STUDIES IN *DOLICHOS LABLAB* (ROXB.) AND (L.)— THE INDIAN FIELD AND GARDEN BEAN. I.

By G. N. Rangaswami Ayyangar, B.A., I.A.S.,
Agricultural Research Institute, Coimbatore,
AND
K. Kunhi Krishnan Nambiar, B.Sc., Ag.,
Millets Breeding Station, Coimbatore.

Received April 30, 1935.

1. *Introduction.*

Dolichos lablab is a field bean usually grown in dry lands as a rain-fed crop. It is grown either pure or mixed with sorghum with which it is a common mixture in the red loams of Coimbatore. It is drilled at intervals among the sorghums and when the earheads are cut, late as the bean is, it twines on the sorghum stalks, profusely flowers and gives the crop of both green and dry pods so much esteemed as the pulse of the poorer classes. Its vines when cut with the sorghum straw give a mixed feed of good fodder value. This close association with sorghum led to its study with a view to its improvement. The study of the garden variety of this bean was taken up as an adjunct to that on the field variety.

This bean must have been one of the most ancient among cultivated plants—possibly more than 3,000 years old. Its wild forms are found in India and this country was probably the place of its origin. From India it is likely that it was introduced into China, Western Asia and Egypt. It is a field crop in Madras, Bombay, Central Provinces and Berar. In the Bombay Presidency it follows rice as a second crop. The garden varieties are rare in Northern India, but common in Central, Western and Southern India and in Bengal.

With the onset of the monsoon there is not a house with any open space attached to it but does not grow this vine which gives the household a continuous supply of good green pods for a few months. It is no wonder therefore that the diversity in its habitat has been enormous and the intensity of the hand of man in the selection and perpetuation of desirable variants, very keen. There is hence a wealth of varieties in this important pulse that makes it a rich repository of genetic material.

2. *Names.*

Lablab is a papilionaceous legume falling under the group *Phaseoleæ*. This field bean is called in Western countries the *Bonavist*, possibly from the

ornamental effect of the vine in full bloom. It is also called the *Hyacinth* bean from the effect produced by the deep lilac flowered variety. It is called *Anapa* and *Chikkudu* in Telugu, *Mochai* and *Avarai* in Tamil, and *Avare* in Kanarese. Its North Indian names are:—*Shim* (Bengali and Hindustani), and *Val* (Gujarati and Mahrati).

Its botanical name is the subject of extensive discussion (Piper and Morse, 1915) but in spite of much alternative nomenclature its name *Dolichos lablab* stands to mark this bean. *Dolichos* is the Greek word for long pod; *lab-lab* is the Arabic or Egyptian name, possibly onomatopœtic to the dull rattle of the seeds inside the dry pods.

3. *Previous Work.*

Very little work has been done on the study of this bean and the inheritance of its characters. Piper and Morse (1915) give a description of a number of varieties. Harland (1920) made a cross between an indeterminate variety (Vilmorin's Stringless) and a determinate variety (St. Vincent Bush White) and found the indeterminate habit a simple dominant to the determinate habit. In seed colour he obtained a 9 : 3 : 4 ratio of black : brown : white and in flower colour a 9 : 7 ratio of purple : white and a 3 : 1 ratio of purple : green in plant body. Jogi Raju (1923) gives an outline description of 10 varieties of this bean.

4. *Varietal Characteristics.*

There are two varieties in this bean, the field bushy variety and the garden twining pole variety. A study of a very large number of selections in each of these showed that the field varieties tend to group round *Dolichos lablab* (Roxb.) and the garden varieties round *Dolichos lablab* (L.) It was seen that while many marked differences exist between the two, there is no clear-cut separation possible between them. The distinction between them on the basis of pod tips (Roxburgh, 1832) and on the basis of the disposition of the long axis of the seeds to the sutures (Prain, 1897) indicative as they are of the broad trend that way, is not clear-cut enough to serve as reliable guides to their separation, especially in view of the wealth of blended forms. The nature of the pod texture, however, constitutes the basic economic difference between the two varieties. The field variety has tough firm-walled parchmented pods. In this variety the seeds alone are consumed. The garden variety has tender edible pods, some of them so soft as to wrinkle on drying. The marked difference in appearance between the field and garden varieties consists in the bushy habit of the former and the ready twining habit of the latter. Harland's separation of the two groups bushy and climbing by their determinate and indeterminate habits respectively is hard to comprehend.

