

A STUDY OF THE GENUS *CAPSICUM*,  
WITH SPECIAL REFERENCE TO  
THE DRY CHILLI—IV\*

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(f) *Pollination and fertilization*.—It has already been shown that dehiscence of the anthers commences after the opening of the flowers, when the weather conditions become dry, sunny and warm. The pollen, however, remains in masses and becomes dislodged only when the flowers are swayed with the wind, but it is not carried very far. Wind pollination is, nevertheless, not general in *Capsicum*, and in selfing experiments, when the plants are bagged to prevent crossing, pollination does not readily take place unless the bags are shaken a few times at mid-day.

Insects are known to be attracted to the flowers, for the sake of the nectar present. Shrivastava (1916) observed the small bee (*Apis florea* F.) visiting the flowers between 7 A.M. and 9 A.M. while Harris according to Erwin (1932) reported the following insects which he considered to play some part in pollination:—The honey bee (*Apis mellifica* L.); the digger bee (*Melissodes rustica* Say.); the solitary bee (*Agapostemon virescens* F.) and the hover fly (*Eristalis latifrons*). Gopalaratnam (1933) also recorded *Apis florea* F. in addition to thrips (*Scirtothrips dorsalis* Hood), butterflies (*Papilio demoleus* L., *P. aristolochiae* F. and *Terias hecabe* L.) and the small black ant (*Camponotus compressus* F.). In Ceylon, the writer found the Dammar bee (*Melipona iridipennis* Dall.) and more commonly the ants (*Meranoplus bicolor* Guen. and *Tapinoma melanocephalum* F.) on the flowers with pollen grains on their legs.

According to Cochran (1936) hand pollination of the flowers produced no significant increase in setting compared with open pollination and he concluded that no stimulus from pollination was necessary for fruit setting. For pollination to be successful, the stigma should be receptive which only obtains when it glistens with a mucilaginous secretion over its surface.

Gopalaratnam (1933) reported that the stigma remains receptive for about 24 hours from the time of opening of the

\* Continued from *The Tropical Agriculturist*, March, 1940.

flower but produced no experimental evidence in support of the same. As judged by the glistening, mucilaginous appearance on the surface of the stigma, it remains receptive throughout the second day after the opening of the flower. An experiment was carried out to determine the period of receptivity of the stigma by emasculating the flowers before dehiscence and pollinating them 24 hours later, the plants being isolated to prevent any pollen reaching them from other plants. The results from six plants are shown in Table I.

TABLE I

Showing the effect of pollinating emasculated flowers twenty-four hours after anthesis

	Number of flowers opened	Number of fruits set	Percentage fruits set
Flowers emasculated and pollinated 24 hours later ..	366	43	31.6
Control ..	325	78	24.0

It will be seen that the stigma has not lost its receptivity a day after anthesis.

When the pollen tubes germinate on the stigma they grow down the tissues of the style, and Cochran (1938) stated that during their course down the style the generative nucleus divides and forms two microgametes. The tube passes through the micropyle and makes its way between the two synergids, coming to rest near the egg. One nucleus fuses with the egg to form the embryo while the other unites with the two polar nuclei to form the primary endosperm nucleus. After fertilization, the styles usually dry up and drop.

The period between pollination and fertilization varies with the temperature and humidity conditions prevailing at the time. Cochran (1938) observed that "after the pollen is deposited on the stigma it remains inactive for a short time under all environmental conditions". From microscopic examination of the ovaries of pollinated flowers he found that, in the case of the World Beater variety of Bell pepper, fertilization took place about 42 hours after pollination when the plants were subject to a temperature of 70 to 80° F. and to a condition of high humidity.

The interval between pollination and fertilization in the Tuticorin chilli was examined by adopting the method of severing the styles of pollinated plants about 1 mm. above the

top of the ovary at various times after pollination; and the results obtained are shown in Table II., the control being flowers with their styles uncut.

TABLE II

Showing the percentage number of fruits set at different intervals between pollination and fertilization

Number of hours after pollination before removal of style	Number of flowers opened	Number of fruits set	Percentage fruits set
1 hour	157	0	0
2 hours	202	4	2
3 "	159	7	4.4
5 "	144	20	13.8
Control	325	78	24

It will be seen that, only after an interval of about five hours, is there an appreciable number of fruits set.

There has been much difference of opinion as to whether *Capsicum* is normally self or cross-pollinated. Shrivastava (1916) reported that the percentage of natural crossing was only between 2 and 5, while Shaw and Khan (1928) found that, in the case of 96 plants subject to open pollination, about 78 per cent. were cross-pollinated. Erwin (1933) obtained a figure of 71 per cent. in a similar test but Gopalaratnam observed that, out of 32 cultures raised by him from single plants, only two showed the result of crossing. An experiment was carried out in the field by emasculating all the flowers in certain plants surrounded by others whose flowers were left un-emasculated. The percentage fruit set is given in Table III., together with a count taken from labelled un-emasculated flowers subject to open pollination.

TABLE III

Showing the percentage of fruit set in emasculated and un-emasculated flowers subject to open pollination

	Number of flowers opened	Number of fruits set	Percentage fruits set
Emasculated	1117	163	14.41
Un-emasculated	1195	410	34.30

This figure, however, does not mean that the percentage of cross-fertilization is as high as this, owing to the fact that self-pollination has been excluded. In other words, the possibility of every flower being self-pollinated instead of being cross-pollinated was not taken into account, but it indicates the extent to which cross-pollination can take place.

