STUDIES ON HETEROSIS, COMBINING ABILITY AND INHERITANCE OF QUALITATIVE CHARACTERS IN WATERMELON, Citrullus lanatus (Thunb.) Mansf.

APPROVED

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PRASAD SACHAN TO THE UNIVERSITY OF UDAIPUR FOR THE
DEGREE OF DOCTOR OF PHILOSOPHY IS THE BONAFIDE
RECORD OF INVESTIGATIONS CARRIED OUT BY HIM UNDER
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INTRODUCTION

Watermelon, _Citrullus lanatus_ (Thunb.) Mansf.
belonging to the family _Cucurbitaceae_ is an important
vegetable crop of India and tropical and sub-tropical
regions of the world. It has got universal popularity
because of its delicious fruits and high productive
capacity.

In India, especially in Rajasthan State, it is
widely grown for human consumption as well as for fodder
in one region or the other. It is available as a desert
crop for the rich and common people and is also useful
in quenching thirst of the poor during hot weather. Its
flesh is used as an antiseptic in typhus fever, seeds are
ground and baked into bread, and seed kernels are used
in medicines.

Watermelons are available in India in numerous
diversified forms varying in fruit shape, size, rind
colour and quality because it is a cross-pollinated crop
and as hardly any care is taken to maintain the genetic
purity, a mixture of varieties are grown in most places.
High yielding capacity, uniform shape, good size,attractive
rind colour and sweet flesh are the prerequisites of a good
watermelon variety. Improved watermelon varieties are
lacking and the existing commercial varieties do not possess
all the desirable characters. Inspite of its universal

popularity this crop has been neglected by the breeders and relatively little improvement work has been done on this crop in our country. In U.S.A., some attempts on watermelon improvement by pure line selection were made by individual growers over hundred years ago but the greatest advances in watermelon breeding started since 1930 (Crall, 1953), while in India it started much later.

After the discovery of the phenomenon of heterosis by Shull (1914), heterosis breeding has been an important item in the kit of tools of the plant breeder. With the knowledge of this phenomenon many agricultural crops including cucurbits were improved and many varietal hybrids of cucumbers, melons and squashes were produced which have been utilised on commercial scale in many countries. In any heterosis breeding it is always desirable to ascertain the genetical architecture for hybrid vigour in order to determine the feasibility of utilising the procedure profitably. Since yield, which is generally a polygenically inherited character, is the main consideration in heterosis breeding, it is of considerable importance to study the pattern of inheritance of this character as well as various other direct or indirect components related to yield. Genetic basis of hybrid vigour particularly in indigenous strains of watermelon has not been determined so far.

The objective of the present investigation was to find out the extent of hybrid vigour for different characters like the length of the main vine, the number of days taken to open first female flower, number of female flowers, number of fruits, weight of fruit, length of fruit, breadth of fruit, total soluble solids (T.S.S.) and total yield per plant; gene system following graphical and numerical approach and combining ability (general and specific) of the parental lines used including reciprocal effects. Gene system and combining ability effects were calculated for the five characters viz., the number of days taken to open first female flower, number of fruits, weight of fruit, total soluble solids, and total yield per plant. Studies were extended to find out the inheritance of qualitative characters viz., mature fruit colour, mature flesh colour, seed colour, seed size and fruit shape.

The present investigations were carried out during the year 1966 to 1968 at the Horticultural Farm, S.K.N. College of Agriculture, Jobner, University of Udaipur, Rajasthan, India.

REVIEW OF LITERATURE

Heterosis:

Heterozygosity is often accompanied by increased vigour and that the F_1 generations are more vigourous than their parents, is a common observation. Whaley (1944) and Shull (1914) pointed out that heterosis is the developmental stimulation resulting from the union of different gametes while hybrid vigour refers to the manifest effects of heterosis.

The hybrid vigour has been found mainly in characters, such as yield, height, maturity, large number of fruits, disease resistance, etc., which are controlled by many genes. The phenomenon of heterosis has been explained to be associated with some factors like heterozygosity (Shull, 1911 a, b; East and Hayes, 1912 and East, 1936), accumulation in the heterozygote of the favourable dominant genes from each parent (Keeble and Pellow, 1910; Bruce, 1910; Jones, 1917; Collins, 1921 and Rickey, 1945), allelic interaction (East, 1936) or over dominance (Hull, 1945) and non-allelic interaction or epistasis (Jones, 1945; Castle, 1946; and Jinks, 1955).

Advances in our knowledge of gene structure and action in recent years have led to the realisation that there may be no absolute distinction between alleles of one gene and alleles of different genes (Pontecorvo, 1955). If this is so the distinction between the two types allelic and

non-allelic interaction has no longer a precise meaning,
but they have different consequences on breeding behaviour
and consequently on breeding programme aimed at utilising
heterosis. According to Bowman (1959) both dominance including
partial or complete and genetic interaction of all kinds when
present in different proportions in different situations
result in heterosis. He further observed that while designing
breeding schemes to maximise heterosis the following points
must be kept in view: firstly, heterosis of economic importance
is most likely to occur in crosses between population already
selected in the desired direction; secondly, the wider the
genetic origin of the population used to produce the cross,
the greater the expected resulting heterosis, though this may
be only partially true for characters closely related to over
all fitness.

Diallel analysis:

As most of the characters in which heterosis is
manifested are governed by polygenes therefore, the study
of inheritance of these characters is important in ascerta-
ining the genetic basis of heterosis. Of the several
biometrical methods available for studying the inheritance
of metric traits the diallel analysis is widely adopted.
The diallel analysis technique in which a complete set of
F_1 hybrids of all possible matings, including parents and/or
reciprocals are used, was first proposed by Jinks and Hayman
(1953). Later, Griffing (1956 a) suggested two other "modified

diallel" methods which included a set of F_1's and reciprocals without the inbreds and another with a set of F_1 hybrids only. The diallel analysis has been extended to F_2, backcross and later generations also (Jinks, 1956; Hayman, 1957; Allard, 1956 a; Johnson and Aksel, 1959). Recently the triallel analysis or the analysis of variance of relatives in translating the component of variance of design into genetic component of variance has also been reported by Rawlings and Cockerham (1962).

Before analysing the diallel crosses it is essential to determine whether all the assumptions mentioned by Jinks and Hayman (1953) and Hayman (1954 a) hold good in the material under test. Four of these assumptions, viz., homozygous parents with normal diploid segregation and absence of material effects and epistasis are common to all biometrical analysis. For diallel analysis two more assumptions, viz., presence of no multiple alleles and random distribution of genes among the parents, must be satisfied. Methods of detection of the failure of these assumptions and its effects on interpretation have been discussed by some workers (Jinks and Hayman, 1953; Jinks, 1954; Hayman, 1954 a, 1957; Dickinson and Jinks, 1956; Allard, 1956 b).

In the diallel analysis there are two approaches, namely, graphical and numerical which can be used either alone or in combination to determine the dominance relationship and gene effects.

Graphical approach: Though diallel crosses of homozygous lines was analysed by Hull (1946) using parent-offspring regression technique for the estimation of dominance in maize yield, yet Jinks and Hayman (1953) were the first to present the graphical approach based on Mather's (1949) components of variation, D and H using second degree statistics such V_r (the variance of parental array), W_r (covariance of the parental array with off-spring and V_{oLo} (variance of parental values). They discussed the importance of the slope of the regression line (W_r, V_r) and its position in relation to the limiting parabolla ($W_r^2 = V_r V_{oLo}$) indicating the degree of dominance when there was no dominance the regression line (W_r, V_r) was a tangent to the limiting parabolla while in case of complete dominance the regression line passed through the point of origin and below that point in case of overdominance. The scatter of array point along the regression line and the line of unit slope indicated the dominant relationship among the parent lines and gene effects respectively. They also discussed the possibility of prediction of the value of completely dominant and completely recessive parents in case there was a strong correlation between the dominance order ($W_r + V_r$) and their parental order of magnitude (y_r) .

The effect of gene interaction on the slope of this regression line ($W_r + V_r$) was further elaborated by Jinks (1954) and he advocated to omit interacting members in the arrays before further analysis was done because genic interaction caused apparent overdominance and heterosis in many cases. Hayman (1954 _a_) applied a genetic algebra to the theory of diallel crosses and also introduced a new statistics W' (the covariance between the array means and the rth array) for use in (W', W_r) graph. He discussed the effect of linkage and different type of epistasis on (W_r, V_r) graph. Dickinson and Jinks (1956) modified the technique of diallel analysis for heterozygous parents by using V_r and W_r corrected for variances due to non-heritable sources.

The importance of W', W_r graph was stressed by Allard (1956 _b_) proposed earlier by Hayman (1954 _a_) and advocated the use of both W_r, V_r and W', W_r graphs in order to have a clear picture of gene action. Allard (1956 _c_) suggested the method to determine genotypes-environmental interaction by comparing the position of array points in W_r, V_r graphs for different years.

The method for standardised deviation graph was presented by Johnson and Aksel (1959), drawn with values for parental measurements (y_r) and the order of dominance ($W_r + V_r$) in order to determine whether dominance was due to positive or negative genes.

Numerical approach: The components of variation,
D and H based on Mather's theory (1949) Jinks and Hayman
(1953) developed an approach to the analysis of data
from diallel crosses of homozygous lines. The analysis
was dependent upon the estimation of the genetic parameters
D, H_1, H_2 and F which provide estimates of over all
dominance, the relative dominance of parents and the
distribution of dominant and recessive allele in the
parental lines entering the diallel system. To test the
accuracy of the estimates, standard errors were derived
from the variance of $W_r - V_r$.

The theory and algebraic analysis of diallel
crosses were presented in detail by Hayman (1954 $\underline{a}$),
giving new notations and adding two more statistics
h^2 and F_r in addition to those given by Jinks and Hayman
(1953). He further gave a quick test to classify the
experiment into one of the four categories as exhibiting
no dominance, partial dominance, complete dominance or
overdominance by testing the deviation of $D - H_1$ from
zero combined with the test of significance of H_2.
Hayman (1954 $\underline{b}$) further described an analysis of variance
method to test the additive, dominance and maternal
effects in diallel crosses. The dominance effect was
further partitioned to determine the direction of dominance
and asymmetry of gene distribution.

A different formula to determine the variance
due to genotypic environment interaction for a diallel
experiment replicated in time and/or space with the
assumption of the presence or absence of non-allelic
interaction was presented by Allard (1956 $\underline{c}$). Later on,
the theory of the diallel analysis of parental and F_1
means to the F_2 and backcross generation derived from
a set of diallel crosses was extended by Jinks (1956).
He reported that the expected statistics for the F_2
generation were of the same general form as those of the
F_1 except that the contribution of 'h' was halved by one
generation of inbreeding. For this reason the coefficient
of H_1 and H_2 were of those of the F_1 statistics, which
the coefficient of F was halved being second and first
degree statistics respectively.

The method of diallel analysis was extended by
Dickinson and Jinks (1956) to crosses involving parental
heterozygosity and gave the parameters D_1, D_{11}, H_1, H_{11},
H_{111}, H_{1v}, F_1 and F_{11}. This analysis provided estimates
of the over all degree of heterozygosity of loci showing
dominance and of the allele frequency at such loci.

The importance of $(H_1/D)^{\frac{1}{2}}$ value as a measure of
degree of dominance was discussed in detail by Hayman (1957)
and came to the conclusion that it was a good measure of
the average degree of dominance in non-epistatic diallels

even when W_r - V_r was variable. In other words, multiple allelism and non-independent distribution of the genes in the parents, though disturbing the (W_r, V_r) graph, do not invalidate $(H_1/D)^{\frac{1}{2}}$ as a measure of the average degree of dominance.

The earlier method proposed by Jinks and Hayman (1953) for the analysis of a fixed set of inbred lines was applied later by Hayman (1960) to sampled inbred lines to indicate the relationship between the five components of additive and dominance variation (D, H_1, H_2, F and h^2) and the two combining ability components (general and specific). The re-analysis of maize yield data supplied by Sprague (1955) both on fixed and random models suggested that care was to be exercised in inferring over-dominance from the analysis of a fixed set of inbred lines.

Combining ability: A technique, that has been extensively used by plant breeders, is to classify the parental lines in terms of their ability to combine in hybrid combinations. Using this method the total genetic variation was partitioned into effects of general and specific combining abilities. Sprague and Tatum (1942) defined the term "general combining ability" as the average performance of a line in hybrid combination and the term "specific combining ability" refferred to those instances in which certain hybrid combinations did relatively better or worse than was expected on the basis of the average performance of parental lines involved.

For testing general combining ability of inbred
lines, a technique was developed by Davis (1927) by means
of inbred X variety cross (top cross). Hayes and Johnson
(1939) studied the segregates from the cross of high and
low combining lines and got lines of good combining ability
more frequently from crosses involving good combiners than
from crosses involving lines having low combining ability.
For the first time, Sprague and Tatum (1942) gave a technique
of estimating general and specific combining ability variances
to detect the amount of additive and dominance variances
respectively, in the yield of single crosses of maize.

The method used by Sprague and Tatum (1942) expounded
by Griffing (1956 a) and developed techniques for working out
general and specific combining ability variances, associated
with lines. The assumptions involved in this technique given
by Griffing (1956 a) were : (1) the parent population must
be a random mating population in equilibrium, (2) the experimental
set of lines must be a random sample from a population
of inbred lines which were derived from the parent population
by the imposition of an inbreeding system free from forces
which changed gene frequencies, (3) a "modified diallel"
crossing system must be used in which the lines themselves
are not included in the experimental test. He pointed out that
twice the general combining ability variance contained not only

the additive genetic variance but also a portion of the epistatic variance (additive X additive) and that the specific combining ability variance included all of the dominance and the remaining epistatic variance. When interpreted in terms of the classical method of covariance between, relatives (Fisher, 1918, 1930) the general combining ability variance was equal to the covariance between parent and offspring in a random mating population at equilibrium.

A mathematical treatment of the problem of estimating the general and specific combining ability from diallel crosses involving four methods (mentioned earlier), was reported by Griffing (1956 $\underline{b}$) depending upon the inclusion of parents and reciprocal F_1 s. Each method necessitates a different form of analysis both on fixed and random models. He advocated the use of method three if there was reciprocal difference and method four when there was no reciprocal difference but pointed out that if the combining ability analysis was employed to determine suitable lines to combine into a synthetic variety, and if considerable inbreeding occurre in the species, it was advisable to include the parents and to use method 1 or 2 depending upon the significance of reciprocal differences.

While discussing the maise yield data Hayman (1957) observed that in the absence of epistasis general combining ability was composed of both additive and dominance portions

while specific combining ability mainly involved dominance.
When epistasis was present it was expected that both these
combining abilities to contain epistatic portion. In general
combining ability, this portion was an average of epistatic
effects in the corresponding array, while in specific combining
ability it was related more directly to the epistasis in a
particular cross. He further pointed out that specific combining
ability was mainly a measure of dominance and epistasis in
unselected and selected materials respectively. Recently ,
Dudley (1963) developed a method for determination of general
and specific combining ability variances for diallel crosses
in such cases which were made without emasculation, such as,
in alfalfa. The amount of bias introduced because of selfing
has also been assessed.

Heterosis and inheritance studies in vegetable crops:

Heterosis has been reported in more than twenty
vegetable crops (Bresnev, 1961) and in some of them e.g.
cucumber, squash, tomato and melons etc. has been exploited
on commercial scale. The characters such as higher yield,
larger size and larger number of fruits, early maturity,
uniformity in size and maturity of fruits, resistance to
diseases and drought, better fruit quality, better flavour
and higher sugar content, thicker flesh, better and wider
adaptability to environmental conditions, have drawn
the attention of several workers who have worked out the

underlying genetic mechanism controlling these characters. The important work done in different vegetables on these aspects is given below.

Watermelon (Citrullus lanatus (Thunb.) Mansf.): The genetics and breeding of watermelon was reviewed by Porter as early as in 1933 and later on by Parris (1949). It is evident from the study that the objectives of most of the genetics and breeding work with this crop has been to determine the inheritance of fruit and seed characters and in developing new varieties. Yanagisawa and Hosono (1951), Tracenko (1953), Buzulin and Nishi (1955), Barna (1961) and Breznev (1961) observed hybrid vigour for yield, earliness, fruit size, disease resistance and fruit quality in watermelon.

Haltern (1943), Walker (1944), Epps (1947), Yeager (1950), School (1951), Dolan (1952), Taylor (1957), Watt (1958), Spurr et al (1960), and Hall (1963) evolved varieties Georgia, Blacklee, Miles, New Hamphshire Midget, Baby Klondike, Rhode Island Red, Hope Diamond, Klondike RS-57, and Crimson Sweet by crossing suitable parents which were early maturing with good eating quality, and higher sugar content, higher yield, good flavour and texture and good size, shape and colour.

Other workers (Melhus, 1942-44; Das Kolov and Popova, 1958; Breznev, 1960; Ivanoff, 1962; Wihov, et al, 1963; Tue, 1964) observed more fruits but smaller size, 30 to 60 per cent increase in yield, good quality, good flavour and better

disease resistance potentialities over the parents. Kihara (1951), reported that the triploid F_1 watermelon produced by pollinating a tetraploid flower with diploid pollen, was seedless. The triploid F_1 hybrid showed considerable heterosis such as growth and resistance to disease and drought.

The fruit weight in watermelon was determined by many genes as reported by Weetman (1937) and Poole and Grimball (1945). They further observed that small size seemed to be dominant over large size but on logarithmic scale the dominance was lacking.

Porter (1933) found out that red flesh was dominant over green and was determined by single dominant gene, where as Bennett (1936) failed to arrive at this conclusion. Porter (1937) observed that dark green skin colour was dominant over yellowish white skin but in crosses with yellow green, the F_1 was intermediate in skin colour and that the F_2 population indicated that a single gene difference was involved. Further he reported that striped skin in watermelon was incompletely dominant over dark green rind giving 1:2:1 ratio in F_2. Similarly, Weetman (1937) found that dark green skin colour was dominant over the light green skin colour which was determined by a single gene difference. Further he observed that a cross between elongate and spherical fruit produced hybrids which were intermediate in shape.

Konsler and Barham (1958) studied the inheritance of seed size and reported that the average seed size of 7.4 mm. was dominant over large size of 17.7 mm. seed and single gene difference was operating.

As far as interspecific hybridisation is concerned, Whitaker (1933), Gold Houen (1938), Furusato et al (1954) made successfully interspecific crosses and reported that all the four species, C.vulgaris, C.colocynthis, C.ecirrhosus and C.naudianus were cross compatible with each other. Later on Khoshoo (1955) confirmed that C.vulgaris and C.colocynthis reciprocally crossed. Shimotsuma (1959) made crosses among diploid and tetraploid strains of colocynthis no.1 and watermelon (Asahi Yamato)and reported that all four strains could be crossed in all combinations. Further Shimotsuma (1963) reported that all the species are closely related with each other and natural hybridization among them was possible.

Arassimovich (1937) found that in crosses of watermelons, F_1 was usually intermediate in sugar content. Though some times heterosis occurred, and transgressive segregation occurred in the F_2, the majority of segregates, however being again intermediate.

Muskmelon (Cucumis melo L.): Scott (1933) found no loss of vigour in inbreeding and was also of the opinion that crossing of inbreds exhibited no heterosis. Munger (1942), however, observed that F_1 hybrid muskmelons were characterised

by an increased vigour, more fruits, more flesh, higher
sugar content and earliness but in most of the cases
differences were not great. Bohn and Davis (1957) observed
that the hybrids exhibited, responses ranging from no
dominance to apparent heterosis for earliness to the total
growth period and in the time required to attain sexual
maturity, which was increased by number of days from planting
to anthesis of first pistillate flower. It was found that
all the hybrids were earlier in flowering and fruit maturity
than respective parents. They concluded that the direct
practical advantage through earlier maturity could be gained
from the use of F_1 muskmelon hybrids for commercial value.
Mahoney, 1939; Ivanoff, 1956; Mossar, 1961 and Baily et al
1964, reported that F_1 hybrids characterised by vigorous
growth, higher sugar content, more flesh and 28.4 per cent
higher yield than the parents.

In Cucumis melo L., the great range of skin colours
and flesh colours obtained in the homozygous condition
suggested that these characters were numerous and perhaps
complex genetically. Hughes (1948) demonstrated that the
white skin and green flesh of the variety "Honey Dew" was
recessive to dark skin and salmon flesh of the variety,
Smith's perfect suggesting, the difference due to single
Mendelion dominant gene. Further he noted in the same crop
that the dark green rind colour of the fruit to be dominant
over white skin and that it differed by a single factor and
the inheritance was found to be simple indicating dominance
of orange over light green and controlled by a single gene pair.

Bains and Kang (1963) reported in muskmelon that the cross between the monoecious Sarda and the andromonoecious Lucknow yielded monoecious F_1 plants and F_2 and backcross segregation showed that the parents differed by one pair of genes for sexual type. When the cylindrical fruited Sarda was crossed with the round flat fruited Lucknow, the F_1 was intermediate. The F_2 and backcrosses indicated that fruit shape is governed by a single locus without dominance. Crosses of Kutana (cream) with the yellow 81-2 and 23-5 lines yielded light yellow F_1 fruits. F_2 segregation suggested a single incompletely dominant gene. Furrowing in the crosses Sarda X Lucknow and Kutana X 18-2 is controlled by a dominant gene and orange flesh is monogenic and dominant over light green. Inheritance studies with respect to flower conditions were made in F_1 by Rosa (1928) in U.S.A. and F_2 by Fujishita (1959) in Japan. Both of them observed dominance of mono ecious over andromonoecious character and the monogenically controlled character was symbolized as M/m. Further he reported that yellow was dominant over green find.

Inheritance studies with respect to flesh colour was reported by Hagiwara and Kaminura (1936). They did not report the colour in F_1 but, observed segregation in F_2 indicating dominance of white orange colour over white.

√ Cucumber (Cucumis sativus L.): Hayes and Jones (1916) were the first to observe heterosis in cucumber manifested in increased early yield and higher total yield due to larger

number of fruits per plant. The highest yielding hybrid
exceeded the better parent by 39 per cent. Jakimovic (1938)
observed hybrids to be earlier, giving higher yields and
showed an increased fruit size when compared to the
corresponding parent. He suggested that for commercial
exploitation of hybrid vigour in cucumber, successful
combinations of varieties should be determined first.
Hutchins (1939) crossed pickling variety "Winou" with nine
slicing varieties and showed conclusively that the F_1
generations exhibited hybrid vigour increasing yield
resulting from increased number of fruits per plant which
confirmed the work of Hayes and Jones (1916). Shifriss (1945)
developed "Burpee" hybrid cucumber (temperate variety X
tropical variety) particularly suitable as an early all
purpose cucumber which gave heavy yield in Southern United
States. It had considerable resistance to downy mildew wilt
and mosaic. Cizov (1945) reported that hybrids were early
and gave higher yield due to increased number of fruits and
also increase in weight of individual fruit. Hutchins (1939)
and Cizov (1945) found differences in reciprocal crosses
indicating lack of maternal influence. A Russian worker,
Alexandrove (1952), observed heterosis in most of the
intervarietal crosses in cucumber and also in their reciprocal
crosses.

Carlson (1952) also reported increased yield in the F_1 seed of cucumber. Alexandrove (1958) again observed that hybrid cucumber yielded 31.3 to 116.9 per cent higher in the open field and 15.6 to 36.7 per cent in the glasshouse. Weigle (1959) stated that hybrids were better than the best varieties and were found superior in all trials. Hybrids had greater potentialities of production in abnormal years. The fruits were intermediate in length and circumference. Barna (1962) stated that by means of appropriate crosses between selected parents the proportion of female plants could be raised to 80 to 85 per cent. Alpatev (1963) and Lorenzetti (1964) reported that the cucumber hybrids were resistant to disease and outyielded 23 to 33 per cent. The earliness was also observed.

As far as colour inheritance was concerned Hutchins (1940) reported that orange and yellow skin colour was dominant to cream and the combination of orange and yellow produced red.

Pumpkin (<u>Cucurbita</u> <u>moschata</u> Poin): Some workers observed hybrid vigour in the first generation progeny of pumpkin, however loss of vigour was not observed in the inbred lines. Hutchins and Croston (1941) reported that seven out of ten F_1 pumpkin hybrids yielded better than the respective parents, due to increase in weight per fruit and also larger number of fruits. Heterotic effect was more when

the parents differed considerably in their phenotypic characters than when the parents were closely related. Lana (1950) studied reciprocal crosses of all possible combinations of five varieties of C.maxima and noted significant differences between reciprocals in one or more pairs or crosses for the various characters such as seed size, seed weight, embryo weight, number of male flowers per plant, yield per plant etc. These differences were associated with the maternal parent. Seed size appeared to influence the growth and development of the hybrids. Thus the maternal parent, probably influenced growth and development both genetically and as a factor for seed size. He further suggested that in order to develop higher yielding hybrids largest seeded individuals be selected as female parents.

Wall (1954) obtained the hybrids from a cross C.pepo X C.moschata and the reciprocal by embryo culture of the F_1 seeds were vigorous in growth and some of the hybrids were produced by using embryos only 3 mm. in length. Hayase (1956) observed in the crosses of C.maxima and C.moschata that hybrids were obtained more readily when C.maxima was the female parent and these hybrids were more vigorous than the reciprocals. The hybrids set fruit readily on backcrossing but fruit set and pollen fertility was low.

Showalter (1956) reported that fruit shape in pumpkin was governed by many pairs of alleles and the F_1 hybrids bore

fruits with necks conspicuously longer than those of either parent. Further he noted that backcrosses to the parental sub-varieties gave progenies equal number of plants similar to the F_1 and backcross parent in neck length. This behaviour was interpreted provisionally as a case of hybrid vigour involving a single pair of genes.

Mescorow (1957) found higher yield 29 to 36 per cent in hybrids of morphologically distinct varieties. Lower number of male flowers, earliness and disease resistance were also observed. Nagaeva (1958) reported that Froth 766 and Victory 124 pumpkin varieties were obtained from a cross of the egg plant Gribovo with the pumpkin Mozolee-vskaja 49. They were early, drought resistant, bushy and out yielded than the parents. Potulnycky (1959) found that the F_1 Cucurbita maxima X C.turbaniformis showed variability in respect of all fruit characters. The F_2 segregated 52 per cent intermediate, 36 per cent maternal types and 8 per cent parental types. Some hybrids were early, high productive or rich in sugars and dry matter. While Zelengur (1959) observed that Cucurbita moschata X C.maxima had an improved set and produced a greater number of well developed seeds when portions of stigmas of C.maxima had been added to the pollen prior to pollination. Belic et al (1960) stated that the seed set of C.maxima X C.pepo was raised from 20 to 63.6 per cent by pollination with a pollen mixture including self

pollen. The sets obtained from C.maxima X C.moschata and C.pepo X C.moschata were 36.3 and 7.2 per cent respectively when the pollination technique was employed. Bresnev (1960) studied the pumpkin hybrids which gave 25 to 30 per cent higher yield and 10 to 12 mg per cent higher carotene content than the parents.

As far as interspecific hybridisation is concerned Candardi (1939) studied the F_1 of C.maxima and the wild species C.andreana, bore exclusively better fruits; the plants were vigorous and extremly fertile. In F_2, backcross and F_3 bitterness behaved as a simple dominant. C.pepo X C.andreana proved almost completely sterile. A high set of fruits was obtained in crossing C.andreana with C.ficifolia but most of the seeds were imperfect. Whitaker (1954) observed that the hybrids obtained from crossing the perennial species, C.ficifolia with the annual C.andreana. The hybrids were annual, very vigorous and completely sterile but produced parthenocarpic fruits with ease when open or back pollinated. He further stated that when cultivated species C.pepo, C.mixta, C.moschata, C.ficifolia and C.maxima were for the most part incompatible when intercrossed; they have apparently developed physiological barriers of sterility that effectively present gene exchange between them. The five species were found to be cross-compatible with the wild species C.lundelliana with C.moschata, C.maxima and C.ficifolia produced self fertile F_1 plants which were cross-fertile with either parent.

Crosses of the wild species with the other two cultivated species resulted in fruits, but the seeds had small embryos; special technique may be required to raise F_1 hybrids from these combinations.