In the very large number of varieties grown at Coimbatore, representing all parts of India and many places outside, it has not been possible to observe a single case of a terminal inflorescence that made the plant habit determinate. The main axis produces about 10-20 internodes after which the growing point generally dries up. The primary, secondary and tertiary branches grow up to about 7, 4 and 3 feet respectively. Up to 30 internodes are produced in primary branches and about 20 in the secondary and tertiary branches. Peduncles arise in leaf axils all over the plant—on the main axis, the primary, secondary and tertiary branches. They are profuse on the last. (Fig. 1.)

It is the compact disposition of the internodes that gives the field variety its bushy habit and not its "determinateness". The bushy habit, the short internodes and the quick succession of axillary inflorescences adapt it to the field pole-less condition without in any way making it determinate. Given favourable chances most of the bushy varieties are capable though tardily of twining up and simulating the garden variety in habit.

Another important character that differentiates the two groups is the presence of oil glands in the field varieties which give the neighbourhood of its cultivation the heavy green bug smell characteristic of this crop. This glandular equipment makes the field variety less susceptible to the attack of aphids than the garden varieties. The glands of the field variety are best manifest at flowering time when they are seen at the axil, inflorescence and heavily on the pods. This oily secretion makes the tough pod very unpalatable as a vegetable; only the seeds are edible. The aroma of the dry pods flavours the drinking water of cattle and all the husk from the threshing floor is used up as a cattle feed. The glands have a volatile oil that could be distilled with steam. In small-scale experiments this oil has proved an antidote to the aphids in the garden varieties (Rangaswami Ayyangar, 1932-33). Further experiments in their extraction and use are indicated as a profitable line in indigenous insecticides. In the garden variety with its edible pods, there is an absence of these glands and their smell.

Field varieties are sown with the advent of the monsoon in July—August, come into flower in November—December and are harvested in January—February. Before flowering these require 16-17 weeks of vegetative growth. Sowings were made with the field variety in all the 12 months of the year and it was noticed that there was a progressive decline in the vegetative period until the December sowings which flowered in 6 weeks. The most adverse sowing proved to be January which took 41 weeks to flower. In the garden pole varieties accustomed to greater accommodation and wider growth conditions and less susceptible to cyclic sowings and more the object of care under

domestication, similar monthly sowings showed that the flowering period could be ushered in, after 26 weeks, as against the 41 weeks of the field variety in the same adverse January sowing. Field and garden varieties grown in pots betray their individuality even when they are seedlings a month old (Fig. 2). These facts show the extent of physiological changes introduced into the garden variety consequent on intense domestication, so much so that years of habit have tended to stabilise differences between the two groups.

On the whole, the evolution tending to the production of garden varieties seems to have been along lines that softened the pods and eliminated the oil from it in addition to giving the vine a marked twining habit, drawn out flowering and a more continuous supply of edible pods.

5. Flowers and their Pollination.

In field varieties flowers arise on glandular fascicles borne along the peduncle. The number of fascicles on the peduncle varies from 6 to 12, nine being the average. The largest number of buds are formed on the bottom fascicle and this number decreases from bottom to top. The top 3 to 4 fascicles and the bottom 1 to 2 are less fertile than the middle ones. The percentage of total pods set to buds produced is only about 20. This remarkable poverty in pod setting is equally chronic in the garden varieties where it is a common experience to find the shade of the arbours of this vine carpeted with fallen flowers.

In the young immature bud the anthers are far behind the level of the stigma. The stamens are alternately long and short, 9 united at the bottom and one free. As the bud grows the staminal filaments elongate more rapidly than the style and the anthers dehisce when those of the long stamens come above or on a level with the stigma. The pollen from these are shed on to the stigma, while the pollen from the short stamens are shed over the hairs of the beard below the stigma. Flowers open generally 2 days after anther dehiscence. They open throughout day-time. None was observed to open at night. Opening is most frequent between 11 A.M. and 5 P.M. Measurements made on buds showed that at the dehiscence stage the buds are slightly smaller than their maximum size. In the variety studied the maximum length attained by the upper posterior margin of the bud was 14·5 mm., while the anthers were found to dehisce inside when this length is between 11 and 13 mm.

Harland considers that this crop is entirely self-fertilised. Stray natural crosses have occurred at Coimbatore. Thrips and the carpenter bee noted by Dr. Harland in the West Indies were also found to frequent these flowers occasionally, serving as agencies in the above stray instances of natural cross fertilization.

