INVESTIGATIONS ON HYBRID VIGOUR

IN

BHINDI (*Abelmoschus esculentus* L. MOENCH)

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THESIS

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CERTIFICATE

This is to certify that the thesis submitted contains the results of bonafide research work carried out by Shri A.Mohamad Isaack under my supervision. No part of the work embodied in this thesis has been submitted earlier for the award of any degree.

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C O N T E N T S

INTRODUCTION

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In recent times, the importance of including more of vegetables in the day-to-day human diet is being stressed. But under the existing conditions, the production of vegetables is very low in our country. To tide over this problem of reduced yield, research workers have launched on different programmes for increasing production. According to Pal and Sikka (1956) exploitation of hybrid vigour which often results from crossing two unrelated varieties or strains needs special attention as a quick, cheap and early method of attaining sufficient increase in agricultural production and the phenomenon of hybrid vigour should make a strong appeal to agriculturists.

In countries like U.S.A., Canada and Bulgaria commercial production and utilization of hybrid seeds of vegetables like onion, cucumbers, melons, cabbage, brinjal, tomato etc., have much advanced. Consequently the vegetable seeds industry has become highly developed. From the detailed studies on vegetables like brinjal, tomato and onion, it has been showed that there is ample scope for the improvement of vegetable crops by exploiting hybrid vigour. In our country attempts to produce desirable hybrids of vegetables have not progressed much.

Bhindi (Okra - Abelmoschus esculentus L. Moench) is a very popular vegetable crop in South India. It can be grown with ease in any part of the year. It is a native of tropical or sub-tropical Africa, and spread to America probably with the slave trade. This plant is also native to India, where its wild forms are met with.

The tender fruits are cooked as a vegetable in curries, stewed or fried, and cooked into soups. Mature fruits and the stems containing crude fibre are used in paper industry. Bhindi is a good source of vitamins A and D and contains vitamin C. It is rich in proteins and mineral elements. It is an excellent source of iodine so useful for the control of goitre. It is good for people suffering from weakness of the heart and brain; but is not fit for those who have weak digestion.

Hybrid vigour in respect of plant height, number of branches, and the number and weight of fruits, has been reported in bhindi by workers like Venkataramani (1952), Gurgel and Nitidieri (1956), Joshi et al (1958), Raman et al (1961) and Raman and Ramu (1962). For commercial exploitation of hybrid vigour, and utilization of

hybrid seeds, male sterility is an useful tool of the plant breeder for producing male sterile lines. But so far, heritable male sterility has not been reported in bhindi.

Nair (1964 unpublished) in his studies on the chemical induction of male sterility in bhindi has found that F, W-450 (Na α B dichloro-isobutyrate) is effective to induce cent per cent male sterility, at 0.25 and 0.30% concentrations. In these concentrations, a high percentage of female sterility was also observed. But lower concentrations of the chemical induced cent per cent male sterility without any remarkable reduction in ovule fertility. This information may require confirmation and if chemical induction of male sterility is found efficient, it can be utilized for the exploitation of hybrid vigour and commercial hybrid seed production in this crop.

The present study is intended to examine the extent to which hybrid vigour has been manifested in intervarietal crosses of four locally available bhindi varieties viz. Local white (L.W.), Pusa red (P.R.), Pusa sewani (P.S.) and Kilichundan (K.C). All twelve hybrids obtained from six cross combinations (six hybrids and

their respective reciprocals) together with the four parents have been used for the study.

REVIEW OF LITERATURE

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Generally when two dissimilar homozygous varieties of plants are crossed, the hybrid will be intermediate in size. But some hybrids are more vigorous than either of the parents. They may have a more luxuriant growth of leaves, and stems and produce greater number of fruits. Even among animals, increase in size occurs in hybrids of certain crosses. This phenomenon is called hybrid vigour.

Early work:

In 1776 Kolreuter studied heterosis by producing hybrids in the plant kingdom. He got good examples of excessive luxuriance in interspecific crosses of Nicotiana, Dianthus etc. (East and Jones, 1919). Knight (1799) described hybrid vigour as a normal sequence to crossing varieties. Mauz (1825), Sageret (1926), Herbert (1837) and Gartner (1849) observed luxuriance in vegetative growth, root development, height, hardiness, number of flowers etc. in many of the hybrids. Naudin (1865) found hybrid vigour in 24 species crosses out of 35 which he made within 11 genera.

The first large scale, systematic study of hybrid vigour was made by Darwin and published in 1876

He compared the heights of inbred parents and their hybrid off-spring for 57 species of plants. Many of his crosses, which included Salvia, morning glory, pinks, lupins, peas, tobacco and maize showed hybrid vigour. He concluded that hybrid superiority resulted from the union of different germinal complexes rather than the mere act of crossing. Crosses involving different flowers of the same plant or different flowers of a closely related family gave very little or no increase in vigour. Since Darwin's time an immense amount of quantitative work has been done on the size of hybrids. East (1908), Jones (1918, 1945) and Shull (1908, 1911) have reported superiority of the hybrids in corn (Zea mays). A review on all such work is not attempted.

Practical application:

Hybrid vigour manifests itself not only in greater weight and height; some hybrids show larger seed, more efficient germination, greater resistance to disease, earlier flowering, higher yields of fruit and greater length of life than their parents. It is not surprising, therefore, that hybrid vigour makes a strong appeal to

agriculturists. According to Pal and Sikka (1956) "it is imperative that attempts should be made to exploit all possible methods of increasing agricultural production. Exploitation of heterosis or the vigour which often results from crossing two unrelated varieties or strains needs special attention in this connection as a quick, cheap and early method of attaining sufficient increase in agricultural production".

1. Hybrid vigour in self pollinated crops:

Hybrid vigour has been studied widely in Brinjal by various workers in U.S.S.R., Japan, Germany and India. Nagai and Kida (1926), Pal and Singh (1946 and 1949), Venkataraman (1946), Odland and Noll (1948), Alpatjev (1949) and Mishra (1961) have noted heterotic effects in economic characters like earliness, fruit size, fruit number, yield etc. In tomato extensive studies have been made by different workers like Powers (1945), Powers and Le Roy (1945), Whaley (1952), Haskell and Brown (1955), Clark (1956) etc. They have found beneficial effects like increased height and spread of plants, disease resistance, earliness in maturity etc. in the F1 offspring. The manifestation of hybrid vigour in useful characters in these crops can be practically utilized since they possess a very

large number of seeds per fruit and from which a large population of hybrids can be raised. This offers good possibilities for large scale production of hybrid seeds by hand pollination, for commercial purposes.

Cotton is another important crop in which heterotic vigour has been reported. Kime and Tilley (1947), Stephens (1950),-Jones and Loden (1951),-as cited by Santhanam (1956) - and Santhanam (1956) have referred to the utilization of hybrid vigour in this crop. The possibility of making use of this phenomenon for increasing production has also been considered. Pal and Sikka (1956) have reported that intervarietal hybrids of Gossypium hirsutum (by recent work at the I.A.R.I.) to exhibit considerable vigour with increased yield and better staple length. Bhatnagar et al (1964) on Mung bean has reported hybrid vigour in characters like height of plants, size of seed and number of seeds per pod, if superiority over the better parent is considered and in all characters when the superiority of the hybrid over the parental mean is studied.

In bhindi, Vijaraghavan and Wariar (1946), Venkataramani (1952), Scientific reports of the I.A.R.I. (for the year ending 30-3-1954, pp. 127; - Anon, 1956). Joshi et al (1958), Raman et al (1961) and Raman and

Ramu (1962) have reported the results of studies on inter-varietal hybrids.

Vijayaraghavan and Wariar (1946) in their work on this vegetable crop to select high yielding bybrid strains, found distinct evidence of hybrid vigour in number, size and weight of fruits in some crosses. Venkataramani (1952) studied intervarietal crosses involving six varieties of bhindi and obtained increased yield ranging from 5.4 to 14.5 percent over the better parent in five crosses. In one cross no vigour was observed. Joshi et al (1958) observed that 13 out of 29 combinations yielded more than the respective superior parents, the range of increase being 9.68 to 62.19% while ten yielded less than the inferior parents, showing nagative heterosis. Some of the crosses showed reciprocal differences. Seven hybrids recorded significantly higher number of fruits than the better parent. The size of fruit was significantly larger compared to the parental varieties as a group. According to Venkataramani (1952) the fruits were either intermediate in size or larger than the parents. Raman and Ramu (1962) reported increase in number and weight of fruits over the better parent in 3 out of 9 crosses.

2. Heterosis in cross pollinated crops:

In certain crops belonging to this group, the flower types are such that controlled pollination can be resorted to with convenience. In maize controlled pollination methods and production of inbreds are so convenient that a very large number of selected hybrids have been evolved and they have recorded very significant increase in yield of grain. In fact, the amount of hybrid maize sown in the corn belt of the United States of America has increased from 0.2 per cent to 82.5% in total acreage. Heterosis has been observed in cabbage by various workers like Pearson (1932), Myers (1942), Odland and Noll (1950) and Nieuwhof and Munger (1950). They have been quoted by Swarup et al (1963). Hybrid seeds of cabbage are commercially used in countries like Japan, Holland and U.S.A. Singh and Mehta (1954) reported heterosis in cabbage in respect of yield.

Krishna Rao et al (1951), Sundarapandyan et al (1960) and Ahuliwala and Patnaik (1963) have observed manifestation of hybrid vigour in pearl millet. Chafoor and Khan (1956), Hirayoshi et al (1956), Subramonian et al (1962) reported hybrid superiority in Sorghum.

Hybrid vigour has been recorded with regard to a number of characters and brief review in respect of the following characters is presented.

1. Height of plant:

Nagai and Kida (1926), Kakizaki (1931), Pal and Singh (1946) and Venkataramani (1946) have reported varying degree of heterosis in respect of plant height in different hybrids of brinjal (Solanum melongena). According to Kakizaki, the average height of hybrids is appreciably larger over the parents and significantly greater than the taller parents in some cases. Mishra (1961) reported that the hybrids on an average possessed increased shoot lengths when compared to the male parent. Only two of the hybrids showed decrease in height over both of the parents.

Totmakov and Alpatjev (1935), Whaley(1939), Powers (1941), Haskell and Brown (1955) and other have all reported increased growth in tomato hybrids. According to Haskell and Brown (1955) and Gottle and Darley (1956) the increased vigour of the hybrids over the parents was manifested in all the vegetative parts. In Phaseolus vulgaris, Malinowski (1955) and in gram, maize and Chillies, Pal (1945) have reported that hybrid vigour

also been found in bitter gourd by Pal and Singh (1946). In Sesamum, Pal (1945) has reported that there was no hybrid vigour in respect of height and some F_1s were below average of the two parents. In Mung bean (Phaseolus aureus) Bhatnagar and Singh (1966) reported superiority of the hybrid in plant height over the better parent.

Chizaki (1934) found that the height of interspecific hybrid of Hibiscus esculentus x H.manihot (L.) was intermediate to the parents. Miller and Wilson (1937) obtained the same result with regard to seven hybrids of bhindi between varieties. In the cross between Hibiscus ficulneus and H.esculentus, Singh et al (1938) found the hybrid to be taller than the parental types. Venkataramani (1952) reported the height of certain hybrids produced by him to be intermediate. In bhindi, Joshi et al (1958) have reported that the hybrids, in general, were taller than their respective superior parents. In eleven out of 29 combinations of Fls were taller than the taller parent, the increase being 0.2 to 18.5%; 12 hybrids were intermediate, being more towards the taller parent, one equalled the smaller parent and five were smaller than the smaller parent. The hybrids in 4 crosses were significantly taller than the

taller parent. In some cases the reciprocal crosses differed. Thus the F_1s in four crosses were found to be significantly different from each other. According to Raman and Ramu (1962) there was decrease in final height of hybrids than the respective parents in inter-varietal crosses of bhindi. Ravindra (1964) observed in his work on bhindi, that in general the plants which recorded heighest plant height were found to possess longer internodes.

2. Branching:

Nagai and Kida (1926), and Kakizaki (1928 and 1931) reported hybrid superiority with respect to number of branches in Brinjal. Pal and Singh (1946) recorded in the same crop an increase in number of branches ranging from 9 to 54% over the better parent in the case of 8 hybrids. But three of the hybrids showed lesser number of branches than the respective inferior parents. Mishra (1961) found that the hybrids of brinjal showed their superiority in the average number of branches. The maximum increase in the hybrids have gone up to 41.6% over the male parent and 39.6% over the female parent, the averages being 17.56 and 13.54 respectively. Only one hybrid had decreased num-

ber of branches, as compared with the two parents. Pal (1945) found that the F_1 plants of sesame were generally intermediate between the two parents and seldom exceeded the better parent. Joshi et al (1958) observed that hybrids of bhindi as a class recorded significantly higher number of branches than the parents. In 14 combinations the F_1 produced greater number of branches than the better parent, the increase ranging from 1.2 to 25.3 per cent. But significant increase was registered only in one combination. In 8 crosses, the hybrids were intermediate, most of them tending towards the superior parent. 5 hybrids produced lesser number of branches than the inferior parent and in one case each, the F_1 hybrid was as good as the superior parent or as poor as the inferior parent.

Raman and Ramu (1962) noted increase in number of branches in two out of nine hybrids of bhindi while seven produced lesser number of branches. The same authors (1963) observed that only one hybrid in this crop, out of crosses between four varieties, exhibited heterosis in respect of spread of the plant.