Grebenscikov (1958) studied so many Cucurbita crosses and found that when C.moschata "Cushaw Squash" X C.foetidissima crossed, fruits developed on the mother plant but no viable seed was obtained. The F_1 hybrid C.moschata X C.maxima "Sweet Meet" was also pollinated by C.foetidissima and one F_1 plant resembled the seed parent was obtained; this hybrid was sterile. Other crosses involving C.foetidissima were completely unsuccessful. Further he reported that C.lundelliana was cross-compatible with cultivated species. He made successful cross of C.mixta and C.pepo variety Oleifera, the F_1 plant was relatively uniform resembled C.pepo. F_2 generation showed decreased vigour as compared with the F_1 and many of the male flowers were sterile. He further reported that C.pepo was more closely related to C.mixta than C.maxima. Whitaker (1959) raised hybrids from a cross C.lundelliana X C.moschata, were moderately fertile and F_2 hybrids and backcrosses to each parental species were obtained. The F_1 hybrid was intermediate between the parents, the F_2 was, as expected variable but the hybrid index values for the characters studied did not reach the parental values.

Pyram-von Becherer (1955) observed that the brown testa were dominant over white and hard testa over soft. In C.maxima plants with white testa proved homozygous for this character where as brown testa segregated when selfed, in the proportion 3 brown:1 white testa colour was then determined by a single gene pair. In C.pepo plants with soft testa were homozygous for this character.

Summer squash or vegetable marrow (Cucurbita pepo L.): Heterosis in reciprocal crosses of Cucurbita pepo was observed by Passmove (1934). Curtis (1939,41) reported that hybrid progeny bore twice the number of fruits as compared to the better parent, and in weight exceeded the mean of the parents by over three times. He also observed that there was no loss of vigour in yield as well as earliness in the F_2 generation. Hutchins and Croston (1941) studied so many crosses of C.pepo and reported that seven F_1 s were significantly higher in yield and earliness than the parents. Scarchuck (1953) crossed "Caserta" variety with "Salerna" and F_1 proved to be early and heavy yielder.

Grebenscikov (1958) made crosses in C.pepo between dwarf vine type varieties and reported that dwarf character was dominant and determined by polygenes. In some cases a segregation ratio of 3:1 for dwarf:vine was obtained and the dwarf formed being less bushy than the vine type. He further

studied the genetics of fruit colour in the F_1 from PEP 846 (White) X PEP 1 (Yellow), had white fruit whilst in the F_2 the segregation was more complicated and all possible shades between white and yellow occurred. The ratios of non green:green in the F_2 s were mostly close to 15:1. In some case the ratio of non green:green was 3:1. But Nath (1965) reported that vine type was dominant over the bush type, late in the growing season. Further Nath and Hall (1963) reported that in C.pepo L. green colour showed simple dominance over the yellow, and green stripes over the plain yellow. Turbinate and Cylinder type of fruits showed no dominance while in crosses with the disc and cylinder type of fruits resulted in intermediate and different shapes other than the parents and gave no definite evidence of its inheritance.

Bittergourd (Momordica charantia L.): Pal and Singh (1946) observed striking hybrid vigour with regard to increased total yield and the best hybrid showed 191.3 per cent increase over the better parent. In length and girth all the hybrids showed negative heterosis except two, which were better than the superior parents. Increase in the number of fruits was also observed. Agrgwal et al (1957) made certain crosses between wild and cultivated plants M.charantia and reported that F_1 fruits were intermediate in size, shape and flavour between those of the parents. Srivastava (1970) also found out striking hybrid vigour in bittergourd, with regard to

increase in growth, yield, earliness, and the best hybrid showed 64 per cent increase over the better parent. The increase in number of fruits was also observed. He reported partial dominance for the characters, number of days taken to open the first female flower and weight of the fruit while for the number fruit and the total yield partial dominance to dominance was indicated. Recessive alleles were more frequent then the dominant alleles in the number of days taken to open the first female flower, the number of fruits and the total yield; while in the weight of the fruit, the dominant genes were more frequent in the parents. The asymmetry of distribution of genes with positive and negative effects was observed in all the characters except in the number of days taken to open the first female flower in which there were in almost equal proportions.

Luffa gourds (_Luffa_ _spp._): Mudaliyar (1936) made preliminary observations on the cross _L.cylindrica_ X _L.acutangula_ and reported that they are easily crossable to each other. This was supported by Singh (1947) and Pathak and Singh (1949). Further they reported that F_1 plants were generally intermediate in morphological characters between the parents. Interspecific hybridisation between _cylindrica_ and _acutangula_ was also carried out by Richharia (1948), Singh and Pal (1949), and they observed that the different interspecific crosses made between ridgegourd (_L.acutangula_) X(both monoecious and hermaphrodite) and spongegourd (_L.cylindrica_ monoecious)

produced F_1 plants which were either of the normal or of the abnormal type, depending on the varieties of the two species entering the cross. The normal type of hybrids resembled the parent varieties in habit growth, length of internodes etc. but the abnormal type was characterised by dark green leaves, short internodes and stunting. The normal type F_1 plants produced bitter fruits, but the abnormal type produced non-bitter fruits like the parent varieties. The abnormal type hybrids showed a decrease of 28.8 per cent in yield compared to L.acutangula, the better parent. The normal type hybrids showed an increase of 57.5 per cent in yield, but since bitter fruits were produced, the increased yield was not considered of any economic importance. Thakur and Choudhury (1965) reported heterosis for yield per plant and girth of fruit in L.acutangula Roxb., and high estimates of heritability were recorded in case of girth of fruit, length of fruit and the number of fruits per plant. The number of fruits and the length of fruits showed high expected genetic gains.

Richharia (1962) studied inheritance of seed surface in intervarietal cross between Satputia No.1 and Gingli No.1 and found that pitted seed surface was dominant to smooth surface and postulated a single factor hypothesis controlling the inheritance of both the characters.

Ram Prakash (1953) in intervarietal crosses
of Snakegourd observed hybrids to be early, more vigorous
than their parents and that they bore more and longer
fruits then the parents. Further he reported that by
controlled pollination with wild varieties could be presented
and hybridisation can be easily taken up by farmers themselves.

Tomato (*Lycopersicon* *esculentum* Vill.); Increase in
yield due to hybrid vigour has not only been reported by
several workers but it is also being exploited on commercial
scale. Heterosis in tomato yield has been reported to be
mainly due to earliness by most of the workers (Growth, 1914,
1915; Stucky, 1916; Currence, 1932;1938; Powers, 1939;
Powers *et* *al*, 1950; Griffing, 1950; Burdick, 1954; Williams,
1959; Williams and Gilbert, 1960; Bankowska, 1961; Bresnev,
1961; Ito, 1961 and Mittal *et* *al*,1962). Baldoni (1948),
however, observed that in crosses between Italian canning
variety, earliness was not always improved. Wittwer (1955)
also made similar observations. Georgieva, 1963; Szwadiak,
1963 and Betlach, 1964 also reported heterosis for yield
and earliness in tomato hybrids.

The three complementary gene pairs for earliness
was suggested by Fogle and Currence (1950) and Burdick
(1954) and they also reported that additive gene action
and partial dominance were involved. Pierce (1958) also
found additive gene action for earliness. Bresnev (1961)
reported complementary effects of dominant genes for
earliness.

The increased yield in F_1 was also due to the dominance of small fruit size and increased number of fruits,(Griffing, 1953). The fruit size of hybrids either approached or was eq al to the geometric mean of the parents and showed dominance or partial dominance of small size (Mac Arthur and Butler, 1938; Mac Arthur, 1941; Larson and Currence, 1944; Powers, 1945 and Griffing, 1948, 1953). Larson (1941), Pal and Singh (1943), Baldoni (1948) and Williams and Gilbert (1960) reported F_1 fruit size to be intermediate where Shifriss (1945) noted that the fruit size in F_1 was smaller than that of the smaller fruited parent. On the other hand, Munger (1947) and Gottle and Darley (1956) found no difference between the size of fruits of the hybrids and that of the parents. Powers (1951) reported that small fruit size was due to genic dominance and that interaction between dominance effects contributed the major portion of the epistasis. Snyder and Larson (1955) and Snyder (1956) suggested that the seed size might be associated with genes for earliness instead of the genes controlling yield, as larger early yields were significantly associated with medium sized seeds. Seed weight was shown to be determined by large number of factors with an additive effect (Snyder, 1956; Snyder and Larson, 1955). Walkof et al (1963) reported that monofactorial inheritance in tomato hybrid and high acidity content was dominant to low while Thompson et al (1964)

observed that acidity was polygenically controlled and
some of the progenies may be linked with genes controlling
fruit size. Ibarbia and Lambeth (1969) studied the mode
of inheritance and gene action in tomato and reported that
more than ten possibly as many as twenty gene pairs controlled
fruit weight. Genes for low fruit weight were partially
dominant and no epistasis was found. Stoner and Thompson
(1966) reported that genetic analysis in tomato hybrids
indicated that epistasis on non-allelic interaction was
primarily responsible for the heterosis. The existance of
dominant genes for high content of soluble solids was
demonstrated. Tayel et al (1959) in his inheritance study
in tomato has found that earliness was dominant over
lateness. At least four pairs of genes appeared to be
involved and a heritability value of 54.4 per cent suggested
that selection might be effective.

Many workers such as Hepler (1929), Shifriss (1945),
Capinpin and Sison (1947), Baldoni (1948), Whaley (1952)
and Haskell and Brown (1955) were of the opinion that
increase in the number of fruits, was one of the most
important components of heterosis. Maternal effect for
fruit number was observed by Hlystova (1961). Pogle and
Currence (1950) and Burdick (1954) suggested multiplicative
inheritance of fruit weight. Generally many loci were
involved and their effects showing additive effects on a

logarithmic scale with constant dominance. Increased vegetative growth in F_1 hybrid was reported by Totmakov and Alpatjev (1935), Whaley (1939), Powers (1941) and Capinpin and Sison (1947).

Ahuja (1968) studied the diallel analysis of eleven tomato inbred lines and found that the epistatic interaction was not detected but dominance estimates indicated partial dominance of low over high locule number. Further he observed that the parent differed in their general combining ability while P_1 s differed in specific combining ability effect while Armstrong (1968) observed that g.c.a. component of variance was greater than that of s.c.a. effects and were directly correlated with cracking resistance of the parents. The additive component of genetic variance was larger than the dominance components.

Giles et al (1963), Lomoljako and Simonov (1968), Mustaev (1964) tested 30, 100 and 150 tomato hybrids respectively and general superiority over the better parent was observed.

Choudhury et al (1965) observed heterosis in tomato and reported that Meeruti X Pusa Ruby, Pusa Ruby X Best of All and Meeruti X Local significantly outyielded by 44.49, 49.83 and 49.93 per cent respectively. In F_2 generation best combiner were of Improved Meeruti X Pusa Ruby, Local X Best of All and Improved Meeruti X Local outyielded their respective

parents by 18.92, 18.78 and 15.19 per cent respectively.
Further, he reported that the F_2 seeds can be produced
even at a cheaper rate than those of parental varieties
because of the larger yield of fruits in the F_1 generation.

Brinjal (Solanum melongena L.): The hybrid vigour
in brinjal was reported first by Nagai and Kida (1926)
and later on by Kakizaki (1931), Daskaloff (1937, 1941),
Venkataramani (1946), Pal and Singh (1946, 1949), Odland
and Noll (1948), Gotoh (1952) and Mishra (1961). Increased
yield in F_1 was due to earliness (Daskaloff, 1937), increase
in vegetative growth (Venkataramani, 1946), and the number
of fruits (O dland and Noll, 1948). Rajkioloer and Pal (1964)
reported that in intervarietal cross (Purple X White) low
yield per plant was obtained and compared with selfings,
was attributed to the depressive effects of emasculation.
Gotoh (1953, 1954 and 1956) reported that the genes for
fruit weight had logarithmically cumulative action with
or without dominance, the genes for fruit shape and
earliness indicated cumulative action and negative dominance
and in case of large size there was overdominance or
epistasis.

Reanalysis of Gotooh's (1953) data by Jinks (1955)
revealed that shape and weight of fruit both showed
significant but incomplete dominance without any indication
of non-allelic interaction for these characters but
flowering time showed complete dominance and absence of

non-allelic interaction. Janick and Topoleski (1963) reported that green flesh colour was dominant over white flesh and that pubescent leaf surface was dominant to glabrous and no linkage was observed.

Nasrallah and Hopp (1963) made interspecific crosses between S.melongena, S.gilo, S.indioum, S.mammosum and S. oiriatum and observed that S.melongena was crossed successfully with S.gilo and S.indioum but the F_1 s were highly sterile. The F_1 of S.melongena X S.gilo was highly vigorous and the fruit were borne in cluster. Further they observed that S.gilo and S.indioum crosses were successful and F_1 s were fertile, therefore, it is possible that these two plants may not represent distinct species. All other interspecific combinations were incompatible.

Chilli (Capsicum annum L.): Deshpande (1933) first demonstrated the existance of heterosis in chilli. The vigour was shown on maturity, height of the plant, thickness of fruit, number of fruits and fruit weight. Pal (1945) also observed hybrid vigour for yield, early maturity and thicker fruits in comparison to better parent. Khambanoda (1950) observed a major gene for incomplete dominance of oblate shape. Bresnev (1961) also observed heterosis for yield, earliness and disease resistance.

Cabbage (_Brassica_ _oleracea_ L. var. _capitata_): Pearson
(1932) and Himic (1935), observed hybrid vigour in cabbage
and found reciprocal differences for yield. Since then
Kaloberdina (1941), Myres (1942), Attia and Vunger (1950),
Odland and Noll (1950), Odland and Isenberg (1950), North
and Squibbes (1952), Woods (1953), Niewhof (1948, 1963),
Haigh (1959), Bresnev (1961,1963), Swarup et al (1963),
Angelus (1966) and Johnson (1968) have also observed hybrid
vigour in yield and other characters. Swarup et al (1963)
found dominance for number of marketable heads,net weight
of heads and maturity and overdominance for yield. Non-allelic
interaction, particularly of a complementary nature, was
present in all the characters except maturity in which there
was a pronounced additive gene effect and only a slight
indication of gene interaction. A predominance of dominant
alleles was found in all the characters except yield in
which there was recessive alleles, plus and minus alleles
were in equal proportions only in the number of marketable
heads. Swarup and Sharma (1965) reported that the estimates
of additive gene effects were low in magnitude but mostly
significant except plot yield and number of marketable heads.
Duplicate epistasis was more pronounced than the complementary
in almost all the cases under observation. Epistatic gene
effects were found to be more important than additive
gene effects and additive X additive and dominance X dominance

gene effects were relatively more important than the additive X dominance effects for different characters. Chiang (1969) reported that length of inner core and the number of days to maturity were inherited largely in an additive manner. While Dickson and Carruth (1967) reported that the core length is controlled by two incomplete dominant gene for short core. Short core was correlated with round head and long core with flat head.

Onion (<u>Allium</u> <u>cepa</u> L.): Hybrid vigour is being utilised in onion on commercial scale through the use of male sterility. Jones and Emsweller (1937), Jones and Davis (1944), Jones and Clarke (1947) and Svensson (1952) made its utilisation on commercial scale possible. Heterosis in onion has been observed for yield, number of large bulbs and uniformity in size, shape and maturity of bulbs and in many other characters. Bresnev (1961) and Ito (1961) also reported hybrid vigour in onion. Munger (1951), Nishi (1951) Jones (1952), Landi (1954) and Hommura and Kosaka (1960), further discussed the advantage of hybrid onion.

Okra (<u>Abelmoschus</u> <u>esculentus</u> (L.) Moench.): The first report on hybrid vigour in okra in respect of the number, size and weight of the fruits was made in 1946 by Vijayaraghavan and Wariar. Venkataramani (1952), Joshi <u>et</u> <u>al</u> (1958), Raman and Ramu (1963) and Raman (1965) also studied the hybrid vigour in F_1 hybrids for different characters including

early flowering, height of the plants, number and weight
of fruit. Singh _et_ _al_ (1962) studied the inheritance of
field resistance to yellow vein mosaic disease. Kalia and
Padda (1962) observed that leaf shape was monogenically
controlled and purple petal venation was monogenically
dominant over yellow petal venation. The same thing was
reported by Kolhe _et_ _al_ (1966), that monogenic inheritance
of calyx, petal and fruit colour was observed. Erickson
and Couto (1963) also reported that red pigmentation of the
main stem, branches and petioles is controlled by a number
of genes, Sharma (1965) made a detailed study on gene
system in okra and observed partial dominance for the
characters like; plant height, early flowering, larger
number of fruits, lighter fruit weight, larger fruit size,
longer fruit, higher yield, larger number of seeds and
heavy seed weight . Recessive alleles were more frequent
than the dominant alleles in the plant height, **fruit
weight, fruit size** and yield, while in flowering, number
of fruits, number of seeds and seed weight, the dominant
genes were more frequent in the parents. The asymmetry
of distribution of genes with positive and negative **effects**
was observed in all the characters except fruit size, in
which these were in almost equal proportion and there were
mostly additive gene effects in all the characters except
number of fruits, fruit weight and yield in which there
was an indication of epistasis.

Other vegetables:

A diallel cross study in cauliflower (Brassica
oleracea L. var. botrytis) was carried out by Haigh (1962)
and Swarup and Pal (1966). Haigh (1962) did not observe
pronounced effect of hybrid vigour, while Swarup and Pal
(1966) observed pronounced heterosis and further they reported
that dominance and epistasis was found towards inheritance of
curd maturity, net weight and curd size. Jhouston (1963) observed
heterotic effect in the determination of leaf weight but not in
leaf number in narrow-stem kale (Brassica oleracea L. var.
acephala D.C.). He reported that general combining ability was
apparently more important than specific combining ability in
the production of the heterotic effect on leaf weight. There
was good correlation between leaf number and stem length.
Leaf number indicated a simpler additive genetic system but
stem yield produced inconclusive results. Heterosis in leaf
size was observed to be due to non-allelic interaction.

Ace (1958) recorded heterosis for yield and plant
vigour in pea (Pisum sativum L.). Nicolaison (1934) reported
heterosis in spinach (Spinacea oleracea L.). Thompson (1956)
and Trebuchet (1954) also reported that F_1 hybrids in spinach
outyielded the standard varieties. Allard (1956 a, b) reported
that the major part of genetic variation for seed size in
lima bean (Phaseolus lunatus) was on only a few major genes
and that the complementary type of gene action was responsible
for the rest of genetic variance resulting in heterosis.

MATERIAL AND METHODS

Experiments were conducted at the Horticultural
Farm of the College of Agriculture, University of Udaipur,
campus Jobner during the year 1966-68 on the sandy loam soils.
Jobner represents the agro-climatic conditions of the semi-arid
zones of Rajasthan where maximum and minimum temperatures
reach upto 40°C and -1°C respectively. The average rainfall
during the study period has been 198 mm to 232 mm. The soil
pH range was 8.0 to 9.0. The nitrogen, phosphorus and potash
contents in the soil were 0.035, 0.0026 and 0.224 per cent
respectively.

Plant materials:

The basic plant material used in the present investigation
was developed through two steps viz., collection and selfing.
Two hundred and fifty seven collections of the watermelon
were made from different parts of India, the United States
and Japan in the beginning of 1965 and they were grown in
summer, 1965 on the above mentioned farm for recording the
phenotypic diversities with regard to vegetative growth and
fruiting. The selected plants were selfed for four generations.
The technique of selfing consisted in doing the controlled
self-pollination using butter paper bags. Selfing was done
for the purpose of bringing homozygosity in the genetic make
up to satisfactory level (93.75 per cent) and finally
establishing the inbred lines to be used in this investigations.

Out of the above selfed materials only ten inbred lines which were most promising from the stand point of manifesting phenotypic diversities (details presented in Table 1 **a** and **b**) were selected and used as parents. All possible inter-crossings as well as reciprocals were made among the selected ten parents. Thus from these, F_1 materials were obtained. There were 90 F_1 hybrids, besides the original ten parents which were used to evaluate hybrid vigour, diallel analysis and combining ability effects.

Besides these quantitative traits certain qualitative characters **viz.**, rind colour of fruit, flesh colour of fruit, seed colour, fruit shape and seed size were also studied. For the study of qualitative characters concerned the F_1 hybrids were selfed and backcrossed with their respective parents, so as to obtain the F_2 and backcross generations also.

Thus the main investigation consisted of two sets i.e. (1) 10 parents and their 90 hybrids used for the study of hybrid vigour, diallel analysis and combining ability effects, and (ii) involved parents, their F_1 and F_2 and backcross generations to study the inheritance of qualitative characters of skin colour, flesh colour, seed colour, fruit shape and seed size. All the treatments (parents and their hybrids) have been specified and symbolised in Table 2. The plant materials of these two sets were grown at the Horticultural Farm of S.K.N. College of Agriculture, Jobner during the February to July, 1968.

TABLE 2

Notations for the F_1 hybrids of watermelon used for the present study

Name of cross (hybrid)	Notation	Reciprocals notation
P-1 X P-2	C-1	C-1R
P-1 X P-3	C-2	C-2R
P-1 X P-4	C-3	C-3R
P-1 X P-5	C-4	C-4R
P-1 X P-6	C-5	C-4R
P-1 X P-7	C-6	C-6R
P-1 X P-8	C-7	C-7R
P-1 X P-9	C-8	C-8R
P-1 X P-10	C-9	C-9R
P-2 X P-3	C-10	C-10R
P-2 X P-4	C-11	C-11R
P-2 X P-5	C-12	C-12R
P-2 X P-6	C-13	C-13R
P-2 X P-7	C-14	C-14R
P-2 X P-8	C-15	C-15R
P-2 X P-9	C-16	C-16R
P-2 X P-10	C-17	C-17R
P-3 X P-4	C-18	C-18R
P-3 X P-5	C-19	C-19R
P-3 X P-6	C-20	C-20R
P-3 X P-7	C-21	C-21R
P-3 X P-8	C-22	C-22R

P-3 X P-9	C-23	C-23R
P-3 X P-10	C-24	C-24R
P-4 X P-5	C-25	C-25R
P-4 X P-6	C-26	C-26R
P-4 X P-7	C-27	C-27R
P-4 X P-8	C-28	C-28R
P-4 X P-9	C-29	C-29R
P-4 X P-10	C-30	C-30R
P-5 X P-6	C-31	C-31R
P-5 X P-7	C-32	C-32R
P-5 X P-8	C-33	C-33R
P-5 X P-9	C-34	C-34R
P-5 X P-10	C-35	C-35R
P-6 X P-7	C-36	C-36R
P-6 X P-8	C-37	C-37R
P-6 X P-9	C-38	C-38R
P-6 X P-10	C-39	C-39R
P-7 X P-8	C-40	C-40R
P-7 X P-9	C-41	C-41R
P-7 X P-10	C-42	C-42R
P-8 X P-9	C-43	C-43R
P-8 X P-10	C-44	C-44R
P-9 X P-10	C-45	C-45R

Experimental design:

The first set of experiment with hybrid vigour, diallel analysis and combining ability, was laid out on an randomised block design with three replications. Within the block, the treatments were allotted on random basis. The crop was planted in rows 3 meters apart and each row had 12 plants per hill, spaced 1.25 meters apart. Three seeds were sown at each hill but only one seedling was retained, thus perfect stand was obtained.

The second set of experiments included thirteen small lay-outs to study the inheritance of five qualitative characters was made from the plants planted in thirteen layouts on randomised block design with two replications. All these layouts were uniform in size. The planting distance was 3X1.25 meters. The three seeds in each hill were sown and after-wards only one seedling was retained.

Usual cultural operations were followed in all the above experiments:

Observations:

For studying hybrid vigour, the characters measured were (i) length of main vine, (ii) number of days taken to open the first female flower, (iii) number of female flowers per plant, (iv) number of fruits per plant, (v) weight of fruit, (vi) length of fruit, (vii) breadth of fruit, (viii)total soluble solids (T.S.S.) and (ix) total yield per plant; for diallel analysis and combining ability effect, the observations were recorded on (i) number of days taken to open the first

female flower, (ii) number of fruits per plant, (iii) weight of fruit, (iv) total soluble solids (T.S.S.) and (v) total yield. The methods followed for studying these character are briefly described below.

(a) <u>Vine length:</u> Total length of the main axis was measured in meters at the end of experiment.

(b) <u>The number of days taken to open the first female flower:</u> The data consisted of number of days counted from the date of sowing the crop till the first female flower appeared.

(c) <u>The number of female flowers:</u> The number of female flowers opening daily were counted and the sum of all these daily countings formed the data expressed as total number of female flowers produced by the plant for the whole experimental period.

(d) <u>The number of fruits:</u> Fruits harvested periodically were counted and final data (as total number of fruits per plant) composed of the pooling of such periodical harvestings done till the end of experiment.

(e) <u>The weight of fruit:</u> Total weight of the fruits harvested divided by the total number of fruits weighted gave the average weight per plant.

(f) <u>The length and breadth of fruit:</u> The length
and the breadth (cm) of all the harvested fruits were
recorded and the average length and breadth computed
therefrom.

(g) <u>Total soluble solids:</u> T.S.S. of each fruit
was recorded with the help of Abbe's Hand Refractometer
just after harvesting and the average was taken up.

(h) <u>The total yield per plant:</u> Periodical
harvesting till the end of experiment were summed up to
give the data on total yield.

All the above observations consisted of the
average of the randomly selected seven plants of each
treatment blockwise, and then the final average figure
was obtained by summation of the above data divided by
three (number of blocks).

The observations on inheritance of qualitative
characters included (1) number of plants with dark green
and light green mature fruits of parents, F_1, F_2 and
backcross generations. Similarly, in other two experiments
no. 2 and 3, the plants having dark green and light green
with dark green stripes, light green and light green with
dark green stripes fruits were recorded for the above said
generations. In experiment no.4 and 5 the number of plants
with red flesh and yellow flesh, and pink and cannery yellow

colour of parents F_1, F_2 and backcross generations for flesh colour inheritance were recorded. For seed colour inheritance 6 separate experiments from 6 to 11 were conducted and each of these experiments, the observations were recorded for parents, F_1, F_2 and backcross generations. The number of plants with black and dark brown seed, black and red seeds, black and dark orange yellow colour seeds, dark brown and red seeds, dark brown and dark orange yellow colour seeds and red and dark orange yellow colour seeds were recorded in these experiments. In experiment no. 12 the number of plants with small and large seeds were recorded for the parents, F_1, F_2 and backcross generations for the study of inheritance of seed size. The seeds with 12 mm and above assumed large size and up to 7 mm is small sized as designated by Poole and Porter (1941).

The seed colours were compared from Nickeson Colour Fan maximum chroma 40 Hues, published by Munsell Colour Co., U.S.A. In experiment no.13 the number of plants with long and round fruit shapes were recorded for parents, F_1, F_2 and backcross generations for fruit shape inheritance study. Fruits 40.00 X 16.00 cm (almost in the ratio of 2:1) long and 20.00 X 21.10 cm (almost in the ratio of 1:1) round shape were categorised for the present study.

Statistical procedure:

(a) <u>Hybrid vigour studies:</u> The following statistical procedure was followed for the analysis of hybrid vigour studies data.

The analysis of variance was carried out to test the differences between ten parents and their 90 F_1 hybrids. It was calculated as Randomised Block Design with set up of table as follows:

Source of variation	d.f.	S.S.	M.S.S.	F
Blocks (replications)	r-1	S_r	M_r	M_r/M_e
Treatments	t-1	S_t	M_t	M_t/M_e
Blocks X treatments	(r-1)(t-1)	S_e	M_e	
Total	(rt-1)			

r = number of replications; t = number of treatments

(b) <u>Diallel analysis:</u> The details of the procedures adopted for the analysis of data on diallel crosses by graphical and numerical approaches are as follows:

The analysis of variance for each character under study was calculated similarly as in the case of hybrid vigour studies and in those cases where the block differences

was found to be significant further analysis, both for
graphical and numerical approach, was conducted as for
grouped randomisation and in cases where significant block
differences were not observed the method for ungrouped
randomisation was followed as suggested by Aksel and
Johnson (1963). In case of ungrouped randomisation the
total sum of squares were subdivided into two parts only,
i.e. between and within treatments sum of squares with
(t-1) and t degree of freedom, respectively, the block
effect sum of squares were included in the within treatment
sum of squares and the environmental component of variation
thus became $E = \frac{1}{2} (S_r + S_e)/(r-1)$ t. The details of the
procedure adopted for graphical and numerical analysis
under ungrouped randomisation are presented below:

A. _Graphical approach:_

(1) _Ungrouped randomisation:_ Before calculating
other statistics a new diallel table was constructed in which
treatment totals over the three replications were averaged
and the reciprocals were replaced by their common mean,
assuming no significant differences between reciprocals.
This table provided basis for the calculation of various
statistics, such as V_{oLo} (variance of the parents),
V_r (variance of the rth array), W_r (the covariance between the
parents and their offspring in r^{th} array) and W' (the covariance

between the array means and the offspring in r^{th} array)
as proposed by Jinks and Hyman (1955) and Aksel and
Johnson (1963). The uniformity of $W_r - V_r$ was tested
using the following formula:

$$t^2 = \frac{(n-2)}{9} \cdot \frac{(Var. \ V_r - Var. \ W_r)^2}{Var. \ V_r \cdot Var. \ W_r - Cov.^2 \ (V_r, W_r)}, \text{ with } n-2 \text{ as d.f.}$$

The significance of t^2 indicated failure of the
hypothesis.