6. *Technique of Crossing.*

It has been noted that the anthers dehisce inside the bud about 2 days prior to the opening of the flower. Buds emasculated and pollinated immediately before the stage of dehiscence are found to be the most successful in setting. With a little experience it is possible to estimate this stage correctly. One of the main difficulties experienced in artificial pollination is the shedding of the bud during manipulation. It is therefore important to handle the mother bud carefully. The bud is lightly held between the thumb and fore-finger of the left hand and the standard slit up with the point of a needle. The standard flaps are then bent down and held up. The overlapping wing petals are also bent down similarly. The keel petals are now slit up and cut off and the undehisced stamens removed. The stigma is examined with a hand lens to make sure that there are no pollen grains sticking to it. The flower is now ready for pollination. A narrow slit at the back of the bud where the margins of the standard unite has been found to indicate that the anthers inside have just dehisced. For providing the pollen a bud at this stage is removed from the male parent. The standard and wing petals of the bud are now removed. The tip of the keel tube is pressed with the fingers and the pistil and anther filaments pulled out. The tube is held pressed in order to hold up as much of the pollen as possible inside it. The keel tube with the mass of pollen inside is then slipped over the stigma of the emasculated bud ensheathing its style and stigma. The use of the keel tube is superior to other methods in that it gives the stigma surroundings approximating the natural and also guards against the risks incidental to handling the pollen directly. The bud is protected against insects by a small tissue paper bag. It has already been noted that the percentage of pods set to buds formed is about 20 under natural conditions. Pod setting under artificial pollination is therefore very meagre, being in some years as low as 2 per cent. of the flowers handled.

7. *Disposition of Hairs on Internodes.*

There are two plant habits—twining and bushy. The former is in the garden varieties, and the latter in the field varieties. In the former the disposition of the hairs on the internode is downward in direction and in the latter, upward (Figs. 3 and 4). In the young seedlings of both the varieties the hairs are upward in the epicotyl, hypocotyl, petiole and pulvinus. In the leaves of both the varieties the hairs are about perpendicular to the leaf surface. The differentiation comes up only in the growing internodes. In the field variety the hairs continue to be upward as in the epicotyl, etc., but in the garden variety the hairs turn downwards, obviously an adaptation gained through continuous garden pole cultivation. This tendency to the

upwardness and downwardness of hairs may be said to be fairly constant, being upward in field varieties and downward in garden varieties. But since there is no clear-cut separation in the agronomic concepts of field and garden varieties, one gradually running into the other, a strict delimitation of this character is therefore beset with difficulties. Anyhow it is interesting to note that this differentiating character behaves as a simple Mendelian unit.

In 1931, a plant with downward hairs was spotted in a population of plants with upward hairs and this was suspected to be a natural cross. The F_2 from this segregated into 398 seedlings with hairs downward and 139 with hairs upward, showing a simple monohybrid segregation. From this F_2, 14 sections of upward hairs were taken and all of them bred true. Of the 46 taken with downward hairs, 34 segregated again for downward and upward hairs and 12 were pure for downward hairs. This disposition of the hairs and its heritable nature gives a fairly reliable guide of a qualitative type to the separation of the field and garden varieties. A number of crosses made and under study between field and garden varieties have given F_1 plants all of them with downward hairs, confirming the simple dominance of the downward hair character associated with the twining habit. The factor responsible for the production of downward hairs may be designated H. Upward hairs will therefore be due to the factor *h*.

8. Erect and Drooping Pods.

A second direction in which the garden varieties have been evolved from the field ones is in the production of drooping pods. Most of the field varieties have erect pods, the pods being perpendicular to, or making an upward acute angle with the peduncle (Fig. 5). Some field varieties have drooping pods (Fig. 6). All the garden varieties have drooping pods, the pods when ripe, drooping down alongside the peduncle. This drooping condition is a consequence of pod softening, in contrast to the erectness of tough pods.

There are a few other distinguishing features associated with this character pair. Erect pods have tough walls that are only slightly segmented. The septa which isolate the segments when unripe detach themselves from the pod walls and allow a free rattle of the seeds inside. The inside of the pod wall is markedly parchmented, the parchment layer being white and opaque. Drooping pods have walls that are segmented and less tough. The septa are generally intact and on shaking, the pods make very little noise. The parchment layer is found only in small patches or is almost absent making the pod walls translucent against light. The surface of the pod wall is slightly wrinkled, betokening the desiccation of softer tissue. On crushing it easily crumples, as opposed to the flaky bits of husk from erect pods.