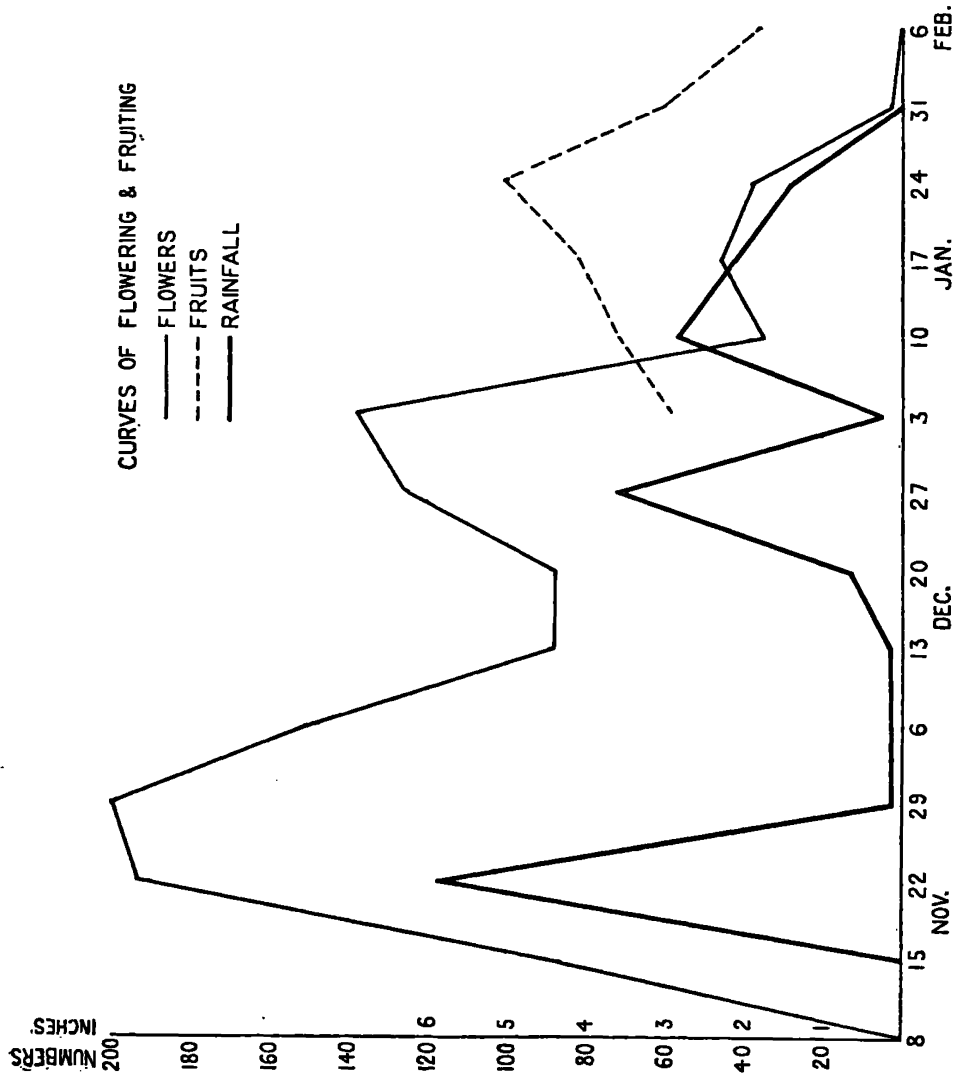


FIG. 1.

PLATE I.

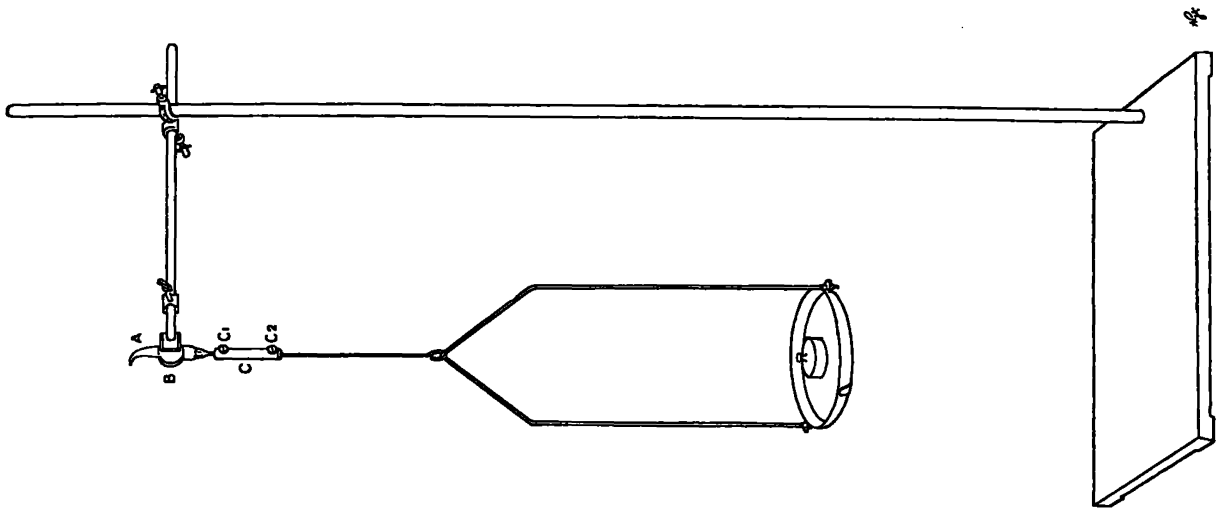


FIG. 2.—APPARATUS FOR TESTING THE BREAKING STRENGTHS OF THE PEDICELS OF DIFFERENT DRY CHILLIES.

As pointed out by Erwin (1933), in view of the fact that *Capsicum* is a nectar-bearing plant and is visited by pollen-carrying insects, cross-pollination can take place to a considerable extent. Furthermore, unless steps are taken to prevent cross-pollination, varieties exhibiting particular characters show evidence of crossing in subsequent generations when these are grown alongside other varieties, and this fact sufficiently indicates that, for practical purposes, the extent of cross-pollination can be considerable. The Bird chilli and the Chilipiquin are, however, the only peppers that do not show any evidence of natural crossing.

(g) *Flowering and setting of the fruit.*—The *Capsicum* plant undergoes considerable variation in the number of flowers which set fruit under different conditions. Gopalaratnam (1933) carried out a census of the daily production of flowers and fruits of five plants of two types in the field and he found that the percentage setting was only 5.9 and 6.9 per cent. in each case. Cochran (1932, 1936) reported the percentage fruit set to vary from 2.59 to 100 under different conditions, reference to which will be made later. The writer obtained figures which varied from 4 to 40 per cent. with different conditions and it was observed that high temperatures, low soil moisture and low atmospheric humidity were responsible for a low percentage set of fruit.

