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

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4. TYPES OF ECONOMIC IMPORTANCE

FOR commercial purposes, the varieties of *Capsicum* of economic importance may be divided into the following types :—

(*a*) The Bird chilli
(*b*) The Dry chilli
(*c*) The Green chilli
(*d*) Pimento
(*e*) Paprika
(*f*) Bell pepper.

While all these names do not signify particular varieties, they each indicate special commercial types.

(*a*) *The Bird chilli.*—This comprises the small but highly pungent fruits of oblong-conical shape belonging mostly to *C. frutescens* L. var. *minimum.* A few small-fruited forms of *C. annum* L. var. *conoides, e.g.*, Tabasco ; var. *acuminatum, e.g.*, Nepaul pepper and var. *longum e.g.*, Japanese chillies are included in this class. They are used commercially, after drying, for pharmaceutical purposes and in the preparation of sauces and Cayenne pepper.

(*b*) *The Dry chilli.*—This is really the variety *acuminatum* in which slender fruits with a fairly thin pericarp are used, after drying, as an ingredient of curry powder. But forms of *longum* and *cuneatum* with fairly thin pericarps are also used in the East as Dry chillies, though they do not command the same high quality as those of the variety *acuminatum.*

(*c*) *The Green chilli.*—This belongs typically to the variety *longum,* in which medium-sized pungent fruits with a thicker pericarp than in types (*a*) and (*b*) are used in the fully developed but green stage for seasoning

* Continued from *The Tropical Agriculturist,* January 1940.

dishes and pickles and as a vegetable in curries. Forms of *acuminatum* and *cuneatum* are, however, also used, part of the crop being picked green and part red ripe for drying.

(*d*) *Pimento.*—This is usually a highly-developed form of the variety *cuneatum*. The fruits have a fairly thick pericarp, with a smooth external surface and are non-pungent. They are used for canning.

(*e*) *Paprika.*—This is an elongated medium-sized fruit of the variety *longum* with a thick pericarp and is mildly or non-pungent. When ground it constitutes the paprika of commerce.

(*f*) *Bell pepper.*—This is a large, non-pungent fruit with a thick pericarp of the variety *grossum*. It is usually used as a vegetable in salads.

(*a*) *The Bird chilli.*—The dried fruits of Bird chillies, owing to their extreme pungency, have long been in demand in Europe and the United States of America for pharmaceutical purposes and are thus exported from Africa, Zanzibar, and Japan. They are also used in the preparation of Cayenne pepper. The true Bird chilli (*C. frutescens* L. var. *minimum*) grows in a semi-wild condition in tropical countries and is not usually cultivated. In Ceylon it commonly appears on newly-burnt jungle-land along with castor, the seed being disseminated with the droppings of birds. The ripe fruits are readily eaten by birds and collection becomes difficult. The fruits are too small and somewhat too pungent while they also lack colour and flavour to be in much demand in the East as a dry chilli for the preparation of curry powder. They are slender, oblong-conical in shape and two-celled. They vary in length from about 12 to 25 mm. and in breadth from 3 to 7 mm. at the widest part. The calyx is cup-shaped and the base of the fruit is compressed. The pedicels are slender, stiff and straight, varying in length from 19 to 30 mm. The pericarp is glabrous, somewhat wrinkled, translucent and leathery. The fruits are always erect and when dried become easily detached from their stalks. The number of seeds varies from 10 to 21 and they are attached to a reddish placenta.

The following are the chief forms of Bird chillies known in the export trade in Europe and the United States of America :—

1. *African chillies.*—These are the most pungent forms exported to Europe and the United States of America, and are usually designated in the trade by the name of the port from which they are shipped. They are largely employed in pharmacy in contrast to the Japanese chillies which are more favoured for culinary use.

There are two forms of African chillies which belong to the var. *minimum*, *viz*, Sierra Leone and Nyasaland. The former are the most pungent chillies known and are grown in the Niger River region of British West Africa. The fruits are slender, from 10 to 15 mm. long, light-red in colour and the stalks are reported to be occasionally present in the consignments of dried pods. The number of seeds varies from 9 to 21.

Nyasaland chillies closely resemble those from Sierra Leone, but are of a brighter red colour which is retained longer in storage. They come from a territory near Lake Nyasa and are shipped from Mombasa being sometimes referred to as Mombasa chillies.

2. *Zanzibar chillies.*—The fruits also belong to the var. *minimum* but are broader and usually duller in colour than the African chillies. They vary in length from 10 to 20 mm. (Tolman and Mitchell 1913) and usually contain more stalks than the Sierra Leone chillies. The number of seeds varies from 8 to 15 per fruit.

3. *Japanese chillies.*—These are the small-fruited forms of *C. annum* L. vars. *acuminatum* and *longum*. They resemble the African chillies but are somewhat larger measuring 10–40 mm. long (Jones 1938). They are brighter red in colour than the African chillies and have a glossy surface. The pods are received without their pedicels and the number of seeds varies from 13 to 49 per fruit. These chillies are less pungent than the African or Zanzibar chillies but are valued for their bright red colour.

(*b*) *The Dry chilli.*—In England and the United States of America, the Dry chilli is also referred to as Cayenne pepper and Finger peppers. In the tropics, it is the most important type of *Capsicum* and is employed as a common ingredient in the preparation of curries, after the pods are lightly roasted and ground to a powder. Whole pods are also used to season curries and other highly-spiced preparations in the East.

In the Dry chilli, quality is a factor of importance. It depends on a high degree of pungency, a good flavour, a medium-sized fruit with a moderately thin pericarp, a bright red colour, a smooth glossy surface and a firm pedicel. Medium-sized pods of about 5 to 7 mm. in length are preferred to long pods, owing to the fact that in storage they remain intact better than longer pods which tend to break at the distal ends. A fairly thin pericarp or fruit wall is necessary, as its moisture content is lower than that of a thick pericarp and drying is more quickly accomplished. When dried, fruits with thick

pericarps show a wrinkled surface and present a dull appearance. A Dry chilli with a bright red colour commands a better price than those which are dull red or even orange or yellow in colour. Red chillies impart an attractive colour to curries prepared from the ground pods. Deep red pods retain their colour in storage for a longer period than those which are of lighter hue. In storage, there is always a certain number of pods with detached pedicels. Unlike the fruits of the Bird chilli which are sold without their pedicels, the Dry chilli fruits should have their pedicels intact so that the seeds may remain within the pods. In the Bird chilli, the base of the fruit is compressed and so the seeds do not readily drop out from the fruit when their pedicels are removed. There is a considerable loss in weight if dried chillies are sold without their seeds. A firm pedicel is, therefore, a desirable feature in the Dry chilli and forms vary in the degree of persistence of their pedicels.

1. *Varieties of the Dry chilli grown and imported into Ceylon.* There are several forms of the Dry chilli which are grown in, as well as imported into Ceylon. The Dry chilli in Ceylon is only grown in areas known as the dry zone, owing to the fact that the crop cannot be easily cured in the wetter regions of the Island. In most parts of the dry zone, the *wanni* (Fig. 1, No. 5), though a form of the variety *cuneatum*, was until recently the commonest Dry chilli. It is grown without irrigation in *chenas* (shifting cultivation), with little or no attention. It appears to be a degenerate form on account of the small size of its fruits whose length and breadth measurements are shown in Table I., along with those of the Ceylon Bird pepper and the Tuticorin, which is held to be the best Dry chilli in Ceylon.

TABLE I.

Showing the Pod Measurements of the Bird, *wanni*, and Tuticorin Chillies in Ceylon.