This erectness of pods seems to be due to the presence of two independent factors E_1 and E_2, either of them or both producing the erectness. The drooping pod seems to have been derived by the dropping out of both these factors for erectness. In segregations for this character both 3 : 1 and 15 : 1 ratios have been obtained (Tables I and II).

TABLE I.

Erect pod × *Drooping pod*—(F_1—*Erect pod.*)

F_2 Family No.	Erect	Drooping
D. L. 101 ..	131	39
,, 112 ..	190	53
,, 116 ..	159	46
,, 672 ..	118	53
,, 673 ..	41	14
Total ..	639	205
Expected, 3 : 1 ..	633	211

The degree of erectness seems to differ a bit according to the genetic composition of erect pods but due to the differential development of the pods and the action of weather conditions, a delineation and pursuit of sub-groups among erect pods have not proved practicable.

9. Narrow Pods.

A third line of evolution leading towards common domestic varieties is a widening or narrowing of the medium pod of the field varieties. There is a wealth of pod sizes and shapes characterising the garden varieties. In the field variety there is only one common pod shape. This is medium in width, being a little broader towards the tip end (Fig. 7). The average length of the pod is $4\frac{3}{4}$ cm. At the broadest part towards the tip end it is about $1\frac{3}{4}$ cm. wide. This is the usual width of pods in field varieties. A simple variant of this pod size has been met with in field varieties (Fig. 8). This variant is narrower than the typical field variety, and more uniformly so through its length. Its width is about $1\frac{1}{4}$ cm. This narrowing in width which is brought about by a lengthening and a deeper inarching of the top suture has not affected pod length, but has naturally had its effect on seed size, which in the narrower pods is smaller and less flat. A single factor W_1 seems to

TABLE II.

Erect pod × Drooping pod—(F_1—Erect pod.)

F_2 Family No.	Erect	Drooping
D. L. 102 ..	230	11
,, 113 ..	143	7
,, 348 ..	54	3
,, 357 ..	377	17
,, 377 ..	281	23
,, 378 ..	316	12
,, 579 ..	213	15
,, 580 ..	239	19
,, 602 ..	319	29
,, 634 ..	64	4
,, 641 ..	21	2
,, 670 ..	156	11
Total ..	2,413	153
Expected, 15 : 1 ..	2,406	160

determine this particular difference in pod width in the field varieties. (Table III.)

10. Septa in Pods.

Narrowness in pod width having been secured, a fourth line of evolution (which arose through an absence of the parchment layer and a softening of the pod tissue) has been a disappearance in some narrow pods of the septate condition and its replacement by the bloated non-septate condition (Fig. 9). One collateral effect of this erasure of the septa in narrow pods is a re-alignment in the disposition of the seed. In the septate pod it is perpendicular to the pod suture. With the disappearance of the septa and the attendant bloating, the seed tends towards having a disposition parallel to the suture. Intermediate between the perpendicular and parallel dispositions are various

TABLE III.

Pod width.

Medium × *Narrow*—(F_1 — *Medium.*)

F_2 Family No.	Medium	Narrow
D. L. 123 ..	48	18
,, 571 ..	32	13
,, 573 ..	46	19
,, 574 .	33	14
,, 576 ..	59	20
,, 577 ..	34	11
,, 578 ..	34	11
Total ..	286	106
Expected, 3 : 1 ..	294	98

TABLE IV.

Septate × *Non-septate*—(F_1—*Septate.*)

F_2 Family No.	Septate	Non-septate
D. L. 628 ..	70	22
,, 675 ..	131	39
,, 929 ..	58	17
,, 930 ..	37	10
,, 931 ..	68	23
,, 933 ..	64	30
Total ..	428	141
Expected, 3 : 1 ..	427	142

stages and varying angles according as the pod is medium, wide or narrow, straight or curved of degrees. The differentiation sought to be made between *D. lignosus*, L. and *D. lablab*, L. in terms of the above seed disposition looks therefore untenable. The septate condition of pods has proved a simple dominant to the soft, bloated non-septate condition as the following experiences will show (Table IV). The septate condition may be denoted by the symbol S and the non-septate by *s*.