3. Number of leaves:

Pal (1945) studied this aspect in Sesamum

and has reported that there is hardly any evidence of hybrid vigour. But he has found in maize that the hybrids were superior to the parents with respect to t the number of leaves. There is high degree of heterosis and difference in the vigour of the reciprocals. According to Malinowski (1955) F_1 generations of crosses of the self pollinated Phaseolus vulgaris evinced hybrid vigour in respect of size and number of leaves. Subramoniyan et al (1962) in their studies on heterosis in sorghum has observed the maximum vigour in the bybrid between the two African sorghums, was for the number of leaves (nodes) per plant. This increase in the number of leaves without an adverse effect of plant height and straw yield is desirable, as the quality of fodder is enhanced by inducing more leafiness to the plant. Satyabalan et al (1960) have recorded observations on number of nodes (leaves) in castor and found that the degree of expression of heterosis varied in different crosses. Aastveit (1962) in barley has found that in a series of diallel crosses, many crosses were heterotic especially in straw length and yield. Bawolska et al (1962) has reported in their studies on tobacco at 2 different places in Poland that no hybrid exceeded the higher parent in leaf number at Pulawy, though some

equalled it. Some hybrids exceeded both the parents in leaf size. Differences were frequently observed between reciprocal hybrids. But at Surhow certain hybrids exceeded both parents in leaf number. Swarup et al (1963) observed heterosis in the F1 of cabbage crosses in the net weight of head (due to size and number of leaves) and has concluded that it would be advantageous to adopt heterosis breeding for improving the economic characters in cabbage.

The hybrid cotton derived from the crinkled leaf mutant with its normal parental form exhibited partial dominance for the crinkled leaf character and included plants with leaves possessing an intermediate degree of crinkling. Santhanam (1956) reported that plants with crinkled leaves were taller and possessed a larger number of nodes and leaves than normal plants.

4. Time of flowering and number of flowers:

In brinjal earliness in flowering of the plants was observed in almost all the F1 hybrids. Nagai and Kida (1926), Kakizaki (1928, 1930 and 1931), and Daskaloff (1937, 1941) also observed early fruiting in hybrid brinjals. Daskaloff (1937, 1941) also observed early fruiting in hybrid brinjals. Venkataramani (1946) have again reported earliness in flowering in brinjal hybrids. Odland and Noll (1948) noted earliness in

productivity and showed that this was correlated with increased total yield. In their studies, Pal and Singh (1946) observed in all the cases except one cross, that flowering was late. According to Venkataramani (1946) flowering was early by 18 days when compared to the early parents. Mishra (1961) reported that the hybrids showed early flowering and greater number of plants in bloom. The range of early flowering in many of the hybrids varied from 20 to 100% over the respective parents. While some others were intermediate. He has also concluded that a cross between the late and early varieties resulted in producing hybrids which were fairly earlier. The F1 hybrids invariably had more number of flowers per cluster.

In tomatoes, the hybrids are characteristic in early fruit set and ripening but this is not clear till the first fruit ripens. Powers (1945), Finlay (1951), Burdick (1954), Haskell and Brown (1955), Hojby (1958) and others have reported earliness in fruiting in tomatoes. According to Powers (1945) the increased yield was due to an increase in the earliness of the crop. Baldoni (1948) and Wittwer (1953) have suggested that earliness was not there always in the bybrids.

Pal (1945) reported comparative earliness in flowering in F1 hybrids in gram. In Sesamum, one cross and its reciprocal was as early as the early parent; other hybrids were intermediate but nearer to early parent. In chillies the hybrids tended to be as early or slightly earlier than the early parent except in one once cross which was slightly late than either of the parents. In studies on bitter gourd, Pal and Singh (1946) noted that most of the hybrids produced a larger number of male and female flowers and were early in flowering, than the parents. Harbhajan Singh (1962) reported early flowering in cucumber. Thacenko and Marcenko (1962) in their work on cucumber observed that earliness in F1 hybrids was related to the conditions under which the parents were grown. Most productive hybrids seeds were obtained from seeds which set immediately after flowering starts.

Bawolska et al (1962) in the hybrids of tobacco found that the majority of them exceeded both the parents in earliness in flowering and number of flowers. Ahluwalia and Patnaik (1963) have found heterosis for earliness in pearl millet.

Venkataramani (1952) found in bhindi that the hybrids were either as early as the early parents or

earlier than the earlier parent in four out of seven crosses. It has been observed by Rao (1953) that bhindi seeds collected from early maturing gruits gave rise to larger number of seeds. These flowered earlier but there was no appreciable difference in the total yield. Scientific reports of the IARI (1955) have showed that the round fruited selections from sabour selection x green velvet types of bhindi resulted in earlier flowering than the former parent.

Raman and Ramu (1962) found that four out of nine hybrids of bhindi were earlier than the earlier parents. They have (in 1963) also observed that all the nine hybrids studied, recorded earlier flowering than the parents. Ravindra (1964) reported that flowering in bhindi was early in monsoon whereas it was late in the winter season.

5. Number of fruits:

In Brinjal heterosis in number of fruits was observed by various authors. Nagai and Kida (1926) and Pal and Singh (1946) noted increase in total yield in the hybrids and this was due to the setting of more fruits per plant. Odland (1948 and Odland and Noll (1948) are in agreement with this view. According to

Mishra (1961) the F1 had significantly higher number of fruits than their respective parents. Amongst the parents, the total average number of fruits per plant ranged from 5.25 to 7.16 and in the F1 hybrids the values were from 7.08 to 13.0, showing thereby appreciable increase over the parents in many cases. Increase in total yield of fruits has also been recorded by Kakizaki (1930), Venkataramani (1946) and Raman et al (1961).

Increase in total yield of tomato hybrids has been recorded by Daskaloff (1937), Powers (1945), Finlay (1951), Harkell and Brown (1955), Gottle and Darley (1956) and Hojby (1956). Whaley (1939) and Baldoni (1949) have attributed the increase in yield to be due to increase in total number of fruits and rather not because of larger sized fruits. In tomato fruit size was intermediate between the parental types and in certain cases tended more towards the smaller parental size (Finlay, 1961). This is in conformity with the earlier observations of workers like Groth (1912) and Larson and Currence (1944). The general trend of observation is that there is little or no difference in yield in the case of reciprocal crosses in tomato. But

Meyer and Peacock (1941) have obtained results showing pronounced reciprocal differences.

Pal (1945) in his studies on gram has reported that the difference in number of pods per plant in parents and their hybrid was more pronounced. In Sesamum, the hybrids generally approached the better parent in respect of number of capsules per plant. In his study on chillies it was found that in two crosses the hybrids were definitely poorer than the parents while in the third, they were intermediate with respect to number of fruits per plant. Pal and Singh (1946) obtained increased yield in hybrids of bitter gourd. Deshi et al (1964) in Indian squash noted increased yield as high as 72% over the parent. Bhatnagar and Singh (1964) in their study on Mung bean revealed that heterosis was exhibited in the number of pods per plant for the three interspecific crosses.

In bhindi, Vijayaraghavan and Wariar (1946) and Venkataramani (1952) recorded increase in yield ranging from 5.4 to 14.5% over the better parent. The findings of Joshi et al (1958) is that the hybrids as a class gave significantly higher yield than the parents. In the case of fruit characters increase in the number

of fruits in the hybrids appears to be significant. Out of 10 combinations which gave significantly higher yields than the superior parents, nine combinations produced significantly larger number of fruits. It has therefore been suggested that increase in number of fruits has been mainly responsible for increased yields. Raman and Ramu (1962) have recorded increase in number of fruits over the superior parents in three out of nine hybrids of bhindi.

6. Weight of fruits:

The increase in yield in tomato has been reported to be due to the increase in total number of fruits rather than by bigger fruits (Whaley, 1939). Baldoni (1949) and Maskell and Brown (1955) are in agreement with this view. According to Finlay (1951) none of the hybrid fruits was larger than that of the larger parent nor smaller than that of the smaller parent. So fruit size, and weight was intermediate between the parents.

In brinjal increase in yield due to weight of fruits was observed by Nagai and Kida (1926), Tateisi (1927), Kakizaki (1928, 30, 31), Dashaloff (1941), Munger (1946), Pal and Singh (1946, 1949), Venkataramani (1946)

and Alpatjev (1949). Mishra (1961) stated that the increase in yield was expressed as an increase in the weight and number of fruits and that there is positive correlation between the number of fruits and their weight.

Pal (1945) recorded in sesamum striking increase in yield in six out of 8 hybrids and the best hybrid exceeded the better parent by 121%. The increase in yield was due to the greater number of capsules per plant and weight of seeds. In Chillies he reported that in two of the crosses, the hybrids were superior to both the parents while in the third, they were intermediate in fruit weight.

Joshi et al (1958) in considering all the hybrids of bhindi as one group and the parents as another, found that the former gave significantly higher yield than the later. Significant results in yield in 3 reciprocal crosses were also noticed. The increase in yield was due to the increased number and weight of fruits. Raman and Ramu (1962) recorded increase in number as well as in the weight of fruits over the superior parents in 3 out of nine bhindi crosses.

7. Length and girth of fruit:

Nagi and Kida (1926), Pal and Singh (1946 and

1949) have observed heterosis in respect of fruit size in brinjal. According to Mishra (1961) there was marked variation in fruit size at the edible stage in hybrid brinjal. Some hybrids had the longest fruits, measuring upto 16.35 cms. on an average. In general, it was concluded that the fruits of hybrids were invariably larger than either both or one of the parents. Hybrid vigour was noticed in fruit length in five out of eight hybrids in comparison with the male parent and of the remaining three only one was found to have slightly lesser values than the average of both of the parents. Only one hybrid had lesser length than the female parent. When the average of both the parents was considered, only one hybrid combination was found to have slightly lesser length.

The maximum increase in diameter was 42.2% in one hybrid. 5 out of 8 hybrids showed fairly high increase in fruit diameter.

Baldoni (1949) and Hascell and Brown (1955) reported that in tomato hybrids the increase in yield was not due to the larger size of individual fruits but due to greater number of fruits. In the view of Finlay (1951) there was no difference in fruit size during the different periods of harvest. No hybrid fruits were

larger than that of the bigger parent nor smaller than that of the smaller parent. In fact, fruit size in the hybrid was intermediate between the parents and some times tended towards the smaller parent.

Malinowski (1955) in his studies on Phaseilus noticed hybrid vigour in fruit size. Bhatnagar and Singh (1964) noted that the average F1 values in three hybrids of Mung bean exceeded the respectively mid parental value in considering the length of pod. But when the superiority of the hybrid over the better parent was considered, the length of pod in one cross failed to show any heterosis.

Joshi et al (1958) found in bhindi that the size of fruits in the hybrids taken as a group was significantly larger when compared to that of the parental strains taken as another group. In F1 hybrids the fruit size was larger than the superior parent, increase in size ranging from 0.17 to 34.78%. 13 combinations were intermediate while in one, the size of fruits was smaller. The reciprocal crosses between two varieties produced fruits significantly larger in size. Out of 10 combinations which gave significantly higher yields than the superior parents, fruit size was significantly bigger only in one combination.

Raman and Ramu (1962) reported that out of nine bhindi hybrids studied, 3 showed superiority in yield (number of fruits) while in respect of weight of fruit (due to bigger size) only two hybrids were better.

8. Number of seeds per fruit:

Bhatnagar and Singh (1964) reported that the number of seeds per pod failed to show any heterosis in Phaseolus aureus in one of the three crosses.

In bhindi, Raman and Ramu (1962) have suggested that there was no correlation between the seed content and fruit size. Studies by them has brought out that in certain combinations of crosses, there was an increase in the seed content of the hybrids when compared with that of the parents. This has led to a reduction of the quality of fruits.

9. Weight of seeds:

Ashby (1937) and Luckwill (1937) have recorded that seeds from cross fertilization in tomato were larger than those produced by self pollination. Similar observations were made by Collins and Kempton (1913) and East and Jones (1920) in maize and by Wingard (1927) in hybrid bean seeds. Ganesan (1942) found in his stu-

dies of three cotton crosses, the seeds produced, weighed considerably more than selfed seeds, the range of increase being 23 to 41%. But the difference was significant only in two cases.

Kakizaki (1928) and Venkataramani (1946) reported heavier seeds in the brinjal hybrids when compared to seeds obtained from selfed seeds. According to Venkataramani (1946) the increase in seed weight was due to the enhanced weight of the embryo region of seed. Engledow and Pal (1934) and Sprague (1936) could not find any increase in embryo weight in wheat and maize respectively. Data on weight of hybrid seeds collected by Subramonian et al (1962) in Sorghum and by Bhatnagar and Singh (1964) in Mung bean showed that the hybrids were superior to the parents in seed weight. In pearl millet also, increase in weight of grains was reported by Soundarapandian et al (1960).

MATERIALS AND METHODS

MATERIALS AND METHODS

This investigation was carried out in the Agricultural Botany Division of the Agricultural College and Research Institute, Vellayani, during the year 1964-65 (October, 1964 to June, 1965).

Seeds of four varieties of Bhindi viz. Local white, Pusa red, Kilichundan and Pusa sewani were obtained from the Superintendent, Agricultural College Farm, Vellayani and utilized to raise the parents and to produce F_1 seeds for the study. The characters of the four varieties are tabulated and presented in Table I.

TABLE I

Character	Local white L.W.	Pusa Red P.R.	Kilichundan K.C.	Pusa sewani P.S.
Stature	Short	Tall	Short, stout	Tall
Branching	branching	branching	Profusely branching	less branching
Stem and petiole colour	Greenish white with light red tinge throughout.	Purple throughout	Green with light violet tinge especially at regions of node.	green with dark reddish tinge along the entire length

Leaves	big and broadly lobed - 5 lobes, less conspicuous	deeply five lobed veins with purple tinge	very large and slightly lobed	5-lobed lobes narrow and conspicuous
Flowers	medium	medium	big	medium profuse flowering
Petal colour	Yellow, claw very prominent	Yellow with reddish veins - clawed	Yellow with purple claw - prominent	Yellow with purple claw
Stigma	Purple and velvetty 5 knobed	Bright red soft and 5 knobed	Purple with 5 big knobs	5 knobed soft and silky
Fruit size	Medium, long, stout, 8-loculed	Medium long and slender 5-loculed	Very long and curved 8-loculed	Medium and stout - 5-loculed
Fruit colour and pubescence	Greenish white minute stellate hairs present - red tinged at the base	Purple with soft hairs.	Green with small hairs	Green with short soft hairs.
Seeds	Rounded in shape and have fine hairs - Grey coloured	Round - greenish grey	Not exactly round - blackish grey	Round and big sized greenish grey

Seeds of the above four varieties for raising parents were sown on 13-10-1964 with spacing of 3' between rows and 2½' between plants in a row. Each row

consisted of seven pits and two adjacent rows were sown with the same variety. So fourteen plants were raised from each variety. Three seeds were sown in each pit; but, only one plant was retained for observation.