		Minimum cm.	Mean cm.	Maximum cm.
Bird	Length	0·9	1·056±0·126	1·2
	Breadth	0·3	0·37 ±0·04	0·4
Wanni	Length	1·5	2·14 ±0·416	2·9
	Breadth	0·9	1·204±0·196	1·8
Tuticorin	Length	5·2	6·324±0·765	7·7
	Breadth	0·9	1·12 ±0·199	1·3

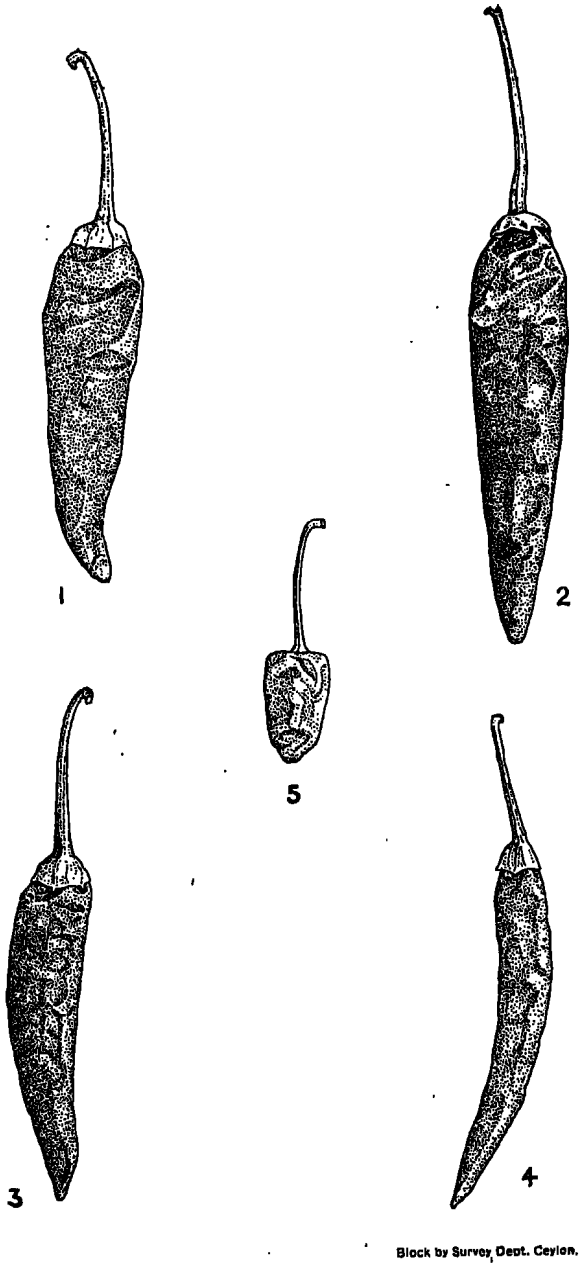

FIG. 1.—THE DIFFERENT FORMS OF DRY CHILLIES GROWN IN CEYLON ($\times \frac{2}{3}$)

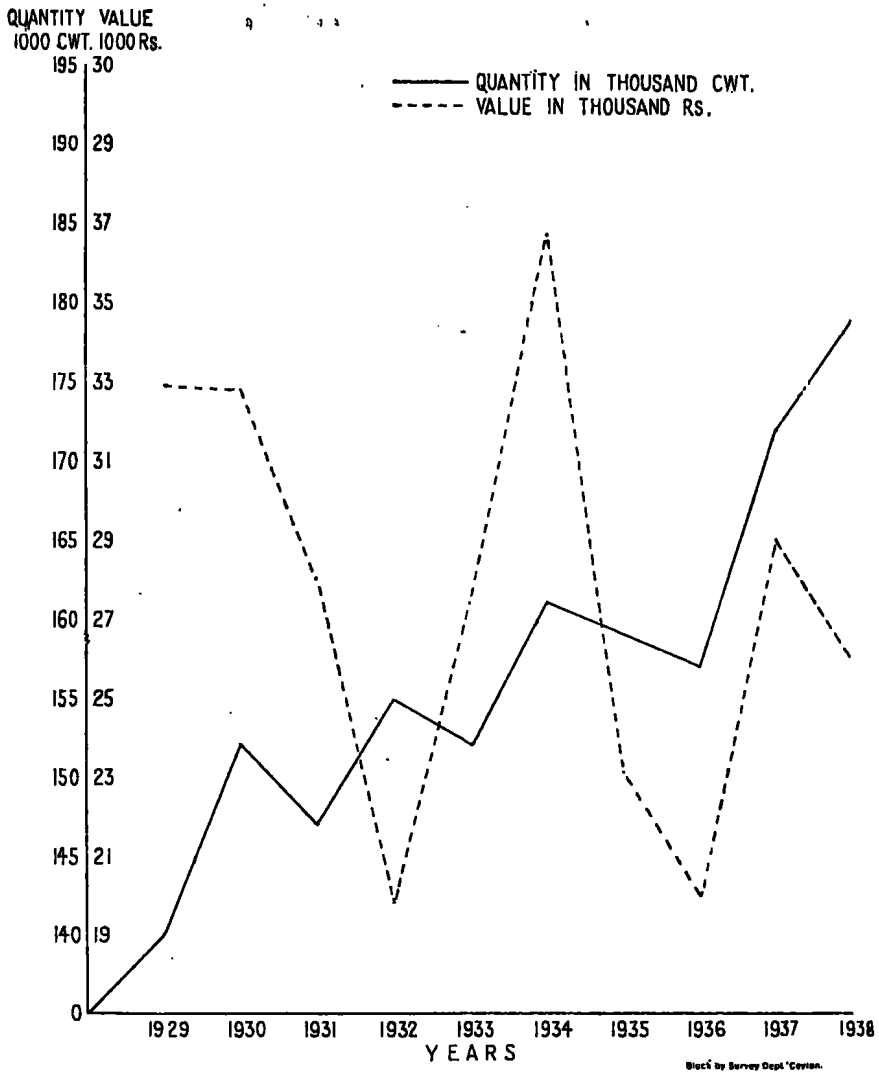

FIG. 2.—CURVES SHOWING THE IMPORTS OF DRIED CHILLIES IN QUANTITY (CWT.) AND VALUE (RS.) TO CEYLON

The *wanni* chilli has been popular largely because it is reputed to grow better than other varieties under the conditions prevailing in *chenas*, where little or no attention is paid to the crop after it is sown.

In the northern part of Ceylon—the Jaffna Peninsula—where a well-irrigation system prevails, there are under cultivation several forms of the Dry chilli, chiefly of the var *acuminatum* which are known, generally, by the chief places around which they are grown. The important forms are var. *acuminatum*—Chankanai and Atchchuvely (Fig. 1, Nos. 1 and 3) and var. *longum*—Point Pedro (Fig. 1, No. 2).

Within the last few years, the Tuticorin, which is regarded as the best quality imported chilli, has proved to be a successful introduction both in the *chena* areas as well as in the Jaffna Peninsula. Not only is the high quality of the imported product maintained but the crop bears well and it is, therefore, replacing quickly all the local varieties of the Dry chilli grown in Ceylon.

In spite of the fact that a considerable quantity of dried chillies is raised annually in Ceylon—unfortunately no local figures of acreage or production are available—there is a large import trade in this condiment. The quantity and value of dried chillies annually imported into Ceylon from 1929 are shown in Fig. 2 and it will be observed that there is a gradual increase in the quantity but not in the value of the product imported.

The following is a list of the varieties known by their trade names in Ceylon, which are imported at various times of the year.

Indian		Other countries.
Patna	..	Singapore
Gujerati	..	Rangoon
Nalchatty	..	Japan
Muladi	..	Java
Tuticorin	..	Hongkong

These are all cultural forms of the var. *acuminatum* with the exception of Rangoon chillies. The first four varieties come from Bengal and are also referred to as Calcutta chillies. The Patna variety is the first to arrive in the year, and continues up to about March. The Gujerati follows next from about the end of January until April. Then comes Nalchatty from about May and after that Muladi chillies from about July until about the beginning of September after which a scarcity of Bengal chillies is felt on the market. From then, shipments are sometimes received from Rangoon and even Java, but the largest consignments come from the port of Tuticorin in South India, from which the name "Tuticorin chillies" is derived.