11. *Depth of Chlorophyll.*

Lablab vines both field and garden have the normal tint of green. All field varieties have the standard green colour. But some of the garden varieties have a chlorina type of green which gives the whole vine looked *en masse* a light green appearance. This light green while being visible in the early vegetative stages of growth is most markedly seen in the mature flower buds in the rear of the standard. Undried pods show this difference between green and light green. In the garden varieties a whole range of light green pods have been picked out and perpetuated and are in existence as definite current varieties. With a background of both green and light green, the super-imposition of purple pigment entire or localised, gives the many varieties with the distinction of their background being either green or light green. All these light green pods when tasted raw have the advantage of being sweeter to the taste than green pods. This sweetness finds an index in their greater susceptibility to the attack of ants than is the case with corresponding green pods. This light green character which is another step in the evolution has proved a simple recessive to the normal green character.

TABLE V.

Green × Light green—(F_1—Green.)

F_2 Family No.	Green	Light green
D. L. 264 ..	104	42
,, 660 ..	17	6
,, 667 ..	97	35
,, 676 ..	318	91
Total ..	536	174
Expected, 3 : 1 ..	533	177

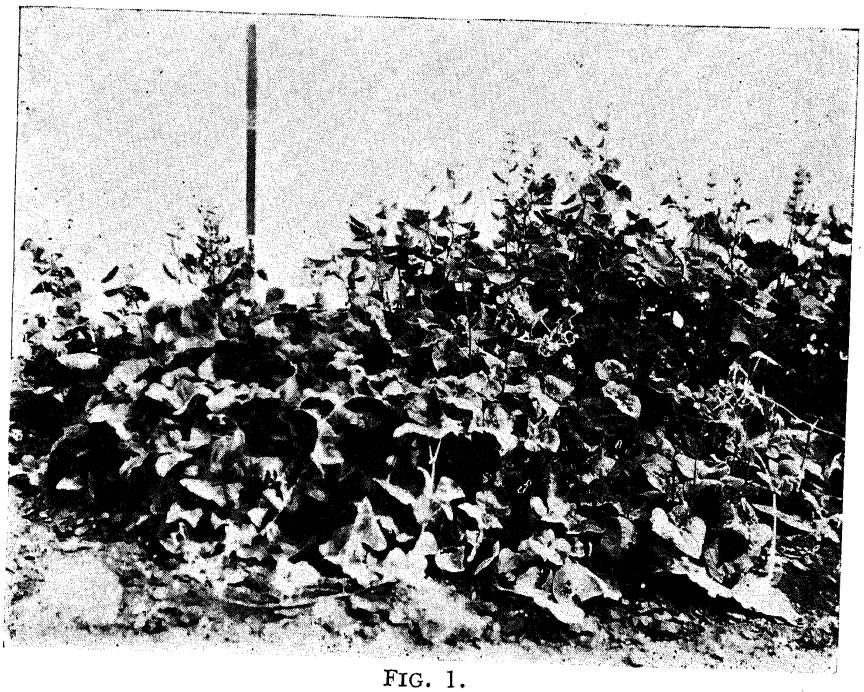

FIG. 1.

a *b*

FIG. 2.

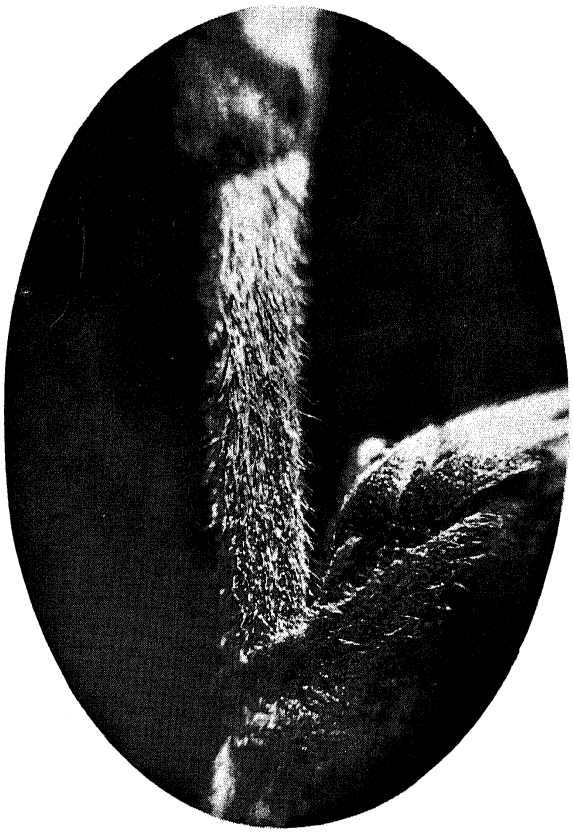

FIG. 3.

