BREEDING BEHAVIOUR OF INTERSPECIFIC HYBRIDS IN THE GENUS *Arachis* L.

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INTRODUCTION

In the genus *Arachis*, both 20 and 40 chromosomed species occur and so far 22 species have been enumerated. (Bentham 1838, Chevalier 1933, Hoehne 1940, 1941, Hermann 1954, John et al 1954, Krapovickas and Rigoni 1957 and Raman 1957). *A.hypogaea* is the only cultivated species and the rest are all wild. As the genes for the desirable characters such as resistance to diseases pests and drought, thinness of shell, profuse branching and flowering, are potentially locked up in these wild species, they form valuable breeding material for the improvement of cultivated species.

The allopolyploid origin of groundnut has been recognised only recently. (Mendes 1947, Stebbins 1957, Raman 1959, 1962 and Kesavan 1961 unpub.). One of the reasons for the success of polyploids in nature appears to lie in their ability to acquire new genes combination by hybridization and introgression from a variety of related species.

The results achieved in species hybridization in the improvement of cultivated groundnut have been encouraging and an attempt has been made in this investigation to spot light the future possibilities in interspecific gene transfer. With this in view, a comparative study of two kinds of F_2 populations has been made and their breeding behaviour evaluated. One is the F_2 population of a tetraploid hybrid between A.hypogaea and A.sp.(A.354). The second is the back-cross F_2 population of the cross A.hypogaea X F_1 (A.hypogaea X A.sp.(A.329). A critical evaluation of these two type of populations revealed that the latter method of breed--ing is a more efficient one, as it has been found to release a wider range of new combinations and intro--gressed forms.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The wild species of *Arachis* possess certain desirable genes for hardiness, resistance to disease and drought, vigour and shell thinness, which are outside the range of variability exhibited by the cultivated varieties of *Arachis hypogaea*. Interspecific hybridization provides the vehicle through which new recombinations are created and it is an integral cog in the introgression of these important characters from the wild to the cultivated species of Arachis. Thus, interspecific breeding in groundnut aims at utilising the interspecific variability to the maximum extent for economic use as well as for getting an insight into the origin and differentiation of species.

Stokes and Hull (1930) were the first to report fertile hybrids between *Arachis hypogaea*. (2n = 40) and *Arachis nambyquare* (2n = 40). Subsequently different combinations of species hybrids involving cultivated *A.hypogaea* (2n = 40) and 40 and 20 chromosomed wild species have been successfully attempted by a few workers. So far, 11 wild species of which 8 with 2n = 40 chromosomes and 3 with 2n = 20 chromosomes, have been utilised for hybridi--zation with the 40 chromosomed cultivated species.

(Stokes and Hull 1930; Gregory 1946, Krapovickas and Rigoni 1950, 1952 and 1957; John <u>et al</u> 1954; Johansen and Smith 1956; Kumar <u>et al</u> 1957, Kumar and D'Cruz 1958, Raman 1958, 1959 a. & b., 1960; Varisai Mohamad 1960 unpub.; Kesavan 1961 unpub.). A summary of results of these interspecific crosses is given in Table A.

The interspecific crosses may be classified into two main groups, viz. (1) straight crosses involving species with the same chromosomes number and (2) back-crosses involving species with different chromosome numbers.

(I) <u>INTERSPECIFIC CROSSES INVOLVING A.HYPOGAEA AND WILD SPECIES WITH THE SAME CHROMOSOME NUMBER (2n = 40)</u> :

So far, 8 species with 2n = 40 chromosomes viz., <u>A.nambyquare</u>., <u>A.marginata</u>., <u>A.glabrata</u>., <u>A.pusilla</u>., <u>A.monticola</u>, and 3 unidentified species <u>A.sp</u>.(A.326), <u>A.sp</u>.(A.328) and <u>A.sp</u>.(A.354) were utilised for crossing with <u>A.hypogaea</u> (Vide Table A). In most of the crosses completely fertile or partially fertile hybrids were obtained. These hybrids derived from parents having chromosomes which are numerically identical and structurally similar and thus the scope for selection of valuable recombinations is enhanced due to allosyndesis and of segregation with respect to interspecific differ--ences. The study of the progenies of such hybrids will indicate the extent to which allosyndesis takes place in hybrids and also the degree of introgression of useful genes. A detailed study of the progenies along the above lines was reported in the case of the hybrid A.hypogaea X A.monticola (Raman, 1958, 1960 unpub., Varisai Mohammed, 1960, unpub.).

A.hypogaea X A.monticola :

A.monticola closely resembles the spreading variety of A.hypogaea in external morphology. Fertile hybrids between this species and cultivated species are obtained easily. The useful characters that are sought to be introduced into the cultivated groundnut are thin shelled nature of the pod to improve the shelling percentage and the non-dormant nature of the pods, besides the hardiness and tolerance to 'tikka' leaf spot disease found in A.monticola. The F_1 showed hybrid vigour and formed mostly 20 bivalents; other associations noted were $2_{IV} + 15_{II} + 2_I$ and $4_{IV} + 11_{II} + 2_I$. Seed set in the hybrid was good though the pod size was reduced. The F_2 revealed (Raman, 1960, unpub., Varisai Mohammed, 1960 unpub.) rare combinants possessing high pod kernel relationship, economic type of branching and resistance to cercospora.

A.hypogaea X A.sp.(A.354) :

Kesavan (1961) reported that the interspecific hybrids between A.hypogaea X A.sp (A.354) were not uniform.

A.sp.(A.354) is perennial and vegetatively propagated. The leaflets are small, dark green, very thick and coreaceous. Pegs are rarely seen and the pods are single seeded with a papery shell. Resistance to 'Cercospora' leaf spot, and drought, profuse flowering and excellent fodder quality consequent on the higher content of protein and calcium in the haulms are some of the economic attributes of this species. (Raman 1960 unpub.)

This species has been reported to exhibit meiotic lability (Kesavan 1961 unpub.). At diakinesis, a maximum of 3 tetravalents plus 14 bivalents to 20 bivalents were observed. Abnormal M.I, such as scattered bivalents around a central equatorial plate, U-shape configuration of metaphase plates have also been reported. He considers this as an incipient polyploid species.

In the habit of growth and leaf characters, the hybrids were intermediate between the two parental species. In stipule and flower characters, they resembled *A.hypogaea* and in pod and kernel characters they were different from both parents, and pods had varying degrees of constriction, mostly one seeded and some had only ill developed kernels. Pollen sterility was intermediate between the parents and the pollen diameter was slightly bigger than both the parents. Differences in morphology and fertility were noted among the hybrids studied. (Kesavan loc.cit.).

At diakinesis, mostly bivalents are formed (20_{II}). These bivalents appeared to be loosely associated. At metaphase I and II, Anaphase I and II, the abnormalities met with in the wild species are dispersed metaphase groupings, late disjunction and scattered second anaphase. But the number of P.M.Cs with such abnormalities in the hybrids were much less. Abnormal spores viz. monads to hexads which took up staining in aceto-carmine and glycerine (1:1) were also observed, in addition to normal tetrads. (Kesavan loc.cit.).

(II) INTERSPECIFIC BACK CROSSES INVOLVING SPECIES WITH DIFFERENT CHROMOSOME NUMBERS :

Darlington (1948) who stressed the importance of interspecific hybridization for the improvements of groundnut, suggested that the 20 chromosomed species of *Arachis* might prove useful in breeding for disease resistance. But the transference of useful genes from the wild 20 chromosomed species to cultivated 40 chromosomed species is rendered difficult through the "bottleneck" of sterility of the allotriploid hybrid.

The technique commonly adopted to overcome such chromosomal sterility in hybrids is induction of polyploidy. By adopting induced autopolyploid method, Knight (1948) transferred the Black-arm disease resistance from diploid *Gossypium arboreum* (2n = 26) to tetraploid *G.barbadense* (2n = 52). Another method adopted is to double the chromosome number of the sterile triploid hybrid and produce a fertile allohexaploid which is then utilized for breeding. This "hexaploid technique" was successfully adopted in cotton (Iyengar et al 1955).

Attempts to utilise induced polyploidy to overcome chromosomal sterlity in hybrids between 20 and 40 chromo--somed species have been made in Arachis. Both artifi--cial and natural allohexaploids in Arachis have been reported. Kumar et al (1957) derived a colchicine induced fertile hexaploid (2n = 60) of the hybrid between A.hypogaea and A.villosa while Raman (1960), D'Cruz and Chakravarthy (1961) raised allohexaploids from seeds gathered from the allotriploids. D'Cruz and Chakravarthy (1961) also recorded that the allohexaploids which were also resistant to Cercospora leaf spot have been used in the improvement of cultivated A.hypogaea. The increase in ploidy, the duplication of the whole genome of the wild species and the formation of multi--valents in the allphexaploids are some of the factors which are the limitations of this technique.

Interspecific back crossing was usually adopted in the case of completely or partially fertile F_1 hybrids, with the object of increasing fertility and incorporating the desirable genes to the cultivated species. Raman (1960) successfully demonstrated interspecific back-crossing for the purposes of completely overcoming at one step the sterility barrier of the allotriploid hybrid. He (1959) also observed the formation of dyad cells with 10/20 distribution of the chromosomes in about 20% of the P.M.cells. The cytological functioning of the 20 chro--mosomed gamete in the allotriploid indicated the feasibility for obtaining fertile euploids. By back-crossing the highly sterile allotriploid to A.hypogaea 40 chromosomed plants, possessing certain desirable characters like resistance to 'tikka' leaf spot, and seed fertility was obtained. (Raman 1960)

Kumar and D'Cruz (1958) made numerous reciprocal crosses between A.hypogaea and the allotriploid of A.hypogaea X A.villosa and only one hybrid was obtained. This back cross hybrid had a spreading habit like its wild parent and was fertile and annual resembling the cultivated parent. Cytological examination has revealed a frequent association of $1_{III} + 19_{II}$ and rarely $20_{II} + 1_{I}$. This back-cross hybrid is an aneuploid of the "trisomic type" with 2n = 41 chromosomes.

Kesavan (1961 unpub.) was able to secure 16 promising 40 chromosomed synthetic hybrids, by back-crossing of A.hypogaea to the F_1 (2n = 30) of A.hypogaea X A.sp.(329) (2n = 20). It was significant that the back-cross hybrids differed from each other in morphological charac--ters and heterogenetic association in the allotriploid was attributed as the cause for the genetic variation in the back-cross tetraploid hybrids. (2n = 40).

The 16 back-cross tetraploids varied from each other with respect to the habit of growth (Bunch, semi--spreading and spreading), number and length of primaries, number of secondaries, leaflet size, pollen sterility depth of burial of pods, constriction, and shape of pods, thinness of shell, shape of kernels and resistance to leaf spot disease. The hybrids also differed from each other with regard to their meiotic stability. A maximum of two quadrivalents are met with in some hybrids.

The origin of only 40 chromosomed hybrids in the back-cross population was attributed to the functional inability of the unbalanced gametes of the allotriploid. (Kesavan 1961, unpub.). These hybrids might be expected to segregate with respect to the characters, incorporated from the wild species and thus provide a wealth of material for further study and selection from the economic point of view.

TABLE - A.

SUMMARY OF RESULTS OF THE INTERSPECIFIC CROSSES INVOLVING *Arachis hypogaea* IN THE GENUS ARACHIS.

S.No.	Species combination.	F_1 hybrid.	Remarks.	Author.
1	2	3	4	5
A. Between species with the same chromosome number (2n=40 x 2n=40).				
i)	Arachis hypogaea X A.nambyquare.	Fully fertile.	F_1 intermediate between the two parents.	Stokes and Hull (1930) John et al (1954) Raman (1960 unpub.)
	——— X ——— (Natural cross)	——— " ———	——— " ———	Srinivasamoorthy and Gopala Iyengar (1950) Bhavanishankar Rao and Srinivasalu (1957).
ii)	——— X A.monticola.	Fertile.	F_1 resembled cultivated par--rent in gross morphology, but pod size reduced. Normal meiosis with 20_{II} other associations noted were $2_{IV} + 15_{II} + 2_{I}$ and $4_{IV} + 11_{II} + 2_{I}$. F_2 gave good recombinations.	Anon (1954-1956). Krapovickas and Rigoni (1957) Raman (1958, 1960 unpub.) Varisai Mohammad (1960 unpub.)
iii)	A.hypogaea X A.marginata.	Partially fertile.	Intermediate between the two parents - profuse flowering and ~~small~~ small pods.	Krapovickas and Rigoni (1950) Raman (1960 unpub.).

Continued ....

TABLE - A (continued)..

1	2	3	4	5
iv)	*A. hypogaea* X *A. sp.* (A.326).	Partially fertile	F_1 showed marked heterosis. Produced medium sized pods. Chromosome association, $2_{IV} + 2_{III} + 13_{II}$.	Raman (1959).
v)	———— Ø X *A. sp.* (A.328)	—— " ——	Similar to the F_1 hybrid of the previous cross.	Raman (1959)
vi)	———— X *A. sp.* (A.354).	—— " ——	Some of the hybrid embryos had poor development. Differences among the viable hybrids were noted as to the habit of growth and leaflet characters. Pods with deep constriction and some with ill developed kernels noted. Mostly 20_{II}s., but showed meiotic liability.	Kesavan (1961 unpub.)
vii)	———— X *A. pusilla*.	—— " ——	The F_1 was semisterile close relationship between the genomes of the parents were suggested.	Johannsen and Smith (1956).
viii)	———— X *A. glabrata*.	Sterile	Difficult to hybridise - many hybrid embryos formed were small. Sterility in the hybrid attributed to important genic differen--ces between the species.	Gregory (1946) cited in Johannsen and Smith (1956)

Continued......

1.	2.	3	4	5.
B. **Between species with different chromosome numbers (2n=40 X 2n = 20)**				
(a) **Straight crosses :**				
ix)	*A.hypogaea* X *A.diogoi.*	Inviable	Hybrid seed failed to develop	Johannsen and Smith (1956)
x)	*A.hypogaea* X *A.villosa.*	Sterile (2n=30)	Very vigorous, perennial, profusely flowering but highly sterile. Frequent association- $10_{II} + 10_{I}$.	Krapovickas and Rigoni (1950, 1952) Kumar *et al* (1957) Raman (1959)
xi)	*A.hypogaea* X *A.sp.*(A.329)	Sterile hybrid (2n=30	Very vigorous, profusely flowering, perennial but highly sterile.	Raman (1959).
(b) **Back-cross :**				
xii)	*A.hypogaea* X F_1 *A.hypogaea* X *A.villosa.*	Fertile, synthetic tetraploid. (2n = 40).	40 chromosomed-annual-*A.hypogaea* like plant with leafspot resistance introduced from *A.villosa.*	Raman (1960)
	——— X ———	Fertile, Aneuploid.(trisomic) (2n = 41)	Spreading, annual, partially fertile hybrid.	Kumar and D'Cruz (1958)
xiii)	——— X F_1(*A.hypogaea* X *A.sp.*(A.329).	Fertile, synthetic tetraploids (2n = 40)	Back-cross hybrids differing from one another in morphological characters and fertility. Seed fertile and the hybrids possessed certain characters introduced from the wild species.	Kesavan (1961 unpub.)

MATERIAL AND METHODS

MATERIAL AND METHODS

Two different segregating populations have been analysed with reference to their recombination and gene introgression. They are :

i) F_2 population of the hybrid between *Arachis hypogaea* (2n = 40) X *A. sp.* (A.354). (2n = 40).

ii) F2 population of the back-cross hybrids between *A. hypogaea* X F_1 of (*A. hypogaea* (2n = 40) X *A. sp.* (A.329) (2n = 20).

The seed materials to raise the above populations were made available to me from the previous workers in the Post graduate faculty. For purposes of comparative study *A. hypogaea* (TMV-2-bunch variety) which was used as female parent in all the above hybridizations was raised, while the other two parental species *viz.* *A. sp.* (A.354) and *A. sp.* (A.329) already available in the breeding plots were made use of.

Detailed pod and kernel characters were recorded before sowing. The pods were then carefully hand shelled and also the size and weight of kernels were recorded. The kernels were classified as 'well filled' and 'ill filled' The shelling percentage was also determined.

Sowing was done in non-replicated rows, with a spacing of 45 cm X 45 cm during October 1961 at the Millets Breeding Station, Coimbatore.

Observations on date of germination and dateof first flowering, were recorded. When the plants are between six to eight weeks old, they were classified as to their habit of growth. The plants were described as to leaf, stem and floral characters.

The following quantitative characters were recorded :-

i) Height of main axis in cm.
ii) Number of primary branches.
iii) Mean length of primaries in cm.
iv) Number of nodes on the primaries.
v) Length of stipule in cm.
vi) Length of petiole in cm.
vii) Length of rachis in cm.
viii) Size of leaflets (length and breadth in cm). of both main axis and primary branches (4th leaf from the top).
ix) Length of calyx tube in cm.
x) Size of standard petal (length and breadth in cm)

Assessment of pollen sterility was made by staining the pollen grains with glycerine aceto-carmine (1 : 1) and counting the stained and unstained pollen grains. Non-stained pollen grains were tak en as sterile and stained as fertile.

The diameter of the pollen grains were measured with the aid of an ocular micrometer whose readings have previously been caliberated with those of the stage micrometer. For each plant, a random sample of 100 fertile pollen grains were measured.

Harvesting of mature pods was done and representa--tive samples were studied for important characters of single and double seeded nature, constriction pattern, reticulation, size and weight of pods and kernels and shelling percentage.

The progenies were grouped according to pollen sterility into highly sterile (above 30%), medium - sterile (6% - 30%) and fully fertile (below 6%) and samples of plants belonging to each group were studied cytologically. In addition, the chromosome number and behaviour of those segregants which showed distinct morphological variations were also determined.

For cytological observation, flower buds were fixed between 7.30 to 9-30 A.M. Three parts of absolute alcohol was mixed thoroughly with 4 parts of chloroform and to this mixture 1 part of glacial acetic acid which has been previously saturated with ferric acetate was added at the time of fixation.

EXPERIMENTAL RESULTS

EXPERIMENTAL RESULTS

The experimental results are presented in two main sections.

I. THE F_2 POPULATION OF THE HYBRID OF *A.hypogaea* X *A.sp.*(A.354)

The pod and kernel characters of the F_1 hybrids of *A.hypogaea* X *A.sp.*(A.354) are furnished in Table I. It may be seen that pods are mostly one seeded (64.5%). They varied in their size and nature of constriction. Some of the pods had very poorly developed, shrivelled or shrunken kernels. Out of 79 kernels obtained, only 37 well filled and the rest were all poorly developed. (53.2%). The pods also varied in their shell thickness (0.08 cm - 0.15 cm) and shelling percentage (9.1 - 93.4%).

The data on the number of seeds sown, and percentage of germination are given in Table (2). The well filled hybrid seeds recorded 100% germination.

Variation with regard to vegetative vigour was noticed. A few plants after developing the main stem and leaflets, revealed retarded growth and finally died before entering the reproductive phase. On examination it was found that there was no symptoms of disease or pest affecting such plants.

A.hypogaea (TMV.2) was early to flower (20-25 days) while *A.sp.*(A.354) was very late. The F_1 resembled

TABLE - 1

Character.	F_1 plant No. (F_2 family No.) I	II	III	V	General Mean.
No. of two seeded pods.	11	4	3	9	6.75
No. of one seeded pods.	14	6	18	11	12.25
No. of well filled kernel.	5	4	13	15	9.25
No. of ill filled kernels.	15	6	11	10	10.25
Size of two seed pods length in cm.	2.09 (1.7 - 2.6)	2.58 (2.25 - 2.73)	2.41 (1.79 - 2.74)	2.54 (2.37 - 2.72)	2.41 (1.7 - 2.74)
Breadth in cm.	1.06 (0.9 - 1.2)	1.13 (1.04 - 1.22)	1.08 (1.02 - 1.23)	1.17 (1.00 - 1.32)	1.10 (0.9 - 1.3)
Size of one seeded pod.	1.44 (1.35 - 1.53)	1.30 (1.07 - 1.76)	1.27 (1.2 - 1.34)	1.46 (1.28 - 1.62)	1.37 (1.2 - 1.62)
Breadth in cm.	1.09 (1.0 - 1.16)	1.04 (0.71 - 1.23)	0.96 (0.87 - 1.01)	1.01 (0.91 - 1.10)	1.02 (0.77 - 1.23)
Weight of two seeded pod in gm	0.43 (0.81 - 0.07)	0.83 (0.61 - 1.06)	1.22 (0.57 - 1.55)	0.68 (0.22 - 0.92)	0.79 (0.07 - 1.55)
Weight of one seeded pod in gm	0.27 (0.11 - 0.63)	0.32 (0.13 - 0.42)	0.72 (0.17 - 0.93)	0.40 (0.35 - 0.45)	0.44 (0.11 - 0.93)
Weight of kernel in gm.	0.22 (0.01 - 0.7)	0.44 (0.06 - 0.79)	0.37 (0.25 - 0.48)	0.40 (0.11 - 0.67)	0.36 (0.06 - 0.79)
Shell thickness in cm.	0.1 (0.08 - 0.15)	0.12 (0.09 - 0.15)	0.11 (0.09 - 0.12)	0.11 (0.09 - 0.13)	0.11 (0.08 - 0.15)
Shelling percentage.	43.7 (9.1 - 86.4)	72.8 (68.9 - 78.6)	70.3 (11.9 - 93.4)	72.5 (64.4 - 82.5)	67.3 (9.1 - 93.4)

TABLE - 2.

Sl No	Family No	No. of seeds sown			No. of seeds germinated.			Percentage.	No. of days for germination Mean / Range.
		Well filled	Ill filled	Total	Well filled	Ill filled	Total		
1	I	5	15	20	5	6	11	55%	6.0 / 4 - 12
2	II	4	6	10	4	4	8	80%	5.0 / 4 - 6
3	III	13	11	24	13	4	17	70%	6.5 / 5 - 29
4	V	15	10	25	15	7	22	88%	5.7 / 5 - 10
	Total	37	42	79	37	21	58	74.3%	

A.hypogaea in flowering. The mean number of days for flowering and the range of F_2 population are given in Table (3).

TABLE - 3

Sl No	Family No	Mean number of days for first flowering.	Range.
1	I	30.7	25 - 47
2	II	28.0	25 - 40
3	III	26.7	26 - 65
4	V	27.5	25 - 36
	Population mean	28.2	25 - 65

Only a few plants took considerably long period for flowering (upto 65 days), and most of the plants came to flowering early.

In the habit and intensity of flowering, they dif-fered from A.hypogaea. Some of them produced profuse flowers like that of the wild species. More number of pegs (4 - 6) were also developed per leaf axil.

There was a tendency for longer duration in most of the plants. Few plants, especially that with woody stem showed a tendency towards profuse flowering and perenniality even after a 5 month period of growth.

The pollen fertility and pollen diameter of the F_2 population, in comparison with those of the parents and F_1 are presented in Table (4).