The (W_r, V_r) graph was drawn taking V_r as the base
line and W_r as the ordinate of the graph according to
the method suggested by Jinks and Hayman (1953). The
observed regression line (W_r, V_r) was drawn using the
expected value of W_r based on the formula $W_r = a+b \ V_r$,
against the actual value of V_r on the (V_r, W_r) graph and
the expected regression line was drawn of unit slope.

The regression coefficient, b, of W_r on V_r, was
calculated as:

$$b = \frac{\text{Covariance of } W_r \text{ and } V_r \text{ values}}{\text{Variance of } V_r \text{ values}}$$

and its standard error, S_b, as per formula given by Smith(1954):

$$S_b = \left\{ \Sigma(y-\bar{y})^2 - b \ \Sigma(x-\bar{x})(y-\bar{y})/(n-2) \ \Sigma(x-\bar{x})^2 \right\}^{\frac{1}{2}}$$

where, $x = V_r$, $y = W_r$ and n is the number of parents.

The 't' value of $(b-0)/S_b$ and $(1-b)/S_b$ with $(n-2)$
degree of freedom from 't' table (Fisher,1938) was
used as a measure for significant deviation of b value

from zero and unity, respectively. Significant deviation
of b from unity, in some cases, indicated presence of
epistasis.

B. Numerical approach:

The following components of variation were calculated
for the analysis of numerical approach.

D : Component of variation due to the additive
effect of genes.

H_1 : Component of variation due to dominance effect
of genes.

h^2 : Dominance effect (as the algebraic sum over
all loci in heterozygous phases in all crosses).

F_r : The covariance of additive and dominance
effects in a single array.

F : The mean of F_r over the arrays.

H_2 : $H_1 (1- (u - v)^2)$

where, u : proportion of positive genes in the parents.

v : proportion of negative genes in the parents,
and where u + v = 1.

The estimates of these components of genetic
variation were determined based on the following formulae
suggested by Hayman (1954 a):

$$\hat{D} = V_{oLo} - \hat{E}$$
$$\hat{F} = 2V_{oLo} - 4W_{oLo1} - 2 (n-2) E/n$$
$$\hat{H}_1 = V_{oLo} - 4W_{oLo1} + 4V_{1L1} - (3n-2) E/n$$

$$\hat{H}_2 = 4V_{1L1} - 4V_{oL1} - 2E$$

$$\hat{h}^2 = 4(M_{L1} - M_{Lo})^2 - 4(n-1) \; E/n^2$$

$$\hat{F}_r = 2(V_{oLo} - V_{oL1} + V_{1L1} - W_r - V_r) - 2(n-2) \; E/n$$

The statistics of the above formulae may be explained as follows:

V_{oLo} : Variance of the parents

V_r : Variance of the rth array

V_{1L1} : Mean variance of the arrays

W_r : The covariance between the parents and their offsprings in the rth array

W_{oLo1} : The mean covariance between the parents and the arrays

V_{oL1} : The variance of the means of the arrays

$M_{L1} - M_{Lo}$: The difference between the mean of the parents and the mean of the n^2 progeny

E : The expected environmental component of variance which is the same as the observed one in the analysis of variance for design.

The procedures followed for the calculation of these statistics and components of variation and their standard errors for ungrouped randomisation methods are is as under:

(1) <u>Ungrouped randomisation</u>: The newly constructed diallel table for the graphical approach was used for the estimation of above mentioned statistics and the components

of variation based on the formulae given above. The
standard errors for the estimates of compoents of variation
(D, H_1, H_2, F, h^2 and E) were calculated by using the
equation, $\frac{1}{2}$ var. $(W_r-V_r) = s^2$ and the term of the main
diagonal of the covariance matrix given by Hayman (1954 $\underline{a}$)
as corresponding multipliers (Appendix I). Consequently,
the standard error for D is SD $= \sqrt{s^2 \times CD}$, for F is
SF $= \sqrt{s^2 \times CF}$ and similarly for other estimates.

After testing the significance of the components
of variation D, F, H_1, H_2 and h^2 the main degree of
dominance was calculated as $(H_1/D)^{\frac{1}{2}}$, the proportion of the
genes with positive and negative effects as $H_2/4H_1$, the
proportion of dominant and recessive genes in the parents
as $(4DH_1)^{\frac{1}{2}} + F/(4DH_1)^{\frac{1}{2}} - F$ and the number of group of genes
which control the character and exhibit dominance as
h^2/H_2. The coefficient of correlation between the parental
order of dominance (W_r+V_r) and parental measurements (y_r)
was calculated to get an idea about the dominance of genes
with positive and negative effects.

(2) **Combining ability analysis:** The combining
ability analysis for different characters was carried out
on the basis of formulae given by Griffing (1956 $\underline{b}$) for the
Method I Model I. In Method I the experimental material
includes parents and their all possible F_1 s both direct

and reciprocals. The Model I is a fixed model in which variety and block effects are constant and the information obtained are applicable to the material under test alone.

The various sum of squares were calculated as follows:

$$S_g = \tfrac{1}{2}p \, \varepsilon_i (X_{.i} + X_{i.})^2 - \tfrac{2}{p^2} (X_{..}^2)$$

$$S_s = \tfrac{1}{2} \varepsilon_i \varepsilon_j x_{ij}(x_{ij} + x_{ji}) - \tfrac{1}{2p} \varepsilon_i (x_{i.} + x_{.i})^2 + \tfrac{1}{p^2} X_{..}^2$$

$$S_r = \tfrac{1}{2} \varepsilon_i \varepsilon_j (x_{ij} - x_{ji})^2$$

Where S_g is the sum of squares due to general combining ability, S_s is the sum of squares due to specific combining ability and S_r is the sum of squares due to reciprocal effects, p is the number of parents, $X_{i.}$ is the row total of the ith array, $X_{.i}$ is the column total of the ith array, x_{ij} is the value of ij^{th} cross and x_{ji} is that of its reciprocal and $X_{..}$ is the grand total of p^2 observations. The relation between these notations can be represented, for example, in an experiment involving three parents as:

$$X_{1.} = \Sigma x_{1j} = x_{11} + x_{12} + x_{13}$$

$$X_{.1} = \Sigma x_{1j} = x_{11} + x_{21} + x_{31}$$

$$X_{..} = \Sigma_i \Sigma_j = x_{11} + x_{12} + x_{13} + x_{21} + x_{22} + x_{23} + x_{31}$$

$$+ x_{32} + x_{33}$$

The analysis of variance table was set up as under:

Sources of variation	d.f.	S.S.	M.S.S.	Expectation of M.S.S.
g.c.a.	p-1	S_g	M_g	$6^2 + 2p(\frac{1}{p-1}) \Sigma g_i^2$
s.c.a.	$\dfrac{p(p-1)}{2}$	S_s	M_s	$6^2 + \frac{2}{p(p-1)} \Sigma_i \Sigma_j s_{ij}^2$
Reciprocal effect	$\dfrac{p(p-1)}{2}$	S_r	M_r	$6^2 + 2(\frac{2}{p(p-1)}) \Sigma_i \Sigma_j r_{ij}^2$
Error	m	S_e	M'_e	6^2

Each mean square was obtained by dividing its sum of squares by the respective degrees of freedom, which the error mean square (M'_e) was obtained by dividing error mean square (M_e) in the analysis of the design of the experiment by the number of replications.

The test for over all differences among the various classes of effects was done as follows:

To test g.c.a. effects $F[(p-1), m] = M_g/M'_e$

To test s.c.a. effects $F[(p(p-1)/2, m] = M_s/M'_e$

To test reciprocal effects $F[(p(p-1)/2, m] = M_r/M'_e$

The estimated components of variances were calculated as follows:

$$\text{g.c.a. components} = \frac{1}{p-1} \sum g_i = \frac{1}{2p}(M_g - M'_e)$$

$$\text{s.c.a. components} = \frac{2}{p(p-1)} \sum_i \sum_j s_{ij}^2 = M_s - M'_e$$

<u>Estimates of various effects:</u> The various effects were estimated as follows:

Population mean $= \hat{u} = \frac{1}{p^2} X_{..}$

g.c.a. effects $= \hat{g}_i = \frac{1}{2p}(X_{i.} + X_{.i}) - \frac{1}{p^2} X_{..}$

s.c.a. effects $= \hat{s}_{ij} = \frac{1}{2}(x_{ij} + x_{ji}) - \frac{1}{2p}(X_{i.} + X_{.i} + X_{.j} + X_{j.}) + \frac{1}{p^2} X_{..}$

Reciprocal effects $= \hat{r}_{ij} = \frac{1}{2}(x_{ij} - x_{ji})$

<u>Standard error of estimates:</u> Standard error of an estimate was calculated as the square root of the variance of the estimate. The variances of the various estimates and their differences were calculated as follows:

The variance of any parent of F_1 mean value is Var $(x_{ij}) = \sigma^2 = M'_e$, and the variance of the difference between any two mean value is:

$$\text{Var} (x_{ij} - x_{kl}) = 2\hat{\sigma}^2$$

$$\text{Var} (\hat{u}) = \frac{1}{p^2} \hat{\sigma}^2$$

$$\text{Var} (\hat{g}_i) = \frac{p-1}{2p^2} \hat{\sigma}^2$$

$$\text{Var} (\hat{s}_{ij}) = \frac{1}{2p^2}(p^2 - 2p + 2)\hat{\sigma}^2 \ (i \neq j)$$

$$\text{Var } (\hat{r}_{ij}) = \frac{1}{p} \hat{\sigma}^2 \quad (i \neq j)$$

$$\text{Var } (\hat{s}_{ij} - \hat{s}_{ik}) = \frac{p-1}{p} \hat{\sigma}^2 \quad (i = j, k; \ j \neq k)$$

$$\text{Var } (\hat{s}_{ij} - \hat{s}_{kl}) = \frac{p-2}{p} \hat{\sigma}^2 \quad (i \neq j, k, l; \ j \neq k, l; k \neq l)$$

<u>Critical difference(C.D.) of estimates:</u> Critical difference was taken as the product of the standard error of the difference of the two estimates and the table 't' value for the error degree of freedom at 5 per cent and 1 per cent level of significance.

(3) <u>Inheritance of qualitative characters:</u> The Chi-square (χ^2) test was used for testing whether the recorded phenotypic observations were in agreement with the expected ratios for 12 qualitative characters **viz.**three for skin colour, two for flesh colour, six for seed colour, one for seed size and one for fruit shape, of the involved watermelon parents, their F_1 and F_2 hybrids and backcross generations. The following was the formula used.

$$\chi^2 = \frac{(O-E)^2}{E}$$

Where O = observed value and E = Expected value. The calculated χ^2 value was compared with the tabulated values at 5 per cent and 1 per cent for the significance.

EXPERIMENTAL RESULTS

There are two sets of experiments for the present investigations in watermelon, Citrulius lanatus (Thunb.) Mansf. The first set of experiments included ten parents and their all possible ninety hybrids, for finding out the extent of hybrid vigour for nine characters, for diallel analysis by graphical and numerical approaches and for evaluating the general and specific combining ability for the parents and their hybrids, including reciprocal effects. The second set of experiments included thirteen layouts for the study of inheritance of thirteen qualitative characters. The observations, thus, recorded for the above are as follows.

1. Hybrid Vigour:

The analysis of variance for nine characters viz., the vine length, the number of days taken to open first female flower, the number of female flowers, the number of fruits, the weight of the fruit, the length of the fruit, the breadth of the fruit, total soluble solids (T.S.S.) and total yield per plant, of the plants under study was done to test the significance of the difference between the treatments (ten parents and their ninety F_1 hybrids) and blocks. The analysis of variance of these characters are presented in Table 3. There was significant difference between treatments for all the nine characters studied. The critical difference values were calculated to test the significance of the hybrids over their parental mean and

TABLE 3

Analysis of variance for the design of experiment to study hybrid vigour of watermelon

Characters	Block			Treatment			Error	
	d.f.	M.S.S.	F	d.f.	M.S.S.	F	d.f.	M.S.S.
Vine length	2	0.0239	0.6349	99	14.4849	384.8273**	198	0.0576
No. of days taken to open first female flower	2	0.0369	0.2964	99	303.3269	2429.1089**	198	0.1244
No. of female flowers	2	0.3602	0.8645	99	263.2895	237.0696**	198	1.1106
No. of fruits	2	2.3132	2.8778	99	127.5566	158.6919**	198	0.8038
Weight of fruit	2	1.0184	2.7341	99	8.2493	22.1457**	198	0.5725
Length of fruit	2	23.3869	4.8182**	99	125.2110	25.798**	198	4.8538
Breadth of fruit	2	22.5879	4.0740*	99	59.6459	10.757**	198	5.5444
T.S.S.	2	0.6475	2.3443	99	3.9796	14.4083**	198	0.2762
Total yield	2	70.1621	1.3576	99	576.7453	11.1599**	198	51.6738

* Significant at 5 per cent level

** Significant at 1 per cent level

over their better parent. Percentage increase or decrease of the hybrids over their parental average and better parent was also calculated and is presented in Tables 4 to 12.

(a) <u>Vine length:</u> The average length of the main shoot in parents varied from 1.25 m (P-5) to 4.56 m (P-10) while it ranged from 2.48 m (C-12 and C-25) to 4.82 m (C-42 and C-45) in their hybrids.

Seventy hybrids recorded increased vine length over their parental average where the increase was from 0.50 to 49.22 per cent and was statistically significant in fifty-nine hybrids only. The maximum average vine length of 4.82 m was recorded in the hybrid C-42 and C-45. One hybrid had the length equal to that of their parental average. In twenty hybrids, however, there was a decrease in the vine length, the reduction was 0.23 to 5.19 per cent, but statistically none was found significant.

The increase in the vine length over their better parents was found in twenty one hybrids which varied from 0.87 to 11.79 per cent and this increase was significant in six hybrids only. In sixty nine hybrids the vine length was reduced than their better parents and the decrease was noticed from 0.22 to 12.75 per cent which was statistically significant in eleven hybrids only. These observations are recorded in Table 4.

TABLE 4

Vine length of watermelon parents and their hybrids during
summer, 1968

Parents/ hybrids	Length of the main shoot (m)	Parental average	Better parent	Percent increase or decrease over	
				Parental average	Better parent
Parents:					
P-1	2.78	-	-	-	-
P-2	2.63	-	-	-	-
P-3	4.24	-	-	-	-
P-4	2.59	-	-	-	-
P-5	1.25	-	-	-	-
P-6	3.20	-	-	-	-
P-7	4.00	-	-	-	-
P-8	3.92	-	-	-	-
P-9	4.05	-	-	-	-
P-10	4.56	-	-	-	-
Hybrids:					
C-1	2.56	2.70	2.78	5.19	7.92
C-1R	2.69	2.70	2.78	0.38	3.24
C-2	4.74	3.51**	4.24**	35.04	11.79
C-2R	4.21	3.51**	4.24**	19.94	0.71
C-3	2.68	2.68	2.78	0.00	3.60
C-3R	2.55	2.68	2.78	4.86	8.28
C-4	2.69	2.01**	2.78	33.83	3.24

C-4R	2.69	2.01**	2.78	33.83	3.24
C-5	3.46	2.99**	3.20	15.71	8.12
C-5R	3.12	2.99	3.20	4.34	2.50
C-6	4.18	3.39**	4.00	23.30	4.50
C-6R	3.98	3.39**	4.00	17.40	0.50
C-7	4.10	3.23**	3.92	26.93	4.59
C-7R	3.90	3.23**	3.92	20.74	0.52
C-8	4.02	3.41**	4.05	17.88	0.75
C-8R	3.95	3.41**	4.05	15.83	2.47
C-9	4.60	3.67**	4.56	25.34	0.87
C-9R	4.31	3.67**	4.56	17.43	5.49
C-10	4.43	3.43**	4.24	29.15	4.48
C-10R	4.09	3.43**	4.24	19.24	5.54
C-11	2.54	2.61	2.63	2.69	3.43
C-11R	2.56	2.61	2.63	1.92	2.67
C-12	2.48	1.94**	2.63	27.83	3.71
C-12R	2.58	1.94**	2.63	32.98	1.91
C-13	3.16	2.91	3.20	8.59	1.25
C-13R	3.11	2.91	3.20	6.87	2.72
C-14	4.35	3.31**	4.00**	31.41	8.75
C-14R	3.99	3.31**	4.00	20.54	0.25

C-15	4.10	3.27**	3.92	25.38	4.59
C-15R	3.98	3.27**	3.92	21.71	1.53
C-16	3.80	3.34**	4.05	13.77	2.18
C-16R	3.71	3.34**	4.05*	11.07	8.40
C-17	4.75	3.59**	4.56	32.31	4.16
C-17R	4.52	3.59**	4.56	25.90	0.88
C-18	4.49	3.41**	4.24	31.67	5.89
C-18R	4.58	3.41**	4.24**	34.31	8.01
C-19	3.83	2.74**	4.24*	39.78	9.67
C-19R	3.91	2.74**	4.24*	42.70	7.79
C-20	4.58	3.72**	4.24**	23.11	8.01
C-20R	4.70	3.72**	4.24**	26.34	10.84
C-21	4.04	4.12	4.24	1.95	4.72
C-21R	4.10	4.12	4.24	0.43	3.31
C-22	4.02	4.08	4.24	1.48	3.19
C-22R	3.92	4.08	4.24*	3.93	7.55
C-23	4.10	4.14	4.24	0.97	3.31
C-23R	4.00	4.14	4.24	3.39	5.67
C-24	4.46	4.40	4.56	1.36	2.20
C-24R	4.39	4.40	4.56	0.23	3.73
C-25	2.48	1.92**	2.59	29.16	4.25
C-25R	2.53	1.92**	2.59	31.77	2.32

C-26	3.16	2.89	3.20	9.34	1.25
C-26R	3.00	2.89	3.20	3.30	6.25
C-27	3.92	3.29**	4.00	19.14	2.00
C-27R	3.88	3.29**	4.00	17.93	3.00
C-28	3.72	3.25**	3.92	14.46	1.11
C-28R	3.80	3.25**	3.92	16.92	3.07
C-29	3.93	3.32**	4.05	18.37	2.97
C-29R	3.83	3.32**	4.05	15.36	5.44
C-30	4.70	3.57**	4.56	31.65	3.07
C-30R	4.55	3.57**	4.56	27.45	0.22
C-31	3.18	2.22**	3.20	43.24	0.63
C-31R	2.99	2.22**	3.20	34.68	6.57
C-32	3.55	2.62**	4.00*	35.49	11.25
C-32R	3.49	2.62**	4.00*	33.20	12.75
C-33	3.68	2.58**	3.92	42.63	6.13
C-33R	3.85	2.58**	3.92	49.22	1.79
C-34	3.81	2.65**	4.05	43.77	5.93
C-34R	3.73	2.65**	4.05*	40.75	7.91
C-35	4.30	2.90**	4.56	48.27	5.71
C-35R	4.18	2.90**	4.56*	44.13	8.34
C-36	4.12	3.60**	4.00	14.44	3.00

C-36R	3.95	3.60**	4.00	9.72	1.25
C-37	3.50	3.56	3.92*	1.69	10.72
C-37R	3.53	3.56	3.92*	0.85	9.95
C-38	3.60	3.62	4.05*	0.56	11.12
C-38R	3.79	3.62	4.05	4.69	6.42
C-39	4.78	3.88**	4.56	23.19	4.82
C-39R	4.67	3.88**	4.56	20.36	2.41
C-40	3.91	3.96	4.00	1.27	2.25
C-40R	3.99	3.96	4.00	0.75	0.25
C-41	4.00	4.02	4.05	0.50	1.24
C-41R	3.91	4.02	4.05	2.74	3.46
C-42	4.82	4.28**	4.56	12.61	5.70
C-42R	4.50	4.28**	4.56	5.14	1.32
C-43	4.00	3.98	4.05	0.50	1.24
C-43R	3.97	3.98	4.05	0.26	1.98
C-44	4.70	4.24**	4.56	10.84	3.07
C-44R	4.49	4.24	4.56	5.89	1.54
C-45	4.82	4.30**	4.56	12.09	5.70
C-45R	4.51	4.30	4.5	4.88	1.10

*Hybrids significantly inferior at 5 per cent level over the parental average/better parent.
**Hybrids significantly superior at 5 per cent level over the parental average/better parent.

(b) <u>Number of days taken to open the first female flower</u>: A minimum and maximum average of 46.35 and 78.21 days for appearance of first female flower was found in P-5 and P-3 respectively. In hybrids number of days taken varied from 38.14 in C-31R to 76.24 in C-2.

Most of the hybrids took fewer days to open the first female flower as compared to their parental average. Sixty seven hybrids had flowered earlier as compared to their parental average and the reduction in the number of days varied from 0.19 to 24.61 per cent, but it was statistically significant in sixty six hybrids.

In twenty three hybrids there was an increase in the number of days to open their first female flower over their parental average and the increase varied from 0.10 to 2.89 per cent. Eighteen hybrids were statistically significant in late maturing.

In case of forty one hybrids early flowering was observed but the results were significant in thirty nine cases only. The reduction in the number of days to open the first female flower ranged from 0.15 to 17.72 per cent. In forty nine hybrids as compared to their earlier parents, the number of days was increased and significant increase was observed in thirty five hybrids. The percentage of increase ranged from 0.65 to 9.29 per cent. These observations are recorded in Table 5.

TABLE 5

Number of days taken to open first female flower in watermelon parents and their hybrids during summer, 1968

Parents/ hybrids	No.of days taken for appearance of Ist female flower	Parental average $H \cdot P \cdot$	Better Parent $B \cdot P \cdot$	Percent increase or decrease over	
				Parental average	Better Parent
Parents:					
P-1	72.15	-	-	-	-
P-2	68.25	-	-	-	-
P-3	78.21	-	-	-	-
P-4	59.45	-	-	-	-
P-5	46.35	-	-	-	-
P-6	52.41	-	-	-	-
P-7	62.43	-	-	-	-
P-8	66.42	-	-	-	-
P-9	55.62	-	-	-	-
P-10	67.45	-	-	-	-
Hybrids:					
C-1	71.15	70.20*	68.25*	1.35	4.24
C-1R	70.65	70.20*	68.25*	0.64	3.51
C-2	76.24	75.18*	72.15*	1.40	5.66
C-2R	75.85	75.18*	72.15*	0.89	5.12
C-3	56.14	65.80**	59.45**	14.69	5.57

C-3R	59.94	65.80**	59.45	8.91	0.82
C-4	46.54	59.25**	46.35	21.46	0.40
C-4R	47.22	59.25**	46.35*	20.32	1.87
C-5	49.35	62.28**	52.41**	20.77	5.84
C-5R	52.80	62.28**	52.41	15.23	0.74
C-6	68.29	67.31*	62.48*	1.45	9.29
C-6R	66.36	67.31**	62.48*	1.42	6.20
C-7	70.16	69.28*	66.42*	1.27	5.63
C-7R	68.41	69.28**	66.42*	1.26	2.99
C-8	51.22	63.88**	55.62**	19.82	7.92
C-8R	53.42	63.88**	55.62**	16.38	3.96
C-9	69.98	69.80*	67.46*	0.25	3.73
C-9R	70.42	69.80*	67.46*	0.88	4.38
C-10	71.48	73.23**	68.25*	2.39	4.73
C-10R	73.96	73.23*	68.25*	0.99	8.36
C-11	50.33	63.85**	59.45**	21.18	15.35
C-11R	52.60	63.85**	59.45**	17.62	11.53
C-12	43.20	57.30**	46.35**	24.61	6.80
C-12R	46.44	57.30**	46.35	18.96	0.19
C-13	48.56	60.33**	52.41**	19.51	7.35
C-13R	51.45	60.33**	52.41**	14.72	1.84
C-14	65.48	65.36	62.48*	0.18	4.80

C-14R	62.39	65.36**	62.48	4.55	0.15
C-15	67.87	67.33*	66.42*	0.80	2.18
C-15R	65.95	67.33**	66.42	2.05	0.71
C-16	50.13	61.93**	55.62**	19.06	9.88
C-16R	53.10	61.93**	55.62**	14.26	4.54
C-17	68.19	67.85	67.46*	0.50	1.08
C-17R	67.92	67.85	67.46	0.10	0.68
C-18	54.35	68.83**	59.45**	21.04	8.58
C-18R	56.43	68.83**	59.45**	18.02	5.08
C-19	50.53	62.28**	46.35*	18.87	9.01
C-19R	48.38	62.28**	46.35*	22.32	4.31
C-20	54.22	65.31**	52.41*	16.99	3.45
C-20R	52.50	65.31**	52.41	19.62	0.17
C-21	65.24	70.34**	62.48*	7.26	4.41
C-21R	63.49	70.34**	62.48*	9.74	1.61
C-22	72.52	72.31	66.42*	0.29	9.18
C-22R	70.58	72.31**	66.42*	2.40	6.26
C-23	53.24	66.91**	55.62**	20.44	4.28
C-23R	55.94	66.91**	55.62	16.34	0.64
C-24	73.30	72.83	67.46*	0.64	8.65
C-24R	70.40	72.83**	67.46*	3.34	4.35

C-25	41.63	52.90**	46.35**	21.31	10.19
C-25R	40.95	52.90**	46.35**	22.59	11.66
C-26	43.82	55.93**	52.41**	21.66	16.40
C-26R	45.56	55.93**	52.41**	18.55	13.08
C-27	61.74	60.96*	59.45*	1.27	3.85
C-27R	60.85	60.96	59.45*	0.19	2.35
C-28	56.54	62.93**	59.45**	10.16	4.90
C-28R	54.65	62.93**	59.45**	13.16	8.08
C-29	46.75	57.53**	55.62**	18.74	15.95
C-29R	47.86	57.53**	55.62**	16.81	13.96
C-30	59.86	63.45**	59.45**	5.66	0.68
C-30R	56.95	63.45**	59.45	10.25	4.21
C-31	40.44	49.38**	46.35**	18.11	12.76
C-31R	38.14	49.38**	46.35**	22.77	17.22
C-32	46.64	54.41**	46.35**	14.29	0.62
C-32R	43.18	54.41**	46.35	20.64	6.84
C-33	46.57	56.38**	46.35	17.40	0.47
C-33R	44.53	56.38**	46.35**	21.02	3.93
C-34	46.92	50.98**	46.35*	7.97	1.22
C-34R	44.90	50.98**	46.35**	11.93	3.13
C-35	46.54	56.90**	46.35	18.21	0.40
C-35R	44.27	56.90**	46.35**	22.20	4.49

C-36	50.19	57.44**	52.41**	12.63	4.24
C-36R	48.33	57.44**	52.41**	15.87	7.79
C-37	52.64	59.41**	52.41	11.40	0.43
C-37R	50.36	59.41**	52.41**	15.24	3.92
C-38	54.88	54.01*	52.41*	1.61	4.71
C-38R	52.62	54.01**	52.41	2.58	0.40
C-39	50.28	59.93**	52.41**	16.11	4.07
C-39R	50.28	59.93**	52.41**	16.11	4.07
C-40	65.68	64.45*	62.48*	1.90	5.12
C-40R	65.86	64.45*	62.48*	2.10	5.40
C-41	52.21	59.05**	55.62**	11.59	6.14
C-41R	55.65	59.05**	55.62	5.76	0.05
C-42	65.95	64.97*	62.48*	1.50	5.55
C-42R	66.85	64.97*	62.48*	2.89	6.99
C-43	50.65	61.02**	55.62**	17.00	8.94
C-43R	52.83	61.02**	55.62**	13.43	5.02
C-44	67.98	66.94*	66.42*	1.55	2.34
C-44R	68.36	66.94*	66.42*	2.12	2.92
C-45	54.86	61.54**	55.62**	10.86	1.37
C-45R	52.45	61.54**	55.62**	14.78	3.70

*Hybrids significantly lower at 5 per cent level over the parental average/better parent.

**Hybrids significantly higher at 5 per cent level over the parental average/better parent.

(c) <u>The number of female flowers:</u> The number of female flowers are important in view of their effect on the number of fruits produced by the plants. The average number of female flowers in parents varied from 32.48 in P-5 to 68.15 in P-3 per plant. In hybrids it ranged from 40.38 in C-25 to 79.54 in C-39 as presented in Table 6.