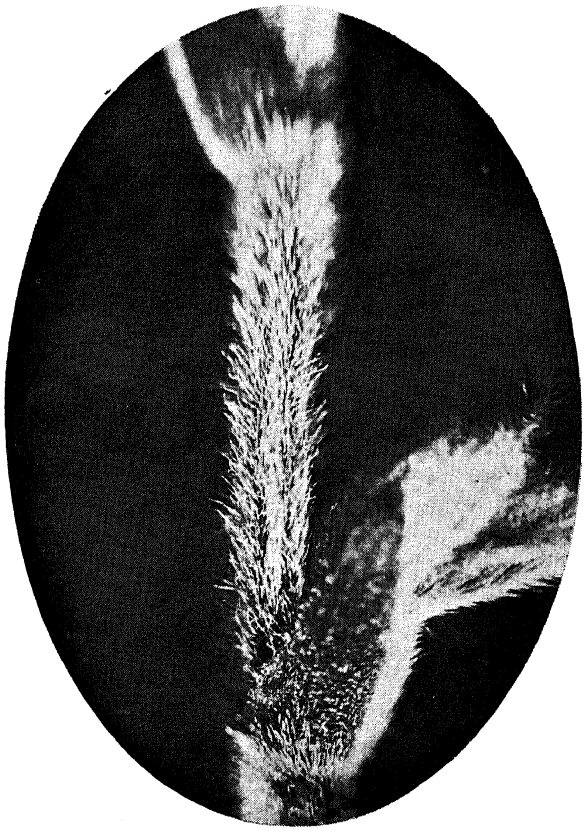

FIG. 4.