1. *Patna and Gujerati.*—The Patna chillies are reported to come from the districts of Patna and Allahabad in India. The pods (Pl. I., Fig. 3, No. 11*) though bright red in colour are too long. The Gujerati (Pl. I., Fig. 2, No.1*) is a small pod and is grown in the Patna district.

2. *Nalchatty and Muladi.*—These chillies are reported to be grown in the Barisal district along the eastern coast of India. The Nalchatty (Pl. I., Fig. 3, No. 6 *) is a shorter and stouter chilli with a brighter red colour than the Muladi (Pl. I., Fig. 3, No. 5 *). It also has fewer seeds than the latter and the pedicels break away more easily from the pericarp. But both lack the pungency and flavour of the Tuticorin chilli.

3. *Singapore.*—These chillies are grown in Siam and are shipped from the ports of Bangkok and Singapore. (Pl. I., Fig. 3, No. 9 *). They lack the colour and pungency of the Tuticorin.

4. *Rangoon.*—These are small chillies grown in Burma and exported from Rangoon. (Pl. I., Fig. 6, No. 5 *).

5. *Japan.*—Long chillies of medium pungency grown in different parts of Japan are occasionally received in Ceylon. (Pl. I., Fig. 3, No. 7 *).

6. *Tuticorin.*—As stated previously, the Tuticorin is the most important Dry chilli imported and introduced into cultivation in Ceylon. It is grown in the Tinnevelly district of South India, where there are two forms known as Sannam or Samba and Gundu. The former has a slender, medium-sized fruit (Pl. I., Fig. 3, No. 1 *) while the latter has a much shorter conical-shaped fruit (Pl. I., Fig. 6, No. 6 *). In this paper, the form with longer fruits will be referred to as Tuticorin. The Gundu sometimes comes into Ceylon from about the middle of August, while the Tuticorin is, generally, received from about September until the end of December. The size of the Tuticorin pod (Fig. I., No. 4) is given in Table I. It has a bright red colour (Nopal red—Ridgway colour standard) with a smooth surface and is the most pungent of all the imported chillies. It gives a good flavour to curries and other preparations made from it and it possesses a firm pedicel. A strain of this chilli has been developed with a high lustre. For these reasons, it commands the highest price in the Ceylon market.

(*c*) *The Green chilli.*—Certain chillies are grown, particularly in the wet zone regions of the tropics, in which the fully developed green fruits are used when fresh for seasoning foods and as a vegetable. In New Mexico, according to Garcia (1908) the

* See Part I. of this paper in *The Tropical Agriculturist*, January, 1940.

fruits are also used for canning. The fruits of the Green chilli vary in length and are, generally, stout and fleshy, owing to the presence of a thicker pericarp than in the Dry chilli forms.

This stype of chilli does not generally meet with a sufficient demand in Ceylon and the East to be of wide commercial importance owing to the fact that it cannot be stored for long without deterioration; it is, therefore, grown largely in the neighbourhood of market centres. Green chillies give a higher yield than fresh red chillies and villagers in Ceylon, generally, prefer to raise green chillies if prices are satisfactory. The sale of green chillies provides the growers with a small but more regular income from their crop, than from dried chillies. Production, however, must necessarily be limited as any extension in cultivation may result in overproduction and consequent fall in prices to an uneconomic level.

The typical Green chilli (Pl. II., Fig. 2, No. 2 *) in Ceylon is a form of the variety *longum* with a medium-sized stout fruit, a fairly thick pericarp and a high degree of pungency. This is the chilli which can be grown successfully in the wet zone areas; if, however, it is allowed to ripen and is then dried, the surface becomes wrinkled. In the dry zone, however, certain forms of the var. *acuminatum* can be used both as a Green and a Dry chilli, and, therefore, part of the crop is picked green and part ripe, although from the point of view of quality, as a Green chilli, these forms do not compare so favourably with the stouter fruits of the var. *longum*. The stage in which the Green chilli is picked can be recognized by a gloss on the surface of the fully-developed fruits, which when firmly pressed between the fingers yield a slight crackle.

Forms of the var. *longum* with much larger fruits (Pl. II., Fig. 1, No. 7) are also popularly grown, particularly in the wet zone, as a vegetable and are known locally as capsicums on account of their large size. They are, generally, mildly pungent and are eaten cooked whole or stuffed with chopped meat in curries. The Elephant's Trunk (Pl. II., Fig. 1, No. 7 *) is the commonest form cultivated in Ceylon.

(*d*) *Pimento*.—The term *Pimento* is now generally used, particularly in U.S.A., for canning peppers. Erwin (1932) states that according to a communication received by him from Knight, the term was acquired in connection with canned peppers imported from Spain into U.S.A. (*Pimento* being Spanish for pepper) and referred chiefly to conical-shaped fruits with a very thick pericarp. He adds that the anglicized form Pimento should be used for this type of pepper instead of the allspice (*Pimento officinalis*) on the grounds of priority, and the name

* See Part I. of this paper in *The Tropical Agriculturist*, January, 1940.

allspice retained as the common name for the latter, and that the term now refers to forms of two varieties of peppers, *viz.*, var. *cuneatum* with large conical-shaped fruits (Pl. I., Fig. 2, No. 17 *) as exemplified by the form Perfection and var. *oblatum* with oblate-shaped fruits, an example of which is Sunnybrook (Pl. II., Fig. 3, No. 5 *). The conical-shaped fruits of such forms as Perfection and Sweet Meat Glory are, however, gaining more favour as a canned pepper of the Pimento type, than the oblate-shaped fruits. The pimentos have a thick pericarp, which is quite smooth, and a tough epicarp which can be easily peeled off after scalding. In New Mexico, an improved variety of the native chilli known as No. 9 was made by Garcia (1921) for canning purposes. The native chillies there are irregular in form, more or less wrinkled, with a thin pericarp and a depression at the calyx end. The improved variety was bred for the purpose of having a smooth, fleshy, tapering, and shoulderless fruit which reduces peeling costs prior to canning.

U. S. A. is now the chief country which undertakes canning of peppers and in Georgia State alone over 15,000 acres are under cultivation supplying 10,000 tons of peppers to the canneries. In middle Georgia, there is a cannery operating with a capacity of 150-200 tons of Pimento per day of 10 hours.†

(*e*) *Paprika.*—True Paprika of the highest grade is produceg only in the southern part of the great plain around the districts of Szeged and Kalocsa in Hungary and is of a bright red colour, slightly pungent as well as sweet and very aromatic. The paprika grown in Szeged district is different in aroma to that from the Kalocsa district, owing to differences of soil and climate (Redgrove 1934). Paprika is also cultivated in Spain, the Hungarian and Spanish paprikas being defined by the U. S. Food Standards as possessing the special flavour and pungency of the Paprika grown in the country by which each is named. Spanish Paprika is not so highly esteemed as Hungarian Paprika, as it is non-pungent and inferior in flavour. According to Young and True (1913) Hungarian and Spanish Paprikas belong to two different forms of pepper. Hungarian Paprika fruits (Pl. II., Fig. 4., No. 5 *) are about 4 to 5 in. long.

In Hungary, Paprika is largely consumed whole, but a variety of dishes are made from it, one being a kind of stew known as goulash. Paprika sauce is also held in great esteem. In Spain, Paprika is used as a vegetable in salads and for stuffing with olives, &c. It may be eaten raw but is, generally, grilled after removal of the seeds and stuffing with forcemeat. Its chief use according to Redgrove (1933) is as culinary colouring matter.

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* See Part I. of this paper in *The Tropical Agriculturist*, January, 1940.

† Personal communication from H. L. Cochran, Associate Horticulturist, Georgia.

