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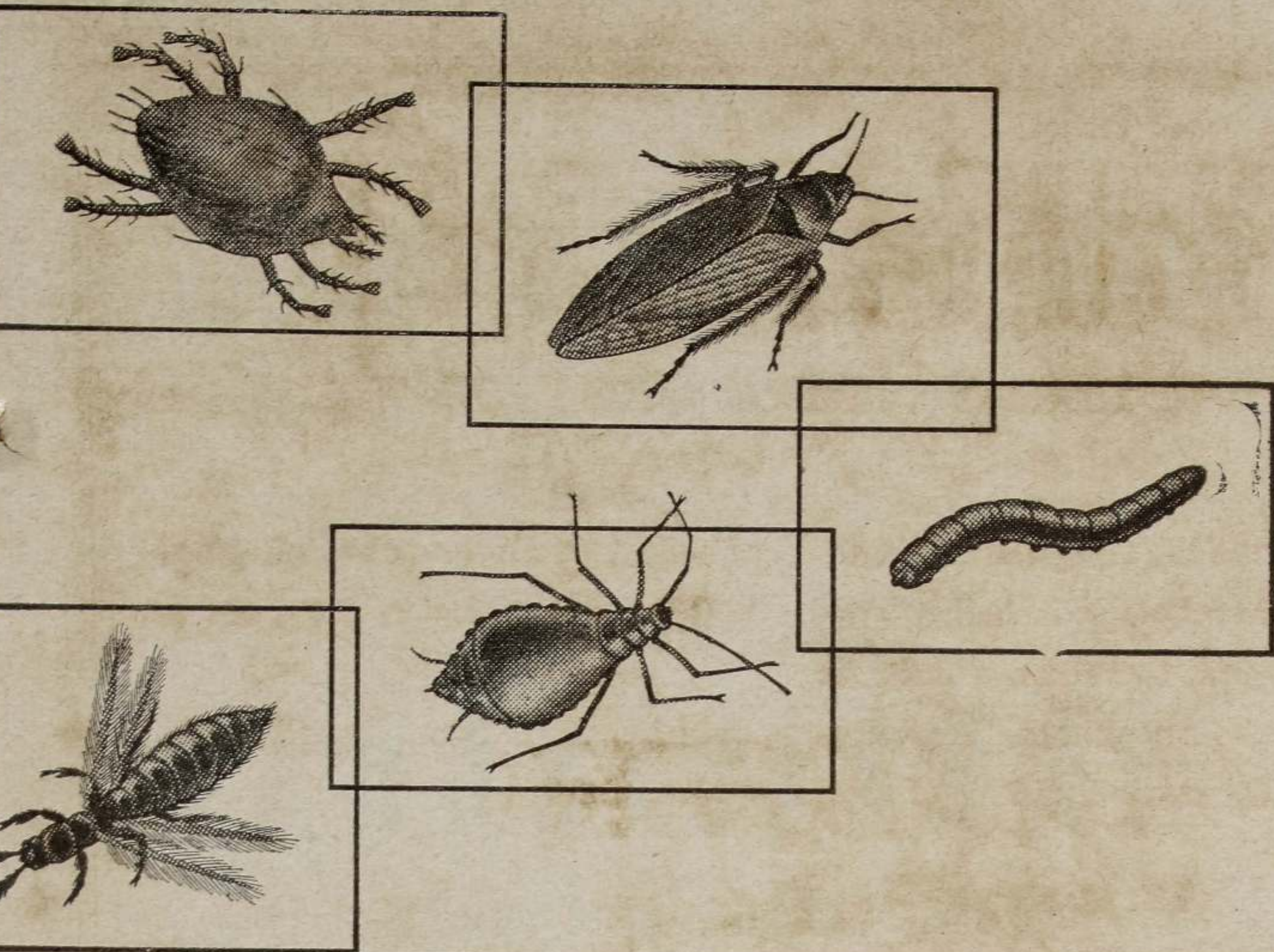

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EDITORIAL

Rice-Transplanters

THERE is little doubt about the virtues of transplanting rice. Transplanting allows extra time for field preparation, ensures adequate spacing between plants, induces tillering, and facilitates effective control of weeds, pests and diseases, all of which contribute to substantial yield increases. The Japanese who developed the technique popularly known as the "Japanese Method" of rice culture place particular emphasis on the value of transplanting seedlings in regular rows. In this method, seedlings raised in well-fertilized nurseries are transplanted in regular rows and heavily fertilized in split applications. Planting in rows permits the use of a rotary weeder to control weeds in the growing crop, and it also facilitates other operations such as fertilizer application and pest control.

In spite of its proven virtues, row-planting of rice seedlings has not made satisfactory headway in Ceylon. Transplanting rice is a traditional practice in the Matale, Kandy and Kegalla Districts of Ceylon, but the seedlings are seldom planted in regular rows. In these areas, transplanting is done mainly by women, and the work is carried out on a system of mutual assistance. In other parts of the country, however, transplanting is practised only to a very limited extent.

The comparatively quick acceptance of the practice of row-seeding rice, with the aid of mechanical devices, is perhaps a fairly accurate indication that the farmers' reluctance to adopting transplanting is chiefly due to its laborious back-breaking nature. Transplanting by hand consumes about 12 units of labour to complete an acre in a day. With unskilled labour the cost can be prohibitive, even if the labour is available. However, quite often there is a paucity of agricultural labour during the peak cultivation seasons in the major rice-growing areas.

With the rapid spread of rice varieties that show a marked response to transplanting and heavy fertilization, the need to popularise transplanting is becoming increasingly important. The H-4 variety of rice which has by its wide regional adaptability, resistance to disease, and high fertilizer response, become popular in Ceylon, has been found to give very high yields when transplanted at sufficiently wide spacing and fertilized heavily. H-4 is a "panicle number" type with a yield potential of 160 bushels per acre, and it apparently responds to transplanting by the production of an increased number of ear heads.

Transplanting of rice has been an established practice for centuries both in China and in Japan, where it is a manual operation done by peasants. Although the need for mechanising this operation has been felt in recent times, particularly in China where there is an acute need for deploying the labour to industrial projects, it had remained only a hope till Lin Tichiang, a Chinese research worker of peasant origin perfected the transplanter now known as Nan 105 B Type. This transplanter which can be drawn in the puddled field by a single bullock or by a small tractor, plants eight neat rows of seedlings in each trip. In China this transplanter is said to cost the equivalent of about Rs. 800. It requires two units of labour to operate and is capable of transplanting about 5 acres in a day.

Since 1956, over 90 different types of mechanical transplanters have been tested out in China and two other types, both hand operated, have shown great promise. Liling No. 2 and Kwangsi 59-3, as these two types are named, can be operated by one person and they are capable of planting about ½ acre and one acre respectively, in a day. In China they cost the equivalent of about Rs. 20 and Rs. 80 respectively.

All these three models were shipped from China as a magnificent gift from the government of the People's Republic of China to the people of Ceylon and were demonstrated with success recently at the Hingurakgoda Farm by a Chinese technician specially flown out for the purpose. The successful development of mechanical devices for transplanting rice seedlings in regular rows under puddled conditions is a significant advancement in the mechanization of rice culture. Rice-transplanters are labour and time saving devices which bid fair to revolutionise rice cultivation in Ceylon and substantially help in achieving self-sufficiency in the not too distant future.

CLIMATIC REGIONS OF CEYLON—I: ACCORDING TO THE KÖPPEN CLASSIFICATION

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(Lecturer in Geography, University of Ceylon)

INTRODUCTION

THE GREEKS must be credited with the earliest attempt to conceive of the concept of climate, as derived from the term *klima,* meaning "to incline". However, since then the term climate came to be used not in strict adherence to the original connotation but in respect of a wider significance. While "weather" may be vividly understood, in terms of the 'momentary state of the atmosphere', the term climate quite paradoxically must retain a sense of abstractness. It may be understood only in respect of time and space, involving also a composite idea. Numerous definitions have been suggested to rend clarity to the concept of climate. While in a broad sense, "the average state of the atmosphere" may denote climate, it is interesting to note that in the mid-ninteenth century work entitled *Kosmas,* "the term climate, taken in its general sense indicates all the changes in the atmosphere which sensibly affect our organs . . ." (Humboldt, 1844). By the beginning of the twentieth century the term is defined with more clarity, "by climate we mean the sum total of the meteorological phenomena that characterise the average condition of the atmosphere at any one place on the earth's surface . . . (it) is the sum total of the weather . . ." (Hann, 1903). Finally we may note the significance of the geographical aspect of climate "... climate has geographical extent; ... the interest of the geographer in climatology arises from the space variation and his system of climatic classifications are clumsy but effective ways of getting out of the difficulty of handling continuous variation in both time and space". (Hare, 1957.)

It must not be misunderstood that since considerations of climate involve some form of 'generalization', that it is of little value, since at no time will the weather of a place conform to the composite idea of climate. The Greeks in strict conformity to the original connotation of *klima* defined climatic 'regions' in respect of latitudinal extent. Hence the three great qualitatively defined climatic regions of the world—the Torrid, the Temperate and the Frigid—were eventually conferred some quantitative demarcating criteria by Supan. Temperature being the only aspect considered, these 'climatic regions' were in effect only 'temperature regions'. Subsequent attempts based on increasing observations of other climatic elements, particularly of temperature and precipitation, conceived of 'climatic homologues' or areas of similar climatic characteristics. As climatological statistics accumulated the geographer's interest was focussed on the recognizance of climatic regions over the earth. The more refined attempts at climatic classifications being attempts at simplification and generalization of statistical meteorology came to be essentially geographic in technique. Since climate is reflected by the soil and climax vegetation of a place, it came to be realized that the eocnomic consequences of climate would be expressed in respect of the agricultural potential of that place or 'climatic region'. Thus climatic classifications came to be expressed in terms of statistical values defining climatic 'regions'. A climatic classification *per se* while exemplifying refinements in the context of quantitative criteria, must nevertheless reflect qualitative characteristics as borne out by the biota complex of each climatic 'region'. In view of the above considerations and since climate is closely related to the agricultural potential of Ceylon, it need hardly be emphasized that a satisfactory demarcation of the climatic regions and the idea is more than justified. However, the attempt will first be made to demarcate the island into climatic regions on the basis of existing world-wide climatic classifications, the most noteworthy being those by Köppen and Thornthwaite. Eventually a 'new' but tentative climatic classification will be suggested and the island demarcated into climatic 'regions'.

THE KÖPPEN CLIMATIC CLASSIFICATION

The climatic classification devised by Wladirmir Köppen, a St. Petersburg-trained biologist, may rightly be considered the earliest comprehensive scheme suggested for this purpose. It was a bold attempt to provide for the first time an objective, quantitatively-determined classification. Köppen must also be credited for demonstrating the then not sufficiently understood relationship between the biota complex and the climate of a particular environment. Thus his climatic boundaries, while quantitatively determined were not merely an expression of convenient arrangement of meteorological statistics, but in effect reflected remarkable correlation with vegetation boundaries. Hence it is not strange that the Köppen classification shows strong resemblance to phytogeographical maps. One must also not forget that the Köppen classification is a unique attempt, to reduce the complex statistical data of meteorological elements, to a simple system of grouping, so that climatic regions on a world-wide basis may be represented by convenient yet easily remembered symbols. The objection, that the classification represents numerical complexity is not truly justified, in view of the tremendous amount of statistical data that have to be expressed in terms of symbols.

The Köppen classification as it appears today is far removed from his original scheme, envisaged in 1884 (Köppen, 1884). This classification based on temperature alone was however not much of an improvement upon the earlier Supan classification. Köppen recognized only three ' climates ', namely :—

I. Tropical over 20° C : Mean annual temperature.
  (*a*) all 12 months, e.g. Batavia.
  (*b*) sub-tropical 4-11 months.

II. Temperature 10°-20° C : Mean annual temperature.
  (*a*) warm summers (Rome).
  (*b*) cold winters (Paris).
  (*c*) (Messina).

III. Polar below 10° C : Mean annual temperature.

It is noteworthy that Köppen himself realized the shortcomings of his ' climatic regions ' and thus continued to revise his scheme for over half a century. In the next revised scheme appearing at the turn of the century (Köppen, 1900), the moisture factor was introduced ; this classification eventually appeared eighteen years later (Köppen, 1918). He also published (with Geiger), a wall map showing the world distribution of his climates. In the final form resembling that available today, Köppen's scheme appeared in *Grundiss der Klimakunde* (Köppen, 1931) and again in a more comprehensive form in the *Handbuch der Klimatologie* (Köppen and Geiger, 1936). Fully comprehensive representations of the classification appear in a number of English publications (James, 1943 ; Hauritz and Austin, 1944).

In the late nineteenth century there appeared an outstanding work dealing with a world-wide classification of vegetation (de Candolle, 1875), on a physiological basis. De Candolle recognized five major plant groups and designated them :—

A. Megatherms—high temperature and abundant moisture ;

B. Xerophytes—short hot season, tolerance of dryness ;

C. Mesotherms—moderate heat and moderate moisture ;

D. Microtherms—less heat and moisture ; tolerance of shorter summers and colder winters ;

E. Hekistotherms—polar zone beyond forest limits.

Köppen adopted the de Candolle scheme as the basis for his climatic classification, bearing in mind the pytogeographical role of climate. He provided quantitative criteria of temperature and moisture to define the boundaries introducing both the mean annual and the mean seasonal values. Thus, to briefly outline the Köppen classification :—

A. Rainy climates (Megathermal)—temperature of coldest month over 18°C (64.4°F) ; no winters (cool or cold season).

B. Dry climates (Xerophytic)—arid or semi-arid ; the distinction of this climate is in terms of 'precipitation effectiveness' which is determined by the use of formulae.

C. Humid climates (Mesothermal) with mild winters—temperature of coldest month less than 64.4°F, but warmer than 26.6°F (−3°C) ; warmest month above 50°F (10°C) ; short winters.

D. Humid climates (Microthermal) with severe winters—temperature of warmest month above 50°F, coldest month below 26.6°F ; severe long winter ; ground frozen for several months.

E. Polar climates (Hekistothermal)—no warm season ; warmest month temperature below 50°F.

These major climates are further sub-divided in terms of specific precipitation and temperature characteristics ; combinations of the various symbols designate climatic types. The merit of this classification is in its scientific character ; the use of distinctive quantitative criteria of climatic elements ; the use not only of average annuals, but also of seasonal considerations ; the use of vegetation as a basis for the choice of the climatic values ; the use of symbols to designate, simplify and effectively, the innumerable climatic types—a minimum of two and a maximum of four symbols for the designation of any climatic type. The modifications that were introduced are not to discredit the classification but to lend it more refinement, in terms of increasing data and verification of the limiting boundaries.

Only the A, B and C climates will be considered here, since the D and E climates do not occur in Ceylon. While the A and C climates occur in Ceylon, the B climate will also be discussed because ' dryness ' is an important consideration in the Island's climate.

The A climates are sub-divided on precipitation considerations :

f : precipitation of driest month is at least 2.4 inches (6 cm.) ;

m : short dry season exists but is compensated by heavy precipitation during the rest of the year ;

w : dry season exists, which is not compensated during the rest of the year ; dry season comes during the low-sun period of the hemisphere ;

w′ : used if the precipitation maximum is in the autumn of hemisphere ;

w″ : used if there are two distinct maxima of precipitation separated by two dry seasons ;

s : used when dry season comes during the high-sun period.

It must be noted that the distinction between m and w (w′, w″ and s) is made on the quantitative relationship between the precipitation of the driest month and the average annual precipitation. This involves a ' compensation ' principle and is derived from the equation :—

Am : $r_{dm} = 3.9 - R/25$.

where r_{dm} = precipitation of the driest month.

R = average annual precipitation.

To facilitate a simpler means of determining the assignment of Am or Aw, a special table based on the formula has been prepared by Kendall and is shown in Table V. It is thus seen from the table that a station with a driest month precipitation of zero (0) would be assigned the ' m ' characteristic provided the average annual precipitation is at least 98.5 inches. Correspondingly the w characteristic will be assigned if the compensation values are not fulfilled. A diagram has been prepared for this purpose (Fig. I).

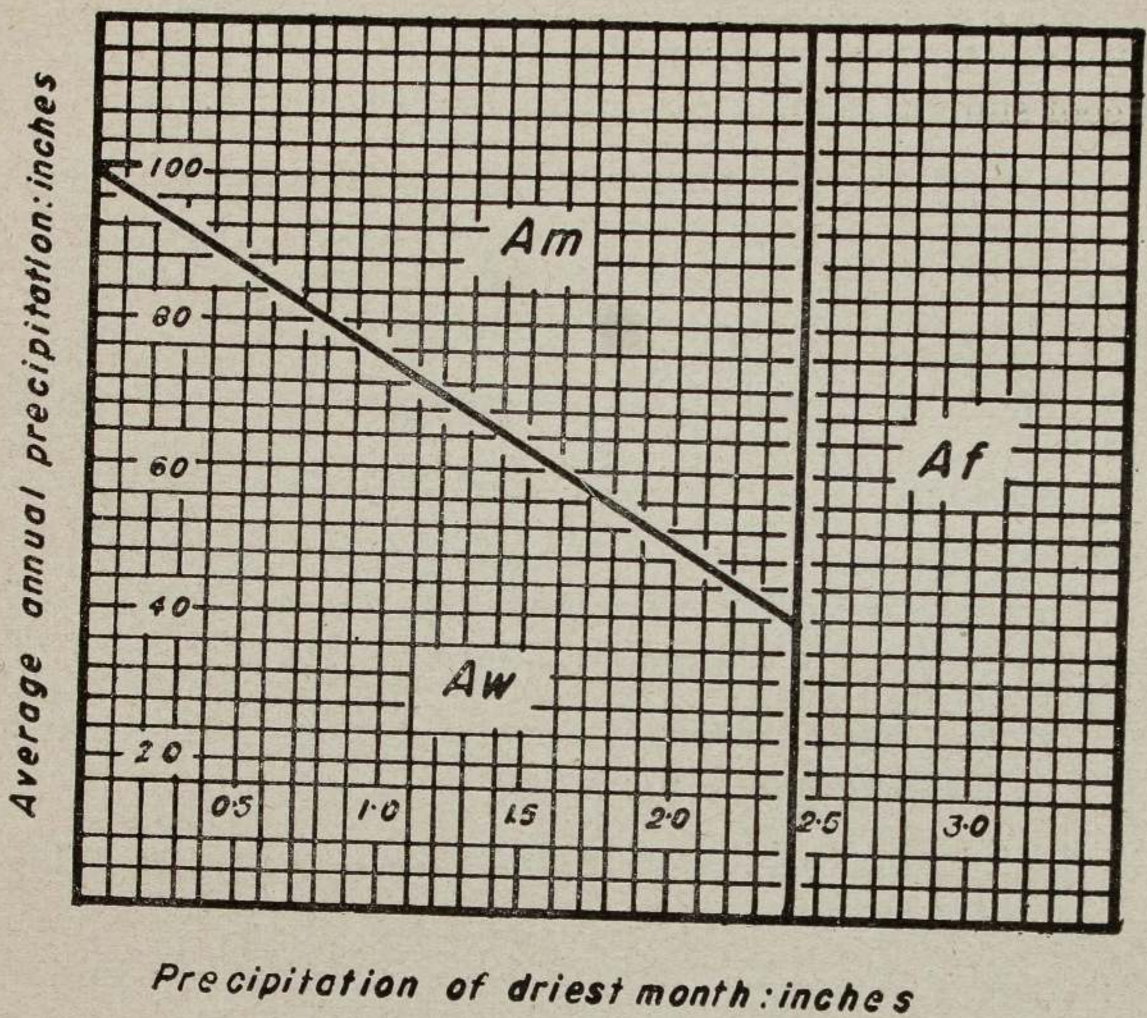

Fig. 1. Diagrammatic representation to illustrate the principle of compensation involved in the designation of the characteristics Af, Am and Aw according to the Köppen classification.

Further tertiary criteria have been provided in respect of the temperature factor. Thus :—

i=range of mean annual temperature less than 9°F ;
g=hottest month comes before the solstice.

THE C CLIMATES

In similar form the C climates may be assigned secondary characteristics in respect of precipitation and temperature. Thus :—

f : no dry season ; precipitation difference between driest and wettest months, less than that required for s or w ; if winter rain and summer drought, driest summer month receives more than 1.2 inches (3 cm.) ;

s : dry season in summer ; rainiest month of winter receives at least three times as much as driest month in summer ; driest summer month has less than 1.2 inches ;

w : dry season in winter ; rainiest summer month receives ten times as much as in driest winter month ;

a : hot summers ; temperature of warmest month over 71.6°F (22°C) ;

b : cool summers ; temperature of warmest month below 71.6°F ;

c : cool, short summers ; only 1-3 months above 50°F ;

i : temperature range (annual) less than 9°F ;

x : maximum rainfall in spring or early summer ;

s′ : maximum rainfall in autumn ;

n : frequent fogs.

It will be noticed that in both the A and C climates, the primary climatic assignment is based on temperature, while the secondary characteristics are based on precipitation ; the tertiary characteristics are again based on temperature values. It must further be pointed out that the same secondary letter f assigned to the A and C climates, while being similar qualitatively differs quantitatively. The driest month precipitation in respect of f in A climate is 2.4 inches, while the corresponding value for f in the C climate is only 1.2 inches, i.e. half the value under A climate. This could be explained in terms of " effectiveness " of precipitation. Thus the lower mean and seasonal temperatures of the C climate permits of lower precipitation to be " effective ", since evaporation is less than in the A climate. Similarly in respect of the distinction of the primary climatic criteria the guiding principle is that of " temperative efficiency " for vegetation.

THE B CLIMATES

The B climate stands out distinctly from the rest of the Köppen climates. It may be noted that the A, C, D and E are in effect ' humid ' climates. In other words, their primary characteristics are based on " temperature efficiency ", while the B climate is primarily defined on the basis of precipitation. Thus the designation ' Dry Climate ' with the vegetation complex being xerophytic. Hence the first step in assigning the Köppen climatic classification is to determine whether the station concerned exhibits characteristics of the Humid climates or the Dry climate. In view of the seasonal nature of precipitation incidence which thereby affect the " effectiveness " of precipitation three formulae are available. The B climate is again demarcated into the Dry or Semi-Arid (BS) and the Arid (BW) types. Thus the formulae are assigned under two bases, namely BS/H, i.e., Dry or

Humid and BW/BS, i.e., Arid or Semi-Arid. Thus if a station does not fulfil the criteria to be designated under the Humid climates, it is further analysed for assignment into the Arid (Desert) or the Semi-Arid (Steppe) climates (BW/BS) criteria.

In its original form the formulae were as follows:—

	BS/H	*BW/BS*
(*a*) Precipitation chiefly in summer	r = 2(t+14)	r′ = t+14
(*b*) Precipitation evenly distributed	r = 2(t+7)	r′ = t+7
(*c*) Precipitation chiefly in winter	r = 2t	r′ = t

r : annual average precipitation in centimeters.
t : mean annual temperature in °C.

The characteristics "chiefly in summer" and "chiefly in winter" denote a 70 per cent. incidence during the respective seasons.

The application of these formulae in terms of inches and °F have been made possible by consulting a special table prepared by Kendall (Tables VI and VII) based on the corresponding formulae devised by Meyer. Thus:—

	BS/H	*BW/BS*
(*a*) Precipitation chiefly in summer	r : ·44 (t—7)	r′ : ·22 (t—7)
(*b*) Precipitation evenly distributed	r : ·44 (t—19·5)	r′ : ·22 (t—19·5)
(*c*) Precipitation chiefly in winter	r : ·44 (t—32)	r′ : ·22 (t—32)

r = annual average precipitation in inches.
t = mean annual temperature in °F.

Two tertiary criteria are also available in respect of temperature distinctions, namely:—

h=hot desert or steppe: mean annual temperature 65°F.

k=cool desert or steppe: mean annual temperature 65°F.

Once again it is possible to note that the refinements of "precipitation effectiveness" and "temperature efficiency" are implied in the climatic criteria considered here. The characteristics 's' and 'w' may also be applied in respect of summer and winter 'dry season', respectively.

It is to Köppen's credit that despite numerous criticisms levelled at his classification, it continues to retain its position as a scheme that is studied and applied over and over again. Nevertheless this is not to discredit the many valid shortcomings pointed out by a number of climatologists. During his lifetime Köppen continued to modify and add refinements to his classification, in the light of more data and shortcomings revealed in the application of his system. There have been very valuable 'criticisms' in respect of the criteria of the demarcating boundaries of particularly the C/D climates and regional assignments of the BS/BW climates. Many of these are in effect 'refinements' adding to the value of Köppen's classification. It must be remembered that Köppen undertook to provide a climate classification of world-wide applicability. In this aspect alone one should expect inherent shortcomings that are inevitable. His task involved the reduction of a mass of climatic data to assimilable form so as to be represented by simple yet effective symbols. Though he did adopt de Candolle's vegetation classification as a base, yet he eventually provided substantive qualitative criteria to designate climatic types. These seemingly arbitrary values have on the whole proved to concord with the biota expression of climate. Köppen in selecting the physiological classification of de Candolle for his climatic base, departed from the approach of the ecologists, who were rather concerned with plant associations. During the period that Köppen revised his original 1884 classification he did have available a physiognomic classification of vegetation (Schimper, 1894) which however appeared almost two decades after de Candolle's classification. As pointed out by the most eminent of Köppen's critic (Thornthwaite, 1943) it was a pity that Köppen chose the physiologic in preference to the physiognomic classification. Though Köppen did not specifically use the terms, " temperature efficiency " and " precipitation effectiveness ", yet throughout his classification this theme is dominant. Perhaps of all the merits the two outstanding ones are (*a*) the objective perspective of his classification whereby climatic regions may be defined in exact quantitative terms and (*b*) the use of widely available climatic data of temperature and precipitation, which in manifold forms, may be used to define climatic boundaries. The primary, secondary and tertiary characteristics that have been used to designate climatic types, represent in their heirarchy of orders a remarkable. The heirarchy exemplified by the primary, secondary and tertiary characteristics of the Köppen classification represent in remarkable form, a symbolic description of the climates of the earth.