TABLE - 4

Sl. No.	Particulars.	Pollen sterility. Mean / Range.	Pollen diameter Mean / Range.
1.	P_1 - A.hypogaea.	$\frac{3.0}{2.8 - 3.2}$	39.83
2.	P_2 - A.sp.(A.354)	$\frac{16.2}{14.4 - 18.0}$	30.43
3.	F_1 - (5 plants).	$\frac{7.75}{6.5 - 9.0}$	42.50
4.	F_2 - (53 plants)	$\frac{6.37}{0.6 - 33.8}$	$\frac{39.6}{37.3 - 44.4}$

There is significant difference in the mean and range of pollen sterility between A.hypogaea($\frac{3.0\%}{2.8-3.2}$) and A.sp.(A.354) ($\frac{16.2\%}{14.4 - 18.0}$). The F_1 hybrids showed variation in pollen sterility, and the mean of the F_1s ($\frac{7.75\%}{6.5 - 9.0}$) is intermediate between those of the two parents. The F_2 showed wider range of variability in in this character, and some of the plants transgressed the parental values. However the mean of the F_2 is about the same as that of the F_1, ($\frac{6.37\%}{0.6 - 33.8}$).

Only two F_2 plants showed pollen sterility beyond the range of A.sp.(A.354) and the values of most of the F_{2s} are similar to that of A.hypogaea in respect of this character. (Vide graph No. 1).

In pollen diameter also, the two parental species differed significantly ~~in the F_1~~; in the F_1 it is greater. In the F_2, however a majority of theplants showed values similar to that of A.hypogaea (Vide graph No. 2).

Taking pollen sterility and pollen diameter together into consideration, the cultivated species possess less pollen sterility and greater pollen diameter, while A.sp.(A.354) has more pollen sterility and less pollen diameter. The pollen sterility in the F_1 is intermediate but pollen diameter is greater than both the parents. In the F_2, few plants showed considerable pollen sterility. There appears to be no apparent correlation between pollen diameter and pollen sterility (Vide scatter diagram No. 1).

Qualitative characters : The F_2 population was grouped according to the -

(i) habit of growth (Bunch, Semi-spreading, spreading and trailing);

(ii) colour of leaf (Pale green, green and dark green)

(iii) texture of leaf (Thck, coreaceous and thin non-coreaceous).

(iv) Hairiness (slightly hairy, hairy and very hairy);

(v) Pigmentation (light purple and dark purple);

(vi) Nature of stem (Herbaceous, semi-woody and woody); and

(vii) Reaction to natural infection to 'tikka' leaf - spot disease. (Highly susceptible, susceptible, fairly tolerant, tolerant and completely resistant) and are presented in Table (5).

In the habit of growth, none of the F_2 plants showed the trailing habit of A. sp. (A.354) most of theplants were like A. hypogaea (bunch) and a few more intermediate. In colour and texture of leaves, nature of stem and pigmentation, the F_2 plants showed parental and intermediate types. In the case of hairiness, in addition to the two parental types, more hairy type also was realised. In the case of reaction to natural infection of 'tikka' leaf spot, none of the F_2 progenies showed the degree of resistance of A. sp. (A.354), though some of the segregants showed tolerance to this disease.

In general, plants like A. hypogaea, F_1 and plants intermediate between A. hypogaea and F_1 hybrids were obtained. The hybrid index value of A. hypogaea for qualitative characters is given as 2 and that of A. sp. (A.354) as 19. The F_2 progenies ranged in their hybrid index value from 0 - 12. (Vide Table - 6).

TABLE - 5

Sl No.	Family No	Habit of growth.				Colour of lea- -ves.			Texture of leaves.		Hairiness			Pigmenta- -tion.		Nature of stem.			Susceptibility to tikka leaf-spot.				
		Bun- -ch.	Semi- sprea- -ding.	Spre- ading	Trai- ling	Pale gre- en.	Gre- en.	Dark gre- en.	Thin non- corea- cious	Thick corea- cious.	Very hai- -ry.	Hairy.	Sli- ghtly hairy	Light pur- ple.	Dark pur- ple.	Herba- ceous	Semi- woody	Woody	Hig- hly susce- ptible	Susce- ptible	Fairly tole- rant	Tole- rant	Comple- tely immune.
1	I	5	6	—	—	6	3	2	8	3	1	9	1	10	1	7	4	—	—	8	1	2	—
2	II	—	1	5	—	2	3	1	2	4	4	2	—	2	4	2	2	2	1	4	2	—	—
3	III	5	9	—	—	4	6	4	3	11	1	13	—	8	6	7	6	1	1	9	5	—	—
4	V	8	8	—	—	8	5	3	2	14	3	13	—	8	8	8	7	1	2	12	1	6	—
	Total.	18	24	5	—	20	17	10	15	32	9	37	1	28	19	24	19	4	4	33	9	8	—

TABLE - 6

Character.	Marks to parents.		Frequency of F_2 progenies, scored to marks.				
	A.hypo-gaea.	A.sp. A.354	0	1	2	3	4
1. Habit growth : (Bunch (0); S.S.(1) S(2) & trailing(3)	0	3	18	24	5	—	—
2. Colour of leaves : (Pale green-0; green-1; & dark green-2)	0	2	20	17	10	—	—
3. Texture of leaves: Thin non-coreaceous-0, Thick-coreaceous -1)	0	1	15	32	—	—	—
4. Hairiness : (Very hairy and hairy-1; and slightly hairy-2)	1	2	9	37	1	—	—
5. Pigmentation : (Pale purple-0; Dark purple-1)	0	1	28	19	—	—	—
6. Nature of stem : (Herbaceous-0; semi-woody-1, woody-2)	0	2	24	19	4	—	—
7. Reaction to natural infection to Tikka leaf spot ; (Highly susceptible causing death-0 Susceptible -1 Fairly tolerant-2 Tolerant -3 Completely resistance.-4)	1	4	4	33	9	8	—
8. Perenniality : Annual like A.hypogaea-0; Perennial like A.sp-4)	0	4	30	11	4	2	—
Total Hybrid Index value. (for qualitative characters)	2	19	0	8	12	6	—

Quantitative Characters :- A comparison of the quantitative characters of the two parents, the F_1 hybrids and the F_2 population are summarised in Tables (7 and 8).

Height of main stem : The F_1 hybrids, though showed variation, were almost intermediate and in the F_2 population, the mean hight is less than that of the F_1. None of the F_2 plants, approached the height of *A. hypogaea*.

Length of primary branch : The F_1 hybrid, though showed longer primary branches (21 cm) than *A. hypogaea*, was far shorter than *A. sp.* (A.354). In the F_2 the length of primary branch is still further reduced ($\frac{13.7}{7.3 - 18.0}$).

The association of height of main stem and length of primary branch and their distribution, on comparison with that of the parents and the F_1 are represented in a scatter diagram (No.2).

Length of stipule :- The F_1 was intermediate and in the F_2 population, no plant exceeded the value of *A. hypogaea*.

Length of Calyx tube and rachis : Both the F_1 and F_2 population showed a clear cut dominant bias towards *A. hypogaea*.

TABLE - 7

Sl. No.	Family No.	Main stem height in cm.	No. of primary branches	No. of secondary branches.	Internodal length of primary branches cm.	Length of primary branch cm.	Length of stipule. cm.	Length of petiole cm	Length of rachis cm	Size of leaflets. Main stem. Length cm	X	Size of leaflets. Main stem. Breadth cm	Size of leaflets. Primary. Length cm	X	Size of leaflets. Primary. Breadth cm	Length of calyx tube cm	Size of standard petal Length cm	X	Size of standard petal Breadth cm
1	I (10 plants)	7.7 1.5-10.6	4.2 0-5	20.71 0 -36	0.8 0.5-1.1	13.8 11.0-16.7	3.2 1.7-3.9	2.5 1.1-3.0	0.8 0.2-1.2	3.7 0.9-4.3	X X	1.7 0.7-2.0	3.8 3.2-4.3	X X	2.0 1.8-2.2	2.7 2.0-3.5	1.0 0.8-1.1	X X	1.3 1.0-1.4
2	II (6 plants)	9.9 5.2-12.6	4.2 4-5	22.7 2 -33	0.8 0.6-0.8	15.8 7.5-18.0	2.3 2.2-3.7	2.9 2.7-3.0	1.0 0.9-1.1	4.4 3.9-5.1	X X	1.9 1.6-2.2	4.0 2.8-4.6	X X	2.0 1.5-2.2	3.1 2.2-3.7	1.1 1.3-1.6	X X	1.4 1.0-1.2
3	III (14 plants)	8.1 6.8-11.5	4.2 3-5	28.3 10-41	0.7 0.6-0.9	13.8 8.0-17.3	3.0 2.1-3.4	2.7 2.2-3.1	0.9 0.6-1.1	3.9 3.2-4.4	X X	1.8 1.5-2.0	3.8 3.3-4.4	X X	1.9 1.7-2.1	3.9 3.1-4.6	1.1 0.9-1.3	X X	1.5 1.4-1.7
4	V (16 plants)	7.7 5.5-11.5	4.0 3-5	18.4 3-30	0.8 0.6-0.9	11.4 7.3-14.8	3.0 2.5-3.7	2.6 2.3-3.6	0.9 0.6-1.0	3.9 3.6-5.3	X X	1.7 1.3-2.3	3.7 3.4-4.4	X X	1.8 1.6-2.2	3.3 2.4-4.4	1.0 0.9-1.2	X X	1.3 1.1-1.6
General mean General range		8.4 1.5-12.6	3.2 0-5	22.3 0-41	0.8 0.5-1.1	13.7 7.3-18.0	2.9 1.7-3.9	2.7 1.1-3.6	0.9 0.2-1.2	4.0 0.9-5.3	X X	1.8 0.7-2.3	3.8 2.8-4.6	X X	1.9 1.5-2.2	3.3 2.0-4.6	1.1 0.8-1.6	X X	1.4 1.0-1.7

TABLE - 8

Particulars.	Main stem height cm	Length of primary branch cm	Length of stipule cm	Length of rachis cm	Length of calyx tube cm	Leaflet area. Main stem. Length X Breadth. cm. cm.	Leaflet area. Primary branch Length X Breadth. cm cm	Standard petal size.
1. P_1 - *Arachis hypogaea*.	21	17	3.9	1.0	3.5	4.3 X 1.9	3.8 X 1.8	1.6 X 1.3
2. P_2 - *A. sp.* (A.354)	absent	100	2.3	0.5	6.7	absent	3.1 X 0.9	2.4 X 1.9
3. F_1 - average of 4 plants.	$\frac{12.1}{8.5-16.0}$	$\frac{21}{16-27}$	$\frac{2.7}{2.1-3.2}$	$\frac{0.9}{0.8-1.1}$	$\frac{3.4}{3.0-3.7}$	$\frac{3.5 \times 1.6}{1.9-4.5 \times 1.3 \times 2.2}$	$\frac{3.3 \times 1.7}{2.7-3.8 \times 1.5-1.9}$	$\frac{1.4 \times 0.8}{1.4-1.5 \times 0.8-0.9}$
4. F_2 - average of 46 plants.	$\frac{8.4}{1.5-12.6}$	$\frac{13.7}{7.3-18.0}$	$\frac{2.9}{1.7-3.9}$	$\frac{0.9}{0.2-1.2}$	$\frac{3.3}{2.0-4.6}$	$\frac{4.0 \times 1.8}{0.9-5.3 \times 0.7-2.3}$	$\frac{3.8 \times 1.9}{2.8-4.6 \times 1.5-2.2}$	$\frac{1.4 \times 1.1}{1.0-1.7 \times 0.8-1.6}$

A graphical representation of the distribution of the length of the Calyx tube in the F_2, along with that of parents and F_1 are given in graph (No.3). A.hypogaea has got a mean calyx tube length of 3.5 cm, while that of the wild species is 6.7 cm. The F_1 mean was 3.4 cm with a range of 3.0 cm - 3.7 cm. The F_2 mean was 3.5 cm with a range of 2.0 cm - 4.6 cm. The mode of F_1 and F_2 coincides with the mean of A.hypogaea, indicating the dominant bias of this character towards the cultivated parent.

<u>Leaflet size</u> :- The F_1 hybrids were intermediate between the parents and in the F_2, the variation was around the F_1 and A.hypogaea. It is significant to note that only one plant transgressed the parental ~~mi~~ limit and this segregant was very weak and died . The scatter digram (No.3) clearly indicates that there is a positive association between the length and breadth of leaflets in the segregating population.

<u>Size of standard petal</u> :- In this character also the F_1 and F_2 showed a dominant bias towards the parent with smaller standard petal viz., A.hypogaea.

In characters such as the number of primary branches ($\frac{3.2}{0 - 5}$), number of secondary branches ($\frac{22.3}{0 - 41}$), inter-nodal length of primary branch ($\frac{0.8}{}$) and length of

The F_2 segregants resembled A.hypogaea in gross morphology, but with a few characters (spreading habit of growth, dark green colour and thick and coreaceous nature of leaflets, profuse flowering, more number of flowers per axil, longer duration, woody nature of stem, reducedheight of main stem and leaflet size and tolerance to 'tikka' leaf spot) introduced from the wild parent.

Pod and kernel characters : Though few plants compared favourably with that of A.hypogaea in pod and kernel characters, majority of the population showed a reduction in the size of pod and kernels. In the case of plants having higher hybrid index and showing most characters of the wild species there was a marked reduc--tion in the size of the pods. In these plants, although a high percentage of pegs are formed the pods were one seeded (about 60%) and shrunken or ill developed kernels (40%) were also noted.

CYTOLOGY :

Mostly bivalents were formed and 20 bivalents were counted at diakinesis and metaphase I. Only in one segregant possessing 5.3% pollen sterility, one trivalent and one univalent was observed in a few cells possibly due to precocious separation of a quadrivalent. The meiosis of fully fertile plants was normal, except for precocious disjunction of quadrivalents and bivalents.

Even in the case of plants showing medium to high sterility (6% - 34%) only bivalents were noted. At diakinesis, 4 nucleolar bivalents were present. The bivalents, especially two rod bivalents appeared to be "loosely associated" having a feeble terminal attachment.

Metaphase I and II showed disturbances which are characteristic of the wild species. Regularly organised metaphase plate was noted only in a low percentage of P.M.Cs. In the rest, varying number of bivalents were seen to be dispersed in groups (Table - 9).

Besides these, the metaphase plate (M.I) assumed peculiar shapes of 'U', 'V', and 'Z'.

During anaphase I, laggards were commonly met with. Only in one singular instance, a thin chromation bride at telophase I was observed.

Besides normal tetrads, abnormal spores <u>viz.</u>, monads to hexads which also took staining in aceto-carmine and glycerine (1 : 1) were observed. (Table - 10).

TABLE - 9

No.of cells with normal metaphase plate (20_{II}s in one equa-torial plate).	Frequency of abnormal M.I cells with Number of bivalents apart.						Total number of cells observed.
	1_{II}	2_{II}	3_{II}	4_{II}	5_{II}	Uncoun-table.	
26	14	22	10	7	9	21	109
23.8%	12.8%	20.2%	9.2%	6.4%	8.2%	19.2%	

TABLE - 10

Normal tetrad	Abnormal spores.						Total observed
	Monad	Dyad	Triad	Unequal tetrad	Pentad	Hexad	
63	2	1	12	7	2	18	105
60%	1.9%	0.9%	11.4%	6.6%	1.9%	17.1%	

These abnormal spores contributed much to the size variation of pollen grains.

II. F_2 POPULATION OF THE BACK-CROSS HYBRID RESULTING FROM THE CROSS *A.hypogaea* X *allotriploid* :

The data on pod and kernel characters of the back-cross hybrids are furnished in Table (11)

It may be observed that pods are mostly two seeded (64.6%). The pods varied in their size, shape, nature of constriction. The kernels that varied in their sige and weight were well filled (87.3%). Variation in shell thickness (0.06 cm - 0.14 cm) and shelling percentage (54.3% - 98.4%) was also noted.

The mean percentage of germination was 73.7% with a range between 47.6% - 92.8%. The mean days for germination in families was 8.9 with a range of 5 - 33 days. (Table 12). The F_2 showed variation with regard to vegetative vigour also. In general, majority of the plants were like *A.hypogaea* in gross morphology.

A.hypogaea and *A.sp.*A.329 differ considerably in their date of first flowering. The former being a short duration (110 - 120 days) annual, flowers within 20 - 25 days after sowing while *A.sp.*(A.329) is a late but profuse flowering plant. The allotriploid hybrid was perennial and intermediate between the two parents in the period of first flowering. The date of flowering of back-cross F_2 population in comparison with those of the back-cross hybrids are given in Table (13).

TABLE - 11

Characters.	BC_1 F_1 Plant No.				(BC_1 F_2 plant No.)						
	A	B	C	D	E	F	H	L	O	P	General Mean.
No.of two seeded pods.	10	6	4	8	27	51	1	51	4	28	19.0
No.of one seeded pods.	16	3	4	3	9	21	11	29	1	8	10.4
No.of well filled kernels	24	11	6	16	54	110	11	115	7	58	41.2
No.of ill filled kernels	2	3	3	3	9	13	2	16	3	5	5.9
Size of two seeded pod Length in cm.	2.29 2.05-2.58	1.89 1.18-2.41	2.19 1.71-2.45	2.34 1.83-2.80	2.46 2.28-2.72	2.21 2.00-2.35	2.85 2.85	2.49 2.[illegible]0-2.72	2.45 1.78.2.90	2.43 1.68-3.00	2.36 1.18-2.90
Breadth cm.	1.10 0.96-1.25	1.03 0.89-1.10	0.82 0.73-0.98	1.10 0.98-1.23	1.09 1.03-1.15	0.99 0.85-1.15	1.32 1.32	1.20 0.92-1.44	1.06 0.82-1.18	1.10 0.76-1.32	1.08 0.73-1.44
Size of one seeded pod Length (cm)	1.26 0.95-1.55	1.35 1.16-1.49	0.95 0.70-1.10	1.23 1.11-1.25	1.36 1.25-1.64	1.22 1.18-1.26	1.54 1.27-1.81	1.81 1.80-1.83	1.32 1.32	1.44 1.10-1.82	1.35 0.70-1.83
Breadth (cm)	0.96 0.82-1.12	1.06 0.99-1.15	0.04 0.50-0.80	1.11 1.05-1.17	1.01 0.85-1.12	0.97 0.95-0.99	0.98 0.81-1.18	0.99 0.98-1.00	1.10 1.10	0.48 0.60-1.18	0.98 0.50-1.18
~~Weight of two seeded pods (gm)~~	~~0.96~~	~~1.06~~	~~0.04~~	~~1.11~~							
Weight of two seeded pods (gm)	1.06 0.88-1.51	0.92 0.54-1.21	0.69 0.42-0.97	0.88 0.48-1.45	0.90 0.67-1.12	0.79 0.66-0.92	1.28 1.28	1.17 0.98-1.32	0.88 0.65-1.24	0.92 0.42-0.96	0.95 0.42-1.51
Weight of one seeded pods (gm)	0.42 0.25-0.67	0.48 0.27-0.70	0.45 0.26-0.64	0.48 0.46-0.55	.0.52 0.30-0.75	0.40 0.22-0.45	0.46 0.38-0.53	0.50 0.42-0.59	0.75 0.75	0.46 0.34-0.56	0.49 0.22-0.75
Weight of kernel (gm)	0.38 0.19-0.62	0.46 0.20-0.62	0.31 0.11-0.47	0.42 0.25-0.65	0.38 0.15-0.60	0.32 0.05-0.45	0.44 0.27-0.75	0.52 0.20-0.84	0.46 0.19-0.62	0.56 0.28-0.72	0.43 0.11-0.84
Shell thickness (cm)	0.09 0.70-0.12	0.09 0.08-0.10	0.09 0.08-1.10	0.11 0.8 -0.14	0.09 0.08-0.11	0.08 0.06-0.11	0.09 0.08-0.10	0.09 0.08-0.12	0.09 0.08-0.12	0.09 0.08-0.10	0.09 0.06-0.14
Shelling percentage	77.2 54.3-91.5	82.7 74.1-88.5	81.4 76.2-86.6	73.4 59.1-85.4	79.5 70.0-84.8	81.1 60.6-91.0	24.4 78.6-92.1	87.8 87.6-88.1	83.6 70.2-98.4	73.2 64.4-81.2	80.2 54.3-98.4

TABLE - 12.

Sl No	Family No	No.of seeds sown. Well filled	Ill filled	Total	Seeds germi-nated	Percent-age of germi-nation.	No.of days for germi-nation. Mean / Range.
1	A	24	2	26	19	73.1	10.9 / 6 - 13
2	B	11	3	14	13	92.8	6.6 / 5 - 10
3	C	6	3	9	8	88.9	7.7 / 5 - 12
4	D	16	3	19	10	52.9	7.0 / 5 - 13
5	E	54	9	63	30	47.6	7.5 / 5 - 33
6	F	110	13	123	102	82.9	11.6 / 5 - 20
7	H	11	2	13	11	84.5	6.3 / 5 - 12
8	L	115	16	131	105	80.2	11.2 / 6 - 25
9	O	7	3	10	5	50.0	6.6 / 5 - 8
10	P	58	5	63	44	69.8	14.0 / 10 - 18
Total.		412	59	471	347	73.7	8.9 / 5 - 33

TABLE - 13

Sl No	Family No	First day of flowering.		
		BC_1 hybrid.	BC_1 F2 population.	
			Mean.	Range.
1	A	41	38.0	30 - 58
2	B	31	34.3	26 - 43
3	C	42	37.7	28 - 58
4	D	36	35.3	28 - 62
5	E	44	38.7	29 - 53
6	F	29	42.9	32 - 53
7	H	48	34.4	31 - 46
8	L	35	34.8	30 - 53
9	O	31	36.5	31 - 42
10	P	57	42.0	37 - 57
General.		39.4 29 - 57	37.5 26 - 62	

Though the average for the back-cross hybrids and their progenies was almost the same with regard to the day of first flowering, the F_2 showed greater variability (26 - 62 days) for this character. The data on pollen sterility and pollen diameter of the parents, F_1, BC_1 F_1 and BC_1 F2 populations are summarised in Table (14) A.hypogaea (2n = 40) has an average of 3.0% pollen sterility while that of the diploid wild species is 8%. The F_1 (2n = 30) pollen sterlity is 90.2%.