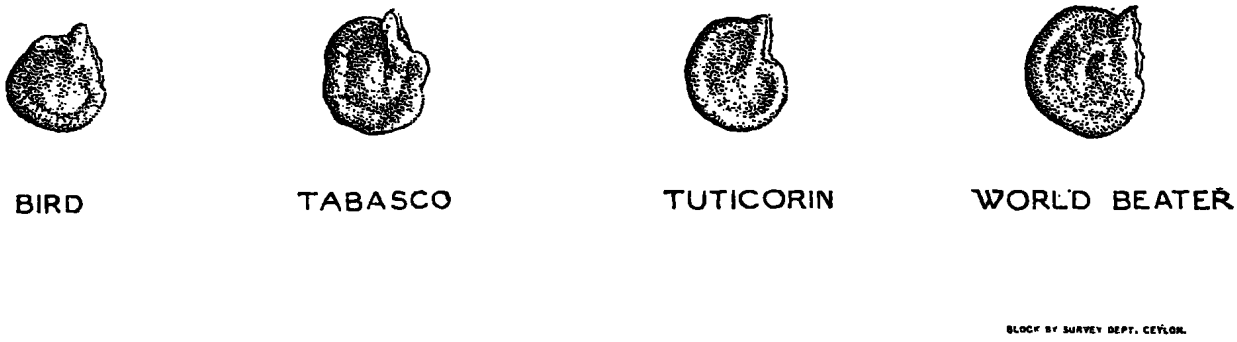

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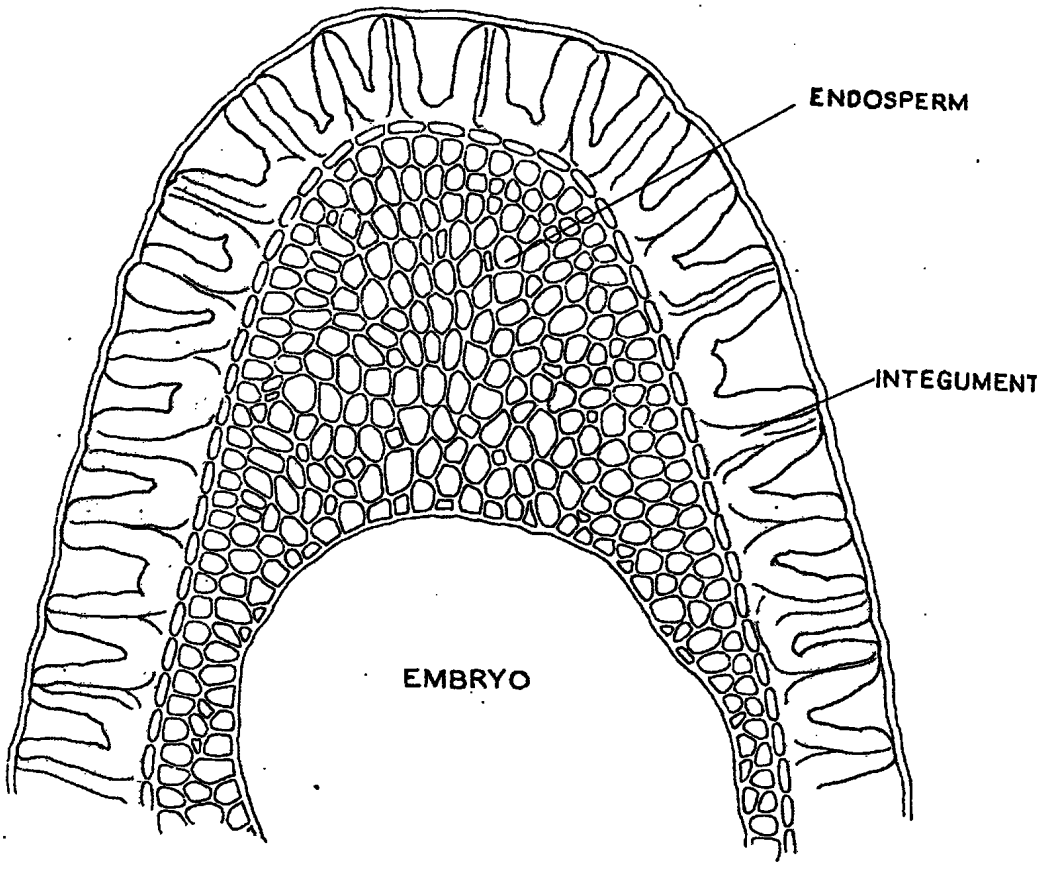
FIG. 3.—SEEDS OF DIFFERENT CHILLIES (×3)



CROSS SECTION OF
TUTICORIN CHILLI SEED
X250

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FIG. 4. (× 125)

There are five grades of Hungarian Paprika marketed under Government supervision and governed by decrees of the Hungarian Ministry of Agriculture. Arranged in ascending order of pungency they are :—

A. Sweet .. 1. Delicate noble sweet .. 2. Noble sweet

B. Hot .. 1. Near Sweet .. 2. Rose 3. Hot

(*f*) *The Bell Pepper.*—According to Erwin (1932), the name Bell pepper is the historic name for this group which includes the large non-pungent fruits with thick pericarps, belonging to the varieties *grossum* and *oblatum*.

They are grown more extensively in Europe and U. S. A., than in the tropical regions of the world, because the demand for mild peppers in the tropics is not as great as it is for pungent peppers and also because these peppers thrive better in temperate and sub-tropical climates where they are less susceptible to sun scald than in warm climates.

They are used in salads and for stuffing either raw or cooked in the mature green or red ripe stage. They are thus gathered when in the mature green, partly red or fully red stages.

The cultivated forms have large fruits, about 3 to 6 in. long and about 3 to 4 in. wide. They are also called Bullnose peppers from the general shape of the apex. They are squarish, sub-truncate to truncate and deeply furrowed, with 3 to 4 loculi. The calyx is flattened and generally seated in a depression at the base of the fruit. The pericarp is as much as 1 cm. thick, while the pedicel is short, stout and curved. The most popular forms are Ruby King, Chinese Giant, California Wonder and World Beater.

5. THE SEED AND GERMINATION

(*a*) *Morphology.*—The seed is discoidal in shape, somewhat flattened and smooth or subscabrous with a deep chalazal depression (Fig. 3). The colour varies from cream-yellow to reddish-yellow in different forms, old seeds becoming brown. They are attached to the placenta in compact rows, chiefly at the basal end of the fruit. The embryo is peripheric, embedded in a copious endosperm and the two cotyledons lie closely pressed together.

The seed coat is derived from a single integument, the cells of which, according to Cochran (1938) who confirmed the earlier findings of Hanausek, Hartwich and Souèges, show radial elongation through degeneration of the periclinal walls and thickening of the anticlinal walls (Fig. 4). The thickenings decrease towards the surface and through disintegration of

* See Part I. of this paper in *The Tropical Agriculturist*, January, 1940.

parts of the integument, small depressions appear on the surface of the seed, giving it a pitted appearance. In transverse section, the thickenings appear irregular and wavy in outline.

The inner epidermal layer of the integument according to Cochran (1928) probably aids in nourishing the embryo and persists until the cotyledons are well differentiated. Although the endosperm becomes partly absorbed, a large portion of it remains at maturity (Fig. 4). It consists of polygonal cells filled with aleurone grains.