In order to ascertain whether there was any correlation between rainfall, flowering and fruiting, daily counts of the flowers and fruit produced from six Tuticorin chilli plants growing in pots were made over a period of two months, and the weekly totals are shown, along with the rainfall, in Plate I., Fig. 1. The total percentage set of fruit over this period was 35, but as the plants showed signs of wilting, when abnormal dry weather prevailed for some time, they were each watered with a gallon of water daily, in order to keep them alive. The co-efficient of correlation ( $r$ ) for rainfall and flowering was examined, and found to be  $+0.20$  with a S.E. for  $r. = \pm 0.303$ . No direct correlation between rainfall and flowering in chillies could be shown in this experiment, but it is possible that the watering may have influenced the flowering to such an extent as to prevent any statistical demonstration of a correlation between flowering and fruiting, although the curves in Plate I., Fig. 1. give some indication of a relationship between rainfall, flowering and fruiting.

(h) *The development of the fruit and seed.*—Cochran (1938) made a detailed study of the development of the fruit and his observations are summarized here. He found that after fertilization the zygote rests for 24–36 hours before division starts. The embryo sac first enlarges especially longitudinally, and

then the zygote divides twice transversely to form a 4-celled embryo, with its cells arranged lineally, as is typical of the *Solanaceae*. From the apical cell, the cotyledons are developed and from the cell below it, the hypocotyl, the initials of the central cylinder and the cortex of the root tip. The root cap primordium and the upper portion of the suspensor develop from the next lower cell and the remaining part of the suspensor from the basal cell. The two apical cells divide longitudinally and the two lower cells transversely forming an 8-celled embryo, but of 6 cells in length. The apical cells then divide periclinally to form the dermatogen outside and after transverse division of the inner group of cells, the initials of the hypocotyl and radicle are formed. The endosperm nuclei begin division well in advance of those of the embryo and soon fill the entire embryo sac. The endosperm is gradually digested but at maturity a large portion of it still remains\*. Both the endosperm and the embryo cells are well filled with reserve food. The integument becomes differentiated soon after the archesporial cell appears, and two days after pollination, the outer epidermal cells of the integument are almost isodiametric. But as the seed matures the cells elongate radially and heavy thickenings are formed on the lateral walls, reaching their maximum size about 30 days after pollination. The thickenings extend the entire length of the wall but becomes smaller towards the outer wall\*.

The period of time taken for the ripening of the fruit varies with different forms. Shaw and Khan (1928) stated that the fruit ripened in 60 to 75 days from anthesis, but give no particulars of the varieties on which these records were based. Gopalaratnam (1933) made observations on six types of chillies and found that the maturation period varies from 47 to 77 days, with a mean which varies from 51 days in the case of the Bird chilli to 60 days in the case of a variety named Yellow by him. The Bird chilli had a minimum maturation period of 47 days and a maximum of 55 days.

The Bird chilli fruit was found to reach maturity in Ceylon between 51 and 65 days from flowering with a mean of 60 days, and the Tuticorin chilli between 51 and 55 days with a mean of 52 days.

### 8. THE FRUIT AND DIFFERENTIATING CHARACTERS

It has already been stated that the fruit is the most important character for the classification of cultural varieties or forms of *Capsicum*. Considerable variation is shown in the size, shape and colour of the fruits. For commercial purposes, the fruits may be used when fully developed (a) in the unripe (b) fresh

\* *Vide* Fig. 4 in Part II. of this Paper in *The Tropical Agriculturist*, February, 1940.

ripe or (c) dried ripe stage. Tolman and Mitchell (1913) have determined the proportion of the different parts of the fruit—the pericarp, seeds and placentae, and stalks in the Hungarian and Spanish Paprika—and they obtained the following percentage results:—pericarp 55·8, seeds and placentae 36·0 and stalks 8·1.

According to Young and True (1913), the removable placentae form about 4 per cent. of the pods.

(a) *The size, shape and position of the fruit.*—The size and shape of the fruits are of value in distinguishing types, and almost every intergrade in these characters is shown from the small needle-like fruits of the Bird chilli to the large bell-shaped fruits of the variety *grossum*. The fruits may also be classed as long, medium or short. They may vary in length from about 0·9 cm. in the case of the Bird chilli to about 20 cm. in some forms of Dry and Green chilli varieties. In transverse section the fruits of different forms may be circular, quadrate, corrugated or irregularly angular.

Senathiraja (1924, 1926) stated that varieties with long fruits have a greater number of fruits per pound than small fruits, and that this is due to the fact that the long fruits contain fewer seeds per fruit and have a smaller cross section. But the size of the fruit bears no relation to the number of seeds per fruit nor to its cross section, so that the reasons given by Senathiraja for the increase in the number of fruits per pound with the increase in size of the fruits cannot be accepted. In fact from Table IV., it will be seen that the number of fruits per pound is greater with the smaller fruit varieties, *e.g.*, Wanni and Tuticorin, than with the larger fruit varieties and this can be explained solely because the longer fruits have a greater weight per fruit on account of their larger pericarp area and thickness than the smaller fruits, and hence the number of fruits per pound should be less.

TABLE IV

Showing the number of pods per pound in stored samples of different chillies

Variety	Number of pods per lb.		
	Minimum	Mean	Maximum
Wanni	1096	1152·3 ± 45	1336
Tuticorin	912	963·5 ± 58·87	1035
Chankanai	455	495·6 ± 30·2	556
Point Pedro	350	405·6 ± 42·01	435

Forms with a thick pericarp as in the case of those belonging to the variety *longum* have a smaller number of fruits per pound than similar-sized fruits with a thinner pericarp such as

occurs in the variety *acuminatum*, and forms which possess a large number of seeds will also have a fewer number of fruits per pound than those which contain fewer seeds but are of equal size and thickness of pericarp. There is a decrease in the average weight of the pods (dried fruits) and consequently an increase in the average number of pods per pound with each picking, after the first two pickings. Joachim, Harbord and Thuraisingham (1939) reported that the number of pods varies from 888 in the first picking to 1,844 in the 7th picking of dry Tuticorin chillies. This is due to the fact that there is a decrease in the size of the pods as the season advances and the plants pass their optimum growth phase.