TABLE - 14

A.hypogaea (F_1)	A.sp. A.329 (2)	Pollen sterility. F_1 hybrid		Pollen sterility. BC_1 F_1 hybrid	Pollen sterility. BC_1 F_2 population.	A.hypogaea F_1	A.sp. (A.329) F2	F_1 hybrid		Pollen diameter. BC_1 F_1 hybrids.	Pollen diameter. BC_1 F_2 populations.	
			A	10.8	3.2 / 0.8 - 9.1				A	41.2 / 35 - 50	39.6 / 30.0-50.0	(17 plants)
			B	16.6	6.0 / 1.0 - 14.0				B	37.0 / 22.5-45.0	43.4 / 30.0-52.5	(11 plants)
			C	6.3	1.5 / 1.0 - 2.0				C	41.3 / 32.5-52.5	38.4 / 32.5-45.0	(5 plants)
			D	9.8	2.2 / 0.9 - 4.6				D	40.8 / 32.5-50.0	39.6 / 32.5-47.5	(6 plants)
			E	4.7	3.7 / 0.5 - 22.4				E	40.3 / 32.5-45.0	39.8 / 32.5-50.0	(9 plants)
			F	5.5	3.0 / 0.9 - 6.4				F	40.8 / 35.0-45.0	38.7 / 32.5-46.2	(4 plants)
			H	12.7	3.7 / 1.0 - 7.5				H	41.0 / 32.5-45.0	40.0 / 30.0-45.0	(5 plants)
			L	3.6	1.2 / 0.7 - 3.5				L	41.5 / 35.0-47.5	37.4 / 29.7-49.5	(34 plants)
			O	9.5	4.1 / 1.4 - 6.7				O	39.0 / 32.5-45.0	39.0 / 32.5-42.5	(2 plants)
			P	11.8	4.0 / 1.7 - 14.7				P	39.2 / 32.5-45.0	38.1 / 33.0-46.2	(10 plants)
3.0 / 2.6-3.2	8.0 / 6 - 10	90.2		9.1 / 3.6-16.6	3.3 / 1.2-22.4	39.8	32.4 / 26.4-36.3	44.2 / 30.6-57.8		40.2 / 32.5-52.5	39.4 / 29.7-52.5	(100 plants)

In the 40 chromosomed back-cross hybrids, there was a phenomenal decrease in pollen sterility. In the BC_1 F2 population, however there was a marked improvement in the pollen fertility. ($\frac{96.7}{77.6 - 98.8}$) (Vide - graph - 4).

In pollen diameter, the triploid has given a higher value than either of its parents. The back cross hybrids and their progenies showed wide variability in respect of this character though the mean leaned towards A. hypogaea (Vide - graph - 5)

A comparison of the relation between pollen sterility and pollen diameter in BC_1 F_1 and BC_1 F_2 population indi--cates that there does not exist any correlation between pollen diameter and pollen sterility. (Vide scatter diagram - 4).

Qualitative characters :

The back-cross F_2 population was classified according the following qualitative characters.

i) Habit of growth (Bunch, Semi-spreading, spreading and trailing).

ii) Colour of leaf (Pale green, green and dark green)

iii) Natureof stem (Herbaceous, semi-woody and woody)

iv) Pigmentation on young peg, calyx tube (light - purple and dark purple).

v) Hairiness on stem (slightly hairy, hairy and very hairy).

vi) Reaction to natural infection of 'tikka' leaf spot (Highly susceptible, susceptible, fairly tolerant, tolerant and completely resistant); and the data are presented in Table (15).

In the habit of growth, in addition to the parental and intermediate types, transgressive types also occurred. One plant was trailing and branching profusely. Two other plants showed a striking resemblence to another species *A.monticola* and possessed trailing habit with the tips of primaries as pressed to the ground. The branching was also moderate. In the nature of stem, most of them resembled the *Arachis hypogaea* parent, and in a few the stem is semi-woody. A few plants, showed extreme susceptibility to 'tikka' leaf spot disease. Only very few plants showed complete tolerance to the disease. The hybrid index value of *A.hypogaea* for qualitative characters is given as 2, and that of *A.sp.*(A.329) as 13. The back-cross F_2 ranged in their hybrid index value from 0 to 9. (Table - 16).

The data collected on quantitative characters of the F_2 population are summarised in Table (17) and compared with that of BC_1 F_1, F_1 and the original parents *viz.*, *A.hypogaea* and *A.sp.A.*329. (Table 18).

The height of main stem was reduced in the F_1 plants. In the F_2 population, however, a few transgressed the

TABLE - 15

Sl No	Family.	Habit of growth. Bunch.	Semi-spreading	Spreading.	Trailing.	Colour of leaf Pale green.	Green	Dark green.	Pigmentation. Light purple	Dark purple	Stem nature Herbaceous.	Semi-woody	Hairiness Hairy	Very hairy.	Susceptibility to Tikka leaf spot. Very susceptible	Susceptible	Fairly tolerant.	Tolerant	Complete resistance.
1	A	6	8	1	–	5	9	2	6	14	16	2	12	–	–	9	6	–	–
2	B	2	6	–	–	3	3	2	2	6	7	1	8	–	2	8	–	–	–
3	C	3	1	1	–	2	1	2	1	4	4	1	5	–	–	5	–	–	–
4	D	1	4	–	–	2	3	–	4	1	5	–	5	–	–	4	1	–	–
5	E	4	6	–	–	3	6	1	4	6	9	1	10	–	–	8	2	–	–
6	F	6	10	1	–	11	3	3	7	10	17	–	12	5	1	14	2	–	–
7	H	–	1	3	1	–	1	4	–	5	–	5	1	4	–	1	–	4	–
8	L	7	17	11	–	10	3	12	3	32	35	–	18	14	1	24	8	2	–
9	O	1	1	–	–	–	1	1	2	–	2	–	2	–	–	1	–	4	–
10	P	8	9	3	–	11	5	4	7	13	20	–	16	4	2	14	4	–	–
	Total	38	63	20	1	47	35	31	36	91	105	10	89	37	6	88	23	7	–

TABLE - 16

	Marks allotted to parents.		Frequency of BC_1 F_2 progenies scored to marks.				
	A.hypogaea.	A.sp. A.329.	0	1	2	3	4
1. Habit of growth (Bunch-0; S.S.-1; S-2 and trailing -3)	0	2	38	63	20	1	—
2. Colour of leaves (Pale green-0; green-1; dark green-2)	0	1	47	35	31	—	—
3. Hairiness (very hairy-0, hairy-1; highly hairy-2)	1	2	37	89	—	—	—
4. Pigmentation (pale purple-0; dark purple-1)	0	0	36	91	—	—	—
5. Nature of stem (Herbaceous-0; semi-woody-1)	—	—	105	10	—	—	—
6. Reaction to natural infection of 'Tikka' leaf spot. (highly susceptible-0; susceptible-1; fairly tolerant-2; tolerant-4; completely resistant-4)	1	4	6	88	23	7	—
7. Perenniality. (Annual like *A.hypogaea*-0; perennial like *A.sp*-4).	0	4	105	7	2	1	—
Total hybrid Index value. (for qualitative characters)	2	13	0	7	6	9	—

the limits of the higher parent (25.4 cm), though in a majority of the population general reduction in height was noticed. In the length of primary branch, the allotriploid exhibited hybrid vigour (70 cm) and surpassed both the parents. The association of the above two characters are illustrated in a scatter diagram (No. - 5).

In the length of stipule ($\frac{3.0\ cm}{2.1 - 4.0\ cm}$), rachis ($\frac{0.9\ cm}{0.6 - 1.4\ cm}$) and petiole ($\frac{2.8\ cm}{1.9 - 4.0\ cm}$), a majority of the back-cross F_2 plants showed values leaning towards A.hypogaea. Variation was also evident in respect of the number of primary branches ($\frac{4.0}{2 - 5}$), secondary branches ($\frac{14.7}{1 - 47}$) and in the internodal length ($\frac{1.0\ cm}{0.7 - 2.0\ cm}$).

In the case of size of leaflets the F_2 population transgressed both the parental limits. The character association of length and breadth of leaflets showed clearly that there is a positive correlation between them. (Vide - Scatter diagram No. 6).

Considering the length of calyx tube, the value for the $BC_1\ F_1$, tended towards A.hypogaea. Though few plants showed distinctly longer calyx tube (upto 6.1 cm) than A.hypogaea, none of them reached the value of the diploid species with the longest length (graph - No. 6). In the size of the standard petal, also, F_2 population showed values almost similar to that of A.hypogaea.

TABLE - 17

BC1 F2 Family No	Height of main stem cm	No. of primary branches.	No. of secondary Branches.	Length of Primaries. cm	Internodal length of primaries cm	Stipule length cm	Petiole length. cm	Rachis length cm	Leaflet area. Main stem. Length X Breadth cm	Leaflet area. Primaries. Length X Breadth cm	Calyx tube length cm	Size of standard Length X Breadth cm
A (17 plants)	9.3 / 6.5–14.5	4.1 / 3–5	20.7 / 5–34	13.2 / 8.0–17.1	0.9 / 0.7–1.1	2.9 / 2.6–3.8	2.9 / 2.4–3.8	0.9 / 0.7–1.3	4.2 X 1.9 / 3.6–5.4 X 1.6–2.5	2.6 X 2.0 / 2.5–4.7 X 1.6–2.6	3.3 / 2.3–4.6	1.2 X 1.5 / 1.0–1.3 X 1.4–1.6
B (7 plants)	8.9 / 6.5–11.6	3.8 / 3–4	19.4 / 4–35	12.8 / 8.6–15.6	0.8 / 0.7–1.0	2.8 / 2.4–3.2	2.7 / 2.2–3.1	0.9 / 0.7–1.0	3.7 X 1.7 / 3.0–4.3 X 1.5–1.8	3.4 X 1.8 / 2.5–4.0 X 1.5–2.1	3.3 / 2.9–4.0	1.8 X 1.1 / 1.3–1.6 X 1.0–1.2
C (5 plants)	7.8 / 6.8–8.4	3.8 / 3–4	16.6 / 5–26	10.1 / 7.3–13.4	0.8 / 0.7–0.8	2.6 / 2.5–2.6	2.6 / 2.3–2.8	0.8 / 0.7–0.9	3.9 X 1.7 / 3.7–4.1 X 1.7–1.8	3.3 X 1.7 / 2.9–3.6 X 1.5–1.8	3.2 / 2.6–3.6	1.5 X 1.2 / 1.4–1.6 X 1.1–1.3
D (5 plants)	8.2 / 7.2–10.1	4.0 / 4–4	18.4 / 6–29	12.3 / 10.7–13.6	0.7 / 0.7–0.8	2.8 / 2.3–3.2	2.8 / 2.5–3.2	0.8 / 0.6–1.0	3.7 X 1.8 / 3.1–4.7 X 1.4–2.0	3.5 X 1.8 / 3.0–4.0 X 1.5–2.1	3.0 / 1.5–2.0	1.4 X 1.0 / 1.2–1.5 X 0.9–1.3
E (10 Plants)	8.3 / 6.6–9.3	3.9 / 3–4	15.8 / 5–20	11.4 / 6.0–16.2	0.7 / 0.6–1.0	2.9 / 2.4–3.2	2.9 / 2.6–3.4	0.8 / 0.7–0.9	4.0 X 1.9 / 3.3–4.7 X 1.5–2.2	3.6 X 1.8 / 3.3–4.2 X 1.4–2.2	3.0 / 2.0–3.6	1.5 X 1.1 / 1.4–1.6 X 1.0–1.2
F (16 plants)	10.0 / 6.5–13.6	3.9 / 3–5	5.7 / 1–18	15.3 / 9.5–20.8	1.2 / 0.8–1.4	3.3 / 2.8–4.2	2.8 / 2.0–3.8	0.9 / 0.7–1.0	4.4 X 1.9 / 3.6–5.4 X 1.7–2.3	3.9 X 1.9 / 3.4–5.1 X 1.7–2.2	2.2 / 1.4–3.4	1.2 X 0.9 / 1.0–1.5 X 0.7–1.2
H (5 plants)	7.5 / 4.2–12.8	4.4 / 4–5	19.8 / 2–47	22.0 / 18.6–30.2	1.1 / 0;8–1.6	2.9 / 2.4–3.1	2.4 / 1.9–3.1	0.7 / 0.6–0.9	3.6 X 1.6 / 3.0–4.3 X 1.5–2.0	2.7 X 1.7 / 2.1–3.1 X 1.4–2.1	4.5 / 3.0–6.1	1.6 X 1.2 / 1.4–1.8 X 1.1–1.4
L (23 Plants)	15.9 / 6–25.4	4.1 / 4–5	9.4 / 1–22	21.2 / 12.5–35.7	1.5 / 1.1–2.0	3.3 / 2.1–4.0	3.1 / 2.7–3.7	1.0 / 0.8–1.4	4.9 X 2.1 / 3.8–5.5 X 1.7–2.7	4.2 X 2.2 / 3.4–5.6 X 1.8–2.7	2.6 / 1.8–3.8	1.6 X 1.3 / 1.1–1.6 X 0.8–1.2
O (2 Plants)	7.3 / 6.4–8.1	4.0 / 4–4	17.5 / 9–25	12.1 / 10.0–14.1	0.8 / 0.7–0.8	3.3 / 3.0–3.6	3.0 / 2.8–3.2	0.9 / 0.8–0.9	4.3 X 2.1 / 4.2–4.4 X 2.2–2.3	4.0 X 2.2 / 3.9–4.0 X 2.1–2.2	3.1 / 2.6–3.6	1.5 X 1.2 / 1.4–1.6 X 1.1–1.2
P (19 Plants)	13.4 / 7.2–19.5	4.2 / 2–4	3.6 / 1–10	17.8 / 6.0–24.7	1.4 / 0.7–1.6	3.6 / 2.9–4.0	3.1 / 2.5–3.6	0.9 / 0.7–1.0	4.6 X 2.1 / 4.1–5.4 X 1.9–2.4	4.1 X 2.1 / 2.9–5.1 X 1.4–2.5	2.6 / 1.4–3.3	1.4 X 1.1 / 1.0–1.6 X 0.8–1.2
General Mean	9.7 / 4.2–25.4	4.0 / 2–5	14.7 / 1–47	14.8 / 6.0–35.7	1.0 / 0.7–2.0	3.0 / 2.1–4.0	2.8 / 1.9–4.0	0.9 / 0.6–1.4	4.1 X 1.9 / 2.0–5.4 X 1.5–2.7	3.6 X 1.9 / 2.1–5.6 X 1.4–2.7	2.8 / 1.4–6.1	1.3 X 1.1 / 1.0–1.8 X 0.7–1.4

TABLE - 18

Sl No	Particulars.	Height of main stem cm.	Length of Primary branch. cm	Length of stipule cm	Length of petiole cm	Length of rachis cm.	Leaflet area. Main stem. Length cm	X	Breadth cm	Leaflet area. Primary branch. Length cm	X	Breadth cm	Length of calyx tube.	Size of standard petal.
1.	(P_1) A.hypogaea.	21	17	3.3	3.9	1.0	4.25	X	1.9	3.8	X	1.8	3.5	1.6 X 1.3
2.	(P_2) A.sp.A.329.	19	40	2.8	1.9	1.0	4.1	X	1.5	2.6	X	1.3	8.5	2.4 X 1.8
3.	F_1 - allotriploid.	12	70	2.1	3.0	1.0	2.9	X	1.3	2.4	X	1.7	7.8	2.2 X 1.2
4.	BC_1 F_1 = A.h..(F_1 of A.h X A.sp.(A.329)	10.7 6.5-17.0	19.1 15-27	2.5 2.0-3.4	4.8 3.8-5.8	0.9 0.5-1.2	3.7 3.0-4.7	X X	1.8 1.5-2.2	3.6 3.3-4.2	X X	2.2 1.8-3.8	4.0 3.6-5.0	1.7 X 1.0 1.6-1.8 X 0.9-1.2
5.	BC_1 F_2 population.	9.7 4.2-25.4	14.8 6.0-35.7	3.0 2.1-4.0	2.8 1.9-4.0	0.9 0.6-4.0	4.1 3.0-5.4	X X	1.9 1.5-2.7	3.6 2.1-5.6	X X	1.9 1.4-2.7	2.8 1.4-6.1	1.3 X 1.1 1.0-1.8 X 0.7-1.4

Though most of the plants resembled A.hypogaea in gross morphology each was variable from A.hypogaea and from one another in one or a few specific characters. Few of the F_2 plants instead of becoming closer to the back-cross parent A.hypogaea, leaned towards the wild species. Few of the segregants were quite distinct from the parents, possessing genomes similar to A.hypogaea.

The segregating population of one family (H) which showed extreme variation as represented and compared by the hybrid index method (Table 19). The hybrid index value of A.hypogaea is 9 while that of A.sp.(A.329) is 34. The allotriploid hybrid, has scored hybrid index value of 33. The back-cross F_1 plant (H) has value of 23 and that of the F_2 population varied from 12-33. Two of the segregants strikingly resembled A.monticola in most of the morphological characters and these plants have got 29 and 30 as their values, while that of A.monticola is 31.

Pod and kernel character :

Most of the plants in the F_2 possess pod characters comparing favourably with that of A.hypogaea. Pods were mostly two seeded (about 64%) and had varying degrees of constriction. In two rare segregants, the pod and kernel characters also resembled A.monticola except for the bigger size and presence of comparatively more number of two seeded pods. In the case of two seeded pods, the

TABLE - 19.

Characters.	A. hypogaea. 2n=40 (AA BB)	A. sp. (A.329) 2n=20 A"A"	Allo-triploid 2n=30 AA"B	BC_1F_1 2n=40 AA^{*} BB	Back-cross F_2 family (H). 2n = 40. $A^{*}A^{*}$ BB. H/2	H/9	H/11	H/5	H/6		A. monticola * 2n = 40 A'A'B'B'
1	2	3	4	5	6	7	8	9	10		11
Perenniality (Annual-0; Perennial-4)	0	3	3	1	0	0	2	2	2		2
Habit of growth. (Bunch-0 - trailing 4)	0	2	3	2	2	0	4	3	3	**	3
Branching pattern Non-branching-0; Branching profusely-4)	0	2	3	1	1	1	2	1	1	**	1
Vegetative vigour (Normal-0; very vigourous-4)	0	2	4	1	1	0	3	2	2	**	2
Hairiness (sparsely hairy-0; very hairy-2)	1	0	2	2	2	1	2	2	2	**	2
Calyx tube length 3.5 cm -0; 8.5 cm -6)	0	6	5	3	1	2	1	3	4		3
Profuseness of flowering (Normal-0; Profuse-4)	0	3	4	2	1	0	3	2	2		3
Length of primary branch 17 cm -0; 70 cm -4)	0	3	4	2	1	0	3	3	3		3
Size of pods (A. hypogaea-5; A.329)-1)	5	1	-	3	3	3	2	2	2		2
Thickness of shell (A.329 very thin-4; A. hypogaea-2)	2	4	-	3	2	2	3	3	3		4

Continued....

TABLE - 19 (continued)...

1	2	3	4	5	6	7	8	9	10	11
Leaf character (*A. hypogaea*-0; *A. sp.* (A.329)-4)	0	4	1	1	3	1	4	3	3	3
Susceptibility to tikka leaf spot disease. (Highly susceptible-0; Resistant -4)	1	4	4	2	2	2	3	3	3	3
Total hybrid index value	9	34	33	23	19	12	33	29	30	33

** Transgressive segregation.

* Species not involved in the cross.

constriction was deep. The kernels were oblong with a slightly bent tip. A third segregant had a trailing habit of growth and the pods in them were very prominently reticulated.

CYTOLOGY :

All the F_2 plants examined showed 2n = 40 chromosomes. The meiosis was normal in fertile plants, forming 20 bivalents. In the plants of the family H, one quadrivalent was formed. Early disjunction of one of the chromosome of the quadrivalent, gave rise to one trivalent and univalent. More than one Metaphase group and scattered anaphase plates were noted. Besides, tetrads, monads, diads, triads and supernumerary spores (pentads and hexads) were also found.

TABLE - 20

Characters.	Straight F_2 of *A. hypogaea* X *A. sp.* (A.354) (2n = 40) (2n = 40) 2n = 40						Back-cross F_2 of *A. hypogaea* X F_1(*A. hypogaea* X *A. sp.* (A.329)) (2n = 40) (2n = 30) 2n = 40					
	Grades of variation.					Total.	Grades of variation.					Total.
	1	2	3	4	5		1	2	3	4	5	
1. Habit of growth. ...	*	*	*	-	-	3	*	*	*	*	*	5
2. Branching pattern ...	*	*	-	-	-	2	*	*	*	-	-	3
3. Duration. ...	*	*	*	-	-	3	*	*	*	*	-	4
4. Vegetative vigour ...	*	*	-	-	-	2	*	*	*	*	-	4
5. Profuseness of flowering..	*	*	*	-	-	3	*	*	*	-	-	3
6. Hairiness of stem ...	-	*	*	-	-	2	*	*	*	-	-	3
7. Height of main stem ...	*	*	-	-	-	2	*	*	*	*	-	4
8. Length of primary branch..	*	*	-	-	-	2	*	*	*	*	-	4
9. Length of calyx tube. ...	*	*	-	-	-	2	*	*	*	-	-	3
10. Leaf characters. ...	*	*	*	-	-	3	*	*	*	*	-	4
11. Pod size. ...	*	*	-	-	-	2	*	*	*	-	-	3
12. Shell thickness ...	*	*	-	-	-	2	*	*	*	-	-	3
13. Disease resistance ...	*	*	*	*	-	4	*	*	*	*	*	5
Total variation index ...						32						48

TABLE - 21

Characters.	*A.hypogaea* (TMV - 2) 2n = 40	*A.villosa* 2n = 20	F_1 A.h X A.v. 2n = 30	BC_1 F_1 A.h X F_1 of A.h. X A.v.	BC_1 F_2 Population.	BC_1 F_3 Population.
1. Habit of growth	Bunch	Trailing	Spreading	Spreading	Spreading (13) : Semi-spreading (33) : Bunch (34)	Spreading (15) : Semi-spreading (4) : Bunch. (3)
2. Stem hairiness	Hairy	Very hairy	Intense-hairy	Very hairy.	Sparsely hairy (30) : Hairy (31) : Very hairy (19)	Hairy (17) : Very hairy. (5)
3. Pigmentation.	Light purple.	Light purple	Light purple	Light purple.	Light green (11) : Green (54) : Light purple. (15)	Light purple (16) : Dark purple. (6)
4. Leaf colour	Light green.	Green	Green	Green.	Light green (27) : Green (33) : Dark green. (20)	Light green (3) + Green (13) : Dark green. (6)
5. Tikka leafspot resistante.	Suscep-tible.	Resistant	Resistant	Resistant.	Susceptible,: Tolerant : Resistant	Highly susceptible: (1) Susceptible : (11) Fairly tolerant (3) : Resistant. (7)
Quantitative Characters :-						
Main stem height	21	15	15	15	10.9(5.5 - 18.1)	9.3 (5.8 - 17.4)
Length of primaries	17	70	90	52	14.9(3.0 - 44.5)	15.3(9.9 - 31.7)
Length of stipule	3.5	1.3	3.5	2.8	3.1 (1.8 - 4.2)	3.2 (2.8 - 3.8)
Length of petiole	4.8	2.4	6.5	2.5	2.8 (1.6 - 4.8)	3.0 (2.4 - 3.8)
Leaf size -	4.5 X 2.0	1.8 X 1.4	4.5 X 1.7	3.5 X 1.7	3.32 X 1.42 (1.7 - 4.8 X 0.8 - 2.2)	4.1 X 2.1 (2.9 - 5.2 X 1.6 - 1.5)
Calyx tube length	3.5	5.5	8.5	2.7	1.9 (1.0 - 3.0)	1.9 (1.7 - 2.1)
Size of standard petal	1.6 X 1.3	2.1 X 1.7	2.3 X 1.8	1.3 X 0.8	1.8 X 0.8 (1.7 - 1.9 X 0.7-0.9)	1.4 X 1.2 (1.4 - 1.5 X 1.1 - 1.2)

III. F_3 population of the back cross hybrid of *A.hypogaea* X allotriploid resulted from *A.hypogaea* X *A.villosa*.

In order to study the breeding behaviour of the back-cross F_2 plant, and F_3 population was raised from a selected F_2 plant. The F_3 population consisting of 22 plants showed segregation for important morphological characters, but the range of segregation was comparatively lesser than that of F_2 and the data are summaried in Table (21).