Some flowers in each variety were selfed to have parental seeds for the next season. Crossing between varieties in all possible combinations was also undertaken to get the F_1 seeds for investigation.

TECHNIQUE OF SELFING

In Bhindi, anthesis occurs between 7 A.M. and 9 A.M. By the next morning all the floral parts except the ovary whither and fall off.

Flower buds which would open the next morning were covered with clean paper bags in the evening and allowed to remain so till the floral parts excepting the ovary have fallen off. The paper bag was then removed and the fruit obtained was labelled, noting the name of the variety and the date of selfing.

CROSSING TECHNIQUE

a) Emasculation: Mature flower buds which would to open the next morning were selected in the evening. The

calyx enclosing the internal floral parts was split open with a pointed needle. Then the petals were carefully cut off with a fine scissors. After removing the petals, the anthers on the staminal column were very cautiously scraped off with a pointed needle. Then, this emasculated flower bud was covered with a clean paper bag.

b) Collecting pollen for crossing: The mature flower buds in those plants which were to be used as male parents were covered with paper bag the same evening for collecting pollen.

c) Crossing: In the next morning, the bag enclosing the emasculated flower (to be used as female parent) was removed and pollen collected from the desired male parent was dusted on the stigma of the emasculated flower by using a camel's hair brush. These operations were done gently and with great care. The pollinated flowers were again bagged and properly labelled. The bag was removed subsequently.

It took more than thirty days for the fruits to get completely mature and dry. The fruits obtained by selfing and crossing were harvested on drying up.

Seeds collected from individual fruits were kept in separate coveres with labels. Only good seeds were used for further work.

From the four parent varieties selected, all the six possible crosses and their respective reciprocals were made. The details of crosses are furnished below:-

Crosses.	Reciprocal crosses
1. L.W. x P.R.	2. P.R. x L.W.
3. K.C. x L.W.	4. L.W. x K.C.
5. P.R. x K.C.	6. K.C. x P.R.
7. P.S. x P.R.	8. P.R. x P.S.
9. P.S. x L.W.	10. L.W. x P.S.
11. K.C. x P.S.	12. P.S. x K.C.

Including the four parental strains, the types collected were sixteen in number.

RAISING OF F_1 PLANTS FOR THE INVESTIGATION OF HYBRID VIGOUR

The four parental varieties and their twelve hybrids were planted in the field with three replications. Each replication consisted of six plots representing six

cross combinations. The plots were bordered all around by one row of Pusa sewani.

Each plot consisted of five rows of eight plants each, representing the respective male and female parents, the direct and reciprocal cross hybrids. In this arrangement both the direct and reciprocal cross hybrids were flanked on either side by the respective parents.

The spacing given for plants in a row was 2½' and between rows, 2'.

Plan of the layout and of a single plot are given in figures I. & II.

Sowing was done on 17-3-1965. In each pit three seeds were sown and for each hybrid, seeds were used only from a single fruit. Germination was complete in seven days. As only one plant in each pit was to be retained, thinning was done on the 15th day (31st March 1965).

OBSERVATIONS RECORDED ON CHARACTERS

Observations on the different aspects studied, were taken from all the plants.

Fig. 1. Plan of the lay out of the experimental field

Fig. 2. A single plot enlarged showing the details

FIG. I

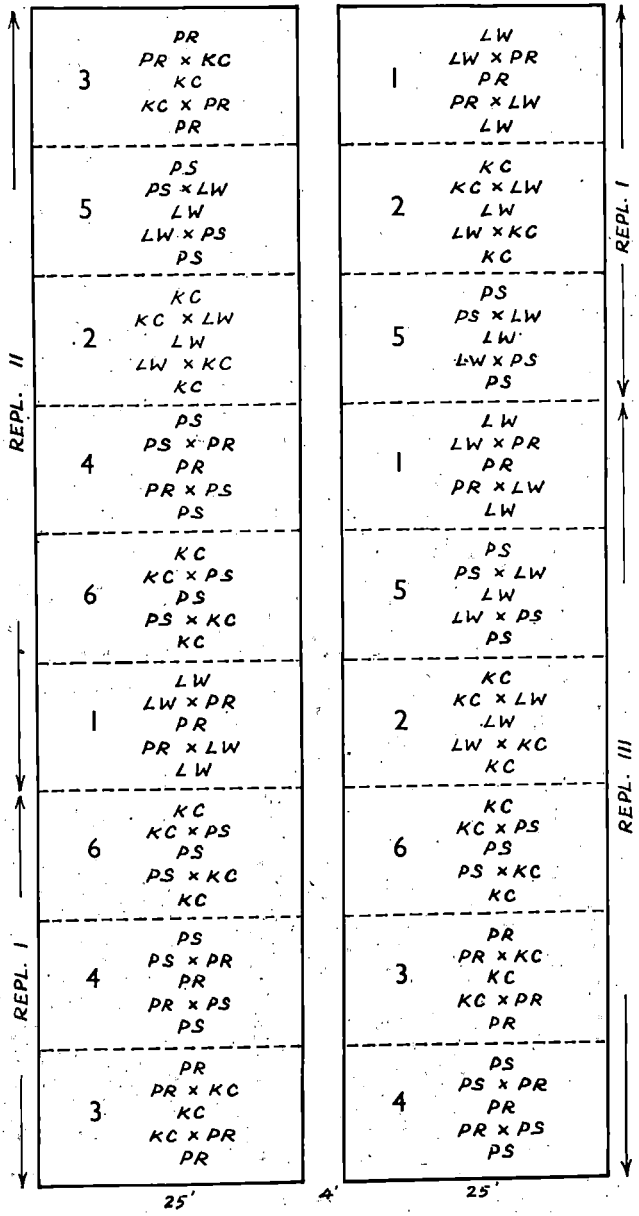
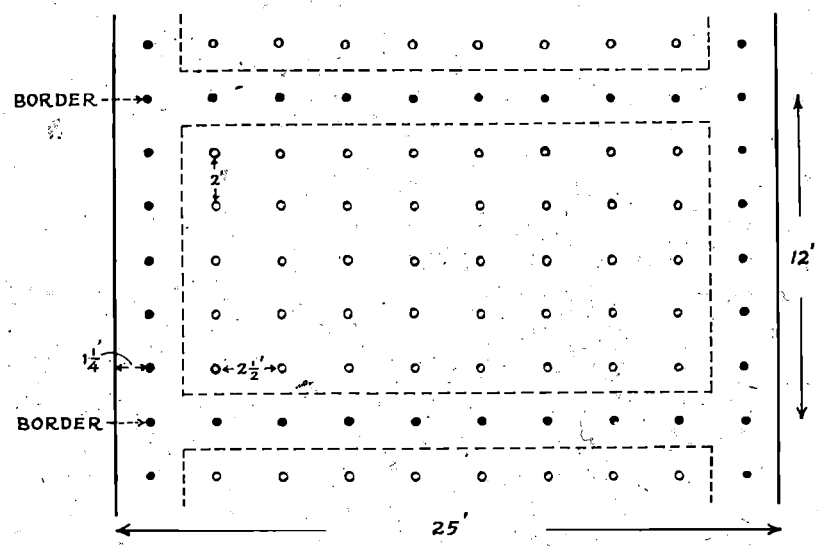
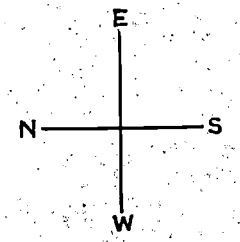


FIG. II



SINGLE PLOT ENLARGED

LAY OUT	: REPLICATED PROGENY ROWS
REPLICATION	: 3
NO. OF VARIETIES	: 16 (4 PARENTS & 12 HYBRIDS)
AREA	: 110' x 54'
PLANTED ON	: 17 - 3 - 1965



1. Height of plant: The height of the main stem from the ground level to the topmost bud leaf was reckoned as the height of the plant and it was measured with a metre scale. The first observation on height was taken on the 25th day after sowing (11-4-1966) and the data have been recorded. Further readings on this aspect were taken at an interval of 15 days. The 2nd and 3rd recording of height were made on the 40th day (26-4-1964) and 55th day (12-5-1965) respectively, after sowing. Further observations were stopped since there was no increase in height. The height recorded on 26-4-1965 was reckoned as the final height and this alone was considered for comparison.

2. Number of branches: The first observation on this item was made on the 25th day after sowing. But no plants produced branches at that time. The total number of branches including primary, secondary and tertiary branches were counted on individual plants at an interval of 15 days. Only the final count made on the 55th day has been presented.

3. Number of leaves: Data on this aspect were recorded simultaneously with the observations on height of plants. The last observation made on the 55th day (12-5-1965) only has been included in this study.

4. Time of flowering and number of flowers: Flowers appeared on a few plants after one month of sowing (from 18-4-1965). Daily observation of flowering in individual plants was made and the details have been recorded for each plant. This was continued till flowering was complete in all plants. The final reading showed the total number of flowers for each plant.

5. Number of fruits: The total number of fruits obtained from each plant was ascertained by the time when flowering was complete. Data on this aspect have been presented.

6. Weight of fruits: The weight of three fruits taken at random from each plant when they attained maximum growth (15 days after flower opening) was recorded. The mean weight of individual fruits was found out from the data collected.

7. Length and girth of fruit: The length of one fruit from each plant and its girth at the middle region was found out at the time of recording weight to compare the same between the parents and hybrids.

8. Number of seeds per fruit: One fruit from each plant (preferably the third one) when dry was collected

and the number of seeds per fruit was counted to see whether there was any difference in seed set between parents and hybrids.

9. Weight of seeds: Weight of 50 good seeds from each fruit per plant was also recorded for comparison.

Different indices have been used by various investigators for estimation of the superiority of the hybrid over the parents. According to Whaley (1944) a valid measure of hybrid vigour would be an estimate of the F_1 superiority over the better parent. Jenkins et al (1939), Kime and Tilley (1947), Balasubramonyam and Narayanan (1948) and Hagberg (1952) are also of the view that the F_1 should be compared with the superior parent to have an estimate of the hybrid superiority (as quoted by Santhanam, 1956). Muntzing (1945), Govinde and Joshi (1950) and Jinks (1956) took the arithmetic mean of the two parents as the basis for hybrid vigour. Santhanam (1951 and 1956) found the superiority of the cotton hybrids over the higher parental mean values as also the mid parental value. Joshi et al (1958) working on Bhindi, Mishra (1961) on brinjal and Bhatnagar et al (1964) on Mung bean have followed the same method. In this investigation, comparison of the F_1 mean with the

higher parental mean as also the arithmetical average of parental means have been made and the significance tested.

RESULTS

R E S U L T S

The results of the investigation have been embodied. The data for the various characters were analysed using the analysis of variance table. The means with respect to each of the characters studied, are furnished in tables and significance tested by using the critical difference. Comparison has been made between the hybrid and better parental means as well as between the hybrid mean and the mid parental value.

1. Height of the plant:

Though the height of the plants at three different stages (viz. 25th, 40th and 55th day after planting has been recorded only the data on the final height of plants were analysed. The analysis of variance table and the table of means of the plants and hybrids are furnished in Tables II and III respectively.

