease by cropping

- Non-exchangeable uptake — Conversion of exchangeable to Non-exchangeable form.

+ Non-exchangeable uptake — Release of Non-Exchangeable by cropping.

TABLE 3

Mean values of non-exchangeable K removed by crops and release of non-exchangeable from soils

S. No.	*Soil or crop*	*Mean of non-exchangeable K removed m.e. per 100g soil*		
SOILS				
1	Chanderia	—	0.062	
2	Amate	—	0.970	
3	Jodhupur	—	0.005	
4	Udaipur	—	0.047	
5	Kankroli	—	0.132	C. D. of soils at 5%
6	Pali	—	0.072	+ 0.086 m.e. per 100 g soil
7	Chittor	—	0.245	C.D. of soils at 1% + 0.115 m.e. pre 100 g soil
8	Gangrar	—	0.137	
9	Nathdwara	—	0.137	
10	Khumbalgarh	—	0.005	
11	Dungarpur	—	0.052	
12	Dabok	—	0.001	
13	Jaipur	—	0.070	
14	Tonk	—	0.072	
15	Kherwara	—	0.063	
CROPS				
16	Maize	–	0.005	C.D. of crops at 5% + 0.048 m.e. pre 100 g soil
17	Cowpea	+	0.030	
18	Jowar	+	0.055	C.D. of crops at 1% + 0.059 m.e. per 100 g soil
19	Urd	–	0.004	

TABLE 4

Values of correlation coefficients between amounts of potassium estimated by different chemical measurements and uptake and non-exchangeable K released on cropping

S.No.	*Chemical measurement*	*MAIZE*		*COWPEA*		*JOWAR*		*URD*	
		Total uptake	*Non-Ex. K removed*	*Total uptake*	*Non-Ex. K removed*	*Total uptake*	*Non-Ex. K removed*	*Total uptake*	*Non-Ex. K removed*
1.	Exchangeable K before cropping	+ 0.642**	– 0.753**	+ 0.634*	—0.672**	+ 0.753**	– 0.054	+ 0.703**	– 0.582*
2.	Exchangeable K after cropping	+ 0.652**	– 0.684**	+ 0.606*	—0.479	+ 0.778**	+ 0.086	+ 0.659**	– 0.470
3.	Total HNO_3 soluble K	+ 0.601*	– 0.592*	+ 0.594*	—0.359*	+ 0.700**	+ 0.194	+ 0.591*	—0.426
4.	Non-exchangeable K by HNO_3	+ 0.572*	– 0.497	+ 0.530*	—0.515*	+ 0.769**	+ 0.243*	+ 0.456*	—0.306

* Significant at 5% level.

** Significant at 1% level.

Investigations on sugarcane chlorosis in Uttar Pradesh

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(Received April, 1973)

II. INFLUENCE OF IRON CHLOROSIS ON GROWTH, YIELD AND JUICE QUALITY

INTRODUCTION

IRON is an indispensable element for green plants. It is required in very small amounts but plays an important role in the synthesis of chlorophyll—the green pigment of leaves. Jacobson and Oertli (1956) claimed that a deficiency of iron progressivley impairs the chlorophyll producing mechanism till the point is reached when chlorophyll synthesis is limited not by the amount of iron but by the inability of leaf to produce it. Therefore, a good correlation was found between iron and chlorophyll under a continuous supply of iron but no relationship was observed under its intermittent supply. Almost similar results were obtained by Sideris and Young (1956) who claimed that following iron difficiency, the iron content had no correlation with chlorophyll content.

Carell and Price (1965) claimed that the rate of chlorophyll synthesis in *Euglena gracilis* was a linear function of the total iron content of the cell and during that part of growth curve, when its rate remained normal, the iron required for chlorophyll synthesis was about 1 microgram per mg. of protein nitrogen. When its content declined below this level, massive derangement occurred in the chloroplasts. As cell growth continues at this stage and the volume of the cell in which iron is required for distribution goes up, its concentration declines in cellular structures especially in the chloroplasts and the activity of the cell is reduced. This reduction in activity progressively impairs growth until it stops completely. Tomar *et al* (1965) observed marked reduction in sugarcane growth due to iron chlorosis during the tillering phase of the crop in Rajasthan.

As sugarcane chlorosis due to iron deficiency under field conditions had been seen for the first time in Uttar Pradesh, detailed observations on its effect on growth, yield and juice quality were made to determine the precise nature and extent of damage.

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MATERIAL AND METHODS

Investigations were undertaken in the field of Sri Lal Krishnakant Singh, of Village Daryapur, District Pratapgrah, where iron chlorosis had assumed serious proportions causing all the apical leaves to be completely bleached from their normal green colour. As the chlorosis was not uniform throughout the whole field and was in patches, 10 clumps of both normal looking and severely affected plants were tagged. At this stage, there was no distinct difference in apparent growth and the two sets of plants were only distinguishable by their green or chlorotic appearance. After about 4 months, observations for total length of millable cane, length of individual internodes of cane from 1 to 10, and weight of individual canes were recorded on the main shoot of both normal and affected plants. The juice of these canes was also extracted and its sucrose, purity coefficient and invert sugar contents were determined. The available sugar per cent. of cane was also ultimately worked out for both sets. The results obtained in respect of growth viz., cane height, average internodal length and weight of millable canes were analysed statistically and the differences of the normal and affected plants were judged at 1 per cent. probability level. The per cent. reduction of each factor under study caused by chlorosis was also determined to evaluate the magnitude of loss caused by chlorosis.

RESULTS AND DISCUSSION

The data pertaining to various characters are persented in Table 1.

TABLE 1—EFFECT FROM IRON CHLOROSIS ON SUGARCANE

S.N.	*Characters*	*Healthy plant*	*Chlorotic plant*	*C.D. at* 1%	% *Reduction/ increase due to chlorosis*
1	Cane height (cm.)	255.6	108.3	24.5	- 57.6
2	Internode length (cm.)	12.0	5.6	1.3	- 53.3
3	Cane weight (gm.)	657.0	171.0	60.0	- 74.0
4	Sucrose % in juice	17.5	10.2	—	- 41.7
5	Purity coefficient	89.0	70.6	—	- 20.7
6	Reducing sugars %	0.15	0.26	—	+73.3
7	Available sugar % in cane	12.12	6.21	—	- 48.7

The results show that the height of sugarcane was reduced due to iron chlorosis by 57.6%, which proved significant even at 1% probability level. This reduction in cane height was mainly due to reduction in the length of individual internodes, to the extent of 53.3% and was highly significant. Owing to the diminution in the cane length, weight of individual canes also declined sharply. This decline proved highly significant and reached the limit of 74.0 per cent. The relatively high percentage of reduction in cane weight as compared to the cane height indicates that the thickness of the cane also decreased due to iron chlorosis besides the length of the cane. Else the magnitude of reduction in cane weight should have been of a similar order to that of cane height. Since all these factors are parameters of the growth efficiency of plants, it may well be concluded that iron chlorosis caused very adverse effect on growth efficiency and reduced it very significantly. The large reduction in the ultimate yield of the crop was, therefore, to be expected.

Like growth, sucrose % and purity coefficient of juice was also reduced considerably due to iron chlorosis and this reduction amounted to 41.7% and 20.7% respectively. The reducing sugars in the juice, however, increased by 73.3% due to chlorosis and this increase was very marked. The reduction in sucrose and purity and the enhancement of the reducing sugar content of the juice can be expected to produce a marked decline in the available sugar percent. in cane. On being calculated this decline in available sugar worked out to 48.7% of the normal cane.

The results thus unmistakably point out that iron chlorosis caused serious damage to the sugarcane crop by inhibiting the growth, reducing the unit weight of canes and thereby the ultimate yield resulting in a great loss to the grower. It also seriously affected the quality of the cane, as the sucrose content and purity coefficient of the juice declined, while the reducing sugar content increased. Thus the available sugar per unit of cane declined causing serious losses due to low recovery.

The damaging effect of iron chlorosis on growth, yield and juice quality was not unexpected nor unusual. The photosynthetic process on which these heavily depended was no doubt hindered for want of chlorophyll and, therefore, the transformation of radiant energy into chemical forms was reduced, causing reduced plant growth and also adversely affecting sucrose accumulation.

SUMMARY AND CONCLUSIONS

Investigations were made to assess the influence of sugarcane chlorosis induced by iron deficiency on growth, yield and juice quality. The result revealed that cane height, cane weight, cane length of individual internodes were reduced very significantly by iron chlorosis. The magnitude of reduction in the three components was observed to be 57.6, 74.0 and 53.3 per cent. respectively as compared to the apparently healthy plant. Iron chlorosis also exercised profound adverse influences on the quality of sugarcane juice and caused serious reduction in sucrose and purity coefficient of juice, which amounted to 41.7 and 20.7 per cent. respectively at the same time reducing

sugar content increased in the juice by 73.3%, as compared to the normal plant. Owing to the reduction in sucrose and purity of juice, available sugar% in cane also declined by 48.7 per cent.

The results thus unmistakably showed that iron chlorosis caused serious damage to the sugarcane crop both by way of reduction in growth and yield and impairment in the quality of juice.

III. MODE OF CHLOROPHYLL DEVELOPMENT AFTER FOLIAR SPRAY OF FERROUS SULPHATE

INTRODUCTION

In earlier papers of this series, characteristic symptoms of iron chlorosis (Singh, 1971 *a*) and its influence on growth, yield and juice quality were discussed (Singh, 1971 *b*) in all essential details so that it may be possible to diagnose iron chlorosis by means of visual observations and reduce the magnitude of loss caused by it to the sugarcane crop by way of reduction in growth and yield and diminution in sucrose content and purity coefficient of juice. In this paper, mode of chlorophyll development and recovery from chlorosis after foliar spray of ferrous sulphate have been set forth indicating the manner of chlorophyll development and crop recovery from the chlorotic condition.