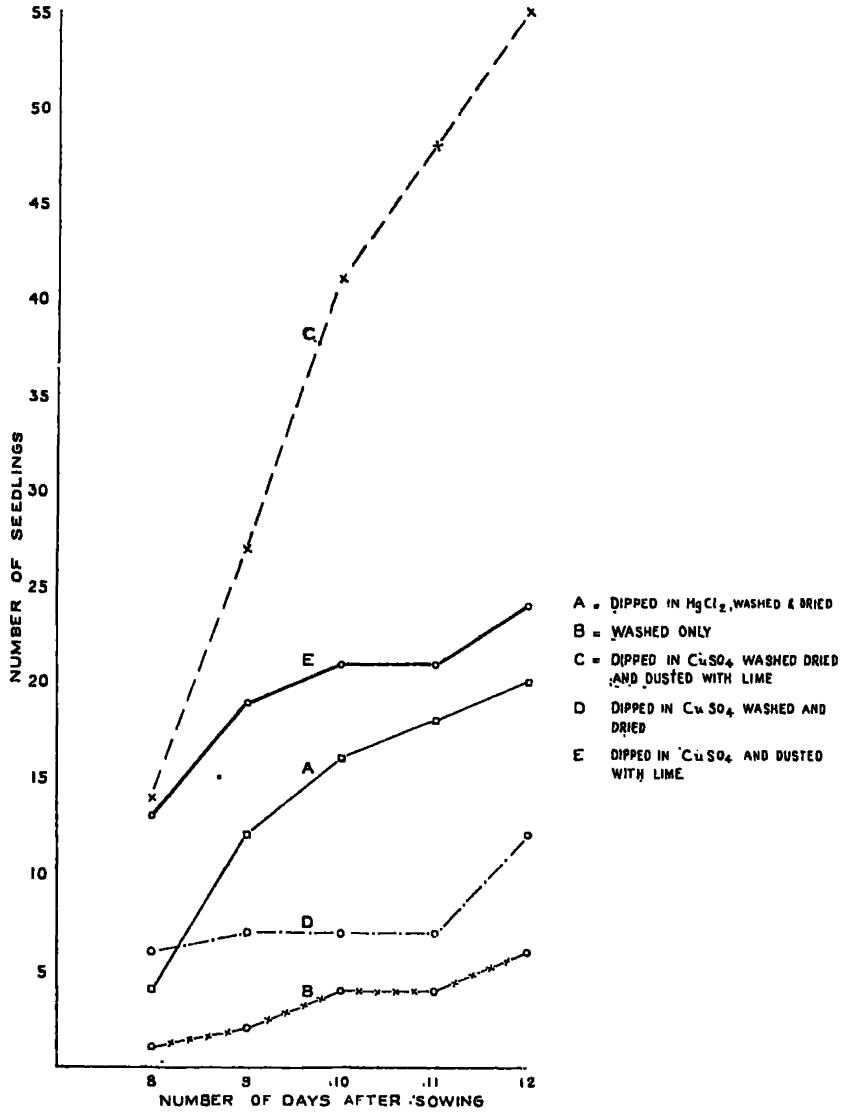
The size of the seed varies from about 2·5 mm. (longest diameter) in the Bird chilli to about 5 mm. in the large Bell pepper, the increase in the size of the seed being correlated with increase in the size of fruit. The number of seeds per fruit varies considerably with different forms. The *wanni* chilli contains a large number of seeds in proportion to the size of the fruit or, in other words, its percentage seediness as determined by the $\frac{\text{weight of seeds} \times 100}{\text{weight of pod}}$ is high. This is one of the disadvantages of this form as a Dry chilli, because a high percentage seediness is not favoured in households where the pods after slight roasting are ground on a hand stone for the preparation of curry powder. The flavour of the pods is somewhat masked when the percentage of seeds present in each pod is high. In Table II the number of seeds per pod and the percentage seediness of the pods (dried fruits) of the *wanni* and Tuticorin chillies are given and it will be seen that the former has a significantly higher percentage seediness than the latter.

TABLE II.

Showing the Percentage Seediness of the Pods of the Ceylon Wanni and Tuticorin Chillies.

Variety.	Mean number of seeds per pod.	Percentage seediness of the pods.
Wanni	53± 9·35	68·24±4·96
Tuticorin	59±12·92	49·76±5·21
Difference for n=24 and P= ±·05 t=2·064 ..	6±12·43	18·48±7·194

(*b*) *Seed Disinfection.*—The disinfection of *Capsicum* seeds against certain disease-producing organisms present on the surface of the seeds such as *Cercospora* leaf spot and the fruit diseases caused by *Vermicularia capsici Syd.*, *Gloeosporium piperatum* E. & E. and *Colletotrichum nigrum* E. & H. is an effective and inexpensive measure for reducing losses from these diseases. *Capsicum* seed, however, is more sensitive to treatment with disinfectants than a number of other seeds (Webber 1922, Higgins 1923 and 1934) and this sensitiveness is



CURVES SHOWING THE EFFECT OF DIFFERENT SEED DISINFECTION TREATMENTS ON THE GERMINATION OF CHILLI SEED

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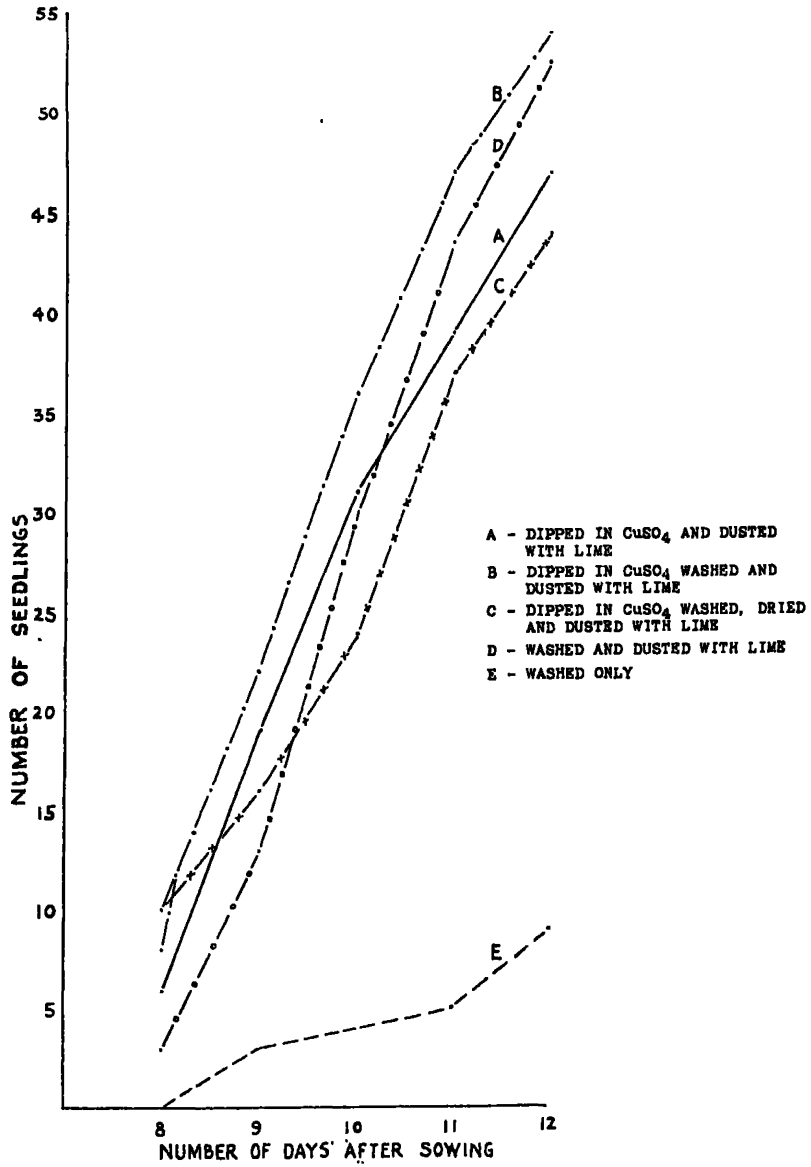
FIG. 5



CURVES SHOWING THE EFFECT OF DIFFERENT SEED TREATMENTS ON THE GERMINATION OF CHILLI SEED

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FIG. 6

greater with dried than fresh seed according to Higgins (1934). For this reason, he has suggested that fresh seed should be disinfected soon after picking of the fruit and then dried for use later. The usual disinfectants recommended for *Capsicum* seed are mercuric chloride ($HgCl_2$) and copper sulphate $CuSO_4$) while proprietary organic mercury compounds are also held to be useful (Webber 1922) and (Higgins 1934). These authors consider $HgCl_2$ (0·1 per cent.) to be very effective but Higgins adds that it is also liable to cause injury to the seed. With regard to $CuSO_4$, the addition of lime is held to be necessary, in order to neutralize the effects of any free copper and Higgins (1923) states that, where lime was withheld, root development was affected. He recommends that fresh seed should be dipped in $CuSO_4$ solution (1 oz. to 2 quarts of water) for 5 minutes and after draining and then dipping in lime water it should be spread out to dry, while dried seed should be soaked in water for 6 to 12 hours before dipping in $CuSO_4$, drained and rolled in air-slaked lime, the seed being planted immediately afterwards.