TABLE II

Analysis of variance table for height of plants

Source	S.S.	d.f.	Variance	F.
Total	12162.48	47		
Blocks	306.79	2	153.39	2.95
Varieties	10298.48	15	686.56	13.22**
Error	1557.21	30	51.91	

** Significant at 5% level

TABLE III

Mean height of parents and hybrids

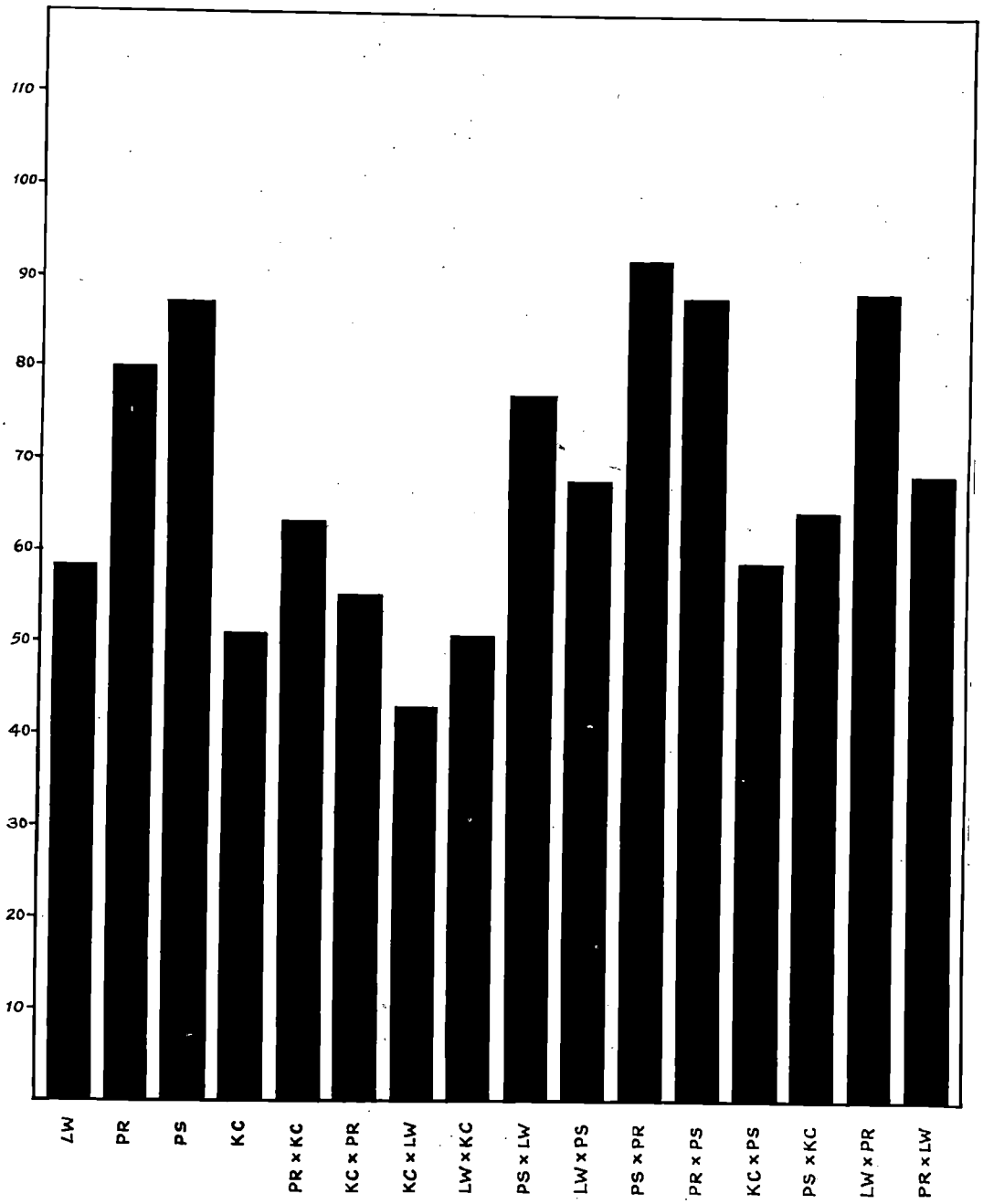
Sl. No.	Varieties.	Mean cms.	Mean of better parent cms.	Mean increase or decrease over better parent cms.	Mean of parents cms.	Mean increase or decrease over mean of parents cms.	Mean of inferior parent cms.
1	L.W	58.33	--	--	--	--	--
2	P.R	80.00	--	--	--	--	--
3	P.S	87.00	--	--	--	--	--
4	K.C	51.00	--	--	--	--	--
5	P.R. x K.C	63.33	80.00	-16.67*	65.50	-2.17	51.00
6	K.C. x P.R	55.33	80.00	-24.67*	65.50	-10.17	51.00
7	K.C. x L.W	43.00	58.33	-15.33*	54.67	-11.67*	51.00
8	L.W. x K.C	51.00	58.33	-7.33	54.67	-3.67	51.00
9	P.S. x L.W	77.33	87.00	-9.67	72.67	+4.66	58.33
10	L.W. x P.S	67.67	87.00	-19.33*	72.67	-5.00	58.33
11	P.S. x P.R	92.00	87.00	+5.00	83.50	+8.50	80.00
12	P.R. x P.S	85.33	87.00	-1.67	85.50	+1.83	80.00
13	K.C. x P.S	59.33	87.00	-27.67	69.00	-9.67	51.00
14	P.S. x K.C	64.67	87.00	-22.33	69.00	-4.33	51.00
15	L.W. x P.R	88.00	80.00	+8.00	69.17	+18.83*	58.33
16	P.R. x L.W	68.33	80.00	-11.67	69.17	-0.84	58.33

Critical difference (hybrid Vs. better parent) - 12.14
do (hybrid Vs. mean of parent)- 10.38
*Significant

Fig. 3. Bar diagram showing the mean heights of the twelve hybrids and the respective parents.

FIG. III

MEAN HEIGHT OF PLANTS (in cms.)



It was found that only one of the 12 hybrids (LW x PR) exhibited significant increase in height over the mean of parents by 27.2%. In the case of the hybrid PS x PR there was an increase in height of 5.7% over the better parent (P.S) and 10.2% over the mean of parents. But this increase was not statistically significant. In the cross P.S x L.W. and P.R x P.S the percentage of increase in height was 6.4% and 2.2% respectively. In all other hybrids the mean height of plants was lesser than the arithmetical average of the respective parents, the range of decrease being 3.3 to 21.3%. If the mean of the taller parent was taken as a measure, hybrids, P.R x L.C., K.C. x P.R., K.C. x L.W., L.W. x P.S., KC x P.S. and P.S. x K.C were significantly inferior. If the mid parental value was considered, this was significant only in the case of K.C x L.W and L.W. x P One hybrid L.W x K.C equalled the lower parent (K.C). The hybrid K.C. x L.W. proved to be shorter than the short parent (K.C), the respective mean values being 43 cms. and 51 cms.

Thus the average values of the parents ranged from 51 cms (KC) to 87 cms. (PS) and that of the hybrids from 43 cms. (KC x LW)to 92 cms. (PS x PR).

2. Number of leaves:

The analysis of variance table (Table IV) for this character showed that there was no significant difference between the varieties and hybrids. Only the block effect was significant. The mean values for the parents ranged from 15.8 (PR) to 17.6 (KC) and that of hybrids from 15.3 (KC x PR) to 18.3 (PR x LW).

The flower buds in bhindi are borne in leaf axils and if there is an increase in the number of leaves it may lead to production of more fruits which result in increased yield.

TABLE IV

Analysis of variance table for number of leaves

Source	S.S.	d.f.	Variance	F
Total	103.20	47		
Blocks	11.52	2	5.76	3.41*
Varieties	41.10	15	2.74	1.62
Error	50.58	30	1.69	

* Significant at 5% level

3. Number of branches:

The mean parental values with regard to the number of branches varied from 2.13 (PS) to 4.14 (KC). In the crosses PR x KC and LW X KC, the hybrids exceeded the better parent (KC) by 4.8% and 8.2% resepctively. But this superiority was not statistically significant. Significant decrease in the number of branches was observed in crosses KC x PS and PS x KC when the higher parental mean was considered. Besides these two hybrids, LW x PR and PR x LW also had less number of branches when mid parental value was taken as the basis for comparison. The hybrids KC x PR, LW x PR and PR x LW were poorer than the inferior parent and in the last case the decrease was significant. The analysis of variance table and the mean values for number of branches are given in Table V and VI respectively.

TABLE V

Analysis of variance table for number of branches

Source	S.S.	d.f.	Variance	F
Total	40.9091	47	[illegible]	[illegible]
Blocks	1.4412	2	0.7206	2.22
Varieties	29.7158	15	1.9811	6.09*
Error	9.7521	30	0.3251	

*Significant at 5% level.

TABLE VI

Mean number of branches in plants and hybrids

Sl. No.	Varieties	Mean	Mean of better parent	Mean increase or decrease over better parent	Mean of parents	Mean increase or decrease over mean of parents	Mean of inferior parent
1	L.W	3.79	--	--	--	--	--
2	P.R	3.73	--	--	--	--	--
3	P.S	2.13	--	--	--	--	--
4	K.C	4.14	--	--	--	--	--
5	P.R x K.C	4.34	4.14	+0.20	3.94	+0.40	3.73
6	K.C X P.R	3.33	4.14	-0.81	3.94	-0.61	3.73
7	K.C x L.W	4.06	4.14	-0.08	3.97	+0.09	3.79
8	L.W x K.C	4.48	4.14	+0.34	3.97	+0.51	3.79
9	P.S x L.W	2.92	3.79	-0.87	2.96	-0.04	2.13
10	L.W x P.S	2.83	3.79	-0.96	2.96	-0.13	2.13
11	P.S x P.R	2.92	3.73	-0.81	2.93	-0.01	2.13
12	P.R x P.S	3.00	3.73	-0.73	2.93	+0.07	2.13
13	K.C x P.S	2.60	4.14	-1.54*	3.14	-0.54	2.13
14	P.S x K.C	2.57	4.14	-1.57*	3.14	-0.57	2.13
15	L.W x P.R	1.29	3.79	-2.50*	3.76	-2.47*	3.73
16	P.R x L.W	1.38	3.79	-2.41*	3.76	-2.38*	3.73

Critical difference:

1. Hybrid Vs. better parent - 0.96
2. Hybrid Vs. mean pf parents - 0.82

4. Time of flowering and number of flowers:

It was observed that none of the hybrids flowered earlier than the early parent. Only in the cross between KC and LW, the hybrid was late in flowering than the late variety (LW). So no statistical estimation of the time of flowering has been attempted.

The analysis of variance table for number of flowers showed that there was significant difference between the varieties and hybrids with regard to flower production (Table VII).

TABLE VII

Analysis of variance table for number of flowers

Source	S.S.	d.f.	Variance	F
Total	408.57	47		
Blocks	28.31	2	14.16	3.29
Varieties	251.37	15	16.76	3.90*
Error	128.89	30	4.30	

*Significant at 5% level

The mean number of flowers produced by the parents varied from 6.9 (KC) to 12.7 (PS). The hybrids PS x PR, LW x PR and PR x LW registered an increase over their better parents (PS and PR respectively); but this was significant only in the latter two cases and that too, when the parental mean was considered. The percentage of increase in these two cases was 41.7 and 36.5 respectively. The crosses PR x KC, KC x LW, PS x LW, PR x PS and KC x PS also showed increase in number of flowers over the mid parental value. In the case of KC x PR there was significant decrease in number (36.6%) when compared to the superior parent; but this decrease was not significant when the mean of the parents was taken into account. The hybrid LW x KC also registered decrease in number. LW x PS and PS x KC equalled the mid parental values. The mean values have been presented in Table VIII.

TABLE VIII

Mean number of flowers in parents and hybrids

Sl. No.	Varieties	Mean	Mean of better parent	Mean increase or decrease over better parent	Mean of parents	Mean increase or decrease over mean of parents	Mean of inferior parent
1	L.W	7.9	--	--	--	--	--
2	P.R	11.2	--	--	--	--	--
3	P.S	12.7	--	--	--	--	--
4	K.C	6.9	--	--	--	--	--
5	P.R x K.C	9.7	11.2	-1.5	9.0	+0.7	6.9
6	K.C x P.R	7.1	11.2	-4.1*	9.0	-1.9	6.9
7	K.C x L.W	7.7	7.9	-0.2	7.3	+0.4	6.9
8	L.W x K.C	6.6	7.9	-1.3	7.3	-0.7	6.9
9	P.S x L.W	11.7	12.7	-1.0	10.3	+1.4	7.9
10	L.W x P.S	10.3	12.7	-2.4	10.3	--	7.9
11	P.S x P.R	13.6	12.7	+0.9	12.0	+1.6	11.2
12	P.R x P.S	12.5	12.7	-0.2	12.0	+0.5	11.2
13	K.C x P.S	10.0	12.7	-2.7	9.8	+0.2	6.9
14	P.S x K.C	9.8	12.7	-2.9	9.8	--	6.9
15	L.W x P.R	13.4	11.2	+2.2	9.6	+3.8*	7.9
16	P.R x L.W	13.1	11.2	+1.9	9.6	+3.5*	7.9

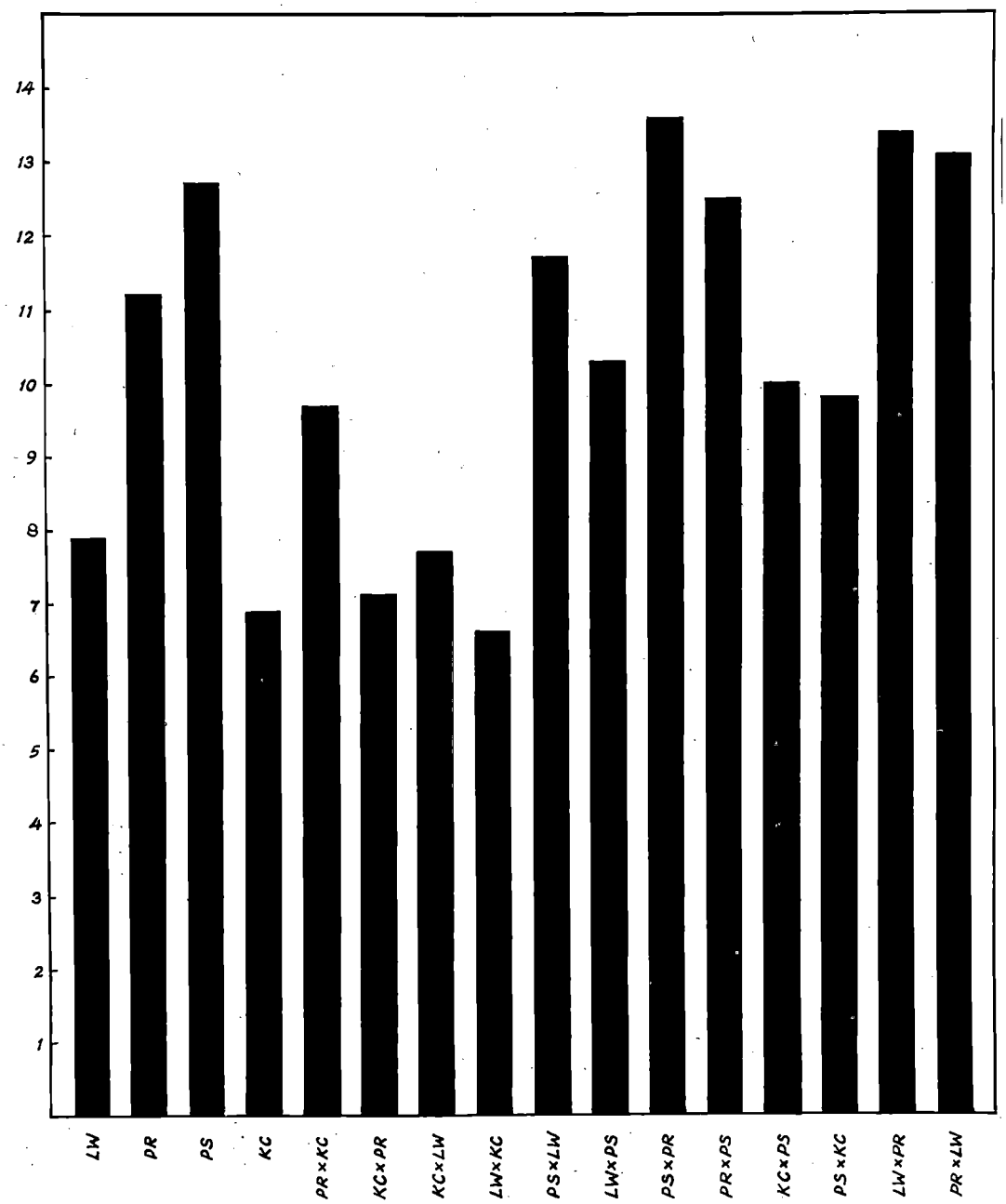
Critical difference:

1. Hybrids Vs. better parent - 3.47
2. Hybrids Vs. mean of parents - 3.00

Fig. 4. Bar diagram showing the mean number of flowers in the hybrids and parents.