THE CLIMATES OF CEYLON ACCORDING TO KÖPPEN

The Available Data

While reliable precipitation data are readily available for a large number of rain-gauge stations in Ceylon, temperature data are confined to only sixteen (16) meteorological stations (*Figure 2; Table I*). It was found that in respect of precipitation records

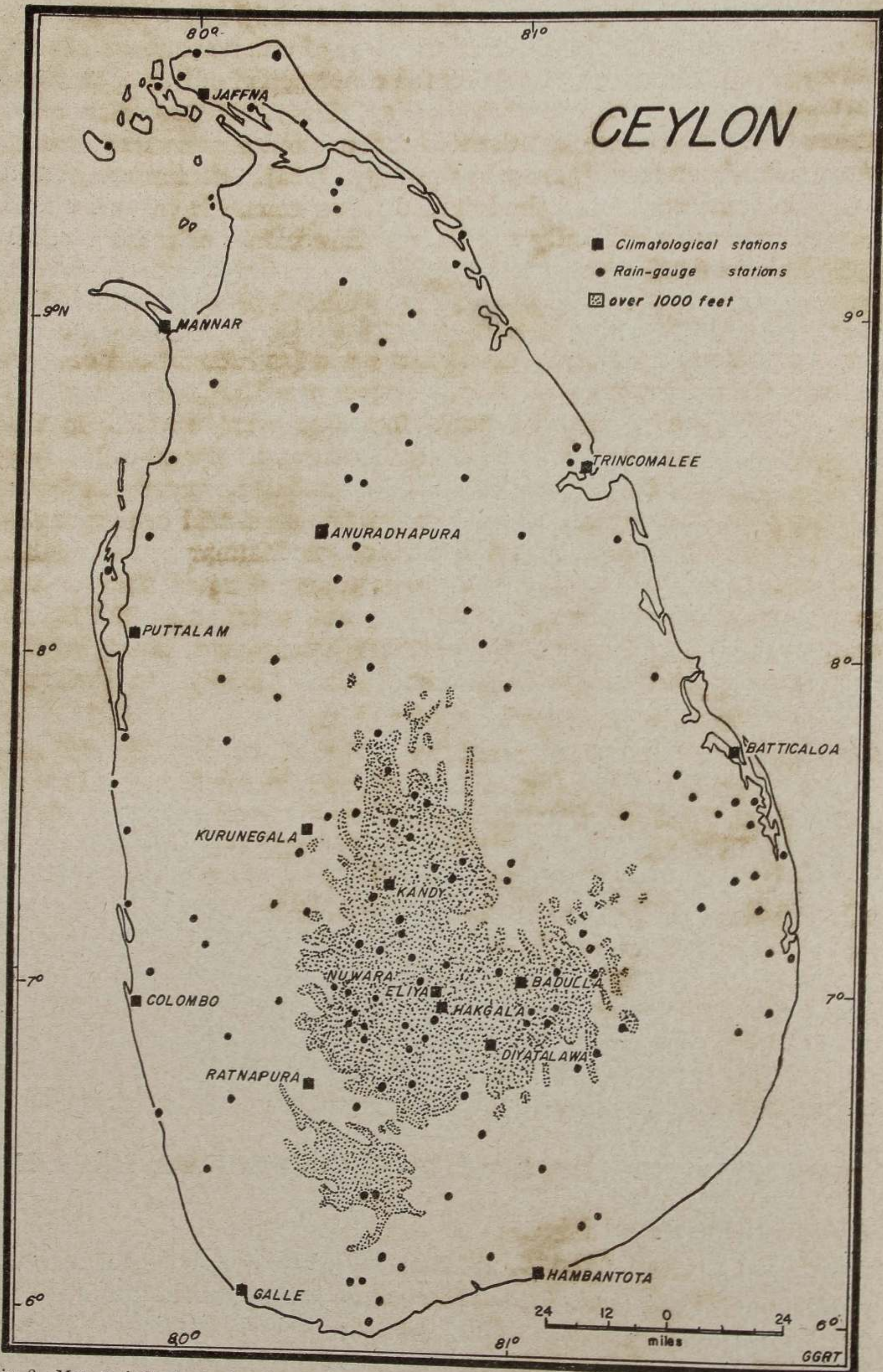

Fig. 2. Map to indicate the location of the main meteorological stations and the rain-gauge stations whose records have been consulted in the application of the Köppen classification to Ceylon.

covering the climatological Standard Period (1911-1940) for Ceylon, there are 177 rain-gauge stations (*Tables II, III and IV*) whose values could be used in this study. The derivation of temperature values for these stations was made possible by the construction of a temperature-elevation ratio chart (Thambyahpillay, 1955). It has also been demonstrated elsewhere that the 4000-foot contour represents a critical vegetation boundary (Thambyahpillay, 1952), demarcating the montane forest zone from the lowland forest zone. It was thus possible to determine carefully the temperature values of those stations located above 4,000 feet.

The B Climates of Ceylon (*Fig. 3 : Table III*)

The B climates may be considered first since (as brought out earlier) a strong distinction may be made between the Humid (H) and the Dry (BS/BW) climates. Köppen's formulae were applied to the precipitation records of all the stations located in the so-called Dry and Arid zones of the island. None of the stations however was found to qualify to be designated even the BS, i.e., semi-arid or steppe climatic type. Thus taking into consideration Mannar with reliable temperature and precipitation data, it may be noted that of the average annual precipitation of 39.74 inches, as much as 32.0 inches occur during the 'winter' of the northern hemisphere. Applying the corresponding formula, i.e., the BS/H 'chiefly in winter'

$$39.74 = .44\ (82.1—32)$$

it is seen that Mannar must be assigned to the Humid climates ! Only two other stations record precipitation lower than that of Mannar ; Silavaturai (37.50 inches) and Marichchukaddi (37.90 inches) both located in the Mannar environment. Though these stations do not record temperature it may be safely surmised that their temperature values will not be less than 80.0°F. Applying the corresponding formulae these stations will enjoy features of the humid climates. This aspect will be discussed at a later stage when considering the 'modifications' of the Koppen climate for Ceylon.

The C Climates of Ceylon (*Fig. 3 : Table IV*)

The C climatic regions may be considered next, since they constitute only small areas in the island. In strict conformity with station designations only two stations (Nuwara Eliya and Hakgala) would exhibit characteristics of the C climate. However, computed temperature values for stations over 4,000 feet seem to suggest a coincidence between the 5,000 foot contour and the C climate boundary. It is thus seen that in Ceylon (Fig. 3) the C climate would include the north-south trending Pidurutalagala-Horton Plains ridge and the western (up to Adam's Peak) and the eastern (up to and

Fig. 3. Map showing the climatic regions of Ceylon based on the original (1936) classification of Köppen.

including the Namunukula Range) extensions bordering the Southern Mountain Wall. The stations, Diyatalawa and Badulla, are thus excluded, since their temperatures exceed the stipulated coldest-month-value of 64.4°F. The Knuckles Range, of over 5,000 feet, would also be included under the C climate. The climatic regions would be designated Humid Mesothermal, since the stations Nuwara Eliya and Hakgala would qualify to be Cfbi in their characteristics. There is no 'dry' season (i.e., f) since no month receives less than 1.2 inches and summers are 'cool' since warmest-month-temperatures do not exceed 71.6°F. Both stations exhibit the tertiary 'i' characteristic, the mean annual temperature range not exceeding 9°F. The main vegetation associations correspond to the montane forest type.

The A Climates of Ceylon (*Fig. 3 : Table II*)

The rest of the island, therefore, would reflect the A climate characteristics. But in view of the marked seasonability of precipitation incidence in Ceylon, the A climate would be exemplified in terms of distinct 'regions'. At the outset it may be pointed out that all the stations exhibit 'isothermal' characteristics, i.e., the mean annual temperature range nowhere exceds 9°F.

A strict application of the Köppen criteria reveals the interesting fact that eight (8) 'types' and thirteen (13) 'regions' may be recognised under the category of the A climate :—

(i) **The Afi climatic region.** Two regions may be recognized :

(*a*) This region is confined to an area immediately to the west of the Cfbi region and the characteristics are clearly evident in the data pertaining to twelve stations, each of them with a driest month precipitation of not less than 2.4 inches. Most of the stations receive average annual precipitation of over 100 inches, with Watawala (218.5 inches) and Padupola (206.6 inches) representing the type stations. All stations reflect the single maximum during 'summer', i.e., southwest monsoon period ; the precipitation during this period constitute 40 to 60 per cent of the average annual value. The typical vegetation is the Tropical Rainy Forest. This area in fact forms the western flanks of the central Highlands and includes the Hatton plateau.

(*b*) This region forms the eastern counterpart of the Watawala-Hatton-Kandy-Pelmadulla climatic region. It exhibits a similar 'regime' pattern except for the opposite-seasonal feature ; the single maximum occurs during the 'winter', i.e., north-east monsoon period, the precipitation during this period amounting to over 75 per cent of the average annual value. St. Martin's (Rangala) represents the type station which receives 83 per cent of its annual total precipitation of 173.4 inches during the 'winter' season. The driest month receives 4.0 inches.

(ii) **Afw″ i climatic region**. This covers the whole of the south-west quadrant of the island except for the small Afi zone, mentioned before and the extension of the Cfbi zone. Heavy precipitation of over 90-200 inches occur annually, while the main contribution is from the SW Monsoon (May to September) 'summer' rains—over 40 per cent of the total; the rest is divided equally between the NE Monsoon and the convectional rains. The stations exhibit double maxima, the 'peaks' of precipitation occurring about April-June and October-November; while the contribution of the SW Monsoon is not to be neglected during the earlier 'peak', the effect of the convectional circulation during the near-equinoctial period is clearly in evidence. Galle, Ratnapura and other stations (*Table II*), though situated at varying distances from the coast, reflect the 'double maxima'. The vegetation, though still of the Tropical Rainy type, has marked differences from that in Afi.

(iii) **Amw ″i climatic region.** There are two distinctive areas:

(*a*) The first is a fairly large area, lying north of the Afw ″ i zone; its northward extension reflects the decreasing precipitation in that direction from the south-west. The annual precipitation is from 60-90 inches and the tendency for lower amounts during the SW Monsoon period and markedly higher amounts during the other months has increased; the double-maxima characteristic still prevails. The vegetation begins to include occasional deciduous trees among the evergreens; toward the northern border, this tendency increases.

(*b*) The second region is a small area located between the Afw ″i and the Asi region to the east. The only available station is Udukiriwila (*Table II*) and a northerly elongated region may be recognised with an average annual precipitation of between 50 and 75 inches. In effect this region forms almost a true boundary, separating the SW Monsoonal from the NE Monsoonal precipitation incident regions. In other words it demarcates the region with a westerly 'aspect' from that with an easterly 'aspect' (Asi region).

(iv) **Asw ″i climatic region.** The entire western part of the northern half of the island comes within this zone. The precipitation is low (35-60 inches), a slight double maxima; with one of the dry seasons more marked than the other prevail ; the two rain 'peaks' are due to the convectional and the NE Monsoon (the latter in the 'winter' season). The vegetation is characteristically deciduous, with the evergreens almost entirely absent ; in the north-west some xerophytic features prevail. Around Mannar and the central part of the Jaffna peninsula, only xerophytic vegetation occurs ; however, this is due perhaps more to edaphic factors (the underlying limestone) rather than to the climatic features. Reference will be made to this aspect at a later stage.

(v) **Asi climatic region.** There are two regions :

(*a*) The eastern half of the northern lowland has a slightly different climatic type from the western half (Aw ″si), mainly reflected by the single maximum rain 'peak' in 'winter' ; this of course is due to the strong NE Monsoon dominancy (50-60 per cent of the average annual precipitation of slightly over 60 inches). The 'dry season' rainfall is less marked than in the Aw ″si zone and the vegetation as a result does not reflect xerophytic characteristics to the degree shown in the western zone. Deciduous forest type prevails with occasional evergreens.

(*b*) A region around the Hambantota-Yala-Southern Platform (eastern part) exhibits climatic characteristics to warrant its being assigned to the Asi region ; low precipitation (average annual is just over 40 inches), and dry seasons during the high-sun period. However, to assign it to a similar climatic zone as that of the eastern part of northern lowland seems unjustified ; the marked 'winter' rains in the Trincomalee-Batticaloa zone and the dry seasons are significantly absent. But, in terms of the climatic classification adopted here, it has no other assignable type. The rainfall in this zone is comparable to that of the Aw ″si zone (43 inches) but it lacks the w″ character ; its vegetational type (xerophytic tendency) is also comparable.

(vi) **Ami climatic region.** In somewhat counterpart relationship to that of the Amw ″i is this zone ; covering a larger area, and extending west from the coast including the Uva Basin and the Dumbara Valley. This region reflects the effect of the NE Monsoon 'winter' rain dominancy as opposed to the SW monsoon 'summer' dominancy in the Amw ″i region. The total precipitation, however, is smaller because of the lesser moisture carrying capacity of the NE Monsoon, while the strong SW Monsoon as it spills over the Central Ridge is a dry wind which warms adiabatically in its descent to blow over this area as a fahn type wind and termed the *Kâchchān* (Thambyapillay, 1958). The vegetation exhibits more deciduous trees while the evergreens occur sparingly ; the 'dry' season from June to August, which comes during the high-sun period of the hemisphere, becomes marked enough to acquire a clear distinction.

(vii) **The Amw′i climatic region.** In the north-eastern part of the island may be recognized a climatic region reflecting unique characteristics. This region extending from the coast (north of Trincomalee and including the Mullaitivu-Pulmodai environment) southwards in an elongated form separates the Asw″i from the Asi region. The stations located in this region (Mullaitivi, Kanukkeni, Nedunkeni and Horowupotana) reflect strong monsoonal precipitation compensation, but derived particularly from the periodical incursions of tropical cyclones and 'disturbances'. In most years these stations have received nearly 40 per cent of their average annual precipitation from 'storms' occurring during the period October to December. However, on the average the precipitation regimes reveal an autumnal 'peak' and hence the assignment of the w′ characteristics.

SUGGESTIONS FOR A MODIFIED KÖPPEN CLASSIFICATION WITH SPECIAL REFERENCE TO ITS APPLICATION TO CEYLON

In the attempt in applying the Köppen classification to Ceylon it was observed that certain shortcomings were inherent in the quantitative criteria designating climatic types. While three major modifications may be suggested, a number of minor 'refinements' have also been incorporated and the results shown in Figure 4.

A/C boundary. First, with regards to the A/C boundary ; there is no doubt that montane vegetation in tropical latitudes exhibits features distinct from lowland Rainy Forest types, the former reflecting the effect of lower temperature. The 'below 64.4°F. coldest month temperature' represents the Köppen criterion for distinguishing the A/C boundary. According to the Oxford School of Forestry Studies, 70°F (average annual) seems to accord remarkably with the zone of contact between the 'montane' and the 'lowland' forest types. Other studies too have substantiated this temperature-vegetation relationship. Of course, the seasonal temperatures also should be taken into consideration, in suggesting new criteria to designate the climatic boundary between the montane and lowland vegetation, in the tropical latitudes. A case in point was revealed during the application of the Köppen criteria to Ceylon. Certain vegetation zones in the highland area,

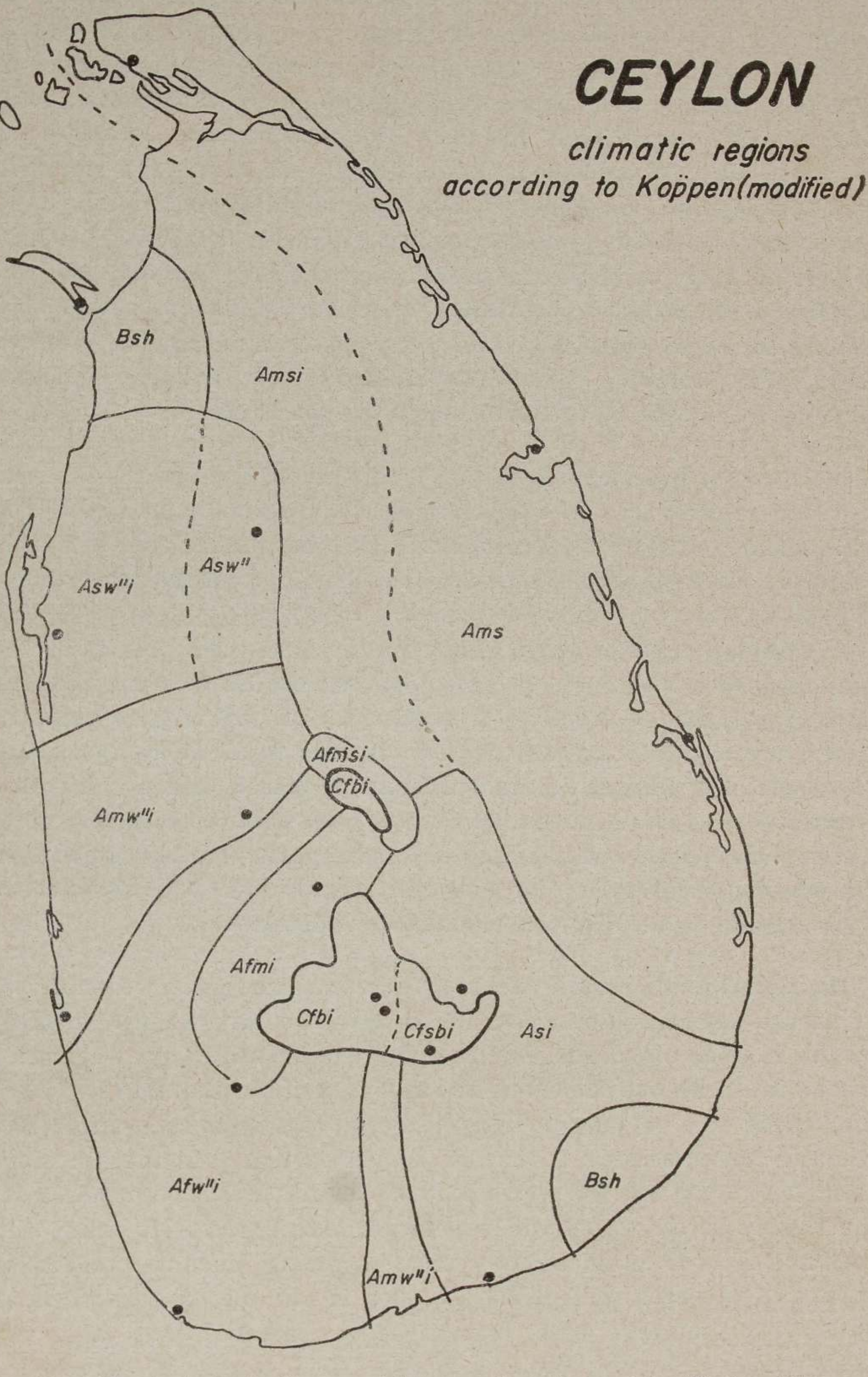

Fig. 4. Map showing the climatic regions of Ceylon according to the suggested modifications of the Köppen classification.

according to Köppen, fall under the A climates (*Fig. 3*) because no month exhibits less than 64.4°F, though the vegetation is of the montane type. Diyatalawa has an annual average temperature of 68°F, with three months below 66°F and one month with 64.4°F. Only three months' record over 70.4°F. The lack of more temperature records in the highland zone makes it difficult to compare this isotherm with other stations ; however, by a process of ' interpolation ' the 3,000 foot contour seems to coincide satisfactorily with the 70°F isotherm, as well as with the contact zone between the montane and lowland vegetation. According to the 64.4°F criterion, only areas above 6,000 feet can be categorized as C climatic types. Thus in modified form a larger area (including parts of the Hatton plateau and the Knuckles Range area) would be included under the C climate.

The Am/Aw boundary. A second modification suggested is that the Monsoon regimes in the tropical latitudes, especially in South-east Asia, have a strong ' opposite-seasonal ' orientation. The Am/Aw boundary criterion needs modification, as the compensatory values (*Table V*) does not prove satisfactory. The adoption of ' effective precipitation ' criteria would prove more satisfactory. Many of the stations with a high incidence of ' Monsoon tendency ' (contributing 40 to 60 per cent of the total precipitation) on the Köppen compensatory criterion, fall under the Aw climatic type. There must also be a method of indicating the dominant ' Monsoon season '. The only possibility of so doing under the present basis is in terms of the ' dry ' season during the ' low-sun ' period of the particular hemisphere. In the equatorial latitudes, the ' low-sun ' period has little significance with regards to the Köppen climatic consideration.

The Bsh climatic region (*Table III*). It was brought out earlier that no part of Ceylon could be considered ' Arid ' or even Semi-Arid (BS) by the Köppen standards. But from the standpoint of the vegetation climax in the Mannar zone and the area east of Hambantota it is clear that these two regions do exemplify at least the semi-arid (BS) climatic characteristics. It may be suggested that it is the limestone basement in the north-western part of Ceylon that is responsible for the thorny scrub-xerophytic vegetation associations. However, this does not seem to be an entirely valid argument since the vegetation climax of the area east of Hambantota is not the expression of an underlying limestone base. It may be remembered that these two areas are also known popularly as the ' Arid ' zones, in view of the low average annual precipitation. The vegetation climax of these regions therefore warrant the designation BShs; the last two characteristics indicate that the average annual temperature is over 64.4°F and the 'rainy' season comes during the 'winter' of the hemisphere.

In terms of Ceylon, therefore, minor modifications to the Köppen classification have been made, and a map prepared (Fig. 4) to compare with the one made using the Köppen classification (Fig. 3) in its strict sense. In making the above comment about the need for modifications to satisfy tropical areas, the writer is aware of the difficulty of fomulating world climatic classification, that would be applicable to all parts of the world with perfect satisfaction. There is no doubt that this classification still stands out with distinction in many respects in its application to tropical areas.

Four important 'refinements' are embodied in the map (*Fig. 4*):—

(*a*) The letter '1' according to the original Köppen criterion designates 'an annual temperature range of less than 9°F'. It is found that in Ceylon, all the climatological stations would, therefore, be assigned the '1' characteristic. However, from local considerations, it is revealed that the stations Jaffna, Anuradhapura, Batticaloa and Trincomalee exhibit annual ranges distinct from those revealed by the rest of the island; therefore, these stations must be distinguished from the others. It may be also brought out that unusually 'hot' periods are associated in Jaffna and Batticaloa with the prevalence of the föhn wind—the *Kâchchān* (Thambyahpillay, 1958). Furthermore these areas are also subjected to strong cold 'outbursts' from across the Bay of Bengal and the Indian mainland. The use of the letter '1' to designate 'annual temperature ranges less than 7°F' would satisfactorily bring this distinction out. Thus they would be designated :—

Trincomalee	..	Ams	Anuradhapura	..	Asw″
Batticaloa	..	Ams	Jaffna	..	Ams.

(*b*) Many of the stations according to the original Köppen assignments are designated Asw″ and Asi, e.g., Mannar, Batticaloa and Trincomalee; however these stations undoubtedly exhibit marked monsoonal characteristics. Using the Köppen compensation formulae, this monsoonal feature is not revealed (*Figure 3*). These stations in the north-eastern lowland have, therefore, been assigned to the Ams and Amsi climatic types (*Figure 4*). These stations also exhibit 'drought'

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conditions and thus warrant being assigned the letter 's' (to indicate 'dry' season during the 'high-sun' period). Thus the following stations have been assigned accordingly :—

Kurunegala	..	Amw″i
Batticaloa	..	Ams
Trincomalee	..	Ams

This monsoonal feature is also revealed by the station already designated Afi, e.g., St. Martin's estate, Rangala. According to the new assignment, this station has been designated Afmsi (*Figure 4*) since a 'by' season is also evident. Similarly the original Afi zone west of the Ctbi zone has been designated an afmi climate.

(*c*) The third modification is the one dealt with already, namely the inclusion of Diyatalawa within the C climate region. According to the original Köppen assignments, this station was assigned to the Ami type, thus not in the least indicative of the sub-Montane climatic characteristics of these environs. The biota as well are certainly not of the Tropical Rainy Forest type, but unmistakably those of Montane or at least sub-Montane characteristics. These stations are now assigned (*Figure 4*) the Cfsbi designation and which is justified.

(*d*) The two areas around Mannar and east of Hambantota have been assigned the BShs climate in consideration of the vegetation climax.

CONCLUSION

The application of the Köppen classification, both in its original as well as the 'modified' forms, serves to demonstrate clearly that the island of Ceylon, despite its relatively small areal extent, does exemplify a number of 'climates'. This is certainly in strong contrast to the common place demarcation of the island into the Wet, Dry and Arid zones. These latter climatic zones are in effect precipitation zones demarcated purely on convenient quantitative average annual values of 75 and 50 inches. Even discussions on soils, vegetation and land use continue to be dominated by the three-fold so-called climatic zones. Thus, the dry zone for example, which in fact is a climatic misnomer, has provoked innumerable investigations and reports; nevertheless the main characteristic underlying these studies is its climatic perspective. It is assumed that the whole areal extent of the dry zone is exemplified by a simple and single type of climate. The wet zone again is similarly considered in respect of its single climatic type. The maps embodied in this paper provide the absurdity of the single climatic perspective of these two zones. The Köppen classification, it was brought out earlier, makes use of two vital climatic vegetation expressions, namely the concepts of "temperature efficiency" and "precipitation effectiveness". These concepts have continued to dominate the many climatic classifications that have been formulated from time to time. In the Köppen scheme, this classification makes use of empirically derived equations justified eventually in terms of 'climatic indicators', i.e., vegetation associations. In the subsequent paper the Thornthwaite climatic classification will be applied to the island and finally on the basis of the results accruing from both these studies, and from the author's own investigations, a tentative classification will be suggested for Ceylon.

REFERENCES CITED

De Candolle, a, "Les Groupes Physiologiques dans le regne vegetal, *Rev. Scientifique,* Ser. 2, XVI (1875), pp. 364-372.

Hann, Julius, *Handbook of Meteorology.* transl. of *Handbuch der Kilmatologie.* (New York: Pitman, 1903), 437 pp.

Hare, F. K., "Dynamic Aspects of Climatology", *Geogr. Annaler,* vol. XXXIX (1957), p. 88.

Hauritz, B. and J. A. Austin, *Climatology* (New York: McGraw Hill, 1944), pp. 109-130 and pp. 135-156.

Humboldt, Alexander Von, *Kosmas.* transl. E. C. Otte (1844), vol. 1.

James, Preston, E., *An Outline of Geography* (New York: Ginn, 1943), pp. 370-379.

Köppen, W., "Die Warmezonen der Erde, nach der Dauer der heissen . . . Welt betrachtet", *Met Zeitschrift,* vol. 1 (1884), pp. 215-226.