In sixty seven hybrids there was an increase in the number of female flowers over their parental average and this increase varied from 0.20 to 54.27 per cent and was statistically significant in sixty five hybrids only. In twenty three hybrids, however, there was a decrease in the number of female flowers which varied from 0.08 to 11.90 per cent and was statistically significant in five hybrids only.

In case of forty hybrids there was an increase in the number of female flowers over their better parent. This increase was from 1.20 to 26.84 per cent and was statistically significant in thirty eight hybrids only. In fifty hybrids there was a decrease in the number of female flowers over their better parent, the decrease was from 0.08 to 18.51 per cent and was statistically significant in thirty three hybrids.

(d) <u>The number of fruits:</u> The number of fruits per plant in parents varied from 5.80 in P-1 to 13.63 in

TABLE 6

Number of female flowers per plant in watermelon parents
and their hybrids during summer, 1968

Parents/ hybrids	No.of female flowers	Parental average	Better parent	Percent increase or decrease over	
				Parental average	Better parent
Parents:					
P-1	56.25	-	-	-	-
P-2	47.33	-	-	-	-
P-3	68.15	-	-	-	-
P-4	42.36	-	-	-	-
P-5	32.48	-	-	-	-
P-6	65.29	-	-	-	-
P-7	47.54	-	-	-	-
P-8	55.74	-	-	-	-
P-9	50.64	-	-	-	-
P-10	62.83	-	-	-	-
Hybrids:					
C-1	51.15	51.79	56.25*	1.24	9.07
C-1R	53.37	51.79**	56.25*	3.05	5.12
C-2	71.21	62.20**	68.15**	14.48	4.49
C-2R	68.00	62.20**	68.15	9.32	0.23
C-3	51.47	49.30**	56.25*	4.40	8.50
C-3R	53.63	49.30**	56.25*	8.78	4.66

C-4	45.84	44.36**	56.25*	3.33	18.51
C-4R	54.38	44.36**	56.25*	22.58	3.33
C-5	68.41	60.77**	65.29**	12.57	4.77
C-5R	65.17	60.77**	65.29	7.24	0.19
C-6	63.58	51.89**	56.25**	22.52	13.03
C-6R	62.46	51.89**	56.25**	20.37	11.04
C-7	68.26	55.99**	56.25**	21.91	21.35
C-7R	65.19	55.99**	56.25**	16.43	15.89
C-8	62.34	53.44**	56.25**	16.65	10.82
C-8R	60.85	53.44**	56.25**	13.86	8.17
C-9	75.47	59.54**	62.83**	26.75	20.11
C-9R	72.64	59.54**	62.83**	22.00	15.61
C-10	70.36	57.74**	68.15**	21.85	3.24
C-10R	68.10	57.74**	68.15	17.94	0.08
C-11	44.47	44.84	47.33*	0.83	6.05
C-11R	43.95	44.84	47.33*	1.99	7.15
C-12	53.55	39.90**	47.33**	34.21	13.14
C-12R	55.64	39.90**	47.33**	39.44	17.55
C-13	65.14	56.31**	65.29	15.64	0.23
C-13R	63.82	56.31**	65.29	13.33	2.26
C-14	60.30	47.43**	47.54**	27.13	26.84

C-14R	58.42	47.43**	47.54**	23.27	22.88
C-15	63.25	51.53**	55.74**	22.74	13.47
C-15R	60.98	51.53**	55.74**	18.33	9.40
C-16	48.36	48.98	50.64*	1.27	4.51
C-16R	48.66	48.98	50.64*	0.66	3.91
C-17	65.38	55.08**	62.83**	13.70	4.05
C-17R	62.40	55.08**	62.83	13.28	0.69
C-18	70.28	55.25**	68.15**	27.20	3.12
C-18R	73.19	55.25**	68.15**	32.47	7.39
C-19	60.65	50.31**	68.15*	20.55	11.01
C-19R	63.88	50.31**	68.15*	26.97	6.27
C-20	72.21	66.72**	68.15**	8.22	5.95
C-20R	75.31	66.72**	68.15**	12.87	10.50
C-21	57.60	57.84	68.15*	0.42	15.49
C-21R	57.75	57.84	68.15*	0 14	15.25
C-22	61.75	61.94	68.15*	0.31	9.40
C-22R	60.86	61.94	68.15*	1.75	10.70
C-23	59.52	59.39	68.15*	0.20	12.67
C-23R	58.67	59.39	68.15*	1.22	13.92
C-24	65.20	65.49	68.15*	0.45	4.33
C-24R	64.30	65.49	68.15*	1.82	5.65
C-25	40.38	37.42**	42.36*	7.91	4.68

C-25R	43.27	37.42**	42.36	15.63	2.14
C-26	65.16	53.82**	65.29	21.07	0.20
C-26R	64.56	53.82**	65.29	19.95	1.12
C-27	47.43	44.95**	47.54	5.51	0.24
C-27R	46.86	44.95**	47.54	4.24	1.44
C-28	55.42	49.55**	55.74	11.84	0.58
C-28R	54.46	49.55**	55.74	9.90	2.30
C-29	49.30	46.50**	50.64	6.02	2.65
C-29R	48.99	46.50**	50.64	5.35	3.26
C-30	69.50	52.59**	62.83**	32.15	10.61
C-30R	68.54	52.59**	62.83**	30.32	9.08
C-31	75.41	48.88**	65.29**	54.27	15.50
C-31R	72.30	48.88**	65.29**	47.91	10.73
C-32	52.59	40.01**	47.54**	31.44	10.62
C-32R	49.38	40.01**	47.54**	23.41	3.87
C-33	60.85	44.11**	55.74**	37.95	9.16
C-33R	56.41	44.11**	55.74	27.88	1.20
C-34	60.48	41.56**	50.64**	45.52	19.43
C-34R	58.26	41.56**	50.64**	40.18	15.04
C-35	70.46	47.65**	62.83**	47.86	12.14
C-35R	68.42	47.65**	62.83**	43.56	8.89
C-36	56.37	56.41	65.29*	0.08	13.67
C-36R	55.96	56.41	65.29*	0.80	14.30
C-37	58.30	60.51*	65.29*	3.66	10.71

C-37R	59.21	60.51	65.29*	2.15	9.32
C-38	57.58	57.96	65.29*	0.66	11.81
C-38R	56.40	57.96*	65.29*	2.70	13.62
C-39	79.54	64.06**	65.29**	24.16	21.82
C-39R	76.65	64.06**	65.29**	19.65	17.39
C-40	46.53	46.64	55.74*	0.24	16.53
C-40R	47.16	46.64	55.74*	1.11	15.40
C-41	43.30	49.09*	50.64*	11.80	14.50
C-41R	46.40	49.09*	50.64*	5.48	8.38
C-42	65.41	55.18**	62.83**	18.53	4.10
C-42R	62.22	55.18**	62.83	12.75	0.98
C-43	52.52	53.19	55.74*	1.26	5.78
C-43R	49.95	53.19*	55.74*	6.10	10.39
C-44	66.40	59.28**	62.83**	12.01	5.68
C-44R	61.52	59.28**	62.83	3.77	2.09
C-45	65.54	56.73**	62.83**	15.52	4.31
C-45R	62.40	56.73**	62.83	9.99	0.69

*Hybrids significantly inferior at 5 per cent level over the parental average/better parent.

**Hybrids significantly superior at 5 per cent level over the parental average/better parent.

P-6, while in hybrids it varied from 6.62 (C-1) to 16.66 (C-31) as presented in Table 7.

The increase in the number of fruits over their parental average was recorded in seventy one hybrids and the increase varied from 0.52 to 53.23 per cent; however, it was statistically significant in forty four hybrids only. Nineteen hybrids were inferior over the parental mean and varied from 0.30 to 10.25 per cent, but statistically none was significant.

An increase in the number of fruits over their better parent was found in forty hybrids which varied from 0.21 to 41.83 per cent and significant increase was, however, observed in eighteen hybrids only. The decrease in the number of fruits in hybrids were also observed over their better parent, thus the decrease was in fifty hybrids which varied from 0.11 to 15.93 per cent, however, fifteen hybrids were statistically significant.

In general, the number of fruits in hybrids was higher than the parents and since it is an important character for higher yield, it indicates the usefulness of the hybrids for better yield.

(e) Weight of the fruit: The average weight of the fruit in parents varied from 1.250 kg in P-5 to S.422 kg in P-3, while the weight of fruit in hybrids

TABLE 7

Number of fruits per plant of watermelon parents and their
hybrids during summer, 1968

Parents/ hybrids	No.of fruits per plant	Parental average	Better parent	Percent increase or decrease over	
				Parental average	Better parent
Parents:					
P-1	5.80	-	-	-	-
P-2	7.65	-	-	-	-
P-3	8.25	-	-	-	-
P-4	9.43	-	-	-	-
P-5	10.57	-	-	-	-
P-6	13.63	-	-	-	-
P-7	7.33	-	-	-	-
P-8	9.55	-	-	-	-
P-9	11.35	-	-	-	-
P-10	8.74	-	-	-	-
Hybrids:					
C-1	6.62	6.72	7.65	1.49	13.47
C-1R	6.70	6.72	7.65	0.30	12.42
C-2	8.85	7.02**	8.25	26.06	7.27
C-2R	8.72	7.02**	8.25	17.80	5.69
C-3	8.52	7.61	9.43	11.95	9.66
C-3R	8.66	7.61	9.43	13.79	9.17

C-4	9.90	8.18**	10.57	21.02	6.34
C-4R	9.75	8.18**	10.57	19.19	7.76
C-5	12.46	9.71**	13.63	28.32	9.59
C-5R	11.92	9.71**	13.63*	22.76	12.55
C-6	8.88	6.56**	7.33**	35.36	21.14
C-6R	8.65	6.56**	7.33	31.85	18.00
C-7	9.53	7.67**	9.55	24.25	0.21
C-7R	9.47	7.67**	9.55	23.46	0.84
C-8	11.52	8.57**	11.35	34.42	1.49
C-8R	11.42	8.57**	11.35	33.25	0.61
C-9	11.14	7.27**	8.74**	53.23	27.31
C-9R	10.80	7.27**	8.74**	48.55	23.56
C-10	10.47	7.95**	8.25**	31.69	26.90
C-10R	10.14	7.95**	8.25**	27.54	22.90
C-11	8.46	8.54	9.43	0.94	10.29
C-11R	8.17	8.54	9.43	4.34	13.37
C-12	11.65	9.11**	10.57	27.88	10.21
C-12R	11.41	9.11**	10.57	25.24	7.94
C-13	12.12	10.64**	13.63*	13.90	11.08
C-13R	12.30	10.64**	13.63	15.60	9.76
C-14	10.85	7.49**	7.65**	44.85	41.83
C-14R	10.13	7.49**	7.65**	35.24	32.41

C-15	10.13	8.60**	9.55	17.79	6.07
C-15R	9.84	8.60	9.55	14.41	3.03
C-16	10.42	9.50	11.35	9.68	8.20
C-16R	10.21	9.50	11.35	7.47	10.05
C-17	10.15	8.19**	8.74	23.93	16.13
C-17R	9.95	8.19**	8.74	21.48	13.84
C-18	9.65	8.84	9.43	9.16	2.33
C-18R	9.45	8.84	9.43	6.90	0.21
C-19	10.35	9.41	10.57	9.98	2.09
C-19R	9.98	9.41	10.57	6.05	5.59
C-20	12.29	10.94**	13.63	12.34	9.84
C-20R	12.98	10.94**	13.63	18.64	4.77
C-21	7.66	7.79	8.25	1.67	7.16
C-21R	7.58	7.79	8.24	2.70	8.13
C-22	8.65	8.90	9.55	2.81	9.43
C-22R	8.50	8.90	9.55	4.50	11.00
C-23	9.75	9.80	11.35*	0.52	14.10
C-23R	9.61	9.80	11.35*	1.94	15.34
C-24	7.62	8.49	8.74	10.25	12.82
C-24R	7.90	8.49	8.74	6.95	9.62
C-25	10.52	10.00	10.57	5.20	0.48
C-25R	10.38	10.00	10.57	3.80	1.80
C-26	12.00	11.53	13.63*	4.07	11.96

C-26R	11.74	11.53	13.63*	1.82	13.87
C-27	9.12	8.38	9.43	8.83	3.29
C-27R	8.94	8.38	9.43	6.65	5.20
C-28	9.82	9.49	9.55	3.47	2.82
C-29R	9.54	9.49	9.55	0.52	0.11
C-29	11.17	10.39	11.35	7.50	1.59
C-29R	10.85	10.39	11.35	4.42	4.41
C-30	13.13	9.08**	9.43**	44.60	39.23
C-30R	12.89	9.08**	9.43**	41.95	36.69
C-31	16.66	12.10**	13.63**	37.68	22.23
C-31R	15.86	12.10**	13.63**	31.07	16.36
C-32	13.36	8.95**	10.57**	49.27	26.39
C-32R	12.98	8.95**	10.57**	45.02	22.80
C-33	11.68	10.01**	10.57	16.68	10.50
C-33R	11.12	10.01	10.57	11.08	5.20
C-34	14.33	10.96**	11.35**	30.74	26.25
C-34R	13.96	10.96**	11.35**	27.37	22.99
C-35	14.16	9.65**	10.57**	46.73	33.96
C-35R	13.76	9.65**	10.57**	42.59	30.17
C-36	11.68	10.48	13.63*	11.45	14.31
C-36R	11.55	10.48	13.63*	10.20	15.27
C-37	11.46	11.59	13.63*	1.13	15.93

C-37R	11.54	11.59	13.63*	0.44	15.34
C-38	12.12	12.49	13.63*	2.97	11.08
C-38R	11.98	12.49	13.63*	4.09	12.11
C-39	15.23	11.18**	13.63**	36.22	11.73
C-39R	14.81	11.18**	13.63	32.46	8.65
C-40	8.07	8.44	9.55*	4.39	15.50
C-40R	8.26	8.44	9.55	2.14	13.51
C-41	9.68	9.34	11.35*	3.64	14.72
C-41R	9.58	9.34	11.35*	2.56	15.60
C-42	9.45	8.03**	8.74	17.68	8.12
C-42R	8.66	8.03	8.74	7.84	0.92
C-43	10.61	10.45	11.35	1.53	6.52
C-43R	9.92	10.45	11.35	5.08	12.60
C-44	10.86	9.14**	9.55	18.81	13.71
C-44R	9.94	9.14	9.55	8.75	4.08
C-45	12.24	10.04**	11.35	21.91	7.84
C-45R	11.88	10.04**	11.35	18.32	4.66

*Hybrids significantly lower at 5 per cent level over the parental average/better parent.

**Hybrids significantly superior at 5 per cent level over the parental average/better parent.

TABLE 8

Average fruit weight of watermelon parents and their hybrids
during summer, 1968

Parents/ hybrids	Average weight of fruit (kg)	Parental average	Better parent	Percent increase or decrease over	
				Parental average	Better parent
Parents:					
P-1	7.161	-	-	-	-
P-2	6.502	-	-	-	-
P-3	8.422	-	-	-	-
P-4	4.347	-	-	-	-
P-5	1.250	-	-	-	-
P-6	2.856	-	-	-	-
P-7	5.155	-	-	-	-
P-8	4.302	-	-	-	-
P-9	3.266	-	-	-	-
P-10	5.410	-	-	-	-
Hybrids:					
C-1	6.565	6.831	7.161	3.90	8.33
C-1R	6.425	6.831	7.161	5.95	10.28
C-2	9.620	7.791**	8.422**	23.47	14.22
C-2R	9.344	7.791**	8.422	19.93	10.94
C-3	6.610	5.754	7.161	14.87	7.70
C-3R	6.556	5.754	7.161	13.93	8.45
C-4	5.650	4.205**	7.161*	34.36	21.11

C-4R	4.150	4.205	7.161*	1.31	42.05
C-5	6.384	5.008**	7.161*	27.47	10.85
C-5R	4.848	5.008	7.161*	3.20	32.30
C-6	7.116	6.158**	7.161	15.55	0.63
C-6R	7.280	6.158**	7.161	18.22	1.66
C-7	7.105	5.731**	7.161	23.97	0.79
C-7R	6.890	5.731**	7.161	20.22	3.79
C-8	6.270	5.213**	7.161	20.27	12.45
C-8R	5.933	5.213	7.161*	13.81	17.15
C-9	7.110	6.285	7.161	13.12	0.72
C-9R	6.950	6.285	7.161	10.58	2.95
C-10	7.925	7.462	8.422	6.20	5.91
C-10R	8.105	7.462	8.422	8.61	3.77
C-11	5.708	5.424	6.502	5.23	12.22
C-11R	5.853	5.424	6.502	7.90	9.99
C-12	4.925	3.876**	6.502*	27.06	24.26
C-12R	3.000	3.876	6.502*	22.60	53.86
C-13	6.262	4.669**	6.502	34.11	3.68
C-13R	4.476	4.669	6.502*	4.13	31.15
C-14	7.450	5.828**	6.502	27.83	14.58
C-14R	7.560	5.828**	6.502**	29.79	16.27
C-15	6.950	5.402**	6.502	28.65	6.89

C-15R	7.110	5.402**	6.502	31.61	9.35
C-16	5.450	4.884	6.502*	11.58	16.18
C-16R	5.507	4.884	6.502*	12.75	15.31
C-17	7.148	5.956**	6.502	20.01	9.93
C-17R	7.246	5.956**	6.502	21.65	11.44
C-18	7.126	6.384	8.422*	11.62	15.39
C-18R	6.964	6.384	8.422*	9.08	17.32
C-19	6.105	4.836**	8.422*	26.24	27.52
C-19R	4.524	4.836	8.422*	6.45	46.28
C-20	7.832	5.639*	8.422	38.88	7.00
C-20R	5.940	5.639	8.422*	5.33	29.48
C-21	7.353	6.788	8.422*	8.32	12.70
C-21R	7.433	6.788	8.422*	9.50	11.75
C-22	7.079	6.362	8.422*	11.27	15.95
C-22R	7.155	6.362	8.422*	12.46	15.05
C-23	6.125	5.844	8.422*	4.80	27.28
C-23R	6.264	5.844	8.422*	7.18	25.63
C-24	8.245	6.916**	8.422	19.21	2.11
C-24R	8.450	6.916**	8.422	22.18	0.33
C-25	3.505	2.798	4.347	25.26	19.37
C-25R	3.623	2.798	4.347	29.48	16.66
C-26	3.935	3.601	4.347	9.27	9.48
C-26R	4.112	3.601	4.347	14.19	5.41
C-27	5.396	4.751	5.155	13.57	4.67

C-27R	5.142	4.751	5.155	8.22	0.26
C-28	3.941	4.324	4.347	8.86	9.34
C-28R	3.887	4.324	4.347	10.11	10.59
C-29	4.282	3.806	4.347	12.50	1.50
C-29R	4.405	3.806	4.347	15.73	1.33
C-30	5.634	4.878	5.410	15.49	4.14
C-30R	5.395	4.878	5.410	10.59	0.28
C-31	2.591	2.053	2.856	26.20	9.28
C-31R	2.606	2.053	2.856	26.93	8.76
C-32	3.505	3.202	5.155*	9.46	32.01
C-32R	4.986	3.202**	5.155	55.71	3.27
C-33	3.486	2.776	4.302	25.57	18.97
C-33R	3.508	2.776	4.302	26.36	18.46
C-34	2.924	2.258	3.266	29.49	10.48
C-34R	2.814	2.258	3.266	24.62	13.84
C-35	3.680	3.330	5.410*	10.51	31.98
C-35R	5.100	3.330**	5.410	53.15	5.73
C-36	4.428	4.005	5.155	10.56	14.11
C-36R	4.206	4.005	5.155	5.01	18.41
C-37	3.733	3.579	4.302	4.30	13.23
C-37R	3.480	3.579	4.302	2.77	19.11
C-38	2.885	3.061	3.266	5.75	11.67

C-38R	3.133	3.061	3.266	2.35	4.08
C-39	3.951	4.133	5.410*	4.41	26.97
C-39R	4.360	4.133	5.410*	5.49	19.41
C-40	5.000	4.728	5.155	5.75	3.01
C-40R	5.328	4.728	5.155	12.69	3.35
C-41	4.825	4.210	5.155	14.60	6.41
C-41R	5.238	4.210	5.155	24.41	1.61
C-42	4.966	5.282	5.410	5.99	8.21
C-42R	4.894	5.282	5.410	7.35	9.54
C-43	4.158	3.784	4.302	9.88	3.35
C-43 R	4.110	3.784	4.302	8.61	4.47
C-44	5.612	4.856	5.410	15.56	3.73
C-44R	5.390	4.856	5.410	10.99	0.37
C-45	4.430	4.338	5.410	2.12	18.12
C-45R	4.530	4.338	5.410	4.42	16.27

*Hybrids significantly inferior at 5 per cent level over the parental average/better parent.

**Hybrids significantly superior at 5 per cent level over the parental average/better parent.

ranged from 2.591 kg in C-31 to 9.620 kg in C-2. Out of ninety hybrids, seventy six hybrids showed an increase in the weight of their fruits over their parental average and it ranged from 2.12 to 55.71 per cent, but it was statistically significant in twenty two hybrids only. Fourteen hybrids decreased the average fruit weight over their parental mean and the decrease varied from 1.31 to 22.60 per cent and one hybrid was statistically significant.

The increase in the fruit weight in hybrids over their better parent was also recorded. Sixteen hybrids increased fruit weight over their better parent and the increase was from 0.33 to 15.27 per cent. This was, however, significant in two hybrids only. Seventy four hybrids had lower fruit weight than their better parent and the decrease ranged from 0.26 to 53.86 per cent and was statistically significant in twenty five hybrids. The data recorded are presented in Table 8.

(f) _Length of the fruit_: The length of the fruits of the parents varied from 16.20 cm in P-5 to 45.00 cm in P-3 and it ranged from 18.42 (C-31) to 48.19 (C-2) in hybrids.

An increase in the length of the fruits over their parental average was recorded in sixty three hybrids, the increase ranging from 0.07 to 29.21 per cent and this increase

TABLE 9

Average length of fruit of watermelon parents and their hybrids
during summer, 1968

Parents/ hybrids	Average length of fruit (cm)	Parental average	Better parent	Percent increase or decrease over	
				Parental average	Better parent
Parents:					
P-1	40.50	-	-	-	-
P-2	28.50	-	-	-	-
P-3	45.00	-	-	-	-
P-4	25.10	-	-	-	-
P-5	16.20	-	-	-	-
P-6	20.50	-	-	-	-
P-7	27.50	-	-	-	-
P-8	24.42	-	-	-	-
P-9	22.32	-	-	-	-
P-10	29.50	-	-	-	-
Hybrids:					
C-1	35.68	34.50**	40.50*	3.42	11.91
C-1R	34.18	34.50	40.50*	0.92	15.61
C-2	48.19	42.75**	45.00**	12.72	7.08
C-2R	43.30	42.75	45.00*	1.28	3.78
C-3	32.00	32.80*	40.50*	2.43	20.99
C-3R	31.60	32.80*	40.50*	3.65	21.98
C-4	32.18	28.55**	40.50*	13.50	20.55

C-4R	23.00	28.35*	40.50*	18.87	43.22
C-5	36.28	30.50**	40.50*	18.95	10.42
C-5R	29.29	30.50*	40.50*	3.96	27.68
C-6	35.12	34.00**	40.50*	3.29	13.29
C-6R	34.68	34.00	40.50*	2.00	14.38
C-7	35.54	32.46**	40.50*	9.48	12.25
C-7R	32.61	32.46	40.50*	0.46	19.49
C-8	35.24	31.41**	40.50*	12.19	12.99
C-8R	30.45	31.41*	40.50*	3.05	24.82
C-9	39.75	35.00**	40.50	13.57	1.86
C-9R	35.62	35.00**	40.50*	1.77	12.05
C-10	36.42	36.75	45.00*	0.89	19.07
C-10R	40.61	36.75**	45.00*	10.50	9.76
C-11	26.82	26.80	28.50*	0.07	5.90
C-11R	30.68	26.80**	28.50**	14.47	7.64
C-12	25.50	22.35**	28.50*	14.09	10.53
C-12R	21.16	22.35*	28.50*	5.32	25.74
C-13	26.42	24.50**	28.50*	7.83	7.30
C-13R	26.47	24.50**	28.50*	8.04	7.13
C-14	34.00	28.00**	28.50**	21.42	19.29
C-14R	36.18	28.00**	28.50**	29.21	26.94
C-15	29.46	26.46**	28.50	11.33	3.36

C-15R	30.28	26.46**	28.50**	14.43	6.24
C-16	25.95	25.41**	28.50*	2.12	8.95
C-16R	28.30	25.41**	28.50*	11.37	0.71
C-17	34.24	29.00**	29.50**	18.06	16.06
C-17R	36.82	29.00**	29.50**	26.96	24.81
C-18	36.26	35.05**	45.00*	3.45	19.47
C-18R	32.45	35.05*	45.00*	7.41	27.88
C-19	30.82	30.60	45.00*	0.71	31.51
C-19R	25.18	30.60*	45.00*	17.71	44.04
C-20	35.48	32.75**	45.00*	8.33	21.15
C-20R	30.26	32.75*	45.00*	7.60	32.75
C-21	36.67	36.25	45.00*	1.15	18.51
C-21R	32.74	36.25*	45.00*	9.69	27.24
C-22	34.52	34.71	45.00*	0.54	23.29
C-22R	30.86	34.71*	45.00*	11.09	31.42
C-23	36.87	33.66**	45.00*	9.53	18.06
C-23R	28.14	33.66*	45.00*	16.39	37.46
C-24	40.32	37.25**	45.00*	8.24	10.40
C-24R	39.12	37.25**	45.00*	5.02	13.06
C-25	22.67	20.65**	25.10*	9.78	9.68
C-25R	19.86	20.65*	25.10*	3.82	20.87
C-26	24.51	22.80**	25.10	7.50	2.35

C-26R	25.76	22.80**	25.10	12.93	2.64
C-27	29.45	26.30**	27.50**	11.97	7.09
C-27R	26.82	26.30**	27.50	1.97	2.64
C-28	23.38	24.76*	25.10*	5.57	6.85
C-28R	21.46	24.76*	25.10*	13.32	14.50
C-29	24.36	23.71**	25.10	2.74	2.94
C-29R	26.24	23.71**	25.10**	10.67	4.54
C-30	30.54	27.30**	29.50	11.86	3.52
C-30R	28.65	27.30**	29.50	4.94	2.88
C-31	18.84	18.35**	20.50*	2.67	8.09
C-31R	18.42	18.35	20.50*	0.38	10.14
C-32	20.38	21.85*	27.50*	6.72	25.89
C-32R	22.62	21.85**	27.50*	3.52	17.74
C-33	19.30	20.31*	24.42*	4.97	20.96
C-33R	21.26	20.31**	24.42*	4.67	12.94
C-34	19.00	19.26	22.32*	1.34	14.87
C-34R	22.00	19.26**	22.32	14.22	1.43
C-35	21.46	22.85*	29.50*	6.08	27.25
C-35R	23.29	22.85**	29.50*	1.92	21.05
C-36	26.00	24.00**	27.50*	9.33	5.45
C-36R	25.22	24.00**	27.50*	5.08	8.29
C-37	24.00	22.46**	24.42	6.85	1.71

C-37R	22.64	22.46	24.42*	0.80	7.28
C-38	20.63	21.41*	22.32*	3.64	7.57
C-38R	21.19	21.41	22.32*	1.02	5.06
C-39	27.00	25.00**	29.50*	8.00	8.47
C-39R	28.50	25.00**	29.50	15.20	2.37
C-40	26.65	25.96**	27.50	2.65	3.09
C-40R	27.80	25.96**	27.50	7.08	1.09
C-41	26.16	24.91**	27.50*	5.01	4.87
C-41R	28.48	24.91**	27.50**	14.33	3.56
C-42	24.38	28.50*	29.50*	14.45	17.35
C-42R	26.79	28.50*	29.50*	6.00	9.18
C-43	21.84	23.37*	24.42*	6.54	10.56
C-43R	25.54	23.37**	24.42**	9.28	4.58
C-44	29.47	26.96**	29.50	9.31	0.10
C-44R	27.64	26.96**	29.50*	2.52	6.30
C-45	27.00	25.91**	29.50*	4.20	8.47
C-45R	28.50	25.91**	29.50	9.99	3.38

*Hybrids significantly inferior at 5 per cent level over the parental average/better parent.