The genetic determination of size and shape in the fruits of *Capsicum* has been studied by several workers. Webber (1912) and Ikeno (1913) found that, in the  $F_2$  generation, a continuous series of fruit sizes and shapes were obtained. Halsted (1913-16) also obtained a similar result but could not recover the parental types. Dale (1928) found that, in a cross between a short fruit variety (Coral gem) and a long fruit (Anaheim), the curves were skewed when plotted out with the class intervals of equal arithmetical magnitude, but were normal when plotted on a logarithmic basis, indicating that there are several undetermined factors for length which exert proportionate rather than additive effects and that there was no disturbing influence on dominance. Deshpande (1933), however, reports that fruit length is probably inherited on a tri-hybrid basis, with shortness as the dominant factor. He crossed a short fruit possessing a purple colour and erect position, and a long fruit with a non-purple colour and pendent position and found that these characters are linked and segregate on a 3:1 basis. Owing to the small population, the  $F_1$  individuals were intermediate, but when the  $F_2$  population was analysed segregation was found to be on a 3:1 basis. The range in variation of shapes is shown in Figs. 1 and 2 of Plate II. taken from Deshpande. Kaiser (1935b) showed that fruit size and shape are controlled by independent genetic determinations. Size is genetically determined by the interaction of a number of size genes, but is subject to considerable modification by environmental factors, the genes operating geometrically and not additively. Shape is genetically determined by the interaction between (1) factors governing relative dimensional growth rates and (2) factors governing the size of the fruit.

The apex of the fruit may be pointed, blunt or lobed with a depression. Shaw and Khan (1928) considered this to be one character for distinguishing their types, and Deshpande (1937) reported that, in a cross between pointed and blunt fruit varieties, the  $F_1$  generation was intermediate or partially pointed;

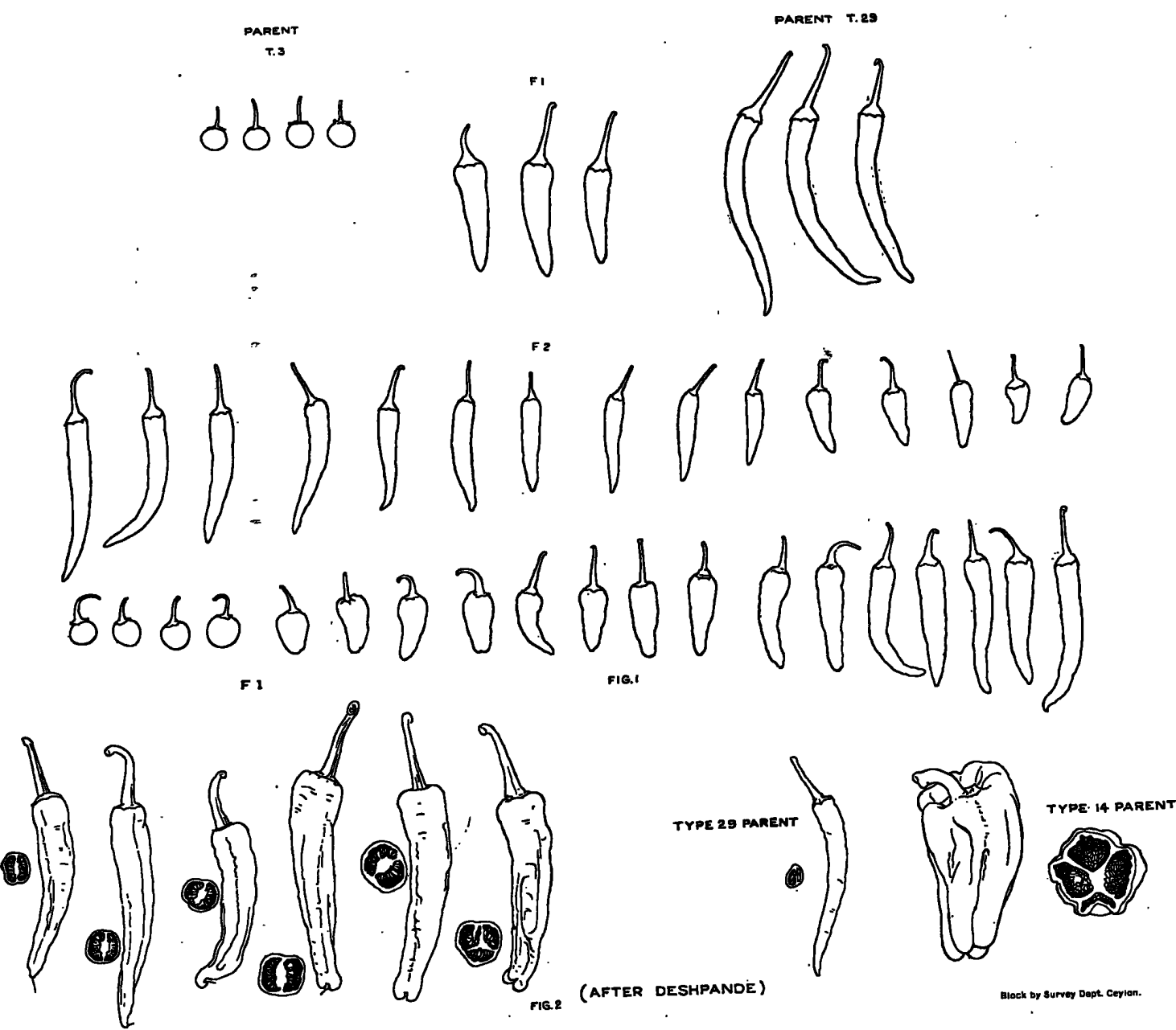


FIG. 2 (AFTER DESHPANDE)

Block by Survey Dept. Ceylon.

PLATE II.