The fertility of the population was found to be improved ($\frac{98.5\%}{97.7\% - 99.3\%}$). The pod and kernel characters of a superior segregant in the BC_1 F_3 population are given in Table (22).

TABLE-22

Particulars.	*A.hypogaea.*	*A.villosa.*	Selected BC_1 F_2 plant.	Selected F_3 segregant.
Size of pod Length Breadth)	2.33 sq.cm	0.85 sq.cm	$\frac{3.43 \text{ sq.cm}}{3.10-4.45}$	$\frac{4.76 \text{ sq.cm}}{2.34-5.02}$
Weight of pod.	0.99 gm	0.23 gm	$\frac{1.09 \text{ gm}}{0.32-1.55}$	$\frac{1.88 \text{ gm}}{0.58-2.03}$
Weight of kernel	0.37 gm	0.18 gm	$\frac{0.41 \text{ gm}}{0.07-0.75}$	$\frac{0.71 \text{ gm}}{0.42-1.01}$
Shelling percen--tage.	74.7 %	78.3 %	$\frac{65.6 \%}{18.7-65.6}$	$\frac{75.5 \%}{32.8-80.4}$

DISCUSSION AND CONCLUSIONS

DISCUSSION AND CONCLUSIONS

In nearly one half of the pods collected from the F_1 hybrids (A.hypogaea X A.sp.A.354) the kernels were small, shrunken and ill developed. The seed failure cannot be attributed to the somatoplastic sterility of Brink and Cooper (1942) since in the present case complete seed abortion did not occur. Seed failure apparently results from a combination of genetically diverse genomes in the seed.

Moffett and Nixon (1958) in their genetical studies on Acacia, observed that zygotic elemination necessarily restricts recombination of parental characters and suggested that it is not unreasonable to suppose that zygotes having potentially the greatest diversity are the most likely to be eliminated. The genic unbalance was encountered in the F_2 population where weak and semi-lethal types occured. This hybrid break down encountered in the F_2 population may be due to genic and cryptic structural differences between the parental genomes (Stebbins 1958). The individuals in the F_2 population which have survived therefore may be considered as more balanced genotypes. This also explains the reason why a skewed segregation towards A.hypogaea was realised in the F_2.

In the case of the back-cross hybrid, a large number of kernels were well filled. There was also greater variability than the straight F_2 population.

The straight F_2 showed a wider variation with regard to pollen sterility, ranging from 0.5 to 33.8%, and has either way transgressed the range covered by the two parental species. Even in the highly sterile plant, there was no higher association of chromosomes, but the bivalents were found to be loosely associated and showed meiotic lability characteristic of A.sp.(A.354) and the F_1 hybrids (Kesavan 1961 unpub.). The sterility in the F_1 may result from disharmonious effects of gene recombinations or from deficiencies and duplications for chromosomal segments (Stebbins 1945, 1958).

In the case of the back-cross hybrids, the two parental species differ in their chromosome numbers. To overcome the "bottleneck" of sterility in the allo-triploid hybrid, interspecific back-crossing was adopted (Raman 1960, Kesavan loc.cit.) Such an instance of over coming the sterility barrier by regaining the chromosomal balance with one back-crossing has been achieved in rare cases. Kanash (1936) and Iyengar (1945) adopted this method in cotton and obtained plants varying in chromosome numbers and in the degree of sterility. In Sorghum an attempt to back-cross the triploid hybrid (Sorghum durra X S.halepense) to S.durra gave rise to fertile tetraploid derivatives (Krishnaswamy 1957). Kumar and D'Cruz (1958) obtained a 41-chromosomed aneuploid from a back-cross involving <u>A.hypogaea</u> and the allotriploid (<u>A.hypogaea</u> X <u>A.villosa</u>).

In the straight F_2 population the segregants were mostly skewed towards <u>A.hypogaea</u>. This may be explained as due to both ecological and gametic selection to favour the production and survival of plants and ~~the~~ with the gross morphology of <u>A.hypogaea</u>. The fact that selective effect of habitats is an important consideration has been shown by Anderson (1949), and Moore and Mulligan (1956)

Linkage also restricts recombinations. It limits the number of types of different recombinations that could be achieved in any one generation, irrespective of the size of population.

If it is assumed that <u>A.hypogaea</u> or a closely related species could have contributed to the origin of <u>A.sp.</u>(A.354) then the F_1 hybrids (<u>A.hypogaea</u> X <u>A.sp.</u>(A.354) might represent, in fact, back-cross hybrids.

The lack of free exchange of genes between the two parental species in the hybrid may also be due to the formation of loosely associated bivalents (Kesavan <u>loc.cit</u>).

The variation noted in the back-cross F_2 plants is due to the heterogenetic assocation and crossing over between A and A' genome (Raman 1959, 1960, Kesavan <u>loc.cit</u>). in the allotriploid.

The variation pattern of the progeny of one of the back-cross hybrid was particularly interesting, as some of the segregants resembled strikingly species like A.monticola whose genomes have been found to be homolo--gous with those of A.hypogaea (Raman 1958). To describe their variation pattern the hybrid index method was adopted. A.hypogaea and A.sp.(A.329) have got 9 and 34 as their total H.I values respectively. The allotriploid hybrid has got a H.I value of 33. The HI value of progenies ranged from 12 to 32. The two segregants resembling A.monticola possess H.I values of 29 and 30 while the pure A.monticola has got a value of 30 when scored by the same criteria. One segregant resembled A.hypogaea with H.I value 12 while still another segregant was tending towards A.sp.(A.329) with H.I value of 19.

When chromosomes of different species are sufficiently alike to recombine more or less freely, the recombinant products are likely to be greatly inferior to the parental combinations. At present, there was no way of control--ling this total disruption of parental genotypes which results from segregation. Back-crossing leads to the partial restoration of the recurrent parental genotype, but not necessarily to the successful transfer of desira--ble characters from the donor parent. On the other hand when the chromosomes of different species are cytologically well differentiated, recombination is drastically reduced and it may be technically possible to limit it to specified chromosomal segments. A greater control of recombination which is afforded in such cases may lead to the increased exploitation of wider crosses by the plant breeder. In interspecific breeding, the objec--tives tend to be limited to the transfer of individual genes or short chromosomal segments from one species to another. In nature, introgression has not been limited to such "unit transfers" - sometimes it has originated new species. (Stephens 1961). It is fairly well esta--blished that new species as well as new barriers to hybridization can arise as a result of segregation from interspecific hybrids. (Stebbins 1942, Anderson 1953, Grant 1956.a).

It may also be of interest to note that in groundnut, it has previously been reported that during the course of intra-specific breeding work, two new types of growth habit were isolated from progenies and they have been assigned the status of new botanical varieties under the species A.hypogaea as variety gigantea (trailing habit) and forma erecta (erect habit) (John and Seshadri 1936, 1957).

Segregation for meiotic lability was noticed in the straight F_2 population. Mostly 20 bivalents are formed and in one instance one trivalent and univalent was noticed due to precocious disjunction of a quadrivalent but the plant was fully fertile. The meiotic lability was noticed only in medium and highly sterile plants.

In the back-cross F_2 population, there was a reduction both in the number of quadrivalents formed as well as the degree of meiotic irregularities. In the F_3 also a further reduction was noticed, thereby indicating a tendency for the improvement of fertility in successive generations.

The total variability index value obtained for the straight cross F_2 was 30 while that of the back-cross F_2 was 46. (Vide Table 20). Normally a straight cross F_2 population may be expected to show extremes of variation and more variability.

As postulated by Raman (1961) and Kesavan (loc.cit) all the 40 chromosome species had probably a common ancestry. So when two such genetically closely related species are crossed the variability released will be comparitively less. In the case of the back-cross it may be assumed that A.sp.(A.329) being a closely related diploid species but not a progenitor, the variability exhibited in the back-cross population has been high.

The derived populations of the back cross hybrids, containing such a wealth of recombined and introgressed forms incorporating certain characters such as resistance to diseases, profuse branching and flowering from the wild species into the cultivated *A.hypogaea* may profitably be utilised in a further programme of breeding, with objec--tives clearly defined as has been stressed by Seshadri (1962).

FUTURE LINE OF WORK :

1) Further selfing and line breeding :

In the back-cross drivatives, further selfing and line breeding may be adopted as there was evidence that in the F_3 population a distinct improvement in the economic characters has been realised. (Vide Table 21 & 22).

2) Selfing and further back-crossing :

Selected plants resembling *A.hypogaea* in gross morphology and possessing certain desirable characters may be selfed and selected plants in the progeny may be further back-crossed with *A.hypogaea*.

In the case of the straight F_2 population, this method is of special importance as this may improve the fertility, meiotic stability and pod characters. By this method it will be possible to reconstitute the genotype of *A.hypogaea* with a limited and desirable gene incorpora--tion from the other wild species.

3) Inter-se crossing and "transgressive breeding" :

Few of the transgressive segregants obtained among the back-cross derivation may be utilized for transgressive breeding as advocated by Palmer (1953). Crossing together such lines will give populations with a relatively high frequency of the highest yielding genotypes.

4) Breeding to pool genes potentially locked up in different diploid species :

Stebbins (1956) has stated that in all examples of outstandingly successful polyploids, their gene pool contains genes derived from three, four or more different diploids. By inter-crossing selected and promising back-cross segregants involving *A. sp.* (A.329) and *A. villosa* it may be possible to pool genes derived from those two diploids to the back ground of *A. hypogaea.*

SUMMARY

SUMMARY

The investigation aims at a comparative study of two kinds of F_2 populations. The first one was derived from hybrids between two tetraploid parents, namely *A.hypogaea* and *A.sp* (A.354), whose genomes are homologous. The second type of tetraploids were derived from back-cross hybrids between *A.hypogaea* and allotriploid (resulting from the cross *A.hypogaea* X *A.sp.*(A.329)).

A comparative morphological and cytological analysis of these F_2 populations have been made. Special techni--ques such as Hybrid Index method and Polygraphic analysis were adopted and the variability expressed in the two F_2 populations have been evaluated.

The possible causes for the occurrence of a skewed recombination in the straight F_2 population have been suggested.

It has been concluded that the back-cross F2 popula--tion exhibited more variability and hence offers greater scope for the interspecific gene transference in the genus *Arachis*.

Future lines of breeding to further the material built up have also been indicated.

A C K N O W L E D G E M E N T

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ILLUSTRATIONS

) GRAPHS :- Pollen sterility, Pollen diameter and Calyx tube length in

Graphs 1 - 3 : F_2 of A.hypogaea X A.sp.(A.354)

Graphs 4 - 6 : F_2 of back-cross hybrid of A.hypogaea X (A.hypogaea X A.sp.(A.329).

) SCATTER DIAGRAMS : Character associations of pollen sterility and pollen diameter; height of main axis and length of primary branches; and length and breadth of leaflets in

Scatter diagrams 1 - 3 : F_2 of A.hypogaea X A.sp.(A.354)

3 - 6 : F_2 of back-cross hybrids of A.hypogaea X(A.hypogaea X A.sp.(A.329).

Graphs 1 to 3 - Straight F_2 population.

P_1 - A.hypogaea (Red)

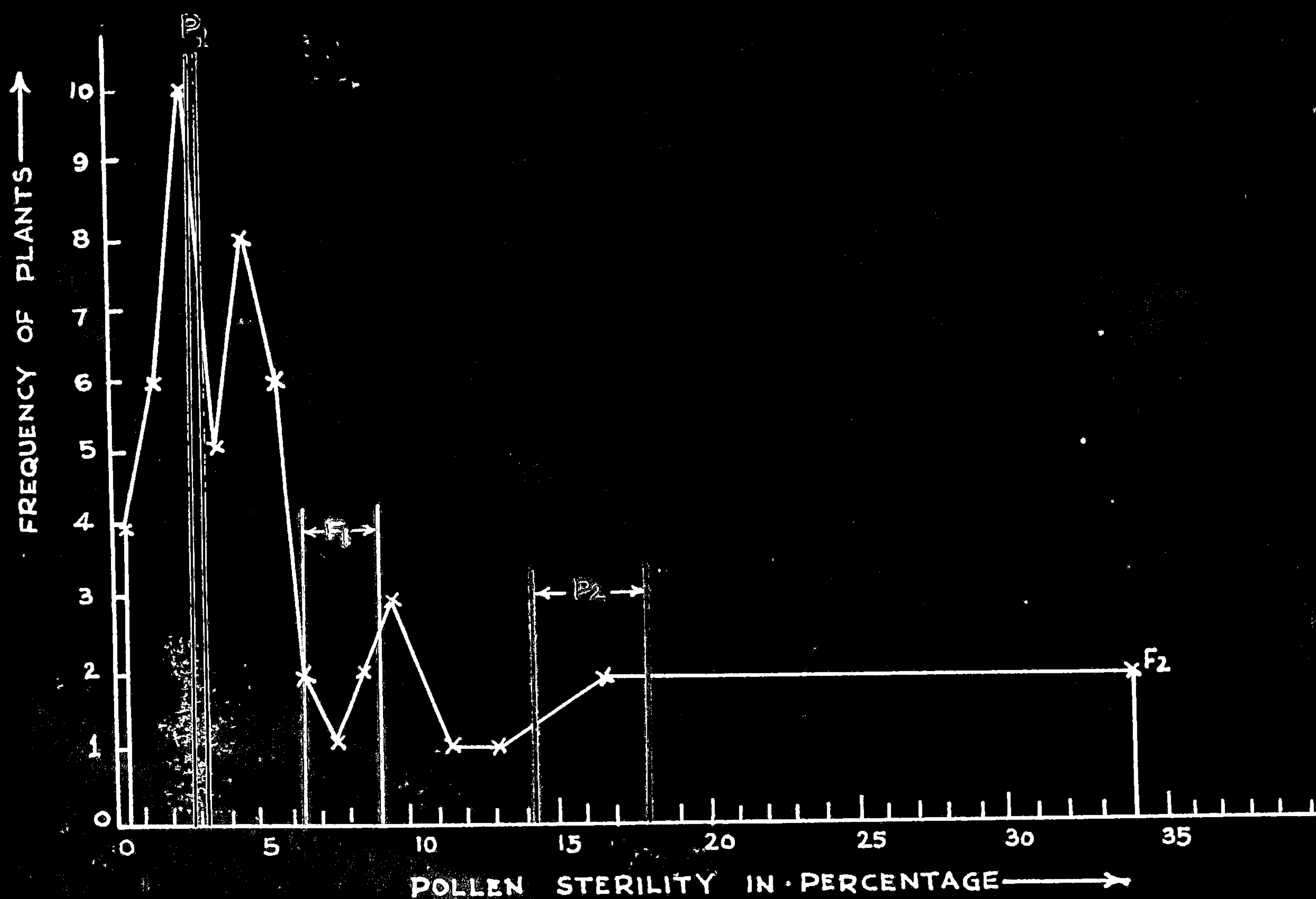
P_2 - A.sp.(A.354) (Deep yellow)

F_1 - Hybrid. (Light yellow)

F_2 - population. (White)

GRAPH - 1 : POLLEN STERILITY.

P_1 is found to have relatively little pollen sterility which has more or less stablised itself, the range of variability being quite small. On the other hand, P2 has much higher pollen sterility and the range of variability is also greater. The F_1 is intermediate between the two parents but closely leans more towards P_1. In the F_2, the range of variability is vastly increased from 0.6% to 33.8% and has therefore transgressed the range covered by the two parents, either way.

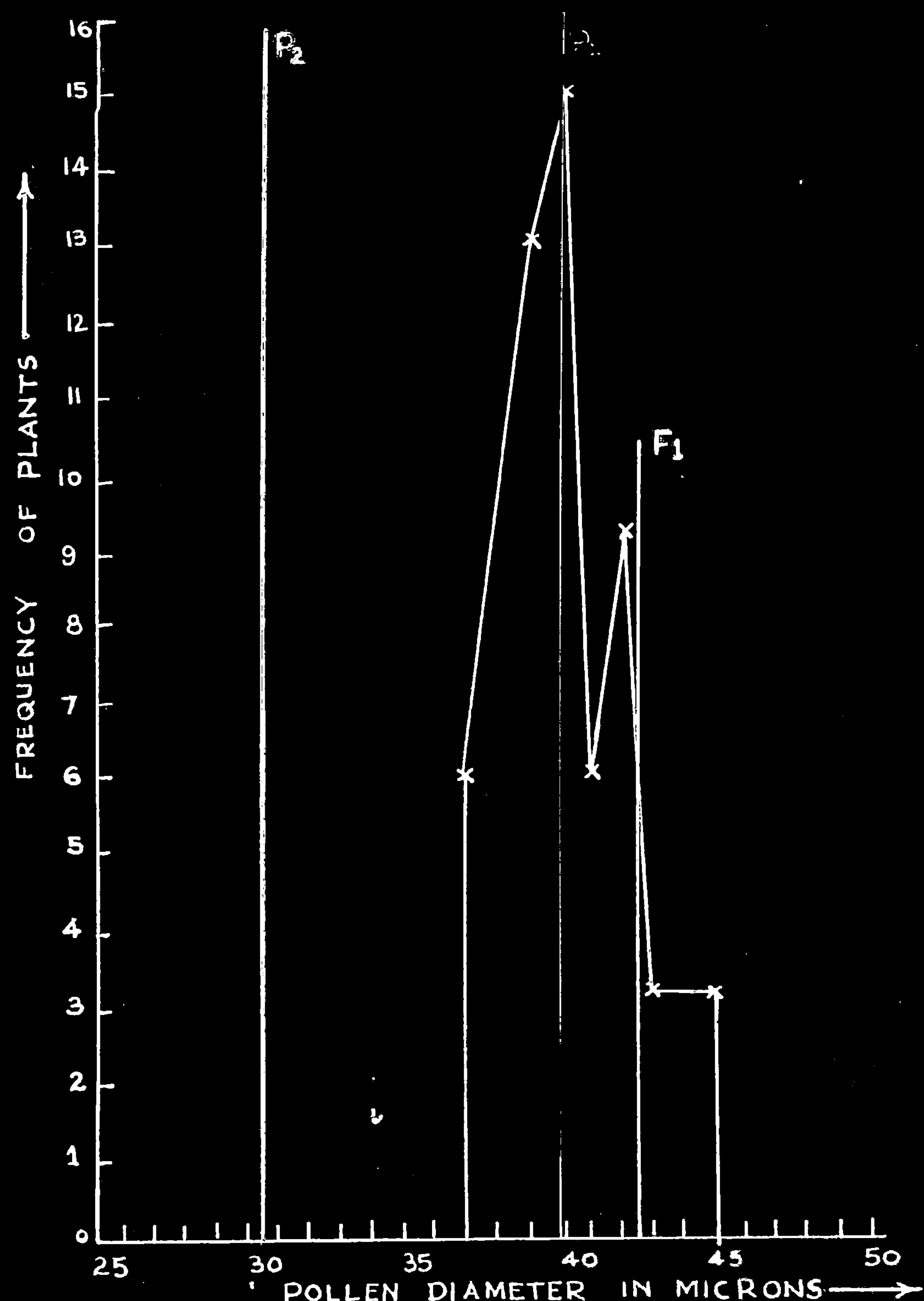


FREQUENCY OF PLANTS
POLLEN STERILITY IN PERCENTAGE
P1
F1
P2
F2
0
1
2
3
4
5
6
7
8
9
10
0
5
10
15
20
25
30
35

GRAPH (No.2) Pollen size.

The pollen size (diameter in microns) is more marked in P_1 than in P_2. The F_1 has recorded greater pollen size than even the P_1, but in the F_2, it is more or less evenly scattered around the pollen size in P_1.

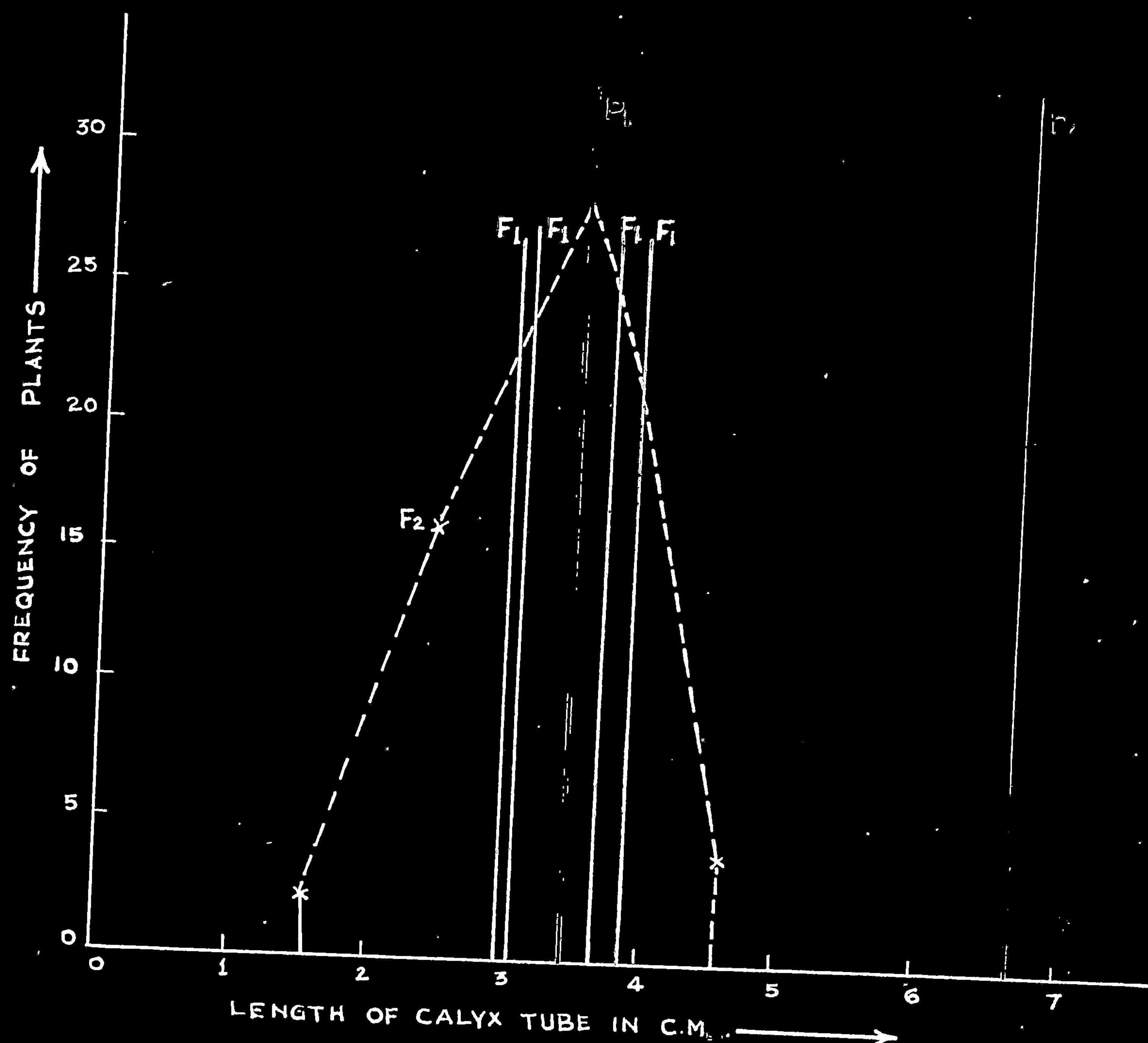
2



FREQUENCY OF PLANTS
POLLEN DIAMETER IN MICRONS
P_2
P_1
F_1
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
25
30
35
40
45
50

GRAPH - 3 :- Calyx tube length.