MATERIAL AND METHODS

As chlorosis has been known to be caused by the deficiency of one or several nutrient elements of which, iron, manganese and nitrogen are considered the more important, an experiment was conducted in the chlorosis affected crop at Pratapgarh. In a randomized block design eight treatments were replicated three times. Iron, Manganese and Nitrogen were sprayed on the crop through solutions of 2% ferrous sulphate, 0.5% mangaeese sulphate and 2% urea respectively—singly, as well as, in various combinations. The treatments thus comprised of the following :—

(1) Ferrous sulphate
(2) Manganese sulphate
(3) Urea
(4) Ferrous sulphate plus Manganese sulphate.
(5) Ferrous sulphate plus Urea
(6) Manganese sulphate plus Urea
(7) Ferrous sulphate plus Manganese sulphate plus Urea
(8) Control (Normal crop)

The sprayings of nutrient solutions were given twice at about 15 days interval beginning from the middle of September, when the newly emerged leaves of apex exhibited complete chlorosis. The rate of application of different solutions remained uniform at 1,000 litres per hectare. In treatments 4, 5, 6 and 7 where more than one nutrient solution was required to be applied, these were sprayed separately one after the other, allowing considerable time for complete absorption. Observations on the mode of chlorophyll development were carefully recorded from initiation to completion.

RESULTS AND DISCUSSION

Fig. 1 shows the effects of different treatments on the development of chlorophyll in the leaves after the first spraying. It is observed that in treatments 1, 4, 5 and 7 where iron had been applied alone or in combination with other elements, chlorophyll commenced developing within two days of spraying and became quite evident in the short period of 15 days. In treatments 2, 3 and 6, however, where manganese, nitrogen or both of these were applied, the plants continued to remain chlorotic and absolotely no chlorophyll development occurred in leaf tissues. As the chlorophyll also developed in the tissues, which actually received iron from the spray mists, a mosaic like appearance with green and white tissues spreading throughout the leaf surface became visible in the intial stages and the density of green colour depended on the intensity of coverage by the spray mist. The results thus indicated that in order to assure uniform supply of iron to all the cells, complete drenching of the leaves with nutrient solution is absolutely necessary. Efforts should, therefore, be made to bathe the leaves completely by sprays.

Fig. 2 shows the different stages of chlorophyll development in leaves from initation to completion. On the extreme left (0) is the leaf which had been completely bleached of normal green colour. The leaf next to it. (1) shows the initial stage of chlorophyll development in tissues, which actually received iron from the spray mists leaving other adjoining tissues chlorotic as before. The third leaf from the extreme left (2) shows the second stage of chlorophyll development in which chlorophyllous tissues are coalescing together and forming a uniform colour pattern on the leaf surface. The fourth leaf (3) shows the third stage of chlorophyll development, when stripes became evident due to different degrees of pigmentation in veins and interveinal areas. The leaf on the extreme right (4) shows the final stage when chlorophyll development attained uniformity throughout the leaf imparting a normal green colour to it.

The mode of chlorophyll development and recovery of crop from chlorosis after foliar application of ferrous sulphate as stated above makes it abundantly clear that the etiolated condition was caused by the deficiency of iron as had been observed earlier by Jacobson and Oertli (1956), Sideris and Young (1956) and Levitt (1969). It became further established that the leaf tissues had lost their normal ability to synthesize chlorophyll in the absence of iron and as soon as iron became available, they regained their power of synthesis with the result green pigments developed in tissues receiving iron from the spray mists in a short period. This finding confirmed the earlier observations of Jacobson and Oertli (1956) who had claimed that a deficiency of iron progressively impairs the chlorophyll producing mechanism to the point that the leaves become incapable of synthesizing green pigments. This fact is further borne out by the manner in which chlorosis developed progressively resulting in different degrees of chlorosis during different stages of plant development viz. no chlorosis in the basal leaves, partial chlorosis with green and white stripes in the leaves of middle portion and complete chlorosis in the leaves of the apical portion of the plant (Singh, 1971 *a*). Such a feature of progressive development of chlorosis in the event of iron deficiency was possibly due to the fact that root growth did not keep pace with the increased demand of iron of the growing shoot meristems and, therefore, resulted in internal stravation which increased with increase in the age of the plant resulting in progressive development of chlorosis.

SUMMARY AND CONCLUSIONS

An experiment was conducted in the chlorosis affected field of sugarcane at Pratapgarh. Ferrous sulphate, magnanese sulphate and urea were sprayed on the plants at 2%, 0.5% and 2% concentrations respectively singly and in combination with each other. As all treatments supplying iron caused favourable effect on the alleviation of chlorosis and resulted in progressive recovery of plants from this malady, close observations on the mode of chlorophyll development were recorded from the initial to the last stages of chlorophyll development in leaves.

The results showed that within two days of ferrous sulphate application, chlorophyll commenced developing and became quite evident within 15 days. In the initial stages, tissues receiving iron from the spray mists only showed chlorophyll development and others remained chlorotic as before. Gradually, these green tissues coalesced together and formed a more or less uniform pattern throughout the leaf surface. Owing to different degrees of pigmentation in the leaf veins and interveinal areas, however, alternate green and whitish green stripes became evident within a few days. Further development of chlorophyll resulted in uniform green colour throughout the whole leaf surface as evidenced in normal leaves. The mode of recovery from chlorosis thus unmistakably pointed out that the chlorotic condition was caused by simple iron deficiency and as soon as iron became available to the tissues, the leaves commenced turning green due to the onset of chlorophyll synthesis. It was further established that owing to the deficiency of iron, tissues had lost their ability to synthesize chlorophyll and had become inactive. The spraying of ferrous sulphate thus activated the synthesis of chlorophyll, thereby causing the recovery from chlorosis.

ACKNOWLEDGEMENTS

The author wishes to express his sinceie thanks to Sri Hukam Singh, the then Entomologist in charge, Sugarcane Research Station, Shahjahanpur for providing required facilities for these investigations, and to Sri Lallan Singh, Junior Physiological Assistant for his assistance in the collection of data. Thanks are also due to Dr. P. B. Bajpal, Assistant Agricultural Chemist for his valuable suggestions.

REFERENCES

CARELL, E. F. and PRICE, C. A., 1965—*Plant Physiology*, 40 : 107.

JACOBSON, L. and OERTLI, J. J., 1956—*Plant Physiology*, 31 : 199–203.

SIDERIS, C. P. and YOUNG, H. Y., 1956—*Plant Physiology*, 31 : 211–222.

TOMAR, P. S., MATHUR, O. P. and OBEROI, D. S., 1965—*Ind. Sug. Jour.*, 9(2) : 123

LEVITT, J., 1969—Introduction to Plant Physiology C. V. Mosby Co., Tokyo, Japan.

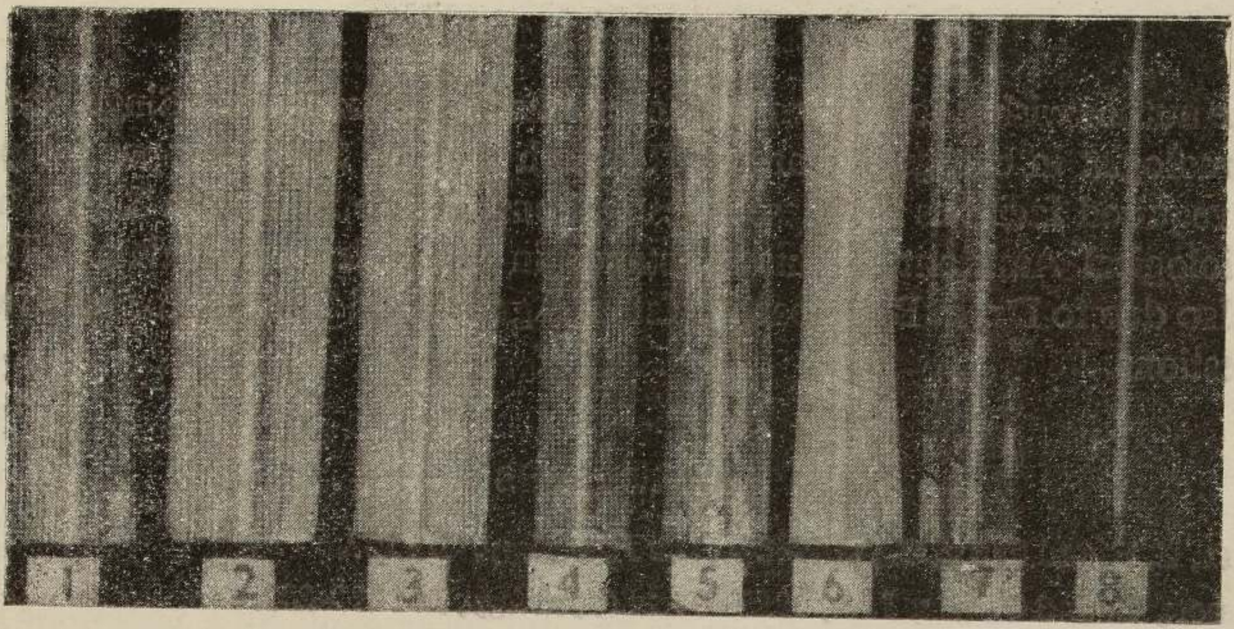

Fig. 1 showing effects of different treatments. From the extreme left are the leaves sprayed with the following:—

(1) Ferrous sulphate (2) Managnese sulphate
(3) Urea (4) Ferrous sulphate plus manganese sulphate
(5) Ferrous sulphate plus urea (6) Manganese sulphate plus urea
(7) Ferrous sulphate plus manganese sulphate plus urea. (8) Normal green leaf