————"Versuch einer Klassifikation der Klimate . . . Planzenwelt", *Geogr. Zeitschrift,* vol. 6 (1900), pp. 593-611.

————"Klassifikation fer Klimate nach Temperatur, Neiderschlag, und Jahreslauf", *Petermann's Mitteilungen,* vol. 64 (1918), pp. 193-203 and pp. 243-248.

————*Grundriss der Klimakunde* (Berlin, 1931).

————"Das Geographische System der Klimate", in vol. I, Part C of Köppen and Geiger: *Handbuch der Klimatologie* (Berlin: Gebruder Borntaeger, 1936).

SCHIMPER, A. F., "*Pflanzen—Geographie auf Physiologischer Grundlage* (1894) transl. into *Plant Geography* by P. Groom and B. Balfour (1903).

THAMBYAHPILLAY, GEORGE, *The Climates of Ceylon* (M. A. Thesis : University of California, U.S.A., 1952), 258 pp.

————"Ceylon and the World Climatic Mosaic", *University of Ceylon Review,* vol. XII, No. 1 (January, 1954), pp. 24-54.

————"The Thermal Factor in Ceylon's Climate", *Univ. Cey. Rev.,* vol. XIII, Nos. 2 and 3 (April-July, 1955), pp. 83-112.

————"The Kachchan : A Fohn Wind in Ceylon", *Weather* (Journal of the Royal Meteorological Society, U. K.), vol. XIII, No. 4 (April, 1958), pp. 107-114.

THORNTHWAITE, C. W., "The Climates of North America according to a New Classification", *Geog. Rev.,* XXI (Oct., 1931), pp. 633-655.

TABLE I—Meteorological Stations (Ceylon), their Climatic Characteristics and Climatic Assignment according to the Köppen Classification

Station	*Height above M. S. L. (feet)*	*Mean Annual Temperature (°F)*	*First Year of observation*	*Mean Annual Rainfall (inches)*	*First Year of observation*	*Köppen climate*
Anuradhapura	295	81·1	1881	56·98	1871	Asw″
Badulla	2225	73·6	1883	71·97	1870	Asi
Batticaloa	26	81·4	1881	68·95	1870	Ams
Colombo Obs.	24	80·5	1908	93·19	1908	Amw″i
Diyatalawa	4093	68·2	1901	65·65	1901	Cfsbi
Galle	70	79·8	1881	95·49	1869	Afw″i
Hakgala	5580	63·1	1884	99·96	1884	Cfbi
Hambantota	60	80·7	1881	43·24	1869	Asi
Jaffna	10	81·6	1881	53·08	1871	Ams
Kandy	1610	77·0	1881	86·84	1870	Afmi
Kurunegala	400	80·6	1887	84·67	1885	Amw″i
Mannar	10	82·1	1881	39·76	1871	Bsh
Nuwara Eliya	6170	59·4	1881	90·47	1869	Cfbi
Puttalam	10	81·0	1881	44·29	1869	Asw″i
Ratnapura	130	80·8	1881	173·59	1869	Afmi
Trincomalee	30	82·1	1881	64·80	1870	Ams

TABLE II—Primary Rain-Gauge Stations (Ceylon) assigned the A climate according to the Köppen Classification

No.	*Station*	*Height (feet) above M. S. L.*	*Year of first Observation*	*Mean annual Rainfall (inches) 1911-1940*	*Köppen climate*
1	Alagalla	1060	1911	103·0	Afmi
2	Allai Tank	20	1876	67·6	Ams
3	Aluthnuwara	300	1900	87·2	Asi
4	Ambanpitiya	660	1872	111·4	Amw″i
5	Amparai Tank	90	1876	72·4	Ams
6	Andankulam Tank	40	1871	67·3	Ams
7	Anninkande Es., Deniyaya	1550	1878	137·9	Afw″i
8	Aranayake	1000	1906	99·1	Afmi
9	Avissawella Es.	250	1898	151·1	Afw″i
10	Avissawella Hospital	100	1871	159·9	Afw″i
11	Baddegama Es.	50	1909	131·5	Afw″i
12	Batalagoda Tank	420	1896	77·1	Amw″i
13	Battulu Oya	20	1911	52·6	Asw″i
14	Beausejour Es., Nakiadeniya	200	1902	146·0	Afw″i

No.	*Station*	*Height (feet) above M. S. L.*	*Year of first Observation*	*Mean annual Rainfall (inches) 1911-1940*	*Köppen climate*
15	Berna Es., Narammala	250	1911	76·7	Amw″i
16	Bibile	790	1900	82·8	Asi
17	Buttala	510	1896	66·2	Asi
18	Chadaiyantalavai	60	1878	70·8	Ams
19	Chavakchcheri	20	1894	56·7	Ams
20	Chilaw	10	1910	55·5	Amw″i
21	Colombo (Fort*)		1870	79·2	Amw″i
22	Colombo (Maligakande)	70	1894	94·3	Amw″i
23	Crystal Hill Es., Matale	1400	1882	84·6	Afw″i
24	Dambulla Hospital	400	1881	66·7	Amsi
25	Dandagamuwa	70	1903	70·9	Amw″i
26	Dandeniya Tank	160	1880	76·9	Afw″i
27	Delft	10	1911	43·2	Amsi
28	Delwita Es., Kurunegala	490	1898	87·1	Amw″i
29	Denegama Tank	290	1876	81·7	Afw″i
30	Gigalle Es., Dehiowita	400	1886	172·9	Afmi
31	Diwella Es., Kegalle	800	1910	108·6	Afmi
32	Diwulana Tank	140	1871	79·4	Ams
33	Dunedin Es., Yatiyantota	400	1883	164·6	Afw″i
34	Ellawella Tank	260	1891	83·2	Afw″i
35	Franklands Es., Veyangoda	100	1885	105·5	Amw″i
36	Gala Oya anicut	740	1910	90·1	Asi
37	Galewela	650	1905	70·1	Amsi
38	Galgamuwa Tank	300	1899	55·3	Asw″
39	Galphela Es., Wattegama	2300	1896	87·4	Afmi
40	Gammaduwa Es., Gammaduwa	2400	1876	114·7	Afmsi
41	Geekiyanakande Es., Neboda	350	1874	165·6	Afw″i
42	Hali Ela Tank	200	1872	97·6	Afw″i
43	Hambegamuwa Tank	500	1896	56·6	Asi
44	Heneratgoda	30	1891	102·4	Amw″i
45	Hiniduma	80	1909	178·5	Afw″i
46	Hiyare	340	1910	117·2	Afw″i
47	Horaborawewa	350	1910	73·4	Asi
48	Horakele Es.	50	1869	66·1	Amw″i
49	Horawupotana	210	1892	64·2	Ams
50	Irakkamam	40	1870	67·0	Ams
51	Iranaimadu Tank	100	1911	61·6	Ams
52	Jaffna College	10	1890	56·5	Ams
53	Kadukkamunai Tank	10	1909	67·3	Ams
54	Kalewewa Tank	470	1889	57·5	Amsi
55	Kalmuani	10	1878	63·1	Ams
56	Kalpitiya	10	1912	40·3	Asw″i
57	Kalutara (P. W. D.)	10	1871	112·5	Afw″i
58	Kanana Es., Bentota	30	1911	143·1	Afw′i
59	Kanangama Es., Dehiowita	200	1883	165·4	Afw″i
60	Kankesanturai (Hospital)	20	1895	50·9	Ams

No.	Station	*Height (feet) above M. S. L.*	*Year of first Observation*	*Mean annual Rainfall (inches) 1911-1940*	*Köppen climate*
61	Kantalai Tank	250	1876	69·8	Ams
62	Kanukkeni	100	1911	61·5	Ams
63	Katugastota	1500	1871	82·1	Afmi
64	Kayts	10	1901	50·3	Ams
65	Keenagaha Es., Balangoda	2100	1907	99·7	Afw″i
66	Kekenadure	160	1871	76·2	Afw″i
67	Kilinochchi	80	1905	60·3	Ams
68	Kirama	260	1875	93·5	Afw″i
69	Kosgolla	360	1905	70·3	Amw″i
70	Koslanda	2260	1897	94·9	Asi
71	Kumbukkan	600	1891	67·4	Asi
72	Kurunegala (P. W. D.)	400	1880	85·0	Amw″i
73	Labugama	380	1870	163·4	Afw″i
74	Madawachchiya	280	1891	56·4	Asw″
75	Magallewewa	180	1872	57·8	Amw″i
76	Maha Illupalama Tank	380	1905	58·4	Asw″
77	Maha Uswewa	180	1892	51·1	Asw″i
78	Mahawalatenne	1800	1894	78·8	Amw″i
79	Mamadola	60	1895	45·1	Asi
80	Manalputty Aar	20	1895	64·5	Ams
81	Mankulamt †	130	1892	61·0	Amsi
82	Maradankadawela	440	1889	64·6	Amsi
83	Mariawatte Es., Gampola	1600	1881	109·0	Afmi
84	Marichchukaddi	10	1894	37·0	Asw″i
85	Matale	1210	1873	81·2	Afw″i
86	Modagama	800	1907	83·7	Asi
87	Mediyawa Tank	20	1905	61·3	Amw″i
88	Mihintale	350	1884	59·0	Asw″
89	Minneriya	310	1899	74·0	Ams
90	Moneragala	700	1898	76·2	Asi
91	Morawake	300	1909	147·5	Afw″i
92	Mullaitivu	10	1871	61·9	Ams
93	Nachchaduwa Tank	400	1906	57·9	Asw″
94	Nedunkeni	120	1894	66·5	Ams
95	Negombo	10	1871	77·4	Amw″i
96	Orange Hill Es., Ragama	50	1885	98·7	Amw″i
97	Orwell Es., Gampola	1700	1898	114·0	Afmi
98	Padupola	1600	1871	206·6	Afmi

No.	Station	Height (feet) above M. S. L.	Year of first Observation	Mean annual Rainfall (inches) 1911-1940	Köppen climate
99	Pallai	20	1881	51·6	Ams
100	Palugaswewa Es.	40	1910	60·5	Amw″i
101	Panilkande Es., Deniyaya	1900	1897	138·1	Afw″i
102	Pathregalla Es., Pothuhera	550	1900	94·3	Afw″i
103	Pelmadulla	480	1871	129·7	Afw″i
104	Peradeniya (Gardens)	1540	1883	92·2	Afmi
105	Periyakulam Tank	50	1876	65·8	Ams
106	Point Pedro	20	1892	52·0	Ams
107	Pomparippu	20	1911	40·2	Asw″i
108	Pulukunavi	90	1908	67·3	Ams
109	Rajawela Es., Kandy	1500	1870	65·1	Afmi
110	Rayigam Es., Ingiriya	300	1897	169·6	Afw″i
111	Rotawewa Tank	30	1887	60·5	Ams
112	Rukam Kulam	80	1869	78·8	Ams
113	Sakamam Tank	40	1872	65·0	Ams
114	Sudupanawela	610	1910	76·6	Asi
115	Taldena	1100	1900	77·8	Asi
116	Tanamalwila	550	1898	51·1	Asi
117	Tangalle	70	1874	55·5	Amw″i
118	Thumpenkeni Tank	40	1902	68·4	Ams
119	Topawewa	200	1891	68·6	Ams
120	Udukiriwila	160	1872	60·9	Amw″i
121	Unichchai Tank	120	1901	81·7	Ams
122	Vaganeri	120	1901	71·7	Ams
123	Vavuniya	320	1885	61·0	Amsi
124	Vicarton Es., Matale	3250	1891	98·0	Afw″i
125	Viragoda	100	1910	72·6	Ams
126	Waragalande Es., Madulkele	2000	1903	91·0	Afmi
127	Wariapolle Es., Matale	1200	1886	80·6	Afw″i
128	Yatederiya Es., Undugoda	650	1888	152·6	Afmi

* *Observations from roof-level.*

† *Discontinued from September 1953.*

TABLE III—Primary Rain-Gauge Stations (Ceylon) assigned the B Climate according to the Koppen Classification

No.	Station	Height (feet) above M. S. L.	Year of first Observation	Mean annual Roinfall (inches) 1911-1940	
1	Mantota	20	1893	42·7	Bsh
2	Murunkan	50	1898	43·6	Bsh
3	Tissamaharama	80	1873	41·5	Bsh

TABLE IV.—Primary Rain-Gauge Stations (Ceylon) assigned the C Climate according to the Koppen Classification

No.	Station	Height (feet) above M.S.L.	Year of first Observation	Mean Annual Rainfall (inches) 1911-1940	Köppen climate
1	Abergeldie Es., Rozelle	3600	1884	162·6	Cfbi
2	Annfield Es., Dickoya	4300	1888	111·5	Cfbi
3	Blair Athol Es., Dickoya	3740	1878	136·9	Cfbi
4	Caledonia Es., Lindula	4270	1881	91·7	Cfbi
5	Campion Es., Bogawantalawa	5000	1887	97·1	Cfbi
6	Dooroomadella Es.	3300	1904	144·5	Cfbi
7	Boragalla Es., Pussellawa	4400	1908	140·0	Cfbi
8	Buckwari Es., Rangala	3300	1888	116·4	Cfbi
9	Dunsinane Es., Punduluoya	5040	1886	121·2	Cfbi
10	Gourakelle Es., Badulla	4200	1877	94·2	Cfsbi
11	Haputale	4880	1897	85·7	Cfsbi
12	Hatton	4140	1896	140·1	Cfbi
13	Helboda Es., Pussellawa	3490	1879	135·1	Cfbi
14	Holmwood Es., Agrapatana	5240	1881	103·7	Cfbi
15	Hope Es., Hewaheta	4600	1889	111·7	Cfbi
16	Kabaragalla Es., Maturata	4750	1885	125·8	Cfbi
17	Kobonella Es., Urugala	3300	1882	137·2	Cfbi
18	Kurundu Oya Es., Maturata	5150	1883	111·6	Cfbi
19	Labookele Es., Ramboda	5000	1886	143·1	Cfbi
20	Ledgerwatte Es., Badulla	4000	1894	116·3	Cfsbi
21	Lr. Spring Valley Es.	3650	1885	93·1	Cfsbi
22	Luccombe Es., Maskeliya	3600	1902	162·8	Cfbi
23	Lunugala Div., Bandarawela	4500	1911	108·9	Cfsbi
24	Mahadova Es., Madulkele	4500	1882	106·0	Cfsbi
25	Maskeliya	4200	1884	119·0	Cfbi
26	Maturata	3230	1906	90·2	Cfsbi
27	Meeriabedde Es., Koslanda	3600	1873	103·7	Cfsbi
28	Mousagalle Es.	4500	1880	102·6	Cfsbi
29	New Forest Es., Galaha	3500	1876	115·0	Cfbi
30	Norwood (New Valley)	3600	1871	Cfbi	
31	Ohiya	5820	1911	90·7	Cfsbi
32	Passara	2800	1900	85·8	Cfsbi
33	Patiagama Es., Deltota	3500	1908	109·0	Cfbi
34	Pussellawa	3000	1880	119·1	Cfbi
35	Sandringham Es., Agrapatana	5250	1881	86·0	Cfbi

No.	Station	Height (feet) above M.S.L.	Year of first Observation	Mean Annual Rainfall (inches) 1911-1940	Köppen climate
36	Sogama Es., Pussellawa	3500	1886	127·9	Cfbi
37	South Wanaraja Es., Dikoya	3700	1885	128·8	Cfbi
38	St. Martin's Es., Rangala	3800	1887	173·4	Cfbi
39	Udahena Es., Bandarawela	4500	1880	110·8	Cfsbi
40	Upper Ohiya Es., Ohiya	6000	1905	97·8	Cfsbi
41	Watagoda	4400	1911	121·1	Cfbi
42	Watawala	3260	1911	218·6	Cfbi
43	Welimade Gp., Welimade	3790	1911	60·3	Cfsbi
44	Woodside Es., Urugala	3000	1898	93·2	Cfbi
45	Yarrow Es., Pussellawa	3350	1883	117·3	Cfbi

TABLE V.—For the Determination of the AM/AW Boundary according to the Koppen Classification

Yearly Rainfall in Inches	Rainfall of Driest Month in Inches	Yearly Rainfall in Inches	Rainfall of Driest Month in Inches	Yearly Rainfall in Inches	Rainfall of Driest Month in Inches
39·5	2·36	59·5	1·56	79·5	·76
40	2·34	60	1·55	80	·74
40·5	2·32	60·5	1·53	80·5	·72
41	2·30	61	1·51	81	·70
41·5	2·29	61·5	1·48	81·5	·68
42	2·26	62	1·47	82	·66
42·5	2·24	62·5	1·45	82·5	·63
43	2·22	63	1·42	83	·61
43·5	2·20	63·5	1·41	83·5	·59
44	2·18	64	1·38	84	·58
44·5	2·16	64·5	1·36	84·5	·56
45	2·14	65	1·34	85	·54
45·5	2·12	65·5	1·33	85·5	·51
46	2·10	66	1·30	86	·50
46·5	2·08	66·5	1·28	86·5	·48
47	2·07	67	1·26	87	·46
47·5	2·04	67·5	1·24	87·5	·44
48	2·02	68	1·22	88	·42
48·5	2·00	68·5	1·20	88·5	·40
49	1·98	69	1·18	89	·37
49·5	1·96	69·5	1·15	89·5	·36
50	1·84	70	1·13	90	·34
50·5	1·92	70·5	1·11	90·5	·32

Yearly Rainfall in Inches	Rainfall of Driest Month in Inches	Yearly Rainfall in Inches	Rainfall of Driest Month in Inches	Yearly Rainfall in Inches	Rainfall of Driest Month in Inches
51	1·90	71	1·10	91	·29
51·5	1·88	71·5	1·08	91·5	·28
52	1·86	72	1·06	92	·26
52·5	1·85	72·5	1·03	92·5	·24
53	1·82	73	1·02	93	·22
53·5	1·80	73·5	1·00	93·5	·20
54	1·78	74	·98	94	·18
54·5	1·77	74·5	·96	94·5	·16
55	1·75	75	·94	95	·14
55·5	1·73	75·5	·92	95·5	·11
56	1·70	76	·90	96	·09
56·5	1·68	76·5	·88	96·5	·07
57	1·66	77	·86	97	·06
57·5	1·64	77·5	·84	97·5	·04
58	1·63	78	·81	98	·02
58·5	1·60	78·5	·80	98·5	·00
59	1·58	79	·78		

TABLE VI.—For the Determination of the BS/H Boundary according to the Koppen Classification

Average Annual Temperature (°F)	*At least 70 Per Cent in Winter*	*Even Distribution*	*At least 70 Per Cent. in Summer*
50	7·88	13·40	18·90
51	8·32	13·84	19·34
52	8·74	14·26	19·76
53	9·18	14·71	20·20
54	9·62	15·14	20·64
55	10·06	15·58	21·08
56	10·50	16·02	21·52
57	10·94	16·46	21·96
58	11·38	16·90	22·40
59	11·82	17·34	22·84
60	12·26	17·78	23·28
61	12·68	18·20	23·70
62	13·12	18·64	24·14
63	13·56	19·08	24·58
64	14·00	19·52	25·02
65	14·44	19·96	25·46
66	14·88	20·40	25·90
67	15·30	20·82	26·32

Average Annual Temperature (°F)	*At least 70 Per Cent in Winter*	*Even Distribution*	*At least 70 Per Cent in Summer*
68	15·74	21·26	26·76
69	16·18	21·70	27·20
70	16·62	22·14	27·64
71	17·06	22·58	28·08
72	17·50	23·02	28·52
73	17·94	23·46	28·96
74	18·38	23·90	29·40
75	18·82	24·34	29·84
76	19·24	24·76	30·26
77	19·68	25·20	30·70
78	20·12	25·64	31·14
79	20·56	26·08	32·08
80	21·00	26·52	32·08
81	21·44	26·96	32·46
82	21·88	27·40	32·90
83	22·30	27·82	33·32
84	22·74	28·26	33·76
84	23·18	28·70	34·20

TABLE VII.—For the Determination of the BW/BS Boundary according to the Koppen Classification

Average Annual Temperature (°F)	*At least 70 Per Cent. in Winter*	*Even Distribution*	*At least 70 Per Cent in Summer*
50	3·94	6·70	9·45
51	4·16	6·92	9·67
52	4·37	7·13	9·88
53	4·59	7·35	10·10
54	4·81	7·57	10·32
55	5·03	7·79	10·54
56	5·25	8·01	10·76
57	5·47	8·23	10·98
58	5·69	8·45	11·20
59	5·91	8·67	11·42
60	6·13	8·89	11·64
61	6·34	9·10	11·85
62	6·56	9·32	12·07
63	6·78	9·54	12·29
64	7·00	9·76	12·51
65	7·22	9·98	12·73
66	7·44	10·20	12·95
67	7·65	10·41	13·16
68	7·87	10·63	13·38
69	8·09	10·85	13·60
70	8·31	11·07	13·82
71	8·53	11·29	14·04

Average Annual Temperature (°F)	*At least 70 Per Cent. in Winter*	*Even Distribution*	*At least 70 Per Cent. in Summer*
72	8·75	11·51	14·26
73	8·97	11·73	14·48
74	9·19	11·95	14·70
75	9·41	12·17	14·92
76	9·62	12·38	15·13
77	9·84	12·60	15·35
78	10·06	12·82	15·57
79	10·28	13·04	15·79
80	10·50	13·26	16·01
81	10·72	13·48	16·23
82	10·94	13·70	16·45
83	11·15	13·91	16·66
84	11·37	14·13	16·88
85	11·59	14·35	17·10

STUDIES ON A LABORATORY METHOD OF TESTING SALINITY RESISTANCE IN RICE VARIETIES

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INTRODUCTION

BREEDING of salt resistant varieties of rice is an important problem in Ceylon. Before the initiation of a breeding program, however, it is necessary to have some measure of the resistance of the varieties to be improved.

The term 'salt resistant' can be expected to include two aspects, the physiological resistance of the plant against salt and the overall tolerance of the plant as shown by its performance under field conditions. For the purpose of breeding a salt resistant variety, both these aspects should be taken into consideration, and it would be very useful if resistance could be determined in the laboratory. This series of experiments was directed towards this purpose.

MATERIAL AND METHODS

In these experiments two groups of varieties were used :

(1) Varieties classified as 'salt resistant', but whose degree of resistance is unknown. These varieties are referred to as 'resistant varieties' in this paper.

(2) Varieties which have not been previously classified, and whose resistance to saline conditions was either in doubt or unknown. These varieties have been referred to as 'non-resistant' for the purposes of this paper.

Varieties belonging to both groups were grown in pots under normal conditions, without special fertilizer or manure. At the end of 40 days the plants were transferred into conical flasks with their roots immersed in water for 48 hours. Thereafter the water was replaced with saline solutions, the salt used being unrefined common salt (Nacl).

The plants were left with their roots immersed in saline solution for a definite number of days after which the evaluation of resistance was made by grouping the plants according to the damage caused. The damage was first observed in the rolling up of the leaf tips, followed by rolling up of the entire leafblade, yellowing, and wilting of the entire plant. On observations made the degree of damage was rated between 0 (least damaged) and 5 (most damaged).

EXPERIMENTAL RESULTS

Experiment 1

Four concentrations of saline solution were used, viz. 0 per cent, 5 per cent, 10 per cent and 20 per cent. It was observed that all concentrations between 5 per cent and 20 per cent were too high to discriminate between the resistant and non-resistant varieties.

Experiment 2

Seedlings were treated with 0, 1, 2, and 4 per cent saline. Plants placed in 4 per cent and 2 per cent were too severely damaged for discrimination. Seedlings in 1 per cent solution showed less severe damage, which varied in the range of material tested.

Experiment 3

Seedlings were treated with 0 per cent, 0.5 per cent, 1 per cent, and 1.5 per cent saline and the evaluation of damage caused was made 2 days and 7 days after treatment.

The analysis of data obtained in this experiment is as follows :—

(1) Table 1 presents the correlation coefficients between the records of the 1st evaluation on the third day and that of the second evaluation on the eighth day.

TABLE 1.—Correlation Co-efficient between the 1st and the 2nd Evaluation

	Degrees of Freedom	*Percentage salt in solutions*		
		0·5%	*1%*	*1·5%*
r	26	0·6390**	0·7131**	0·5581**

***Significant at 1 per cent level.*

From Table 1 it is clear that the correlation between the 1st and 2nd evaluation was closest with the 1 per cent solution of salt.

(2) Each set of records was tested in order to determine the relationship to the previous classification of the salt resistant varieties used. The result is presented in Tables 2 and 3. Where very low frequencies were involved, Yates' correction was applied.

TABLE 2.—Contingency Table (1% salt solution)

	First evaluation			Second evaluation		
	Damage		*Total*	*Damage*		*Total*
	0·3	*4–5*		*0–2*	*3–5*	
'Resistant'	10	2	12	10	2	12
'Non-resistant'	4	12	16	2	14	16
Total	14	14	28	12	16	28
X^2			7·1458			11·300e

TABLE 3.—Application of the Chi-Square test to the results of Experiment 3 in relation to the previous classification of resistance

		Salt solution		
		0·5%	*1·0 %*	*1·5%*
1st Evaluation	X^2	1·8046	7·1458	1·6072
	Probability	10–0·20	< 0·01	0·20–0·50
2nd Evaluation	X^2	2·0255	11·3000	5·0286
	Probability	0·10–0·20	<0·01	0·02–0·05

According to Table 2 the most reliable evaluation of resistance was obtained using 1 per cent salt solution. Higher values of Chi-Square obtained from the 2nd evaluation, suggest that eighth day evaluation is superior to third day evaluation. Generally the 'salt-resistant' group showed less severe damage than the non-resistant group.

Statistical Analysis of Full Data

Data obtained in the second and third experiments included the treatments 0.5 per cent, 1 per cent, 1.5 per cent, 2 per cent, and 4 per cent. Separate analyses of variance were made of the data obtained from these treatments and of the data obtained using the treatments 1 per cent and 1.5 per cent in Experiments 2 and 3.

From these analyses repeatability of the records was estimated by the method of intraclass correlation and Chi-Square analysis on the relationship between the degree of damage and the 'salt-resistance'. The results are presented in Table 4.