An experiment was carried out to examine the effect on germination of $HgCl_2$ and $CuSO_4$ disinfectants. Well-dried seed of the Tuticorin chilli was used and sown in Petri dishes of about 10 cm. diameter, in each of which a wad of Johnson and Johnson's absorbent cotton wool, 1½ cm. thick, was placed evenly and moistened with 20 cc. of water. Previous tests on the germination of seed in porous unglazed dishes immersed in water, with and without clean quartz sand, proved unsuccessful. Six Petri dishes with their lids removed were used for each treatment and in each 16 seeds were placed. Every three days 10 cc. of water were added to each dish to replace loss from evaporation. The following were the treatments :—

A. Dipped for 5 mins. in $HgCl_2$ (0·1 per cent.), washed in running tap water for 15 mins., dried in the room for 30 mins. and sown.
B. Control—washed in running water for 15 mins., dried for 30 mins. and sown.
C. Dipped for 8 mins. in $CuSO_4$ (1·25 per cent.), washed in running water for 15 mins., dried for 30 mins., dusted with air-slaked lime and sown.
D. As in C, but no lime added.
E. Dipped for 8 mins. in $CuSO_4$ (1·25 per cent.), dusted with air-slaked lime and sown.

Records of the number of seedlings, on the basis of the appearance of the unfolded cotyledons were made from the 8th to the 12th day and the results are shown graphically in Fig. 5. An analysis of variance for the results on the 12th day are given in Table III.

TABLE III.

Analysis of Variance for Germination.

	DF	sum of squares	variance	F	1 per cent. point.
Between treatments ..	4 ..	240·53 ..	60·13 ..	17·9 ..	4·18
Within treatments=error	25 ..	84·17 ..	3·3668 ..		
Total ..	29 ..	324· 7			

Means of treatments.					General Mean.	Sig. diff.
A	B	C	D	E		
3·3	1	9·16	2	4 ..	3·89 ..	2·18

The results show that treatments A and D are not significantly better than the control B, while E and C are significantly better. This means that copper, only in the presence of lime, stimulated germination. When the excess copper was washed off before the addition of the lime, the germination was better than when the lime was added immediately after dipping in copper.

In a second experiment, the following treatments were adopted :—

A. Dipped for 8 mins. in $CuSO_4$ (1·25 per cent.), dusted with air-slaked lime and sown.

B. Dipped in $CuSO_4$, washed in running water for 15 mins., dusted with lime and sown.

C. Dipped in $CuSO_4$, as in B, but dried in the room for 30 mins., after being washed and before being dusted with lime.

D. Washed in running water for 15 mins., and then dusted with lime.

E. Control. Washed in running water for 15 mins.

The seed was sown in the same way as before and the results are shown graphically in Fig. 6 of the number of seedlings which appeared between the 8th and 12th day. An analysis of variance for the results obtained on the 12th day is shown in Table IV.

TABLE IV.

Analysis of Variance for Germination.

	DF	sum of squares.	variance	F	1 per cent. point.
Between treatments ..	4 ..	127·54 ..	31·89 ..	6·82 ..	4·18
Within treatments=error	25 ..	116·84 ..	4·67 ..		
Total ..	29	244·37			

Means of treatments.					General Mean.	Sig. diff.
A	B	C	D	E		
7·83	9	7·17	8·83	3·33 ..	7·23 ..	2·55