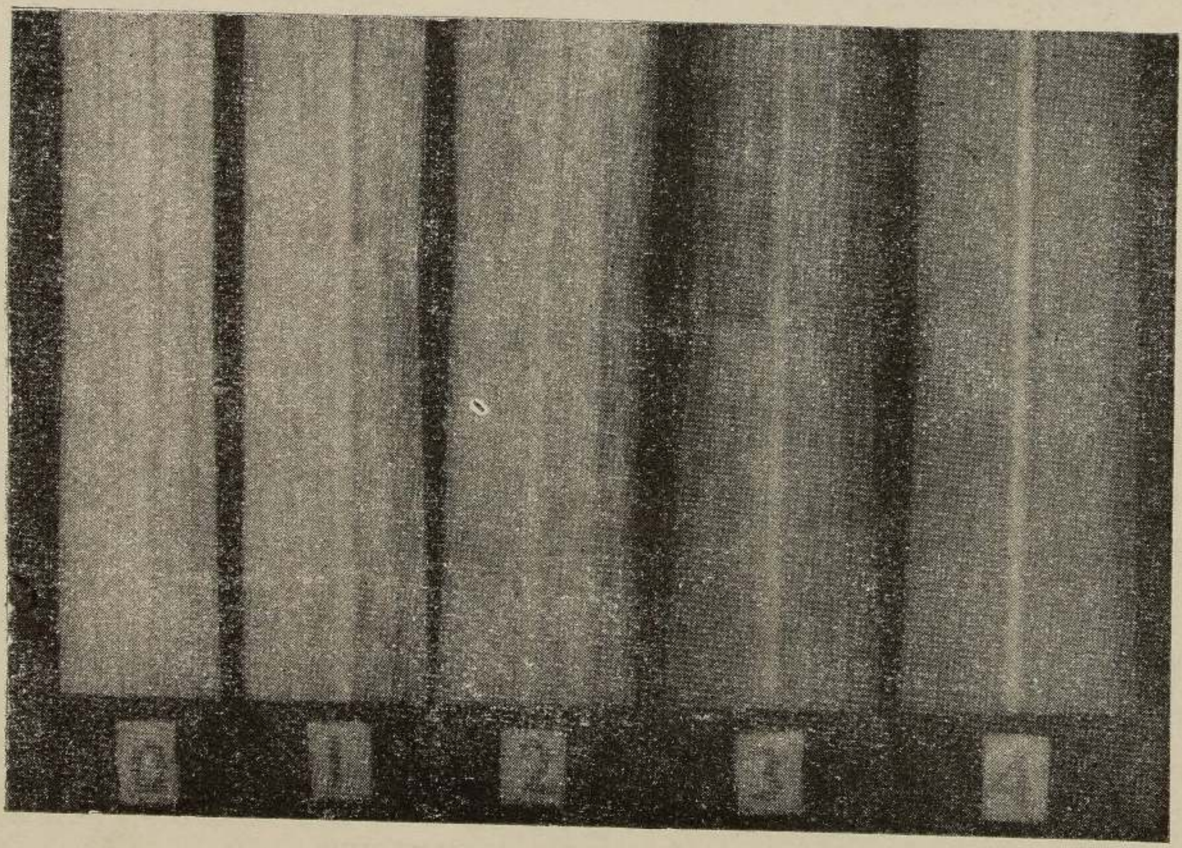

Fig. 2 showing different stages of chlorophyll development and fate of chlorosis after foliar spray of ferrous sulphate. From the extreme left are —

(0) Completely chlorotic leaf
(1) Chlorotic leaf showing chlorophyll development in tissues obtaining iron
(2) Chlorotic leaf showing chlorophyllous tissues coalescing together
(3) Partially recovered leaf showing green and whitish green stripes
(4) Normal green leaf of uniform colour

Testing of four weeds as additional hosts of some plant viruses

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(Received April, 1973)

Weeds, in many agricultural areas, serve as the main reservoir of vectors of plant virus diseases. Plant viroses in which weeds or wild hosts play an important role as a virus source include many of our most important diseases. Harrisons (1964) has observed that most nematode-transmitted viruses should be considered as pathogens of wild plants that become important in crops when infested land is brought under cultivation. Nearly all namatode-transmitted viruses and their vectors have extensive weed-host ranges that ensure survival on wild hosts when immune crops are grown.

Bidens pilosa L., *Calotropis procera* (Linn). R. Br. ex Ait. *Sonchus arvensis* L and *Xanthium strumaritium* L. have been found to be growing wild as common weeds in almost all the fields around Delhi. These plant species have not been reported as hosts of any virus disease from India except *Calotropis gigantea* (Ait). R. Br. on which a strain of cucumber mosaic virus has been observed in Trivendrum (Wilson and Jose, 1967). With a view to study whether these plants are functioning as natural reservoir hosts of important plant viroses, it was thought worthwhile to investigate the possibility of employing these as indicators of other viruses.

Separate sets of young, glasshouse raised, vigorously growing seedlings were mechanically inoculated with 14 viruses maintained in this laboratory on their principle and on collateral hosts. For inoculations, conventional method of macerating infected leaf material in a pestle and rubbing the test seedling by means of a cotton wool swab, was employed. Plants were maintained on glasshouse benches at a temperature of 85-100°F. Observations are presented in Table 1.

It is interesting to note that out of 14 viruses inoculated only Brinjal mosaic virus, chilli mosaic virus and tobacco mosaic virus (CPO and PP strains) could infect *S. arvensis* whereas *X. strumarium, B. pilosa and C. procera* could not be infected by any virus tested in India. *S. arvensis*, therefore, might be probably functioning as natural reservoir host of these three viroses. Though Brinjal mosaic virus is considered as a strain of cucumber mosaic virus (Seth *et al.*, 1967), the former infected *S. arvensis* whereas latter could infect none. On the other hand, Florida strain of cucumber mosaic virus has been found infecting *X. orientale* (Anderson, 1955).

A perusal of literature indicates that *S. arvensis* has been found infected with lucerne mosaic virus (Hein, 1957*a*), mosaic of sugar beet (R.A.M., 1932) parastolbur virus of potato (Valenta et al., 1961) ; and potato stem mottle virus (Schmelzer, 1956) ; *S. asper* with lettuce mosaic virus (Ainsworth, 1939) ; sugarcane mosaic (Zummo and Charpentier, 1964) and purple-top wilt of potato (Bonde and Schultz, 1953) ; *S. oleraceus* with aspermy virus of chrysanthemums (Hollings, 1956), beet yellow stunt virus (Duffus, 1964*a*) ; beet yellows (Bjorlings, 1958), beet western yellow (Duffus, 1964*b*) ; Cucumber mosaic (Hein, 1957*b*), Kok-saghyz yellows (Ryjkoff, 1943), lettuce big-vein virus (Campbell, 1965), lettuce necrotic yellows (Stubbs and Grogan, 1963) lucerne mosaic (Behncken (1966), pineapple yellow-spot virus (Linford, 1932), potato stem mottle (Kohler, 1956), rugose leaf curl (Cryll, 1964), sowthistle yellow vein virus (Duffus, 1963), tobacco yellow dwarf (Helson, 1950), tomato spotted wilt (R.A.M., 1941) and vine virus 1 (Ochs, 1958) ; *S. sp.* with cucumber mosaic virus (Schwarz, 1959). *Bidens pilosa* has been observed naturally infected with Bidens mottle virus (Christie *et al.*, 1968) and tomato spotted wilt virus (Annual Report, 1949). *C. gigantea* has been reported to be infected by a mosaic disease in nature (Wilson and Jose, 1967).

It will be no doubt interesting to test the infectivity of other viroses on these plant species which can be grown readily.

ACKNOWLEDGEMENT

We wish to record our gratitude to Dr. S. P. Raychaudhuri, Head of the Division for his keen interest and constant encou.agement. The authors are grateful to Dr. B. A. Kvicala, Institute of Virology, Slovak Academy of Sciences, Bratislava, for critically going through the manuscript.

REFERENCES

ANDERSON, C. W., 1955 : Viruses of vegetable crops and miscellaneous plants in Florida *Proc. Fla. hort. Soc.* 67 (1954) : 102–105.

AINSWORTH, G. C. and OGILVIE, L., 1939 : Lettuce mosaic. *Ann. Appl. Biol.* *26* : 279–297.

ANNUAL REPORT OF THE DEPARTMENT OF AGRICULTURE AND STOCK FOR THE YEAR, 1948–49, Queensland. 99.1949.

BEHNCKEN, G. M., 1966 : Lucerne mosaic in Queensland. *Qd. J. Agric. Sci. 23* (1) : 91–92.

BJORLING, K., 1958 : Incidence of beet yellows virus in weeds in Sweden and some notes on differential hosts for strains of the virus. *K. Vetensksam. Arsb.* 1958, 2 : 17–32.

BONDE, R. and SCHULTZ, E. S., 1953 : Purple-top wilt and similar diseases of potato. *Bull. Me agric. Exp. Sta. 511* : 30.

CAMPBELL, R. N., 1965 : Weeds as reservoir hosts of the lettuce big-vein virus.—*Can. J. Bot. 43* (9) : 1141–1149.

CAPOOR, S. P., 1962 : Southern sunnhemp mosaic virus. *Phytopathology 52* : 393–397.

CAPOOR, S. P. and VARMA, P. M., 1948 : Enation mosaic of *Dolichos lablab*, a new virus disease. *Curr. Sci.* 17 : 2 : 57–58.

CHENNILU, V. V., SACHCHIDANANDA, J. and MEHTA, S. C., 1968: Studies on a mosaic disease of cowpea from India. *Phytopath. Z. 63* : 381–387.

CHRISTIE, S. R., EDWARDSON, J. R. and ZETTLER, F. W., 1968 : Characterization and electron microscopy of a virus isolated from *Bidens* and *Lepidium.*—*Plt. Dis. Reptr.* 52 (10) : 763–768.

DUFFUS, J. E., 1935 : Possible multiplication in the aphid vector of Sowthistle yellow vein virus, a virus with an extremely long insect latent period. *Virology 21* : 194–202.

DUFFUS, J. E., 1964A : Annual Meeting of the Pacific Division of the American Phytopathological Society, Vancouver, B.C. 34–26 June, 1964.—Abs. in *Phytopathology* 54 (12) : 1431–1438.

DUFFUS, J. E., 1964B : Host relationships of Beet western yellows virus strains.—*Phytopathology 54* (6) : 736–738.

GRYLL, N. E., 1954 : Rugose leaf curl—a new virus disease transovarially transmitted by leafhopper *Austroagallia torrida.*—*Aust. J. Biol. Sci.* 7, 1 : 47–58.