TABLE 4.—**Analysis of variance of full data, estimation of repeatability, and independency test (with previous classification of salt-resistance)**

	Full data including salt solutions of concentrations	
	0·5%–4%	*1%–1·5%*
Number of Experiments involved ..	6 ..	3

Analysis of variance

Source	*D. F.*	*M. S.*	*D. F.*	*M. S.*
Blocks ..	.. 5 ..		.. 2	
Varieties ..	.. 27 ..	5·4189**	.. 27	3·9660**
Res. vs. N. R. ..	.. 1 ..	70·5009**	.. 1	56·1944**
Wn. resistant ..	.. 11 ..	2·0745*	.. 11	1·3005
Wn. N. R. ..	.. 15 ..	3·5326**	.. 15	2·4389**
Error ..	.. 135 ..	0·8845	.. 54	0·8700

*, ** *exceed 5 per cent and 1 per cent points respectively.*

Estimated components of variance and repeatability values

Error variance ..	.. (SE^2)	0·8845	.. 0·8700
Variance due to varietal difference	.. (SV^2)	0·7687	.. 1·0320
Bepeatability ..	.. (R)	0·4607	.. 0·5426

Chi-Square Analysis

2 ..	.. 5·53	.. 9·72
Probability ..	.. 0·01–0·02	.. $<$0·01

It was observed that—

(1) Varietal differences in response were distinct.

(2) The salt-resistant variety group differed significantly from the non-resistant group.

(3) Differences between varieties within the resistant variety group were not always significant.

(4) Differences between varieties within the 'non-resistant' group were highly significant.

(5) Repeatability values indicate that evaluation after treatment with a 1 or 1.5 per cent. salt solution is more accurate than evaluation made in 4 per cent. (high concentration) or 0.5 per cent (lower concentration).

(6) Degree of damage observed in 1-1.5 per cent solution showed better agreement with the previous classification than that observed in 4, 2, or 0.5 per cent. solutions.

The evaluation of the 28 varieties used, on damage caused by saline solutions (1 per cent and 1.5 per cent.) on the basis of these experiments is shown in Table 5.

TABLE 5.—Classification of Varieties used according to experimental data

	Degree of damage				
	1	*2*	*3*	*4*	*5*
'Resistant'	Hom 504 Gido 142 Giongian Gitrang 131 Temlop Tamgiam Kagga	Bile Kagga Kallurundai Perum Karuppan Uvar Vellai	Uvar Karuppan		
'Non-resistant'		MYAC 104 H-106 NYAC 12 M-104	M. S. 3081 H 501 Sulai 27614 Perillanel 26014	H-4 H-5 H-105 M-302 M-201 Sulai 301	M-3 H-102

CONCLUSION

In this series of experiments our primary aim was to suggest a method of evaluating the saline resistance of rice varieties in the laboratory.

Both varieties of known resistance, and unknown resistance were used.

From the results of experiments we concluded that there is a correlation between degree of damage in 1 per cent. salt solution and saline resistance of varieties.

Evaluation made on the eighth day after commencement of the experiment is more reliable than that made on the third day.

Varietal differences caused by immersion of the root system in solutions of salt was very apparent, 'salt-resistant' varieties showing a higher degree of tolerance than those in the 'non-resistant' group.

The classification of 'salt-resistant' varieties on the basis of these experiments agreed with their previous classification.

METHOD OF BREEDING OF COCONUT PALMS

A Comment on "The Improvement of the Coconut Palm by Breeding and Selection" of Dr. S. C. Harland

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DR. S. C. HARLAND has extended a comprehensive discussion on the method of breeding of the coconut palm, suggesting a number of research problems to be conducted in relation to the improvement of the plant (Harland, 1957). Among them, is the use of the paired crosses for the purpose of selecting genetical high yielders. He recommends it in place of the selection of phenotypically superior mother plants in a coconut palm population. The ground for this argument is that the data collected by the Coconut Research Institute of Ceylon show that there are no significant differences in yield of progenies whether they are derived from selected high-yielding or low-yielding mother palms. He concludes that " high yield is not transmitted by a mixed group of offspring from high yielding mother palms exposed to natural crossing ".

It will be a matter of vital importance to the coconut breeders, whether the selection of mother palms on the basis of phenotypic characters should really be replaced by the paired crossings. That is because the paired cross method recommended by Harland would require a great deal of labour and, in addition, they would have to wait another ten or more years for the detection of genetical high yielders.

In 1958, I had an opportunity to visit the Coconut Research Institute of Ceylon. Then I went through the original data and found that Harland's understanding was not correct because of the two reasons to follow :

(1) The data actually show that the yield of progeny of the " high-yielding " mother palms was not much different from that of the " low-yielding " ones. However, the " high-yielding " mother palms and the " low-yielding " ones were not selected from the same population. The selection for high yield had been made in an estate at Kirimetiyana, while that for low yield in another estate at Bandirippuwa. Perhaps, if Harland was aware of this, he would never have drawn the conclusion as he did. It would be needless to say that the effect of selection cannot be compared, if it was made in different populations.

(2) Most of those palms which have been evaluated as low yielders at the time of selection were later found to be not really low-yielding. Yield of those plants was not low in comparison with other remaining plants of the same population in later years. It means that selection for low yield had never been actually made.

That Harland unfortunately misinterpreted the selection experiment of the Coconut Research Institute of Ceylon can be shown by the following data which show comparatively the yield of nuts of progenies of high yielding mother palms and selected heap-nut from the same estate (Table 1).

Table 1—Mean Yield per Palm per Year of Progenies of Selected High-yielding Palms and Heap-nuts

(*Unpublished data of Coconut Research Institute of Ceylon, kindly supplied by Dr. D. V. Liyanage*)

	11th to 14th year		*15th to 18th year*	
	Nuts	*Husked Nuts (lb.)*	*Nuts*	*Husked Nuts (lb.)*
Progenies of selected palms (A)	57·6	87·6	75·7	120·4
Progenies of heap nuts (B)	46·0	71·7	64·1	107·6
Percentage increase of (A) over (B)	25·2	22·2	18·1	11·9

From Table 1, we find that selection of mother palms would not be ineffective in improving yield capacity of coconut palms. Then, what will be the effectiveness of mother palm selection for yield in coconuts and how to attain our aims of improving yield of the plant ?

Dr. Liyanage and I co-operated in re-examining the data from the progeny trials, which have accumulated for a number of years in the Coconut Research Institute of Ceylon. The details of this analysis will be published before long (Liyanage and Sakai, 1960), and it will be satisfactory to describe only the summarized results in this paper.

Four characters which are supposed to be more or less related to the yield of copra were investigated for their heritability and the genetic correlations amongst them. The four characters are : flowering-period, i.e. number of months from planting seedling to the appearance of first inflorescence, number of nuts and total weight of copra produced from a single tree per year, and weight of a husked-nut. Heritability values and genetic correlations are presented in Table 2.

Table 2—Heritability (in bold face) and Genetic Correlations (in italics) for Four Characters of the Coconut Palm

	Flowring period	*Number of Nuts**	*Total wt. of Copra**	*Nut weight**
Flowering-period	**0·23**	—	—	—
Number of nuts *	*—0·72*	**0·48**	—	—
Total weight of Copra	*—0·81*	*0·79*	**0·67**	—
Nut weight *	*—0·25*	*—0·22*	—	**0·95**

* *Averaye value of the harvests gathered during the four years, 16th to 19th years after planting.*

From Table 2, we find that weight of a husked-nut has the highest heritability, while the flowering-period the lowest of the four. Total weight of copra and number of nuts are intermediate regarding heritability. Needless to say, the number of nuts, total weight of copra or nut weight produced from a single plant may vary from year to year. Accordingly, heritability of the same character may vary according to different number of years involved in the study. The correlation between number of nuts harvested from a single plant in different years has been computed by means of the intra-class correlation. The correlation or the repeatability of number of nuts is,

$$r(a) = 0 \cdot 2179$$

$$r(b) = 0 \cdot 4605$$

where $r(a)$ stands for the repeatability of the actual number of nuts harvested each year, while $r(b)$ for the repeatability of number of nuts harvested, the effect of years on actual number of nuts, however, being removed.

Again from Table 2, we find that total weight of copra is positively highly correlated with the number of nuts and to some extent with the weight of a husked-nut but negatively highly correlated with the flowering-period. Thus, it is expected that the yield ot copra would be improved by selecting plants which bear either larger number of nuts or heavier nuts. Selection of palms in respect of early flowering might also bring about improvement in the yield capacity of their offspring. Selection of mother palms can also be conducted taking into consideration all of the four characters. In the latter case, construction of a selection index combining all the four characters in such a way as to make the correlation between the value of the index and the genotypic value of individual palm in respect of yield capacity maximum. The selection indexes worked out for the above population of the coconut palms for the improvement of the yield of copra are as follows :

$I(^{A}) = C - 1.07\ N - 38.38\ W - 0.23\ F$, for population A where C = yield (lb.) of copra, N = Number of nuts, W = weight (lb.) of a nut and F = flowering period (month). It is surprising to find that the weight factor for the number of nuts becomes negative in this formula, in spite of its high positive correlation with the yield of copra.

Now, let us compare the efficiency of selection of mother palms on different criteria. Assume that we select 5 per cent. of most superior individuals with regard to a given criterion in the population of the coconut palms with the purpose of improving yield of copra. The selection can be made for any one character : flowering-period, weight of a husked-nut, number of nuts and yield of copra. The selection index will be another criterion for mother palm selection. The genetic progress theoretically expected by these selections is presented in Table 3.

Table 3—Expected genetic progress in yield of Copra by selection of Seed parents on different criteria in Coconuts

Selection criteria of seed parents	*Genetic progress in yield of copra*
Weight of a husked-nut	16·0 lb.
Flowering-period	14·6
Number of nuts	21·7
Yield of copra	30·4
Selection index	42·6

It is found in Table 3, that the use of the selection index would be the most effective in improving the yield capacity of the coconut palm. Among the four single characters, the yield of copra would be most useful and weight of a husked-nut or the flowering-period the least for the purpose of the breeding.

Strictly speaking, values of heritability, as well as the extent of genetic correlation, should differ with changes in environmental conditions, such as locality, year, etc., and especially changes in the genetic constitution of populations. Therefore, it may not be quite correct to generalize on the results of this investigation and insist on their applicability to other countries, other populations, and so on. It is desirable that similar studies be made on different environments. However, a study of this kind will require a certain number of years, because it is necessary to grow families from a number of mother palms. On the assumption that genotype-environment interaction would be negligible, and the genetic constitution of different populations of the coconut palm would not be very different from each other, we may not be very wrong in accepting that selection could be conducted along the lines just mentioned.

As stated at the beginning of this paper, Harland recommended the use of the paired crosses for the purpose of detecting genetically high yielding seed parents. However, I have to state here that at least under the present circumstances, the improvement of the coconut palm in respect of yield of copra would be attained better by the selection of mother palms through the use of a selection index, than the use of paired crosses.

SUMMARY

Studies on heritability and genetic correlation of four characters, which are more or less related to yield capacity of coconut palms, suggest that selection of mother palms in an open-pollinated population would be effective. The selection on the basis of copra yield would be more effective than the selection on the basis of any one of other characters such as flowering-period, number of nuts or weight of a husked nut. Most effective would be the use of the selection index.

The method of paired crosses as recommended by S. C. Harland would not be very useful from the standpoint of practical coconut breeding, because it will require a great deal of labour and a certain number of years, say more than ten, for detecting genetical high yielders above.

LITERATURE CITED

Liyanage, D. V., and Sakai, K. I., (1960).—*Heritabilities of certain yield characters of the coconut palm. Jour. Genet.* (*In press*).

Harland, S. C., (1957).—*The improvement of the coconut palm by breeding and selection.* Bull. No. 15. Coconut Research Institute of Ceylon, 1-14.

PRELIMINARY STUDIES ON INFLUENCE OF STARTER SOLUTION AND BETA-INDOLE ACETIC ACID ON FURTHER GROWTH AND DEVELOPMENT OF ONION (ALLIUN CEPA, Linn.) TRANSPLANTS

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Application of starter solutions of the essential elements, given in the vicinity of the root system of transplants in a readily available form and in desired quantities are believed to reduce the shock and to stimulate the growth of young seedlings. Growth regulator treatments to transplants before setting in the field are also known to render beneficial effects on the plants. Fertilizers and growth substances are now regarded as essential aids to the increased production of commercial vegetable crops. This has led to intensive researches about the nature of responses of these fertilizers and growth substances.

Pearse (1948) and Anonymous (1949 and 1952) found that the application of nitrogenous fertilizers in irrigation water secured very good results. Sayre (1939) pointed out that nutrient solution, when applied to soil in immediate contact with roots, was entirely absorbed by the plants. Carrier and Snyder (1950), McCrory (1946) and Campbell (1958) stated the use of starter solutions in increasing vegetable production. Baker (1937) obtained increased yields with the addition of commercial P_2O_5 and mono-ammonium phosphate to the transplanting water.

Besides starters, synthetic plant growth regulators applied as solutions before transplanting also affect the growth of seedlings favourably. Laude (1941), Macht and Crumbein (1937) obtained encouraging results with the use of Indole-acetic acid on different crops. Amlong (1943), Mennum (1941) and Tureckaja (1948) obtained significantly higher yields by treating the roots of several vegetable crops with growth substance solutions prior to transplanting to the open ground.

Present investigation was, therefore, carried out to study the influence of starter solutions and beta-indole acetic acid on the growth and development of a popular bulb crop like onion (*Alliun cepa*, Linn.).

MATERIAL AND METHODS

The trial was laid out in a randomised design accommodating 24 plots with six treatments replicated four times. The following treatments were practised :—

(1) **Dung Starter :** Fifteen pounds of fresh cow-dung was mixed with ten gallons of water in an earthen container. The mixture was stirred daily for ten days, and then decanted and filtered through a coarse cloth to obtain a clear liquid. This filterate was diluted with tap water till it developed a light tea colour and kept ready for use (Treatment A.)

(2) **Chemical Starters :** Two chemical starters were prepared by dissolving (*a*) ammonium sulphate (1.5 lbs.) and potassium dihydrogen phosphate (2.2 lbs.) ; and (*b*) sodium nitrate (2.2 lbs.) separately in 35 gallons of water (Treatments B and C respectively). The solutions were thoroughly stirred before application.

(3) **Growth Regulator Solutions :** Two concentrations of indole-acetic acid viz., 10 and 20 parts per million (Treatments D and E respectively), were prepared in distilled water. Control plants (Treatment F) were supplied with tap water.

Treatment of Seedlings : Healthy and uniform-sized seedlings (40 days old) were uprooted from the nursery. The roots were thoroughly washed with tap water to remove the adhering soil. Roots of the two lots were immersed in 10 and 20 p.p.m. solutions of indole-acetic acid for four hours, prior to transplanting in the open field. Roots of the seedlings meant for other treatments were immersed in tap water for a similar duration. These seedlings were washed with water and transplanted on November 28 (at a distance of 9 inches in rows one foot apart) in randomly selected beds.

Respective starter solutions were applied around the root zone immediately after transplanting at the rate of one pint per plant. Control and regulator treated transplants were supplied with an equal amount of water.

Observations were started one month after transplanting. Height and number of leaves per plant were noted at ten days interval, while fresh and dry weight of leaves and bulbs were determined fortnightly.

EXPERIMENTAL FINDINGS

(*a*) **Maximum Height of Plants:** The height of the plants growing under the influence of different treatments varied considerably. Treated plants gave a superior response over the control (Table 1). From the very start of the initial observation, there was a steady increase in height of the treated plants, particularly the treatment B (Figs. 1—5). Treatment B produced a significantly superior height (61.97 cm.) as compared to others (except C). Control plants attained the minimum average height (52.97 cm.)

It is evident from the Table 1 that the period between 50 and 60 days after transplanting was the grand period of increase in height. A decline in height of plants was observed after 100 days of transplanting.

(*b*) **Average Number of Leaves per Plant:** Data regarding average number of leaves per plant under each treatment during the growing period are recorded in Table 2. In the beginning, there were 2 to 3 leaves per plant, but their number continued to increase and the ultimate average ranged between 9.35 and 14.72. The maximum number of leaves per plant was obtained under Treatment B, which appears significantly superior to all the treated and untreated ones.

(*c*) **Average Fresh Weight of Leaves Per Plant:** Leaves of twenty randomly uprooted plants from each treatment at successive stages of growth were weighed separately. The fresh weight of leaves varied markedly among the different treatments (Table 3).

All the treatments (except A) showed a significantly superior response over control. Green weight of leaves under treatment A is 83.5 per cent superior to that of control.

(*d*) **Average Dry Weight of Leaves:** Leaves taken for the fresh weight were dried and weighed for each treatment. It is clear from Table 4 that the highest dry weight of leaves was obtained under Treatment B.

(*e*) **Average Fresh Weight of Bulbs:** Bulbs from the twenty randomly uprooted plants were weighed at successive stages of growth (Table 5). Treated plants were significantly superior to control in this respect. A maximum increase in fresh weight of bulbs was noticed between 105 and 135 days after transplanting. Treatment B, here also, produced the best fresh weight.

This increase in percentage of fresh weight under Treatment B, 135 days after transplanting, was found to be 89.26 per cent (Fig. 6) superior to control.

(f) **Average Dry Weight of Bulbs**: The bulbs taken for fresh weight were dried and weighed separately as recorded in Table 5. Treatment B appears most outstanding in this regard as well, while control produced a minimum weight.

A clear and comparative assessment regarding the efficiency of the various treatments can be well had from Figs. 1—6. Fig. 1 depicts the pronounced difference caused in growth of transplants within one month after the initial treament. This initial progress was maintained with respect to height of plants, number of leaves, fresh and dry weight of leaves and bulbs per plant throughout the period of investigation. In the end (Fig. 6) 135 days after transplanting, Treatment B produced the most outstanding and beneficial results.

SUMMARY

The present investigation was carried out to study the possibilities of the use of different starer solutions (dung) ; Ammonium-sulphate mixed with Pot. dihydrogen phosphate, and sodium nitrate ; and 10 and 20 parts per million solutions of indole-acetic acid on the growth and yield of onion. Transplants were treated with regulator solutions for four hours before setting in the field, while starter solutions were applied in the vicinity of roots immediately after transplanting. The treated plants obtained a superior growth and yield than untreated ones. Ammonium sulphate mixed with potassium dihydrogen phosphate applied as starter solution was responsible for maximum increase in the fresh weight of leaves and bulbs (83.5 per cent and 89.26 per cent respectively) over control. Control plants obtained the minimum averages in all respects.

ACKNOWLEDGMENT

The authors take this opportunity to express their grateful thanks to Dr. R. K. Tandon, Principal, Government Agricultural College, Kanpur, for his keen interest and encouragement in the work.

REFERENCES

1. AMLONG, H. U. 1943.—*Hormone treatment of Plants*. (German), Hort. Absts. 15 (1945), Entry 421.
2. ANONYMOUS. 1949. *Report on Agri. Expt. Sta.* June 30th, 1949, pp. 336, Iowa Expt. Res. Sta.
3. ——.1952.—Cornell Deptt. of Vegetable Crops. Corn. Agri. Expt. Sta. Bull., 835 (1952), pp. 6.
4. BAKER, C. E. 1937.—*Early fruiting of Tomatoes as induced by the use of soluble phosphate, Proc. Amer. Soc. Hort. Sci. 35* : 668-72.

5. Cambell, J. S. 1958.—*Influence of transplant type and starter solution on tomato yields in Trinidad,* Trop. Agriculture, *35* : 134-144.

6. Carrier, L. E., and Snyder, W. E. 1950.—The effect of a starter solution on *several nursery and florist crops.* Proc. Amer. Soc. Hort. Sci., 55 : 513-16.

7. Laude, H. N. 1941.—*Combined effects of patassium supply and growth substances on plant development.* Bot. Gaz : *103* : 155-67.

8. Macht, D. I., and Grumbein, M. L. 1937.—*Inflence of indole-acetic, indole-butyric and naphthalene acetic acids on roots of Lupinus albus seedlings.* Amer. J. Bot. *24* : 457-60.

9. McCrory, S. A. 1946.—*Four essentials for a good tomato Crop,* Hort. Absts. *18* (1948), Entry 499.

10. Mennum, E. C. 1941.—*Effect of several growth substances on vegetable crop plants.* Proc. Amer. Soc. Hort. Sci., *38* : 477-78.

11. Pearse, H. L. 1948.—*Growth substances and their practical importance in Horticulture,* C. A. B. Tech. Comm. No. 20.

12. Sayre, C. B. 1939.—*Use of nutrient solution and hormones in water for transplanting tomatoes and their effect on earliness and total yield,* Proc. Amer. Soc. Hort. Sci. *36* : 732-36.

13. Tureckaja, R. H. 1948.—*The effect of applying growth substances to seedlings of vegetable plants on their further growth and development* (Russian) Hort. Absts. *21*, 1951, Entry 539.

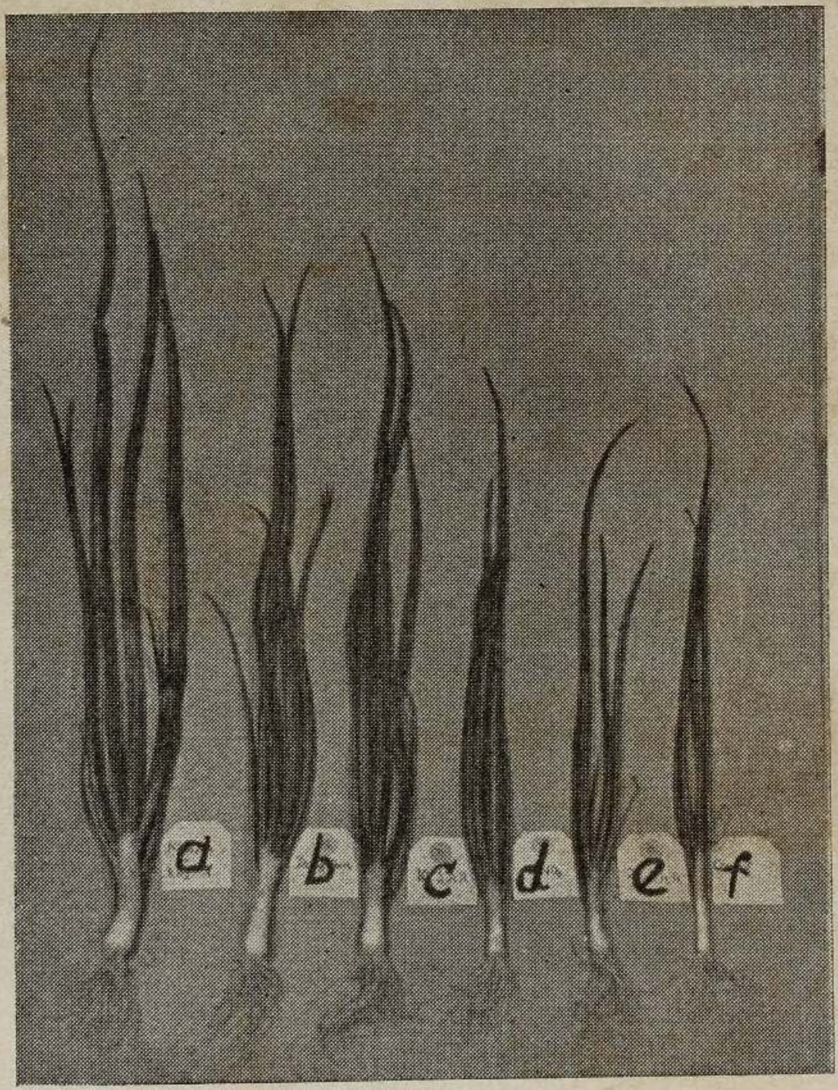

Fig. 1.—Transplants showing the influence of different treatments, 30 days after the initial treatments of— a. Ammonium svlphate mixed with Potassium di-hydrogen phosphate ; b. Dung starter ; c. 10 p.p.m., I.A.A. ; d. Sodium nitrate ; e 20 p.p.m., I.A.A. ; f. Controls.

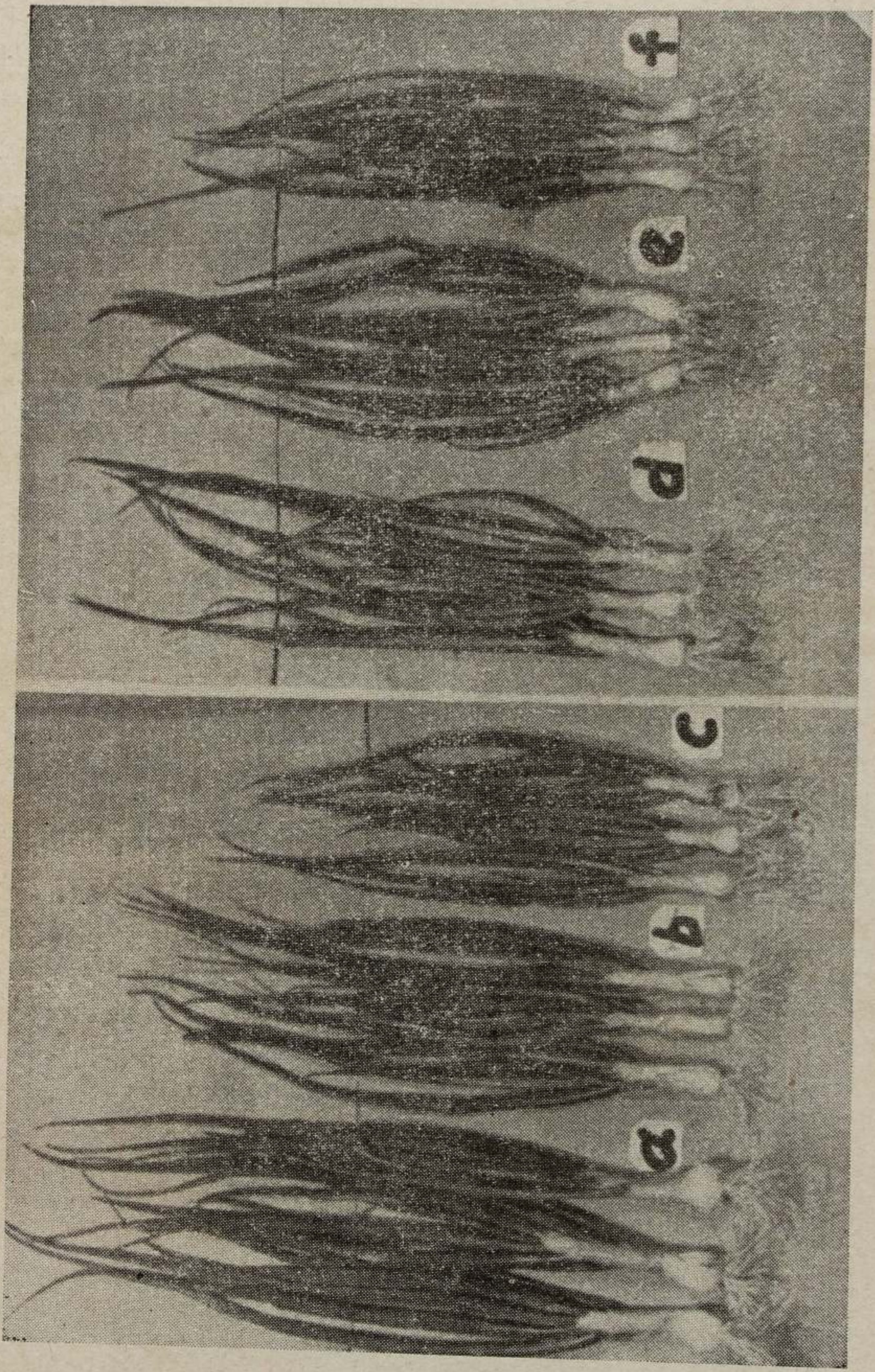

Fig. 2.—Transplants, 45 days after the treatment.