FIG. IV

MEAN NUMBER OF FLOWERS



5. Number of fruits:

The analysis of variance with respect of this character is given below.

TABLE IX

Analysis of variance table for number of fruits

Source	S.S.	d.f.	Variance	F
Total	361.48	47		
Blocks	12.06	2	6.03	2.43
Varieties	275.73	15	18.38	7.47*
Error	73.69	30	2.46	

*Significant at 5% level

The effect due to varieties is significant. On comparing the values of the hybrid and the better parent it was observed that the hybrid LW x PR registered significant increase in number, the percentage being 36.6. If the mean of the two parents were considered PS x KC and PR x LW also produced significantly higher number of fruits. In the case of hybrids PR x KC, KC x PR, PS x LW, PS x PR, PR x PS and KC x PS also there was increase in number as against the mid parental mean. LWx PS produced fruits equal in number to the mid parental value. The number of fruits produced by KC x LW and LW x KC was less by 17.6% and 7.9% respectively, compared to the mean of parents. If the higher parental value was

considered, nine hybrids (PR x KC, KC x PR, KC x LW, LW x KC, PS x LW, LW x PS, PR x PS, KC x PS and PS x KC) showed decrease in number. Of these KC x LW was inferior to the lower parent, the mean values being 4.2 and 4.4 respectively. The mean values are given in Table X.

TABLE X

Mean number of fruits in parents and hybrids

Sl. No.	Varieties	Mean	Mean of better parent	Mean increase or decrease over better parent	Mean of parents	Mean increase or decrease over mean of parents	Mean of inferior parent
1	L.W	5.8	--	--	--	--	--
2	P.R	8.2	--	--	--	--	--
3	P.S	10.6	--	--	--	--	--
4	K.C	4.4	--	--	--	--	--
5	P.R x K.C	7.8	8.2	-0.4	6.3	+1.5	4.4
6	K.C x P.R	6.5	8.2	-1.7	6.3	+0.2	4.4
7	K.C x L.W	4.2	5.8	-1.6	5.1	-0.9	4.4
8	L.W x K.C	4.7	5.8	-1.1	5.1	-0.4	4.4
9	P.S x L.W	9.5	10.6	-1.1	8.2	+1.3	5.8
10	L.W x P.S	8.2	10.6	-2.4	8.2	--	5.8
11	P.S x P.R	11.4	10.6	+0.8	9.4	+2.0	8.2
12	P.R x P.S	10.3	10.6	-0.3	9.4	+0.9	8.2
13	K.C x P.S	8.1	10.6	-2.5	7.5	+0.6	4.4
14	P.S x K.C	10.2	10.6	-0.4	7.5	+2.7*	4.4
15	L.W x P.R	11.2	8.2	+3.0*	7.0	+4.2*	5.8
16	P.R x L.W	10.7	8.2	+2.5	7.0	+3.7*	5.8

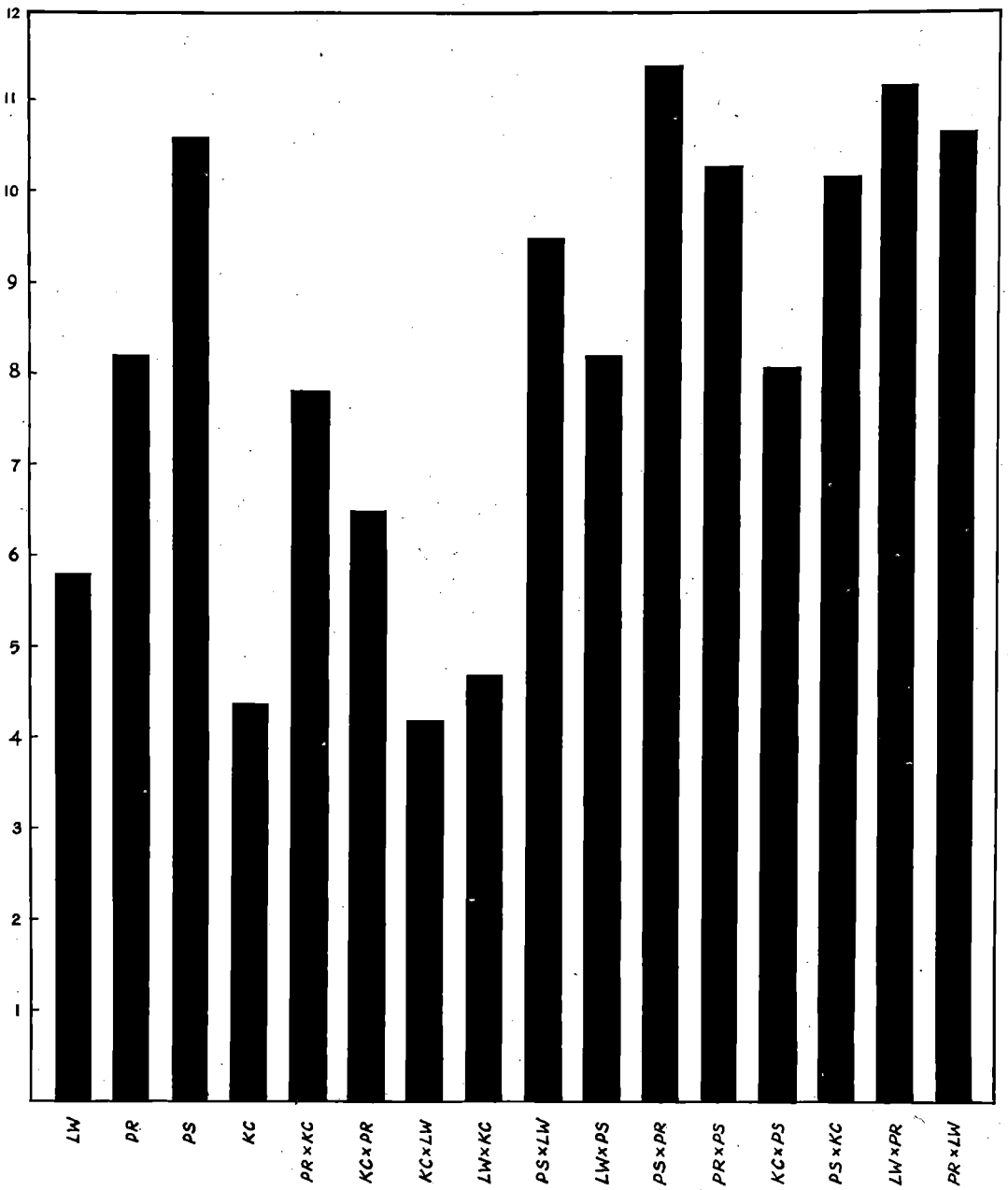
Critical difference:

1. Hybrid Vs. better parent - 2.61
2. Hybrid Vs. mean of parents - 2.26

Fig. 5. Bar diagram showing the mean number of fruits obtained from the hybrids and parents.

FIG. V

MEAN NUMBER OF FRUITS



6. Weight of fruits:

The weight of fruits collected from all the plants has been statistically analysed and analysis of variance is presented in Table XI.

TABLE XI

Analysis of variance table for weight of fruits

Source	S.S.	d.f.	Variance	F
Total	1377.08	47		
Blocks	53.44	2	26.72	1.90
Varieties	900.70	15	60.05	4.26*
Error	422.94	30	14.09	

*Significant at 5% level

The mean weight of fruits in the four parental varieties ranged from 23.3 gm. (PR) to 33.0 gm. (KC). The hybrid LW x PR registered an increase in weight of 30.6% compared to the better parent (LW). This increase in weight was significant. Hybrids PR x KC, LW x KC, PS x LW and PS x KC were better than the mean of the parents. In the case of hybrids KC x PR, LW x PS, PR x PS, KC x PS and PR x LW, the increase was not significant. The hybrid KC x LW was inferior to the inferior parent (LW).

The mean values of the parents and hybrids are presented in Table XII.

TABLE XII

Mean weight of fruits in hybrids and parents

Sl. No.	Varieties	Mean	Mean of better parent	Mean increase or decrease over better parent	Mean of parents	Mean increase or decrease over mean of parents	Mean of inferior parent
1	L.W	25.2	--	--	--	--	--
2	P.R	23.3	--	--	--	--	--
3	P.S	28.4	--	--	--	--	--
4	K.C	33.0	--	--	--	--	--
5	P.R x K.C	34.6	33.0	+1.6	28.2	+6.4*	23.3
6	K.C x P.R	32.7	33.0	-0.3	28.2	+4.5	23.3
7	K.C x L.W	25.1	33.0	-7.9*	29.1	-4.0	25.2
8	L.W x K.C	36.4	33.0	+3.4	29.1	+7.3*	25.2
9	P.S x L.W	32.3	28.4	+3.9	26.8	+5.5*	25.2
10	L.W x P.S	32.0	28.4	+3.6	26.8	+5.2	25.2
11	P.S x P.R	25.7	28.4	-2.7	25.9	-0.2	23.3
12	P.R x P.S	28.4	28.4	[illegible]	25.9	+2.5	23.3
13	K.C x P.S	35.1	33.0	+2.1	30.7	+4.4	28.4
14	P.S x K.C	36.2	33.0	+3.2	30.7	+5.5*	28.4
15	L.W x P.R	32.9	25.2	+7.7*	24.3	+8.6*	23.3
16	P.R x L.W	24.7	25.2	-0.5	24.3	+0.4	23.3

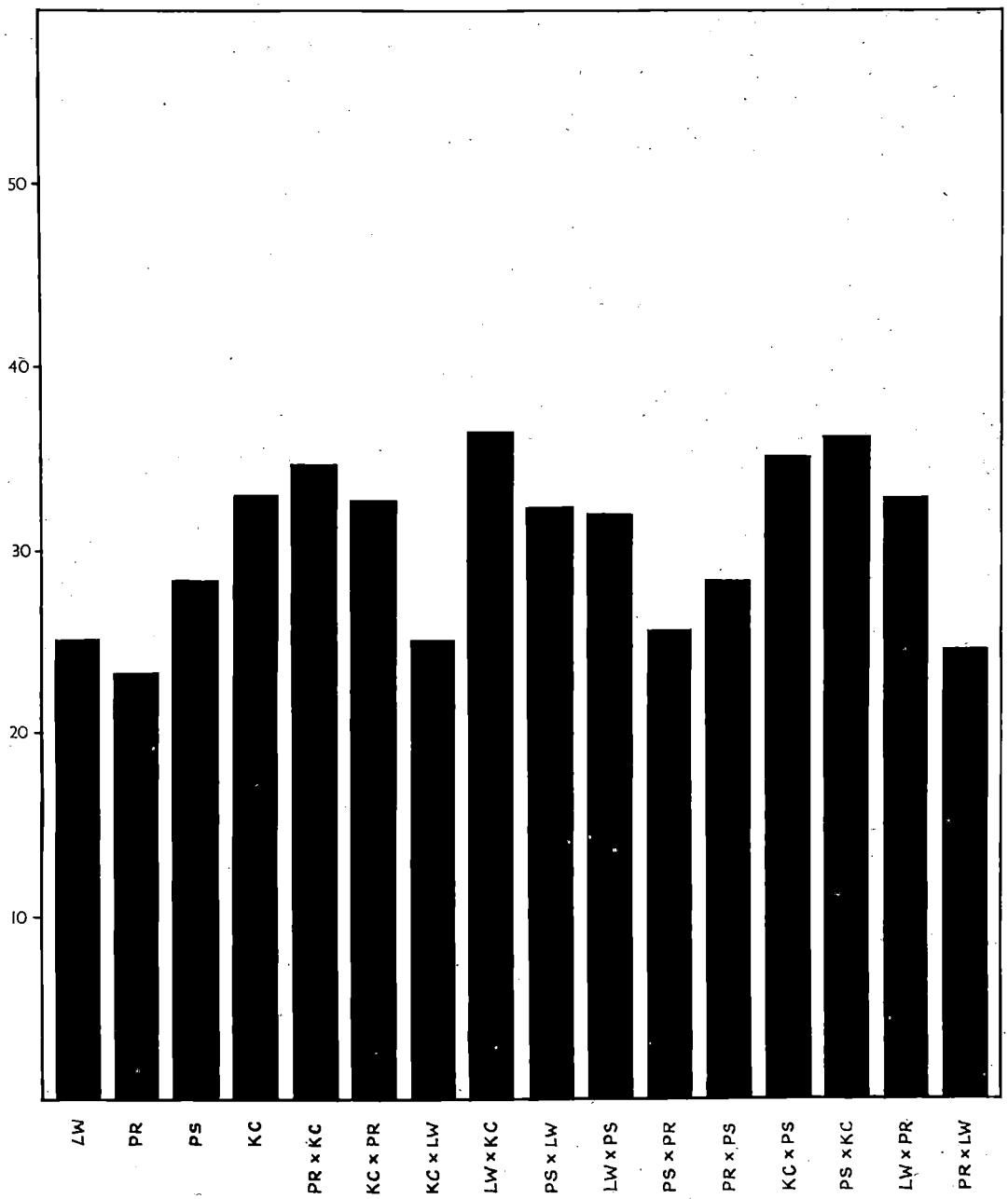
Critical difference:

1. Hybrid Vs. superior parent - 6.24
2. Hybrid Vs. mean of parents - 5.43

Fig. 6. Bar diagram showing the mean weight of fruits in the hybrids and the parents.