HARRISON, B. D., 1964 : The transmission of plant viruses in soil. In Plant Virology ed. M.K. Corbett, H. D. Sisler. 6 : 118–47 Gainesville : Univ. Florida Press. 527 pp.

HEIN, ALICE, 1957A—Contributions to the knowledge of the virus diseases of weeds. II. The lucerne mosaic and the *Lamium* yellow mosaic viruses. *Phytopath. Z. 29,* 1 : 79–116.

HEIN, ALICE 1957B—Contributions to the knowledge of virus diseases of weeds . III. Cucumber mosaic virus—*Phytopatha. Z. 29,* 2 : 144–147.

HELSON, G. A. H., 1950 : Yellow dwarf of tobacco in Australia, V. Transmission by *Orasius argentatus* (Evans) to some alternative hostplants. *Aust. J. agric. Res. 1,* 2 :fi144–147.

HOLLINGS, M., 1955—Aspermy virus and flower distortion in chrysanthemums—*J. Minist. 62,* 6 : 275–277.

KHATRI, H. L. and CHENULU, V. V., 1967 : Studies on a mosaic disease of *Phlox. Pl. Dis. Reptr. 51* (9) : 768–771.

KOHLER, E. 1956 : On a seasonal reversible change of virulence in tobacco rattle virus.—*NachBl, dtsch. PflschDienst* (Braunschweig), stuttgart *8*, 6 : 93—94.

LINFORD, M. B., 1932 : Transmission of the pineapple yellow-spoot virus by *Thrips tabaci. Phytopathology 22*, 4 : 301–324.

MATHUR, S. B., MISHRA, M. D. and TEWARI, V. P. 1963 : A new strain of tobacco mosaic virus affecting Chilli pepper variety Puri Orange. *Pl. Dis. Reptr. 50* : 619–622.

MISHRA, M. D., 1963 : Host range and physical properties of a virus causing mosaic symptoms and necrosis on chillis *Capsicum* annum L. *Ind. J. Miscrobiol.* 3, *3* : 77–84.

NAGARAJAN, S., 1969 : Studies on a mosaic disease of Dhalia. M.Sc. Thesis, Indian Agricultural Research Institute, New Delhi (India).

OCHS, G. 1958 : Concerning three viruses as agents of Vine diseases.—*Z. PfiKrankh.* 65, 1 : 11–17.

PHATAK, H. C. and VERMA, V. S., 1967 : A strain of tobacco mosaic virus from potato.—*Phytopath Z 59* : 385–389.

REVIEW OF APLIED MYCOLOGY, 1932 : Mosaic disease of the sugar beet. 90.

REVIEW OF APLIED MYCOLOGY. 1941 : Plant diseases notes contributed by the Biological Branch : 194.

RYJKOFF, V. L., 1943 : Kok-saghyz yellows.—*C. R. Acad. Sci. U.R.S.S.*, N.C., *xl* i, 2 : 94–96.

SCHWARZ, R. 1959 : New vectors for a variant of turnip and swede mosaic virus and for cucumber mosaic virus. *Z. PflKrankh, 66*, 2 : 89–90.

SCMELZER, K., 1956 : Contributions to the knowledge of the transmissibility of viruses by *Cuscuta* species—*Phytopath. Z. 28*, 1 : 1–56.

SETH, M. L., RAYCHAUDHURI, S. P., and RAM NATH, 1967 : A new mosaic disease of Brinjal (*Solanum melongena* L.)—*Phytopath. Z. 59* : 385–389.

SINGH, SHAMSHER, SACHCHIDANANDA, J., PRAKASH, NAM and VARMA, ANUPAM. 1970 : Primula mottle virus. *Indian Phytopath. 23*, 1 : 148–150.

SMITH, K. M., 1950 : Some new virus diseases of ornamental plants—*J. R. Hort. Soc. 75* : 350–353

STUBBS, L. L. and GROGAN, R. G., 1963 : Necrotic yellows, a newely recognized virus disease of lettuce. *Aust, J. agric. Res. 14* (4) : 439–459.

VALENTA, V., MISIGA, S., and MUSIL, M., 1961 : Distribution of parastolbur in Slovakia. *Biologia, Bratislova 16* (3) : 178–183

WILSON, K. I. and JOSE, P. C., 1967 : Mosaic disease of *Calotropis gigentes* R. Br. *Agric. Res. Jnl. Kerala* 5 (1–2) : 92.

ZUMMO, N. and CHAREENTIER, L. J., 1964 : Vector-virus relationship of sugarcane mosaic virus by the brick-red sowthistle aphid (*Dactynotus ambrosiae* Thos. *Pl. Ris. Reptr. 48* (8) : 636 639.

TABLE I

Host reactions

Virus	*B. pilosa*	*C. procera*	*S. arvensis*	*X. strumarium*	*Incubation period in days*
Alfalfa mosaic virus (Type strain)	—	—	—	—	—
Brinjal mosaic virus (Seth etal, 1967)	—	—	Mild mottling	—	14–18
Chilli mosaic virus (Mishra, 1963)	—	—	Mild mottling	—	15–20
Cowpea mosaic virus (Chenulu etal, 1968)	—	—	—	—	—
Cucumber mosaic virus (Type strain)	—	—	—	—	—
Dolichos enation mosaic virus (Capoor and Varma, 1948)	—	—	—	—	—
Nasturium ringspot virus (Smith, 1950)	—	—	—	—	—
Pholx mosaic virus (Kharti, 1967)	—	—	—	—	—
Potato virus X (Type strain)	—	—	—	—	—
Potato virus Y (Type starin)	—	—	—	—	—
Primula mottle virus (Singh et al, 1970)	—	—	—	—	—
Sunnhemp mosaic virus (Capoor, 1962)	—	—	—	—	—
TMV—CPO strain (Mathur et al, 1966)	—	—	Mild mottling	—	15.20
TMV—PP strain (Phatak and Varma, 1967)	—	—	Mild mottling	—	15.20
Dahlia mosaic virus (Nagarajan, 1969)	—	—	—	—	—

Weather Summaries from July, 1972 to March, 1973

1972

July : Weak monsoon conditions prevailed over the Island from the 1st to the 10th. On most days during this period the rainfall was light and isolated and confined mainly to the south-western lowlands. On the 11th, a depression formed in the North-west Bay of Bengal which activated the monsoon and fairly widespread rain was experienced in the South-west quarter. These conditions lasted till the 16th, a large number of falls over 5 inches (125 mm) being recorded along the South-western slopes of the central hills on the 15th and 16th. A comparatively drier spell then set in till the 19th, when the monsoon trough in the Bay of Bengal moved close to the East coast, giving thundershowers in the East. During the next few days, scattered thundershowers were experienced over the central region of the Island. From the 24th, scattered showers were experienced in the South-west and on the last four days of the month, generally dry weather prevailed.

The larger monthly totals of rainfall (totals over 26 inches—635 mm) were experienced over the Watawala-Ginigathena-Maskeliya area. Over the adjoining region of the central hills and over parts of Sabaragamuwa, the rainfall ranged from 15 to 25 inches (375 to 625mm). Over the South-western lowlands rainfall was below 10 inches (250 mm), Colombo and a few other coastal stations receiving less than 2 inches (50 mm). Over the North-central and Northern Provinces, rainfall was mainly below 2 inches (50 mm), drought conditions being experienced over most of this region. The highest monthly totals were 29.75 inches (756 mm) at Carolina Group (Watawala), 28.00 inches (713 mm) at Arslenn Estate (Ginigathena) and 27.71 inches (704 mm) at Luccombo Estate (Maskeliya).

Rainfall was generally below normal, being particularly so in the South-west ,where some stations recorded deficits of 5 to 10 inches (125 to 250 m). Rainfall was a little above normal only over small areas of the central hills and Uva and at a few isolated stations. The biggest deficits were 8.22 inches (209 mm) at Maskeliya, 6.48 inches (165 mm) at Digalla Estate (Dehiowita) and 6.06 inches (154 mm) at Maliboda Estate (Deraniyagala). The highest excesses were 7.17 inches (182 mm) at Rasagalla Estate (Balangoda), 6.20 inches (157 mm) at Sandrinham Estate (Agrapatana) and 5.21 inches (132 mm) at Labookelle Estate (Ramboda).

There were 31 daily falls over 5 inches (125 mm), all of these being recorded on the 15th or 16th. The highest was 8.47 inches (215 mm) which was recorded at Luccombe Estate (Maskeliya) on the 16th. There were 29 stations recording nil rainfall.

Day temperatures were above average, being well above average at Puttlam, Colombo and Ratnapura. Night temperatures were mostly a little above normal. The highest temperature recorded was 98.1°F (36.7°c) at Vavuniya on the 31st. The lowest at a coastal station was 72.7°F (22.6°C) at Hambantota on the 9th and for the whole Island 49.4°F (9.6°C) at Nuwara Eliya on the 29th. Day humidity ranged from 75 to 85% over the South-west quarter and 70 to 80% in the North and North-west. Over the North-central and Eastern regions of the Island, the day humidity ranged from 60 to 70%. Night humidity ranged from 75 to 80% in the East and North-east and between 80 and 95% elsewhere. Mean cloud amounts and mean air pressures were generally about average. Wind mileages were above average in the North and South-east and below average elsewhere, the direction being mainly South-westerly.

August : Weak monsoon conditions prevailed at the beginning of the month and scattered rain was experienced in the South-west quarter till the 4th. From the 5th to the 11th, the monsoon became more active and heavier falls were experienced in the South-west quarter, particularly on the South-western slepos of the central hills. Thereafter, a comparatively dry spell set in, which lasted till the end of the month. During this period, light isolated falls were experienced in the South-west on some days.

The larger monthly totals of rainfalls (totals over 20 inches—500 mm) were experienced over the Norton Bridge-Ginigathena area. Rainfall over the adjoining region of the central hills and over small areas of Sabaragamuwa ranged from 10 to 20 inches (250 to 500 mm). Over the South-western lowlands, rainfall was below 10 inches (250 mm), the coastal stations recording less than 5 inches (125 mm). Drought conditions continued to prevail over the greater part of the Northern, North-central and North-western Provinces, a large number of stations in these areas experiencing no rain. The highest monthly totals were 26.64 inches (677 mm) at Norton Bridge, 22.98 inches (584 mm) at Kenilworth Estate (Ginigathena) and 19.18 inches (487 mm) at Carolina Group (Watawala).