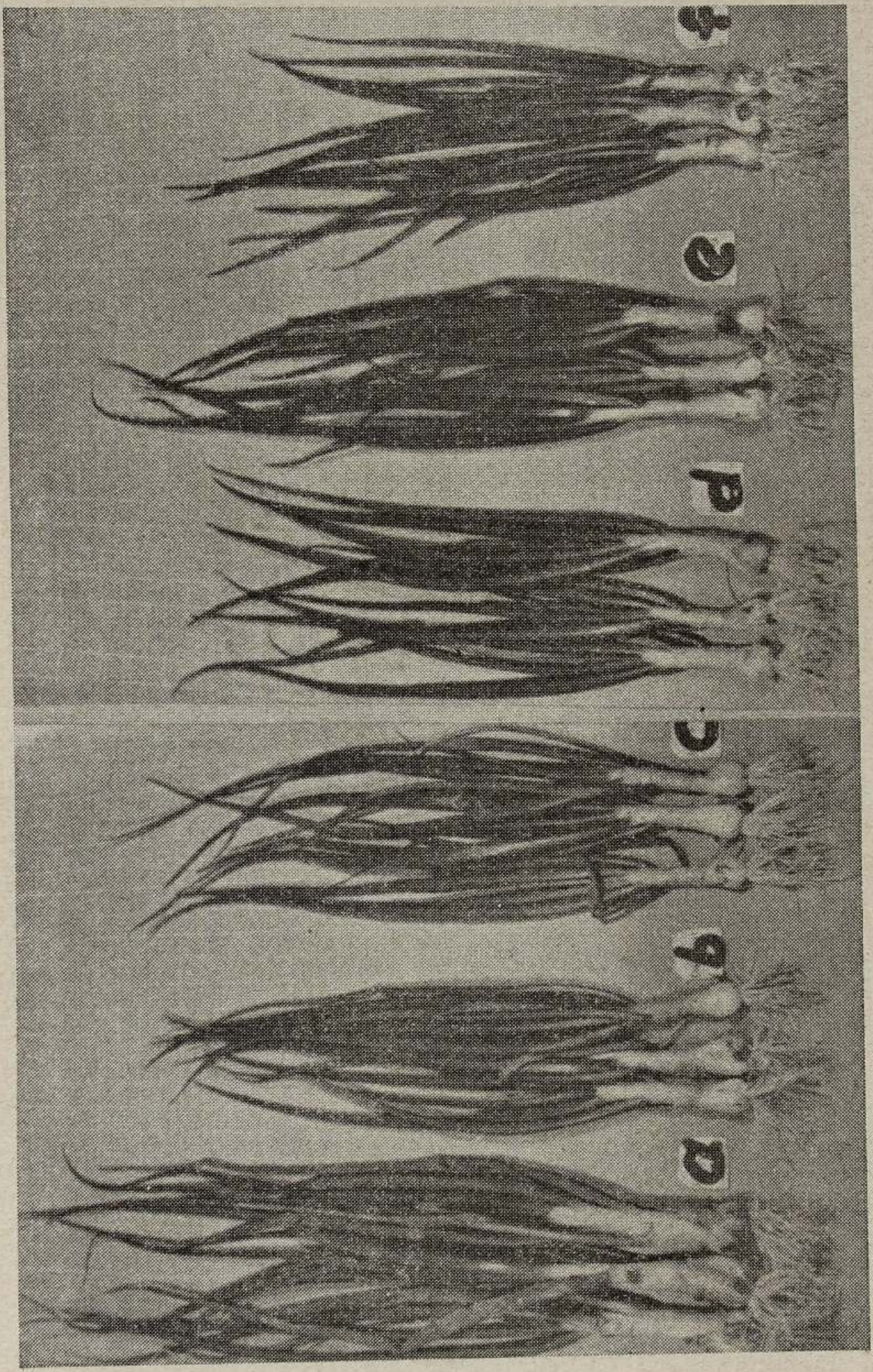

Fig. 3.—Transplants, 60 days after the treatment.

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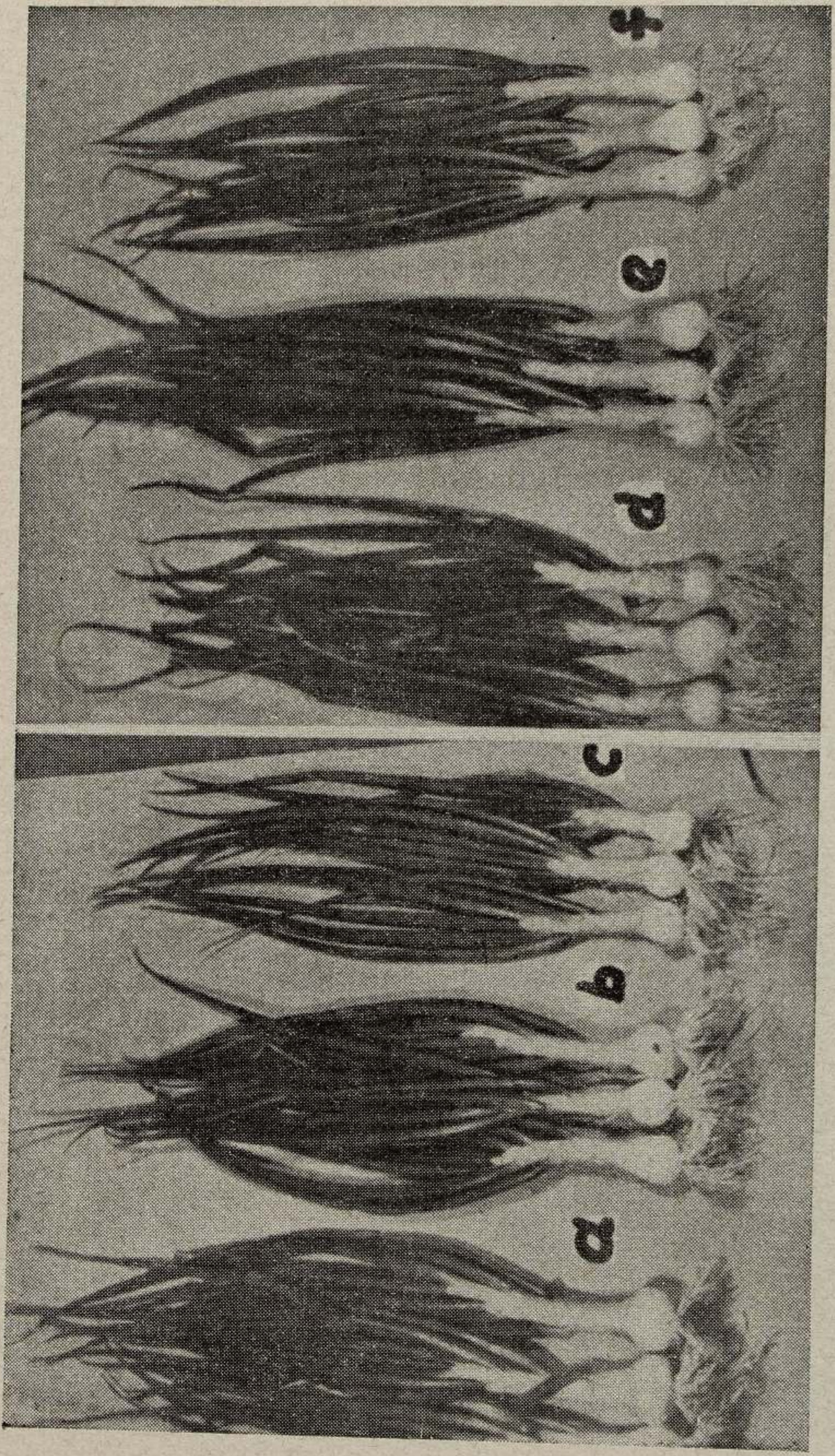

Fig. 4.—Transplants, 90 days after transplanting.

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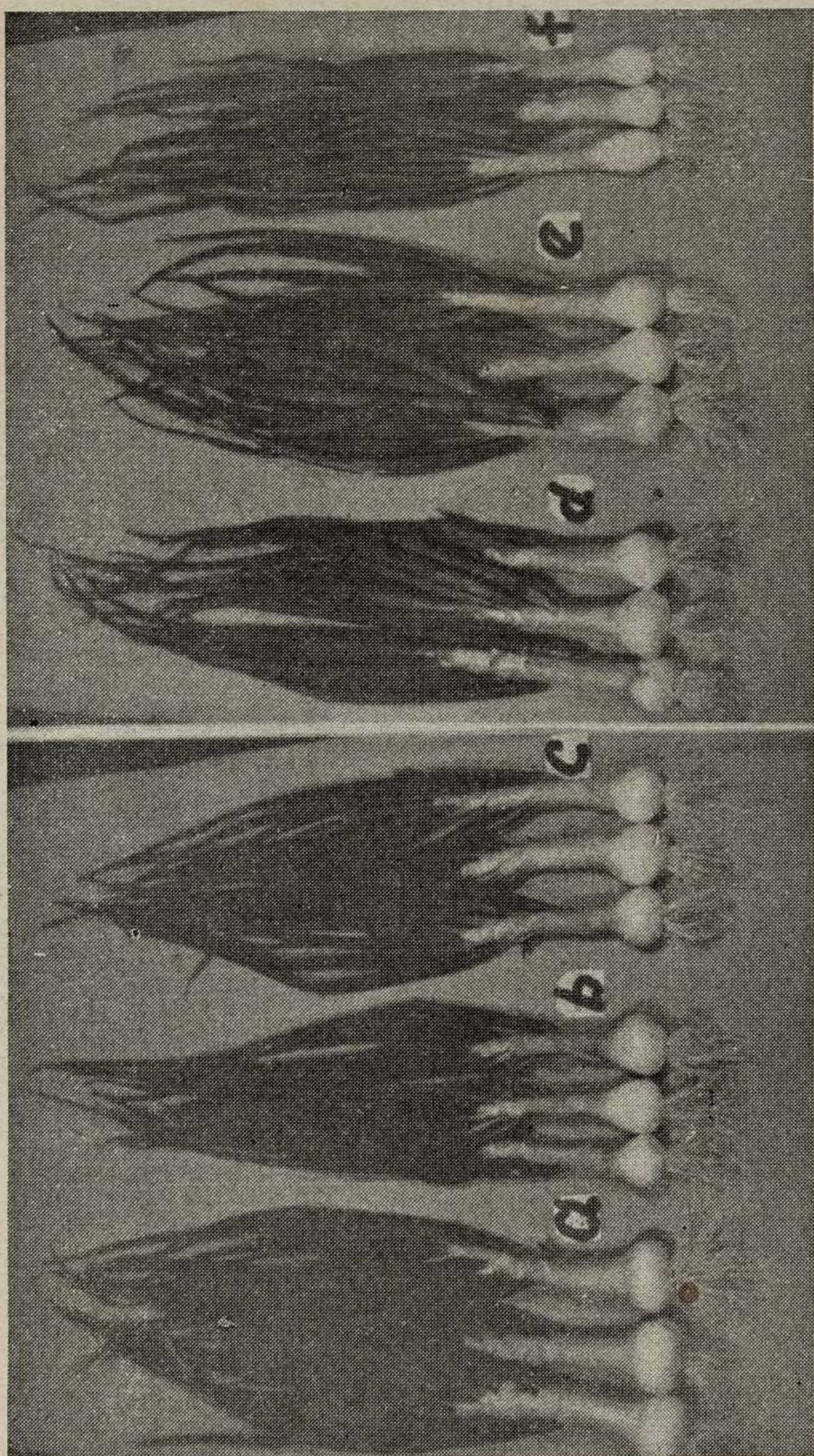

Fig. 5.—Transplants, 120 days after transplanting.

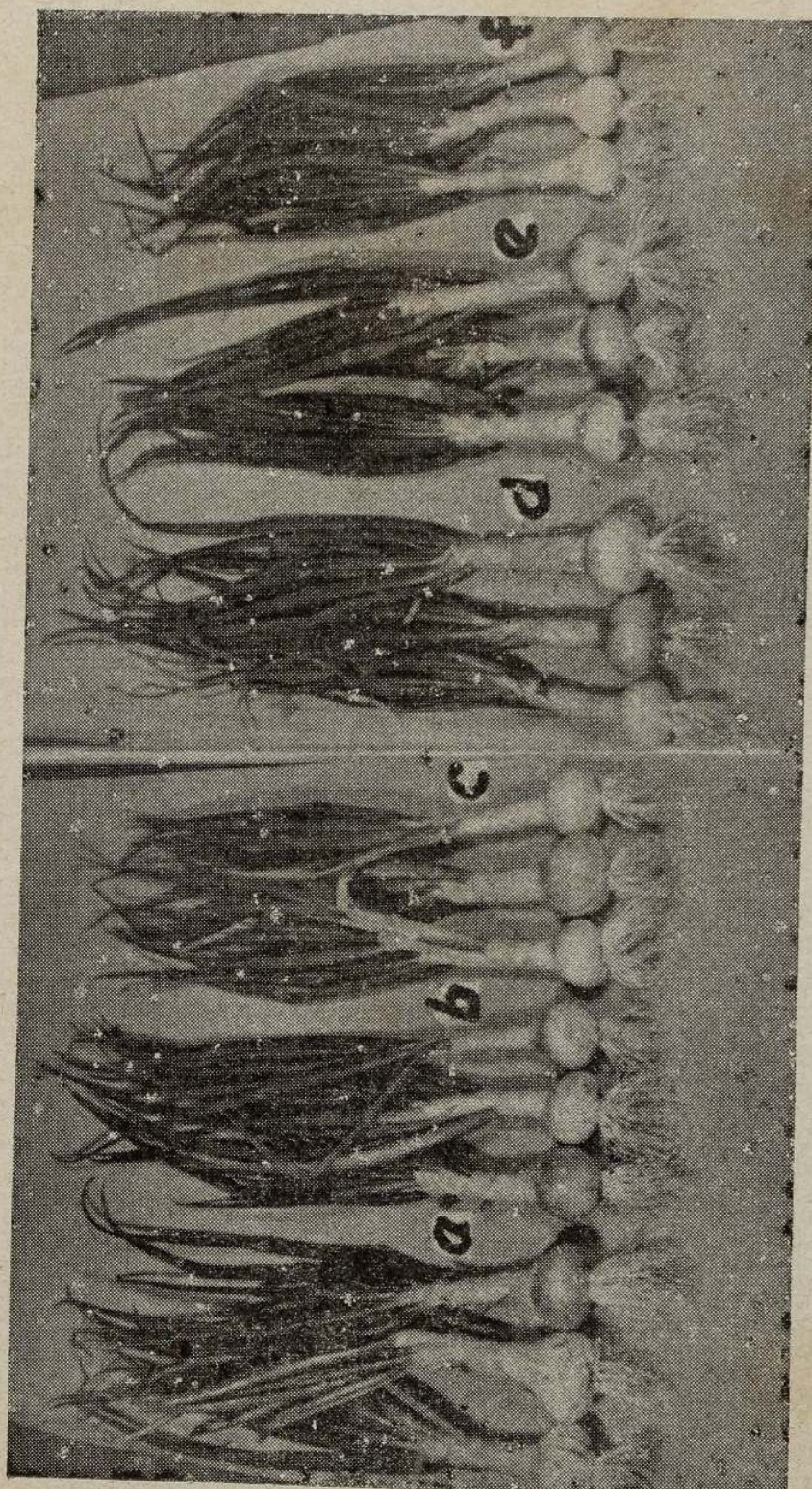

Fig. 6.—*Onion plants showing the marked influence of different treatments on the growth and development of foliage and bulbs, 135 days after the initial treatment and the transplanting.*

Table 1.—Showing the average height of plants in centimeters at successive periods of growth (Average of 40 plants)

Age in Days after transplanting	Treatments					
	A	B	C	D	E	F
30 ..	9·95	14·00	8·27	9·05	9·42	7·50
40 ..	15·47	22·82	13·05	12·87	13·80	11·70
50 ..	19·72	33·27	17·47	17·97	19·47	14·90
60 ..	37·02	51·65	32·80	35·45	37·35	32·20
70 ..	48·75	61·60	46·70	47·40	48·27	43·82
80 ..	55·32	65·10	56·10	53·20	55·00	50·67
90 ..	62·22	68·65	64·65	59·07	59·55	58·07
100 ..	65·02	71·00	67·52	61·47	62·40	57·55
110 ..	63·42	69·15	65·45	60·87	61·40	56·17
120 ..	61·97	68·05	64·25	59·42	60·50	52·97

C. D. at 5 per cent level = 4·85 (for final observation)

B	C	A	E	D	F
68·05 ..	64·25 ..	61·97 ..	60·5 ..	59·42 ..	52·97

Table 2.—Showing the average number of leaves per plant at successive periods of growth (Average of 40 plants)

Age in days after transplanting	Treatments					
	A	B	C	D	E	F
30 ..	2·57	3·27	2·60	2·47	2·40	2·32
40 ..	3·07	4·37	3·02	3·32	3·17	2·85
50 ..	4·00	5·02	3·95	4·30	4·22	3·42
60 ..	5·25	6·55	5·40	5·75	5·70	4·62
70 ..	6·70	7·50	6·25	6·66	6·42	6·05
80 ..	7·65	9·77	7·62	7·90	7·97	6·95
90 ..	8·50	11·65	8·62	8·66	8·77	7·77
100 ..	9·67	13·05	10·30	10·70	9·72	8·10
110 ..	10·52	14·67	11·05	10·95	10·57	9·50
120 ..	10·57	14·72	11·35	11·80	11·37	9·35

C. D. at 5 per cent. level = 1·02 (for final observation)

B	D	E	C	A	F
14·72 ..	11·80 ..	11·37 ..	11·35 ..	10·57 ..	9·35

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Table 3.—Showing the average fresh weight of leaves per plant in gms. at successive periods of growth (Average of 20 Plants)

Observations on days after trans-planting	*Treatments*					
	A	*B*	*C*	*D*	*E*	*F*
30 ..	12·98	24·49	16·35	13·99	15·43	10·465
45 ..	22·055	46·975	28·38	24·275	26·90	19·950
60 ..	39·165	72·415	49·39	37·820	45·78	32·725
75 ..	58·280	90·380	68·975	52·895	60·45	47·945
90 ..	78·360	106·460	88·085	70·235	74·56	50·115
105 ..	86·540	128·175	101·450	81·940	89·87	67·240
120 ..	91·650	150·500	116·880	92·225	118·565	79·200
135 ..	97·620	162·610	126·630	115·800	129·440	88·590

S. E. of difference between treatment means = 5·89
C. D. at 5 per cent level = 12·55
(For final observation)

B	E	C	D	A	F
162·61 ..	129·44 ..	126·63 ..	115·80 ..	97·62 ..	88·59

Table 4.—Showing the average dry weight of leaves per plant in gms. at successive periods of growth (Average of 20 Plants)

Observation on days after trans-planting	*Treatments*					
	A	*B*	*C*	*D*	*E*	*F*
30 ..	3·095	5·145	4·12	2·975	3·45	2·57
45 ..	4·930	9·37	5·94	5·575	4·26	3·69
60 ..	6·475	11·405	8·625	6·93	6·625	5·55
75 ..	9·3	12·645	9·775	7·57	8·145	6·515
90 ..	10·34	13.965	11·85	9·975	10·25	7·445
105 ..	11·094	15·84	13·56	11·135	12·54	8·945
120 ..	12·568	20·035	14·476	12·45	14·648	10·84
135 ..	14·32	21·58	16·76	13·57	17·33	12·04

S. E. of difference between treatment means = 0·76
C. D. at 5 per cent level = 1.619
(For final observation)

B	E	C	A	D	F
21·58 ..	17·33 ..	16·76 ..	14·32 ..	13·57 ..	12·04

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Table 5.—Showing the average fresh weight per bulb in gms. at successive periods of growth (Average of 20 plants)

Age in days after transplanting	*Treatments*					
	A	*B*	*C*	*D*	*E*	*F*
30 ..	2·675	5·250	3·305	2·760	2·805	2·125
45 ..	6·875	23·835	10·775	7·585	9·805	5·600
60 ..	19·880	48·575	20·125	23·575	28·470	16·725
75 ..	40·845	76·000	38·520	43·350	36·285	26·670
90 ..	49·530	90·250	58·550	52·940	45·480	35·800
105 ..	67·610	128·045	84·175	72·685	78·965	49·775
120 ..	98·345	186·540	128·650	95·484	108·880	76·685
135 ..	137·470	204·270	169·800	156·170	160·470	107·930

C. D. at 5 per cent level = 4·6
(For final observation)

B	C	E	D	A	F
204·27 ..	169·80 ..	160·47 ..	156·17 ..	137·47 ..	107·93

Table 6.—Showing the average dry weight per bulb in gms. at successive periods of growth (Average of 20 bulbs)

Age in days after transplanting	*Treatments*					
	A	*B*	*C*	*D*	*E*	*F*
30 ..	0·55	1·275	0·740	0·610	0·825	0·530
45 ..	1·935	2·275	1·105	1·370	1·525	0·730
60 ..	4·735	7·570	3·240	3.025	3·160	2·475
75 ..	6·305	11·160	7·030	4·950	6·170	3·975
90 ..	7·575	13·950	8·430	6·660	9·450	5·350
105 ..	10·170	19·480	11·846	10·850	12·190	10·175
120 ..	15·660	24·340	17·300	16·250	19·130	13·760
135	22·970	30·620	26·960	24·370	26·430	17·980

C. D. at 5 per cent level = 4·68
(For final observation)

B	C	E	D	A	F
30·62 ..	26·96 ..	26·43 ..	24·37 ..	22·27 ..	17·98

THE CULTURE OF FLOWERING PLANTS IN THE LOW AND MID COUNTRY OF CEYLON *

Cultural Notes on some Annuals and Perennials suitable for the Low and Mid Country

D. T. EKANAYAKE

(Assistant Superintendent, Botanic Gardens)

ALYSSUM

CRUCIFERAE *Alyssum maritimum*

An attractive annual with very small leaves. Horticultural varieties like *A. maritimum var. minimum* reach a height of only 2 inches. There are varieties with white, violet and lilac flowers. Alyssum is an excellent annual for edging borders and for rock gardens. Propagated by seeds, which are very minute, and are best sown *in situ*. Alyssum is early-flowering, and takes about 4 or 5 weeks to flower.

ANCHUSA

BORAGINACEAE *Anchusa italica*

A very showy annual, growing to a height of about 3 ft. Flowers are bright blue resembling Forget-me-nots, and are borne on lateral branches arising from the main stem. Anchusa is suitable for both low and medium elevations, and is very showy when grown in borders. It is propagated by seeds, and takes about 2-2½ months to flower.

ANGELONIA

SCROPHULARIACEAE *Angelonia salicaraefolia*

A perennial, growing to a height of 2 or 3 ft. with toothed, lanceolate leaves. The flowers are bluish-purple and scented. Variety *alba* has white flowers. Angelonia is more suitable for borders. Propagation is by cuttings or division. It thrives well in any type of soil, and needs very little attention.

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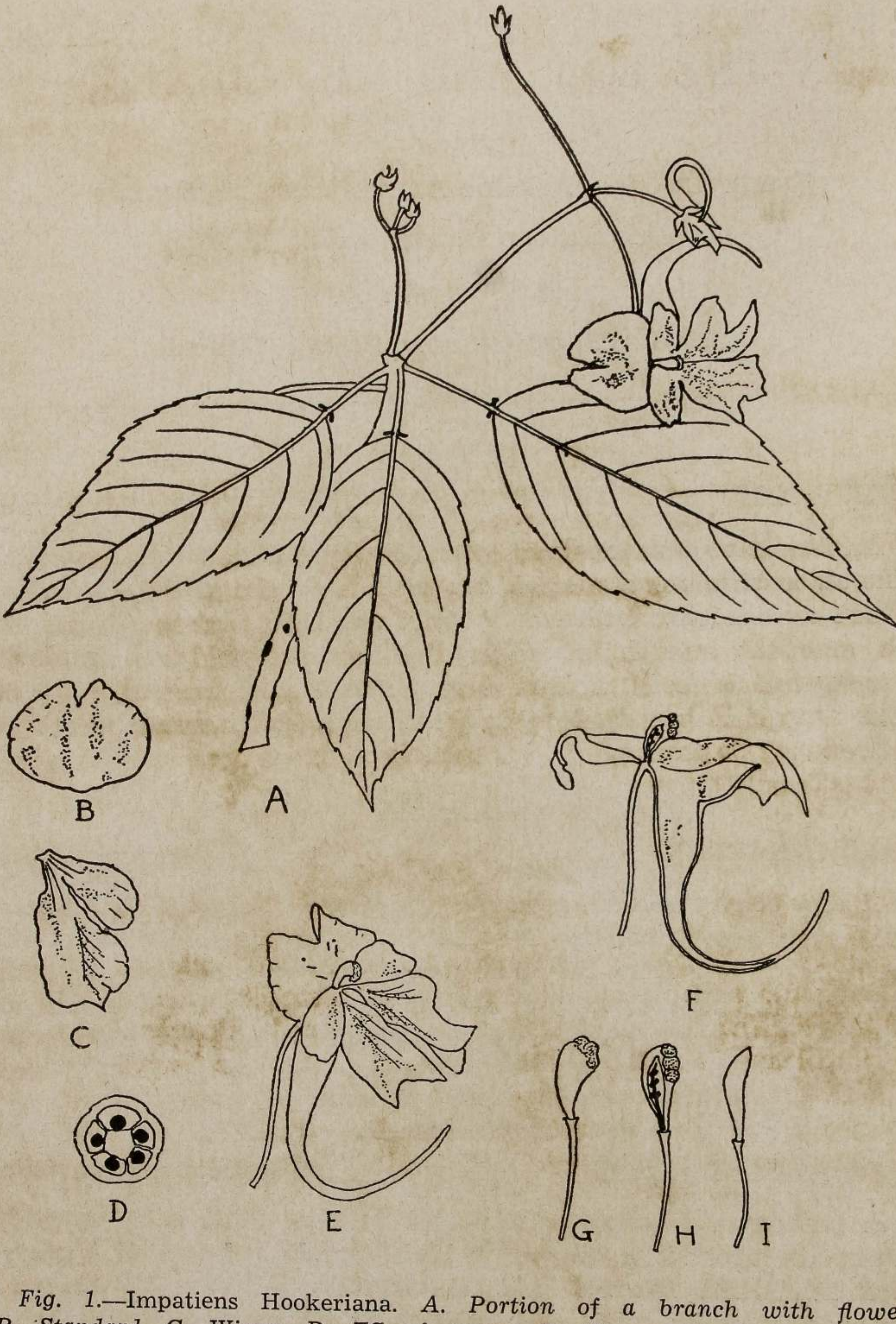

Fig. 1.—Impatiens Hookeriana. *A. Portion of a branch with flower B. Standard, C. Wings, D. TS of ovary, E. Flower, F. LS of flower, G. Androecium and gynoecium, H. LS of androecium and gynoecium, I. Capsule.*

ASTER (CHINA)

COMPOSITAE *Callistephus chinensis*

A very popular annual, native of China and Japan. The leaves are deeply lobed, hairy and ovate. In the flower there is a central disc surrounded by ray petals. There are several varieties, whose colours range from white to shades of violet, purple, blue and rose, but there are no yellow flowers. Asters grow from 6 inches up to 2 ft. Propagation is by seeds, and plants flower in about 3 months. China Asters require a rich, loamy soil incorporated with cattle manure and leaf mould. Application of a fertilizer mixture or a liquid manure is recommended.