FIG. VI

MEAN WEIGHT OF FRUITS (in gms.)



7. Length of fruits:

Hybrid vigour in respect of length of fruit was observed in eleven out of the 12 crosses when the mid parental value was considered. But this was significant only in crosses KC x PR, KC x PS, PS x KC and LW x PR. If the better parental mean was taken into account, heterosis was exhibited by six hybrids only (KC x PR, PS x LW, PS x PR, KC x PS, PS x KC and LW x PR); but none of these was significant. In the hybrid PR x LW reduction in length was 3.8%.

It was also observed that all the hybrids produced fruits longer than the shorter parent.

The analysis of variance table for fruit length and the mean values of parents and hybrids are presented in Tables XIII and XIV respectively.

TABLE XIII

Analysis of variance table for length of fruits

Source	S.S.	d.f.	Variance	F
Total	383.65	47		
Blocks	14.69	2	7.35	2.71
Varieties	287.64	15	19.98	7.08*
Error	81.32	30	2.71	

*Significant at 5% level

TABLE XIV

Length of fruits in hybrids and parents

Sl. No.	Varieties	Mean	Mean of better parent	Mean increase or decrease over better parent	Mean of parents	Mean increase or decrease over mean of parents	Mean of inferior parent
1	L.W	14.8	--	--	--	--	--
2	P.R	16.3	--	--	--	--	--
3	P.S	17.9	--	--	--	--	--
4	K.C	21.2	--	--	--	--	--
5	P.R x K.C	20.5	21.2	-0.7	18.8	+1.7	16.3
6	K.C x P.R	23.1	21.2	+1.9	18.8	+4.3*	16.3
7	K.C x L.W	18.8	21.2	-2.4	18.0	+0.8	14.8
8	L.W x K.C	19.8	21.2	-1.4	18.0	+1.8	14.8
9	P.S x L.W	18.0	17.9	+0.1	16.4	+1.6	14.8
10	L.W x P.S	17.8	17.9	-0.1	16.4	+1.4	14.8
11	P.S x P.R	18.3	17.9	+0.4	17.1	+1.2	16.3
12	P.R x P.S	17.9	17.9	--	17.1	+0.8	16.3
13	K.C x P.S	22.6	21.2	+1.4	19.6	+3.0*	17.9
14	P.S x K.C	22.5	21.2	+1.3	19.6	+2.9*	17.9
15	L.W x P.R	19.0	16.3	+2.7	15.6	+3.4*	14.8
16	P.R x L.W	15.0	16.3	-1.3	15.6	-0.6	14.8

Critical difference:

1. Hybrid Vs. better parent - 2.75
2. Hybrid Vs. mean of parents - 2.39

8. Girth of fruits:

The length of fruit together with the girth is responsible for the variation in size and weight which may lead to difference in yield. The range of girth in the four parents was from 7.2 cms. (PS) to 7.9 cms. (LW). Significant reduction in girth of fruit was observed in the hybrid KC x LW when the parental mean was considered. But in KC x PR, this was not significant. Another hybrid PS x KC showed significant increase in girth and in this case the mean of the two parents was taken for comparison. Heterotic effect, though not significant from statistical point of view, was also noticed in the crosses PR x KC, LW x KC, PS x LW, PS x PR, PR x PS, KC x PS, LW x PR and PR x LW. There was no difference between the mean of parents and that of the hybrid in the case of LW x PS. None of the hybrids was inferior to the smaller parent with respect to this character. The analysis of variance and the mean values of parents are furnished in Tables XV and XVI respectively.

TABLE XV

Analysis of variance table for girth of fruits

Source	S.S.	d.f.	Variance	F
Total	9.00	47		
Blocks	0.23	2	0.115	1.21
Varieties	5.93	15	0.295	4.16*
Error	2.84	30	0.095	

*Significant at 5% level

TABLE XVI

Mean girth of fruit in hybrids and parents

Sl. No.	Varieties	Mean	Mean of better parent	Mean increase or decrease over better parent	Mean of parents	Mean increase or decrease over mean of parents	Mean of inferior parent
1	L.W	7.9	--	--	--	--	--
2	P.R	7.2	--	--	--	--	--
3	P.S	7.8	--	--	--	--	--
4	K.C	7.5	--	--	--	--	--
5	P.R x K.C	7.8	7.5	+0.3	7.4	+0.4	7.2
6	K.C x P.R	7.2	7.5	-0.3	7.4	-0.2 ~~+0.4~~	7.2
7	K.C x L.W	6.9	7.9	-1.0*	7.7	-0.8*	7.5
8	L.W x K.C	8.1	7.9	+0.2	7.7	+0.4	7.5
9	P.S x L.W	8.1	7.9	+0.2	7.9	+0.2	7.8
10	L.W x P.S	7.9	7.9	--	7.9	--	7.8
11	P.S x P.R	7.8	7.8	--	7.5	+0.3	7.2
12	P.R x P.S	7.8	7.8	--	7.5	+0.3	7.2
13	K.C x P.S	7.8	7.8	--	7.7	+0.1	7.5
14	P.S x K.C	8.2	7.8	+0.4	7.7	+0.5*	7.5
15	L.W x P.R	8.0	7.9	+0.1	7.6	+0.4	7.2
16	P.R x L.W	7.7	7.9	-0.2	7.6	+0.1	7.2

Critical difference:

1. Cross Vs. better parents - 0.51
2. Cross Vs. mean of patents - 0.45

9. Number of seeds per fruit:

To find whether there is any difference between varieties and hybrids with respect to this character, the data were analysed statistically. It was found from the analysis of variance (Table XVII) that the effects due to blocks as well as the varieties tried, were significant. The mean values for the parents and hybrids were calculated and they are presented in Table ~~XVII &~~ XVIII.

TABLE XVII

Analysis of variance table for number of seeds/fruit

Source	S.S.	d.f.	Variance	F
Total	2458.68	47		
Blocks	340.17	2	170.08	5.74**
Varieties	1229.73	15	81.98	2.77**
Error	888.78	30	29.63	

**Significant at 5% level

TABLE XVIII

Mean number of seeds per fruit in hybrids and parents

Sl. No.	Varieties	Mean	Mean of better parent	Mean increase or decrease over better parent	Mean of parents	Mean increase or decrease over mean of parents	Mean of inferior parent
1	L.W.	65.5	--	--	--	--	--
2	P.R	61.3	--	--	--	--	--
3	P.S	54.8	--	--	--	--	--
4	K.C	64.9	--	--	--	--	--
5	P.R x K.C	68.4	64.9	+3.5	63.1	+5.3	61.3
6	K.C x P.R	66.9	64.9	+2.0	63.1	+3.8	61.3
7	K.C x L.W	63.1	65.5	-2.4	65.2	-2.1	64.9
8	L.W x K.C	72.5	65.5	+7.0	65.2	+7.3	64.9
9	P.S x L.W	63.1	65.5	-2.4	60.2	+2.9	54.8
10	L.W x P.S	68.9	65.5	+3.4	60.2	+8.7*	54.8
11	P.S x P.R	58.2	61.3	-3.1	58.1	+0.1	54.8
12	P.R x P.S	61.3	61.3	-0.2	58.1	+3.0	54.8
13	K.C x P.S	65.7	64.9	+0.8	59.9	+5.8	54.8
14	P.S x K.C	72.5	64.9	+7.6	59.9	+12.6*	54.8
15	L.W x P.R	69.7	65.5	+4.2	63.4	+6.3	61.3
16	P.R x L.W	59.4	65.5	-6.1	63.4	-4.0	61.3

Critical difference:

1. Hybrid Vs. better parent - 9.06
2. Hybrid Vs. mean of parents - 7.85

The mean number of seeds per fruit in the parents varied from 54.8 (PS) to 65.5 (LW). The height mean number of seeds was observed in the hybrids LW x KC and PS x KC. Increase in number of seeds was also noted in the hybrids PR x KC, KC x PR, LW xx PS, KC x PS and LW x PR. But these were not significant. In the case of hybrids LW x PS and PS x KC, the increase was significant when the mean of the two parents was taken for comparison. KC x LW and PR x LW produced lesser number of seeds than the lower parent, the percentage of decrease being 3.2 and 6.3 respectively.

10. Weight of seeds:

The analysis of variance table is furnished below.

TABLE XIX

Analysis of variance table for weight of seeds.

Source	S.S.	d.f.	Variance	F
Total	7.5496	47		
Blocks	0.2230	2	0.1115	1.85
Varieties	5.5195	15	0.3679	6.11*
Error	1.8071	30	0.0602	

*Significant at 5% level

The weight of 50 seeds in parents ranged from 2.86 gm. (LW) to 3.80 gm. (PS). There is no significant difference in seed weight except in the case of hybrids KC x PS and LW x PR. In the cross KC x PS, there is decrease in weight by 14.5% over the mean of the higher parent (PS). But, for LW x PR the increase in weight was 13.9% over the mid parental value.

Decrease in weight when compared to the higher parental mean was noticed in nine other hybrids (PR x KC, KC x PR, KC x LW, PS x LW, LW x PS, PS x PR, PR x PS, PS x KC and PR x LW). LW x KC and LW x PR registered increased weight. When the mean of the two parents was used for comparison, six hybrids had reduced weight and five others possessed increased seed weight. But there is no significant difference. The mean values for parents and hybrids are furnished in Table XX. In the case of KC x LW and PR x LW the weight of seeds was lesser than that of the respective inferior parent (LW).

TABLE XX

Mean weight of seeds in hybrids and parents

Sl. No.	Varieties	Mean	Mean of better parent	Mean increase or decrease over better parent	Mean of parents	Mean increase or decrease over mean of parents	Mean of inferior parent
1	L.W	2.86	--	--	--	--	--
2	P.R	3.06	--	--	--	--	--
3	P.S	3.80	--	--	--	--	--
4	K.C	2.92	--	--	--	--	--
5	P.R x K.C	2.97	3.06	-0.09	2.99	-0.02	2.92
6	K.C x P.R	2.93	3.06	-0.09	2.99	-0.06	2.92
7	K.C x L.W	2.64	2.92	-0.28	2.89	-0.25	2.86
8	L.W x K.C	3.01	2.92	+0.09	2.89	+0.12	2.86
9	P.S x L.W	3.56	3.80	-0.24	3.33	+0.23	2.86
10	L.W x P.S	3.49	3.80	-0.31	3.33	+0.16	2.86
11	P.S x P.R	3.42	3.80	-0.38	3.43	-0.01	3.06
12	P.R x P.S	3.66	3.80	-0.14	3.43	+0.23	3.06
13	K.C x P.S	3.25	3.80	-0.55*	3.36	-0.11	2.92
14	P.S x K.C	3.55	3.80	-0.25	3.36	+0.19	2.92
15	L.W x P.R	3.37	3.06	+0.31	2.96	+0.41*	2.86
16	P.R x L.W	2.80	3.06	-0.26	2.96	-0.16	2.86

Critical difference:

1. Hybrid Vs. better parent - 0.428
2. Hybrid Vs. mean of parents - 0.355

D I S C U S S I O N

D I S C U S S I O N

In the present investigation 12 hybrids obtained by all possible combinations of four varieties (Local white, Pusa red, Pusa sewani and Kilichundan) were studied in comparison with the parental varieties for heterotic effect on the following nine characters.

1. Height of plant
2. Number of leaves
3. Number of branches
4. Time of flowering and number of flowers
5. Number of fruits
6. Weight of fruits
7. Length and girth of fruits
8. Number of seeds per fruit and
9. Weight of 50 seeds from each fruit.

The results obtained with respect to these characters are discussed and presented.

1. Height of plant: The results obtained clearly indicate that none of the hybrids showed significant increase in height over the better parent, although the hybrid PS x PR recorded 5.7% increase over the better parent. But one hybrid (LW x PR) out of the 12, exhibited significant increase

over the mean of parents. In PS x LW and PR x PS the percentage of increase was 6.4 and 2.2 respectively, over the mean of parents. In all the other hybrids the mean height was lesser than the mean of the respective parents. The range of decrease varied from 3.3 to 21.3%.

If the better parental mean was considered, six hybrids were significantly inferior, and LW x KC equalled the lower parent. The hybrid KC x LW was shorter than the short parent viz. KC. From the above it is evident that only one hybrid showed significant heterotic effect.

Chizaki (1934) found the interspecific hybrid of Hibiscus esculentus x H.manihot to be intermediate to the parents in height. Miller and Wilson (1937) got similar results in intervarietal hybrids of bhindi. The interspecific hybrid between Hibiscus ficulneus and H.esculentus, according to Singh et al (1938) is taller. Venkataramani (1952) reported the height of hybrid bhindi to be intermediate in comparison to the parents.