Rainfall was generally below normal, being particularly so in the South-west, where some stations recorded deficits of 5 to 10 inches (125 to 250 mm). Rainfall was above normal only at a few isolated stations. The biggest deficits were 8.21 inches (209 mm) at Maliboda Group (Deraniyagala), 7.41 inches (188 mm) at Ingoya Estate (Kitulgala) and 7.25 inches (184 mm) at Weweltalawa Division, Halgolla Group (Yatiyantota). The highest excesses were 1.08 inches (27 mm) at Ella Wella Tank, 0.72 inches (18 mm) at Bata-ata and 0.57 inches (14 mm) at Anningakanda Estate (Deniyaya).

There were only 3 daily falls over 5 inches (125 mm), the highest being 5.62 inches (143mm) at Luccombe Estate (Maskeliya) on the 7th. There were 62 stations reporting nil rainfall.

Day and night temperatures were generally above normal. The highest temperature recorded was 97.4°F (36.3°C) at Trincomalee on the 28th and 29th. The lowest at a coastal station was 72.8°F (22.7°C) at Ratmalana on the 22nd and for the whole Island 50.0°F (10.0°C) at Nuwara Eliya on the 1st. Day humidity ranged from 70 to 80% over the South-west and the Western coastal area and from 55 to 65% over the North-central and Eastern regions of the Island. Night humidity ranged mainly from 75 to 90%. Mean cloud amounts were about average, while mean air pressures were a little above average. Wind mileages were below average in the West and East and above average elsewhere, the direction being mainly South-westerly.

September : The fairly dry South-west monsoon conditions experienced from about the middle of August, continued to prevail until the 6th. However, from the 7th to the 13th, the upper winds strengthened under the influence of cyclonic storms to the East of the Island and frequent showers were experienced mainly in the South-west quarter. The upper winds weakened during the next few days, resulting in evening thunderactivity. From the 18th to the 20th, normal South-west monsoon conditions prevailed once again. On the 21st, intermonsoon weather conditons set in and thundershowers were fairly widely experienced till the end of the month.

The larger monthly totals of rainfall (totals over 30 inches—750 mm) were experienced over Kalawana and the Yatiyantota-Norton Bridge-Deraniyagala area. Rainfall over the adjoining areas ranged from 20 to 30 inches (500 to 750mm), decreasing to 10 to 20 inches (250 to 500mm) over the South-western lowlands, while the coastal area from Panadura to Chilaw recording rainfall in the range 5 to 10 inches (125 to 250 mm). Over the Northern of the Island, rainfall was mainly below 5 inches (125 mm), while over the North-central and Eastern regions the rainfall ranged from 2 to 19 inches (50 to 250 mm). However, the Minneriya-Polonnaruwa area recorded rainfall in the range 10 to 20 inches (250 to 500 mm). The highest monthly totals were 32.91 inches (368 mm) at Iranganie Estate (Kalawana), 32.54 inches (826 mm) at Weweltalawa Division, Halgolla Group (Yatiyantota) and 31.19 inches (792 mm) at Norton Bridge.

Rainfall over the Island was generally above normal, being particularly so over the Minneriya area and parts of the South-west quarter. The highest excesses were 17.50 inches (444 mm) at Minneriya 15.85 inches (403 mm) at Iranganie Estate and 13.45 inches (342 mm) at Sunderland Estate (Eheliyagcda). The biggest deficits were 2.62 inches (66 mm) at Nilloomaley Estate (Madulkele) and 2.23 inches (57 mm) at Yarrow Estate (Pussellawa).

There were 10 daily falls over 5 inches (125 mm), the highest being 9.43 inches (240 mm) at Ingoya Estate (Kitulgala) on the 14th. There was only one station reporting nil rainfall

Day and night temperatures were mainly about or a little above normal. The highest temperature recorded was 98.1ıF (36.7°C) at Vavuniya on the 13th. The lowest at a coastal station was 70.5°F (21.4°C) at Kankesanturai on the 8th and for the whole Island 44.9°F (7.2°C) at Nuwara Eliya on the 5th. Day humidity ranged from 70 to 80% in the South-west quarter and from 60 to 75% in the North and Northeast. Night humidity ranged from 75 to 80% in the East and North-east and from 80 to 95% elsewhere. Mean cloud amounts were about or a little above normal, while mean air pressures were generally about normal. Wind mileages were above normal in the North and mainly below normal elsewhere, the direction being mainly South-westerly.

October : The intermonsoon evening thunderstorms which set in during late September, continued without a break during October. Very moist conditions in the upper air and light winds resulted in widespread thunder activity.

The larger monthly tootls of fainfall (totals over 35 inches—875 mm), were experienced over the South-western hill country, particularly in the Agrapatana, Yatiyantota and Deraniyagala areas. Over the adjoining regions and part of Uva and the Bentota-Balapitiya area, the rainfall ranged from 20 to 35 inches (500 to 875 mm). Over the greater part of the Northern, North-central and Eastern Provinces, rainfall ranged from 5 to 15 inches (125 to 375 mm). The highest monthly totals were 51.44 inches (1307 mm) at Sandringham Estate (Agarapatana), 47.81 inches (1214 mm) at Wewaltalawa Division, Halgolla Group (Yatiyantota) and 37.57 inches (954 mm) at Liniyagala Estate (Deraniyagala.)

Rainfall over the Island was generally above normal, being particularly so over parts of the South-west quarter and the Vavuniya and Puttalam areas. The highest excesses were 41.84 inches (1063 mm) at Sandirngham Estate, 19.99 inches (508 mm) at Vavuniya, 19.94 (506 mm) at Alagalla and 18.20 inches (462 mm) at Western Salterns (Puttalam). The biggest dificits were 8.22 inches (209 mm) at Sirikandura Estate (Matugama), 7.60 inches (195 mm) at Gikiyanakande Estate (Neboda) and 4.71 inches (120 mm) at Halwatura Estate (Ingiriya).

There were 34 daily falls over 5 inches (125 mm), the highest being 10.00 inches (254 mm) at Rambodagalla Estate (Kurunegala) on the 25th. There were no stations reporting nil rainfall.

Day and night temperatures were mainly about normal. The highest temperature recorded was 94.1°F (34.5°C) at Ratnapura on the 17th. The lowest at a coastal station was 71.4°F (21.9°C) at Kankesanturai on the 29th and for the whole Island 50.2ıF (10.1°C) at Nuwara Eliya on the 15th. Day humidity ranged from 80 to 85% over the hill country and from 75 to 80% elsewhere. Night humidity ranged from 85 to 90% in the South and East and from 90 to 95% elsewhere. Mean cloud amounts and mean air pressures were a little above normal. Wind mileages were below normal, the direction being variable.

November : Till 18th November, there was fairly widespread evening thunderactivity on most days, typical of intermonsoon conditions. From the 19th to the 23rd, a dry Northerly wind resulted in fair weather being experienced over the Island. From the 24th to the end of the month, light moist winds once again gave rise to evening thundershowers inland, which spread to most coastal areas.

The larger monthly totals of rainfall (totals over 30 inches—750 mm) were experienced at Yatiyantota and over isolated areas of Uva. Rainfall over the rest of the South-west quarter and Uva ranged from 10 to 25 inches (250 to 625 mm). Over the greater part of the Northern 10 to 25 inches (250 to 625 mm). Over the greater part of the Northern, North-central and Eastern Provinces, rainfall ranged from 5 to 15 inches (125 to 375 mm). The highest monthly totals were 42.74 inches (1086 mm) at Weweltalawa Division, Halgolla Group (Yatiyantota), 32.44 inches (824 mm) at Geelong Estate (Moneragala) and 32.14 inches (816 mm) at Blackwood Estate (Haputale).

Rainfall was above normal over parts of the South-west quarter, Uva and the Southern half of the Eastern Province. Rainfall over the rest of the Island was generally below normal. The highest excesses were 23.02 inches (585 mm) at Weweliatawa Division, Halgolla Group, 16.01 inches (107 mm) at Geelong Estate and 14.21 inches (361 mm) Lemas Estate (Koslanda). The biggest deficits were 9.90 inches (251 mm) at Kanakarayankulam, 8.65 inches (220 mm) at Kanukkeni and 8.08 inches (205 mm) at Allai Tank.

There were 21 daily falls over 5 inches, the highest being 8.00 inches (203 mm) at Gokarella on the 26th. There were no stations reporting nil rainfall.

Day and night temperatures were mainly above normal. The highest temperature recorded was 95.5°F (35.3°C) at Ratnapura on the 26th. The lowest at a coastal station was 63.6°F (17.4°C) at Katunayake on the 21st and for the whole Island 43.3°F (6.3°C) at Nuwara Eliya on the 22nd. Day humidity ranged from about 70 to 80%, while night humidity ranged from about 85 to 95%. Mean cloud amounts and mean air pressures were a little above normal. Wind mileages were below normal, the direction being variable.

December : Under the influence of a tropical depression which formed in the South-central Bay of Bengal, there was fairly widespread light to moderate rain on the 3rd and 4th. Weak North-east monsoon weather conditions prevailed from the 5th to the 15th, with rain in the North and East and occasional evening thundershowers in the South and West. From the 16th to the 21st, another depression in the South-west Bay gave moderate to fresh North-easterly winds and fairly widespread rain over most of the island. Normal North-east monsoon weather prevailed from the 22nd to about the end of the month. A significant feature of the weather this month was the atmospherec pressure which was considerably above average on three days from the 26th to the 28th.

The larger monthly totals of rainfall (totals over 40 inches—1000 mm) were experienced in the Gammaduwa area. Rainfall over the adjoining areas of the North-eastern slopes of the central hills and over a small part of the Uva highlands ranged from 20 to 40 inches (500 to 1000 mm). Over the South-west quarter, the rainfall ranged from 2 to 15 inches (50 to 375 mm), while in the North and East the rainfall ranged mainly from 5 to 15 inches (125 to 375 mm). The highest monthly totals were 41.39 inches (1051 mm) at Dooroomadella Group (Gammaduwa), 41.04 inches (1042 mm) at Mousekande Estate (Gammaduwa) and 33.72 inches (856 mm) at Iddumekelle Estate (Madugoda).