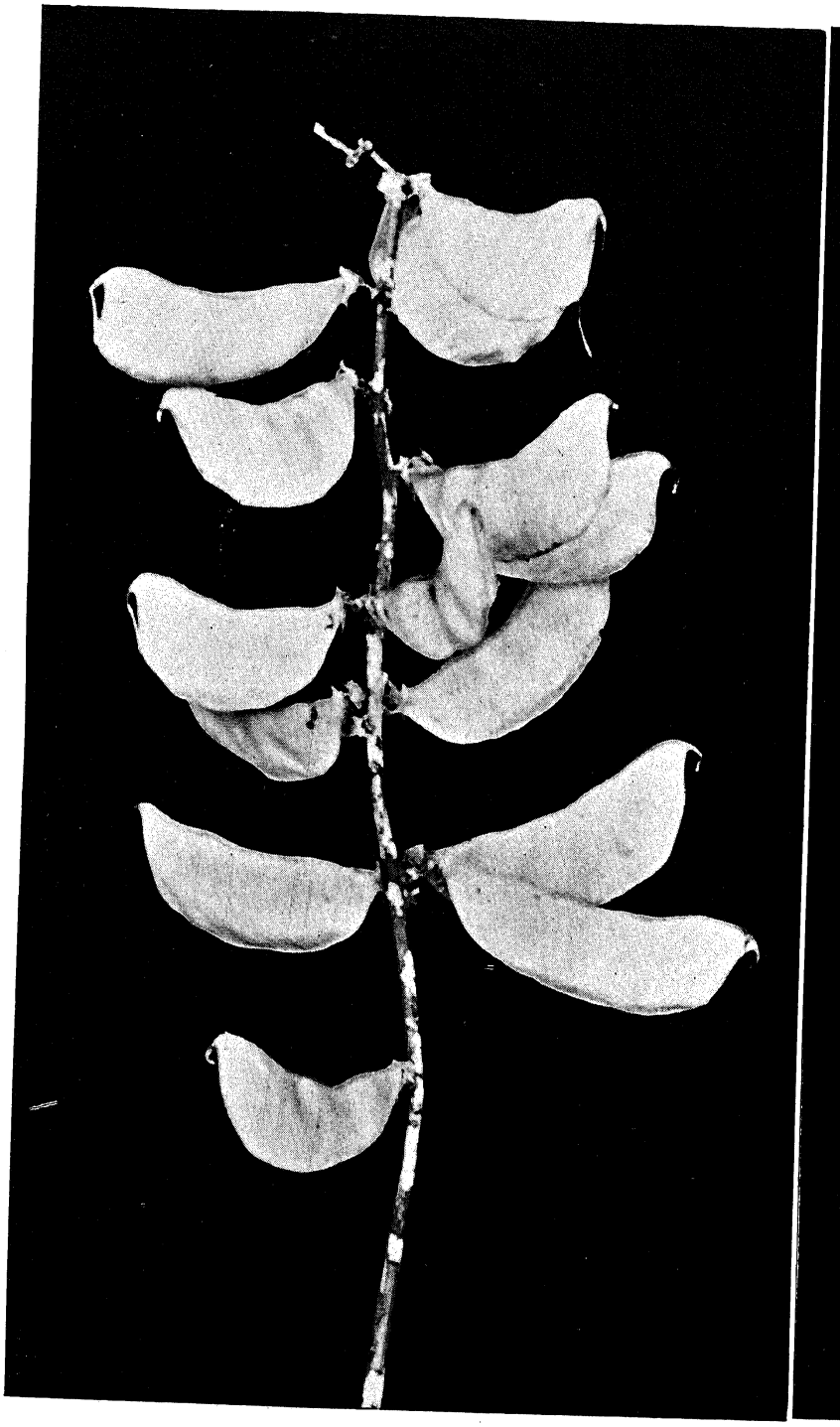

FIG. 5.

FIG. 6.

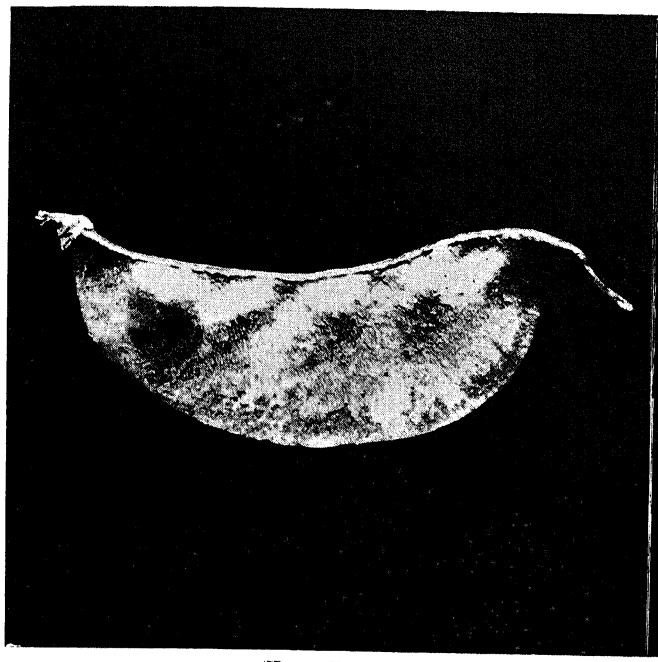

FIG. 7.

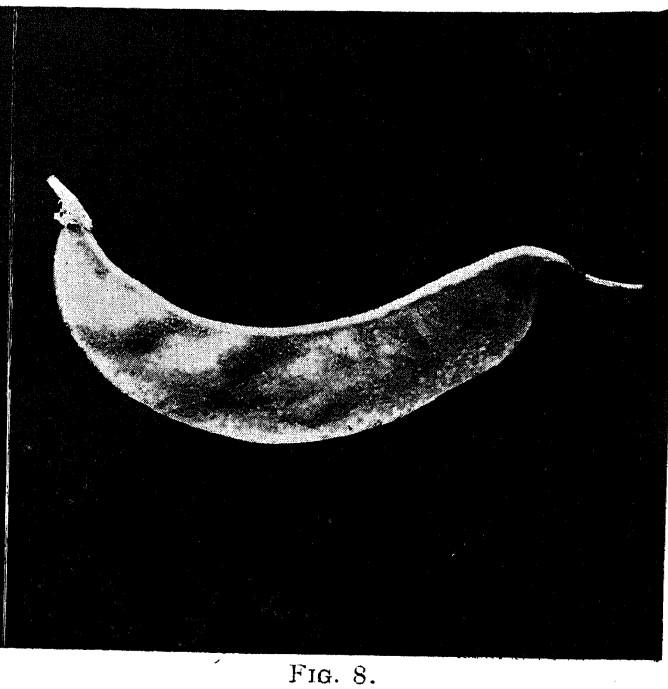

FIG. 8.