Showing the range in shape and size of the fruits in the progeny of crosses between different varieties of *Capsicum* (after Deshpande).

Fig. 1.—Cross between a Cherry pepper and a Dry chilli.

Fig. 2.—Cross between a Dry chilli and a Bell pepper.

but owing to the difficulty of distinguishing pointed from partially pointed classes, he grouped them, in the  $F_2$  generation, into one and found segregation to be on a 3:1 basis. The  $F_3$  cultures from plants with pointed fruits proved to be heterozygous, thus indicating monohybrid segregation.

In the case of fruits with a bulged base and non-bulged base, Deshpande (1933) found  $F_1$  bulged and in the  $F_2$ , 3 bulged to 1 non-bulged. Fruits with a bulged base were observed by him to be linked with a pateriform calyx. Miller and Fineman (1938), however, did not obtain a satisfactory fit with the  $\chi^2$  test, indicating that some ratio other than 3:1 is involved in this pair of characters.

The pendent and erect position of the fruits occurs in all varieties of *Capsicum annum* L., but in *C. frutescens* L. the erect position only prevails. The inheritance of this character has been studied by Webber (1912), Ikeno (1913) and Kaiser (1935). They found that the pendent position in *C. annum* is dominant to the erect and segregation takes place in a monohybrid ratio. Kaiser's experiments indicate that the position of the fruit is determined by a genetical factor which operates through a specific geotropic growth response.

(b) *The pericarp.*—The pericarp or fruit wall varies in thickness with different forms. In the varieties *conoides* and *acuminatum*, it is generally thin; in *cuneatum*, there may be forms with a thin pericarp, e.g., Wannai or with a thick pericarp, e.g., Perfection, while in the varieties *longum* and *grossum* it is, generally, thick. In Table V., the thickness of the pericarp of certain forms in which the fruits are utilized after drying, is given.

TABLE V  
Showing the thickness of the dried pericarp of different forms of chillies

Variety	Thickness of Pericarp		
	Minimum mm.	Mean mm.	Maximum
Bird	0.10	$0.138 \pm 0.0210$	0.19
Wannai	0.10	$0.122 \pm 0.0166$	0.15
Tuticorin	0.10	$0.136 \pm 0.0216$	0.18
Chankanai	0.14	$0.188 \pm 0.0245$	0.24

Deshpande (1935) found that thickness is inherited in a simple monohybrid ratio. Among the cultivated forms, those which are pungent generally have a thin pericarp, while those which are mild have a thick pericarp. The former are used dried and the latter fresh, as fruits with a thick pericarp, when dried, shrivel and the surface becomes wrinkled.

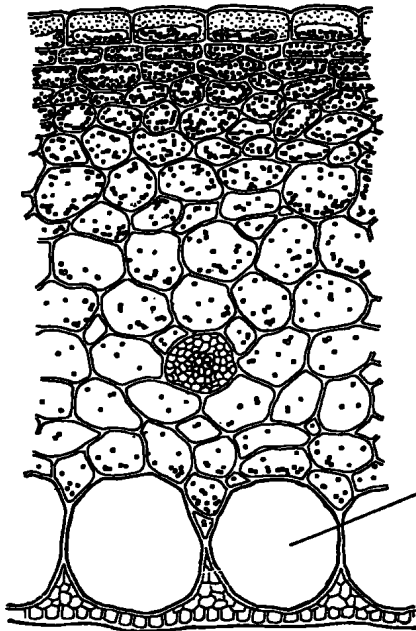


FIG. 4

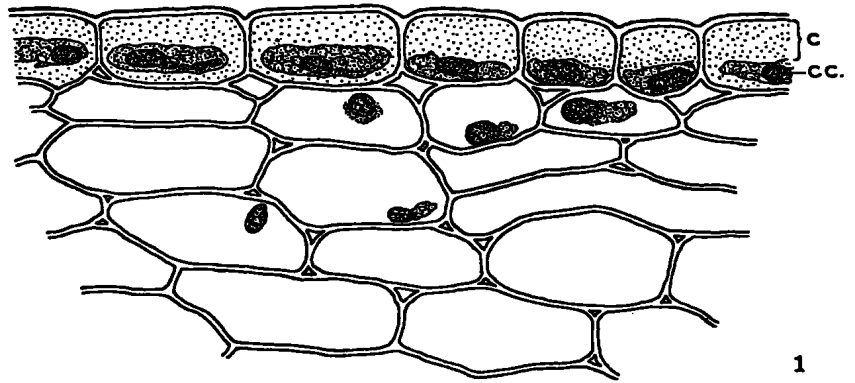


FIG. 1

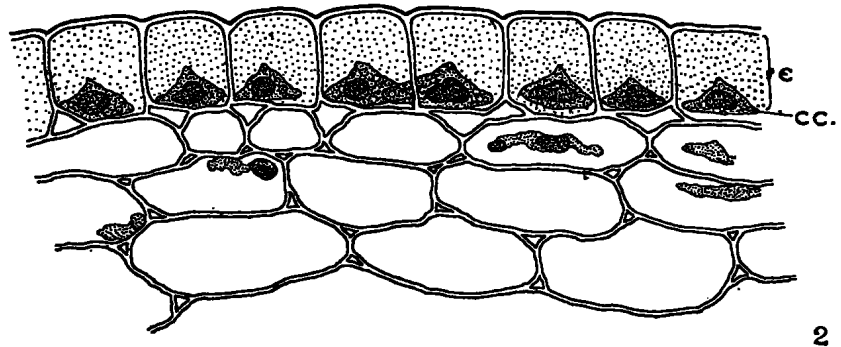


FIG. 2

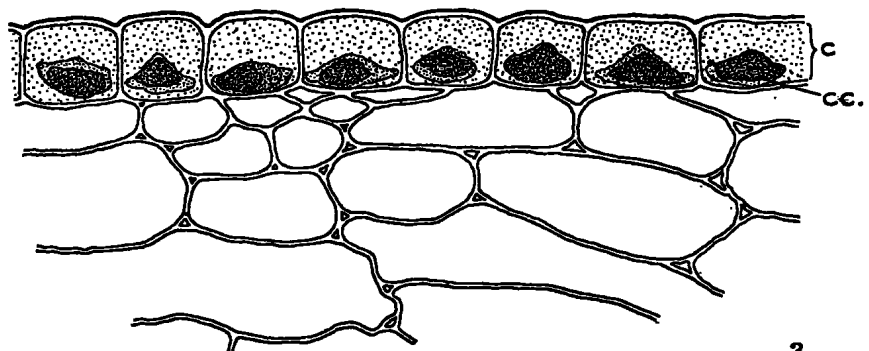


FIG. 3

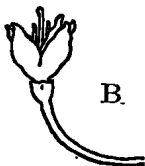


FIG. 5

Block by Survey Dept. Ceylon.