The calyx tube length in the P_2 (wild species) is nearly twice that of the cultivated parent, P_1. In the F_1 the variation in the calyx tube length is very closely around the P_1. In the F_2 again, the range of variability is around the P_1 only, though a little wider than the range of F_1s. In both F_1 and F_2, there is a strong pull or dominant bias towards the cultivated parent.



FREQUENCY OF PLANTS
LENGTH OF CALYX TUBE IN C.M.
P1
P2
F1
F1
F1
F1
F2
0
5
10
15
20
25
30
0
1
2
3
4
5
6
7

3

Graphs 4 to 6 - Back-cross F_2 population.

P_1 - *A.hypogaea* (Red)

P_2 - *A.sp.*(A.329) (Deep yellow)

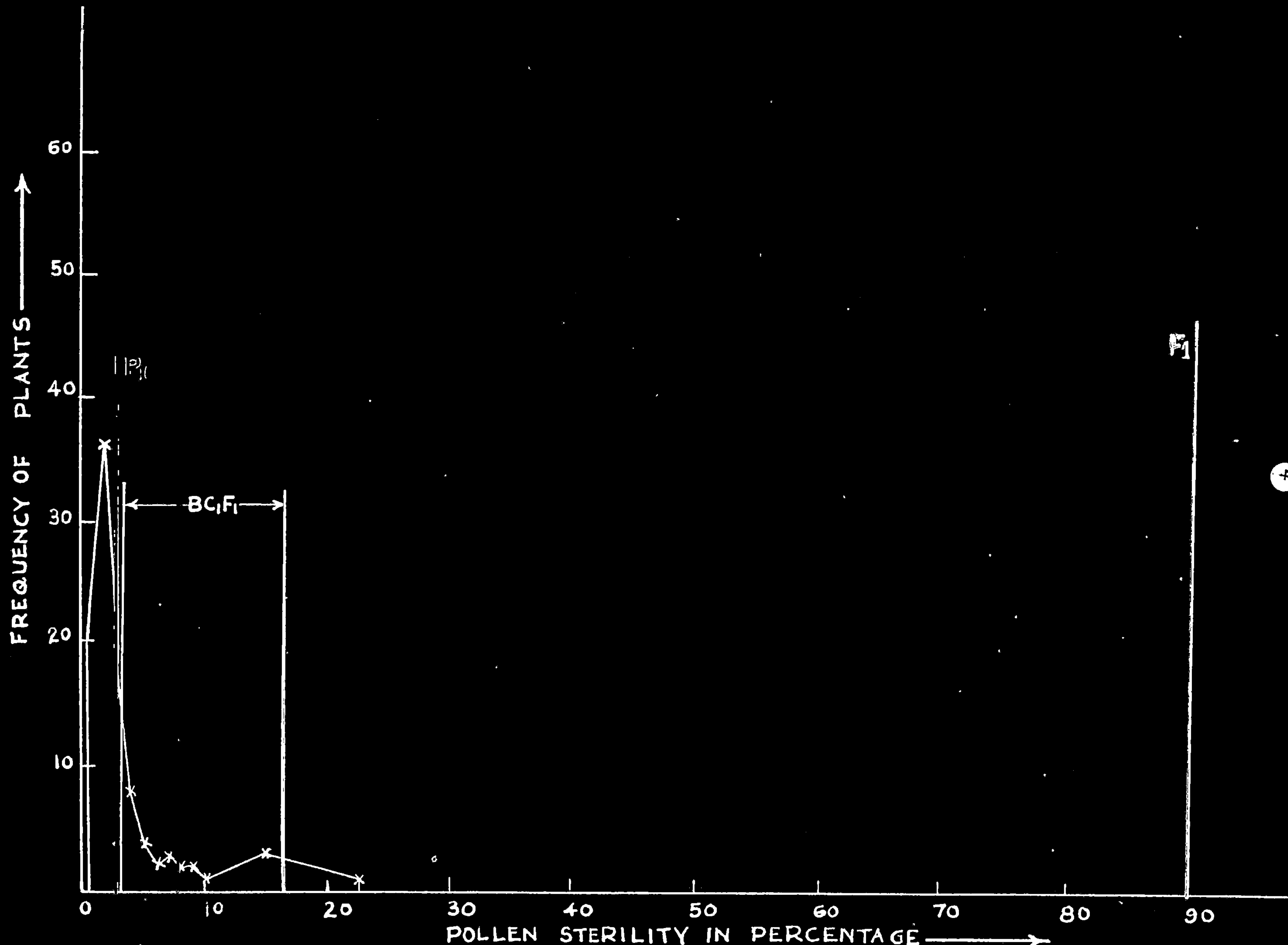
F_1 - Allotriploid (Light yellow)

BC_1 F_1 - (Back-cross hybrids) (Green)

BC_1 F_2 - Population (White).

Graph - 4 :- Pollen Sterility.

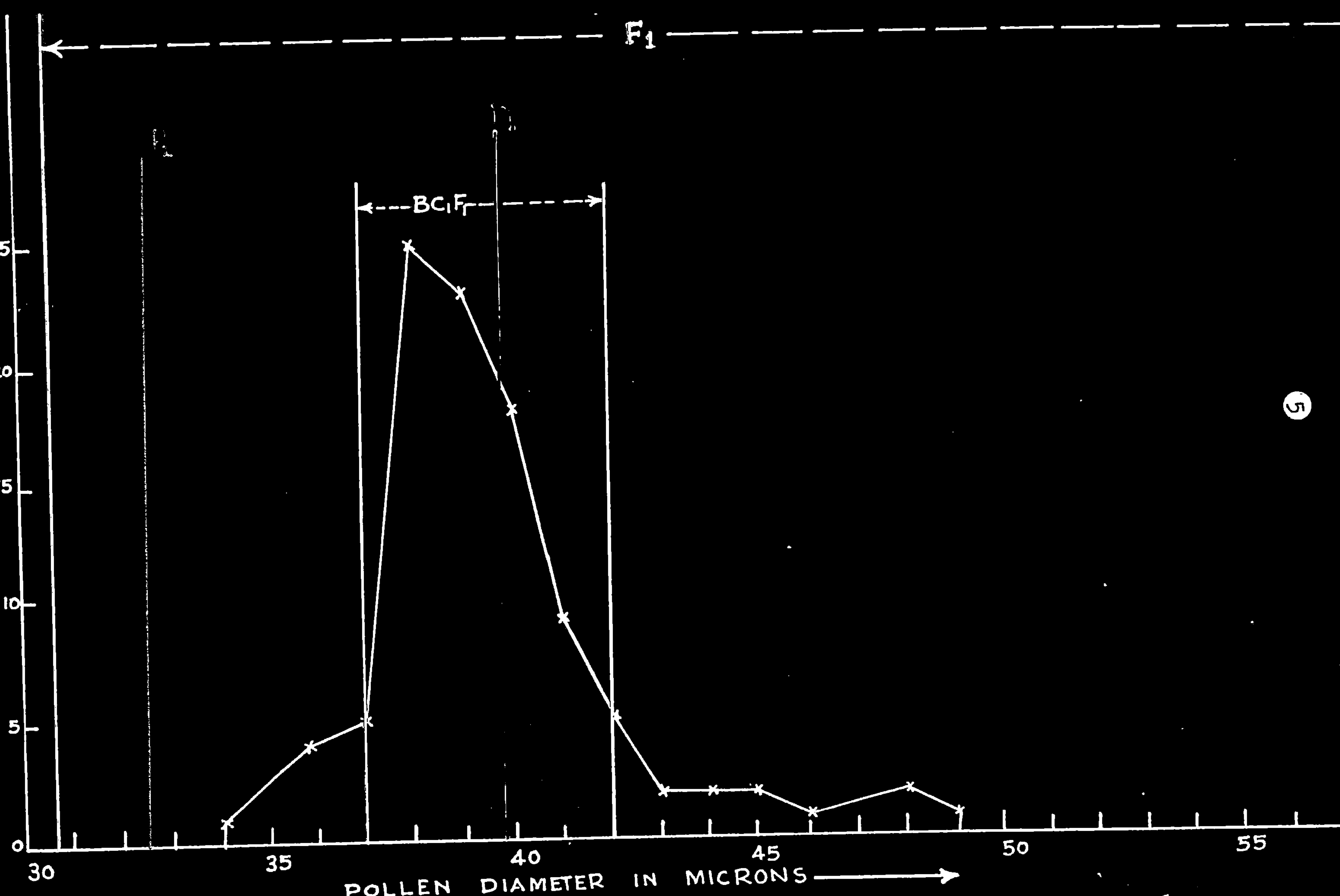
The pollen sterility is more or less alike in P_1 and P_2. The F_1 shows pollen sterility as much as 90.2 %. On back-crossing with P_1, the back-cross showed high fertility. In the BC_1 F_2 population, the pollen sterility shows a slightly wider range of variability with an average that approaches the P_1.



FREQUENCY OF PLANTS
60
50
40
30
20
10
0
10
20
30
40
50
60
70
80
90
POLLEN STERILITY IN PERCENTAGE
BC1F1
F1

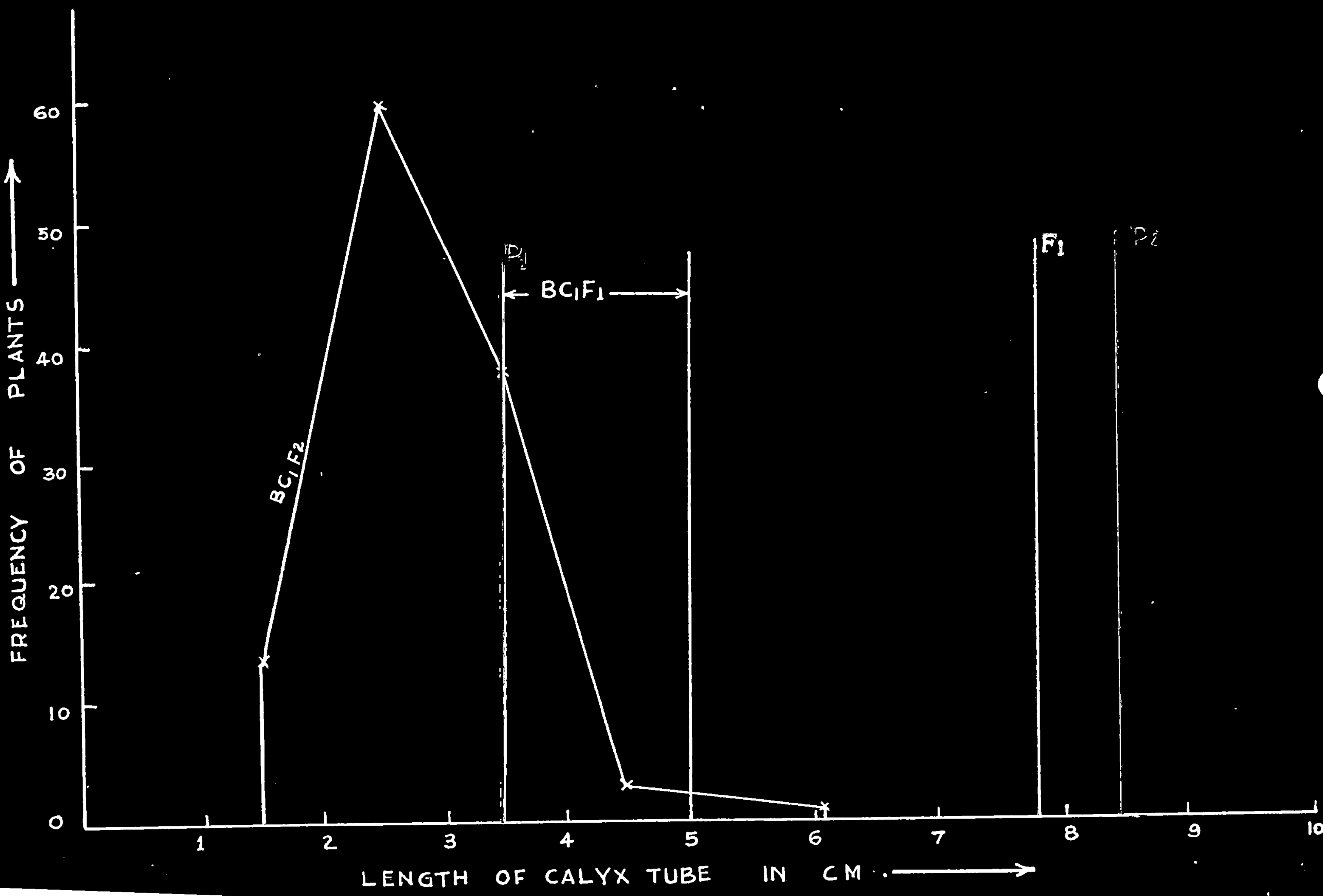
GRAPH - 5 :- Pollen size.

In respect of Pollen diameter the range of variation in the F_1 (allotriploid) for outstrips the two parents on either side, but its back-cross with P_1, considerably reduces the range which is closely scattered around P_1. In the BC_1 F_1, but there is a slightly wider range of variability.


F1
P1
P2
BC1F1
0
5
10
30
35
40
45
50
55
POLLEN DIAMETER IN MICRONS
5

GRAPH - 6 :- Calyx tube length.

The calyx tube length of the allotriploid hybrid is intermediate between the two parents, but leaning markedly towards P_2 parent. Its back-cross, with P_1, reduces the length of the calyx tube which approaches P_1. But the back-cross F_2 population, shows a calyx tube which in most plants is less than that of P_1 though very few segregants showed calyx tube leaning towards the wild species.



FREQUENCY OF PLANTS
LENGTH OF CALYX TUBE IN CM
0
10
20
30
40
50
60
1
2
3
4
5
6
7
8
9
10
BC1F2
P1
BC1F1
F1
P2

Scatter diagrams 1-3 (Straight F_2 population).

+ (P_1) - *A.hypogaea.* (Red)

+ (P_2) - *A.sp.*A.354 (Deep yellow)

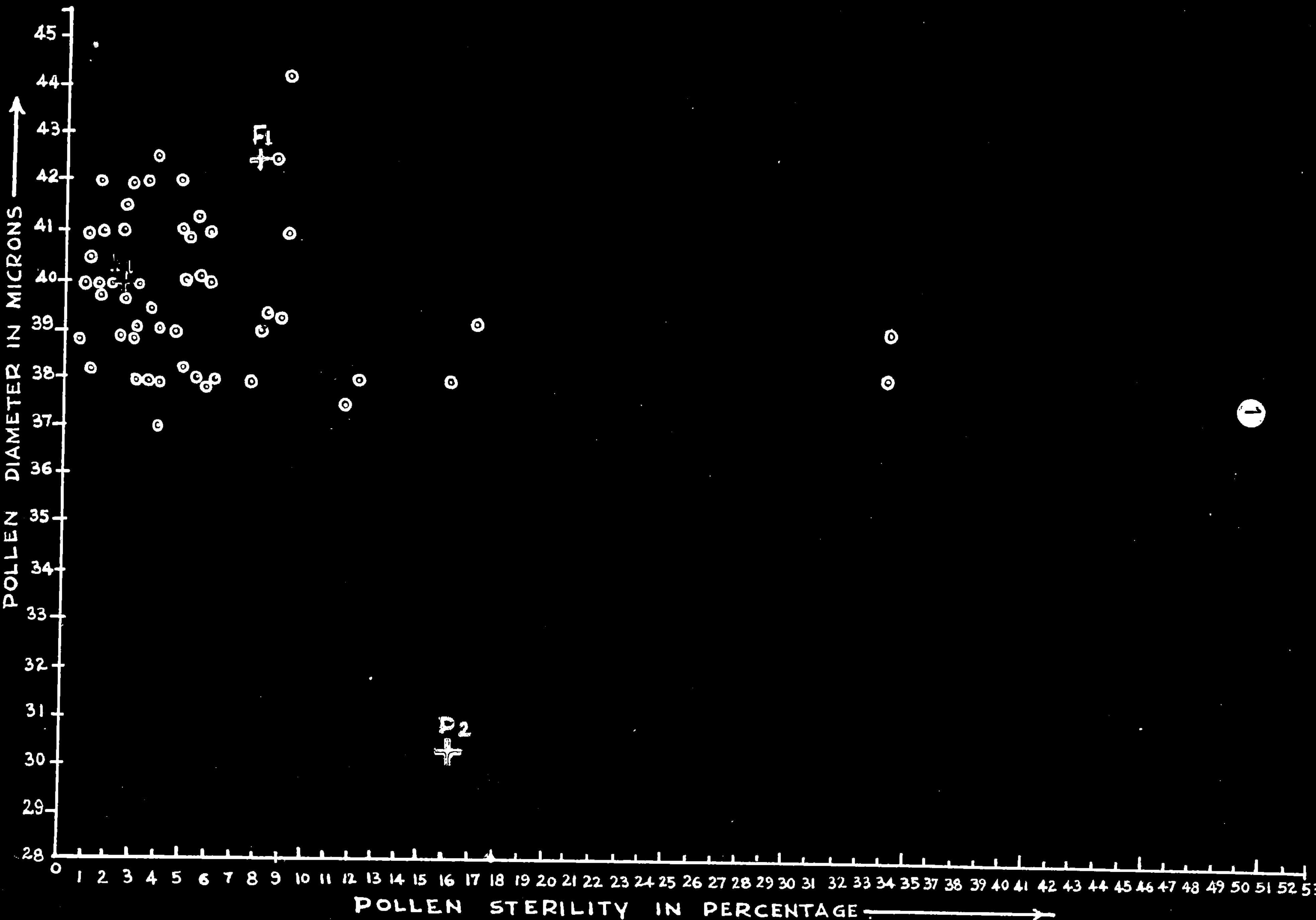
X (F_1) - (F_1) hybrids. (Light yellow)

O F_2 - population (white)

SCATTER DIAGRAM : 1-Association of Pollen size and pollen sterility.

The F_1 was intermediate in pollen, sterility between the two parents and surpassing both in regard to pollen size. The F_2 either way transgressed the range covered by both parents in pollen sterility even though the size of pollen is more or less evenly scattered around the pollen size of F_1.

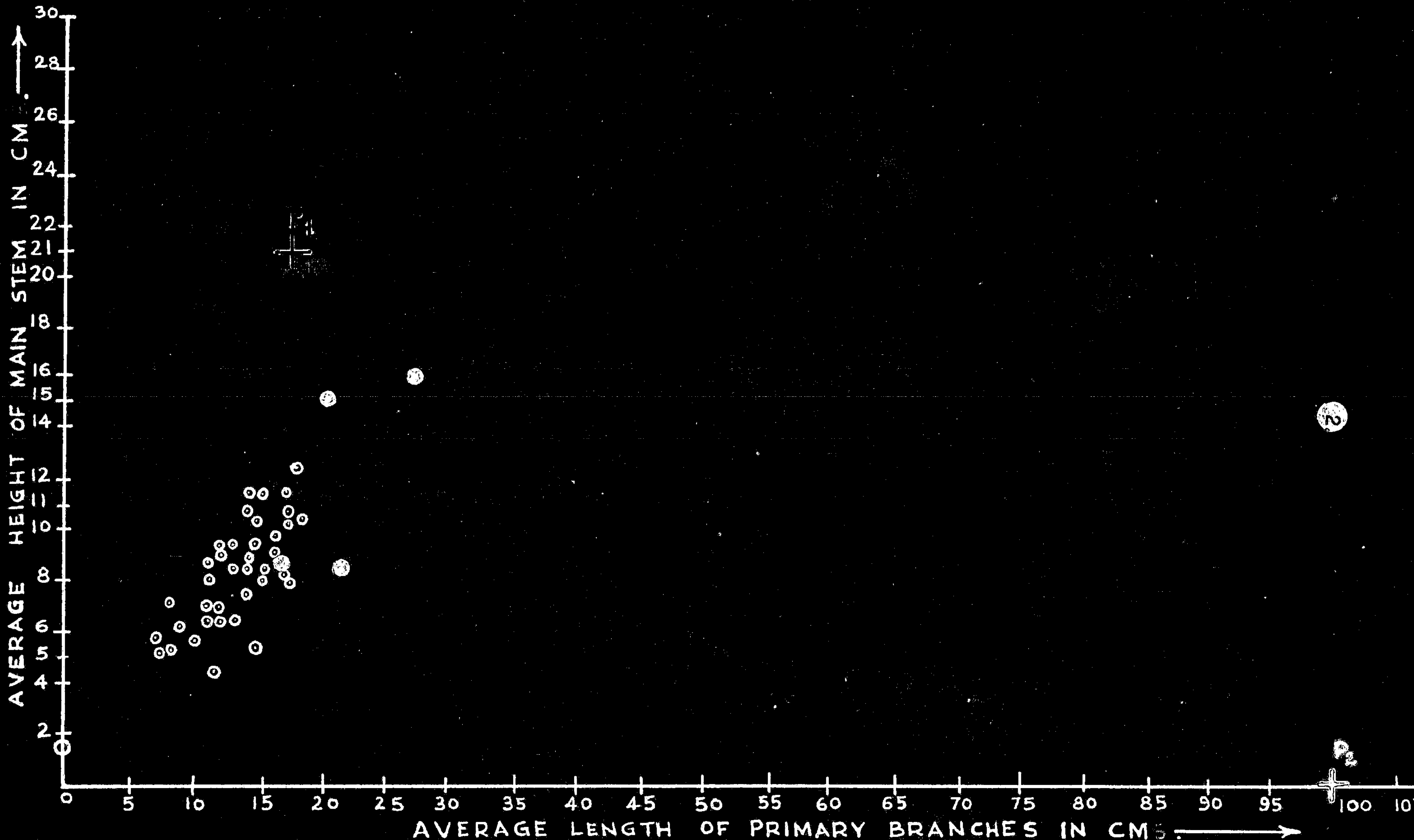
There is no evidence of association between the two characters, *viz.*, pollen size and pollen sterility.