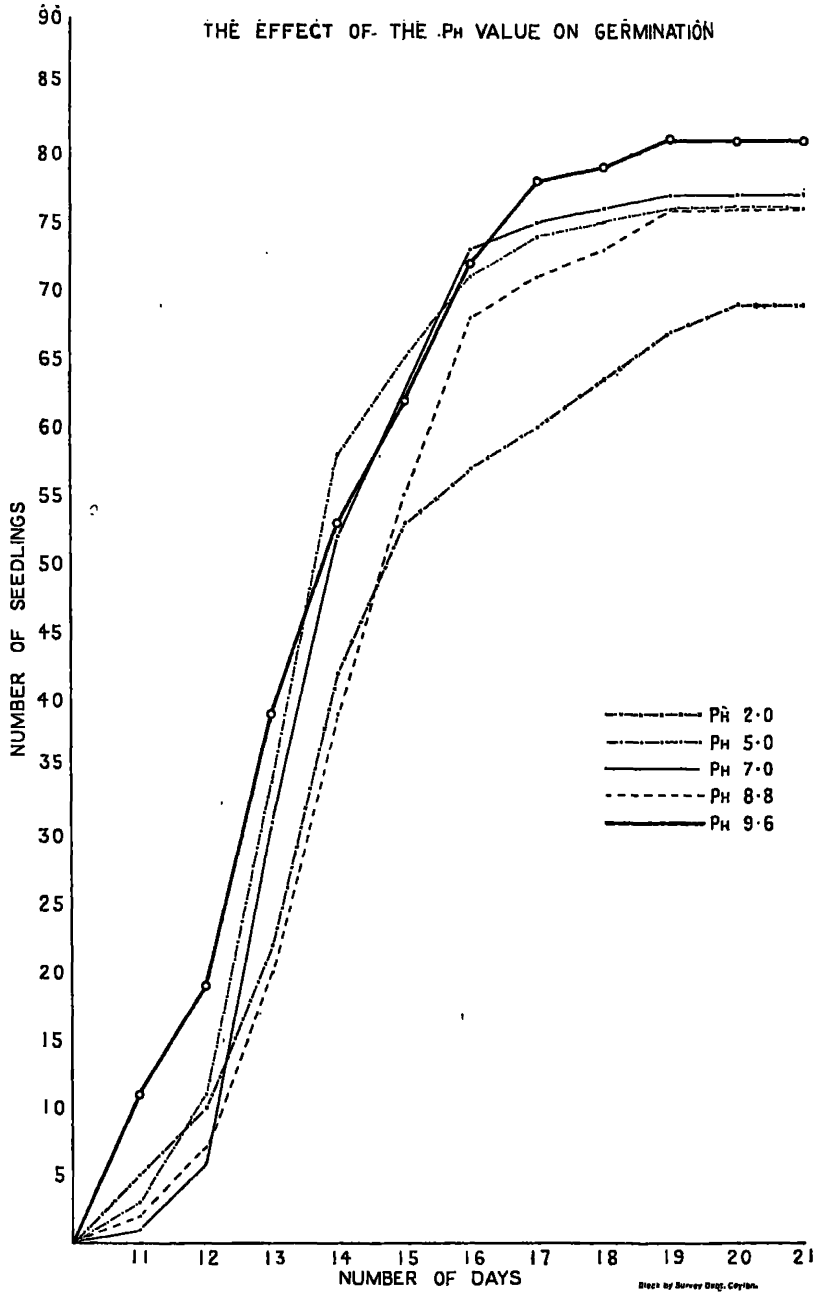

FIG. 7

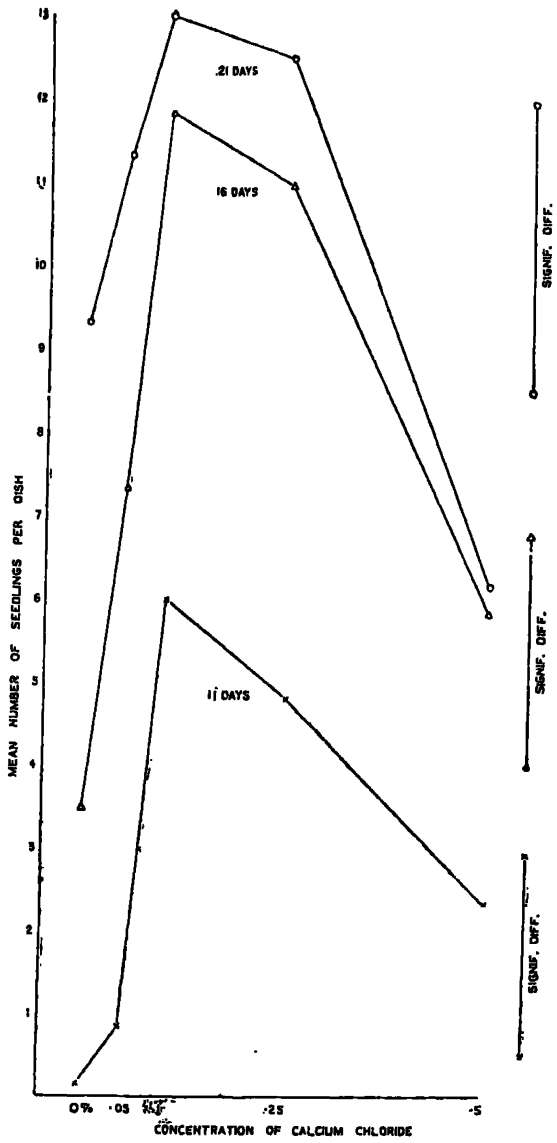

FIG. 8.—GERMINATION ON THREE DIFFERENT DAYS AT VARYING CONCENTRATIONS OF CALCIUM

The results show that the treatments A–D are significantly better than the control E, but are not better than each other. As lime alone appeared to stimulate germination, it indicated either a direct effect of the calcium ion or of the pH value of the medium due to the presence of the lime. On the 12th day, when the experiment was terminated, the water in the wads of cotton wool in the dishes of each series was squeezed out and the pH value determined. The results are shown in Table V.

TABLE V.

Giving the pH Value of the Water in which Chilli Seed was germinated after different Disinfection Treatments.

Treatment.	pH value.
A	7·3
B	7·8
C	7·4
D	8·2
E	4·4

Apparently, the better germination observed in series A–D in which lime was dusted on the seed prior to sowing was due to the higher pH value of the water, resulting from the presence of the lime, while the poorer growth of the control was the effect of the highly acid condition of the water, probably due to the excretion of organic acids from the root tips during germination.

In order to test this view, a series containing the following pH values were prepared by the addition of small quantities of concentrated H_2SO_4 to a 0·3 per cent. K_2HPO_4 solution which is well-buffered:—2·0, 5·0, 7·0, 8·8 and 9·2. Six Petri dishes were used for each series but instead of cotton wool as in the previous experiments, finely-sifted coir dust, previously moistened with distilled water which was found to be more satisfactory, was placed in each dish to its surface level. The lids were removed and 16 seeds of the Tuticorin chilli sown about 3 mm. below the surface in each dish. Soon afterwards, 25cc. of the particular solution for each treatment were added to each dish respectively in the series. Records of the number of seedlings which appeared are shown graphically in Fig. 7 and the results on the 18th day after sowing shown in the analysis of variance in Table VI.

TABLE VI.

Analysis of Variance for Germination.

	DF	sum of squares.	variance	F	5 per cent. point.
Between treatments ..	4 ..	21·57 ..	5·39 ..	2·5 ..	2·87
Within treatments=error	25 ..	53·80 ..	2·152 ..		
Total ..	29	75·37			

The treatments are not significant.

This experiment indicates that the pH value of the medium has no effect on germination. It remained, therefore, to examine the effect of Ca on germination and the following concentrations of $CaCl_2$ were then tested :—

A. Control 0 per cent. (distilled water.)
B. 0·05 per cent. $CaCl_2$.
C. 0·1 per cent. $CaCl_2$.
D. 0·25 per cent. $CaCl_2$.
E. 0·5 per cent. $CaCl_2$.

The same technique as in the previous experiment was adopted and in Figure 8, the effect of the concentration of Ca on the germination on three different days is shown, with the significant differences obtained for each. It will be seen that the optimum concentration of $CaCl_2$ lies at about 0·1 per cent. and these experiments thus indicate that the stimulating effect of seed disinfection with $CuSO_4$ and lime is due to the presence of the Ca ion.

(*c*) *Germination.*—When conditions become favourable for germination, a slight swelling of the seed coat takes place, followed by the protrusion of the radicle from the micropyle (Fig. 9, No. 1). It curves downwards (Fig. 9, No. 2) and when it reaches a length of about 5 to 10 mm., the hypocotyl begins to develop and shows a bend. This is the first visible sign of germination above the surface of the soil. The hypocotyl then elongates and straightens out, while the cotyledons which are epigeal become gradually drawn out of the seed coat (Fig. 9, No. 7) and after emerging together they separate from each other, until each assumes a more or less horizontal position. Sometimes, the cotyledons find difficulty in being drawn out of the seed coat owing to a twist in their position within the seed coat and after remaining partially extruded they may eventually die. At other times, the seed coat becomes attached to the cotyledons at their tips (Fig. 9A) and later persists at the tip of one of the cotyledons, (Fig. 9B) but eventually drops. When the cotyledons are quickly extruded, they appear yellowish but soon turn green in the presence of diffused light. They are lanceolate or ovate-lanceolate while the true leaves are ovate-lanceolate or broadly ovate.

At higher temperatures, germination is more rapid. In nursery beds in the dry zone areas of Ceylon where the temperature ranges from 80° to 90°F. in the shade, the hypocotyl bends become generally visible on the 4th and 5th days and the cotyledons appear unfolded on the 6th and 7th days. About the 12th day, the first pair of leaves appears. Cochran (1936) has studied the relationship between temperature and germination.