PLATE III.

- Fig. 1—Cross section of part of the fruit wall showing the epidermal cells of a glossy Tuticorin chilli pod.  
 Fig. 2—Cross section of part of the fruit wall showing the epidermal cells of a Wannu chilli pod with a dull surface.  
 Fig. 3—Cross section of part of the fruit wall showing the epidermal cells of a Tuticorin chilli pod with a dull surface.  
 C = epidermal cell  
 CC = cell contents  
 Fig. 4—Cross section of the fruit wall of the Tuticorin chilli.  
 Fig. 5—Showing stage in which flowers absciss.  
 A—World Beater  
 B—Tuticorin.

A cross section of the pericarp of a Tuticorin chilli fruit is shown in Plate III., Fig. 4. The outer epidermis consists of rectangular cells with a smooth cuticle and strongly thickened walls. The hypodermis consists of a few layers of thin-walled, rectangular cells with densely-filled chloroplasts. Beneath it are about six to ten layers of thin-walled parenchyma, while adjacent to the inner epidermis occur giant cells, the contents of which are filled with air. The purpose of these is not understood but they are probably responsible for the buoyancy of the fruits. In the larger-fruited forms, such as Elephant's Trunk and Bell peppers, these giant cells are much larger than those in the small-fruited forms. The inner epidermis exhibits small thick-walled scleranchyma abutting on the giant cells with groups of thin-walled parenchyma between the bulges of the giant cells.

(c) *The colour and lustre of the fruit.*—Most forms are green when immature, on account of the presence of chlorophyll in the outer layers of the pericarp though certain forms exist with white, greenish yellow, yellow, orange, purple or purplish-black fruits in the unripe condition. On ripening, the fruits are either red, yellow or orange, red fruit forms being the most common. The usual change of colour in ripening is from green by stages to red or orange or yellow, but there are some forms which show various gradations from the green to yellow, orange and red, all these colours being shown on different parts of the same fruit. Halsted (1918) states that this latter maturation colour display is recessive to the direct line of colour change.

The principal forms of dry chillies are red fruited, which are preferred on account of the attractive colour they impart to curries and other dishes in which chilli powder, ground from slightly roasted pods, is used. In certain parts of India, however, yellow-fruited forms are more popular because of their greater pungency (Deshpande 1933).

The Dry chilli and the forms used for canning, pickling or as paprika are, generally, of a red ripe colour, while the green chilli and the Bell peppers are consumed in the mature green stage, though Bell peppers are also sold fresh ripe along with green fruit.

Howard (1925) studied the colour pigments of *Capsicum*, and reported that in the red fruit forms the pigments are due to a mixture of carotene, zanthophyll, and carotin, while in the yellow fruits the pigment is due to carotene. The proportion of lycopersicin is much less than that of carotene in the red fruit varieties. The pigments are located in the plastids which are contained mostly in the epidermis and the first few

layers below it. This author stated that, in the process of ripening, the chromoplasts gradually elongated from an oval or subglobose shape to a much elongated spindle form in the red ripe stage. Atkins and Sherrard (1913–15) and also Halsted (1918) observed that, in the dark green fruits, the number of chloroplasts was much greater than in the light green fruits.

More recent work by Zechmeister and Von Chlonkoy cited by Thorpe and Whiteley (1935) has shown that the red colour of *Capsicum* is due to a mixture of carotene and capsanthin, a carotenoid pigment allied to carotene and present to a much greater amount than carotene. Japanese red chillies were found by these authors to contain also the alkaloid, zeanthanin. The development of the colour in the ripe fruit is, according to Thorpe and Whiteley, possibly due to gradual dehydrogenation of the parent substance during ripening.

The mode of inheritance of colour in *Capsicum* has been investigated by several workers (Webber 1912, Ikeno 1913, Atkins and Sherrard 1913–15, Halsted 1918, &c.). They are all agreed that the red colour of the ripe fruit is dominant over the yellow or orange and the green colour of the immature fruit is dominant over yellow. Dark green of the immature fruit, according to Halsted (1918), is dominant to light green, inheritance of these colours being on a monofactorial basis, but at maturity it is not possible to distinguish these two classes by their colour. Deshpande (1936) has, however, shown that the purple colour is due to two factors, one of which is a basal factor and the other an intensifying factor. The purple colour is partially dominant to its allelomorph, but in the ripe fruit, colour is determined by a single factor.

A gloss on the surface of the pericarp of cured chillies is a quality of importance in the Dry chilli, and strains which develop a glossy surface on curing command a better price in the Ceylon market as a Dry chilli than those which are dull in appearance. In order to ascertain the cause of glossiness on the surface of the pod, microtome sections of the epidermis and the first few layers of the pericarp were prepared of the following chillies :—

1. Tuticorin.—strain with glossy pericarp.
2.        ,,     —strain with dull pericarp.
3. Wannu   —strain with dull pericarp.

The sections were cut 10  $\mu$  thick and stained in Erlich's haematoxylin and also in Gentian green. Examination of the sections showed that the difference in lustre was associated with the difference in the shape of the epidermal cell contents (Plate III., Figs. 1–3). In the glossy Tuticorin chilli, most of the cell contents are almost rectangular whereas in the dull strains of

Tuticorin, and the Wanni chillies, there is a larger number of somewhat pyramidal-shaped cell contents. In the case of the rectangular-shaped cell contents, the reflecting surface below the cuticle is a plane, whereas in the pyramidal-shaped cell contents, the surface is somewhat papillose, and, therefore, a certain amount of scattering of the light rays takes place. No differences in the cuticle could be observed, nor in the fat content of the pericarps shown by the following figures obtained from samples of 100 pods of the glossy Tuticorin and Wanni chillies.