POLLEN DIAMETER IN MICRONS
45
44
43
42
41
40
39
38
37
36
35
34
33
32
31
30
29
28
F1
P2
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53
POLLEN STERILITY IN PERCENTAGE

SCATTER DIAGRAM - 2 :- Height of main stem and and length of primaries.

In the two parents, the length of the primaries differ vastly from 17 cm. in P_1 to 100 cm. in P_2. The latter has no main stem, while the main stem in P_1 is 21 cm. tall. In both F_1 and F_2 while the range in the length of primaries is scattered closely around P_1, the height of main stem is intermediate between the two parents.

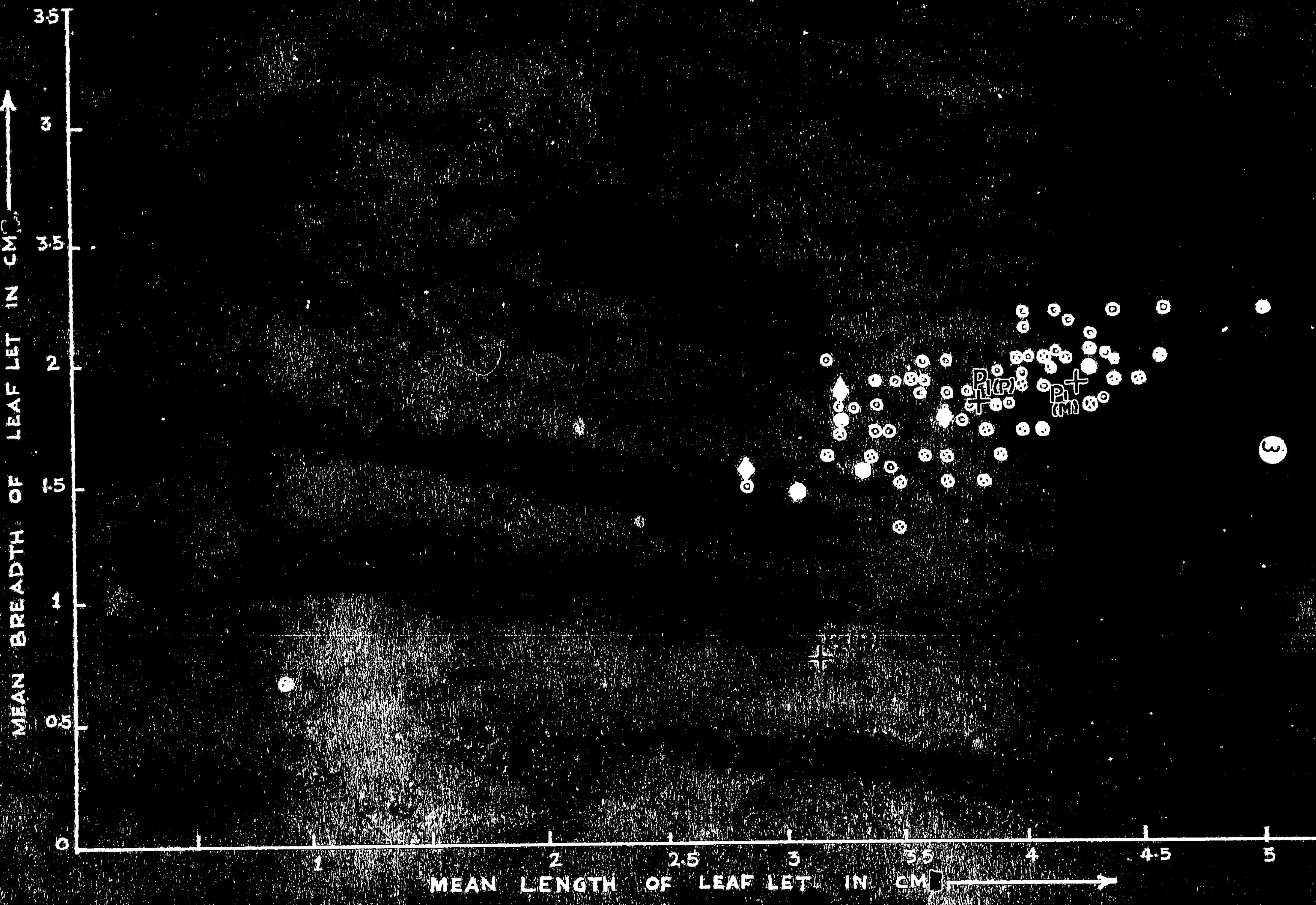

AVERAGE HEIGHT OF MAIN STEM IN CM.
30
28
26
24
22
21
20
18
16
15
14
12
11
10
8
6
5
4
2
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
P1
P2
AVERAGE LENGTH OF PRIMARY BRANCHES IN CMS.

SCATTER DIAGRAM - 3 :- Association of length and breadth of leaflets.

Both in the length and breadth of leaflets, the two parents differ widely, the leaflets in the wild species (P_2) being about half the size of those in cultivated species.(P_1). The range of variability of this character in both F_1 and F_2 is scattered closely around the cultivated parent and the variation in F_2 is more wider than in F_1. There is an indication of a positive association between the length and breadth of leaflets in the population.

○ ⊗ leaflets on the main stem.

◇ ⊙ leaflet on the primary branch.



MEAN BREADTH OF LEAF LET IN CM
MEAN LENGTH OF LEAF LET IN CM
3.5
3
3.5
2
1.5
1
0.5
0
1
2
2.5
3
3.5
4
4.5
5

Scatter diagrams 4 - 6 Back-cross F_2 population.

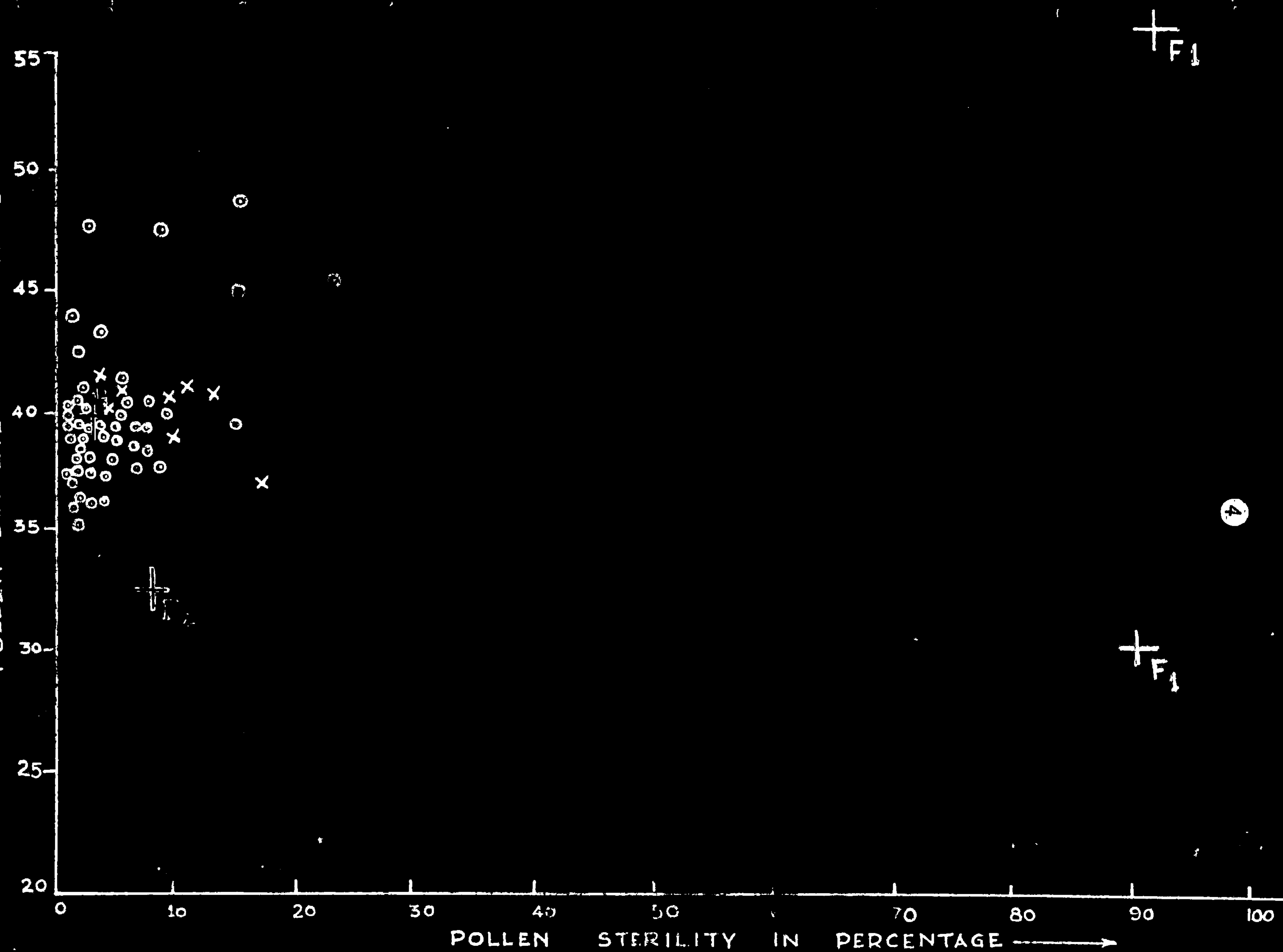
+ (P_1) A.hypogaea (Red)
+ (P_2) A.sp.A.329 (Deep yellow)
+ F_1 - allotriploid. (Light yellow)

X BC_1 F_1 - back-cross hybrids (Green)

O - Back-cross F_2 population (White).

SCATTER DIAGRAM - 4 : Association of Pollen size and Pollen sterility.

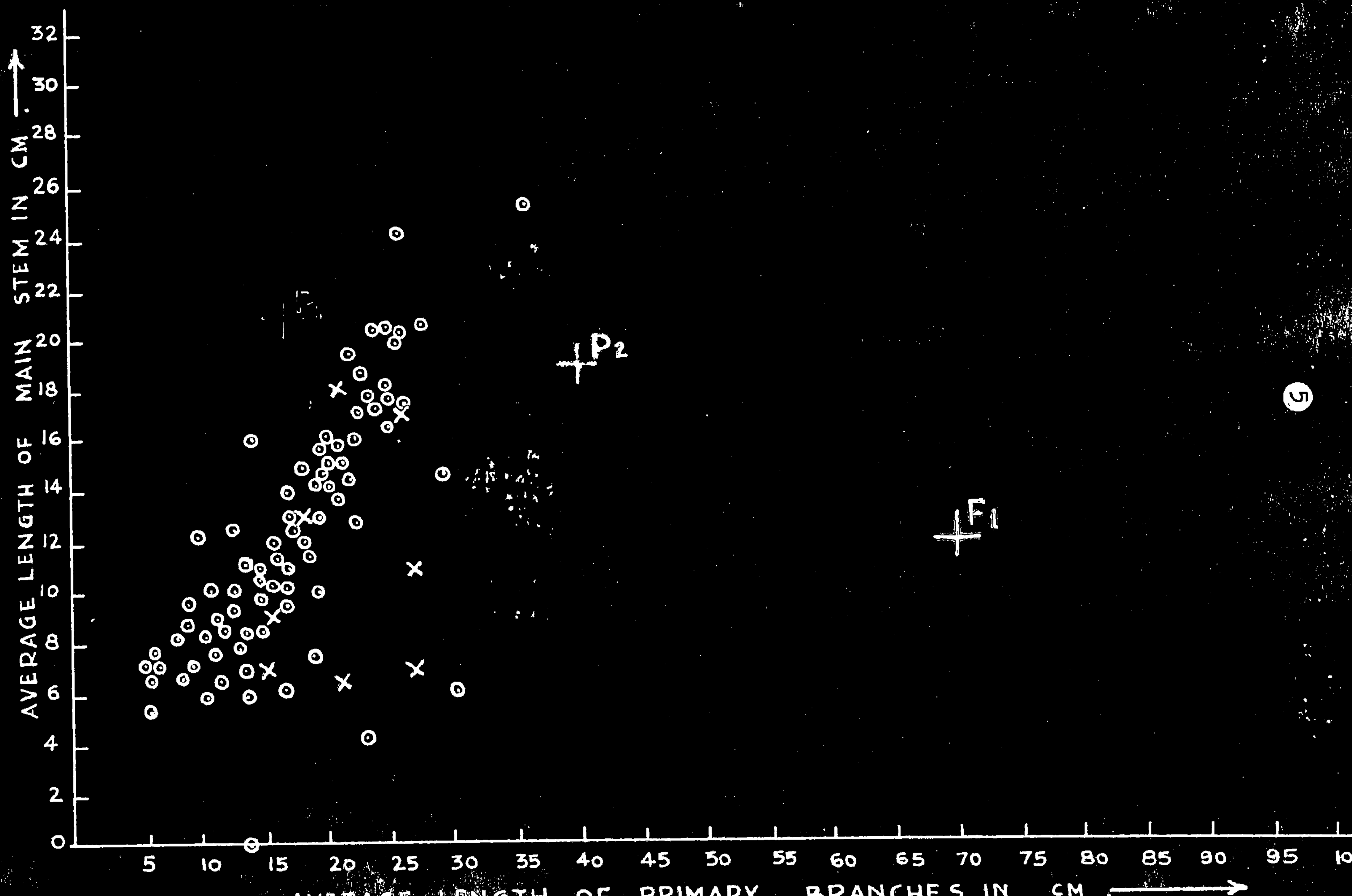
In the allotriploid hybrid, the pollen sterility was very high and the range of variation of pollen size far outstrips the two parents on either side. In the BC_1 F_1 and back-cross F_2 populations, the pollen size and pollen sterility approached that of the P_1, but the F_2 showed a wider variability. Apparently there is no association between pollen size and sterility.



F1
F1
POLLEN STERILITY IN PERCENTAGE

SCATTER DIAGRAM - 5 :- Association of main stem height and length of primary branch.

The F_1 allotriploid for over reaches both parents in respect of mean length of primaries and shows markedly less mean height of stem. In the back-cross hybrids, the mean length of primaries swings to somewhere between the parents, but slightly leaning towards P_1. However the length of main stem is still less than both parents. In the BC_1 F_2 generation, there is a further reduction in the length of primaries but the length of main stem is more or less the same as ~~the~~ in the previous generation The diagram also indicates a positive association between the length of primaries and height of main stem.


AVERAGE LENGTH OF MAIN STEM IN CM.
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
P2
F1
OF PRIMARY BRANCHES IN CM

SCATTER DIAGRAM - 6 :- Association of length and breadth of leaflets.

There is a marked reduction in the size of leaflets in the allotriploid plant, from both parents. But in the back-cross F_1 and in the subsequent F_2 progeny, the leaf size (length and breadth) is restored back to the cultivated parent (P_1), with a range of values extending from the F_1 to far beyond the cultivated parent.

⊙ - leaflets on the main stem.

◇ - leaflets on the primary branch.


F1(P)
F1(M)
P2(P)
P2(M)

PLATES

PLATE - 1.

Fig. 1 :- A.sp.(A.354) 2n = 40.
(1/20 Nat. size)
(Through the courtesy of Sri V.S.Raman).

Fig. 2 :- A.hypogaea (2n = 40) (top row) and
F_2 segregants of A.hypogaea X
A.sp.A.354 (bottom row). One of the
segregant is very weak and semi-lethal.
(1/10 Nat.size).

Fig. 3 :- F_2 segregant (top row) and
A.hypogaea (bottom row).
(1/10 Nat.size).

PLATES

Plates I - XIII :- PHOTOGRAPHS

Morphology, variations in leaf, floral, pod and kernel characters of

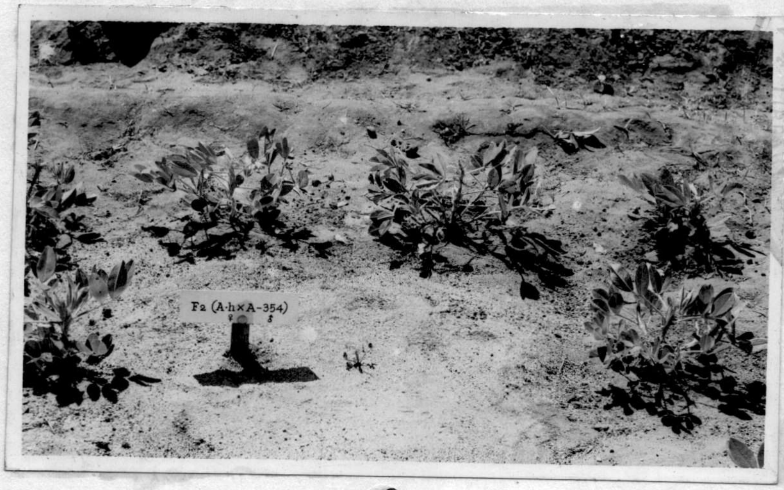
a) A. hypogaea, A. sp. (A.354), their hybrids and F_2 populations;

b) A. hypogaea, A. sp. (A.329), their hybrid, back-cross hybrids and F_2 populations.

Plates XIV - XV :- MICRO PHOTOGRAPHS.

Meiosis in the straight F_2 and back-cross F_2 populations.

1



2

3

PLATE - II

Fig. 1 - 3 :- F_2 segregants of A.hypogaea X A.sp.A.354.
The segregant in Fig. 1 produces very high number of pegs and is 33.8 % pollen sterile.
(½ Nat. size).

1

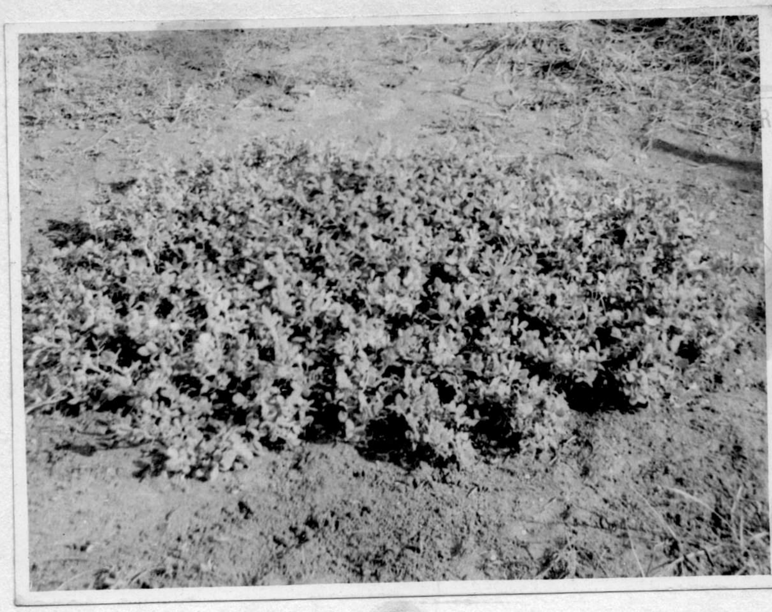
2

3

PLATE - III

Fig. 1 :- Allotriploid (2n = 30) of *A. hypogaea* X
A. sp. (A.329).
(1/6 Nat. size)
(Through the courtesy of Sri V.S. Raman).

Fig. 2 & 3 :- Back-cross F_2 segregants of
A. hypogaea X (*A. hypogaea* X *A. sp.* (A.329)).
(1/3 Nat. size).



1

2

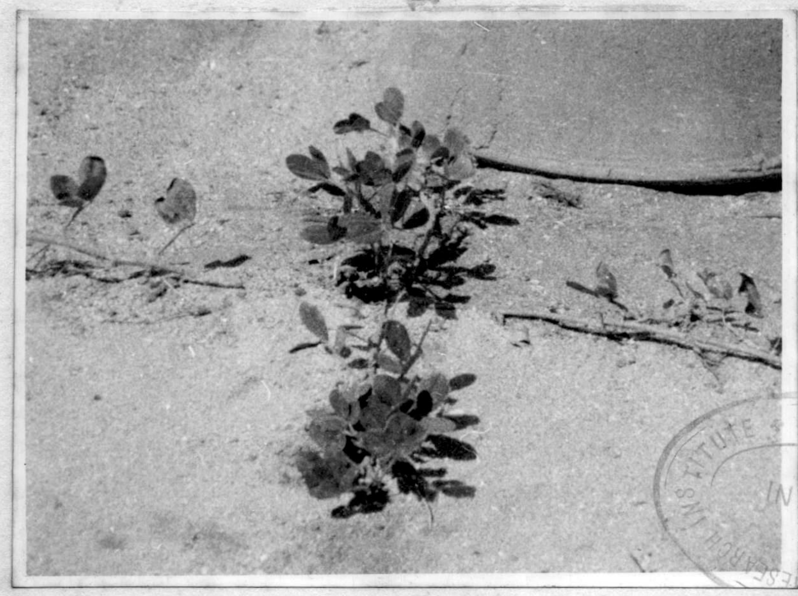
3

PLATE - IV.

Fig. 1 & 2 :- Back-cross F_2 segregants, resembling
<u>A.monticola</u> (which is a species not
involved with cross).
(1/6 Nat. size).

Fig. 3 :- A back-cross segregant showing
trailing and profuse branching
habit.
(1/6 Nat. size).

1



2

3

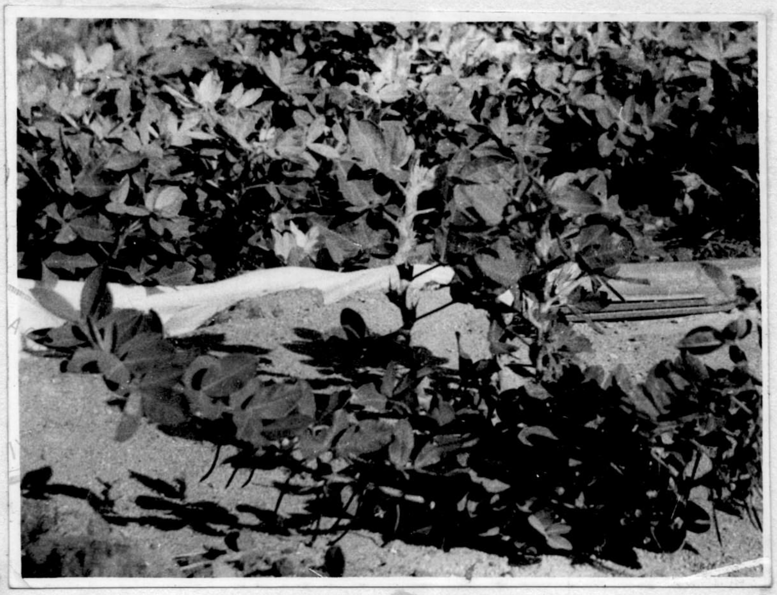
PLATE - V.

Fig. 1 - 3 :- Back-cross segregants.