Rainfall was above normal over the central highlands and was generally below normal over the South-western mid-country and lowland areas and in the North and East. The highest excesses were 11.63 inches (295 mm) at Dooroomadella Group, 10.03 inches (255 mm) at Gammaduwa Estate (Gammaduwa) and 8.75 inches (222 mm) at Kurundu Oya Estate, (Maturata). The biggest deficits were 9.47 inches (241mm) at Anningkande Estate (Deniyaya), 9.31 inches (236 mm) at Panilkande Estate (Deniyaya) and 7.85 inches (199 mm) at Detenagalla Estate (Pinnawela).

There were 46 daily falls over 5 inches (125 mm), the highest being 9.67 inches (245 mm) at Keenakelle Division, Queenstown Group (Hali-Ela) on the 19th. There were no stations reporting nil rainfall.

Day and night temperatures were above normal, the night minimum at Nuwara Eliya, in particular, being appreciably above normal. The highest temperature recorded was 95.7°F (35.4°C) at Ratnapura on the 10th. The lowest at a coastal station was 69.6°F (20.9°C) at Katunayake on the 21st and for the whole Island 42.2°F (5.7°C) at Nuwara Eliya on the 1st. Day humidity ranged from about 70 to 85%, while night humidity ranged from about 85 to 95%. Mean cloud amounts were a little above normal while mean air pressures were about normal. Wind mileages were mainly above normal, the direction being mainly Northeasterly.

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January : Warm and dry North-easterly winds over Sri Lanka gave drought conditions over the entire Island up to 23rd January. On the 24th, a low pressure area formed to the South-east of the Island and scattered rain, with occasional isolated evening thunderactivity was experienced till the end of the month.

The larger monthly totals of rainfall (totals over 100 mm) were experienced over parts of the North-eastern slopes of the central hills, a small area of the Uva highlands and parts of the Kegalle and Ratnapura Districts. Over the rest of the Island, rainfall was mainly below 100 mm, a large number of stations in the North-western and North-central Provinces and in the extreme North experiencing no rain at all. The highest monthly totals were 206 mm at Koboella Estate (Urugala), 202 mm at Liniyagala Group (Deraniyagala) and 164 mm at Palatupana Lewaya.

Rainfall was below average, drought conditions being experienced over a large part of the Island. The biggest deficits were 547 mm at Dooroomadella Group (Gammaduwa), 444 mm at Gammaduwa Estate (Gammaduwa) and 423 mm at Kurundu Oya Estate (Maturata). There were only two small excesses, these being 15 mm at Avissawella and 9 mm at Migahajandura.

There was only 1 daily fall over 125 mm, this being 131 mm at Liniyagala Group on the 31st, while 102 stations reported nil rainfall.

Day temperatures were above normal, being appreciably so at the inland stations. Night temperatures were mainly about a or little below normal. However, there was a cold spell from the 15th to the 22nd and during this period, ground (frost was reported from Nuwara Eliya on 4 days—the 16th, 17th, 19th and 20th. The highest temperature recorded was 36.4°C at Ratnapura on the 21st. The lowest at a coastal station was 18.0°C at Kankesanturai on the 19th and for the whole Island 3.1°C at Nuwara Eliya on the 21st. Day humidity ranged mainly from 70 to 75% in the South and East and from 60 to 70% elsewhere. Night humidity was about 70% at Nuwara Eliya and in the North-east and ranged mainly between 80 and 90% over the rest of the Island. Humidities less than 30% were recorded at Nuwara Eliya on the 15th, 16th and 18th. Mean cloud amounts were about normal, while mean air pressures were little above normal. Wind mileages were mainly below normal, the direction being generally North-easterly.

February : Scattered rain and thundershowers were experienced during the first week of the month. There was practically no rain from the 7th to the 9th, but from the 10th to the 19th and on the 22nd and 23rd, scattered evening thundershowers were experienced over the central hills and in the South-west. During the rest of the month, generally fair weather prevailed.

The larger monthly totals of rainfall (totals over 200 mm) were experienced over parts of the South-west quarter and in the Madugoda area on the north-eastern slopes of the central hills. Over the South-west coastal area, rainfall was below 200 mm, while over the Northern and North-western Provinces, parts of the North-central and Eastern Provinces and in the South-east, rainfall was mainly below 50 mm. The highest monthly totals were 333 mm at Tawalama (Hiniduma), 321 mm at Eheliyagoda Group (Eheliyagoda) and 319 mm at Goluwa-watte (Matara).

Rainfall was generally below average, only parts of the South-west quarter experiencing rainfall above average. The highest excesses were 154 mm at Eheliyagoda Group, 143 mm at St. Leonard's Estate (Elpitiya) and 74 mm at Hiyare Reservoir (Galle). The biggest deficits were 138 mm at Baddegama Estate (Baddegama), 134 mm at Dooroomadella Estate (Gammaduwa)and 128 mm at Weweltalawa Division of Halgolla State Plantation (Yatiyantota

There was only 1 daily fall over 125 mm, this being, 147 mm at Anningkande Estate (Deniyaya) on the 1st. 17 stations, mainly in the North-west and South-west, reported nil rainfall.

Day and night temperatures were above normal. The highest temperature recorded was 36.9°C at Ratnapura on the 21st. The lowest at a coastal station was 20.2°C at Katunayake on the 20th and for the whole Island 3.0°C at Nuwara Eliya on the 8th. Day humidity ranged from 70 to 80% over the central hills and in the East and North and from about 55 to70% elsewhere. Night humidity was about 75% in the North-east and ranged from about 80 to 95% elsewhere. Mean cloud amounts were about normal, while mean air pressures were a little above normal. Wind mileages were mainly above normal, the direction being variable in the South-west and mianly North-easterly elsewhere..

March : Intermonsoon weather prevailed during March, with light variable surface and ower level winds. From 1 to 19, the upper air was relatively dry, and evening convective showers were very isolated over the hills and other inland areas. There were occasional days of clear weather over the entire Island. Evening thunderstorms became fairly widespread from 19. to 31.

The larger monthly totals of rainfall (totals over 400 mm) were experienced over parts of Galle, Matara, Ratnapura, Avissawella and Kalutara Districts. Elsewhere in the South-west quarter (excluding parts of central hill country) and parts of Puttalam, Kurunegala, Badulla and Hambantota Districts and a few isolated places in the North-central and Eastern Provinces rainfall ranged from 100 to 400 mm. Rainfall over the rest of the Island was below 100 mm. The highest monthly totals were 269 mm at Pelawatte State Plantation (Meegahatenne), 582 mm at Anningkande Esttae (Deniyaya) and 576 mm at Lauderdale Estate (Ittakanda).

Rainfall was above normal over most parts of North-western, Western, Southern and Sabaragamauwa Provinces and a few isolated places in the Central, North-central and Northern Provinces. Elsewhere rainfall was below normal The highest excesses were. 337 mm at Hiyare reservoir (Galle), 251,mm Anningkande Estate and 241 mm at Godaka-wela. The biggest deficits were 166 mm at Lemas Estate (Koslanda), 160 mm at Dooroomadella Estate (Gammaduwa) and 148 mm at West Haputale Division (Ohiya).

There were 4 daily falls over 125 mm, the highest being 230 mm at Madugoda on the 31st. 13 stations, mainly in the Jaffna and Trincomalee Districts, reported nil rainfall.

Temperatures were above normal. The highest temperature recorded was 38.4°C at Kurunegala on the 20th. The lowest at a coastal station was 20.2°C at Kankesanturai on the 12th and for the whole Island 5.3°C at Nuwara Eliya on the 9th. Day humidity ranged from about 60 to 75% in the ceastal area3 and from about 55 to 70% elsewhere. Night humidity ranged from about 80 to 90Æ. Mean cloudamounts were above normal, while mean air pressures were a little above normal. Wind mileages were mostly below normal, the direction being variable in South-west and mainly North-easterly elsewhere.

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JULY, 1972

Station	Temperature F°				Humidity		Cloud	Rainfall			
	Mean Max.	*Off-set*	*Mean Min.*	*Off-set*	*Day*	*Night*	*Amount*	*Amount Inches*	*Off-set*	*Rain Days*	*Off-set*
Anuradhapura	91·5	+0·6	76·5	+0·7	64	88	5·4	1·04	−0.21	4	+1
Badulla	87·6	+1·3	65·6	+·12	63	89	5·8	2·95	+1.01	12	+5
Batticaloa	92·5	+0·7	77·7	+0·7	64	78	5·6	1·98	+9.04	7	+3
Colombo	87·3	+2·6	78·9	+2·1	76	84	6·0	1·65	+3.85	11	−4
Diyatalawa	78·5	+0·6	62·5	+0·1	68	86	5·7	2·46	+0.15	7	−2
Galle	84·4	+1·7	78·1	+1·4	79	84	5·4	2·11	−4.61	19	0
Hambantota	88·5	+1·3	77·2	+0·8	72	84	4·8	2·92	+1.22	7	0
Jaffna	87·0	+0·8	81·2	+1·3	76	81	6·0	1·65	+0.91	2	0
Kandy	82·9	+1·9	70·7	+0·9	70	85	6·2	5·47	−0.61	18	+2
Kankesanturai	90·8	+0·8	79·9	+0·6	71	87	5·4	0·47	−0.46	3	+1
Katunayake	87·6	—	77·9	—	74	85	6·2	2·74	—	10	—
Kurunegala	88·1	+1·8	76·5	+1·3	74	88	6·4	4.89	+0.49	13	−3
Maha Illuppallama	91·9	+2·0	76·6	+1·6	60	82	5·8	0·81	—	4	—
Mannar	87·7	+0·6	80·2	+1·0	76	82	5·7	0·36	+0.08	2	+1
Nuwara Eliya	66·0	+0·7	56·0	+1·0	86	91	6·4	10·35	+1.59	17	−5
Puttalam	89·6	+3·2	79·1	+0·8	79	91	5·9	0·33	−0.34	1	−2
Ratmalana	86·8	+1·7	77·8	+1.0	74	82	6·2	3·19	—	12	—
Ratnapura	88·7	+2·1	74·6	+0.3	76	95	6·0	9·77	−2.30	23	−1
Trincomalee	93·6	+1·0	78·8	+0·7	60	76	5·6	5·79	+3.66	6	+2
Vauniya	92·8	—	76·3	—	61	88	5·8	0·45	−0.61	3	0