	Total ether extract.
Tuticorin glossy	5.36
Wanni dull	5.44

There are no oil glands in the pericarp which may account for differences in glossiness, and a possible explanation lies in the physical effect caused by the reflection of light as a result of the particular shape of the epidermal cell contents. Counts were made of the number of rectangular- and pyramidal-shaped cell cavities in the epidermis of the glossy Tuticorin, dull Tuticorin and dull Wanni pericarps and the results are shown in Table VI.

TABLE VI

Showing the percentage of rectangular-shaped cell contents in the epidermis of the pericarp of glossy and dull chillies

Strain	Pyramidal Cell Contents	Rectangular Cell Contents	Total	Percentage Rectangular
A. Tuticorin glossy	79	240	319	75.23 ± 2.4
B. Tuticorin dull	207	68	275	24.73 ± 2.6
C. Wanni dull	254	70	324	21.61 ± 2.3

For  $n = 99$  and  $P = .01$ ,  $t = 2.576$ .

S.E. of the difference between A and B (50.63 per cent.)  
= ± 3.55 per cent.

S.E. of the difference between A and C (53.63 per cent.)  
= ± 3.33 per cent.

S.E. of the difference between B and C (3.12 per cent.)  
= ± 1.1 per cent.

These results show that glossy pods have a significantly higher percentage of rectangular to pyramidal cell contents in the epidermis.

(d) *The breaking strength of the pedicel.*—A persistent pedicel is a desirable feature of the Dry chilli the pods of which are sold with their pedicels attached and their seeds intact. A certain amount of breakage does, however, occur in storage, and forms differ in the percentage of stalkless pods present after a certain

period of storage. Chillies having a high percentage of pods with their pedicels intact command a better price than those which, in storage, possess a large number of stalkless pods, and it is generally recognized amongst condiment dealers in Ceylon that the Tuticorin chilli is superior to other dry chillies in this respect.

A persistent pedicel is a genetic character according to Halsted (1912), who found that, in crossing a small fruit variety with erect and easily detachable pedicels and forms with pendent, elongate fruits but more or less persistent pedicels, the former type was dominant to the latter.

In order to ascertain the breaking strengths of the pedicels in different Dry chillies, the pedicels were individually subject to a vertical force and the weight required to sever them from their pods recorded. The apparatus used is shown in Plate I., Fig. 2. A pod (A) is clamped in the inverted position about  $\frac{1}{2}$  cm. above the calyx between two cork discs (B) and the pedicel is inserted at one end of a metal socket (C) and fastened by tightening the screw ( $C_1$ ). At the other end, a wire of about  $\frac{1}{10}$  in. gauge attached to a pan is inserted and tightened by means of the screw ( $C_2$ ). Weights are then added to the pan until the stalk is severed from its pod. The detached stalk is then removed from the socket and another pod clamped into position and inserted into the socket. Using 100 pods for each variety, the mean breaking strength in grams for different forms is given in Table VII.

TABLE VII

Showing the mean breaking strengths of the pedicels in different chillies

Variety	Mean breaking strength of pedicel in grams
A. Wanni	474 $\pm$ 201
B. Atchchuvvely	589 $\pm$ 252
C. Chankanai	681 $\pm$ 338
D. Tuticorin	847 $\pm$ 310
Difference between D and A	373 $\pm$ 369

Owing to the high standard errors obtained for the mean breaking strengths of the pedicels in each form, it is not possible to demonstrate any significant differences between them, although considerable differences in the means exist, between such forms as the Wanni and the Tuticorin.

#### 9. FACTORS AFFECTING GROWTH, FRUITING AND RIPENING

Growth and yield which is a measure of the fruiting capacity of the plant are dependent on the factors of nutrition, temperature, soil as well as atmospheric moisture, and light, apart from the internal heritable factors which are responsible for yield differences

between strains produced under identical growth conditions. Both these sets of factors not only influence the production of flowers but also the setting of fruit, reference to which has already been made, and in this section attention will be directed towards the effect of the environmental factors of nutrition, temperature, moisture and light on the production of flowers and the setting of the fruit in the genus.

(a) *Nutrition*.—Several workers have indicated the importance of nitrogen in the nutrition of the chilli plant. Stuckey and McClinton (1921) found that nitrogen increased plant growth and fruit production, although there was greater susceptibility to blossom end rot. Lloyd (1926), however, found that in trials with different forms of Bell peppers carried out over a period of 5 years, nitrate of soda, applied at the rate of 1 oz. per plant in 2 applications of  $\frac{1}{2}$  oz. each—the first about a month after planting out and the second three weeks later—had no effect in increasing yield. He also reported that bonemeal at the rate of 2 oz. per plant after planting out gave no response. Lloyd's experiments were not subject to any statistical analysis and no definite conclusions can therefore be drawn from them.

Cochran (1936) working with World Beater plants in pots, found that high nitrogen significantly increased the number of blossoms formed and the number that set fruit, the increase being greater at temperatures of 70° to 80°F. than at 60° to 70°F. There was, however, little effect on earliness of bud formation or anthesis, although vegetative growth was better. Nitrogen was given at intervals of 10 days by adding 100cc. to each plant of a solution of nitrate of soda at 1 oz. per gallon of water.

Under field conditions Joachim and Paul (1938) examined the effect of fertilizers in increasing the yield of Tuticorin chillies at two centres in the dry zone of Ceylon. They found that nitrogenous fertilizers at 20 lb. and 40 lb. N per acre gave significant fresh weight increases, which varied from 8 to 18 cwt. per acre at one centre and 12 to 37 cwt. per acre at the other centre, over the unmanured plots which yielded 23·9 cwt. and 31·6 cwt. per acre respectively. These fertilizers, particularly sulphate of ammonia, showed a tendency to induce early bearing. Phosphorous and potash, however, when included in a mixture with nitrogen had no effect in increasing yield nor did farmyard manure used alone or in conjunction with the fertilizers at 3 tons per acre, possibly because this quantity was inadequate.