**Hybrids significantly superior at 5 per cent level over the parental average/better parent.

was significant in fifty five hybrids. Twenty seven hybrids reduced length over the parental average and the reduction was from 0.54 to 18.87 per cent, which was significant in twenty two hybrids.

Fifteen hybrids also recorded an increase in the length of the fruits over their better parent and it ranged from 1.09 to 26.94 per cent, however, it was significant in eleven hybrids only. In seventy five hybrids there was a reduction in the length of fruits over the better parent and the decrease varied from 0.10 to 44.04 per cent and was significant in sixty four hybrids.

The observations recorded on the length of the fruits of parents and their hybrids are presented in Table 9.

(g) **Breadth of the fruit:** The average breadth of the fruit of parents varied from 13.63 cm in P-5 to 27.00 cm in P-10 and their hybrids fruits from 15.10 cm in C-6 to 34.57 cm in C-17B.

An increase in the breadth of the fruit was recorded in fifty four hybrids over their parental average and it ranged from 1.51 to 31.73 per cent and was statistically significant in fifty two hybrids.

TABLE 10

Average breadth of fruit of watermelon parents and their
hybrids during summer,1968

Parents/ hybrids	Average breadth of fruit (cm)	Parental average	Better parent	Percent increase or decrease over	
				Parental average	Better parent
Parents:					
P-1	16.00	-	-	-	-
P-2	26.50	-	-	-	-
P-3	18.00	-	-	-	-
P-4	23.28	-	-	-	-
P-5	13.63	-	-	-	-
P-6	18.50	-	-	-	-
P-7	25.50	-	-	-	-
P-8	22.12	-	-	-	-
P-9	20.35	-	-	-	-
P-10	27.00	-	-	-	-
Hybrids:					
C-1	16.00	21.25*	26.50*	24.70	39.62
C-1R	20.16	21.25*	26.50*	5.12	23.92
C-2	20.50	17.00**	18.00**	20.58	13.88
C-2R	17.46	17.00**	18.00	2.70	3.00
C-3	16.00	19.64*	23.28*	18.53	31.27
C-3R	19.12	19.64*	23.28*	2.64	17.86

C-4	16.00	14.81**	16.00	8.03	0.00
C-4R	18.00	14.81**	16.00**	21.53	12.50
C-5	15.50	17.25*	18.50*	10.15	16.22
C-5R	21.28	17.25**	18.50**	23.36	15.02
C-6	15.10	20.75*	25.50*	27.23	40.79
C-6R	20.28	20.75*	25.50*	2.27	20.48
C-7	15.50	19.06*	22.12*	18.67	29.93
C-7R	19.50	19.06**	22.12*	2.30	11.85
C-8	15.18	18.17*	20.35*	16.46	25.41
C-8R	18.82	18.17**	20.35*	3.57	7.52
C-9	16.10	21.50*	27.00*	25.12	40.38
C-9R	22.58	21.50**	27.00*	5.02	16.38
C-10	20.29	22.25*	26.50*	8.81	23.44
C-10R	17.18	22.25*	26.50*	22.79	35.17
C-11	24.42	24.89	26.50*	1.89	7.85
C-11R	28.25	24.89**	26.50**	13.49	6.60
C-12	23.64	20.06**	26.50*	17.85	10.80
C-12R	19.86	20.06	26.50	1.00	25.06
C-13	24.28	22.50**	26.50*	7.91	8.38
C-13R	24.32	22.50**	26.50*	8.08	8.23
C-14	32.19	26.00**	26.50**	23.80	21.47
C-14R	34.25	26.00**	26.50**	31.73	29.24

C-15	28.23	24.31**	26.50**	11.61	6.52
C-15R	28.17	24.31**	26.50**	15.87	6.30
C-16	24.83	23.42**	26.50*	6.02	6.31
C-16R	26.48	23.42**	26.50	13.06	0.08
C-17	32.48	26.75**	27.00**	21.42	20.29
C-17R	34.57	26.75**	27.00**	29.23	28.03
C-18	16.28	20.64*	23.28*	21.13	30.07
C-18R	21.48	20.64**	23.28*	4.06	7.74
C-19	15.26	15.81*	18.00*	3.48	15.23
C-19R	15.18	15.81*	18.00*	3.98	15.67
C-20	16.28	18.25*	18.50*	10.80	12.00
C-20R	19.29	18.25**	18.50**	5.69	4.27
C-21	16.15	21.75*	25.50*	25.75	36.67
C-21R	23.62	21.75**	25.50*	8.59	7.38
C-22	17.00	20.06*	22.12*	15.26	23.15
C-22R	20.54	20.06**	22.12*	2.39	7.15
C-23	16.43	19.13*	20.35*	14.30	19.27
C-23R	19.46	19.17	20.35*	1.51	4.38
C-24	16.83	22.50*	27.00*	25.20	37.67
C-24R	24.01	22.50**	27.00*	6.71	11.08
C-25	21.86	18.45**	23.28*	18.48	6.10
C-25R	17.80	18.45*	23.28*	3.53	23.54

C-26	22.67	20.89**	23.28	3.52	2.63
C-26R	23.52	20.89**	23.28	12.58	1.03
C-27	27.36	24.59**	25.50**	12.50**	12.17
C-27R	25.08	24.39**	25.50	2.82	1.65
C-28	21.52	22.70*	23.28*	5.20	7.57
C-28R	19.28	22.70*	23.28*	15.07	17.19
C-29	22.20	21.81	23.28*	1.78	4.64
C-29R	24.36	21.81**	23.28**	11.69	4.63
C-30	28.34	25.14**	27.00**	12.72	4.96
C-30R	26.32	25.14**	27.00	4.69	2.52
C-31	15.68	16.06*	18.50*	2.37	15.25
C-31R	16.58	16.06**	18.50*	3.23	10.38
C-32	17.84	19.56*	25.50*	8.80	30.04
C-32R	20.26	19.56**	25.50*	3.57	20.55
C-33	16.59	17.87*	22.12*	7.17	25.00
C-33R	19.42	17.87**	22.12*	8.67	12.21
C-34	16.86	16.99	20.35*	0.77	17.15
C-34R	19.78	16.99**	20.35	16.42	2.81
C-35	18.93	20.31*	27.00*	6.80	29.89
C-35R	22.42	20.31**	27.00*	10.38	16.97
C-36	24.85	22.00**	25.50	12.95	2.55
C-36R	23.28	22.00**	25.50*	5.81	6.88

C-37	22.17	20.31**	22.12	9.15	0.22
C-37R	20.21	20.31	22.12*	0.50	8.64
C-38	18.41	19.42*	20.35*	5.21	9.54
C-38R	19.15	19.42	20.35*	1.40	5.90
C-39	25.29	22.75**	27.00*	11.16	6.34
C-39R	26.35	22.75**	27.00	15.82	2.41
C-40	24.63	23.81**	25.50	3.44	3.42
C-40R	25.93	23.81**	25.50	8.90	1.68
C-41	24.25	22.92**	25.50*	5.80	4.91
C-41R	26.35	22.92**	25.50	14.96	3.33
C-42	23.45	26.25*	27.00*	10.67	13.15
C-42R	24.25	26.25*	27.00*	7.62	10.19
C-43	19.50	21.23*	22.12*	8.15	11.85
C-43R	23.30	21.23**	22.12**	9.75	5.33
C-44	27.26	24.56**	27.00	10.99	0.96
C-44R	25.26	24.56**	27.00*	2.85	6.45
C-45	25.60	23.67**	27.00*	8.15	5.19
C-45R	26.42	23.67**	27.00	11.61	2.15

*Hybrids significantly inferior at 5 per cent level over the parental average/better parent.

**Hybrids significantly superior at 5 per cent level over the parental average/better parent.

The breadth of the fruit of thirty six hybrids was reduced, varying from 0.50 to 27.23 per cent, but this reduction was significant in thirty one hybrids only.

Twenty hybrids recorded an increase in the breadth of the fruits over their better parents ranging from 0.22 to 29.24 per cent and was statistically significant in fifteen hybrids. In as many as sixty nine hybrids there was a reduction in the breadth of fruits over their better parent and it ranged from 0.08 to 40.79 per cent and was statistically significant in fifty eight hybrids. One hybrid was equal to their better parent.

The observations recorded for the breadth of fruits of the parents and their hybrids are presented in Table 10.

(h) <u>Total soluble solids (T.S.S.)</u>: The T.S.S. of the fruits is important in view of their effect on the sweetness. The average T.S.S. of the fruits from the parents varied from 6.00 per cent in P-3 to 11.00 per cent in P-2. In hybrids the average T.S.S. of fruits ranged from 7.00 per cent in C-22 to 11.50 per cent in C-5R, C-6R, C-9R, C-1 9R, C-31, C-35R, C-39R.

TABLE 11

Average T.S.S. of watermelon parents and their hybrids
during summer, 1968.

Parents/ hybrids	T.S.S. (Percent)	Parental average	Better parent	Percent increase or decrease over	
				Parental average	Better parent
Parents:					
P-1	10.50	-	-	-	-
P-2	11.00	-	-	-	-
P-3	6.00	-	-	-	-
P-4	9.00	-	-	-	-
P-5	9.50	-	-	-	-
P-6	10.00	-	-	-	-
P-7	9.00	-	-	-	-
P-8	8.50	-	-	-	-
P-9	9.00	-	-	-	-
P-10	9.00	-	-	-	-
Hybrids:					
C-1	10.50	10.75	11.00	2.33	4.55
C-1R	10.50	10.75	11.00	2.33	4.55
C-2	9.50	8.25**	10.50*	15.15	9.53
C-2R	8.50	8.25	10.50*	3.03	19.05
C-3	10.00	9.75	10.50	2.56	4.77
C-3R	9.50	9.75	10.50*	2.57	9.53
C-4	10.00	10.00	10.50	0.00	4.77
C-4R	10.00	10.00	10.50	0.00	4.77
C-5	10.50	10.25	10.50	2.43	0.00

C-5R	11.50	10.25**	10.50**	12.19	9.52
C-6	10.00	9.75	10.50	2.56	4.77
C-6R	11.50	9.75**	10.50**	17.94	9.52
C-7	10.00	9.50	10.50	5.26	4.77
C-7R	10.50	9.50**	10.50	10.52	0.00
C-8	10.00	9.25**	10.50	8.10	4.77
C-8R	9.50	9.25	10.50*	2.70	9.53
C-9	10.00	9.75	10.50	2.56	4.77
C-9R	11.50	9.75**	10.50**	17.94	9.52
C-10	10.00	8.50**	11.00*	17.64	9.10
C-10R	8.50	8.50	11.00*	0.00	22.73
C-11	11.00	10.00**	11.00	10.00	0.00
C-11R	10.00	10.00	11.00*	0.00	9.10
C-12	11.00	10.25**	11.00	7.31	0.00
C-12R	10.00	10.25	11.00*	2.44	9.10
C-13	10.50	10.50	11.00	0.00	4.55
C-13R	11.50	10.50**	11.00	9.52	4.54
C-14	10.50	10.00	11.00	5.00	4.55
C-14R	11.50	10.00**	11.00	15.00	4.54
C-15	10.50	9.75**	11.00	7.69	4.55
C-15R	9.50	9.75	11.00*	2.57	13.64
C-16	10.50	9.50**	11.00	10.52	4.55
C-16R	9.50	9.50	11.00*	0.00	13.69
C-17	10.50	10.00	11.00	5.00	4.55
C-17R	11.00	10.00**	11.00	10.00	0.00

C-18	7.50	7.50	9.00*	0.00	16.67
C-18R	8.00	7.50	9.00*	6.66	11.12
C-19	8.50	7.75**	9.00	9.67	5.56
C-19R	8.50	7.75**	9.00	9.63	10.53
C-20	8.50	8.00	10.00*	6.25	15.00
C-20R	9.00	8.00**	10.00*	12.50	10.00
C-21	7.50	7.50	9.00*	0.00	16.67
C-21R	8.50	7.50**	9.00	13.33	5.56
C-22	7.00	7.25	8.50*	3.45	17.65
C-22R	8.00	7.25**	8.50	10.34	5.89
C-23	8.00	7.00**	8.00	14.28	0.00
C-23R	7.50	7.00	8.00	7.14	6.25
C-24	8.00	7.50	9.00*	6.66	11.12
C-24R	8.50	7.50**	9.00	13.34	5.56
C-25	10.00	9.25**	9.50	8.10	5.26
C-25R	9.50	9.25	9.50	2.70	0.00
C-26	11.00	9.50**	10.00**	15.78	10.00
C-26R	10.00	9.50	10.00	5.26	0.00
C-27	9.00	9.00	9.00	0.00	0.00
C-27R	9.00	9.00	9.00	0.00	0.00
C-28	8.50	8.75	9.00	2.86	5.56
C-28R	8.00	8.75*	9.00*	8.58	11.12
C-29	9.50	9.50	9.00	0.00	5.56
C-29R	8.00	8.50	9.00*	5.89	11.12
C-30	9.00	9.00	9.00	0.00	0.00
C-30R	9.00	9.00	9.00	0.00	0.00
C-31	11.50	9.75**	10.00**	17.94	15.00
C-31R	10.00	9.75	10.00	2.56	0.00
C-32	9.00	9.25	9.50	2.71	5.27

C-32R	9.00	9.25	9.50	2.71	5.27
C-33	9.00	9.00	9.50	0.00	2.71
C-33R	8.50	9.00	9.50*	5.56	10.53
C-34	9.00	8.75	9.50	2.85	5.27
C-34R	10.50	8.75**	9.50**	20.00	10.52
C-35	9.50	9.25	9.50	2.70	0.00
C-35R	11.50	9.25**	9.50**	24.32	21.05
C-36	9.50	9.50	10.00	0.00	5.00
C-36R	11.00	9.50**	10.00**	15.78	10.00
C-37	9.00	9.25	10.00*	2.71	10.00
C-37R	10.50	9.25**	10.00	13.51	5.00
C-38	9.50	9.00	10.00	5.55	5.00
C-38R	10.00	9.00**	10.00	11.11	0.00
C-39	9.00	9.50	10.00*	2.71	10.00
C-39R	11.50	9.50**	10.00**	21.05	15.00
C-40	8.50	8.75	9.00	2.86	5.56
C-40R	8.00	8.75*	9.00*	2.58	11.12
C-41	9.00	8.50	9.00	5.88	0.00
C-41R	8.50	8.50	9.00	0.00	5.56
C-42	9.00	9.00	9.00	0.00	0.00
C-42R	9.00	9.00	9.00	0.00	0.00
C-43	8.00	8.25	8.50	3.04	5.89
C-43R	8.50	8.25	8.50	3.03	0.00
C-44	8.00	8.75*	9.00	8.58	11.12
C-44R	8.50	8.75	9.00	2.86	5.56
C-45	9.00	8.50	9.00	5.88	0.00
C-45R	8.50	8.50	9.00	0.00	5.56

* Hybrids significantly inferior at 5 per cent level over the
parental average/better parent.

**Hybrids significantly superior at 5 per cent level over the
parental average/better parent.

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The increase in T.S.S. of fruits over the
parental average was recorded in fifty two hybrids
and the increase varied from 2.43 to 24.32 per cent;
however, it was statistically significant in thirty
hybrids only. Nineteen hybrids had the T.S.S. equal
to that of their parental mean and in nineteen hybrids
the average T.S.S. was decrease from 2.33 to 8.58
per cent, but statistically significant decrease was
noticed in three hybrids only.

An increase in the T.S.S. from 4.54 to 21.05
per cent of hybrids over the higher parent was also
recorded in thirteen cases but the significant increase
was, however, observed in nine hybrids only. Fifty seven
hybrids had lower T.S.S. than their better parents and
the decrease ranged from 2.71 to 22.73 per cent and was
statistically significant in twenty four hybrids. Twenty
hybrids had the T.S.S. equal to that of their higher
parent. The data recorded for T.S.S. are presented in
Table 11.

(i) <u>Total yield per plant</u>: Yield is the most
important character of economic importance in which a
producer is mainly interested. The yield per plant in
parents varied from 13.285 kg in P-5 to 69.558 kg in
P-3, while it ranged from 33.634 kg (C-38) to 87.094 kg
(C-20R) in their hybrids.

TABLE 12

Total average yield per plant of watermelon parents and their
hybrids during summer, 1968.

Parents/ hybrids	Average yield per plant (kg.)	Parental average	Better parent	Percent increase or decrease over	
				Parental average	Better parent
Parents:					
P-1	41.619	-	-	-	-
P-2	49.966	-	-	-	-
P-3	69.558	-	-	-	-
P-4	41.084	-	-	-	-
P-5	13.285	-	-	-	-
P-6	38.950	-	-	-	-
P-7	37.768	-	-	-	-
P-8	41.119	-	-	-	-
P-9	37.002	-	-	-	-
P-10	47.321	-	-	-	-
Hybrids:					
C-1	43.340	45.792	49.966	5.36	13.27
C-1R	43.005	45.792	49.966	6.09	13.94
C-2	85.106	55.588**	69.558**	53.10	22.35
C-2R	81.445	55.588**	69.558**	46.51	17.08
C-3	56.520	41.351**	41.619**	36.68	35.80
C-3R	56.815	41.351**	41.619**	37.39	36.51
C-4	55.913	27.452**	41.619**	103.67	34.34

C-4R	40.432	27.452**	41.619	47.28	2.86
C-5	70.023	40.284**	41.619**	73.81	68.24
C-5R	60.776	40.284**	41.619**	50.86	46.02
C-6	63.193	39.693**	41.619**	59.20	51.83
C-6R	62.948	39.693**	41.619**	58.58	51.24
C-7	67.655	41.369**	41.619**	63.54	62.55
C-7R	65.099	41.369**	41.619**	57.36	56.41
C-8	72.190	39.310**	41.619**	83.64	73.45
C-8R	67.623	39.310**	41.619**	72.02	62.48
C-9	79.190	44.470**	47.321**	78.07	67.34
C-9R	74.806	44.470**	47.321**	68.21	58.08
C-10	82.858	59.762**	69.558**	38.64	19.12
C-10R	82.203	59.762**	69.558**	37.55	18.17
C-11	48.835	45.525	49.966	2.27	2.27
C-11R	47.973	45.525	49.966	5.37	3.99
C-12	57.798	31.625**	49.966	82.76	15.67
C-12R	45.678	31.625**	49.966	44.43	8.59
C-13	63.592	44.458**	49.966**	43.03	27.27
C-13R	71.432	44.458**	49.966**	60.67	42.96
C-14	81.126	43.867**	49.966**	84.93	62.36
C-14R	76.655	43.867**	49.966**	74.74	53.41
C-15	70.527	45.542**	49.966**	54.86	41.14
C-15R	70.006	45.542**	49.966**	53.71	40.10

C-16	56.960	43.484**	49.966	30.99	13.99
C-16R	56.298	43.484**	49.966	29.46	12.67
C-17	72.618	48.643**	49.966**	49.29	45.33
C-17R	72.091	48.643**	49.966**	48.20	44.28
C-18	68.740	55.321**	69.558	24.25	1.18
C-18R	66.114	55.321**	69.558	19.50	4.96
C-19	63.250	41.421**	69.558	52.70	9.07
C-19R	51.140	41.421	69.558*	23.46	26.48
C-20	75.006	54.254**	69.558	38.24	7.83
C-20R	87.094	54.254**	69.558**	60.53	25.21
C-21	56.196	53.663	69.558*	4.72	19.21
C-21R	56.245	53.663	69.558*	4.81	19.24
C-22	61.195	55.338	69.558	10.58	12.03
C-22R	60.705	55.338	69.558	9.69	12.73
C-23	59.675	53.280	69.558	12.00	14.21
C-23R	60.088	53.280	69.558	12.77	13.62
C-24	62.738	58.439	69.558	7.35	9.81
C-24R	66.710	58.439	69.558	14.15	4.10
C-25	37.039	27.184	41.084	36.25	9.85
C-25R	37.806	27.184**	41.084	39.07	7.98
C-26	47.553	40.017	41.084	18.83	15.74
C-26R	48.218	40.017	41.084	20.49	17.36

C-27	49.164	39.426	41.084	24.69	19.66
C-27R	45.955	39.426	41.084	16.56	11.85
C-28	38.665	41.101	41.119	5.95	5.99
C-28R	36.898	41.101	41.119	10.23	10.27
C-29	47.782	39.043	41.084	22.38	16.30
C-29R	47.733	39.043	41.084	22.25	16.16
C-30	73.970	44.202**	47.321**	67.34	56.31
C-30R	69.494	44.202**	47.321**	57.21	46.85
C-31	43.021	26.117**	38.950	64.72	10.45
C-31R	41.302	26.117**	38.950	58.14	6.03
C-32	50.645	25.526**	37.768**	98.40	34.09
C-32R	57.731	25.526**	37.768**	126.16	57.85
C-33	40.560	27.202**	41.119	49.10	1.36
C-33R	38.988	27.202**	41.119	43.32	5.19
C-34	41.794	25.143**	37.002	66.22	12.95
C-34R	39.272	25.143**	37.002	56.19	6.13
C-35	62.108	30.303**	47.321**	104.95	31.25
C-35R	56.392	30.303**	47.321	86.09	19.16
C-36	51.582	38.359**	38.950**	34.47	32.43
C-36R	48.466	38.359**	38.950	26.34	24.43
C-37	42.653	40.034	41.119	6.54	3.73
C-37R	39.900	40.034	41.119	0.34	2.97

C-38	33.634	37.976	38.930	11.44	13.65
C-38R	34.563	37.976	38.950	8.99	11.27
C-39	56.820	43.135**	47.321	31.72	20.07
C-39R	62.768	43.135**	47.321**	45.51	32.64
C-40	40.350	39.443	41.119	2.29	1.88
C-40R	43.924	39.443	41.119	11.36	6.82
C-41	46.864	27.385**	37.768	71.13	24.08
C-41R	50.194	27.385**	37.768**	83.29	32.90
C-42	46.860	42.544	47.321	10.14	0.98
C-42R	42.607	42.544	47.321	0.14	9.97
C-43	44.103	39.060	41.119	12.91	7.25
C-43R	40.764	39.060	41.119	4.36	0.87
C-44	60.921	44.220**	47.321**	37.76	28.73
C-44R	52.241	44.220	47.321	18.13	10.39
C-45	54.214	42.161**	47.321	28.58	14.56
C-45R	53.840	42.161**	47.321	27.70	13.77

*Hybrids significantly inferior at 5 per cent level over the parental average/better parent.

**Hybrids significantly superior at 5 per cent level over the parental average/better parent.

Eighty three hybrids recorded increased yield
of fruits over their parental average the increase was
from 0.14 to 126.16 per cent and was statistically
significant in fifty seven hybrids. In seven hybrids,
however, there was a decrease in the yield, the reduction
was from 0.34 to 11.44 per cent but none was statistically
significant.

Fifty nine hybrids registered an increase in the
yield over their superior parents, with the increase from
3.73 to 73.45 per cent, and this was significant in
thirty five hybrids. In thirty one hybrids the yield was
also lower than their better parents and the per cent
decrease recorded ranged from 0.57 to 26.48 but the decrease,
was significant in three hybrids only. The data recorded
for the yield per plant are presented in Table 12.

2. Diallel analysis:

Before proceeding for the diallel analysis, the
analysis of variance for the five characters _viz_., the
number of days taken to open the first female flower,
the number of fruits, the weight of the fruit, total
soluble solids (T.S.S.) and the total yield per plant
was carried out to test the significance of the differences
between treatments (ten parents and their ninety hybrids)
and blocks. The results are presented in Table 3. The 'F'
test for the above mentioned characters indicated significant
differences between treatments, and therefore, further

TABLE 13

't' Values to test the uniformity of $W_r - V_r$

Characters	No. of days taken to open first female flower	No. of fruits	Weight of fruit	T.S.S.	Total yield
't' Value	6.9075*	0.8469	3.3591	0.0031	15.5337**

* Significant at 5 per cent level

** Significant at 1 per cent level

analysis for genetic differences was made. Since block differences were not found to be significant for all the five characters, therefore, only ungrouped randomisation method was followed.

For the genetic analysis of the data recorded for the diallel experiment the statistics V_{oLo}, V_r, W_r, $\overline{W}$, V_{oL1} and $M_{L1}-M_{Lo}$ were calculated from the reciprocal means of the generation mean data for each character. These values are presented in Table 14. The V_r, W_r values from these tables were utilized for the calculation of the regression coefficients of W_r on V_r (b) and their standard errors (S_b), which have been presented in Table 15. The analysis of variance of W_r-V_r and also the t^2 value of the 't' test of the uniformity of W_r-V_r were also computed from these values and presented in Table 13. The statistics V_{oLo}, V_r, W_r, V_{oL1}, $M_{L1}-M_{Lo}$, V_{1L1}, W_{oLo1} and W from the analysis of variance presented in Table 3, were used for the estimation of the components of variation D, F, H_1, H_2, h^2, E and their standard errors which have been presented in Table 16. These components of variation were used for the calculation of mean degree of dominance $(H_1/D)^{\frac{1}{2}}$, the proportion of the genes with positive and negative effects, $(H_2/4H_1)$, the proportion of dominant and recessive genes in the parents, $(4DH_1)^{\frac{1}{2}} + F/(4DH_1)^{\frac{1}{2}} - F$ and the number of group of genes

TABLE 14

Values of V_r, W_r, V_{oLo}, V_{oL1} and $(M_{L1} - M_{Lo})$ for different characters

Parental lines	No. of days taken to open first female flower		No. of fruits		Weight of fruit		T.S.S.		Total yield	
	V_r	W_r	V_r	W_r	V_r	W_r	V_r	W_r	V_r	W_r
P-1	107.25	96.28	4.04	3.86	1.6177	2.3869	0.36	0.64	133.6099	97.2139
P-2	104.75	93.98	2.95	2.89	1.2909	3.0023	0.68	0.68	145.1362	15.4880
P-3	113.73	93.72	1.88	2.04	1.4415	2.3446	0.85	1.21	92.3011	21.9035
P-4	46.39	45.05	2.23	2.11	1.4080	2.4107	0.88	1.19	123.7465	109.8048
P-5	8.09	14.68	4.54	3.07	1.5170	3.9998	0.59	0.78	155.4873	152.1659
P-6	19.51	22.93	2.52	1.16	1.2905	2.3802	0.46	0.87	185.4909	140.8517
P-7	61.12	67.35	2.91	2.16	1.7494	2.5866	1.03	1.26	143.7894	51.7109
P-8	84.63	84.55	1.14	1.69	2.1475	2.9256	0.82	1.12	155.3636	100.9657
P-9	9.86	13.18	4.19	1.35	1.4709	2.5111	0.57	0.84	124.5549	81.8936
P-10	89.87	87.27	5.62	3.74	2.0979	4.1314	1.11	1.19	119.4640	45.3021
Mean	64.52	62.40	3.20	2.41	1.6031	2.8679	0.73	0.98	143.8943	81.7300
V_{oLo}	92.30		4.98		5.5812		1.96		192.1346	
V_{oL1}	45.13		1.51		1.3857		0.52		44.8908	
$(M_{L1}-M_{Lo})^2$	291.20		15.66		2.5997		1.31		1351.9895	

TABLE 15

Estimates of b, S_b, $(b-0)/S_b$ and $(1-b)/S_b$ for different characters

Characters	b	S_b	Statistics	
			$(b-0)/S_b$	$(1-b)/S_b$
No. of days taken to open first female flower	0.8439	0.0352	23.97**	4.43**
No. of fruits	0.4344	0.0189	22.28**	29.83**
Weight of fruit	0.9946	0.2141	4.64**	0.025
T.S.S.	0.8583	0.1712	5.01**	0.82
Total yield/plant	0.8869	0.5188	1.70	0.21

* Significant at 5 per cent level

** Significant at 1 per cent level

TABLE 16

Estimates of D, F, H_1, H_2, h^2 and E and the ratios, $(H_1/D)^{\frac{1}{2}}$, $(H_2/4H_1)$, $\dfrac{(4DH_1)^{\frac{1}{2}} - F}{(4DH_1)^{\frac{1}{2}} + F}$ and h^2/H_2

Characters	No. of days taken to open first female flower	No. of fruits	Weight of fruit	T.S.S.	Total yield
D	92.26** ± 4.64	4.70** ± 0.64	5.4546** ± 0.3620	1.87** ± 0.074	174.8464** ± 27.388?
F	-65.26** ± 10.71	-0.12 ± 1.69	-0.5217 ± 0.8353	-0.13 ± 0.17	29.6881 ± 65.193?
H_1	100.67** ± 9.88	7.39** ± 1.57	0.1676 ± 0.7706	0.73** ± 0.15	392.6881** ± ?0.296?
H_2	77.49** ± 8.40	6.20** ± 1.16	1.1228 ± 0.6549	0.65** ± 0.13	361.4384** ± 49.546?
h^2	1164.81** ± 5.62	62.57** ± 0.78	10.3533** ± 0.4384	5.21** ± 0.089	5401.7343** ± 33.164?
E	0.041 ± 1.40	0.27 ± 0.19	0.1266 ± 0.1091	0.09** ± 0.022	17.2882* ± 8.257?
$(H_1/D)^{\frac{1}{2}}$	1.0445	1.2521	0.1752	0.6276	1.4979
$H_2/4H_1$	0.1924	0.2099	0.1671	0.2215	0.2302
$\dfrac{(4DH_1)^{\frac{1}{2}} + F}{(4DH_1)^{\frac{1}{2}} - F}$	0.4941	0.9894	0.1604	0.8886	1.1746
h^2/H_2	15.031	10.0833	9.2209	7.9552	14.9451

* significant at 5 per cent level

** significant at 1 per cent level

TABLE 17

Values of parental order of dominance ($W_r + V_r$) and parental measurement (y_r) for different characters and their correlation coefficient $r(W_r + V_r), y_r$

Characters	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10	$r(W_r + V_r), y_r$
No. of days taken to open first female flower											
$W_r + V_r$	203.53	198.74	212.45	91.45	22.78	42.44	128.47	169.18	23.04	177.15	0.9
y_r	72.15	68.25	78.21	59.45	46.35	52.41	62.48	66.42	55.62	67.46	
No. of fruit											
$W_r + V_r$	7.91	5.84	3.93	4.35	7.61	3.69	5.07	2.84	5.54	9.37	-0.3
y_r	5.80	7.65	8.25	9.43	10.57	13.63	7.33	9.55	11.35	8.74	
Weight of fruit											
$W_r + V_r$	4.004	4.293	3.786	3.818	5.516	3.670	4.336	5.073	3.982	6.229	-0.2
y_r	7.161	6.502	8.422	4.347	1.250	2.856	5.155	4.302	3.266	5.410	
T.S.S.											
$W_r + V_r$	1.00	1.36	2.06	2.08	1.37	1.34	2.29	1.95	1.41	2.30	-0.4
y_r	10.50	11.00	6.00	9.00	9.50	10.00	9.00	8.50	8.00	9.00	
Total yield											
$W_r + V_r$	290.823	160.624	114.204	233.55	307.653	326.342	195.500	256.329	206.448	164.766	-0.
y_r	41.619	49.966	69.558	41.084	13.285	38.950	37.768	41.119	37.002	47.321	

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is an indication of partial dominance as well (<u>vide infra</u>).
The proportion of the genes with positive and negative
effects in the parents $(H_2/4H_1)$ is less than 0.25, suggesting
some asymmetry at loci showing dominance, but as H_2 signifi-
cantly different from H_1, it may be assumed that the parents
contain positive and negative genes in dissimilar proportions.
The proportion of dominant and recessive genes $(4DH_1)^{\frac{1}{2}}$
$+ F/(4DH_1)^{\frac{1}{2}} -F$, in the parents are less than one which is
also supported by the value of F. It is, therefore, apparent
that there are about two times more recessive genes controlling
this character in the parents than the dominant genes. The
number of group of genes showing dominance (h^2/H_2) is more
than fifteen. There is significant correlation between the
parental order of dominance and the parental measurement
(Table 17). This significant positive correlation (0.948)
indicates that the negative genes (i.e., those for early
flowering) are mostly dominant. As r^2 is not close to unity
the regression of y_r on W_r+V_r does not exist and therefore,
it is not possible to predict the values of the completely
dominant and recessive parents.