According to Joshi et al (1958) the bhindi hybrids were in general, taller than their respective superior parents. In 11 out of 29 combinations the F_1s were taller than the tall parent, 12 were intermediate being more towards the taller parent. Of the remaining six

hybrids, 5 were shorter than the short parent and one equalled the short parent. In some cases reciprocal crosses differed. According to Raman and Ramu (1962) only one hybrid of bhindi out of nine exhibited heterosis in respect of height.

From the foregoing, it is clear that the height of plants in bhindi hybrids ranged between the two extremes viz. taller than the tall parent and shorter than the short parent. So the superiority of the hybrid could not be fixed and the degree of heterosis varied in different crosses.

The observations of authors like Nagai and Kida (1926), Kakizaki (1931), Pal and Singh (1946), Venkataramani (1946) and Mishra (1961) in brinjal agree with this findings in bhindi. Similar situations have been reported by various other authors in different crops.

2. Number of leaves: The analysis of variance for number of leaves in the parents and hybrids showed that the varietal differences are not significant. Pal (1945) obtained similar results in Sesamum and reported that there was hardly any evidence of hybrid vigour. According to him the hybrids in maize were superior with respect to the number of leaves. In tobacco, heterotic effect in leaf

number and size was noticed by Bawolska et al (1962) and the hybrids exceeded both the parents. Swarup et al (1963) found heterosis in the F_1 of cabbage crosses in the net weight of head. This was due to the bigger size and number of leaves. It is, therefore, advantageous to adopt heterosis breeding in tobacco and cabbage for exploiting the economic character viz. increased number and size of leaf. In cotton also, Santhanam (1956) obtained in the hybrid between crinkled leaf mutant and normal parental form, plants with larger number of leaves than normal plants.

Though hybrid vigour in number of leaves has been reported in other crops, this has not been observed in bhindi by previous workers. The increase in the number of leaves (nodes) may lead to the production of more fruits and consequent increase in yield, since the flowers are borne in the leaf axils. In the present study, this does not provide any scope since no heterosis was observed in any of the hybrids.

3. Number of branches: The superiority of the hybrids PR x KC and LW x KC over the better parent (KC) by 4.8 and 8.2 per cent respectively, was not statistically significant. Of the hybrids KC x PS, PS x KC, LW x PR and

PR x LW, the former two had significantly lesser number of branches whereas in the latter two cases, the decrease was not significant. Three other hybrids were poorer than the respective inferior parents.

Joshi et al (1958) observed that the hybrids of bhindi as a class recorded significantly higher number of branches than the parents. Out of 14 hybrids, significant increase over the better parent was registered in one case only. In eight crosses, the hybrids were intermediate, mostly tending towards the superior parent. Five had lesser number of branches than the inferior parent and in one case each, the F_1 hybrid was as good as the superior parent or as poor as the inferior parent. Raman and Ramu (1962) also noted increase in number of branches in two out of nine hybrids of bhindi; while seven produced lesser number of branches.

Hybrid superiority with respect to number of branches has been reported in brinjal by Nagai and Kida (1926) and Kakizaki (1928 and 1931). Pal and Singh (1946) and Mishra (1961) reported that the hybrids of brinjal showed superiority in most cases and decreased number of branches was noted in one case.

From the findings of the various authors, it

is clear that all the hybrids are not identical in their performance. They tend to surpass the better parent only in a few cases, whereas in the majority of cases, they had superiority over the mean of two parents. Some have been noted to be intermediate. Very few cases showed equality to the lower parent and even inferiority when compared to the parent having less number of branches.

It is desirable to select those hybrids which are otherwise good and possessing more branches. Since more flowers and fruits may be produced in the branches, they are likely to produce better yield than the less branching types.

4. Time of flowering and number of flowers: In brinjal, earliness in flowering of the hybrids was reported by Nagai and Kida (1926), Daskaloff (1937 and 1941), Odland and Noll (1946) and Venkataramani (1946). According to Venkataramani, flowering was early by 18 days compared to the early parents. Mishra (1961) observed early flowering in many hybrids, the range being 20 - 100% over the respective parents; some others were intermediate. Pal and Singh (1946) found that in all cases except one, flowering was late.

Authors like Powers (1945), Finlay (1951),

Haskell and Brown (1955) and Hojby (1958) have observed early flowering in tomato hybrids. But Baldoni (1948) suggested that earliness was not there always in the hybrids. According to Pal and Singh (1946) most of the hybrids in bitter gourd produced a larger number of flowers and were early in flowering.

In bhindi, Venkataramani (1952) found that the hybrids were either as early as the early parent or earlier than the early parent in four out of seven crosses. Rao (1953) observed that the seeds collected from early maturing bhindi fruits gave rise to larger number of plants and such plants flowered earlier. But there was no appreciable difference in yield. Raman and Ramu (1962) found that nearly half the hybrids were earlier than the early parent. According to Ravindra (1964), flowering in bhindi was early in monsoon whereas it was late in the winter.

In this study it was found that none of the hybrids was earlier than the early parent. Only in the cross between KC and LW, the hybrid was late in flowering than the late variety.

With regard to the number of flowers there was increase in eight hybrids, of which two registered significant superiority over the better parent. Two hybrids showed decrease in number. The remaining two equalled

the mid parental value. So two thirds of the hybrids were better than the parents in flower production. To that extent, utilization of heterosis is useful in this crop. Increased production of flowers facilitates increased production of fruits which is a desired trend in crop production.

5. Number of fruits: In brinjal, heterosis in respect of this character has been reported by various authors like Nagai and Kida (1926), Pal and Singh (1946), Odland (1948), Odland and Noll (1948). Mishra (1961) obtained hybrids which produced significantly higher number of fruits. Raman et al (1961) recorded increased in total yield of fruits.

Increase in total yield in tomato hybrids has been recorded by authors like Daskaloff (1937), Powers (1945), Finlay (1951), Haskell and Brown (1955), Hojby (1956) and others. According to Whaley (1939) and Baldoni (1949) the increase in yield is due to increase in total number of fruits and not because of larger size of fruits. The general trend of observation is that there is little or no difference in the case of reciprocal crosses in tomato. But Meyer and Peacock (1941) have obtained results showing pronounced reciprocal differences. Bhatnagar and

Singh (1964) recorded heterosis in number of pods in Mung bean.

In bhindi, Vijayaraghavan and Wariar (1946) and Venkataramani (1952) recorded increased yield. Joshi et al (1958) reported that the hybrids as a class gave significantly higher yield and increase in the number of fruits in the hybrids appeared to be significant. Nine out of ten combinations which gave significantly higher yields than the superior parents, produced significantly larger number of fruits. Raman and Ramu (1962) have also recorded increase in number of fruits over the superior parents in three out of nine crosses.

In the present study, one hybrid (LW x PR) registered a significant increase in the number of fruits over the better parent (LW). Two other hybrids (PS x KC and PR x LW) also produced significantly higher number of fruits in comparison with the mean of the parents. The number of fruits borne on six other hybrids were not significantly higher while one equalled the mid-parental value. Of the remaining two, one was inferior to the lower parent.

6. Weight of fruits: Whaley (1939), Baldoni (1949) and Haskell and Brown (1955) have reported that the increase

in yield in tomato was not due to larger sized fruits, but due to more number. According to Finlay (1951) the fruit size and weight in hybrid tomatoes were intermediate between parents.

In brinjal increase in yield due to increased weight of fruits was reported by previous authors like Tateisi (1927), Munger (1946), Pal and Singh (1946 and 1949), Venkataramani (1946) and Alpatjev (1949). According to Mishra (1961), the increase in yield was due to an increase in the weight and number of fruits.

Joshi et al (1958) in their study of intervarietal hybrids of bhindi observed that the hybrids as a group gave significantly higher yield than the parents. The increase in yield was due to the increased number and weight of fruits. Raman and Ramu (1962) recorded increase in number as well as in the weight of fruits over the superior parents in 3 out of nine bhindi crosses.

The present findings on this aspect showed that one hybrid registered significant increase in weight of 30.6% over the better parent. Four others were better than the mean of the parents while in five other hybrids the increase was not significant. One was inferior to the poor parent.

On comparing the performance of the hybrids, it was found that 5 hybrids were significantly superior to the mean of parents and they could be selected as varieties suited for cultivation, since weight of fruit is an important factor contributing to yield.

7. Length and girth of fruit: In brinjal heterosis in respect of fruit size was observed by Nagai and Kida (1926) and Pal and Singh (1946 and 1949). Mishra (1961) noted marked variation in fruit size in hybrid brinjals. Some of them had the longest fruits, measuring up to 16.35 cms. on an average. The hybrid fruits were invariably larger than either both or none of the parents. Out of eight hybrids, only one had slightly lesser values than the average of both parents. In five out of eight hybrids, he observed fairly high increase in fruit diameter also.

In tomato Finlay (1951) noted no difference in fruit size. But Baldoni (1949) and Haskell and Brown (1955) also suggested that in tomato hybrids, the increase in yield was not due to the larger size of individual fruits. Considering the length of pods in Mung bean, Bhatnagar and Singh (1964) noted superiority of 3 hybrids over the mid parental mean and one cross failed to show any heterosis in pod length.

Joshi et al (1958) noticed significant superiority of hybrids in the majority of cases. Some were intermediate to the parents and in one hybrid the size of fruit was smaller. In reciprocal crosses between varieties, the fruits produced were significantly larger. They decided the size of fruit as the product of the length of fruit and the girth at mid region of the fruit. According to Raman and Ramu, in respect of weight of fruit (due to bigger size) only two out of nine bhindi hybrids were better.

In the present study, hybrid vigour in fruit length was observed in eleven out of the 12 crosses, when the mid-parental value was considered. But the superiority was established only in crosses KC x PR, KC x PS, PS x KC and LW x PR. When higher parental value was compared, none of them was significant. In one hybrid, the length of fruit was reduced by 3.8%.

In the girth of fruit, only one hybrid showed (KC x LW) reduction when the higher parental mean was considered. The hybrid PS x KC showed significant increase in size. Heterotic effect, though not significant, was noticed in eight crosses. No hybrids were inferior to the lower parent.

The length of fruit together with girth is responsible for the variation in size and weight thus leading to difference in yield. It has, therefore, been suggested that the increase in number together with size and weight of fruit is responsible for increased yields, and on this basis, selection could be made from among the better types.

8. Number of seeds per fruit: Bhatnagar and Singh (1964) reported that the number of seeds per pod failed to show any degree of heterosis in Phaseolus aureus.

In bhindi Raman and Ramu (1962) suggested that there was no correlation between the seed content and fruit size. The study also revealed that certain combinations of crosses showed increase in the seed content. The increased number may lead to a reduction of the quality of fruits. Quality of fruits is the ultimate aim and so reduction in number will be an advantage.

In this investigation, the highest mean number of seeds was observed in hybrids LW x KC and PS x KC. Two other hybrids KC x LW and PR x LW had only lesser number of seeds, than the lower parent. If the fruits are meant for culinary purposes, reduction in number of seeds

will be advantageous. On the other hand if the fruits are meant for collecting seed materials, increase in number of seeds per fruit will be appreciated.

9. Weight of seeds: In tomato, Ashby (1937) and Luckwill (1937) have recorded bigger seeds in the hybrids. The same phenomenon was noted by Collins and Kempton (1913) and East and Jones (1920) in maize. Ganesan (1942) observed the same results in cotton. In brinjal also Kakizaki (1928) and Venkataramani (1946) got heavier seeds in hybrid brinjals. Bhatnagar and Singh (1964) showed that the hybrid seeds were superior to the parents in seed weight. No significant difference in seed weight was noted except in hybrids KC x PS and LW x PR. Decrease in weight, when compared to the higher parental mean, was noticed in nine hybrids.

From the results obtained it may be seen that there is no significant difference in seed weight between the parental means and that of the hybrids.

S U M M A R Y

SUMMARY

This investigation was carried out in the Agricultural Botany Division of the Agricultural College and Research Institute, Vellayani, during the year 1964-65 (October, 1964 to June, 1965).

Seeds of four varieties of bhindi viz. Local white, Pusa red, Pusa sewani and Kilichundan, obtained from the Agricultural College Farm were used and sown in the Botanic garden of the College on 13-10-1964. A large number of flowers, in each variety were selfed to have the parental seeds for the next season. Crossing between varieties in all possible combinations was also undertaken to get F_1 seeds for the investigation.

From the four parental varieties selected, all six possible crosses and their respective reciprocals were made.

The four parental varieties and their 12 hybrids were planted in the field on 17-3-1965, with 3 replications. Each replication consisted of 6 plots, representing six cross combinations. The plots were bordered all around by one row of Pusa sewani. Each

plot consisted of 5 rows of eight plants each, representing the respective male and female parents, the direct and reciprocal hybrids, the latter two being flanked on either side by the respective parents.

The results of observations of the following characters are given.

1. Height of plant: None of the hybrids showed significant increase in height over the better parent although PS x PR recorded 5.7% increase over the better parent (PS). One hybrid (LW x PR) exhibited significant increase over the mean of parents. LW x KC equalled the lower parent and KC x LW was shorter than the short parent (viz. KC).

2. Number of leaves: The analysis of variance for the number of leaves in the parents and hybrids showed that the varietal differences are not significant.

3. Number of branches: The superiority of the hybrids PR x KC and LW x KC over the better parent (KC) by 4.8 and 8.2% were not significant. Two hybrids LW x PR and PR x LW, had significantly lesser number of branches. Three other hybrids were poorer than the respective inferior parents.

4. Time of flowering and number of flowers: It was found that none of the hybrids was earlier than the early parent. Only in the cross between KC and LW, the hybrid was late in flowering.

With regard to number of flowers, two hybrids registered significant superiority over the better parent; two showed decrease in number and two equalled the mid parental value.