A further experiment was carried out by Joachim, Harbord and Thuraisingham (1939) using single and double dressings of nitrate of soda at 133 lb. per acre (=20 lb. N per acre) for the single dressing and they obtained an average fresh weight

increase of 10·2 and 18·8 cwt. per acre respectively over the unmanured plots which gave a mean of 37·8 cwt. per acre. These increases proved to be highly significant and on the basis of a dry weight outturn of 30 per cent. the increases are equivalent to 3 and 5·5 cwt. per acre respectively of dry chillies. In this experiment, however, nitrogen appeared to delay bearing.

(b) *Temperature*.—The Bird chilli does not develop freely in temperate climates, and even if grown it is reported that it does not ripen or set seed as in the case of other varieties. On the other hand, the more highly developed forms of Bell pepper fare better in temperate climates with a growing season temperature range of 60—70°F., than under tropical conditions, where the temperature range may be from 70° to 100°F. in the shade.

Cochran (1936) carried out studies with the World Beater pepper and found that, of the four ranges of temperature, *viz.*, 50–60°, 60–70°, 70–80° and 90–100°, maximum growth occurred at 70–80° temperature range. The plants were dark-green in colour, stocky and much branched. At the higher temperatures, the root system was poorer and it is possible that, with the smaller root system, water absorption is reduced while transpiration is greater. With these conditions of lower water absorption and greater transpiration and also an increased respiration, carbon assimilation and hence growth becomes reduced, as seen in the smaller fresh weights of the plants recorded by Cochran. He also found that early blossoming and maturity of fruit are favoured by high temperatures, but from the point of view of setting of fruit, with the exception of the lowest temperature range (50–60°F.), the higher the temperature, the lower the setting of the fruit. At 60–70° the percentage of blossoms that set fruit is 73·53 and at 70–80°, 44·26 and at 90–100°, 0. At the highest temperature (90–100°F.) no fruit set because the buds and flowers that formed continually abscised. At blossoming time, if the plants are shifted from 90–100° to 50–60°F. there is an increase in the percentage of fruit set from 0 to 99·3, while the shift from 70–80° to 50–60° increased the set from 43·32 to 98·7 per cent. Cochran also attributed the abnormalities in the flower and fruit of *Capsicum* to high temperatures.

(c) *Moisture*.—The moisture content of the soil has an important effect in the growth and yield of *Capsicum*. The crop does well when it receives an ample but well-distributed supply of moisture. In U.S.A. *Capsicum* is reported to be more drought resistant than either the egg plant or tomato (Beattie and Doolittle 1937), but according to Garcia (1921) it is not grown under dry farming conditions in New Mexico (the average annual rainfall varying between 8 and 20 ins.) because the rainfall there is inadequate for chillies. Lloyd (1926) reckoned that,

over a period of 5 years, the yields of pepper can be increased by about 15 per cent. by irrigation. In India and Ceylon, where chillies are grown both with and without irrigation, much higher yields are obtained under irrigated conditions. The crop is generally irrigated in Western India (Bhartarkar 1912) while in the southern part of South India it is grown under irrigation and in the northern part as a dry crop (Gopalaratnam 1933A). In Ceylon, the crop is irrigated in the north of the Island (the Jaffna Peninsula), but is grown under rain fed conditions elsewhere in the dry zone, and the yields obtained in the former area are almost double those in the latter.

Cochran (1936) found that high soil moisture hastens bud formation, anthesis and setting of fruit, while excessive transpiration increases blossom drop, though at a temperature of 90–100°F., and even high soil moisture, no blossoms set fruit.

(d) *Light*.—The effect of the length of day on growth, flowering and fruit setting in peppers has been investigated by Auchter and Harley (1924), Deats (1925) and Cochran (1938). With seven or fifteen hours of sunlight daily, there was no difference in flowering according to Auchter and Harley, but with longer illumination the plants took more time to reach the flowering stage. They also found that the intensity of illumination had no effect on the time of flowering, for plants grown in diffuse light under cheese cloth shade, blossomed at the same time as those which received full sunlight.

Deats (1925) exposed Bell peppers to three different lengths of day during the winter, the plants being grown in the green house under similar conditions of temperature, humidity, &c. In the short day 6½ hours illumination was provided, in the long day 17½ hours, while the controls were subject to the normal length of day (10 hours) from November to April. She found that the rate of growth as measured by the height and diameter of the stems and the size and thickness of the leaves was directly proportional to the length of the day. With the short day plants, which were pale in colour, no flowers were produced, but there were more flowers and fruit in the controls than in the long day plants, although there was no difference in the time of flowering between the controls and the long day plants.

Cochran (1936) subjected World Beater pepper plants to the normal length of day (10 hours) from December to April in U.S.A. and to a long day period (14 hours). He found that growth was more rapid and the time of flowering about 10 days longer than in the long day period. There was also a significant

decrease in fruiting in the long day period (14·04 per cent. at 70–80°F.) confirming the results of the previous workers that peppers require a moderately short day for fruiting.

Light apparently has little effect in inducing ripening of the fruit. An experiment was carried out using 24 fruits each of light-green and dark-green fruited strains of the Elephant's Trunk chilli, the fruits being picked when they were just beginning to turn colour. Half of each of these two varieties was placed in total darkness and the other half in diffused light on the laboratory table. The number of days taken for each fruit to turn completely red was recorded and the results are given in Table VIII.

TABLE VIII

Showing the mean number of days taken for the ripening of the fruits of the Elephant's Trunk chilli in light and darkness

Mean Number of Days			
Strain A—Light Green		Strain B—Dark Green	
Light	Darkness	Light	Darkness
6·5	7·83	5·33	5·92
t = 0·80		t = 0·76	
When n = 22 and P = ·05		t = 2·07	

The differences are, therefore, not significant.

*(To be continued.)*