(b) The number of fruits:

Graphical approach: A perusal of table (15) reveals
that the coefficient of regression (b) was significant and
the regression line differs significantly both from a slope
b=0 and b=1 indicating the presence of epistasis. The W_r, V_r
graph (Fig.2) shows that the regression line cuts the
ordinate above the point of origin (0) indicating the

Fig 1. V_r, W_r GRAPH FOR NUMBER OF DAYS TAKEN TO OPEN THE FIRST FEMALE FLOWER.

b = 0.8439 ± 0.0352

1 = P - 1
2 = P - 2
3 = P - 3
4 = P - 4
5 = P - 5
6 = P - 6
7 = P - 7
8 = P - 8
9 = P - 9
10 = P - 10
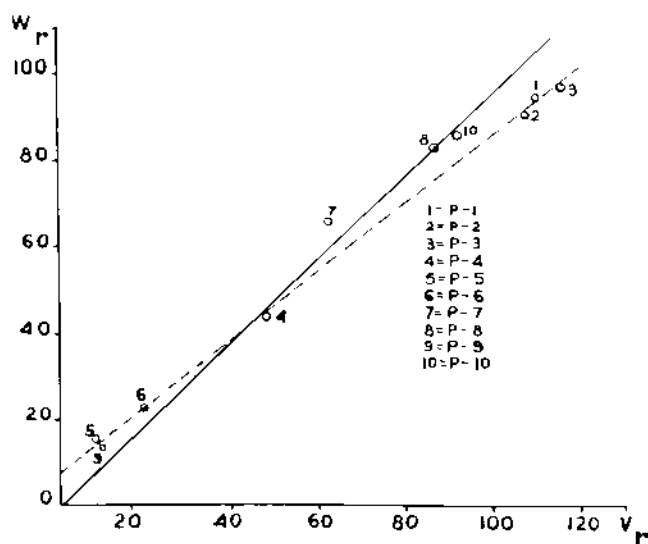
Fig 2. V_r, W_r GRAPH FOR NUMBER OF FRUITS

b = 0.4344 ± 0.1896

1 = P - 1
2 = P - 2
3 = P - 3
4 = P - 4
5 = P - 5
6 = P - 6
7 = P - 7
8 = P - 8
9 = P - 9
10 = P - 10
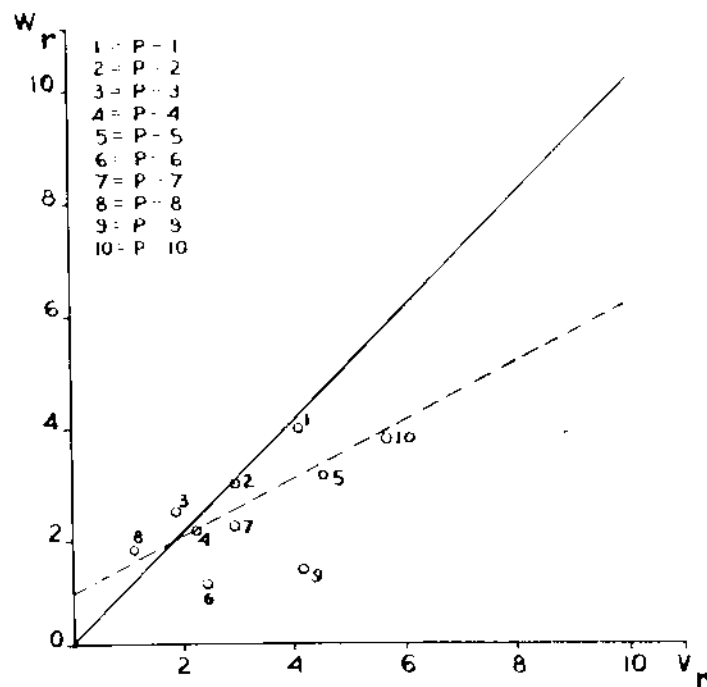
partial dominance for this character. The array points
are widely scattered showing diversity among the parents.
The W_r, V_r graph further reveals the presence of epistasis
as most of the array points (except that of 3 and 8) are
lying below the line of unit slope (0,0).

Numerical approach: The uniformity of W_r-V_r, as
revealed by the insignificant 't' value (Table 15) indicates
the validity of the hypothesis of the diallel analysis. The
estimates of all the six components of variation, viz.,
D, F, H_1, H_2, h^2 and E and their standard errors presented
in Table 16 indicate that these estimates are significant
except in case of 'F' and 'E'. The negative and non-significant
value of 'F' indicates that the recessive alleles are only
slightly more frequent in the parent than the dominant
alleles. From Table 16 it appears that the mean degree of
dominance over all loci shows dominance (vide-infra). There
is asymmetry of genes with positive and negative effects
in parents. The proportion of dominant and recessive genes
$(4DH_1)^{\frac{1}{2}}$ +F/$(4DH_1)^{\frac{1}{2}}$ -F in the parents is nearly one. And
about ten group of genes are controlling this character.
The coefficient of correlation between the parental order
of dominance (W_r+V_r) and parental measurements (y_r) was
found to be negative but non-significant (Table 17).

(c) Weight of the fruit:

Graphical approach: It is clear from the Table 15 that the value of 'b' is significant and the regression line differs significantly from a slope b=0, but not from a slope b=1, which indicates that the gene system was additive and without any gene interaction. The W_r, V_r graph (Fig.3) indicates that the no array point falls below the line of unit slope (0,0). This also indicates absence of non-allelic interaction. The regression line cuts the ordinate above the point of origin (0) showing partial dominance for this character. The array points are clustered (except 2,5,3 and 10), revealing the low amount of genetic diversity among the parents.

Numerical approach: The analysis of variance of W_r-V_r shows non-significant line (array) effects indicating thereby the validity of the hypothesis of diallel analysis (Table 13). The estimates of all the six components of variation, viz., D,F,H_1,H_2, h^2 and E and their standard errors presented in Table 16 show that all are insignificant except D and h^2. The negative value of F indicates that the recessive alleles are more frequent in the parents. There is an indication of partial dominance as the value of H_1 is less than that of D. It appears from Table 16 that the mean degree of dominance overa all loci $(H_1/D)^{\frac{1}{2}}$ is

Fig. 4. V_r, W_r GRAPH FOR T.S.S.
b = 0.8583 ± 0.1712

1 = P-1
2 = P-2
3 = P-3
4 = P-4
5 = P-5
6 = P-6
7 = P-7
8 = P-8
9 = P-9
10 = P-10

Fig. 3. V_r, W_r GRAPH FOR FRUIT WEIGHT
b = 0.9946 ± 0.2141

1 = P-1
2 = P-2
3 = P-3
4 = P-4
5 = P-5
6 = P-6
7 = P-7
8 = P-8
9 = P-9
10 = P-10
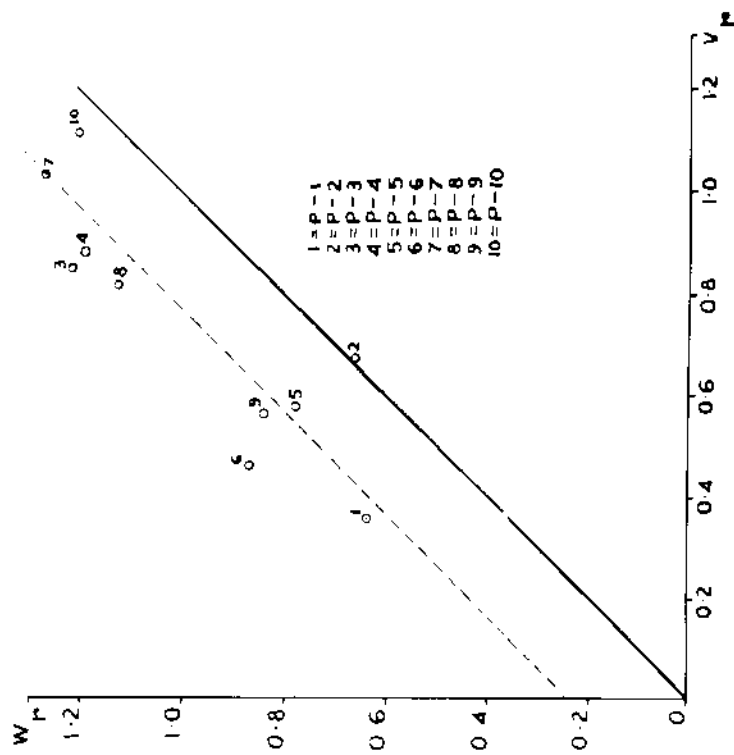
also partial dominance. The proportion of the genes with
positive and negative effects in the parents ($H_2/4H_1$), was
found to be less than 0.25 denoting asymmetry at loci
showing dominance, which is also supported by the significant
difference between H_1 and H_2. It may be assumed that the
parents contained positive and negative genes in dissimilar
proportions. The proportion of dominant and recessive genes
$(4DH_1)^{\frac{1}{2}} + F/(4DH_1)^{\frac{1}{2}} - F$, in the parents is 0.16, indicating
the presence of negative genes higher (six times) than that
of positive genes. About nine group of genes seem to control
this character.

(d) Total soluble solids (T.S.S.):

Graphical approach: It is evident from the Table 15
that b is found to be significant closer to the unity (b=1)
revealing the gene system to be additive without any
complication of epistasis. The W_r, V_r graph (Fig.4) shows
that all the array points except 2 fall above the line
of unit slope confirming the absence of epistasis. The
regression line had cut the ordinate well above the point
of origin (0) showing partial dominance for this character.
The array points are scattered along the regression line
indicating genetic diversity among the parents.

Numerical approach: It is evident from the
uniformity test $W_r - V_r$ (Table 13) that 't' value is non-
significant, indicating the validity of the hypothesis of the

diallel analysis. The estimates of all the six components except of 'F' are significant (Table 16). The mean degree of dominance for all loci showed partial dominance. The proportion of genes with positive and negative value of F indicates that the recessive alleles were more frequent. The recessive genes were nearly 1.25 times of the dominants. There is no significant correlation between the parental order of dominance and parental measurements.

(e) <u>Total yield per plant:</u>

<u>Graphical approach:</u> From the Table 15 it appears that the coefficient of regression (b) does not significantly differ from a slope b=0 and b=1 revealing the gene system to be non-additive and the presence of epistasis. The regression line cuts the ordinate just above the point of origin indicating dominance for this character. The array points are scattered revealing the genetic diversity among the parents. The W_r, V_r graph also indicates the presence of epistasis as all the array points lie below the line of unit slope (Fig.5).

<u>Numerical approach:</u> The significant value of 't' (Table 13) indicates the failure of one or more of the assumptions for diallel analysis. The estimates of all the six components of variation D, F, H_1, H_2, h^2 and E and their

Fig. 5. V_r, W_r GRAPH FOR TOTAL YIELD

b = 0.8869 ± 0.5188
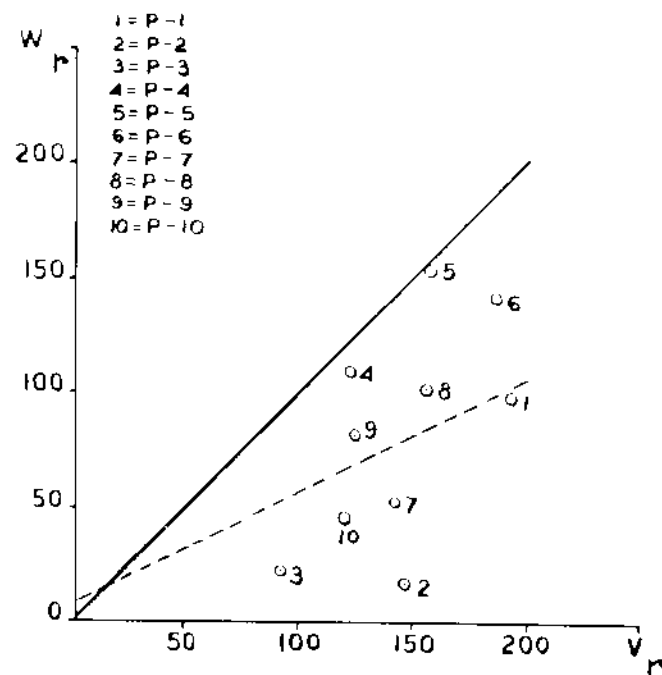
standard errors presented in Table 16 indicate that
all the estimates except of F are significant. The
average degree of dominance shows complete dominance
ove all loci. The proportion of genes with positive
and negative effect is about 0.25 suggesting the symmetry
of loci showing dominance. It is also supported from the
perusal ation of the values of H_1 and H_2. The proportion
of dominant and recessive genes (1.17) indicates that
they were equally frequent. Nearly fifteen groups of
genes seem to be responsible for controlling this character.

3. Combining ability:

The results of the analysis of variance for
general and specific combining abilities and reciprocal
effects are given in Table 18. From the perusal of that
table it appears that the variance associated with general
combining ability (g.c.a.) was highly significant for
all the five characters, namely, the number of days taken
to appear first female flower, the number of fruits, the
weight of fruit, the total soluble solids (T.S.S.) and
total yield per plant studied in the present investigations.
Significant specific combining ability (s.c.a.) variance
was also noted in all these characters except T.S.S.,
which was found insignificant. However, the mean squares
for g.c.a. were larger than those for s.c.a. in all the

TABLE 18

Analysis of variance for combining ability

Characters	General combining ability			Specific combining ability			Reciprocal effects			Error		Components of variance
	d.f.	M.S.S.	F	d.f.	M.S.S.	F	d.f.	M.S.S.	F	d.f.	M.S.S.	$1/92\sigma^2_1$ $1/452...$
No.of days taken to open first female flower	9	902.6390	7255.9405**	45	39.0009	313.512**	45	2.3936	19.2411**	198	0.1244	45.125 38.8...
No.of fruit	9	31.8516	39.626**	45	2.9129	3.623**	45	0.7633	0.949	198	0.8038	1.552 2.9...
Weight of fruit	9	27.699	74.359**	45	0.4476	1.201*	45	0.5365	1.44*	198	0.3725	1.366 0.0...
T.S.S.	9	10.116	36.525**	45	0.286	1.035	45	0.4611	1.669**	198	0.2762	0.492 0.0...
Total yield	9	1146.906	22.192**	45	185.124	3.582**	45	75.4525	1.46*	198	51.6798	54.761 133.4...

* Significant at 5 per cent level

** Significant at 1 per cent level

characters. The variance due to reciprocal effect was found to be significant for all the characters except number of fruits. The estimated components of variance for g.c.a. ($1/9 \sum_{g_i}^2$) and s.c.a. ($1/45 \sum_{s_{ij}}^2$) were also calculated and presented in Table 18. The estimated component of variance for g.c.a. was larger than that of s.c.a. for every character except number of fruits and total yield per plant.

The estimated effects of g.c.a. ($\hat{g_i}$) of the parental lines, s.c.a. ($\hat{s}_{ij}$) of the F_1 hybrids and their reciprocals ($\hat{r}_{ij}$) for each of the above mentioned five characters were calculated and presented in Tables 19 to 23. The significant relationship of all these characters for the estimated general combining ability effects ($\hat{g_i}$) was also determined and tabulated there. The characterwise analysis of these estimated effects are presented below:

(a) <u>Number of days taken to open the first female flower</u>: Significant general combining ability effects (g_i) are shown by the parents P-3, P-1, P-10, P-8, P-2 and P-7 for late flowering. P-3 shows the maximum effect for lateness and P-7 minimum effect for latness. However, there was the difference between all the parents for late flowering. Significant g.c.a. effects were also shown by the parents P-5, P-6, P-9, and P-4 for early flowering

TABLE 19

Estimates of g.c.a. effects, g_i, of parents (diagonal, underlined), s.c.a. effects, S_{ij}, (above the diagonal) and reciprocal effects, r_{ij} (below the diagonal) of F_1 hybrids for number of days taken to open first female flower

♀ \ ♂	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10
P-1	+6.22**	+3.80**	+5.05**	-1.48**	-4.33**	-4.61**	+1.12**	+1.80**	-5.95**	+2.08**
P-2	0.25	+3.67**	+4.29**	-5.50**	-3.84**	-3.12**	+0.29**	+1.98**	-4.10**	+2.49**
P-3	0.19	1.24**	+7.56**	-5.46**	-3.09**	-3.65**	-3.16**	+2.73**	-5.01**	+2.40**
P-4	1.90**	1.13**	1.04**	-3.89**	+0.20**	-0.86**	+5.22**	-1.75**	-0.83**	+0.42**
P-5	0.34*	1.62**	1.07**	0.34*	-12.20**	+2.03**	-2.85**	-3.39**	+6.07**	-4.27**
P-6	1.72**	1.44**	0.86**	0.37**	1.15**	-7.73**	-2.97**	-2.01**	+9.44**	-4.90**
P-7	0.96**	1.54**	0.87**	0.49**	1.73**	0.93**	+2.77**	+1.74**	-0.88**	+1.74**
P-8	0.87**	0.96**	0.97**	0.94**	1.02**	1.14**	0.09	+4.05**	-4.36**	+2.22**
P-9	1.10**	1.48**	1.35**	0.55**	1.01**	1.13*	1.72**	1.09**	-5.14**	-3.08**
P-10	0.22	0.13	1.45	1.45**	1.13**	1.04**	0.45**	0.19	1.20**	+4.69**

* Significant at 5 per cent;   ** Significant at 1 per cent level;   S.E. g_i = 0.0431;

S.E. $(g_i - g_j)$ = 0.064;   S.E. s_{ij} = 0.130;   S.E. r_{ij} = 0.143;   S.E. $(s_{ij} - s_{ik})$ = 0.182;

S.E. $(r_{ij} - r_{kl})$ = 0.2031.

(Table 19),P-5 having maximum and P-4 minimum g_i effects
for early flowering. The specific combining ability effect
(s_{ij}) were significant in forty four hybrids. Ninteen
hybrids show significant s_{ij} for late flowering, hybrid
P-6 X P-9 shows maximum and hybrid P-2 X P-7 shows the
minimum s.c.a. effects for late flowering. Twenty five
hybrids expressed significant s.c.a. for early flowering,
hybrid P-1 X P-9 gave maximum and hybrid P-4 X P-9 minimum
s_{ij} for early flowering. Reciprocal effects (r_{ij}) were
significant in thirty nine hybrids, the maximum and
minimum effects being in crosses P-1 X P-4 and P-4 X P-5
respectively. P-2 X P-4 and P-5 X P-10 crosses shown
equal r_{ij} effects likewise 3 X 4 and 6 X 10, 1 X 8 and 3 X 7,
1 X 5 and 4 X 5 were shown equal r_{ij}, effect.

(b) <u>Number of fruits</u>: A significant positive
general combining ability effects (g_i) for this character
was observed for the parents P-6, P-5, P-9 and P-10; P-6
showing the maximum effect and P-10 the minimum. The
significant negative effects for number of fruits were
recorded for the parents P-1, P-3, P-7, P-2, P-8 and P-4;
P-1 showing the maximum negative effect and P-4 showing
the minimum.

However, no significant difference was observed
between P-9 and P-10 (Table 24). No significant differences

TABLE 20

Estimates of g.c.a. effects, g_i, of parents (diagonal, underlined), s.c.a. effects, S_{ij} (above the diagonal) and reciprocal effects, r_{ij} (below the diagonal) of F_1 parents for number of fruits/plant.

♀ \ ♂	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10
P-1	-1.26**	-1.82**	+0.71*	-0.24	1.06**	+0.55	+0.58	+0.85**	+1.53**	+1.12**
P-2	0.04	-0.76**	+1.74**	+1.01**	-0.14	+0.07	+1.76**	+0.84**	-0.11	-0.28
P-3	0.06	0.16	-1.18**	+0.64	-0.79*	+0.32**	-0.68*	-0.14	-0.33	-2.15**
P-4	0.07	0.14	0.10	-0.42**	-1.27**	-0.56	-0.03	+0.20	+0.23	+1.83**
P-5	0.07	0.12	0.18	0.07	+1.63**	+1.73**	+2.05**	-0.13	+1.31**	+1.22**
P-6	0.27	0.09	0.34	0.13	0.40	+2.38*	-0.25	-0.78*	-1.52**	+1.53**
P-7	0.11	0.36	0.04	0.09	0.19	0.06	-1.02**	-0.70*	-0.53	-1.01**
P-8	0.03	0.14	0.07	0.14	0.28	0.04	0.09	-0.61**	-0.31	-0.08
P-9	0.05	0.10	0.07	0.16	0.18	0.07	0.05	0.34	+0.68**	+0.27
P-10	0.17	0.10	0.14	0.12	0.20	0.41	0.39	0.46	0.18	+0.58**

* Significant at 5 per cent level; ** Significant at 1 per cent level; S.E. g_i = 0.109;

S.E. (g_i-g_j) = 0.163; S.E. s_{ij} = 0.331; S.E. r_{ij} = 0.366; S.E. $(s_{ij}-s_{ik})$ = 0.462;

S.E. $(r_{ij}-r_{kl})$ = 0.517; ...

were also observed among the parents (1,3 and 7); (7 and 2);
(2 and 8); and P-8 and P-4 in this respect. Out of forty five
crosses, fourteen showed significant s.c.a. effects for
greater number of fruits per plant and the crosses P-5 X P-7
and P-1 X P-3 had maximum and minimum s_{ij} effects respectively.
Eleven hybrids exhibited significant s_{ij} effects for the
lower number of fruits per plant, the maximum and minimum
effects being the crosses P-3 X P-10 and P-3 X P-7 respect-
ively. However, no significant reciprocal effects (r_{ij})
were observed.

(c) Weight of the fruit: It is revealed from the
Table 21, that out of ten parents involved in this experiment
six parents namely P-3, P-1, P-2, P-10 and P-7 showed
significant (g_i) for greater fruit weight, P-3 shown the
largest effect and P-7 the lowest. However, P-10 and P-7
did not differ significantly for this character. The
significant negative g.c.a. effects for fruit weight were
recorded for the parents P-5, P-6, P-9, P-4 and P-8;
P-5 shown the maximum negative effect and P-8 the minimum
and no significant (g_i) effect was found between the
parents P-4 and P-8. Out of forty five F_1 six F_1 hybrids
showed significant positive specific combining ability
(s_{ij}) effects and the cross P-2 X P-7 and P-1 X P-8 had
maximum and minimum effect respectively. Three hybrids

TABLE 21

Estimates of g.c.a. effects, g_i, of parents (diagonal underlined), s.c.a. effects, s_{ij} (above the diagonal) and reciprocal effects, r_{ij} (below the diagonal) of F_1 parents for fruit weight

♀ ＼ ♂	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10
P-1	+1.30**	-1.16**	+0.80**	+0.24	-0.04	-0.27	+0.32	+0.57*	+0.30	+0.08
P-2	+0.70	+0.94**	-0.31	-0.20	-0.12	+0.02	+1.48**	+0.95**	+0.03	+0.60**
P-3	0.13	0.09	+1.97**	+0.03	0.00	+0.11	-0.15	-0.00	-0.27	+0.72**
P-4	0.02	0.07	0.08	-0.36**	+0.29	+0.29	+0.06	-0.84**	+0.21	+0.23
P-5	0.75**	0.96**	0.79**	0.05	-1.76**	+0.27	-0.06	+0.13	+0.14	+0.01
P-6	0.76**	0.89**	0.94**	0.08	0.00	-1.31**	+0.05	-0.20	+0.02	-0.17
P-7	0.08	0.05	0.04	0.12	0.74**	0.11	+0.16*	-0.12	+0.37	-0.88**
P-8	0.10	0.08	0.03	0.02	0.01	0.12	0.16	-0.27**	-0.07	+0.13
P-9	0.16	0.02	0.06	0.06	0.05	0.12	0.20	0.02	-0.91**	-0.25
P-10	0.08	0.04	0.10	0.11	0.71**	0.20	0.03	0.11	0.05	+0.24**

* Significant at 5 per cent level; ** Significant at 1 per cent level; S.E. g_i = 0.074;
S.E. (g_i-g_j) = 0.111; S.E. s_{ij} = 0.225; S.E. r_{ij} = 0.249; S.E. $(s_{ij}-s_{ik})$ = 0.334;
S.E. $(s_{ij}-s_{kl})$ = 0.315; S.E. $(r_{ij}-r_{kl})$ = 0.352

TABLE 22

Estimates of g.c.a. effects, g_i, of parents (diagonal underlined), s.c.a. effects, s_{ij}, (above the diagonal) and reciprocal effects, r_{ij} (below the diagonal) of F_1 hybrids for T.S.S.