5. Number of fruits: One hybrid (LW x PR) recorded significant increase in the number of fruits over the better parent (LW) and PS x KC and PR x LW also had increase in number, compared to the mean of parents. One was inferior to the lower parent.

6. Weight of fruits: One hybrid registered significant increase in weight of 30.6% over the better parent, while 4 others were better than the mean of parents. One was inferior to the poor parent.

7. Lengths and girth of fruit: The superiority ~~of~~ in length of fruits was established only in crosses KC x PR, KC x PS, PS x KC and LW x PR, when mid parental value was compared. With regard to higher parental value, none was significant. In one hybrid the length of fruit was reduced by 3.8%.

In the girth of fruit KC x LW only showed reduction, considering the higher parental mean. PS x KC showed significant increase in girth. No hybrids were inferior to the lower parent.

8. Number of seeds per fruit: The highest mean number of fruits was observed in crosses LW x KC and PS x KC. Two other hybrids KC x LW and PR x LW had only lesser number of seeds, than the lower parent.

9. Weight of seeds: No significant difference in seed weight was noted except in hybrids KC x PS and LW x PR. Decrease in weight when compared to the higher parental mean was noticed in nine hybrids.

From this study, it has been observed that no hybrid has expressed heterotic vigour in respect of all characters. But hybrids of LW x PR have recorded heterotic vigour in respect of most of the characters studied; except for the number of branches and number of leaves. In certain instances this has been statistically significant and so this can be considered as the best combination.

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ILLUSTRATIONS

PLATE I

Fig. 1. Photograph of the hybrid LW x PR and the respective parents (grown in pots)

Fig. 2. Photograph of the hybrid LW x PR and the respective parents (grown in the experimental field)

PLATE I

Fig. 1

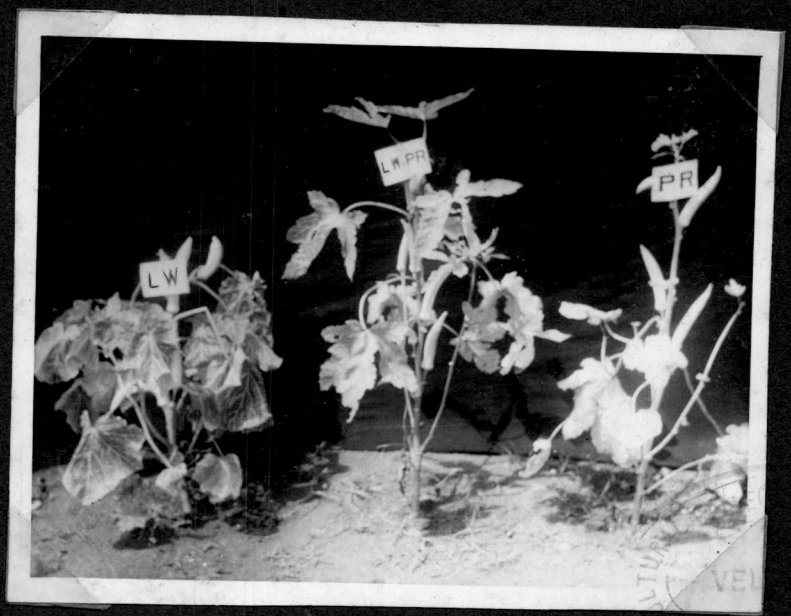


Fig. 2

PLATE II

Fig. 1. Photograph of the hybrid PS x PR and the respective parents (grown in pots)

Fig. 2. Photograph of the hybrid PS x PR and the respective parents grown in the experimental field)

PLATE II

Fig. 1

Fig. 2

PLATE III

Fig. 1. Photograph of the hybrid LW x KC and the respective parents (grown in pots)

Fig. 2. Photograph of the hybrid LW x KC and the respective parents grown in the experimental field)

PLATE III

Fig. 1

Fig. 2

PLATE IV

Fig. 1. Photograph of the hybrid PS x KC in comparison with the respective parents

Fig. 2. Photograph of the reciprocal hybrid KC x PS with the parents

(Plants grown in the experimental field)

PLATE IV

Fig. 1

Fig. 2

PLATE V

Fig. 1. Photograph of the hybrid PS x KC and the respective parents (grown in pots)

Fig. 2. Photograph of the hybrid LW x PS and the respective parents grown in the experimental field.

PLATE V

Fig. 1

Fig. 2

PLATE VI

(Figures 1 - 3)

Fig. 1. Photograph of fruits obtained from cross combinations between LW & PS.

Fig. 2. Photograph of fruits obtained from cross combinations between PR & LW

Fig. 3. Photograph of fruits obtained from the cross combinations between KC & LW

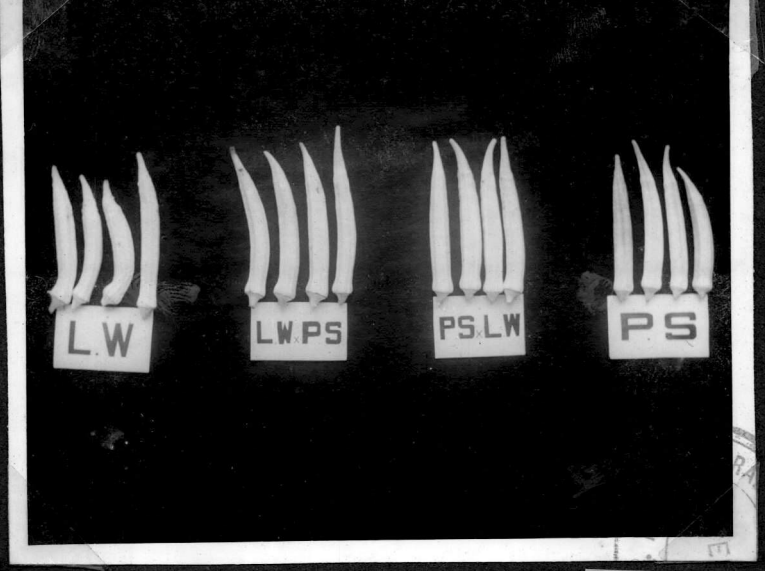
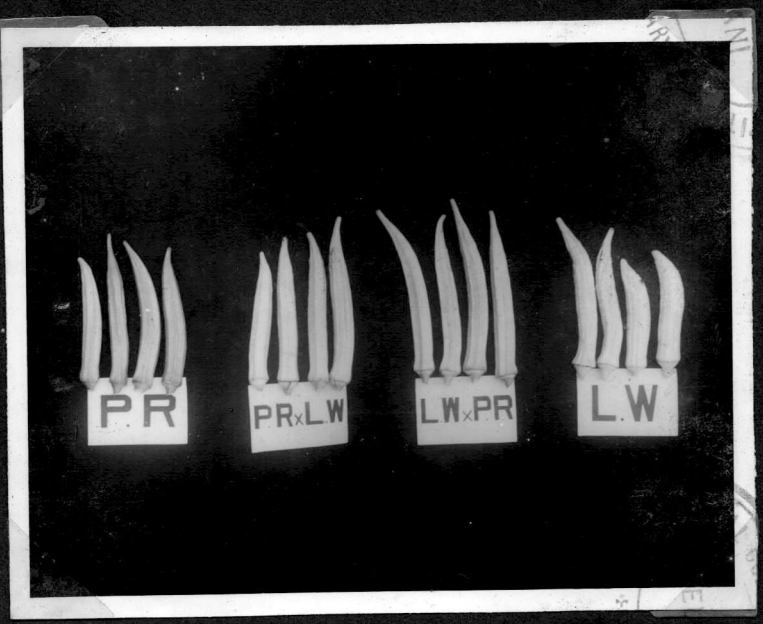


Fig. 1



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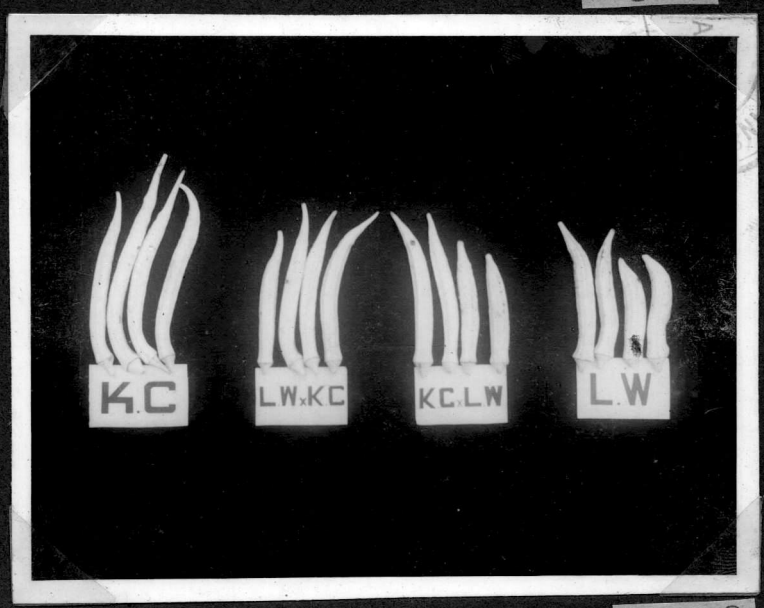

Fig. 3

PLATE VII

(Figures 1 - 3)

Fig. 1. Photograph of fruits obtained from cross combinations between KC & PS

Fig. 2. Photograph of fruits obtained from cross combinations between KC & PR

Fig. 3. Photograph of fruits obtained from cross combinations between PR & PS

PLATE VII

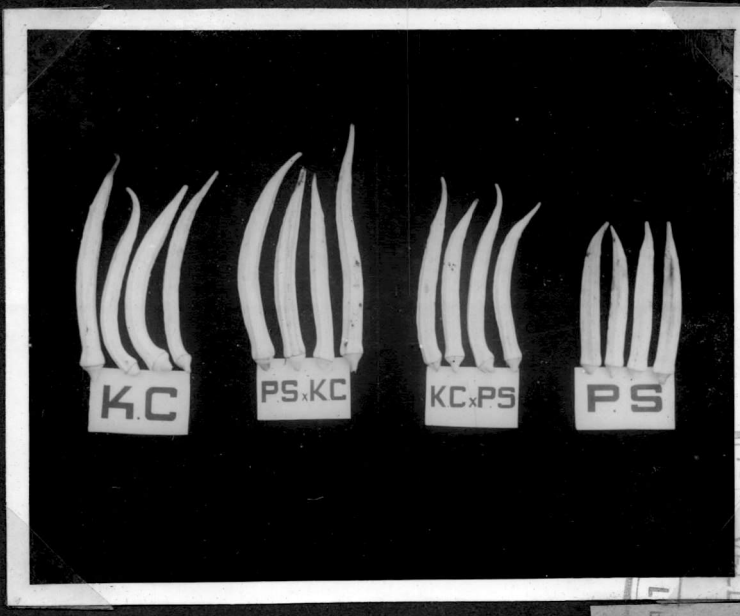

Fig. 1

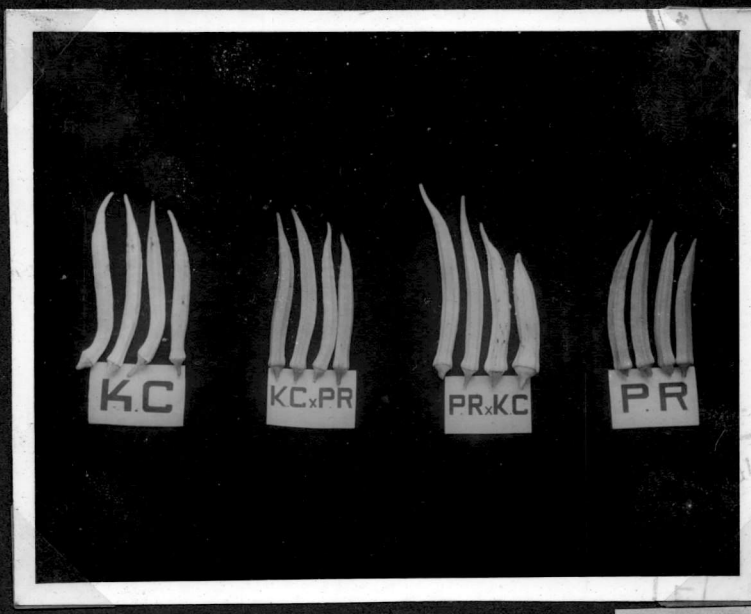

Fig. 2

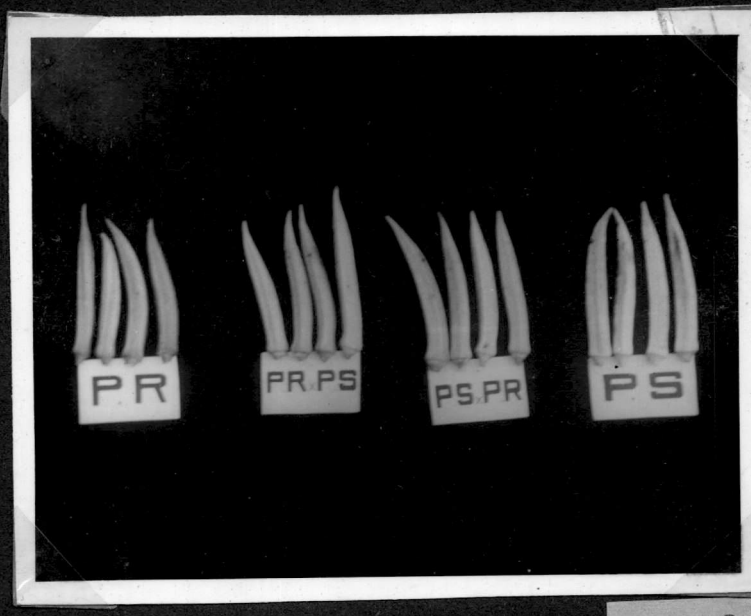

Fig. 3