BALSAM

GERANIACEAE *Impatiens various spp.*

The Balsams comprise a number of species, mostly annual and some perennial. The commonest species are *I. balsamina* and *I. sultani.* The former is an annual, while the latter though a perennial, should be treated as an annual when grown for decorative purposes. Both species have a number of horticultural varieties which grow to a height of 2-2½ ft. *I. sultani* is much branched, and is suitable for the annual or perennial border. Both species yield a number of varieties whose colours range from white to pink, rose, red, purple and orange. Propagation is by seeds. In addition, varieties of *I. sultani* may be propagated from cuttings. Balsams are early-flowering, and take only a few weeks to flower.

BROWALLIA

SOLANACEAE *Browallia spp.*

Mostly tender blue-flowered annuals, whose native habitat is South America. *B. americana* has hairy leaves, and reaches a height of about 12 inches. The flowers are either blue or purple. *B. grandiflora* has smooth leaves, and light blue flowers, and reaches a height of about 2-2½ ft. Browallia species are suitable for beds and borders. The dwarf species are suitable for rock gardens. Propagation is by seeds, and plants thrive well in poor soils. Browallia varieties are fast growing and early flowering.

CALENDULA

COMPOSITAE *Calendula officinalis*

A favourite annual in Up Country gardens, but suitable for medium elevations. The petals of flowers of this species are used for flavouring purposes. Calendula plants grow to a height of 1-2 ft. The leaves

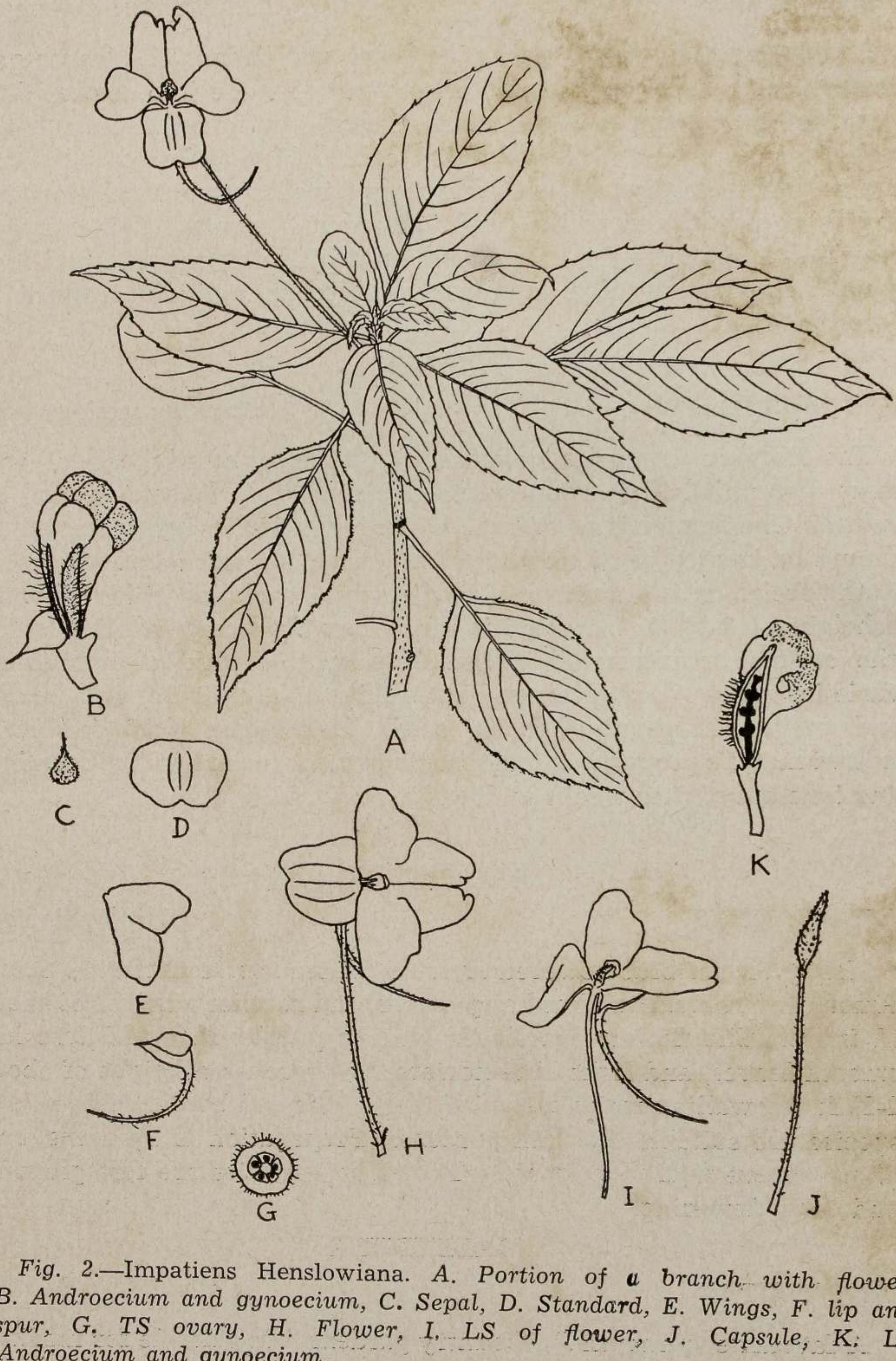

Fig. 2.—Impatiens Henslowiana. *A. Portion of a branch with flower, B. Androecium and gynoecium, C. Sepal, D. Standard, E. Wings, F. lip and spur, G. TS ovary, H. Flower, I. LS of flower, J. Capsule, K. LS Androecium and gynoecium.*

are hairy, and flowers are yellow or deep orange. The petals of flowers close in the evening. Propagation is by seeds, and they may be sown in boxes or *in situ*. Calendula requires a loamy soil enriched with cattle manure and leaf mould. This species is suitable for beds, borders and rock gardens.

CANDYTUFT

CRUCIFERAE — *Iberis umbellata*

A very showy annual, growing to a height of 9-15 inches. The leaves are lance-shaped, and the flowers are in umbels. Each flower has 4 petals of which two are longer. There are varieties with pink, red, white and purple flowers. Candytuft is more suitable for mid-elevations for edging borders, and for rock gardens. Cultivation is easy, and it thrives well in rich garden soil in exposed situations. The seeds are sown in boxes, and later the seedlings are transplanted 6 inches apart. Candytuft takes about 2 months to flower.

CANNA

CANNACEAE — *Canna indica*

The most important and most popular bedding perennial in tropical countries. There are a large number of varieties whose colours range from white, yellow, orange to pink and deep red. The culture of Cannas is simple and easy. Cannas require a rich, moist soil. The beds should be well dug, and the top soil should be incorporated with cattle manure. The size of the flowers depends on the amount of organic manure used. Cannas are propagated by the division of the root-stock (rhizome). The rhizomes are planted 15 inches apart. Cannas should be regularly watered during the dry season. Each rhizome produces a number of new shoots, and thus, clumps of plants are formed. Shoots should be cut, and removed as soon as they have finished flowering. A Canna bed should be replanted every 6 months to obtain better flowers. Cannas take about 2-2½ months to flower after planting. There are practically no pests and diseases in Cannas except leaf-eating insects, which may be controlled by lead arsenate spray. Beetles and caterpillars sometimes damage rhizomes, and they should be destroyed by watering around the plants with " INTOX 8 " or "ALDRIN ".

CHRYSANTHEMUM

COMPOSITAE — *Chrysanthemum spp.*

A genus, consisting of both annual and perennial species, most of which are native to Asia. The leaves in the ordinary garden Chrysanthemum are toothed, and plants reach a height of 2 to 3 ft.

6——J. N. R. 15900 (3/61)

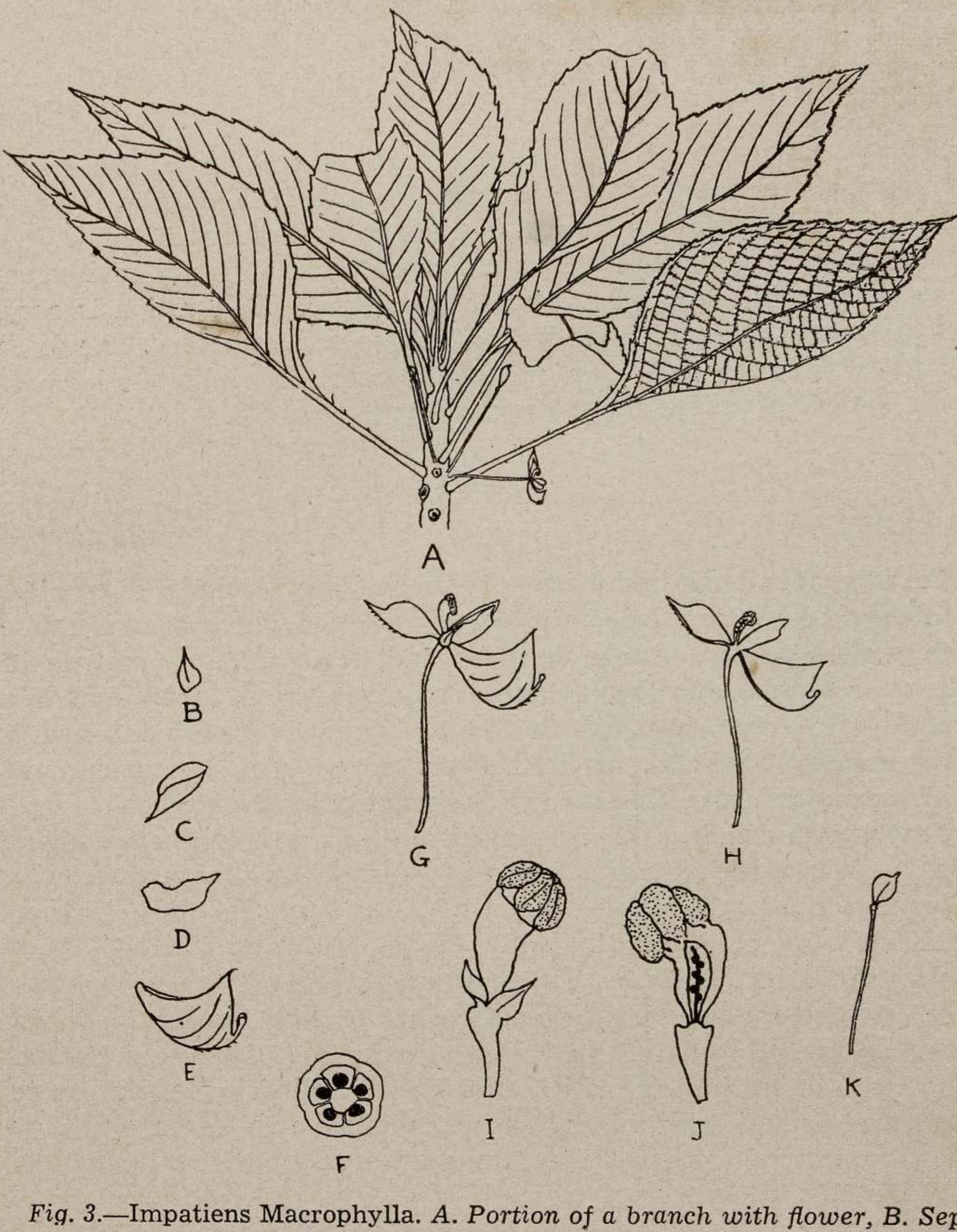

Fig. 3.—Impatiens Macrophylla. *A. Portion of a branch with flower, B. Sepal, C. Standard, D. Wings, E. lips and spur, F. TS Ovary, G. Flower, H. LS flower, I. Androecium and gynoecium, J. LS Androecium and gynoecium, 10. K. Capsule.*

The flowers are borne on heads. The florists' Chrysanthemums are derived from *C. morifolium* and *C. indicum*. The horticultural varieties are obtainable in a number of colours in double and single forms. Unfortunately, the large flowered varieties are not suitable for tropical climates. Only the small-flowered white, yellow and copper-coloured varieties are grown in low and mid elevations.

The garden Chrysanthemums are propagated by division of the root-stock or cuttings. Chrysanthemums require a rich soil which has been well manured with cattle manure and leaf mould. They should be planted in exposed situations. Chrysanthemums are suitable for beds and borders. When the plants are firmly established, the terminal buds should be removed to encourage the formation of lateral branches. Superfluous flower buds may be removed to improve the quality of flowers. Chrysanthemums come into flower in about 2 or 3 months. In addition to outdoor cultivation, Chrysanthemums are suitable for pot culture.

COCK'S-COMB

AMARANTACEAE — *Celosia spp.*

Very popular annuals in the low and mid-elevations. There are two species which are commonly cultivated, *C. cristata* and *C. plumosa*. *C. cristata* (Cock's-comb) is about 9-12 inches high. The flower spike is crested and resembles a Cock's-comb. Cock's-comb is available in a number of colours like purple, red, crimson and yellow. The flower spikes of *C. plumosa* are feathery, and are crimson, red or yellow.

Propagation is by seeds, which are very small. They are sown in boxes, and transplanted in beds about 12 inches apart. Both species thrive well in ordinary garden soil, and need only very little attention. Cock's-comb flowers in about 2 months.

COREOPSIS

COMPOSITAE — *Coreopsis spp.*

Popular annuals and pernnials in gardens. *C. grandiflora* is a perennial species grown in low and mid-elevations. It reaches a height of 1-2 ft., and has lance-shaped leaves. The flowers are bright yellow. A number of species are annuals, some of which are often cultivated. *C. coronata* has orange flowers with a crimson zone. *C. tinctoria* is also a common garden annual, and has golden flowers with a purple centre. This purple centre is encircled by a crimson zone. This species has a number of forms with numerous colour variations.

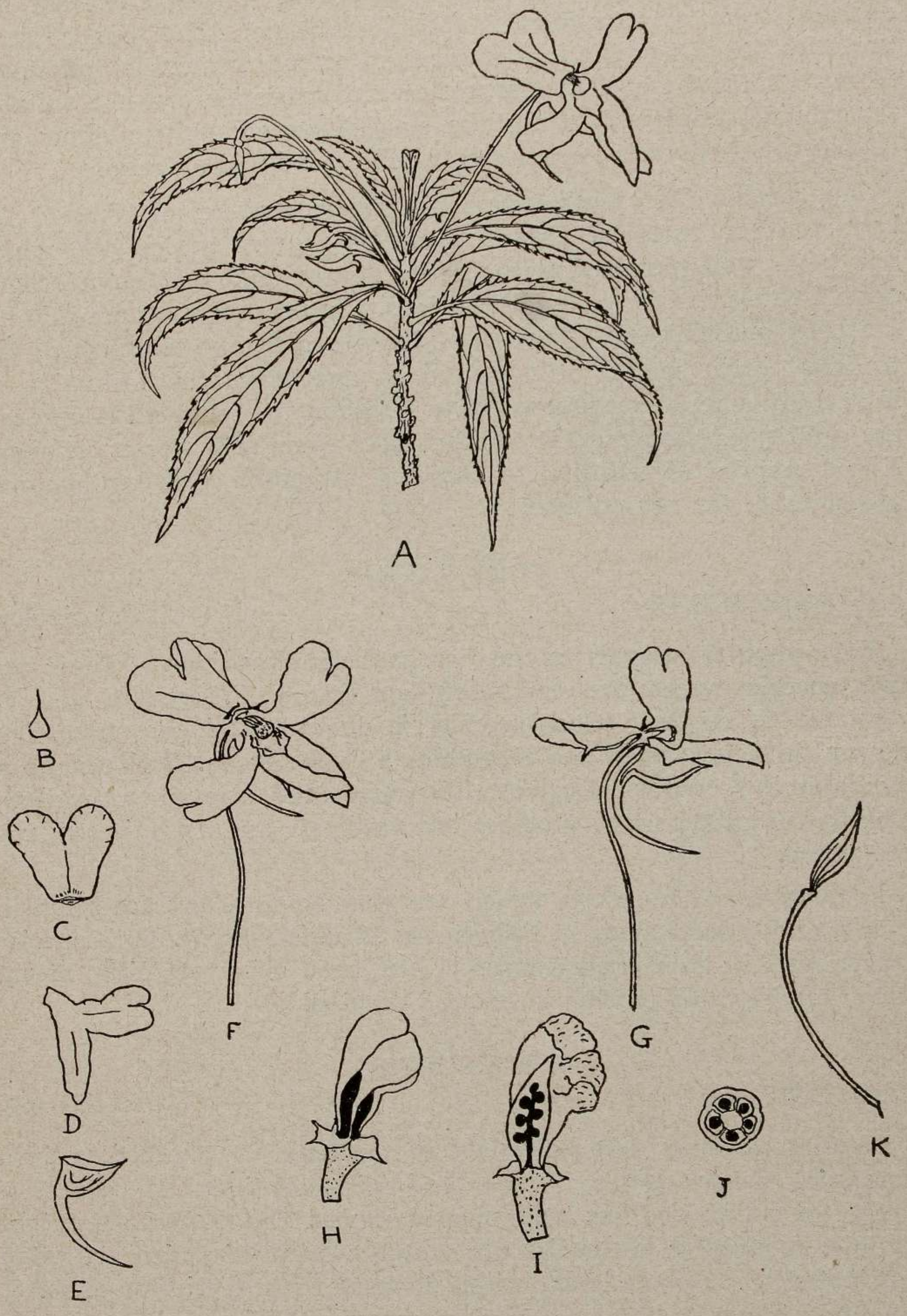

Fig. 4.—Impatiens Cuspidata. *var. bipartita. A. Portion of branch with flower, B. Sepal, C. Standard, D. Wings, E. Lip and spur, F. Flower, G. L. S. of flower, H. Androecium and gynoecium, I. L. S. Androecium and gynoecium, J. T. S. ovary, 10. K. Capsule.*

Coreopsis is suitable for beds, borders and rock gardens. The perennial *C. grandiflora* is propagated by division while the annual varieties are propagated by seeds. The cultivation of Coreopsis is simple, and it can be grown in any kind of garden soil. Coreopsis is suitable for dry areas.

COSMOS

COMPOSITAE *Cosmos spp.*

Cosmos or Mexican Aster is a popular annual grown in low and mid-elevations. There are three species of Cosmos, *C. bipinnatus, C. sulphureus,* and *C. diversifolius.* In *C. bipinnatus,* the leaves are deeply cut, and feathery. The flowers are pink, white or crimson in colour. It is an annual, and reaches a height of about 4 ft. *C. sulphureus* grows to a height of about 4 ft., and has leaves about 1 ft. long, and 3-pinnately cut. The flowers are golden-yellow. *C. diversifolius* is a tall perennial, usually treated as an annual in cultivation. It has pinnate leaves, and the flowers are dark purple or crimson in colour.

Propagation is by seeds. Cosmos is more suitable for the back of a border, and its culture is very easy. The soil should be sandy, and it is not advisable to manure the plants heavily. Too much manure may produce more foliage and less flowers. When the plants are about 2 ft. high, the terminal buds should be removed to make the plants bushy.

DAHLIA

COMPOSITAE *Dahlia spp.*

A tuberous-rooted perennial genus, commonly cultivated for its magnificent flowers. The genus is related to the common weed found in Ceylon, *Bidens chinensis.* The horticultural varieties have arisen from two species, namely *D. rosea* and *D. juarezii.* The Cactus Dahlia is derived from *D. juarezii.* The original species are native of Mexico. All the old types of Dahlia like Single, Pompon, Fancy and Show types have arisen from *D. rosea.*

The cultivated Dahlia are generally grouped as follows :—

(1) *Decorative Dahlia.* The rays of flowers are variable.

(2) *Cactus Single Dahlia.* The flowers are single, and the margins of rays are recurved.

(3) *Cactus Double Dahlia.* Double flowered, rays with recurved margins.

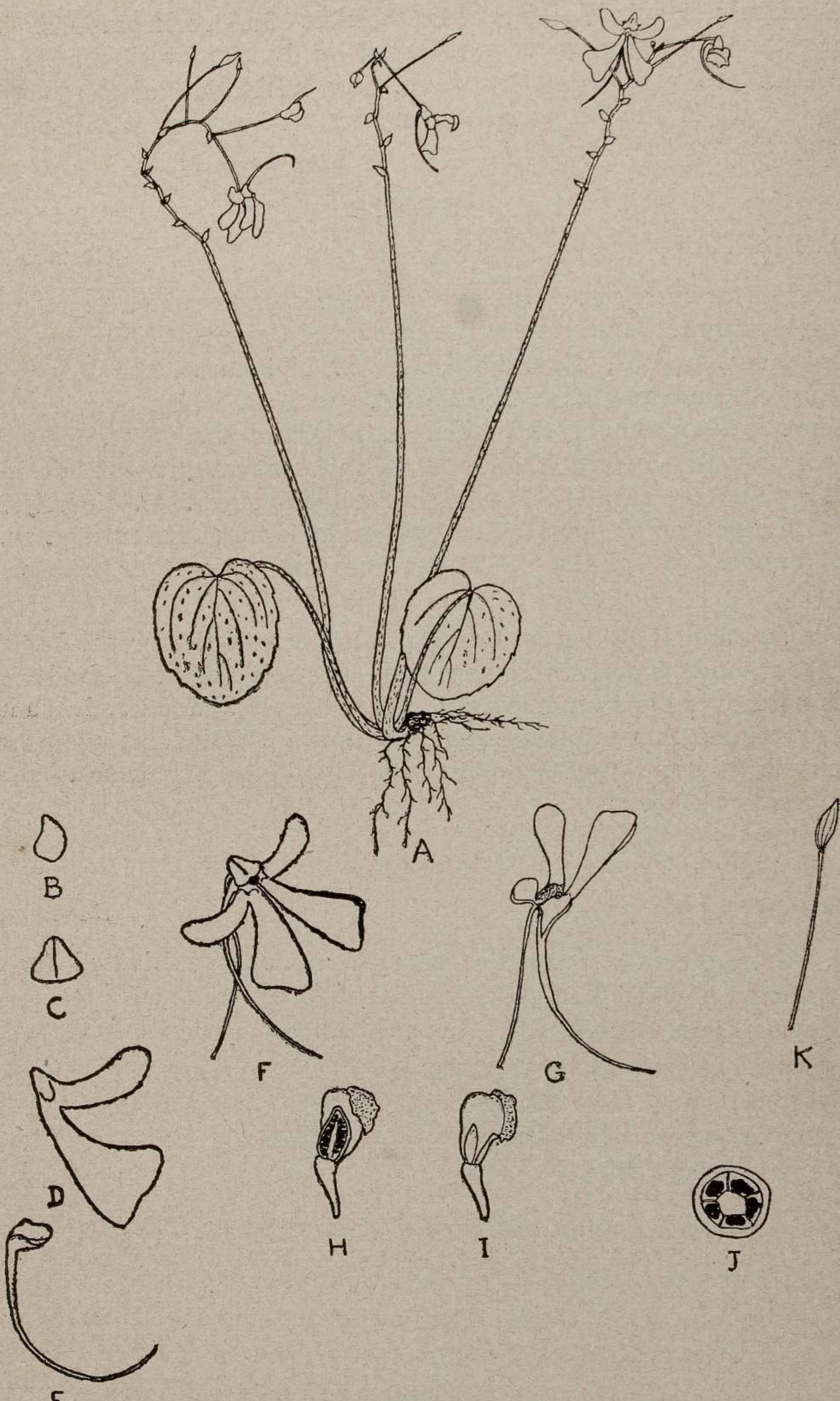

Fig. 5.—Impatiens acaulis. *A. Whole plant, B. Sepal, X 3. C. Standard, D. Wings, E. lip and spur, F. Flower, G. LS flower, H. LS Androecium and gynoecium, I. Androecium and gynoecium, J. TS ovary, K. Capsule.*

(4) *Fancy Dahlia.* The flower has two or more colours, striped or with edges of a lighter colour.

(5) *Show Dahlia.* The rays are cupped, the colours single or the edges of the rays darker.

(6) *The Pompon Dahlia.* Small double-flowered Dahlia with cupped rays.

(7) *Single Dahlia.* Flowers single and rays are flat.

(8) *Peony-flowered Dahlia.* The rays are variable in form.

(9) *The Collarette Dahlia.* The rays are variable in form.