♀ \ ♂	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10
P-1	+0.75**	-0.53**	+0.08	-0.89**	-0.49*	+0.01	+0.66**	+0.68**	+0.01	+0.43*
P-2	0.00	+1.01**	+0.13	+0.31	-0.21	-0.21	+0.68**	+0.21	+0.03	+0.28
P-3	0.50*	0.75**	-1.31**	-0.11	+0.11	+0.14	+0.01	+0.03	+0.61**	+0.11
P-4	0.25	0.50*	0.25	-0.32**	+0.31	+0.56**	-0.04	-0.26	-0.44*	-0.09
P-5	0.00	0.50*	0.00	0.25	0.26**	+0.28	-0.56**	-0.26	+0.53**	+0.78*
P-6	0.50*	0.50*	0.25	0.50*	0.75**	+0.76**	-0.31	+0.21	-0.21	+0.03
P-7	0.75**	0.50*	0.50*	0.00	0.00	0.75**	-0.13*	-0.39*	-0.06	-0.31
P-8	0.25	0.50*	0.50*	0.25	0.25	0.75**	0.25	-0.66**	-0.04	-0.54**
P-9	0.25	0.50*	0.25	0.25	0.75**	0.25	0.25	0.25	-0.48**	-0.21
P-10	0.75**	0.25	0.25	0.00	1.00**	1.25**	0.00	0.25	0.25	+0.01

*Significant at 5 per cent level; **Significant at 1 per cent level; S.E. g_i = 0.064;

S.E. $(g_i - g_j)$ = 0.096; S.E. s_{ij} = 0.194; S.E. r_{ij} = 0.214; S.E. $(s_{ij} - s_{ik})$ = 0.287;

S.E. $(s_{ij} - s_{kl})$ = 0.271; S.E. $(r_{ij} - r_{kl})$ = 0.303

showed negative s.c.a. effects for this character, the
cross P-1 X P-2 and P-4 X P-8 had maximum and minimum
effect respectively. A significant reciprocal effect
(r_{ij}) was recorded in eight F_1 s, the maximum and minimum
effects being in crosses P-2 X P-5 and P-5 X P-10 respectively.

(d) Total soluble solids (T.S.S.): The significant
g.c.a. effects (g_i) for higher T.S.S. were shown by the
parental lines P-2, P-6, P-1, P-5 and P-10, Table 22. P-2
having the maximum effect while P-10 had the minimum. Five
parental lines namely P-3, P-8, P-9, P-4 and P-7 showing
significant g_i effects for lower T.S.S., P-3 and P-7 had
the maximum and minimum effects respectively. Parents P-6
and P-1 did not significantly differ for this character
(Table 11). Eight hybrids had the significant specific
combining ability effects (s_{ij}) for higher T.S.S., the
crosses P-5 X P-10 and P-1 X P-10 exhibiting the maximum
and minimum effects respectively. The significant s.c.a.
effects for lower T.S.S. were observed in seven crosses,
hybrid P-1 X P-4 and P-7 X P-8 showing the maximum and
minimum effects. Out of forty five, nineteen crosses showed
significant reciprocal effects (r_{ij}), the maximum and the
minimum effect were observed in the crosses P-6 X P-10,
P-4 X P-6, The seven crosses P-2 X P-3, P-1 X P-7, P-1 X P-10,
P-1 X P-6, P-5 X P-9, P-6 X P-7 and P-6 X P-8 showed the equal
(r_{ij}) effect (0.75) among each other. The remaining crosses

TABLE 23

Estimates of g.c.a. effects g_i of parents (diagonal underlined), s.c.a. effects, s_{ij} (above the diagonal) and reciprocal effects r_{ij} (below the diagonal) of F_1 hybrids for total yield

♀＼♂	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10
P-1	+6.449**	-24.373**	+8.844**	-0.153	-1.648	+4.284	+4.809	+10.058**	+14.373**	+10.297**
P-2	0.167	+6.879**	+7.669**	-8.847**	+1.486	+3.466	+20.201**	+13.517**	+0.669	+5.223**
P-3	1.830	0.327	+13.264**	+3.790	+0.558	+13.120**	-8.856**	-2.183	-2.463	-8.792**
P-4	0.147	0.431	1.313	-4.345**	-1.604	+8.858**	-0.092	-7.747**	+3.016	+15.825**
P-5	7.740**	6.339*	6.056*	0.383	-11.344**	+1.840	+8.720**	+1.249	+2.797	+5.343*
P-6	7.623**	7.580**	7.356**	0.332	0.859	-3.057*	+1.263	-5.541*	-11.930**	+2.593
P-7	0.122	2.235	0.024	1.604	7.543**	1.558	-2.904*	-4.797	+2.353	-7.613**
P-8	1.278	0.260	0.245	0.879	0.786	1.376	1.787	-4.846**	-1.799	+1.376
P-9	2.283	0.331	0.206	0.024	1.261	0.464	1.665	1.669	-5.636**	-0.587
P-10	2.192	0.263	1.986	2.238	7.342**	2.974	2.126	4.340	0.187	+5.536**

*Significant at 5 per cent level; **Significant at 1 per cent level; S.E. g_i = 1.245;

S.E. (g_i-g_j) = 1.313; S.E. s_{ij} = 2.657; S.E. r_{ij} = 2.934; S.E. $(s_{ij}-s_{ik})$ = 3.937;

S.E. $(s_{ij}-s_{kl})$ = 3.712; S.E. $(r_{ij}-r_{kl})$ = 4.150.

P-1 X P-6, P-2 X P-4, P-2 X P-5, P-2 X P-6, P-2 X P-7, P-2 X P-8
P-2 X P-9, P-3 X P-7, P-3 X P-8 and P-4 X P-6 showed the equal
r_{ij} effect (0.50).

(e) <u>Total yield per plant:</u> Significant general
combining ability effects (g_i) were shown by the parents
P-3, P-2, P-1 and P-10 for higher yield where P-3 showed
the maximum and P-10 the minimum effects for greater yield.
However, there was no significant difference between the
parents P-2, P-1 and P-10 for higher yield. Significant
g.c.a. effects were also shown by the parents P-5, P-9,
P-8, P-4, P-6 and P-7 for lower yield, P-5 having the maximum
and P-7 having the minimum negative (g_i) effects for lower
yield and no significant differences were found between the
parents P-9 and P-8 and among P-8, P-4, P-6 and P-7 for this
character. The specific combining ability effects (s_{ij}) were
significant in twenty one hybrids. Thirteen hybrids showed
significant s_{ij} for higher yield, where the hybrid P-2 X P-7
showed the maximum and P-2 X P-10 the minimum s.c.a. effect
for higher yield. Eight hybrids expressed significant s.c.a.
effect for lower yield, hybrid P-1 X P-2 gave the maximum
and hybrid P-6 X P-8 the minimum s_{ij} for lower yield.
Reciprocal effects (r_{ij}) were significant in eight hybrids
the maximum and minimum effects being in crosses P-1 X P-6
and P-3 and P-5 respectively.

.ng of parents for g_i

Ch_j	Significance grouping for G_i
Nu' 7X9, 2X5, 2X7, too,2X6, 3X9, 2X3, fe ,=5X10,6X8, 6X9, , 3X4 =6x10,5x8, , 2X8, 4X8, 6X7, , 3X6, 4X9, 4X7,	3, 1, 10,8,2,7, (5,6,9,4)
Nt	6, 5, 9, 10 (1,5,7,2,8,4)
W. 3X5, 1X6, 1X5,	3, 1, 2, 10, 7 (5,6,9,4,8)
T =1X7 =1X10 =5X6 , 1X3 =1X6 = 2X4 =2X9 =3X7 = 3X8	2, 6, 1, 5, 10 (3,8,9,4,7)
T 1X5, 3X6, 5X10	3, 2, 1, 10 (5,9,8,4,6,7)

† 8=P-8, 9=P-9 and 10=P-10

The highly significant F ratio was found in
all the five characters for both general and specific
combining ability effects except onecharacter i.e. T.S.S.
for which s.c.a. was found insignificant (Table 18). This
indicates that there were true differences existing
among these effects except the character, T.S.S. for
s.c.a. which is insignificant. Reciprocal effects were
also found signi icant for all these characters except
the number of fruits. The estimated components of variances
for g.c.a. and s.c.a. indicates that the former was greater
in three cases only viz., number of days taken to open
first female flower, weight of fruit and T.S.S. while in
two characters viz., number of fruit and total yield,
the s.c.a. was greater than g.c.a.

4. Inheritance of qualitative characters:

Thirteen experiments were carried out to study
the inheritance of five qualitative characters, viz.,
skin colour of the fruit, flesh colour of the fruit, seed
colour, seed size and fruit shape. All these observations
were taken on fully riped fruits. The observations recorded
for these experiments are given below:

(a) Skin colour of the fruit:

Experiment No.1: The parents involved in this case
were P-7 (having dark green skin colour) and P-10 (having

TABLE 25

Inheritance of fruit colour in watermelon

Population	Phenotype		Total	Expected ratio	X^2 value		
	Dark green	Light green			Calculated	Tabular 1%	5%
P-7	22	-	22	-			
P-10	-	18	18	-			
(P-7 X P-10) F$_1$	25	-	25	-			
F$_1$ X P-7	52	-	52	-			
F$_1$ X P-10	48	53	101	1:1	0.247	6.635	3.841
(P-7 X P-10) X (P-7 X P-10) F$_2$	64	20	84	3:1	0.063	6.635	3.841

TABLE 26

Inheritance of fruit colour in watermelon

Population	Phenotype		Total	Expected ratio	x^2 value		
	Non-striped	Striped			Calcu-lated	Tabular 1%	5%
P-10	27	-	27	-			
P-3	-	31	31	-			
(P-10 X P-3) F_1	-	43	43	-			
F_1 X P-10	44	39	83	1:1	0.301	6.635	3.841
F_1 X P-3	-	62	62	-			
(P-10 X P-3) X (P-10 X P-3) F_2	24	67	91	3:1	2.747	6.635	3.841

TABLE 27

Inheritance of fruit colour in watermelon

Population	Phenotype				Total	Expected ratio	X^2 value		
	Dark green with dark green stripes	Light green with dark green stripes	Dark green with deep dark green stripes	Light green with no green stripes			Calculated	Tabular 1%	5%
P-7	18	-	-	-	18	-			
P-3	-	20	-	-	20	-			
(P-7 X P-3)F₁	-	-	47	-	47	-			
F₁ X P-7	31	-	29	-	60	1:1	0.6666	6.635	3.841
F₁ X P-3	-	46	43	-	89	1:1	0.1010	6.635	3.841
(P-7 X P-3) X (P-7 X P-3) F₂	10	9	32	3	54	9:3:3:1	0.0942	11.341	7.815

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light green skin colour). In F_1 all the plants produced dark green skin coloured fruits. F_1, F_2, backcross and testcross observations are presented in Table 25. The two parents differ by one pair of genes for fruit colour. The dark green colour was completely dominant over light green.

Experiment No.2: In this experiment the parents involved were P-10 (with non-striped fruits) and P-3 (with striped fruits). The data recorded from the parents, F_1, F_2 and backcross generations are presented in Table 26. The two parents differ by one pair of genes in respect of skin colour of the fruit, and striped skin colour was completely dominant over non-striped character.

Experiment No.3: The parents involved in this experiment were P-7 having darkgreen skin colour, and P-3 having lightgreen with dark green stripes. The parents, F_1, F_2 and backcrosses were grown and data recorded are presented in Table 27. The observations indicated that the dark green and the striped pattern were two independent traits as the crosses between dark green with light green striped assorted independently in F_2 giving a ratio of 9:3:3:1 (9 dark green striped; 3 dark green non-striped; 3 light green striped; 1 light green non-striped). The study also revealed that there was no linkage and the genes for these traits were situated in different chromosomes.

(b) <u>Flesh colour of the fruit:</u>

<u>Experiment No.4:</u>   The parents taken for the flesh colour inheritance were P-6 having red flesh and P-4 having yellow flesh. In F_1 all the plants produced the fruits, having red flesh. F_1, F_2 and backcross observations are presented in Table 28, shows that the two parents differed by single pair of genes in respect of flesh colour, and red flesh colour was completely dominant over yellow.

<u>Experiment No.5:</u>   The two parents P-3 having cannery yellow flesh and P-10 having pink flesh, were involved for the study of flesh colour inheritance. The F_1, F_2 and backcross were grown and the data recorded are presented in Table 29.

The results of F_1, F_2 and backcross generations indicated that the flesh colour of the parents differed by one pair of genes, and the complete dominance of cannery yellow over pink was there.

(c) <u>Seed colour:</u>

<u>Experiment No.6:</u>   The parents involved in this experiment consisted of black colour seed (P-8) and dark brown colour seed (P-2). The observations recorded from the parents, F_1, F_2 and backcross are presented in Table 30.

TABLE 28

Inheritance of flesh colour in watermelon

Population	Phenotype		Total	Expected ratio	X^2 value		
	Red	Yellow			Calcu-lated	Tabular 1%	5%
P-6	21	-	21	-			
P-4	-	17	17	-			
(P-6 X P-4) F$_1$	44	-	44	-			
F$_1$ X P-6	52	-	52	-			
F$_1$ X P-4	28	26	54	1:1	0.074	6.635	3.841
(P-6 X P-4) X (P-6 X P-4) F$_2$	82	26	108	3:1	0.148	6.635	3.841

TABLE 29

Inheritance of flesh colour in watermelon

Population	Phenotype		Total	Expected ratio	X^2 value		
	Cannery yellow	Pink			Calculated	Tabular 1%	5%
P-3	19	—	19	—			
P-10	—	17	17	—			
(P-3 X P-10) F_1	39	—	39	—			
F_1 X P-3	42	—	42	—			
F_1 X P-10	23	18	41	1:1	0.609	6.635	3.841
(P-3 X P-10) X (P-3 X P-10) F_2	76	29	105	3:1	1.152	6.635	3.841

The two parents differ by single pair of genes for seed colour, and black colour was completely dominant over dark brown.

Experiment No.7: The two parents P-8 and P-9 (black and red seeded respectively) were involved in this case. In F_1 all the plants produced black seeded fruits. F_1, F_2 and backcross observations are presented in Table 31. The two parents differed by one pair of genes in respect of seed colour and black colour was dominant over red.

Experiment No.8: In this experiment two parents P-8 and P-4 having black and dark orange yellow seeds respectively, were crossed. In F_1 all the plants produced the fruits having black seeds. The data recorded from the parents, F_1, F_2 and backcross generations are presented in Table 32. The seed colour of the parents differed by single pair of genes and black colour was completely dominant over dark orange yellow.

Experiment No.9: The parents involved in this case were P-2 having dark brown seed and P-9 having red colour seed. The parents F_1, F_2 and backcrosses were grown and data recorded are presented in Table 33. The seed colour of the parents differed by one pair of genes and dark brown colour was dominant over red.

TABLE 30

Inheritance of seed colour in watermelon

Population	Phenotype Black	Dark brown	Total	Expected ratio	χ^2 value Calcuated	Tabular 1%	5%
P-8	14	-	14	-			
P-2	-	18	18	-			
(P-8 X P-2) F_1	33	-	33	-			
F_1 X P-8	54	-	54	-			
F_1 X P-2	42	38	80	1:1	0.200	6.635	3.841
(P-8 X P-2) X (P-8 X P-2) F_2	44	13	57	3:1	0.438	6.635	3.841

TABLE 31

Inheritance of seed colour in watermelon

Population	Phenotype Black	Red	Total	Expected ratio	X^2 value Calculated	Tabular 1%	5%
P-8	22	–	22	–			
P-9	–	18	18	–			
(P-8 X P-9) F_1	46	–	46	–			
F_1 X P-8	52	–	52	–			
F_1 X P-9	42	38	80	1:1	0.200	6.635	3.841
(P-8 X P-9) X (P-8 X P-9) F_2	33	12	45	3:1	0.200	6.635	3.841

TABLE 32

Inheritance of seed colour in watermelon

Population	Phenotype Black	Phenotype Dark orange yellow	Total	Expected ratio	X^2 value Calculated	X^2 value Tabular 1%	X^2 value Tabular 5%
P-8	20	-	20	-			
P-4	-	16	16	-			
(P-8 X P-4) F$_1$	32	-	32	-			
F$_1$ X P-8	41	-	41	-			
F$_1$ X P-4	34	39	73	1:1	0.342	6.635	3.841
(P-8 X P-4) X (P-8 X P-4) F$_2$	29	8	37	3:1	0.675	6.635	3.841

TABLE 33

Inheritance of seed colour in watermelon

Population	Phenotype		Total	Expected ratio	X^2 value		
	Dark brown	Red			Calculated	Tabular 1%	5%
P-2	22	-	22	-			
P-9	-	16	16	-			
(P-2 X P-9) F_1	40	-	40	-			
F_1 X P-2	38	-	38	-			
F_1 X P-9	24	22	46	1:1	0.086	6.635	3.841
(P-2 X P-9) X (P-2 X P-9) F_2	54	17	71	3:1	0.126	6.635	3.841

TABLE 34

Inheritance of seed colour in water elon

Population	Phenotype			Total	Expected ratio	X^2 value	
	Dark brown	Dark orange	yellow			Calcul- ated	Tabular 1% 5%
P-2	21	-	-	21	-		
P-4	-	24	-	24	-		
(P-2 X P-4) F$_1$	27	-	-	27	-		
F$_1$ X P-2	34	-	-	34	-		
F$_1$ X P-4	20	22	-	42	1:1	0.095	6.635 3.841
(P-2 X P-4) X F$_2$	44	15	-	59	3:1	0.015	6.635 3.841

TABLE 35

Inheritance of seed colour in watermelon

Population	Phenotype			Total	Expected ratio	X^2 value		
	Red	Dark orange	yellow			Calculated	Tabular	
							5%	1%
P-9	17	-	-	17	-			
P-4	-	21	21	21	-			
(P-9 X P-4) P_1	-	32	32	32	-			
F_1 X P-9	21	19	-	40	1:1	1.00	3.841	6.635
F_1 X P-4	-	36	36	36	-			
(P-9 X P-4) X (P-9 X P-4) F_2	22	68	80	80	3:1	0.050	3.841	6.635

Experiment No.10: The two parents P-2 and
P-4 having dark brown and dark orange yellow coloured
seed were involved for the seed colour inheritance.
In F_1 all the fruits produced the dark brown seed.
The parents, F_1, F_2 and backcross observations were
also taken and presented in Table 34. The two parents
differed by single pair of genes and dark brown seed
colour was dominant over dark orange yellow colour
seeds.

Experiment No.11: The parents involved in
this experiment consisted of red seeds (P-9) and dark
orange yellow seeds (P-4). The observations recorded
from the parents, F_1, F_2 and backcrosses are presented
in Table 35. The two parents differed by one pair of
genes and dark orange yellow colour was dominant over
red.

(d) Seed size:

Experiment No.12: The parents involved in
the seed size inheritance were of small size (P-2) and
large size (P-1). The data recorded from parents, F_1,F_2
and backcrosses are presented in Table 36. The two
parents differed by single pair of genes for seed size
and small seed size was completely dominant over large
size.

TABLE 36

Inheritance of seed size in watermelon

Population	Phenotype		Total	Expected ratio	X^2 value	
	Small seeded plants	Large seeded plants			Calculated	Tabular
						1% 5%
P-2	28	–	28	–		
P-1	–	32	32	–		
(P-2 X P-1) F_1	30	–	30	–		
F_1 X P-2	42	–	42	–		
F_1 X P-1	32	35	67	1:1	0.134	6.635 3.841
(P-2 X P-1) X (P-2 X P-1) F_2	42	15	57	3:1	0.157	6.635 3.841

TABLE 37

Inheritance of fruit shape in watermelon

| Population | Phenotype | | | Total | Expected ratio | x^2 value | | |
| | Long | Oval | Round | | | Calculated | Tabular | |
							1%	5%
P-1	24	-	-	24	-			
P-6	-	-	35	35	-			
(P-1 X P-6) F_1	-	51	-	51	-			
F_1 X P-1	26	23	-	49	1:1	0.183	6.635	3.841
F_1 X P-6	-	37	32	69	1:1	0.362	6.635	3.841
(P-1 X P-6) X (P-1 X P-6) F_2	30	62	28	120	1:2:1	0.199	6.635	3.841

(e) <u>Fruit shape:</u>

Experiment No.13: In this experiment two parents P-1 and P-6 having long and round fruits respectively, were involved. In F_1 all the plants produced oval fruits. The data recorded from the parents, F_1, F_2 and backcrosses are presented in Table 37. In F_2 segregation of 1:2:1 (1 long, 2 oval, 1 round) was observed. This indicates that the trait is monogenic, but incompletely dominant.

DISCUSSION

In the present investigation the results of the experiments conducted for testing the hybrid vigour, diallel analysis, following graphical as well as numerical approach, general and specific combining ability and reciprocal difference of the parents and their hybrids and inheritance of some qualitative characters are included. These investigations were carried out on ten selected parents in two main experiments. The studies in first experiment include, the hybrid vigour over parental average and better parent, the diallel analysis to find out the presence of epistasis in various F_1 hybrids, the degree of dominance in parents, the distribution of genes with positive and negative effects and the proportion of dominant and recessive alleles. The general and specific combining ability of the parents and the reciprocal effects of the crosses were also determined in this experiment. The studies were further extended to F_2 and backcross generation to observe the inheritance of some qualitative characters in the second set of experiments. All these aspects are discussed individually in the following pages.

Hybrid vigour:

Heterosis was exhibited in many F_1 hybrids and it was manifested in almost all the characters studied. Although

many P_1 hybrids were found to be better than the mid-parent showing thereby heterosis, it was considered more useful to study in detail only those crosses in which the P_1 hybrids were better than their respective better parents, since these can be usefully exploited commercially. Observations recorded for nine characters, **viz.**, the vine length, the number of days taken to open the first female flower, the number of female flowers, the number of fruits, the weight of fruit, the length of the fruit, the breadth of the fruit, the total soluble solids (T.S.S.) and the total yield are discussed below for each character.

Vine length: Fifty nine hybrids significantly increased the vine length over their parental average and six hybrids increased the vine length significantly over their better parents. The maximum length was attained by the hybrid C-42 and C-45, which had an average length of 4.82 m. A decrease in hybrid vine length, however, was also recorded, and none hybrid showed significant reduction in length over the parental average, but eleven hybrids showed significant reduction in length over the better parent. The minimum average length of 2.48 m. was attained by the plants of hybrid C-12 and C-25. The vine length of parents varied from 1.25 m. in P-5 to 4.56 m. in P-10.

Increased length of the vine does not necessarily mean higher yield as is evident from the recorded observations, although in some of the hybrids with increased vine length the yield was high. The vine length, therefore, as such does not appear to be a definite economic character for this crop.

No report is available on vine length in watermelon, therefore, the work done on this aspect on other cucurbitaceous crops are discussed. Pal and Singh (1946) and Srivastava (1970) working on the hybrid vigour studies in bittergourd reported identical findings of increased vine length; and in some of the hybrids, as in the present findings, the length was significantly reduced. Baily et al (1964) reported that F_1 hybrids showed vigorous plant growth in muskmelon. But on the other hand Ram Prakash (1953) reported decrease in vine length of snakegourd hybrids when compared with their parents. Similarly, Rajendran (1961) also observed a significant reduction in vine length in bottlegourd hybrids. Further he pointedout that with the increased fruit yield the vine length showed a decrease. The present observations on watermelon are contrary to the reports of Ram Prakash (1953) on snakegourd and those of Rajendran (1961) on bottlegourd, and are almost identical with the work of Baily et al (1964) on muskmelon, Pal and Singh (1946) and Srivastava (1970) in bittergourd.

Number of days taken to open the first female

flower: It was observed that among the parents, P-5
was the earliest to flower, taking on an average 46.35
days after sowing to open the first female flower. The
maximum number of days (average 78.21 days) to open
the first female flower was taken by the parent P-3.
The earliest hybrid to produce female flower was C-31R
which took on an average 38.14 days, while the maximum
delay was recorded in the hybrid C-2 which took on an
average 76.24 days.

In most of the hybrids first female flower was
produced earlier than their parental average. Out of
ninety hybrids, sixty seven were earlier to flower and
as many as sixty six were significantly earlier to flower.
The decrease in days was recorded from 0.19 to 24.61
per cent over their parental average. Forty one hybrids
were early to produce female flower when compared with
their respective early parents and this was significant
in thirty nine hybrids.

The earliness is an important economic character,
as it gives earlier yield and at the same time widens
the flowering and fruiting span of the plants which
ultimately results in higher fruit yield. In view of

this the present investigations on earliness in
watermelon are of significance importance.

Yanagisawa and Hosono (1951), Tracenko (1953),
Buzulin and Nishi (1955), Barna (1961), Bresnev (1961)
and Haltern (1943), while working on the hybrid vigour
in watermelon also recorded earlier appearance of
flowers. The present observations are almost identical
with theirs. Like-wise Pal and Singh (1946), rivastava
(1970) in bittergourd; Munger (1942) and Bohn and Davis (1957)
in muskmelon; Shifriss (1945) and Cizov (1945) in
cucumber, Meaccrow (1957) and Nagaeva (1958) in pumpkin,
Curtiss (1939) and Hutchins and Croston (1941) in squash,
and Rajendran (1961) in bottlegourd reported that a
majority of the hybrids were earlier as is also shown
by the results of the present study.

Number of female flowers: The average number of
female flowers in parents varied from 32.48 in P-5 to
68.15 in P-3 per plant, while in hybrids it varied from
40.38 in C-25 to 79.54 in C-39 per plant. When the number
of female flowers of hybrids was compared with the average
of their parents it was found that sixty five hybrids
had significantly higher number, although the increase
was recorded in sixty seven hybrids. The increase in the

number of female flowers in hybrids, when calculated over their better parents, was found to be significant in thirty eight cases. The maximum number of female flowers was recorded in the hybrid C-39 which had on an average 79.54 flowers per plant.

The number of female flowers in cucurbits is of significant economic importance since only these flowers form fruits. The plants with lesser number of female flowers will naturally have lesser potentiality for number of fruits, which is evident from the record of the present investigation.

The increase in the number of female flowers in watermelon hybrids has not been reported earlier, while in bittergourd hybrids, Pal and Singh (1946), and Srivastava (1970) recorded a significant increase in the number of female flower. The different hybrids showed varying proportion of male to female flowers. Rajendran (1961) also recorded a significant increase in the number of female flowers in the F_1 hybrids of bottlegourd. He observed that the total average number of female flowers produced by the parents was thirty seven while that of the hybrids was fifty seven per plant. Mescrow (1957) recorded similar increase in the number of female flowers in Cucurbita maxima. These findings are similar to the present observation on watermelon.

Number of fruits: The number of fruits per plant
in parents varied from 5.80 in P-1 to 13.63 in P-6, while
in hybrids it varied from 6.62 in C-1 to 16.66 in C-31.
Seventy one hybrids had more number of fruits when compared
with their parental average and out of that forty four
hybrids were significant. While eighteen hybrids showed
significant increase in number of fruits per plant over
better parents as well. A decrease in the number of fruits
was also recorded in some of the hybrids.

The number of fruits in the plant appears to
be somewhat related with the number of female flowers
and the size of the fruit. Generally, a plant with larger
fruits had lesser number of fruits as compared to the
plants with smaller fruits. The increase in the number
of fruits is an economic character in which we are
interested as this ultimately influences the yield. The
maximum number of fruits were recorded in the hybrid C-31
which had 16.66 fruits per plant and a majority of the
hybrids manifested heterosis for this character.

In the watermelon cross, Valkovska X Marble 17,
Daskalov and Popova (1958) recorded appreciable number
of fruits, while in cucumber hybrids, Hayes and Jones
(1916) recorded heterosis in yield due to larger number
of fruits per vine. This was later confirmed by Hutchins
(1938) and Cizov (1945) who reported similar results in

cucumber. The increase in the number of fruits in hybrids of watermelon as observed in the present findings, has been also reported by Pal and Singh (1946) and Srivastava (1970) in bittergourd hybrids. Similar results were also found by Hutchins and Croston (1941) in winter squash; Curtis (1939, 1940, 1941) in Cucurbita pepo; Yunger (1942) in muskmelon and Rajendran (1961) in bottlegourd.

Weight of the fruit: The average weight of the fruits in the parents varied from 1.250 kg (P-5) to 8.422 kg (P-3) and in the hybrids it ranged from 2.591 kg (C-31) to 9.620 kg (C-2). It was observed that most of the hybrids had the average weight between the range of the weight of the parents involved. In some of the hybrids, however, the increase in fruit weight over their parental average and even over the better parent was also recorded. In some of the hybrids a decrease in fruit weight was observed. In view of present findings it appears that the increase in number of fruits per plant in hybrids has caused reduction in their average fruit weight.

In cucumber hybrids an increase in fruit weight was observed by Jakimovic, 1938 and Cisov, 1945. Similar results of increase in fruit weight were reported by Hutchins and Croston (1941) in pumpkin; Curtis (1939-41)

in summer squash and Srivastava (1970) in bittergourd, as has been recorded in the present investigation.