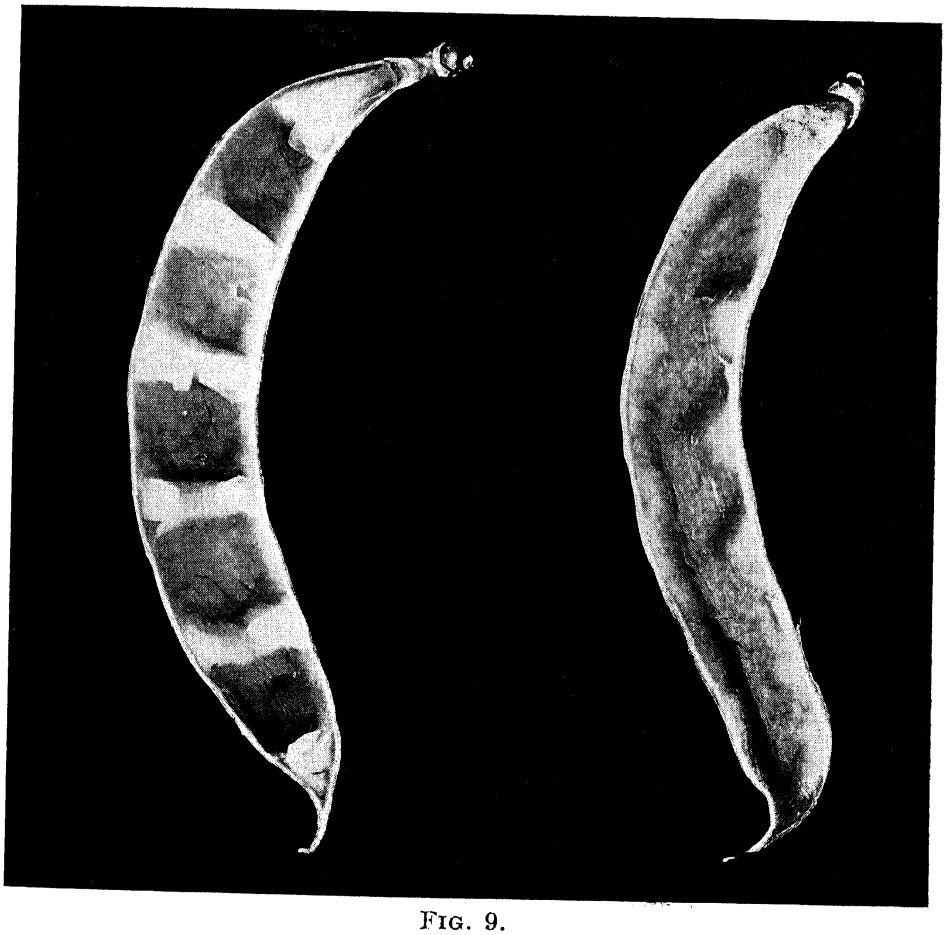

FIG. 9.

(Table V.) This lighter manifestation of chlorophyll green is provisionally designated by the symbol C_a (Green), and c_a (light green).

Summary.

Dolichos lablab exists both as a field and as a garden variety. The latter has evolved out of the former. The downward hairs (H) in the internodes of the garden variety are a simple dominant to the upward hairs (*h*) of the field variety. Erect pods (E_1, E_2 or E_1E_2) are dominant to drooping pods (e_1e_2). Two factors exist, either of which or both might give erect pods. In the absence of both, pods droop. Pods of medium width (W_1) proved dominant to pods of narrow width (w_1). In narrow podded garden varieties the septate (S) condition of the pods proved dominant to the non-septate (*s*) bloated condition. In field varieties all pods are green in colour. In garden varieties pods may also be light green in colour. This difference is reflected in the whole plant. The normal green colour (C_a) is a simple dominant to the light green (c_a).

REFERENCES.

1. Harland, S. C. .. .. *J. Genet.*, 1920, **10**, 219.
2. Jogi Raju, G. .. .. *J. Madras Agric. Stu. Un.*, 1923, **11**, 123.
3. Piper, C. V., and Morse, W. J. .. .. "The Bonavist, Lablab or Hyacinth bean," *U.S.A. Dept. Agric. Bull.*, No. 318, 1915.
4. Prain .. .. *J. Asiatic Soc. Beng.*, 1897, **66**, Part II, 429.
5. Rangaswami Ayyangar, G. N. .. .. *Madras Agric. Sta. Repts.*, 1932–33, 381.
6. Roxburgh .. .. *Flora Indica*, 1832, **3**, 305.

EXPLANATION OF PLATES.

FIG. 1.—*Dolichos lablab*—Field variety.

FIG. 2.—Seedlings, a month old.—(*a*) field, and (*b*) garden variety.

FIG. 3.—Downward hairs.

FIG. 4.—Upward hairs.

FIG. 5.—Erect pods.

FIG. 6.—Drooping pods.

FIG. 7.—Medium broad.

FIG. 8.—Narrow.

FIG. 9.—Septate and Non-septate pods.