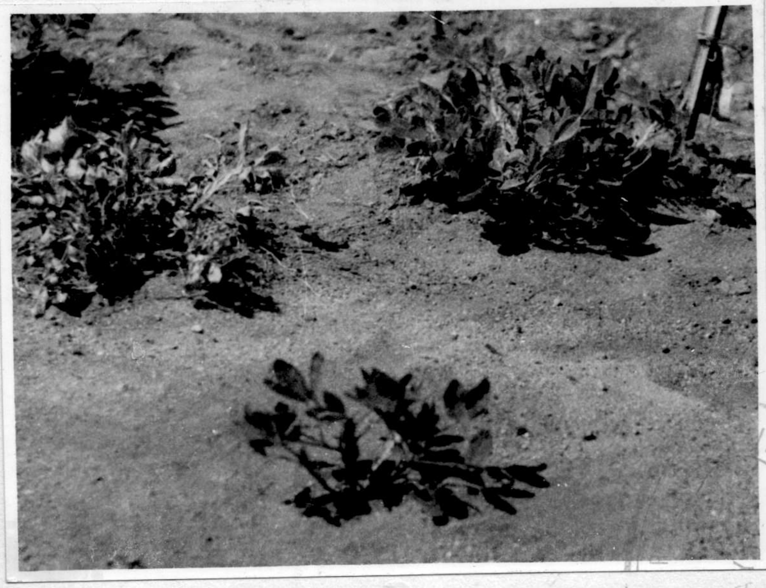
1 :- Very vigorous, having tall main axis and long, tip ascending primary branches. (1/ Nat. size)

2 :- One segregant is stunted in growth. (1/6 Nat. size).

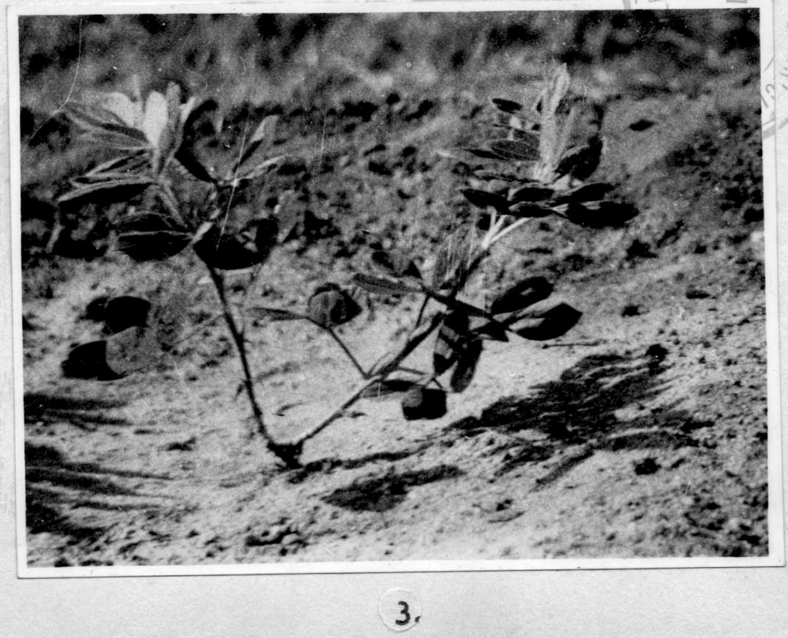
3 :- One segregant with no main axis and have only two primaries. (1/3 Nat. size).



1



2



3.

PLATE - VI.

Fig. 1 :- Back-cross F_3 segregants of *A. hypogaea* X F_1 of (*A. hypogaea* X *A. villosa*).
(1/6 Nat. size).

Fig. 2 :- Back-cross F_3 segregants - One is very vigorous and showed improved economic characters.
(1/12 Nat. size).

1

2.

PLATE - VII.

LEAF CHARACTERS OF

1 - *A.sp.*(A.354)

2 - *A.hypogaea*.

3-6 F_1 plants of *A.hypogaea* X *A.sp.*(A.354)

Left - Leaf from main stem.

Right- Leaf from primary branch.

(1/3 Nat. sise)

(Through the courtesy of Sri P.C. Kesavan).

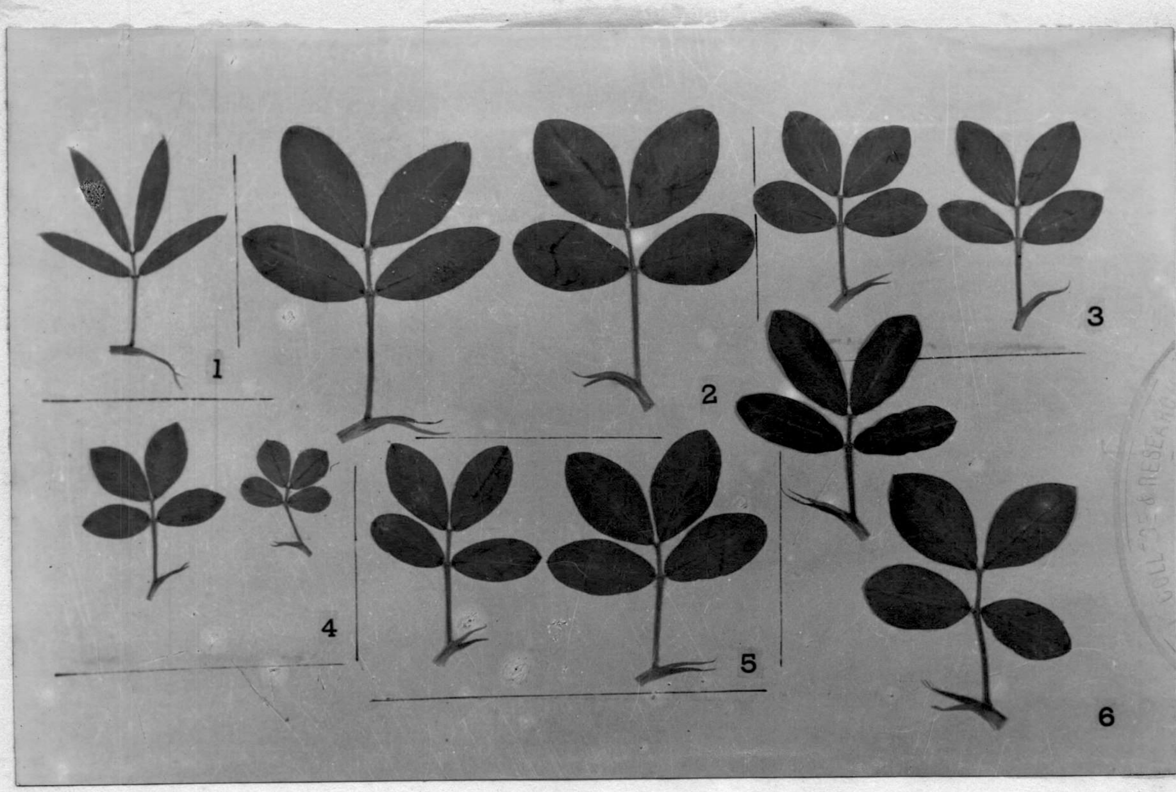
VARIATION IN LEAF CHARACTERS IN THE F_2 POPULATION.

A - Leaf from main stem.

B - Leaf from primary branch.

C - Abnormal leaned with supernumarary leaflets.

(1/3 Nat. size).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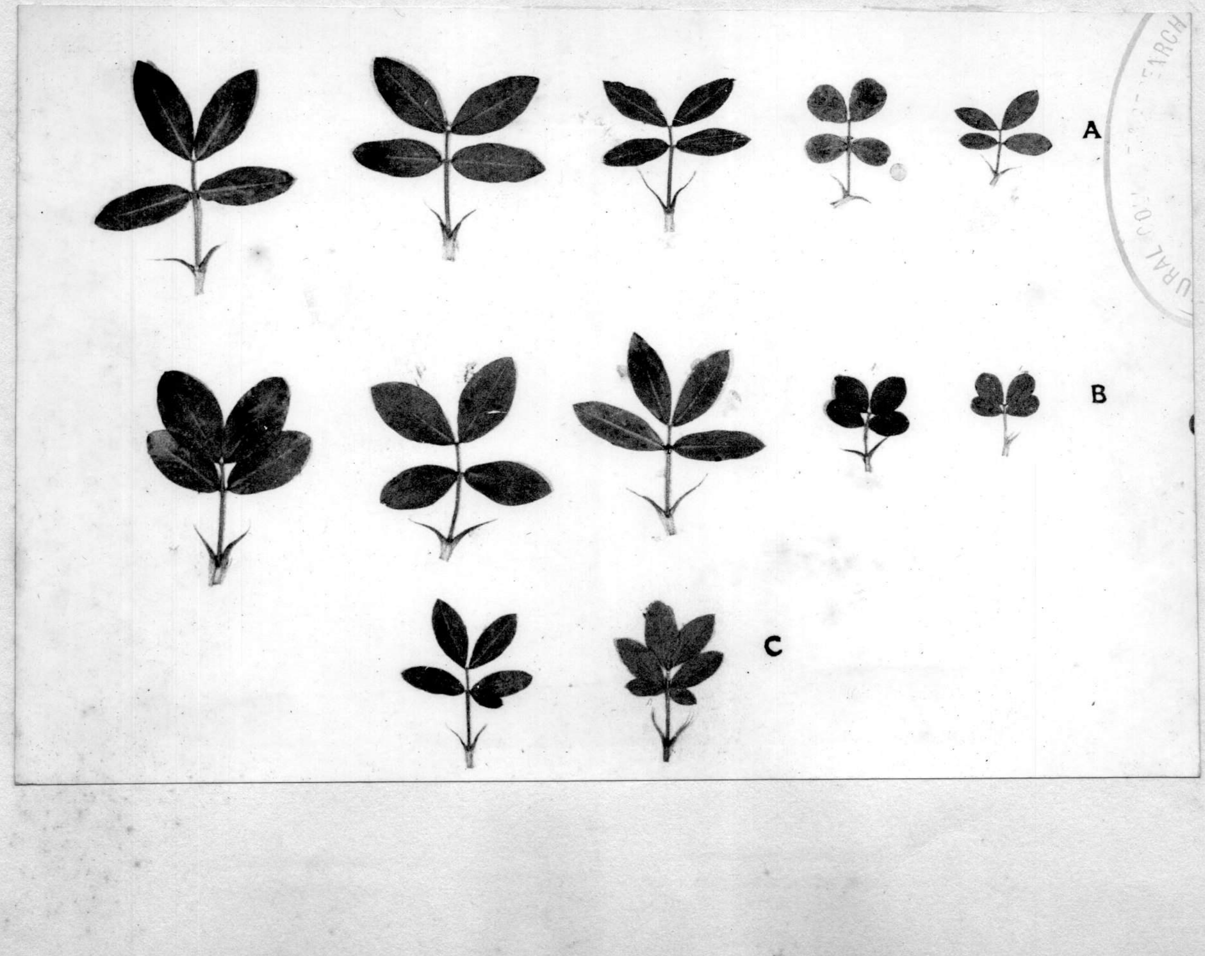

A
B
C

PLATE VIII.

VARIATION IN LEAF CHARACTERS IN THE BACK-CROSS HYBRIDS.

(1/2 Nat. size)

(Through the courtesy of Sri P.C. Kesavan)

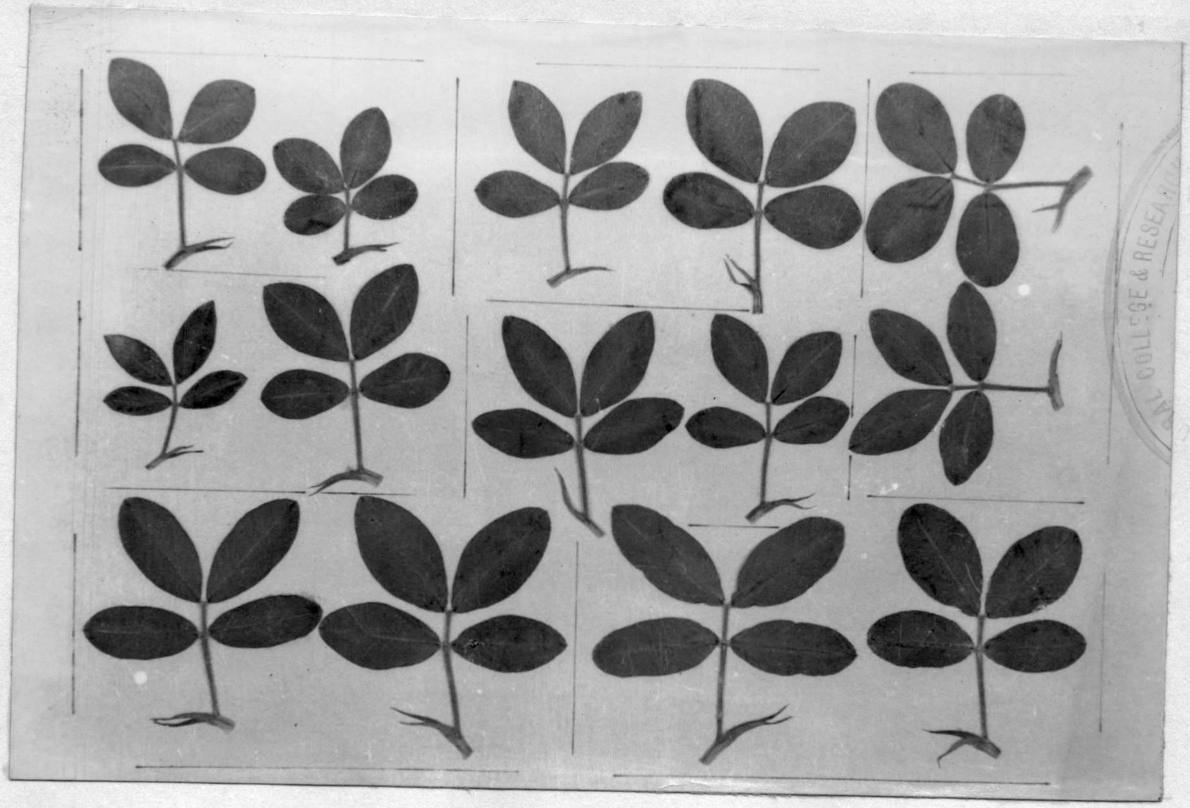
VARIATION IN LEAF CHARACTERS IN THE BACK CROSS F_2 POPULATION.

A - Leaf from main stem.

B - Leaf from primary branch.

C - Abnormal leans with supernumarary leaflets.

(1/3 Nat. size)



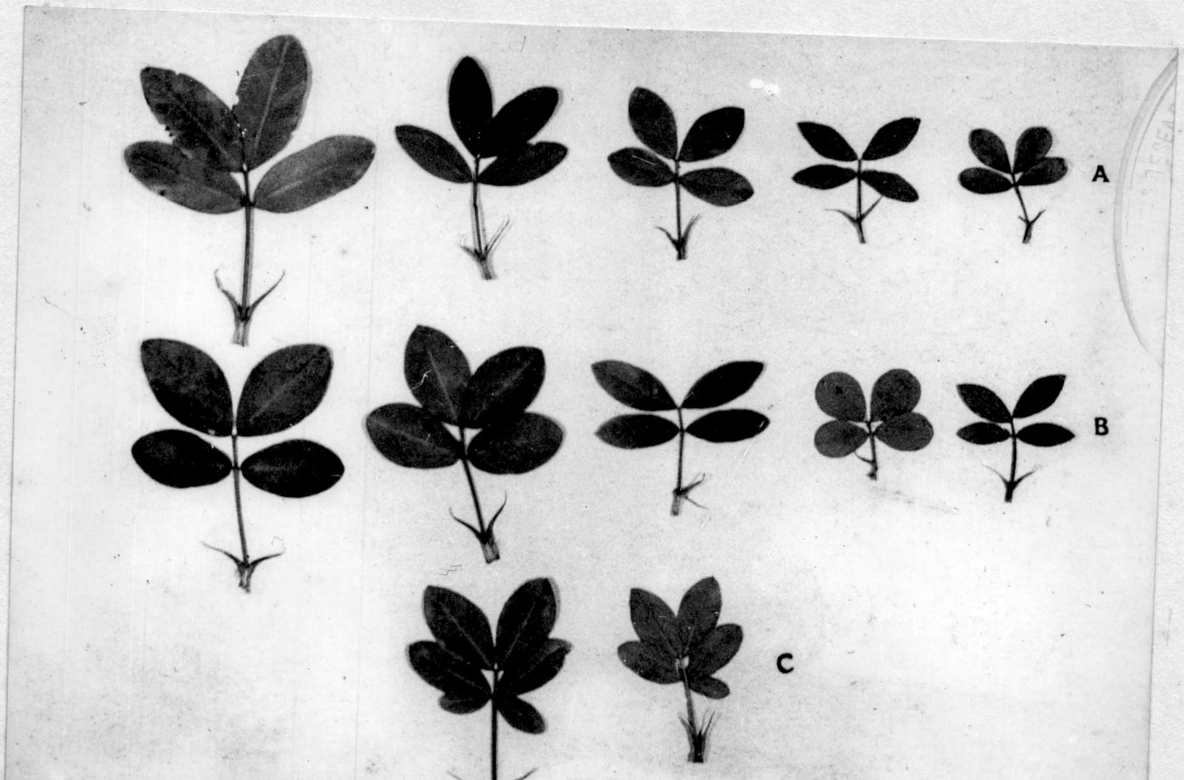

A
B
C

PLATE IX.

VARIATION IN FLORAL CHARACTERS.

Fig. 1 : P_1 - A.hypogaea.

P_2 - A.sp.(A.354)

F_2 - F_2 segregants of A.hypogaea X A.sp.(A.354).

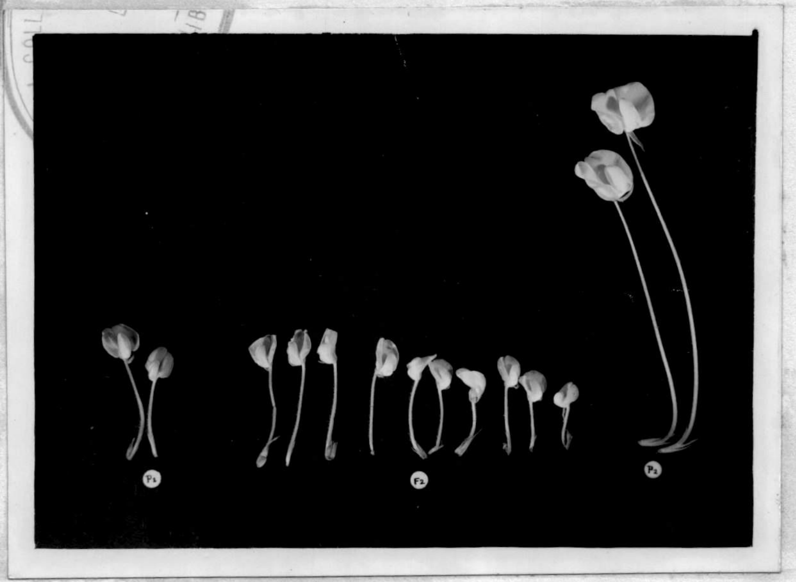
(1/2 Nat. size).

Fig. 2 : P_1 - A.hypogaea

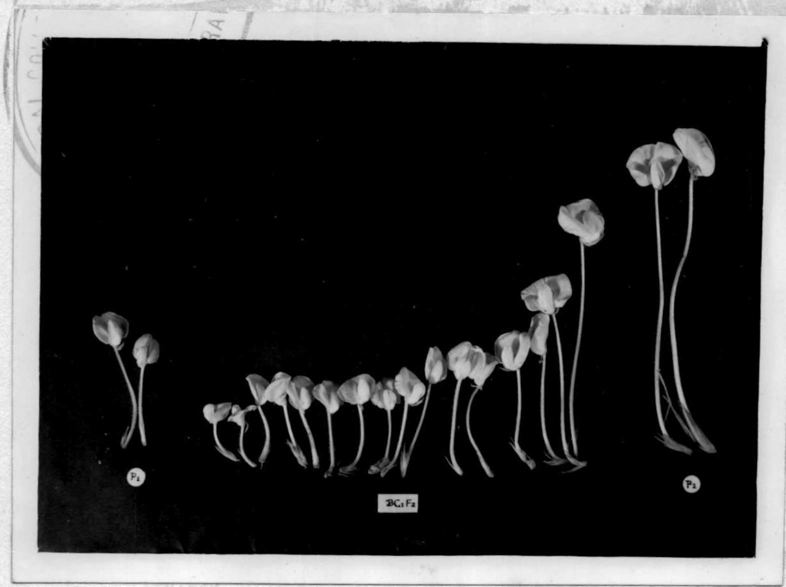
P_2 - A.sp.(A.329)

BC_1 F_2 - Back-cross F_2 segregants of A.hypogaea X F_1 of A.hypogaea X A.sp.(A.329).

1/2 Nat. size).



1



2

PLATE - X.

VARIATION IN POD CHARACTERS.

1 - 8 - Back-cross hybrids.

9 - F_1 hybrid of *A.hypogaea* X *A.sp.*(A.354) (1/2 Nat. size).

(Through the courtesy of Sri P.C.Kesavan)

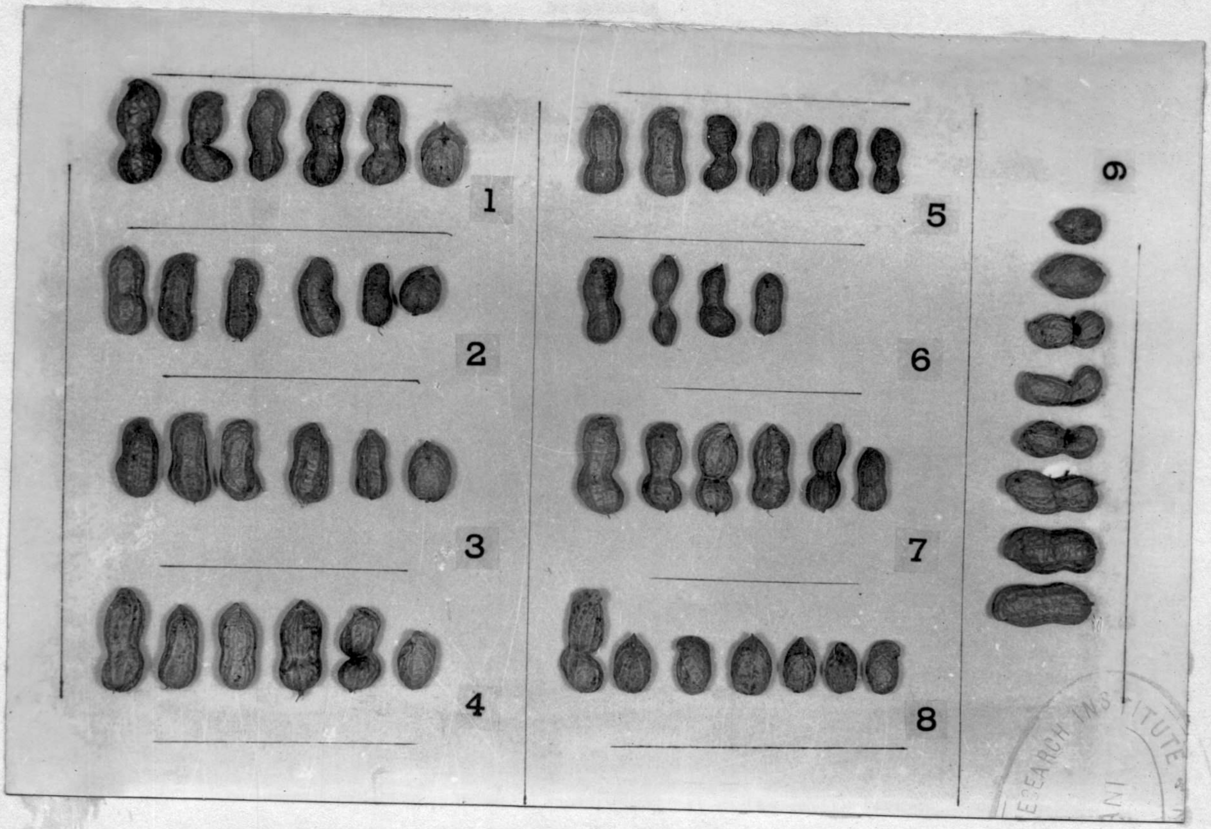
VARIATION IN POD CHARACTERS IN

A - F_2 of *A.hypogaea* X *A.sp.*(A.354)

B - F_2 of back-cross hybrids.