AUGUST, 1972

Station	Temperature F°				Humidity		Cloud	Rainfall			
	Mean Max.	*Off-set*	*Mean Min.*	*Off-set*	*Day*	*Night*	*Amount*	*Amount Inches*	*Off-set*	*Rain Days*	*Off-set*
Anuradhapura	91·9	+0·5	75·9	+0·4	60	88	5·4	0·02	−1.82	1	−4
Badulla	88·6	+2·4	63·2	−1·5	54	89	4·0	0·82	−2.96	3	−6
Batticaloa	91·5	+1·0	77·1	+0·5	65	76	4·8	0·35	−2.08	2	−4
Colombo	87·2	+2·3	78·2	+1·2	73	84	5·6	2·41	−2.46	10	−5
Diyatalawa	79·2	+1·3	60·6	−1·2	61	83	5·0	0·35	−3.17	3	−7
Galle	83·5	+0·9	77·6	+0·8	78	82	5·8	3·89	−3.15	18	−1
Hambantota	84·9	−2·0	75·9	−0·3	76	88	5·4	2·83	+1.17	5	−3
Jaffna	85·8	−0·3	80·3	−0·9	78	82	5·9	0·04	−1.20	1	−3
Kandy	82·8	+0·7	68·1	−1·7	68	87	5·6	2·44	−3.15	15	+1
Kankesanturai	90·4	+0·4	79·5	+0·4	72	87	5·4	0·01	−1.45	1	−2
Katunayake	87·9	—	76·8	—	72	86	5·5	1·94	—	10	—
Kurunegala	88·5	+1·7	75·4	+0·4	70	88	6·6	1·77	−2.76	15	−1
Maha Illuppallama	92·1	+1·2	76·2	−1·1	56	79	5·6	0	—	0	—
Mannar	86·6	−0·5	79·5	+0·8	76	82	5·6	0	−0.63	0	−2
Nuwara Eliya	65·9	−0·3	54·8	+0·2	81	85	5·9	3·96	−3.11	11	11
Puttalam	89·2	+2·4	78·9	+0·9	75	80	5·8	0·06	−0.78	3	−1
Ratmalana	86·6	+1·3	77·0	−0·4	71	82	5·8	1·19	—	12	—
Ratnapura	88·9	+2·1	73·5	−0·7	74	95	5·6	9·28	−3.62	23	−1
Trincomalee	94·1	+1·8	78·6	+1·1	55	74	5·4	1·04	−3.01	2	−5
Vavuniya	93·5	—	75·7	—	57	88	6·1	0	−2.69	0	−6

SEPTEMBER, 1972

Station	Temperature F° Mean Max.	Off-set	Mean Min.	Off-set	Humidity Day	Night	Cloud Amount	Rainfall Amount Inches	Off-set	Rain Days	Off-set
Anuradhapura	92·9	+0·7	75·4	+0·2	63	88	5·2	3·03	+0·29	10	+5
Badulla	86·9	+1·1	66·7	+2·3	63	87	5·3	8·06	+4·41	12	+3
Batticaloa	89·7	-0·1	77·0	+0·7	69	80	5·0	5·13	+3·15	11	+6
Colombo	87·4	+2·1	77·0	+0·5	76	86	6·0	7·77	+1·73	20	+3
Diyatalawa	77·3	-0·5	61·6	+0·6	70	89	5·6	4·64	+0·92	17	+6
Galle	83·9	+1·1	76·5	-0·3	78	84	5·8	15·31	+8·25	25	+6
Hambantota	85·6	-0·8	76·5	+0·3	78	84	5·8	7·48	+5·69	15	+7
Jaffna	86·2	-0·1	80·0	+0·5	78	82	5·6	1·86	-0·01	3	0
Kandy	84·9	+2·8	68·2	+0·7	65	87	5·6	5·14	+0·33	14	+2
Kankesanturai	90·1	0	79·0	-0·2	74	86	5·2	1·83	-0·15	4	0
Katunayake	88·4	—	75·2	—	73	91	5·9	8·07	—	19	—
Kurunegala	90·0	+2·2	75·1	+0.6	70	91	5 8	5·35	+1.05	21	+7
Maha Illuppallama	92·8	+0·8	75·2	0.3	56	84	6·0	3·19	—	8	—
Mannar	87·8	+0·4	79·5	+0.6	76	85	5·6	0·26	-0·67	2	0
Nuwara Eliya	68·0	+1·1	54·1	+0.6	83	88	6·3	7·40	+0·90	19	-1
Puttalam	90·0	+2·7	78·0	0	75	89	5.6	2·92	+1·53	9	5
Ratmalana	90·0	+1·1	75·1	-1.2	73	86	6·2	7,93	—	21	—
Ratnapura	89·0	+1·7	73·0	-0.5	78	95	6·0	23.53	+11·13	25	+3
Trincomalee	94·4	+2·1	77·4	+0.2	60	78	5·5	6.53	+3·03	9	+3
Vavuniya	93·7	—	75·1	—	60	88	5·7	8.11	+5·0	10	+4

OCTOBER, 1972

Station	Temperature F° Mean Max.	Off-set	Mean Min.	Off-set	Humidity Day	Night	Cloud Amount	Rainfall Amount Inches	Off-set	Rain Days	Off-set
Anuradhapura	87·4	-1.9	73·8	+0·2	78	95	6·0	16·26	+7·09	27	+11
Badulla	82·6	-0.5	66·7	+1·1	79	92	6·4	21·58	+13·07	30	+13
Batticaloa	86·2	-0.8	75·8	+0·4	78	88	5·8	16·96	+9·95	19	+ 5
Colombo	85·8	+0.9	75·4	+0·6	80	93	6·6	18·23	+4·29	27	+ 6
Diyatalawa	75·2	-1.3	61·6	+0·9	84	94	6·4	15·33	+5·38	30	+11
Galle	84·3	+1.4	74·8	-0·7	78	88	6·6	20·47	+6·45	23	+ 2
Hambantota	84·9	-1·2	75·8	+0·3	77	88	6·2	9·76	+4·81	17	+ 4
Jaffna	85·6	+0.2	77·8	0	80	86	6·5	15·36	+5·77	19	+ 6
Kandy	83·6	+0.5	69·9	+1·9	76	90	6·4	+7·44	+7·26	30	+13
Kankesanturai	87·0	-0.3	76·3	-1·0	80	93	6·2	12·24	+3·51	19	+ 8
Katunayake	87·2	—	74·3	—	74	90	6·3	16·48	—	25	—
Kurunegala	87·9	+0.6	73·9	+0·6	79	95	6·6	+28·91	+15·92	26	+ 6
Maha Illuppallama	87·8	-1·5	73·6	+0·4	73	88	6·1	12·58	—	25	—
Mannar	86·9	+0.3	77·1	-0.3	81	91	6·3	9·57	+2·97	22	+11
Nuawra Eliya	68·9	+1.2	54·6	+2·2	87	94	6·6	15·37	+6·62	31	+10
Puttalam	87·3	+0.7	75·1	-0·7	86	93	6·6	24·21	+17·37	25	+12
Ratmalana	86·0	+0.6	73·9	-1·2	77	90	7·0	19·81	—	27	—
Ratnapura	89·7	+2.5	73·2	+0·4	83	98	6·6	21·72	+2·10	26	+ 3
Trincomalee	86·9	-1.4	75·5	-0·3	75	86	6·0	22·27	+13·03	21	+ 5
Vavuniya	87·5	—	73·6	—	79	.93	6·8	28·77	+19·99	26	+11

NOVEMBER, 1972

Station	Temperature F° Mean Max.	Off-set	Mean Min.	Off-set	Humidity Day	Night	Cloud Amount	Amount Inches	Rainfall Off-set	Rain Days	Off-set
Anuradhapura	87·4	+1·6	72·5	+1·0	76	93	5·3	6·83	−2·95	17	−2
Badulla	81·4	+2·0	65·6	+0·1	75	92	5·7	10·09	−0·43	21	+1
Batticaloa	85·1	+0·9	75·0	+0·7	77	90	6·3	13·39	+2·16	16	−2
Colombo	87·0	+1·8	73·9	+0·6	75	93	5·8	12·40	−0·37	17	−2
Diyatalawa	74·9	+0·5	60·0	+0·2	79	97	6·2	10·64	−0·30	21	−1
Galle	84·6	+1·0	74·0	−0·2	75	88	6·0	12·92	+0·23	22	+3
Hambantota	85·3	−0·1	75·0	+0·9	78	90	6·2	7·60	+0·22	15	0
Jaffna	85·0	−0·9	76·0	+1·1	76	88	6·2	10·94	−5·25	14	−4
Kandy	83·9	+1·1	88·3	+0·9	72	90	5·8	12·79	+2·96	21	+4
Kankesanturai	85·8	+1·8	75·5	−0·1	77	88	5·9	13·31	−2·77	12	−4
Katunayake	88·6	—	72·5	—	68	88	5·4	10·25	—	15	—
Kurunegala	88·9	+1·2	72·6	+0·8	74	95	6·5	19·50	+8·42	17	−2
Maha Illuppallama	88·0	+2·4	71·9	+0·9	70	88	6·5	7·59	—	17	—
Mannar	86·1	+1·7	76·9	+1·1	77	86	5·8	4·97	+4·49	15	−2
Nuwara Eliya	69·7	+1·9	53·4	+2·0	80	88	6·9	9·03	+0·82	22	+1
Puttalam	87·5	+1·7	73·4	+0·2	77	93	5·9	10·79	+0·75	15	−3
Ratmalana	87·6	+1·3	72·3	−0·9	71	90	6·2	11·86	—	18	—
Ratnapura	91·8	+4·0	72·1	−0·1	76	95	6·4	13·15	−0·77	22	+1
Trincomalee	85·0	+1·3	75·4	+0·5	75	84	6·2	17·80	+3·82	17	−2
Vavuniya	87·2	—	72·2	—	75	93	6·4	10·79	−0·76	19	+1