(10) *Dwarf Dahlia.* Plants are dwarf.

Cultivation of Dahlia. Propagation of Dahlia is by division of roots or cuttings. The most common and easiest method is by division of roots. All Dahlia varieties produce tuberous roots. These roots store large quantities of food material. There are no young shoots (eyes) on the tubers, but they are found on the crown to which all the tuberous roots are attached. To obtain best results, Dahlia tubers should be imported every year.

Dahlias require a very rich soil. They can be grown in ordinary garden soil provided the soil is enriched with farmyard manure and leaf mould. The cattle manure should be well forked into the soil. In addition to organic manure, the following mixture may be applied to the soil.

2 parts Sulphate of ammonia.
2 parts Superphosphate.
1 part Sulphate of potash.

The tubers are best planted about 15 inches apart. However, taller varieties need further spacing. Tubers should not be planted too close to each other. It is best to "start" the tubers before planting out in beds. When the tubers are received, they should be placed in a sand bed and watered. After a few days, the 'eyes' will put out new shoots. During planting, holes are made about 15 inches apart, and the tubers are planted in such a way that the crowns of the tubers are just below the surface of the soil. Dahlia plants grow very rapidly. The soil around the plants should be well tilled. Deep tillage is very essential during the growing period. Forking should be stopped as soon as flower buds appear. Watering Dahlia plants should be done very carefully. Before watering, the soil should be examined to check whether the soil is moist. Excessive watering is injurious to plants. It is best to water them well when the soil is dry.

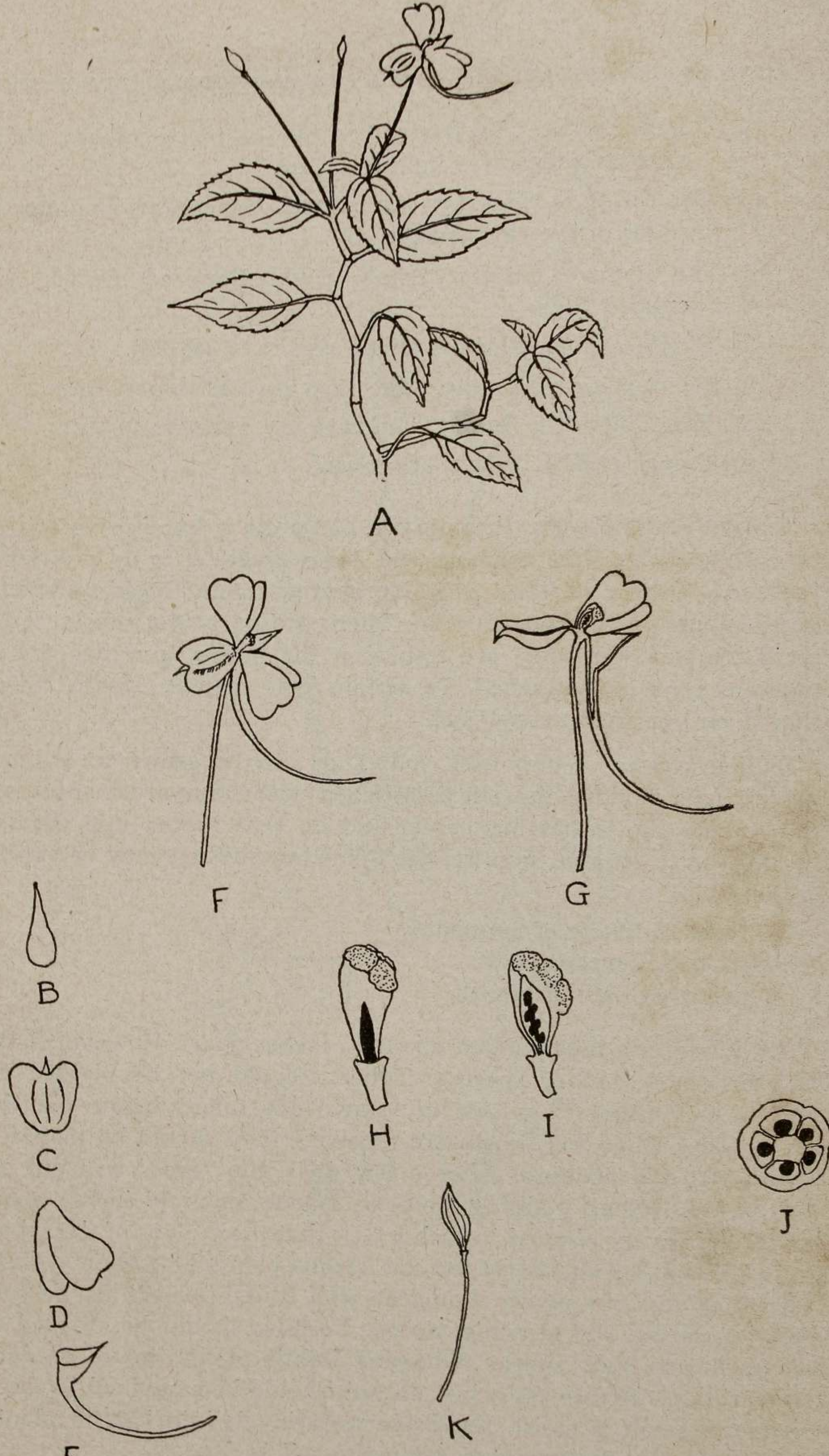

Fig. 6.—Impatiens leptopoda. *A. Portion of a branch, B. Sepal, C. Standard, D. Wings, E. Lip and spur, F. Flower, G. LS flower, H. Androecium and gynoecium, I. LS Androecium and gynoecium, J. TS Ovary, K. Capsule.*

A few days after the tubers are buried in beds, young shoots grow from the crown of the tubers. All these shoots should not be allowed to grow into adult plants. The weak shoots should be removed leaving a single strong shoot. By this practice, the food material is diverted to a single shoot. When this shoot has produced 3 or 4 pairs of leaves, the apical bud of this shoot should be pinched off to encourage the production of lateral branches from the base of the stem. Branches produced from the base of the main stem produce larger flowers. Most Dahlia varieties need support when in flower: this particularly applies to plants which produce very large heads of flowers. Staking the plants should be neatly done, as poor staking is very unsightly. Dahlia takes about 1½-2 months to flower in the low and mid-elevations of Ceylon.

After flowering, the plants should be allowed to die back. Watering should be cut down to the minimum. When the plants are dead, the tubers should be lifted, and they should be allowed to dry up in a shady place. It is best to store the tubers in a box or barrel, covering the tubers with some saw dust or very dry sand. However, the quality of the flowers tends to degenerate in successive generations.

Pests and diseases in Dahlia. Common pests are caterpillars, green-fly and other aphids, red spider and beetle larvae. Caterpillars and other leaf-eating insects feed on leaves, flower buds and flowers. Greenfly and other aphids attack the young shoots. Red spider is a troublesome pest during dry weather: it lives on the lower surface of leaves. Dahlia tubers are liable to be attacked by beetle larvae. The above pests are destroyed by using the methods outlined in the section dealing with pests and diseases.

Unlike pests, diseases are not very common in Dahlia. In wet weather, diseases like black spot may appear. Such diseases are controlled by using copper fungicides.

DIANTHUS (PINK)

CARYOPHYLLACEAE *Dianthus spp.*

A genus consisting of a number of species, most of them of perennial habit, but best treated as annuals in the garden. The stems are jointed, leaves are grass-like, and flowers are terminal. *Dianthus barbatus* is the common Sweet Wiliam. In this species, the stem is 4-angled, and petals of flowers are toothed and bearded. There are a number of horticultural varieties producing red, purple, pink, maroon and white flowers. *D. chinensis* is the Chinese or Indian Pink, native of Central

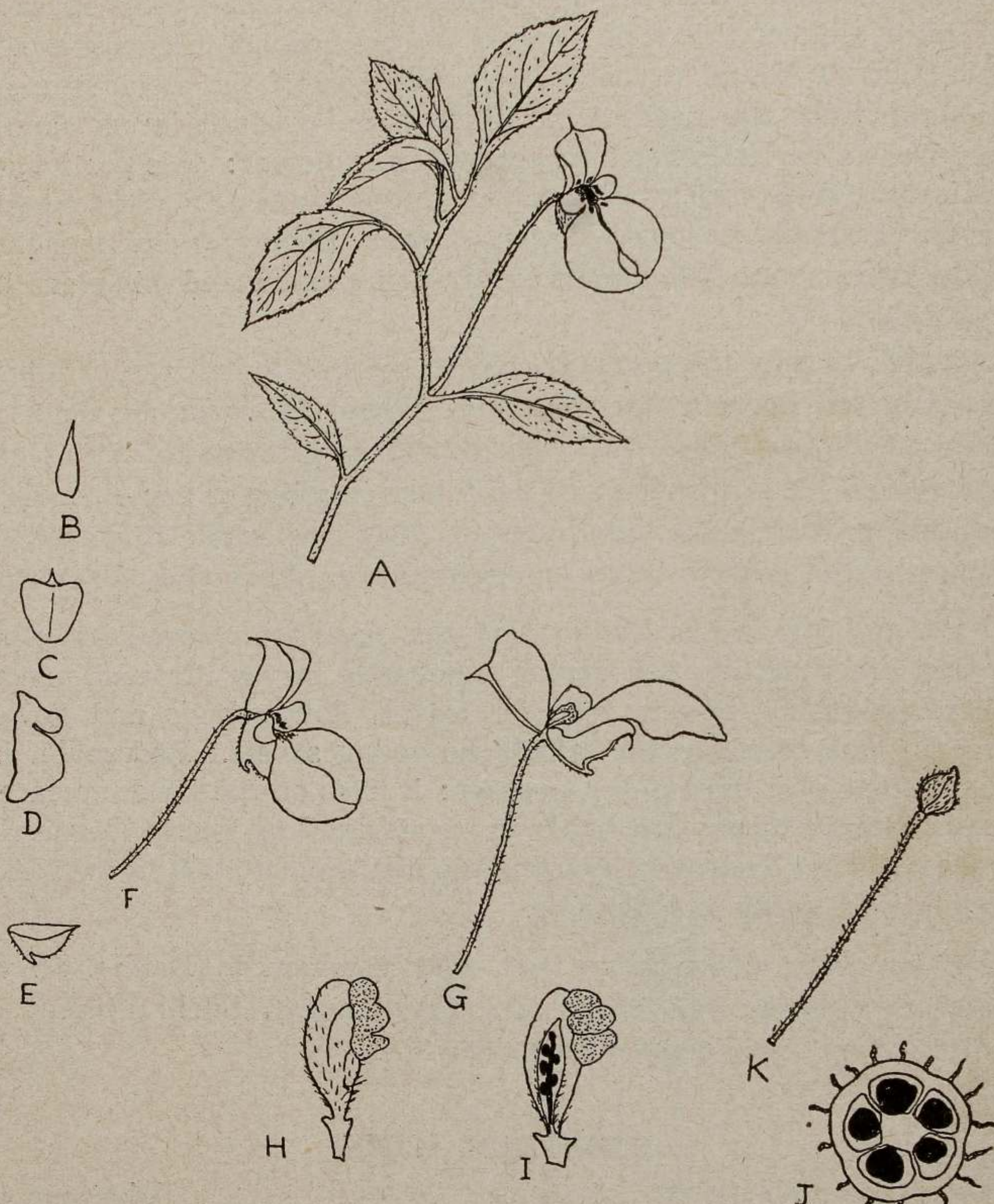

Fig. 7.—Impatiens truncata. *A. Portion of a branch, B. Sepal, C. standard, D. Wings, E. Lip and spur, F. Flower, G. LS flower, H. Androecium and gynoecium, I. LS androecium and gynoecium, J. TS ovary, K. Capsule.*

Asia. The Indian Pink reaches a height of about 9 inches. The flowers are scented, and their petals have frilled edges. Varieties are obtainable with colours ranging from white to pink and also scarlet.

Propagation is by seeds or cuttings. Dianthus prefers a well drained loamy soil. The seedlings should be planted about 9 inches apart in beds or borders. Dianthus takes about 3 months to flower from seeds.

GERBERA
(Barberton Daisy)

COMPOSITAE *Gerbera jamesonii*

Gerbera is a favourite flower among florists. Barberton Daisy has become a very popular cut flower due to its lasting qualities. It is a stemless, hairy plant, the leaves are numerous and pinnatifid. The flower heads are solitary, and are borne on long and slender stalks. The rays of the flowers are strap-shaped. There are single as well as double flowered varieties. Their colours range from white, amber, orange to dep red.

Barberton Daisy is suitable for edging beds and borders. It is also suitable for interplanting with other flowering plants like Gladioli. Gerbera requires a rich well drained soil enriched with cattle manure and leaf mould. Propagation is by division. Barberton Daisy takes about 2-2½ months to produce a crop of flowers.

GLADIOLUS

IRIDACEAE *Gladiolus spp.*

The members of this genus are corm-bearing herbs, native of Africa, Europe and Western Asia. The leaves are erect, and they are sword-shaped. Thus, Gladiolus is sometimes referred to as the Sword Lily. The flowers are funnel-shaped, and are borne on long spikes. The modern horticultural varieties are derived from a large number of species, the most important ones are *G. primulinus, G. cardinalis, G. byzantinus, G. gandavensis, G. colvillei,* and *G. childsii.* The original species have been modified in recent years by hybridization. Today, Gladioli are available in a large number of colours such as white, yellow, pink, rose, red, scarlet, magenta and purple.

In Ceylon, Gladioli are more suitable for cultivation in the medium and higher elevations, although they could be grown fairly successfully in low elevations. Gladioli are suitable for beds and borders. In beds, Gladioli may be interplanted with other varieties like Barberton Daisy.

Propagation is by corms, which are imported mainly from Holland. Gladioli thrive well in ordinary garden soil, but a sandy loam is preferable. Before planting out, it is best to 'start' the tubers in a sand bed. When the corms are sprouted, they are planted out in beds 9-12 inches apart. The corms are planted in holes provided with a layer of river sand at the bottom. Tillage is very essential during the growing period. A dressing of bone meal is also recommended during this period. Gladioli take about 60 days to flower in the low and mid elevations of Ceylon. During the growing period, the old corm is used up, and a new one is formed. After the flowers are withered, the flower spikes should be cut, and the corms should be allowed to ripen. Watering should be restricted, and when the leaves dry off, the corms should be lifted, and stored in dry sand or wood shavings for about two months.

GYNANDROPSIS

CAPPARIDACEAE *Gynandropsis speciosa*

A tender annual, suitable for borders, and growing to a height of 2-4 ft. There are two varieties, one with white flowers and the other with pink flowers, the stem and petioles are hairy, and are armed with thorns.

Propagation is by seeds. Gynandropsis does not require a rich soil, a sandy soil is preferable. The seedlings should be planted out at the back of a border. Gynandropsis takes about 1½-2 months to flower.

MARIGOLD

COMPOSITAE *Tagetes spp.*

A native genus of South America, and a popular annual in gardens. The annual 'French' and the 'African' Marigold are derived from *Tagetes patula* and *T. erecta* respectively. The 'French' Marigold is a very hardy annual reaching a height of 1-1½ ft. The leaves are fern-like, and the flowers are yellow or red in colour. The flowers are borne on long flower stalks. The horticultural varieties of *T. patula* have a colour range from yellow to orange and red. The 'African' Marigold is also a hardy annual, which attains a height of 2 or 3 ft. The leaves are pinnate, and flower heads are born on solitary flower stalks. The 'African' Marigold has a single colour which is bright yellow.

Marigolds are very hardy, and their flowers can stand heavy rain. They are suitable for beds, borders and rock gardens. Propagation is by seeds, which should be sown in boxes. The dwarf varieties should be planted 9-12 inches apart, while the tall Marigolds are best planted 18-24 inches apart. Marigold takes about 1½-2 months to flower, but the tall 'African' Marigold may take a little longer time. There are practically no pests or diseases in Marigold.

MICHAELMAS DAISY

COMPOSITAE *Aster spp.*

A herbacious, perennial genus, consisting of a number of species cultivated for their brightly coloured flowers. Michaelmas Daisies comprise the garden varieties of *A. ammellus, A. novae-angliae* and *A. novi-belgii.* Their colour range varies from white to shades of pink, blue, purple, red and intermediate hues. Plants reach a height of 2-3 ft.

Michaelmas Daisies are suitable for beds, borders and rock gardens. Propagation is by division, and they require a rich, well drained soil. Michaelmas Daisies are planted 9-12 inches apart, and they take 1½-2 months to flower.

NASTURTIUM

GERANIACEAE *Tropaeolum majus*

Tropaeolum majus, commonly but wrongly called Nasturtium, is a climbing perennial. The leaves are round or kidney-shaped. The flowers have spurs, and are about 2-2½ inches across. The flowers are yellow or orange in colour. There are a number of varieties, single or double-flowered, whose colours range from orange to pink and red.

Propagation is by seeds or cuttings. Suitable for rock gardens, banks and borders. Nasturtium takes about 2-2½ months to flower from seeds, but cuttings flower early. It grows in poor soil. Nasturtiums are suitable for mid-elevations.

NICOTIANA

SOLANACEAE *Nicotiana alata, var. grandiflora*

Nicotiana alata, var. grandiflora is the common flowering tobacco of Brazil and Chile. In gardens, it is usually treated as an annual. The leaves are sessile, and the basal leaves are longer than the terminal ones. The stem grows to a height of about 2-5 ft. In the species, the petals are white on the upper surface and light purple on the lower surface. The horticultural varieties have colours such as pink, mauve, cream and crimson. The flowers are sweet scented.

The flowering tobacco plant is suitable for the back of a border. Propagation is by seeds. When raised from seeds, Nicotiana takes about 2½-3 months to flower. It prefers a fairly rich, loamy soil.

PETUNIA

SOLANACEAE *Petunia hybrida*

A straggling, perennial garden plant, usually grown as an annual. The common Petunia is derived from two S. American species namely, *P. axillaris* and *P. violacea.* The stem and leaves are hairy, flowers are showy, white, red, purple, rose or crimson in colour. Some varieties have flowers in which the petals are deeply fringed.

Petunia is suitable for beds, borders and for rock gardens. Propagation is by seeds or in the case of fancy types by cuttings. The seeds are minute, and should be sown in boxes or pans. Petunias grow in ordinary garden soil provided the soil is well treated with organic manure. Excessive manuring should be avoided. If the soil is very rich, more foliage may be produced, and this may result in the production of less flowers. Petunia seedlings should be planted 12-15 inches apart in sunny situations. In the shade, plants produce only a few flowers. Petunia takes about 2½-3 months to flower. Insect pests and diseases are rare in Petunia.

PHLOX

POLEMONIACEAE *Phlox Drummondii*

This genus has both annual and perennial species, but the species suitable for our climate is *Phlox Drummondii,* which is an annual. It is an erect, branched, herbacious plant with lance-shaped leaves. The flowers are in clusters, and in the original species, the flowers are rose red. However, its horticultural varieties have colours such as red, crimson, pink, purple, mauve, white, yellow and their conbinations. Variety *cuspidata* has star-like flowers, and is called Star Phlox.

Propagation is by seeds. Phlox is a very showy bedding plant for Low Country. It is also suitable for troughs and window boxes. Phlox thrives well in a sandy loam which has been well manured with organic manure. The seeds should be sown in boxes, and they take 2-3 weeks to germinate. The seedlings should be exposed to the morning sun regularly. The seedlings are planted 9-12 inches apart. When the seedlings are well established, their terminal buds should be pinched off to encourage the formation of lateral branches. The branches should be pegged down to protect them from strong wind.

At this stage, it is extremely useful to treat the plants with a liquid manure or a fertilizer mixture. Phlox takes about 2½–3 months to flower. It continues to flower for a very long time, and this could be prolonged if the old flowers are removed from time to time.

PLUMBAGO

PLUMBAGINACEAE *Plumbago spp.*

A genus consisting of straggling shrubs, commonly cultivated in tropical gardens. Plumbago is suitable for beds, especially the perennial border. *P. capensis* is the most common species. It is a semi-climbing species with oblong or spathulate leaves, and bears blue flowers in clusters. *P. capensis, var. alba* has white flowers. *P. rosea* has a climbing habit with purplish red flowers. *P. rosea, var. coccinea* has scarlet flowers.

Most Plumbago species have a climbing habit, but they could be trained to a height of 2–2½ ft. by regular pruning. Plumbago species thrive well in ordinary garden soil. Propagation is by cuttings or division. After flowering, the plants should be cut back, and the soil should be manured. It is better to replant Plumbago species once a year. Mealy bugs are troublesome pests in Plumbago. The infested plants should be treated with a suitable insecticide.

PORTULACA

PORTULACACEAE *Portulaca grandiflora*

A prostrate, trailing herb native of Brazil. It is also called the Sun Plant or Rose Moss. The stem and leaves are fleshy, and plants reach a height of 6–9 inches. The flowers are about 1 inch in diameter, and are red, pink, purple, yellow or crimson in colour. The flowers open in the morning when the sun is bright, and close in the evening. Portulaca is suitable for all dry districts of Ceylon.

Propagation is by seeds or cuttings. The seeds should be sown in boxes. Portulaca is suitable for carpet beds, rock gardens and for edging beds and borders. Plants raised from seeds take about 2–2½ months to flower.

SALVIA

LABIATAE *Salvia spp.*

A very popular shrubby, perennial genus cultivated in gardens for their showy flowers. A number of species are cultivated in our low and mid-elevations. *S. coccinea* is an annual or perennial with scarlet flowers, native of S. America and West Indies. *S. farinacea* is a perennial about 2 ft. high, the stem is hairy, and leaves lance-shaped. The flowers are blue in colour, var. *alba* has white flowers. *S. leucantha* is a small shrub about 2 ft. high, the branches are wooly-white. The leaves are lance-shaped, hairy above, and wooly-white beneath. The flowers are purple in colour. *S. splendens* commonly called Scarlet Sage is a shrubby perennial, treated as an annual in cultivation, the Scarlet Sage reaches a height of over 2 ft. The leaves are glabrous with serrated margins. The flower spikes are terminal on branches, and the flowers are scarlet in colour. *S. splendens* has a number of varieties producing white, purple or dark scarlet flowers.

Propagation of *S. coccinea* is by seeds, while *S. farinacea* and *S. leucantha* are usually propagated by division or cuttings. *S. splendens* is propagated by seeds, cuttings or division. Salvia species thrive well in ordinary garden soil. The soil should be enriched with cattle manure before planting. All four species are suitable for beds, borders and rock gardens. *S. splendens* is a favourite bedding plant in low and mid-elevations of Ceylon. In fact, it may be regarded as the most attractive scarlet-flowered bedding plant suitable for these elevations. Plants raised from seeds take about 2–2½ months to flower, but plants raised from cuttings or division come into flower earlier.

TORENIA

SCROPHULARIACEAE *Torenia Fournieri*

Torenia Fournieri is a common garden annual, reaching a height of 6–9 inches, the stem is 4-angled, and the leaves have serrated margins. The flowers are 2-lipped, and are dark purplish-blue and pale blue in colour. One lobe of the flower is marked with a yellow blotch. Variety *alba* has white flowers.

Torenia is suitable for carpet beds, rock gardens and for edging borders. Propagation is by seeds, which are very small. Torenia thrives well in ordinary garden soil, and it requires very little attention.

VERBENA

VERBENACEAE *Verbena spp.*

An annual or perennial genus with a number of species producing very attractive flowers. It is best to treat the perennial species as annuals for decorative purposes. The plant is creeping in habit with dissected leaves. The flowers are terminal, and are borne on broad heads. The modern Verbenas have arisen from four spcies namely, *V. bonariensis*, *V. venosa*, *V. hybrida* and *V. canadensis*. The colours of the modern Verbenas vary from white to rose, pink, red, purple and dark purple.

Verbena is an excellent plant for carpet beds, rock gardens and for edging borders. Propagation is by seeds or cuttings. Verbenas thrive well in ordinary garden soil, and it is best to manure the soil with organic manure before planting. Verbena prefers dry weather, and hence this plant is not suitable for growing during wet weather. Seeds should be sown in boxes, and later transplanted. The seedlings or rooted cuttings should be planted 9-12 inches apart. Seedlings flower in about 2–2½ months, while cuttings take a little shorter time.

ZINNIA

COMPOSITAE — *Zinnia elegans*

Zinnia elegans is an annual, native of Mexico. It is an erect, stiff plant reaching a height of 2–3 ft., and provided with ovate leaves. The flowers are daisy-like, and in the original species they are purple or lilac in colour. The modern horticultural varieties are either single or double-flowered with colours ranging from white, yellow to orange, scarlet, crimson and almost every colour except blue.

Zinnias are suitable for beds and borders in the Low Country. They are not very suitable for cultivation in humid districts. Zinnia prefers a sandy loam enriched with cattle manure and leaf mould. Propagation is by seeds, which should be sown in boxes, the seeds take about three days to germinate. Zinnias are fast growing, and the seedlings should be transplanted when they are about 3 inches high. Zinnias flower in about 6 weeks.

Wilt is a very common disease of Zinnia. Diseased plants should be removed, and destroyed immediately, otherwise the disease may spread to healthy plants.

INTERNATIONAL VETERINARY ACTIVITIES

Sir Thomas Dalling

(Consultant of the Food and Agriculture Organization of the United Nations (FAO), Rome, Italy)

The nutrition of the rapidly increasing human population throughout the world causes much concern and assistance is being given in several directions by international organizations to increase the production of food for human consumption. The Food and Agriculture Organization of the United Nations, a Member of the United Nations group of specialised agencies, was set up in October, 1944, and is one of these Organizations. Beginning with 42 Member Countries, the number has now increased to 76. The aims of FAO are :—(1) to help nations to raise the standard of living ; (2) to improve nutrition of the people of all countries ; (3) to increase the efficiency of farming, forestry and fisheries ; (4) to better the conditions of rural people ; (5) through all means to widen the opportunity of all people for productive work.

The importance of livestock in all countries is appreciated by the Organization and Animal Production receives much attention. Improvement in livestock production is urgently required to increase the availability of the much needed proteins of animal origin and of animal by-products. In addition, animals are still required in some regions for use for agricultural and transport purposes and their value in soil fertilization will probably continue. Improvement of animal health and control of animal diseases are recognised as vital factors in increasing animal production and efforts are being directed towards these ends. Although more livestock is necessary, it follows that the better the health of animals, the greater will be the production from smaller numbers of animals ; a smaller total area of land will be required to produce food for these smaller numbers and so, eventually, more land could be available to raise crops to feed the human population. Improvement of animal health and control and eradication of animal diseases constitutes a world-wide challenge which requires the active collaboration of all countries.