C - Pods of *A.monticola* (a species not involved in the cross, but some segregants resembled in pod characters to *A.monticola*).

(1/2 Nat. size)


1
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7
8
9

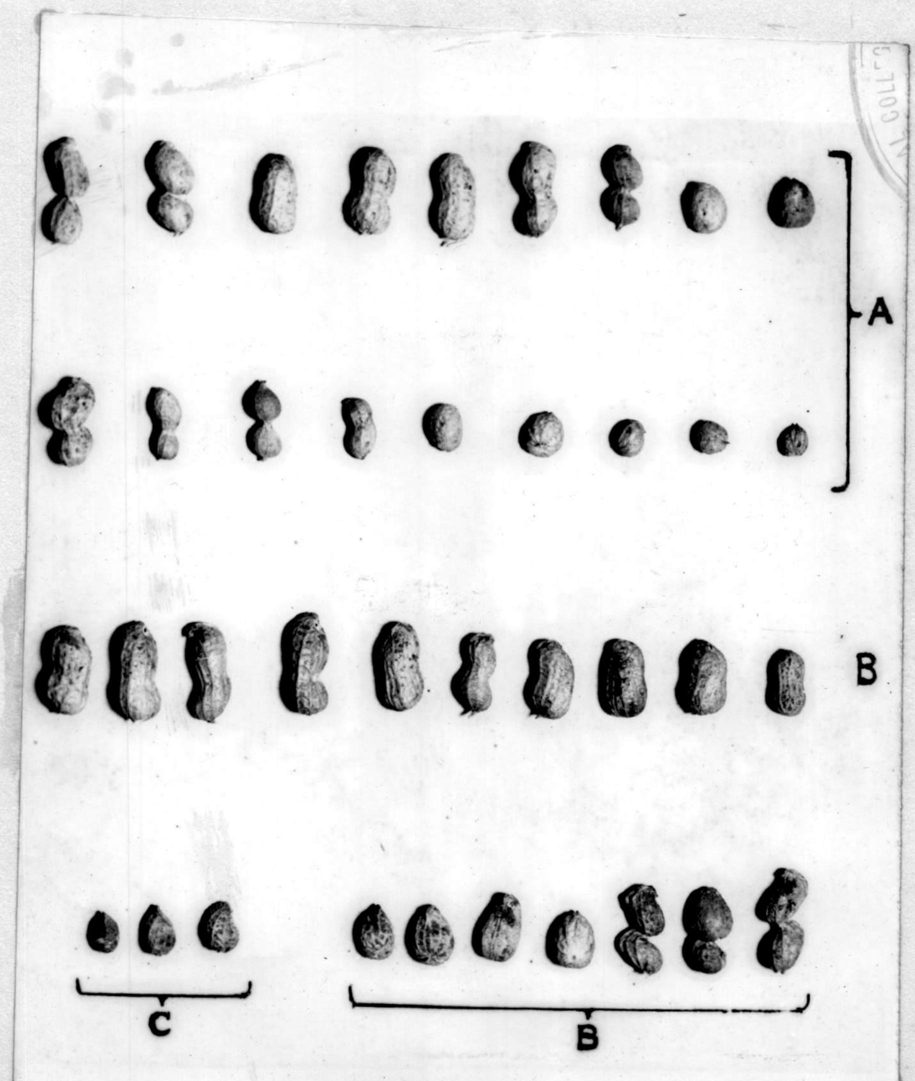
A
B
C
B

PLATE - XI

VARIATION IN KERNEL CHARACTERS

Fig. 1 - 8 Back-cross hybrids.

9 F_1 of A.hypogaea X A.sp.A.354.

10 A.sp.(A.329)

11 A.sp. (A.354).

(Nat. size)

(Through the courtesy of Sri P.C.Kesavan).

VARIATION IN KERNEL CHARACTERS.

A - F_2 of A.hypogaea X A.sp. (A.354)

B - Back-cross F_2 of A.hypogaea X
(F_1 of A.hypogaea X A.sp.A.329).

C - A.monticola (A species not involved in the cross, but some segregants resembled in kernel characters to A.monticola).

(½ Nat. size)


1
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6
7
8
10
9
11

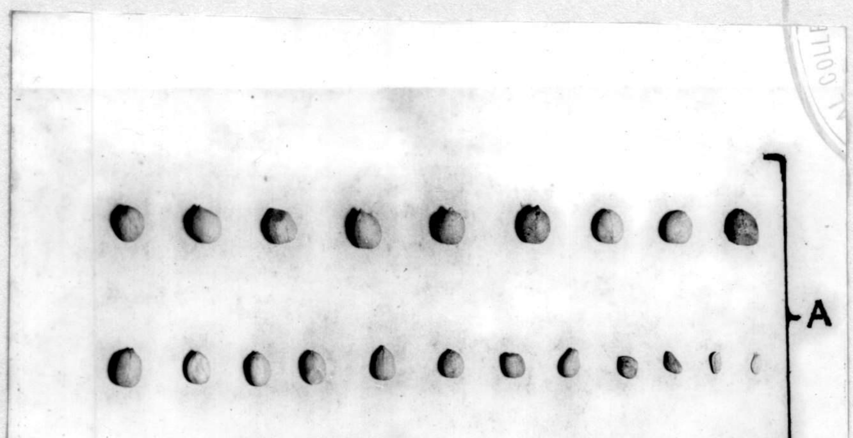

A
B
C
B

PLATE - XII

Fig. 1 : Variation in kernel characters in the straight F_2 population.

A & D - Well filled kernels.

A,C,E & F- Ill filled and shrivelled kernels. (indicating zygotic elimination).

(Nat. size)

Fig. 2 : Improvement in Pod and kernel characters in the back-cross F_3 segregant.

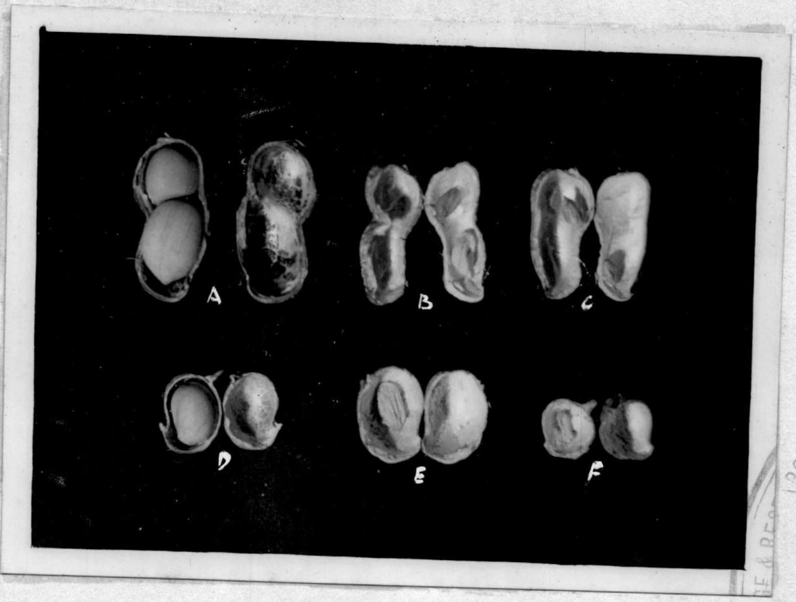
A.h - *A.hypogaea*.

A.v - *A.villosa*.

BC_1F_3 - Back-cross F_3 segregant.

(There was 100 % improvement in size of pod and kernel in the selected segregant).

(3/4 Nat. size)


A
B
C
D
E
F

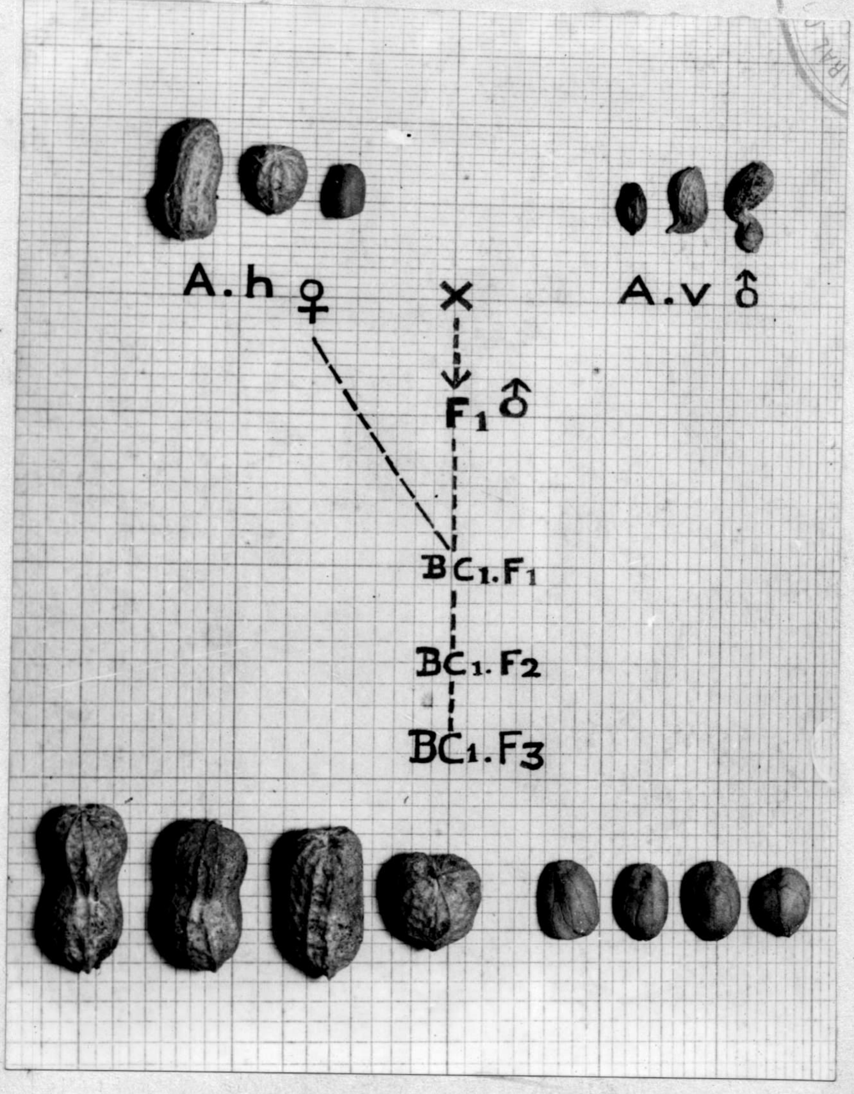

A.h ♀
×
A.v ♂
F1 ♂
BC1.F1
BC1.F2
BC1.F3

PLATE - XIII.

FLORAL ABNORMALITIES IN THE BACK CROSS F_2 POPULATION.

Upper row (A, B, C & D(- Normal flowers and peg development.

Lower row (E, F, G & H) - Abnormalities.

(Note the elongation of the 'Stipe' which ends in a leafy out-growth, abnormal flowers, with floral parts converted into vegetative parts and absence of peg development).

(1/2 Nat. size)

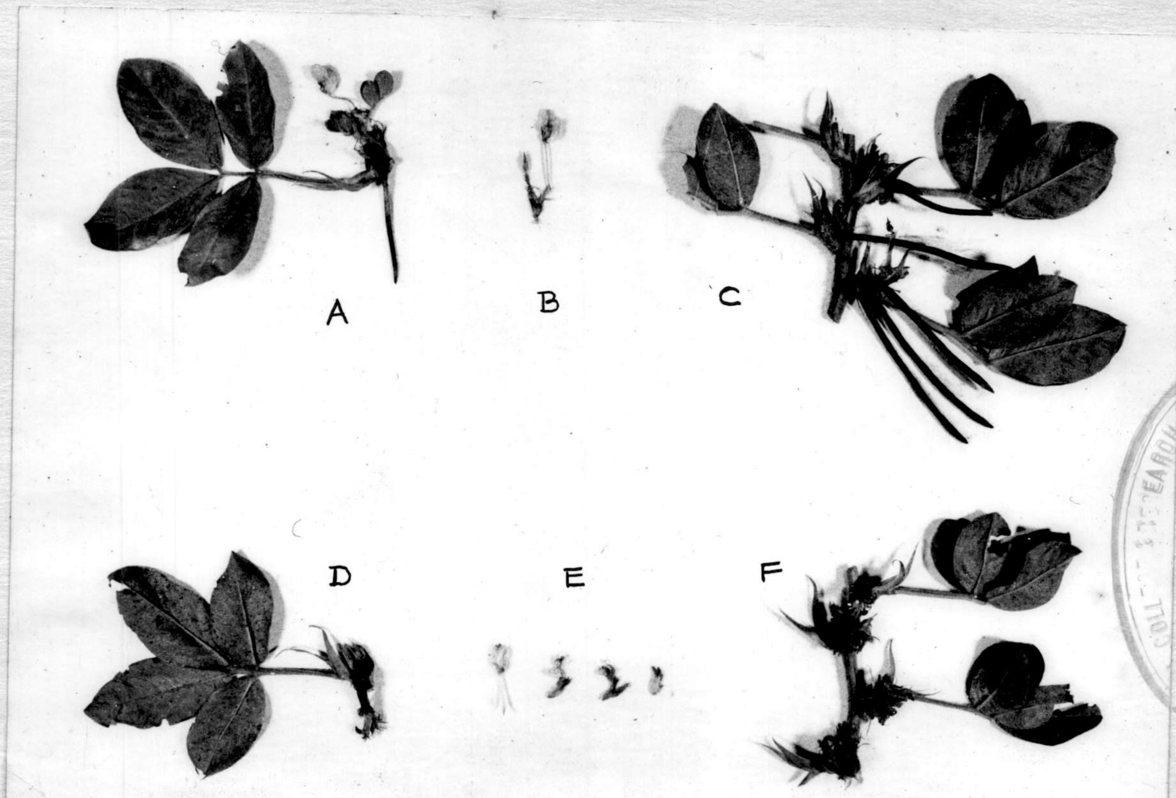

A
B
C
D
E
F

PLATE - XIV.

Figs. 1 - 7 - Meiosis in straight cross F_2 plants. (2n = 40).

Fig. 1 - Metaphase plate I - (disturbed)

Fig. 2 - Anaphase I - (scattered)

Fig. 3 - Anaphase I - (4 groups).

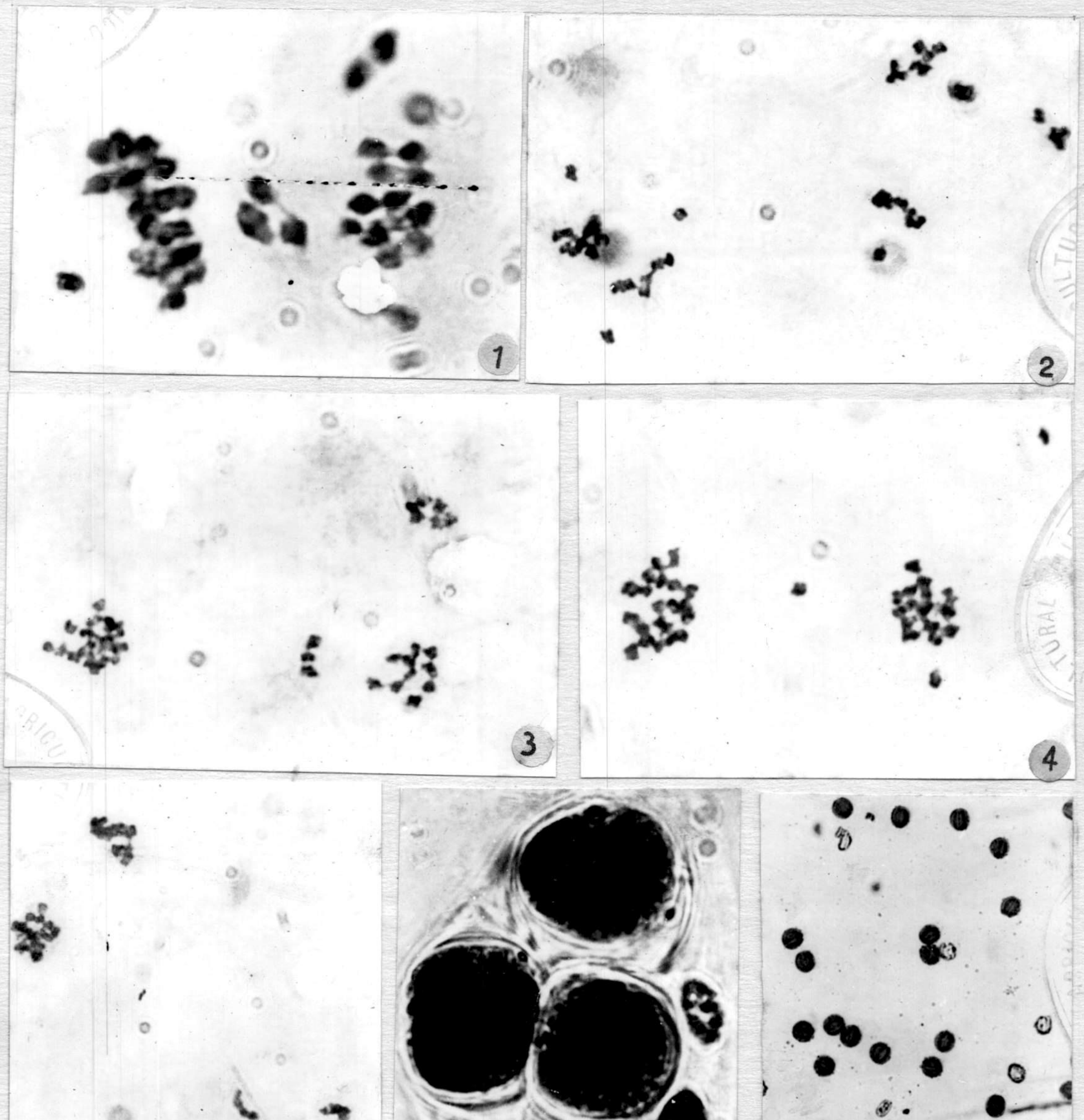
Fig. 4 - Anaphase I (with laggards)

Fig. 5 - Anaphase II - (with laggards)

Fig. 6 - Hexad.

Fig. 7 - Pollen grains.

(Fig. 1 X 1500; Figs. 2-5 X 950; Fig. 6 X 120; Fig.7 X 70).


1
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4
5
6
7

PLATE - XV.

Figs. 1 - 7 : Meiosis in back-cross F_2 plants. (2n = 40).

Fig. 1 : Metaphase I - 20_{II}

Fig. 2 : Metaphase I - $1_{III} + 18_{II} + 1_{I}$

Fig. 3 : Metaphase I - 5 groups.

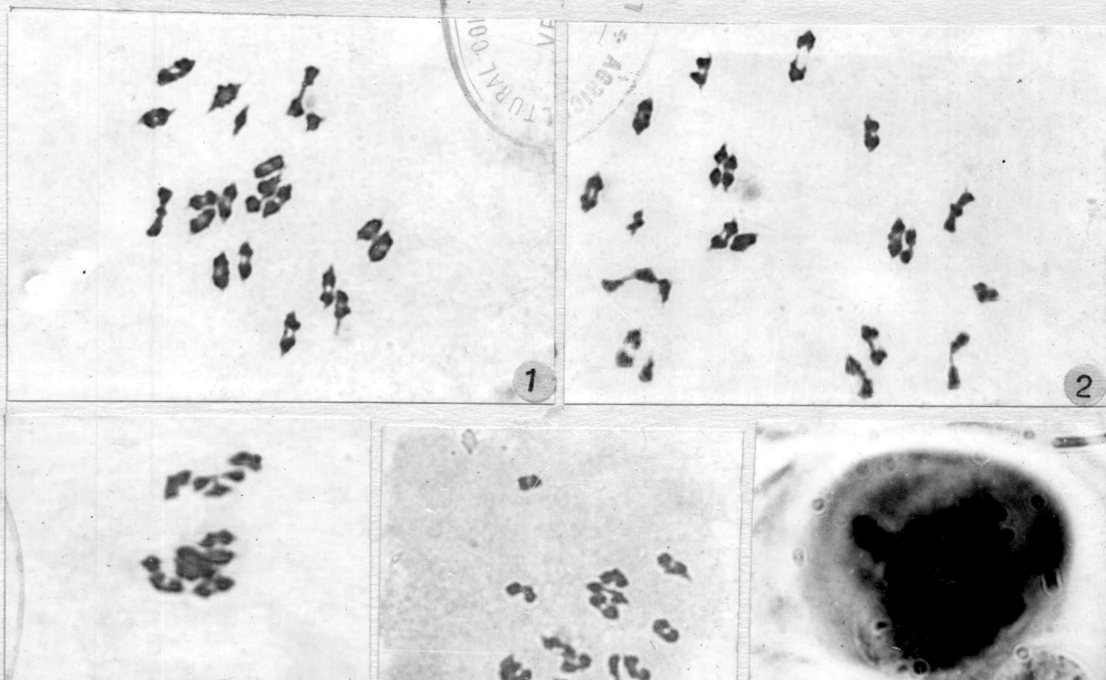
Fig. 4 : Metaphase I - $1_{IV} + 18_{II}$

Fig. 5 : Triad.

Fig. 6 : Monad.

Fig. 7 : Pollen grains.

(Figs. 1 - 4 X 1030, Figs. 5 & 6 X 330; Fig. 7 X 70)


1
2
3
4
5
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7