DECEMBER, 1972

Station	Temperature F° Mean Max.	Off-set	Mean Min.	Off-set	Humidity Day	Night	Cloud Amount	Amount Inches	Rainfall Off-set	Rain Days	Off-set
Anuradhapura	85·3	+2·0	73.0	+2.7	77	93	4.8	6.19	−3.55	19	+2
Badulla	79·1	+2·5	65.7	+1.0	78	92	6.0	14.96	+4.14	18	−2
Batticaloa	84·1	+2·1	76.3	+2.5	82	88	5.7	12.92	−4.0	15	−5
Colombo	87·3	+1·7	74.9	+2.5	74	88	5.4	6.44	−0.44	14	+2
Diyatalawa	73.4	+1·3	60.4	+1.5	81	94	6.2	7.39	−0.62	18	−2
Galle	85.3	+1·7	75.7	+2.3	73	86	5.4	4.10	−0.23	11	−3
Hambantota	85.6	+0·8	75.6	+2.4	77	86	5.6	2.95	−1.81	9	−3
Jaffna	83.2	+0·6	75.9	+2.6	78	86	6.0	6,45	−4.05	17	+3
Kandy	82.3	+0·6	68.1	+2.2	74	87	5.8	11.57	+3.28	17	+4
Kankesanturai	83.4	+0·5	75.9	+0.6	82	88	6.1	8.93	−1.32	18	+5
Katunayake	88.6	—	73.2	—	68	86	5.6	7.33	—	11	—
Kurunegala	86.8	+1·2	73.3	+2.5	75	93	5.8	7.59	+0.64	15	+1
Maha Illuppallama	85.8	+2·0	72.5	+2.7	73	88	5.5	6.61	—	17	—
Mannar	84.4	+1·8	76.6	+1.6	71	88	5.8	8.21	+0.24	17	+4
Nuwara Eliya	66.9	−0·8	53.2	+3.7	84	88	5.9	10.32	+2.81	19	+2
Puttalam	86.4	+1·5	74.0	+2.6	76	90	5.3	7.00	+0.96	15	+2
Ratmalana	87.6	+0·9	73.0	+1.0	70	88	5.6	7.63	—	15	—
Ratnapura	90.7	+2·6	72.4	+0.7	77	95	5.8	6.06	−2.35	14	−2
Trincomalee	83·5	+2·2	76·9	+1.7	78	82	5·8	10.23	−4·49	19	+1
Vavuniya	84.9	—	72.8	—	80	93	5.8	19.27	+8.35	21	+5

JANUARY, 1973

Station	Temperature F°				Humidity		Cloud	Rainfall			
	Mean Max.	Off-set	Mean Min.	Off-set	Day	Night	Cloud Amount	Amount inches	Off-set	Rain Days	Off-set
Anuradhapura	30·3	+1·7	20·3	-0·4	66	92	3·4	1	- 122	1	-11
Badulla	25·3	+0·7	16·7	-1·1	73	89	5·0	31	- 198	6	-11
Batticaloa	28·2	+0·7	23·4	+0·2	74	86	5·5	2	- 277	3	-13
Colombo	31·1	+0·8	22·4	+0·2	69	88	4·6	10	- 78	2	- 6
Diyatalawa	23·2	+1·1	13·2	-1·0	76	91	5·2	18	- 134	6	-11
Galle	29·3	+0·5	23·0	+0·2	72	86	5·4	36	- 77	7	- 4
Hambantota	30·0	+0·6	22·6	-0·1	70	83	5·5	78	- 23	6	- 3
Jaffna	29·6	+1·2	22·3	0	66	88	4·0	4	- 93	2	- 6
Kandy	29·4	+1·5	17·7	-0·6	62	86	4·9	4	- 115	3	- 5
Kankesanturai	29·5	+1·2	22·8	-1·1	68	84	3·4	0	- 82	0	- 6
Katunayake	32·7	—	21·2	—	56	83	4·3	1	—	2	—
Kurunegala	32·1	+1·8	20·6	-0·4	62	92	5·0	0	- 98	1	- 8
Maha Illuppallama	30·9	+2·0	19·8	-0·8	62	87	4·5	5	—	1	—
Mannar	29·8	+1·4	23·3	-0·3	70	88	4·3	1	- 86	3	- 5
Nuwara Eliya	22·1	2·2	8·6	-0·1	65	70	5·6	4	- 141	5	- 8
Puttalam	31·5	-1·7	20·9	-0·3	66	90	4·1	0	- 73	0	- 9
Ratmalana	31·0	+0·3	21·1	-0·9	65	87	5·2	0	—	0	—
Ratnapura	34·2	+2·3	21·3	-0·5	66	93	5·8	57	- 94	4	- 9
Trincomalee	28·4	+1·4	25·1	+0·9	67	72	5·0	1	- 210	1	-12
Vavuniya	29·8	—	19·8	—	68	92	4 2	21	- 118	3	- 7

FEBRUARY, 1973

Station	Temperature F°				Humidity		Cloud	Rainfall			
	Mean Max.	Off-set	Mean Min.	Off-set	Day	Night	Cloud Amount	Amount inches	Off-set	Rain Days	Off-set
Anuradhapura	32·4	+1·7	22·6	+1·9	64	93	2·9	5	- 49	2	- 4
Badulla	27·3	+1·2	18·3	+0·9	72	89	5·2	32	- 89	5	- 5
Batticaloa	29·3	+1·1	24·8	+1·6	78	88	4·4	44	- 134	7	- 3
Colombo	32·3	+1·7	23·9	+1·6	70	86	3·9	43	- 53	7	0
Diyatalawa	24·7	+0·8	15·0	+1·0	72	88	4·2	16	- 70	5	- 5
Galle	31·1	+1·6	23·8	+0·6	67	81	4·5	66	- 50	8	- 1
Hambantota	31·0	+1·1	24·2	+1·4	71	86	3·8	2	- 56	3	- 2
Jaffna	30·3	+0·5	23·9	+1·5	68	88	3·4	21	- 16	4	+ 1
Kandy	31·3	+1·7	19·7	+1·8	58	85	3·5	19	- 64	4	- 1
Kankesanturai	30·3	—	24·3	—	72	86	3·6	30	- 4	3	+ 1
Katunayake	34·3	—	22·8	—	57	84	2·8	51	- 6		
Kurunegala	34·7	+52·	22·3	+1·4	58	90	3·5	7	- 53	5	- 1
Maha Illuppallama	32·9	—	21·9	—	60	88	3·2	13	—	4	—
Mannar	31·1	+1·2	24·4	+1·1	69	86	3·0	17	- 17	4	+ 1
Nuwara Eliya	22·6	+1·7	10·2	+2·5	72	81	4·5	26	- 50	7	- 2
Puttalam	33·6	+2·3	22·7	+1·4	64	93	3·2	34	- 12	2	- 3
Ratmalana	32·3	—	23·2	—	63	81	4·3	17	—	3	—
Ratnapura	35·1	+2·0	22·4	+0·6	66	93	5·4	62	- 119	7	- 5
Trincomalee	29·8	+1·7	26·0	+1·7	69	74	4·4	11	- 84	3	- 3
Vavuniya	31·4	—	21·8	—	66	90	3·6	14	- 40	4	0

MARCH, 1973

Station	Temperature F°				Humidity		Cloud	Rainfall			
	Mean Max.	Offs-et	Mean Min.	Off-set	Day	Night	Amount	Amount	Off-set	Rain Days	Off-set
Anuradhapura	35·0	+1·8	23·2	+1·3	60	90	3·4	62·2	-36·6	4	- 3
Badulla	29·0	+0·9	18·3	+0·4	66	89	4·6	105·4	-4·6	13	+ 2
Batticaloa	30·3	+0·6	24·6	+0·7	75	88	4·3	109·2	+24·2	6	- 2
Colombo	32·5	+1·5	24·2	+0·9	71	88	4·6	110·7	-6·9	10	- 1
Diyatalawa	26·4	+0·9	15·0	+0·4	66	88	4·4	128·3	+ 6·9	10	- 2
Galle	30·8	+0·6	24·2	+0·3	68	12	5·1	213·9	+97·3	13	+ 2
Hambantota	31·9	+1·3	24·5	+0·9	70	84	5·0	35·8	-30·5	5	- 2
Jaffna	32·3	+0·7	24·8	+0·5	64	84	4·0	18·5	-11·5	1	- 2
Kandy	32·7	+1·6	19·9	+0·5	56	85	4·3	68·3	-51·8	9	+ 1
Kankesanturai	32·2	—	23·8	—	70	93	3·4	0	-24·6	0	- 2
Katunayake	33·8	—	23·0	—	60	84	3·8	187·2	—	12	—
Kurunegala	36·1	+2·3	23·0	+0·8	56	90	4·6	167·6	- 2·6	10	0
Maha Illuppallama	35·4	—	22·1	—	50	83	2·8	—	—		—
Mannar	32·8	+1·1	24·7	+0·6	68	86	3·4	47·0	+ 2·6	3	- 1
Nuwa ra Eliya	24·4	2·6	10·9	+3·0	61	78	4·4	32·8	-63·7	10	- 1
Puttalam	33·6	+1·3	23·2	+0·4	66	90	3·8	56·6	-19·3	7	0
Ratmalana	31·9	—	23·3	—	64	86	4·8	268·2	—	11	—
Ratnapura	34·8	+1·4	23·1	+0·6	69	93	6·1	311·4	+67·8	14	- 4
Trincomalee	31·3	+1·4	25·6	+0·8	67	80	3·9	30·0	-18·3	2	- 2
Vavuniya	34·3	—	22·4	—	57	90	4·0	13·5	-49·0	2	- 2