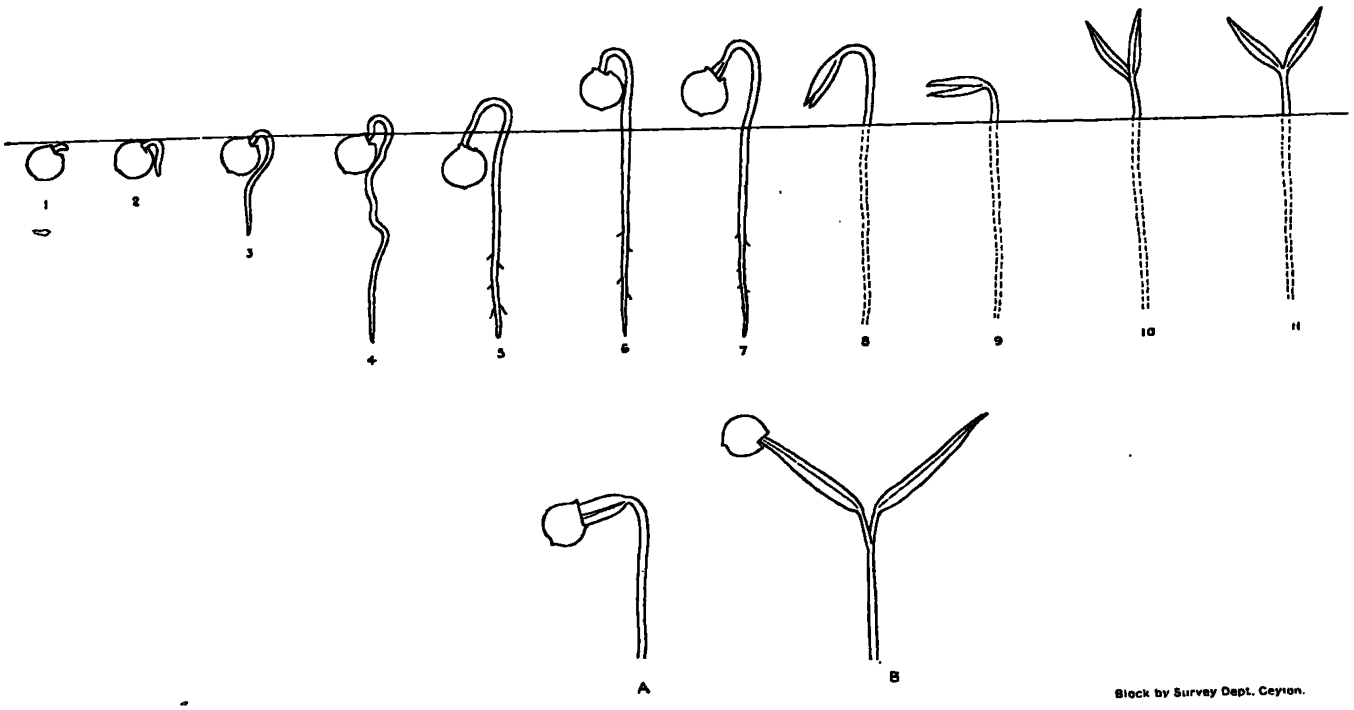

FIG. 9.—SHOWING THE DIFFERENT STAGES IN THE GERMINATION OF CHILLI SEED

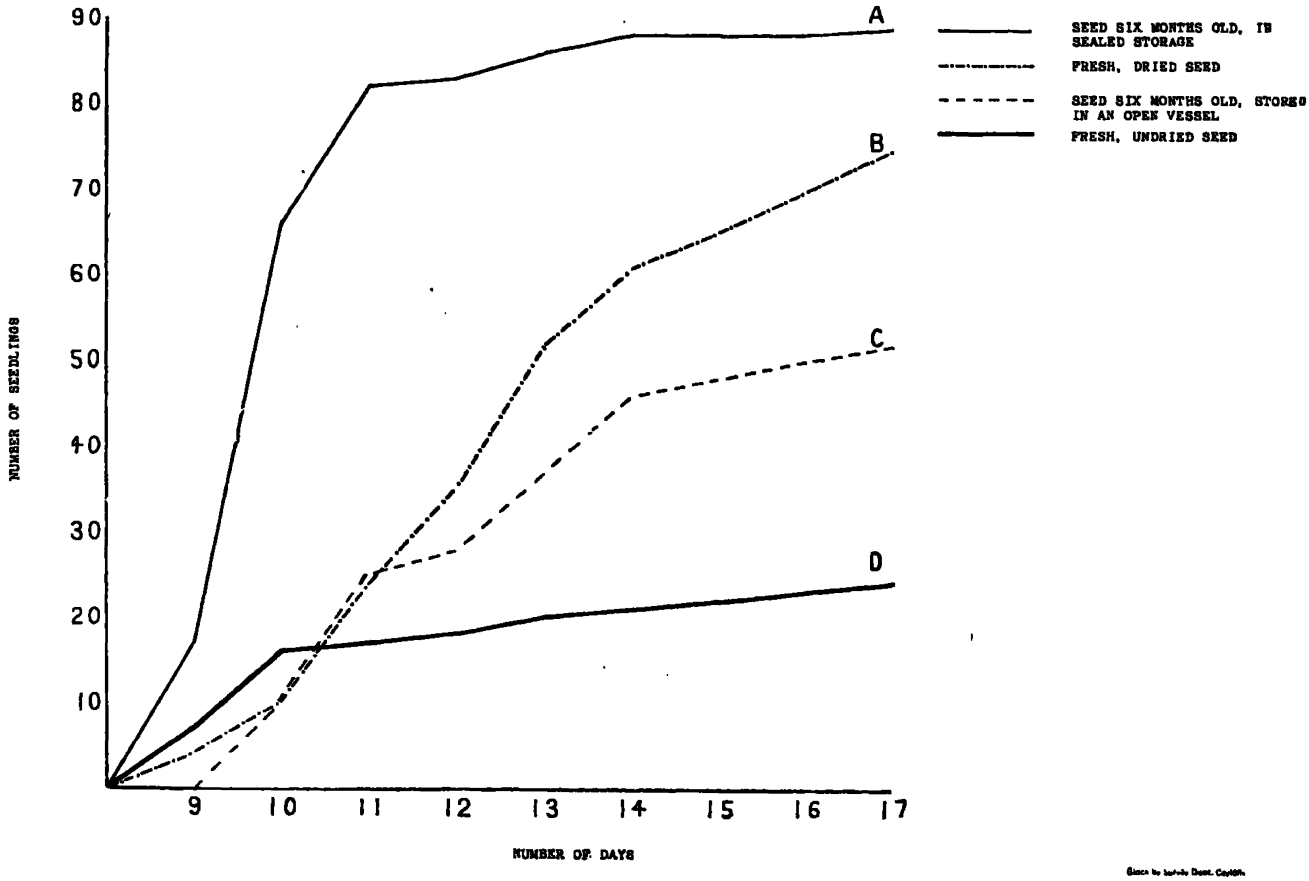

FIG. 10.—CURVES SHOWING THE VIABILITY OF SEED UNDER DIFFERENT STORAGE CONDITIONS

At 40°–50°F. he found no germination of World Beater peppers even after 45 days. The minimum temperature at which germination took place was 50°–60°F. and the number of days taken for emergence of the seedlings was 30–31, the average percentage germination being 59. At 60°–70°F. the number of days taken was 19–20 and the average percentage germination 72 while at 70°–80°F. germination was effected in 10–11 days and the average percentage germination was 78. At 90°–100°F. germination took place in 5–6 days and the percentage germination was 74. Although germination was most rapid at 90° to 100°F. no statistical analysis was presented and it is, therefore, not possible to conclude at which temperature the percentage germination was significantly best. The Bird chilli, however, differs from other chillies in taking about 10 to 12 days longer to germinate under ordinary conditions in Ceylon.

(*d*) *Viability of the Seed.*—Certain vegetable seeds require a period of dormancy before they can germinate satisfactorily. Barton (1935) tested the germination of pepper seeds at the following intervals :—Freshly picked, 1, 2 and 3 years storage. She found that after 2 years the seed lost its germination considerably. She reports that, when air-dried seeds were stored in open containers, their viability was maintained for 2 years, but when kept sealed viability was lost within a year. When dried over CaO and sealed there was a slight decrease in germination after 3 years. Open storage of seeds dried over CaO was inferior to sealed storage and after 3 years there was marked decline in germinative power. She also found (Barton 1938) that low temperatures were necessary for successful storage for periods longer than four years. Odland (1938) carried out tests with a number of vegetable seeds which he planted in lots of 100, on the day of harvest and at varying intervals up to 6 months. No significance for F at P = ·05 was obtained by him for the different intervals of time with peppers, while cucumbers, pumpkins, and musk melons gave a significant value for F at P = ·01. He found that peppers germinated equally well at all ages up to 6 months, after which there was a gradual decline. He does not, however, state the method of drying or storing the seed. The writer carried out an experiment with the following treatments :—

A. Sun-dried seed in sealed storage for 6 months.
B. Seed used immediately after picking and drying in the sun.
C. Sun-dried seed kept in an open vessel for 6 months.
D. Fresh undried seed from red ripe fruits.

Six Petri dishes with finely-sifted coir dust were used as in the previous germination experiments reported in this paper

and the seed was disinfected in $CuSO_4$ solution (1·25 per cent). for 5 mins. and dusted with lime. Counts of the number of seedlings were made and the results are shown graphically in Fig. 10 and an analysis of variance for the 13th day given in Table VII.

TABLE VII.

Analysis of Variance for Germination.

	DF	sum of squares.	variance	F	·1 per cent. point.
Between treatments ..	3 ..	413·78 ..	137·93 ..	30 ..	4·94
Within treatments=error	20 ..	91·50 ..	4·57		
Total ..	23	505·28			

Means of treatments.					General mean.		Sig. diff.
A	B	C	D	..			
14·33	8·67	6·17	3·0	..	8·04	..	3·5

It will thus be seen that contrary to Odland's results, sun-dried seed germinates much better after a 6 months period of storage than soon after picking, while fresh undried seed germinates poorly.

(To be continued.)