Most attention is, of course, being given to countries classified as under or less-developed, because the potentialities in some of them to increase animal production is great. Concurrently with work on improvement in animal health and disease control, production of more and better feeding stuffs for animal consumption, improvement of pastures, improvement in some aspects of animal husbandry and improvement in breeds to meet their required purposes all receive attention. It is with animal health and diseases that most veterinary technical assistance is concerned.

Veterinary technical assistance is given in several ways. At the headquarters of the Organization in Rome there is a team of veterinarians, drawn from different countries, part of whose duty is to provide information and advice on veterinary subjects to any Member Country, on request. The requested information may already be available in FAO or it may be necessary to consult literature, reports, etc., or even to get into touch with veterinary and other authorities in different parts of the world. It is not uncommon to put veterinarians in personal touch with such authorities in other countries. There is an extensive library in FAO Headquarters, in which textbooks, journals and reports are available to the staff and they are freely made use of in supplying information, opinions and advice to Member Countries. The headquarters veterinarians are largely responsible for the veterinary field work carried out by FAO : they are in regular communication with the veterinarians assigned to Member Countries and supervise and advise them on their work. They visit Member countries periodically to discuss programmes with the responsible authorities, to give any necessary advice on veterinary topics and to take part in meetings on veterinary and other subjects of a local, regional or world-wide character. World-wide types of meetings are also held, from time to time, at headquarters, for which the necessary arrangements are in the hands of the veterinary staff. They also participate in meetings convened, separately or jointly with FAO, by other international organisations which have veterinary interests. Veterinarians from headquarters are sometimes called upon to be members of teams which visit countries or regions to carry out surveys on any particular subject concerning agricultural and allied projects. From the Animal Health Branch of the Organization information, collected from many sources, is supplied for publication and the Branch itself publishes articles of general interest. An example of such a publication is the Annual Year-book on Animal Health which contains full particulars in tabular form, of the incidence of animal diseases in countries throughout the world with particulars of the methods adopted for their control and a series of articles on topical subjects, some prepared in Rome and some by well-known veterinarians in various parts of the world.

Technical assistance to individual member countries is given in several ways. Following discussions in the country and in Rome, requests are made by the countries for technical assistance in specific subjects. The requests are placed in order of priority and are carried out according to the availability of the funds and the possibility of making detailed arrangements. Normally, one or more veterinarians, appointed by FAO, are assigned to the requesting country to proceed with the work. These veterinarians drawn from many parts of the world are usually experienced in the type of work required and have often had service in countries with climatic and other conditions similar to those of the country in question. Young veterinarians, specially qualified and experienced in some special veterinary subject may also be appointed, especially for work which does not demand experience of a special climatic condition.

A veterinarian assigned to a country works as an adviser, assisting and collaborating in planning and operating schemes for animal health improvement and disease control and in giving instruction to national veterinarians and others on techniques for the diagnosis, prevention and control of diseases.

For the satisfactory control of some animal diseases in a country and for preventing the introduction of disease, legislative action is necessary and regulations have to be formulated : FAO veterinarians give advice on this subject and often assist in drawing up the regulations.

Some of the veterinarians spend much of their time in the laboratories in the country to which they are assigned, teaching and supervising the preparation of biological products for use in animal disease control schemes. Others are concerned with the veterinary schools in the country and advise on and assist in the introduction of changes which are considered beneficial. Activities in slaughterhouses come under the purview of some of the assigned veterinarians. They advise on the construction and establishment of new slaughterhouses and alterations in existing premises to meet more modern requirements, plan operations and supervision of staff, advise on and give instruction in meat inspection, refrigeration techniques and safe disposal of waste and condemned material as well as on the care and inspection of animals destined for slaughter during their transport to and after collection at the slaughter-house.

Veterinarians work sometimes in more than one country in a region, devising schemes which may benefit the whole region by preventing spread of infections from country to country. One of the conditions imposed by FAO on member countries receiving such technical assistance is that one or more national veterinarians are attached to the FAO veterinarian so that the work may be continued satisfactorily and without a break after his departure.

For the diagnosis of and control of many of the infectious diseases biological products are required. For various reasons including economy, the required materials are being produced in the different countries, where these products have been prepared in the past. More modern techniques are now in and result in more efficient products. Special equipment is required and FAO has supplied a considerable amount to a number of member countries. In the control of other diseases, drugs not available in a country or region are sometimes necessary, for example, for the control of parasitic diseases such as liver fluke disease and diseases caused by worms in the stomach and intestine of sheep and cattle. FAO has supplied considerable quantities of the necessary drugs in order that extensive control schemes could be successfully inaugurated. Similarly, the control of diseases caused by external parasites, for example, sheep scab, has been encouraged by the provision of a quantity of the necessary medicaments for use in the form of dips and sprays.

FAO provides assistance for training in modern scientific methods. This is done as much as possible by FAO veterinarians during their assignments to a country. In addition, however, fellowships are awarded by FAO to selected national veterinary personnel, enabling them to proceed to another country to receive special tuition and experience in a specific subject, a group of subjects, or in the more general aspects of animal health and disease control. Such trained national personnel, on return to their country at the completion of their training, are expected to be employed in the type of work in which they gained experience abroad, to meet the requirements in their country.

While fellowships are allotted mostly for individual travel and training, FAO also convenes and operates Training Centres for veterinarians from countries often in a region. The courses vary from more general instruction for 2-3 weeks on such subjects as the preparation and testing of virus-vaccines, to more detailed work for several months on subjects such as milk and meat hygene and infertility in animals. For the courses of longer duration, the host country sometimes provides part of the necessary financial outlay.

In order to obtain up-to-date information on specific subjects and to bring together recognised world authorities on them, FAO has set up panels whose members, conversant with essential parts of the subject, meet from time to time and, together with FAO, prepare reports for general distribution. Examples are those dealing with infertility in animals and with tick-borne diseases. FAO also links up with other international organizations in the formation and work of such panels, for example, brucellosis, created jointly by FAO and the World Health Organization (WHO), the subject being of much importance in both human and veterinary medicine.

For discussions of problems of animal health and control of animal diseases which affect the economy of a number of countries in a region and to draw the attention of governments to the steps which can be taken to improve the position, meetings, attended by representatives of the countries, are convened in the region. Sometimes such meetings are arranged jointly by FAO and another international organization—the International Office of Epizootics (OIE), which has been in existence since 1927 and whose headquarters is in Paris. The reports from such meetings, agreed by all present, are circulated to governments of all FAO member countries and are made available for distribution.

FAO collaborates with other international organisations interested in veterinary problems in different parts of the world. The International Office of Epizootics, mentioned above, is an independent organisation whose work is confined entirely to veterinary matters and whose finances are provided by its 63 member countries. In addition to convening regional meetings on veterinary problems often jointly with FAO, an annual meeting is held in Paris when delegates from member countries and observers from many parts of the world attend. In addition to receiving reports of the animal disease from member countries, papers are given and discussions take place on some of the most recent research work on animal disease problems. Representatives of FAO participate fully at these annual meetings.

The OIE also collects and disseminates information on outbreaks of diseases: information is sent to interested countries whenever received, and to all other countries at short regular intervals. OIE also publishes an interesting journal bi-monthly. Research work is encouraged and is sometimes financed by OIE. A close association exists between FAO and OIE.

The World Health Organization whose headquarters are in Geneva, is interested also in veterinary work, particularly in animal diseases which may have a bearing on human health. Meetings are held from time to time when full consideration is given to the most recent available information on diseases affecting both animals and man. These are attended by experts, both medical and veterinary, in the specific subjects and the meetings form a common ground for exchange of information, following which reliable and up-to-date reports are published. Most of these meetings are arranged jointly by WHO and FAO. Milk and meat hygienes are also held with by WHO in collaboration with FAO. This collaboration is extremely valuable to both medical and veterinary services.

The Organization for European Economic Co-operation (OEEC) with its headquarters in Paris has also shown considerable interest in veterinary matters. At one time it had a Working Party on Animal Health, whose chairman was a member of the FAO staff. In addition to issuing valuable publications and producing films on some of the diseases of economic importance in Europe, it arranged meetings of veterinary representatives from European countries when the problems of animal health were discussed. FAO participated fully in these meetings. Although the Working Party on Animal Health has been disbanded, the OEEC is still much interested in veterinary activities and, undoubtedly, would again give serious consideration to calling together representatives of European countries to discuss any vital problems of animal disease which might arise.

Then, there is the International Veterinary Congresses with headquarters in Utrecht, Holland. It has world-wide country membership and a meeting is held once every four years when delegations from many countries meet and many important papers are presented and discussions on them take place. This body is supported financially by small contributions from veterinarians in the member countries. FAO is represented on the governing body and a member of the FAO veterinary staff is a member of some of the Committees.

FAO also collaborates wherever and whenever possible with organizations in the United States of America which are carrying out much good work on veterinary matters in many of the less-developed countries throughout the world: and with the Organismo Internactional Regional de Sanidad Agropecuaria (OIRSA) which works in Central America, to whose headquarters a veterinarian, appointed by FAO, is attached.

Although FAO is not empowered, generally, to engage in research, the need for such work is fully appreciated and encouragement is given whenever possible. There are a few special fellowships, recently provided, for award, under certain conditions, for research purposes : some have already been awarded to veterinarians who are working abroad.

To complete this article a few examples of the field work of FAO veterinarians may be of interest.

Rinderpest or cattle plague is one of the diseases of cattle and buffalo most dreaded in parts of Africa and the Far East. In some countries, it is always present although in a "silent" or somewhat quiescent state : on occasion, however, the infecting virus attains a high degree of virulence and the disease sweeps over districts and countries, sometimes invading several countries and causing a high death rate. In some parts of the world the disease is the cause of severe economic loss not only in animal production but also in general agriculture because at critical times there may remain no or only a few cattle or buffaloes for use in agricultural activities. From the results of research work, vaccines, the systematic use of which will prevent spread of the infection, are available. FAO veterinarians have worked in some of the infected countries, teaching the national personnel how to prepare the vaccines and advising on extensive schemes for the control of the disease ; training centres have been held where the preparation of the vaccines and their testing for efficiency have been demonstrated to groups of future workers ; equipment for the preparation of the vaccines has been supplied ; fellowships have been awarded to enable national personnel to receive instruction in the working and maintenance of the equipment. All this assistance has led to the application of control measures which are resulting in lowering the incidence of rinderpest and has already been responsible for the clearing of some large areas. With a continuation of concentrated effort by the countries concerned and full collaboration between infected countries in a region, the progress should continue until rinderpest is no longer a menace to livestock production and to the economy of countries.

FAO takes much interest in veterinary education, realizing fully that sound veterinary education is an essential requirement for an efficient veterinary service. FAO veterinarians have visited many countries for information on veterinary schools and educational systems : regional meetings have been held when the only subject of discussion has been veterinary education to meet the requirements of the region : an FAO veterinarian spent some considerable time in Calcutta, India, and following his advice many alterations were made in the veterinary college there and in teaching veterinary students : FAO has now arranged a world-wide meeting on veterinary education to be held in London in April, 1960, when it is hoped to discuss the subject in general terms and to make recommendations.

Foot-and-mouth disease continues to influence animal production in some parts of the world and to impede export and import of livestock and products of animal origin. Countries, free from the disease, impose severe restrictions which prevent or minimise the risks of introducing the infection. FAO is much concerned with the general position ; FAO veterinarians advise countries on methods of control and eradication and on legislative measures to protect countries against invasion ; world-wide meetings have been held for discussions on the conditions which might be imposed for safeguarding countries against the introduction of the disease ; the European Commission for the Control of Foot-and-Mouth Disease was set up, at the request of governments, as a unit of FAO with its own budget and is engaged in assisting European member countries in the application of measures to eradicate the disease from the country and from the whole of Europe ; FAO keeps in close touch with research workers on all aspects of the disease and makes recent information available.

Haemorrhagic septicaemia in cattle and buffaloes causes much economic loss, especially in eastern parts of the world. Having learned of some important work on the causal organism which might lead to the development of better vaccines for the control of the disease, FAO appointed a veterinarian, familiar with this work, to make further observations on the subject and to prepare and test out the value of the vaccines under consideration. All the field work was carried out in the Far East and vaccines are still being tested on an extensive scale ; the available information indicates that this newer type of vaccine is an improvement on those formerly used.

Contagious bovine pleuropneumonia is an important disease of cattle in parts of Africa, India, Australia and some few areas in Europe. Research is being pursued in different countries on improvements in the vaccines now in use for its control. FAO convened a meeting of the veterinarians interested in this subject and formed a panel composed of research workers who will meet from time to time when they will compare and discuss the results of their work and provide up-to-date information for distribution.

Brucellosis in goats and sheep continues to cause much economic loss and much human disease in some parts of the world. FAO, with the collaboration of WHO, provided some assistance for the study of suitable vaccines for the protection of goats and sheep and consequent reduction in the risk of human infections. This assistance was continued for several years and has been of much value in the development of at least two types of vaccines, both of which have given promising results in small observations and will now be tested in the field on a large scale.

The serious effects of parasitic infestations of animals on animal production are well recognized, not only because of the death rate but also because of the losses from interrupted and slow development. Different types of parasites assume higher importance in different areas. Important diseases are caused by the protozoan group of parasites which are " tick-borne ". Realizing their importance, FAO convened a meeting attended by observers from many countries and an up-to-date report was produced for distribution. Because of the complexity and extent of the subject and the amount of research and investigation work in progress, FAO has set up a panel of workers on the subject : one meeting has been held and a report from it is available. Other types of parasites have not been forgotten and FAO veterinarians have investigated and given advice on the control of parasites causing such diseases as liver fluke disease, parasitic gastro-enteritis and others in several widely separated parts of the world. In some South American countries, theoretical and practical instruction has been given on several occasions to groups of veterinarians and others.

The introduction of artificial insemination as a method of breeding has attracted the attention of those interested in livestock improvement in practically all countries and there has been much demand for technical assistance from FAO for instruction of the method. FAO veterinarians have spent long periods in some countries demonstrating techniques and advising on and assisting in the introduction of schemes ; veterinary personnel have been sent abroad to study methods in other countries. Sexual hygiene and infertility control have always been taught and dealt with side-by-side with artificial insemination and three training centres have been held in Sweden, each of some ten months' duration, when very thorough training in all these subjects has been given to groups of selected veterinarians, mostly from Near East and Far East countries. FAO also organized a meeting at which recommendations were made on the conditions for the export and import of semen.

These are examples of some of the work carried out by FAO on more specific subjects of animal health and disease control. In addition, much work of a more general nature is undertaken under the technical assistance programmes when surveys of disease are made and advice given on the more general aspects of disease control and the improvements of animal husbandry and nutrition, including necessary changes, all with the object of improving and increasing livestock production.

METEOROLOGICAL REPORT

Summary for July to September, 1960

THE MAIN feature of the weather during July was the presence of a low pressure area over Ceylon which caused widespread and heavy rain between the 15th and 19th. Due to these rains several thousands of acres of paddy in the Amparai-Batticaloa Districts were damaged and Colombo North experienced local floods with the low-lying areas going under water. On account of the associated unsettled weather conditions, fairly widespread thundery showers were experienced from the 9th to the 19th. During rest of the month, southwest monsoon weather prevailed with rain confined mainly to the southwest quarter and the central hills. Rainfall was heaviest in the southwest quarter, where there were several monthly totals of over 20 inches, while the lowest totals (totals below 5 inches) were recorded in the northern and north-western parts of the Island and at a few places in the north-central, eastern and southern provinces. Rainfall was generally above normal, the large excesses (over 15 inches) occurring in the western low-country and Monaragala area. The bigger deficits (those over 5 inches) were recorded among the central hills. There were over 30 daily falls over 5 inches, 10.85 inches at St. Joseph's College Farm, Kelaniya, on the 17th being the highest.

Monsoon conditions, with light to moderate rain in the south-west quarter, continued during August. Occasional evening thundery activity was evident in the east and north. Greater monthly totals of rainfall (of the order of 15 inches) were found along the south-western slopes of the central hills. Outside the south-west quarter, the rainfall was mostly below 2 inches, over 50 stations receiving no rain at all. Rainfall for the month was below normal practically everywhere. Bigger deficits (10 to 15 inches) occurred in the central area of the south-west quarter, while slight excesses of the order of 2 inches were recorded in Gampola area. There were no daily falls over 5 inches.

Monsoon weather continued throughout September too, with showers in the south-western parts, chiefly in the hill-country, where rainfall was experienced practically every day. The monsoon current strengthened occasionally resulting in heavier rain, particularly during the latter half of the month. This rain was heaviest on the 27th and 28th when a number of daily falls over 5 inches were recorded in the hill-country causing a few land-slides and local flooding. Scattered thunder activity was also evident on several days with fairly heavy thundershowers in the north-central and eastern areas on the 11th and 12th. Rainfall was heaviest (totals over 40 inches) on the south-western slopes of the central-hills and least in the north-western and northern coastal regions, where the monthly aggregates were less than 2 inches. About 15 stations had no rain at all. Rainfall was above normal along the south-western slopes of the central hills and in the adjacent mid-country, while elsewhere, except for a few scattered excesses, it was below normal. The higher excesses were of the order of 25 inches. The bigger deficits were of the order 5 inches and occurred in the Colombo District. There were 16 daily falls of over 5 inches, the highest being 1.33 inches on the 27th at Kenilworth Estate, Ginigathena.

D. J. JAYASINGHE,
Director.

Department of Meteorology,
Bullers Road,
Colombo 7, 31st October, 1960.

METEOROLOGICAL REPORT FOR THE QUARTER JULY TO SEPTEMBER, 1960

	JULY										
	Temperature				Humidity		Amount of Cloud	Rainfall			
	Mean Maximum	Offset	Mean Minimum	Offset	Day	Night (from Min.)		Amount	Offset	Rain Days	Offset
Anuradhapura	89·1	—1·8	74·7	—1·1	72	90	6·4	6·50	+ 5·18	11	+ 8
Badulla ..	85·2	—1·0	65·9	+1·6	70	95	6·4	3·01	+ 0·84	14	+ 7
Batticaloa ..	89·5	—2·4	76·8	—0·1	70	84	5·6	7·86	+ 6·82	11	+ 7
Colombo ..	84·9	+0·2	75·6	—1·3	76	86	6·0	18·38	+12·89	19	+ 3
Diyatalawa ..	76·7	—1·2	62·8	+0·3	72	81	6·0	5·94	+ 3·98	13	+ 6
Galle ..	82·4	—0·3	75·8	—0·8	82	88	6·3	14·98	+ 8·64	24	+ 5
Hambantota ..	86·3	—1·0	76·3	0	74	86	6·0	4·08	+ 2·07	12	+ 4
Jaffna ..	86·2	+0·1	79·5	—0·3	80	87	6·4	4·39	+ 3·84	7	+ 6
Kandy ..	81·4	+0·3	70·0	+0·2	74	87	7·1	8·52	+ 2·63	24	+ 7
Kankesanturai	89·3	—0·6	78·9	—0·2	73	86	5·9	1·85	+ 1·31	6	+ 5
Kurunegala ..	86·1	—0·2	74·6	—0·6	76	90	7·0	7·77	+ 3·89	17	+ 2
M'Illuppalama	88·4	—1·2	74·2	—0·7	70	88	6·4	8·56	+ 7·13	15	+ 2
Mannar ..	87·2	0·1	77·9	—1·2	80	91	6·4	2·67	+ 2·32	6	+ 5
Nuwara Eliya ..	65·6	+0·3	55·0	+0·1	83	88	7·3	12·75	+ 1·73	27	+ 3
Puttalam ..	86·9	+0·7	76·4	—1·8	72	84	6·4	5·16	+ 4·17	13	+10
Ratmalana ..	85·7	+1·0	76·5	+0·2	78	91	6·8	15·24	+ 9·78	20	—
Ratnapura ..	86·8	+0·2	73·3	—1·1	74	88	6·6	15·80	+ 3·03	28	+ 4
Talawakele ..	69·7	—0·5	59·9	+0·4	87	94	7·0	10·22	— 3·08	29	—
Trincomalee ..	89·9	—2·5	77·2	—0·8	67	80	6·2	6·65	+ 4·92	6	+ 3
Mullaitivu ..	90·1	—	76·1	—	71	91	5·6	3·41	+ 1·91	6	0
Vavuniya ..	89·2	—	74·6	—	66	84	6·6	5·10	+ 4·02	12	—
Katunayake ..	82·9	—	76·1	—	82	91	6·4	16·13	—	22	—

	AUGUST										
	Temperature				Humidity		Amount of Cloud	Rainfall			
	Mean Maximum	Offset	Mean Minimum	Offset	Day	Night (from Min.)		Amount	Offset	Rain Days	Offset
Anuradhapura	91·2	—0·2	75·0	—0·5	64	88	6·0	0·34	— 1·28	2	— 2
Badulla ..	88·2	+2·2	64·9	+0·4	64	94	5·6	0·65	— 2·55	5	— 4
Batticaloa ..	91·6	+1·2	77·2	+0·7	66	80	5·0	0·93	— 1·02	3	— 3
Colombo ..	85·0	+0·1	77·0	0	74	82	6·6	1·65	— 2·38	5	— 9
Diyatalawa ..	79·0	+1·1	61·8	+0·1	62	81	5·6	0·52	— 2·60	6	— 3
Galle ..	82·4	—0·2	77·2	+0·5	80	86	5·0	5·19	— 0·95	15	— 4
Hambantota ..	87·5	+0·6	77·1	+1·0	71	82	5·4	1·40	— 0·04	6	— 2
Jaffna ..	85·7	—0·3	80·0	+0·7	80	85	5·6	0·39	— 0·72	2	— 1
Kandy ..	82·1	—0·1	69·5	—0·2	70	85	6·3	1·61	— 3·13	14	0
Kankesanturai	90·6	+0·6	79·6	+0·6	70	85	5·0	0·39	— 0·87	2	— 1
Kurunegala ..	87·6	+0·8	75·4	+0·5	72	88	6·6	0·85	— 2·77	7	— 7
M'Illuppallama	90·1	—0·7	75·0	—0·2	64	84	6·0	0·06	— 1·55	2	— 1
Mannar ..	86·9	—0·5	78·7	0	78	86	5·6	0	— 0·66	0	— 2
Nuwara Eliya ..	67·1	+1·0	54·8	+0·4	79	85	6·8	6·35	— 1·16	21	— 1
Puttalam ..	87·2	+0·6	77·3	—0·6	68	82	6·5	0·05	— 0·60	4	+ 1
Ratmalana ..	85·0	0·2	78·0	+0·7	76	84	7·0	1·95	— 1·53	6	—
Ratnapura ..	87·8	+1·0	74·0	—0·2	68	86	6·2	5·81	— 5·58	21	— 2
Talawakele ..	72·3	+1·4	59·6	+0·4	85	94	6·5	8·15	— 1·93	22	—
Trincomalee ..	93·2	+1·1	78·2	+0·9	58	76	6·0	0·28	— 3·33	2	— 5
Mullaitivu ..	94·5	—	76·4	—	63	88	4·8	0·49	— 1·46	3	—
Vavuniya ..	92·0	—	74·4	—	58	86	5·2	0·71	— 1·66	2	—
Katunayake ..	85·2	—	77·5	—	79	86	6·6	1·26	—	6	—

	SEPTEMBER										
	Temperature				Humidity		Amount of Cloud	Rainfall			
	Mean Maximum	Offset	Mean Minimum	Offset	Day	Night (from Min.)		Amount	Offset	Rain Days	Offset
Anuradhapura	91·5	— 0·2	76·0	+ 1·0	62	84	7·0	0·89	— 2·87	1	— 6
Badulla ..	85·6	— 0·1	65·8	+ 1·5	66	95	6·1	1·38	+ 3·11	8	— 2
Batticaloa ..	91·1	+ 1·4	76·8	+ 0·6	66	82	5·9	3·60	+ 1·21	4	— 2
Colombo ..	84·7	— 0·7	75·6	— 0·9	78	86	6·7	4·55	— 2·29	16	— 1
Diyatalawa ..	77·1	— 0·7	62·5	+ 1·6	66	84	6·2	1·42	— 2·99	8	— 3
Galle ..	82·2	— 0·6	76·3	— 0·4	82	86	6·0	5·51	— 3·30	23	+ 5
Hambantota ..	86·2	— 0·3	76·4	+ 0·3	75	86	6·2	2·76	— 0	13	+ 4
Jaffna ..	85·7	— 0·5	79·7	+ 0·4	81	87	6·0	0·11	— 2·42	3	— 1
Kandy ..	80·2	— 2·0	70·5	+ 3·0	75	82	7·2	9·78	+ 3·80	27	+ 13
Kankesanturai	90·4	+ 0·6	79·4	+ 0·3	71	85	6·0	0·63	— 2·34	6	+ 2
Kurunegala ..	86·9	— 0·8	75·6	+ 1·3	73	91	7·5	2·22	— 3·33	19	+ 5
M'Illuppallama	90·0	— 1·2	75·3	+ 0·6	61	84	6·8	2·71	— 0·34	1	— 4
Mannar ..	86·8	— 0·9	78·8	— 0·1	78	86	6·4	0·08	— 1·16	1	— 2
Nuwara Eliya ..	63·7	— 3·1	56·0	+ 2·7	85	85	7·6	16·29	+ 8·05	25	+ 5
Puttalam ..	87·0	0	78·0	+ 0·2	68	74	7·1	0·33	— 1·25	2	— 4
Ratmalana ..	85·3	— 0·4	76·9	+ 0·5	77	88	6·9	4·33	— 2·51	19	—
Ratnapura ..	86·2	— 1·0	73·7	+ 0·2	73	88	7·0	16·82	+ 2·30	27	+ 6
Talawakele ..	67·6	— 4·4	60·0	+ 1·7	89	89	8·0	19·35	+ 9·60	26	—
Trincomalee ..	92·1	0	78·4	+ 1·3	58	74	6·4	5·56	+ 2·13	4	— 4
Mullaitivu ..	93·9	—	77·2	—	62	84	5·8	0·20	— 2·49	5	—
Katunayake ..	86·2	—	77·3	—	79	86	6·9	0·93	—	10	—
Vavuniya ..	91·6	—	75·7	—	58	82	5·9	0·96	— 2·77	4	—

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