Length of the fruit: The length of the fruit of the parents varied from 16.20 cm (P-5) to 45.00 cm (P-3) and it ranged from 18.42 (C-31R) to 48.19 (C-2) in hybrids. Only fifty six hybrids increased significantly the length of their fruits over their parental average, while twenty two hybrids reduced the length over their parental average. Similarly, eleven hybrids only had significantly longer fruits over their better parent. Sixty three hybrids significantly decreased the length of the fruit over their better parent. It is, therefore, apparent that majority of hybrids had the fruit length between the length of their parents, which is responsible for the medium size of hybrid fruit in terms of length. While Daskalov and Popova (1958) and Barna (1962) observed that the fruit size in watermelon hybrids was smaller than their parents, on the other hand Tracenko (1953) and Bresnev (1960) found the longer fruit size in the same crop. In the present findings it does not hold good. The hybrids were almost of medium size. Jakimovic (1938) and Cisov (1945) also found larger fruits in cucumber hybrids. Similar results were recorded in pumpkin by Teigle (1959). The negative hybrid vigour in bittergourd for length of fruit was reported by Pal and Singh (1946).

<u>Breadth of the fruit:</u> The breadth of the fruit
from the parents varied between 13.63 cm (P-5) and
27.00 cm (P-10) and in the hybrids it ranged from 15.10 cm
(C-6) to 34.57 cm (C-17R). A significant increase in the
breadth of hybrid fruits over the parental average was
observed in fifty two hybrids, and in thirty one hybrids
it was significantly lower, while in others the increase
or decrease was insignificant. The increase in breadth
of the hybrids over the better parent was also observed
in twenty hybrids, while a significant decrease was
recorded in fifty nine hybrids. It is, therefore, apparent
that the majority of the hybrids were intermediate in
their fruit breadth, while Dashalov and Popova (1958)
and Barna (1962) recorded the smaller size of fruits in
watermelon hybrids, than their parents. On the other hand
Tracenko (1953) and Bresnev (1960) recorded the fruits
of bigger size in the hybrids than their parents.

<u>Total soluble solids (T.S.S.):</u> The average T.S.S.
of the fruits in the parents varied from 6 per cent (P-3)
to 11 per cent (P-2) while in hybrids it ranged from
7 (C-22) to 11.5 per cent (C-5R, C-6R, C-9R, C-13R, C-14R,
C-31, C-35R and C-39R).

The increase in T.S.S. of fruits over the parental
average was statistically significant in thirty hybrids,

however, the significant decrease was noted in three hybrids only. The twenty hybrids had the T.S.S. equal to that of their parental mean. The nine hybrids showed significant increase over their better parent while significant decrease was recorded in twenty four hybrids. Twenty hybrids had the T.S.S. equal to that of their higher parent. Ivanoff and Albritton (1962) found, an increase in sugar content in watermelon hybrids, while Arassimovich (1937) reported that F_1s were usually intermediate in respect of sugar content, though sometimes heterosis occurred. In the present findings, some of the hybrids showed increase and some of the hybrids decrease in sugar content. While some of the hybrids showed neither increase nor decrease in sugar content over their parents. The present findings support the finding of Ivanoff and Albritton (1962) on one hand and Arassimovich (1937) on the other.

The maximum T.S.S. was obtained by the hybrids C-5R, C-6R, C-9R, C-13R, C-14R, C-31R, C-35R and C-39R, each having 11.50 per cent T.S.S. followed by C-11, C-12, C-17R, C-26R, C-36R, which were having 11 per cent T.S.S.

Total yield: The average total yield per plant of the parents varied from 13.295 kg (P-5) to 69.558 kg

(P-3), while it ranged from 33.634 kg (C-38) to 87.094 kg (C-20R) in their hybrids. Out of ninety hybrids, fifty seven hybrids increased the yield over their parental average significantly. Significant increase in yield was also recorded by hybrids over their respective better parent in thirty five hybrids. In some of the hybrids, however, reduction in yield was recorded. Thus majority of the hybrids manifested heterosis regarding total yield. The increase in the yield was also recorded in watermelon hybrids, by Krebscenko (1939), Yanagisawa and Hosono (1951), Tracenko (1953), Kihara (1951), Popova (1960), Ivanoff and Albritton (1962), Vanwinden and Van Reet (1962), Mozsar (1964) and Zuev (1964). In other cucurbitaceous vegetables heterotic yield was recorded by Hayes and Jones (1916), Jakimovic (1938), Hutchins (1938), Shifriss (1945), Cisov (1945), Alexandrove (1952), Carlson (1952) and Weigle (1959) all on cucumber; Passmove (1934) and Curtis (1939-41) in summer squash; Pal and Singh (1946), Srivastava (1970) in bittergourd; Richharia (1952) in Luffa; Ram Prakash (1953) in snakegourd and Rajendran (1961) in bottlagourd. Hutchins and Croston (1941), Lana (1950) and Mesocrow (1957), also observed similar increase in yield in pumpkin and squash. Munger (1942), Bohn and Davis (1957) in muskmelon also observed that hybrids outstripped their respective better parent and also the commercial varieties.

The yield is the most important character of economic importance and in the present findings many promising hybrids have been recorded which appear. An increased vine length of hybrids was established in majority of the cases, but the vine length does not appear to influence the yielding capacity of the plants. A significant increase in the number of female flowers per plant and their early opening is of the utmost commercial importance, because it is the number of female flowers which ultimately influence the number of fruits per plant which in turn effects the yield. The early flowering also expands the flowering and fruiting span of the plants which helps in better or higher production.

Maximum yield was obtained by the plants of hybrid C-20R (87.094 kg) followed by the hybrids, C-2 (85.106 kg), C-10 (82.858 kg), C-10R (82.203 kg), C-2R (81.445 kg), C-14 (81.126 kg), C-9 (79.190 kg), C-14R (76.655 kg), C-20 (75.006 kg), C-9R (74.806 kg), C-30 (73.970 kg), C-17 (72.618 kg), C-8 (72.190 kg), C-17R (72.091 kg), C-13R (71.432 kg), C-15 (70.527 kg), C-5 (70.023 kg), C-15R (70.006 kg) where the average yield per plant was more than seventy kilogrames. In these, seventeen hybrids, i.e. P-1, P-2, P-3, P-6, P-7, P-8, P-9 and P-10, were involved. P-1 was involved in two hybrids P-2 in five hybrids, P-3 in two hybrids, P-6 in two hybrids, P-7, P-8 and P-9 each

in one hybrid and P-10 in three hybrids. It is, therefore, apparent that P-2 showed the maximum potentiality for increased yield.

Diallel analysis:

The diallel analysis for the ninety F_1 hybrids including reciprocals and their ten parents showed that partial dominance was present for the character weight of the fruit and total soluble solids (T.S.S.). For the number of days taken to open the first female flower, number of fruits and total yield showed overdominance as indicated by the $(H_1/D)^k$ value (Table 16). Combining ability analysis Table 18 indicates that both g.c.a. and s.c.a. effects were highly significant for all the characters studied except s.c.a. effects for T.S.S. Epistasis, probably of complementary type, was also observed for three characters viz., number of days taken to open first female flower, number of fruits and total yield (Table 15). Allard (1956a) and Morgan et al (1967) have suggested that complementary type of gene action may inflate $(H_1/D)^{\frac{1}{2}}$ ratio from partial dominance to overdominance and this will be reflected in the increase of V_r towards W_r. In the present case, mean degree of dominance for weight of the fruit and T.S.S. is, therefore, presumed as partial dominance and for the other three

characters, _viz_., number of days taken to open the first
female flower, number of fruits and total yield, in the
range of partial dominance to dominance, rather than over-
dominance, as it is presumed that complementary type of
gene action has inflated $(H_1/D)^{\frac{1}{2}}$ ratio in these characters.
Partial dominance for earliness was also observed by
Hayman (1954 _a_) in _Nicotiana rustica_, Joshi _et al_ (1961)
in linseed, Burdic (1954) in tomato, Sharma (1965) in
okra and Srivastava (1970) in bittergourd.

In the present study, recessive alleles were
more frequent than the dominant alleles in the number
of days taken to open the first female flower, the number
of fruits, the fruit weight and T.S.S., while in the
total yield character the dominant genes were more
frequent in the parents as indicated by the value of
F and $(4DH_1)^{\frac{1}{2}}+ F/(4DH_1)^{\frac{1}{2}} -F$ (Table 16). Sharma (1965)
observed that the recessive alleles were more frequent
than the dominant alleles in the fruit weight and total
yield while in flowering and the number of fruits, the
dominant genes were more frequent in the parents of okra.
Srivastava (1970) observed that recessive alleles were
more frequent than the dominant for number of days taken
to open first female flower, the number of the fruit and
and the total yield but in the fruit weight the dominant
alleles were more frequent than the recessive ones.

There is asymmetry of distribution of genes with positive and negative effects, in all the characters, except the total yield, in which these are in almost equal proportion (Table 16). Sharma (1965) also observed that the asymmetry of distribution of genes with positive and negative effects in all the characters except fruit size, in which these are in almost equal proportion. While Srivastava (1970) observed almost equal porportion of dominant and recessive genes for number of days taken to open the first female flower in bittergourd and for the other characters the genes were distributed asymmetrically.

The significant positive correlation between parental order of dominance and parental measurement was observed for the number of days taken to open the first female flower, which in turn indicates that negative genes for earliness are mostly dominant. While significantly negative correlation between parental order of dominance and parental measurement was observed for total yield which in turn indicates that negative genes for higher yield are mostly dominant. Srivastava (1970) also found the similar results for number of days taken to open the first female flower. In okra also negative genes are dominant for flowering and the fruit weight while for other characters equal proportion of dominant genes are positive and negative (Sharma, 1965).

Epistasis probably of complementary type is
indicated in all the characters except that of weight
of fruit and T.S.S. where additive gene effect has been
observed in the present findings. Similar results were
obtained by Srivastava (1970) in bittergourd. Sharma
(1965) reported enistasis in the number of fruit, the
fruit weight and the yield while in all other characters
additive gene effects was observed in okra. Pierce (1958)
found additive gene action for earliness in tomato.
Breznev (1961) reported complementary effects of dominant
gene for earliness.

The number of genes or the group of genes that
exhibit dominance out of the total number of genes
controlling a particular character are given in Table 16.
About fifteen, ten, ten, eight and fifteen groups of genes
showing dominance were indicated for the characters, the
number of days taken to open the first female flower,
number of fruits, weight of fruit, T.S.S. and total yield
respectively.

Combining ability:

The combining ability analysis provides estimates
of variance due to g.c.a., s.c.a. and reciprocal effects.
It also leads to identification of parents with high g.c.a.

effects and in locating cross combinations showing
high s.c.a. effects.

The results obtained suggest that both g.c.a.
and s.c.a. are operative for the expression of all the
five characters studied. The magnitude of g.c.a. as
compared to s.c.a. in the expression of number of days
taken to open the first female flower, weight of fruit
and T.S.S. is, however, high which indicates that for
these characters additive type of genic variance is more
prevalent. In case of other two characters, number of
fruits and total yield the magnitude of s.c.a. is higher
as compared to g.c.a. which indicates that the non-additive
gene action is more prevalent for the expression of these
characters. Reciprocal effects are significant for all the
characters except number of fruits but in magnitude the
variance is lower than g.c.a. and s.c.a. variance and
thus its contribution in the expression of these characters
is presumed to be very little.

From the study of g.c.a. effects for total yield,
it was found that four parents, namely, P-3, P-2, P-1
and P-10 possess high g.c.a. effect. Among these, the
highest effect was obtained for P-3. High g.c.a. effects
are related to additive genic effects or additive X additive
interaction effects (Griffing, 1956a,b; Sprague, 1966)

which represent the fixable genetic components of the variation. Thus, these parents appear to be worthy of exploitation in practical plant breeding.

The parents which show high to average g.c.a. effects are presented in Table 38. In each column the inbreds are listed from the top downward, in order of the magnitude for their g.c.a. effects. P-3 which is a good general combiner for yield also showed high g.c.a. effects for the fruit weight and yield. The other parents which show high to average g.c.a. effects for most of the characters are P-6, P-2, P-1, P-5 and P-10. All these parents are good general combiners except P-6 and P-5 for the total yield also, suggesting thereby that combining ability effects for the total yield are possibly related to combining ability for various yield contributing traits.

TABLE 38

Parents showing high to average g.c.a. effects for different characters in watermelon

No.of days taken to open first female flower	No.of fruits	Weight of fruit	P.C.S.	Total yield
P-5	P-6	P-3	P-2	P-3
P-6	P-5	P-1	P-6	P-2
P-9	P-9	P-2	P-1	P-1
P-4	P-10	P-10	P-5	P-10
		P-7	P-10	

In contrast to the g.c.a. effects, s.c.a. effects represent dominance and epistatic components of variation which are non-fixable and can be related with heterosis. The results presented show that for all the traits, over all s.c.a. effects are of higher order and, therefore, individual s.c.a. effects were determined. For the total yield, thirteen cross combinations exhibited high s.c.a. effects. These crosses represent the total three possible combinations between parents of high and low g.c.a. effects, viz., high X high, high X low and low X low. Such results have also been reported by various workers in different crops (Gupta, 1962, in linseed, Mukherjee, 1966, in maize; Paroda, 1968, in wheat, etc.). High X low and low X low can be made use of only through commercial exploitation of heterosis.

As stated earlier, parents P-3, P-2, P-1 and P-10 show high g.c.a. effects for total yield and four combinations among them P-1 X P-10, P-1 X P-3, P-2 X P-3 and P-2 X P-10 show high s.c.a. effects. These combinations can be utilized in different ways. Since additive and additive X additive effects (high g.c.a.) are of considerable importance, single plant selection can be practised in the segregating generations of these crosses to isolate superior inbreds. Penny et al (1963) have stated that the recurrent selection

TABLE 39

Hybrids showing high s.c.a. effects with regard to different
characters in watermelon

No.of days taken to open first female flower	No. of fruits	Weight of fruit	T.S.S.	Total yield
P-1 X P-9	P-5 X P-7	P-2 X P-7	P-5 X P-10	P-2 X P-7
P-2 X P-4	P-4 X P-10	P-2 X P-8	P-1 X P-8	P-4 X P-10
P-3 X P-4	P-2 X P-7	P-1 X P-3	P-2 X P-8	P-1 X P-9
P-3 X P-9	P-2 X P-3	P-3 X P-10	P-1 X P-7	P-2 X P-8
P-6 X P-10	P-5 X P-6	P-2 X P-10	P-3 X P-3	P-3 X P-6
P-1 X P-6	P-1 X P-9	P-1 X P-8	P-4 X P-6	P-1 X P-10
P-8 X P-9	P-6 X P-10		P-5 X P-9	P-1 X P-8
P-1 X P-5	P-5 X P-9		P-1 X P-10	P-4 X P-6
P-5 X P-10	P-5 X P-10			P-1 X P-3
P-2 X P-9	P-1 X P-10			P-5 X P-7
P-2 X P-5	P-3 X P-6			P-2 X P-3
P-3 X P-6	P-1 X P-8			P-5 X P-10
P-5 X P-8	P-2 X P-8			P-2 X P-10
P-3 X P-7	P-1 X P-3			
P-2 X P-6				
P-3 X P-5				
P-9 X P-10				
P-6 X P-7				
P-5 X P-7				
P-6 X P-8				
P-4 X P-8				
P-1 X P-4				
P-7 X P-9				
P-4 X P-6				
P-4 X P-9				

is a breeding system having some theoretical superiority
over the standard system of continuous self-pollination.
They have further stated that this system has value when
the objective is to develop superior population or when
the ultimate goal is the utilization of inbred lines for
the production of hybrids. In view of this it may be
desirable to treat the advanced generation of these
crosses as separate populations and to use them in recurrent
selection. Reciprocal recurrent selection procedures as
proposed by Comstoc. et al (1949) can be followed to
exploit additive as well as non-additive effects.

Specific combining ability effects were also
estimated for yield components as well. The combinations
showing best combining effects for different characters
are listed in Table 39. These results show that, in
general, s.c.a. effects for a combination show no particular
relationship with the g.c.a. effects of the parents
involved. All the three types of combinations, thigh X high,
high X low and low X low show high s.c.a. effects. As
mentioned earlier for the total yield, the crosses in which
both the parents involved were good general combiners
for a particular trait could be exploited for breeding
programme. Such crosses are listed below .

P-1 X P-10   : For higher sugar and total yield.

P-1 X P-3   : For higher fruit weight and total
  and   yield.
P-2 X P-10

P-5 X P-10   : More number of fruits and higher
                  sugar content.

P-4 X P-5   : For early flowering only.
  and
P-4 X P-9

P-5 X P-6,   : For higher number of fruits only.
P-6 X P-10
  and
P-5 X P-9

P-2 X P-7   : For higher fruit weight only.
  and
P-3 X P-10

P-2 X P-3   : For total yield only.

In the present material reciprocal cross effects
are significant for all the characters except number of
fruits. These are however, of lower order as compared to
g.c.a. effects and s.c.a. effects. Reciprocal effects
have also been reported by Pal and Singh (1946) and
Srivastava (1970) in the diverse material of bittergourd
studied by them. This suggests that reciprocal effects
indeed may be widely spread in this crop and the yield
in the F_1 hybrid may be the function of both genotype
and cytoplasm. These studies point out the need for

including reciprocal crosses in such biometrical
studies. In the absence of reciprocals, the estimates
obtained may be biased. Anand (1967) has shown in
linseed that maternal effects biased the estimates of
g.c.a. for the seed per capsule, the fruit bearing
branches, the height and the capsule number.

Inheritance of qualitative characters:

The three experiments were carried out to study
the inheritance of skin colour of the fruit, showed that
the dark green skin colour was dominant over light green,
the striped character (dark green stripes) was dominant
over non-striped ones while dark green and striped skin
colour were two independent traits. In first two experiments,
all the F_1 hybrids had dark green coloured fruits and
striped fruits respectively which indicated complete
dominance. The F_2 generation progeny showed a ratio
of three dominant to one recessive for these characters.
When the F_1 hybrids were crossed with dark green (dominant)
parent, all the plants produced dark green coloured fruits
and when the F_1 hybrids were crossed with the light green
(recessive) parent the plants produced dark green and
light green fruits in one to one ratio. The same ratio

was obtained in case of striped (dominant) vs non-striped
(recessive) in term of dominance and recessiveness. The
genotype of dark green, light green, striped and non-striped
thus would be _CG_, _gg_, _SS_, and _ss_ respectively. The above
findings confirm that the plants with dark green vs light
green and striped vs non-striped differed by one pair of
genes and the dark green and striped were dominant over
light green and non-striped respectively. While in the
third experiment,all the F_1 hybrids (dark green X striped
skin colour) produced dark green striped fruits. When F_1
hybrids were crossed with dark green parent, the plants
produced fruits with one dark green stripes to one dark
green non-stripes. The same ratio of one (dark green stripes)
to one (light green stripes) was obtained when F_1 hybrids
were crossed with striped skin coloured parent. The F_2
generation progeny showed a ratio of 9:3:3:1 (9 dark green
striped, 3 dark green non-striped, 3 light green striped
and 1 light green non-striped). The genotype of dark green
fruited plants would thus be _GGss_ and that of striped
colour fruited _ggSS_, as the findings confirm that these
two traits inherited independently and there is no linkage.

Porter (1937) observed that dark green skin colour
of watermelon was dominant over yellowish white skin, but
in crosses with yellow green the F_1 was intermediate in
skin colour and that the F_2 population indicated that a

single gene difference was involved. Similarly, Weetman (1937) found that the dark green skin colour of watermelon was dominant over the light green skin colour which was determined by a single gene difference. Nath and Dutta (1971) also reported the same thing as reported by Weetman (1937). The similar results were also obtained in the present study. Hughes (1948) noted that the dark green rind colour of fruit was dominant over white skin in muskmelon which differed by a single factor and the inheritance was found to be simple dominance. Nath and Hall (1965) recorded in squash that green fruits were dominant over yellow (at immature state) and was monogenically controlled.

The study on flesh colour inheritance showed that the red flesh colour was dominant over yellow and cannery yellow flesh was dominant over pink. The F_1 hybrids had red fleshed and cannery yellow fleshed fruits respectively. The F_2 progeny of the two experiments showed a ratio of three dominant to one recessive. When the F_1 hybrids were crossed with red fleshed (dominant) parent, all the plants produced red fleshed fruits and when the F_1 hybrids were crossed with yellow fleshed (recessive) parent, the plants were produced having one to one ratio. The same ratio was obtained in the cross between cannery yellow and pink fleshed parents. The genotype of red flesh, yellow flesh, cannery yellow and pink thus would be RR, rr, CC and cc, respectively.

The above findings confirm that the plants with red flesh vs yellow flesh and cannery yellow vs pink flesh differed by single pair of genes and red flesh was dominant over yellow while that of cannery yellow over pink.

Porter (1933) found that red flesh was dominant over ~~green~~ yellow in watermelon, and was determined by single dominant gene where Bennett (1936) failed to arrive at this conclusion. Hagiwara and Kamimura (1936) studied flesh colour inheritance in muskmelon. They did not report the colour in F_1 but, observed segregation in F_2 indicating dominance of white orange over white colour. While Hughes (1948) demonstrated that the green flesh was recessive to salmon flesh and the differences were due to single dominant gene in muskmelon.

The six experiments were conducted to study the seed colour inheritance (Tables 30 to 35). The results indicated that black seed colour was dominant over dark brown, dark orange yellow and red while dark brown was dominant over dark orange yellow and red. The dark orange yellow colour was dominant over red. All the pairs of characters studied, were differed by single pair of genes and the inheritance was simple in 3:1 ratio. The genotypes proposed from the present study for black, dark brown, dark orange yellow and red is as $\underline{BB}$, $\underline{b_1 b_1}$, $\underline{b_2 b_2}$ and $\underline{b_3 b_3}$ respectively,

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in order of dominance (b_1 is dominant over b_2 and so on). The above findings confirm by the F_1, F_2 and backcrosses observations which are discussed below.

All the F_1 hybrids of black X dark brown seeded, produced, the plants with black seeds. The F_2 generation progeny showed a ratio of three black to one dark brown seeds. When the F_1 hybrid was crossed with black seeded parent, all the progeny had black seeded plants and when the F_1 hybrid was crossed with dark brown seeded parent the progeny produced plants in the ratio of one black to one dark brown seeded plant. While in case of black X red seeded parent, the F_1 plants were black seeded. In F_2, they segregated into three black to one red. When F_1 was crossed with black seeded parent, all the progenies produced black seeded plants while crossed with recessive parent, the progeny segregated into one black to one red.

Black and dark orange seeded parents when crossed, the F_1 hybrids produced all black seeded plants. In F_2 generation, the progeny segregated into a ratio of three black to one dark orange yellow. When the F_1 was crossed with black seeded (dominant) parent the progeny produced all black seeded plants only. When the F_1 was crossed with dark orange yellow (recessive) parent the

segregation occurred with one black to one dark orange yellow.

In case of dark brown X red seeded parent, the F_1 hybrids were all dark brown seeded. In the F_2, they segregated into three dark brown to one red. Then F_1 was crossed with dark brown seeded parent all the progeny produced dark brown seeded plants while crosses with recessive parent progeny segregated into one dark brown to one red.

The cross between dark brown and dark orange yellow seeded parent, produced progeny with dark brown seed colour. In the F_2 generation, the dark brown and dark orange yellow seeded type plants segregated in the ratio of 3:1, whereas the backcross generation with dark orange yellow parent produced plants in 1:1 ratio of dark brown to dark orange yellow.

A cross between dark orange yellow and red seeded parent, produced hybrids with seeds having dark orange yellow colour only. The F_2 population showed segregation in the ratio of 3 dark orange yellow to one red seeded plants. The backcross of F_1 with red seed produced progeny which segregated into 1 dark orange yellow to one red seed type.

Another qualitative character, seed size, inheritance (Table 36) showed that the small size was dominant over large size. All the F_1 hybrid plants produced small seeds, while F_2 generation showed a ratio of three small seeded plant to one large seeded plant. When the F_1 was backcrossed with small seeded parent, all the progeny plants produced small seeds and when F_1 hybrid was crossed with large seeded parent, the progeny had the plants in the ratio one small seeded to one large seeded plant. It is, therefore, concluded that the small seed size was completely dominant over large size. The genotype proposed for small seeded parent t us would be SS while for the large seeded parent ss.

In the present study, the seed size was adopted after the designations of Poole and Porter (1941) who reported three seed length phenotypes viz., short (average 6 mm), medium (average 10 mm), and long (average 13 mm). These authors postulated that two factors were operating to produce a typical dihybrid segregation in F_2 of nine medium (LS) to three long (ls) to four short (Ls and ls). Later, Poole and Grimball (1945) reported 3 medium to 1 long seed (LS vs ls) in F_2 generation in watermelon. Konsler and Barham (1958) used two parents with seed length 7.4 mm and 12.7 mm and the segregation in F_2 and backcross indicated that a single gene was involved. They postulated that

that probably the medium class was wider than was
originally thought by Poole and Porter (1941) and
that the seed size 7.4 mm was in the category of
medium class. In the present materials, the seed
with 12 mm assumed large size and 7 mm small sized
parents and the findings are accordance with that
of Konsler and Barham (1958). Srivastava (1970)
also reported that small seeded parent was completely
dominant over large seeded in bittergourd and this
difference was controlled by a single gene.

The inheritance study of fruit shape showed
that the long fruited parents were incompletely
dominant over round fruited parent. The F_1 hybrids
produced the plants with oval fruits. In F_2 generation
progeny showed a ratio of 1 long: 2 oval: 1 round. When
the F_1 was back crossed with long fruited parent, progeny
segregated into one long to one oval while with round
fruited parent it gave oval and round with 1:1 ratio.
It is, therefore, concluded that the long fruited plants
and round fruited plants differed by single pair of genes
and long fruited parent was incompletely dominant over
round. Similar results were also obtained by Weetman (1937)
in watermelon.

SUMMARY AND CONCLUSION

The present thesis includes,the results and
the conclusions of the two main experiments. The first
one was a diallel cross experiment with ten parents
and their all possible ninety F_1 hybrids; and the
second experiment included thirteen small layouts
for parents, F_1 hybrids, F_2 and backcross generations
involving nine parents. These experiments were carried
out at the Horticultural Farm of the University of
Udaipur, Campus Jobner. The first experiment was
analysed for the extent of hybrid vigour for nine
characters over the parental average and better or
higher parent, diallel analysis by graphical and
numerical methods to get an indication of the genetic
make up of the involved parents in this experiment.
The general combining ability of these parents, the
specific combining ability of all the crosses involving
these ten parents and the reciprocal effects in these
crosses were also determined. The second set of experiments
were analysed separately for qualitative characters
inheritance following Chi-square test. The results,
thus obtained and discussed are as follows:

1. Fifty nine and six hybrids increased the vine length over their parental averages and higher parents respectively. None of the hybrids reduced the vine length significantly over their parental average while eleven hybrids reduced the vine length when compared to the higher parent.

2. Most of the hybrids reduced the number of days taken to open the first female flower. Sixty six hybrids and thirty nine hybrids reduced it significantly when compared with their parental average and early parent. Eighteen hybrids, however, increased the number of days taken to open the first female flower over their parental average and thirty five hybrids increased it when compared with their early parent.

3. Sixty five hybrids and thirty eight hybrids increased the number of female flowers over their parental average and higher parent respectively. Reduction in the number of female flowers was recorded in five hybrids when compared with the parental average and thirty three hybrids when compared with the higher parent.

4. Forty four and eighteen hybrids increased the number of fruits per plant over their parental average and higher parents respectively. None of the hybrids

reduced the number of fruits significantly over parental mean, however, the reduction was observed in fifteen hybrids only over their higher parents.

5. Twenty two hybrids and two hybrids increased the fruit weight over their parental average and higher parent respectively while the reduction in fruit weight was recorded in twenty nine hybrids over their better parent and in one over parental mean.

6. Fifty six and eleven hybrids increased the average fruit length over their parental average and longer parent respectively while twenty two hybrids reduced the fruit length over parental average and sixty three hybrids over their longer parent.

7. Fifty two hybrids and fifteen hybrids increased the average fruit breadth over their parental average and thicker parent respectively. A reduction in fruit breadth was, however, recorded in thirty one hybrids and fifty nine hybrids respectively when compared with their parental average and thicker parent.

8. Thirty hybrids and nine hybrids increased the T.S.S. over their parental average and better parent. The reduction in sweetness was recorded in three hybrids and

twenty four hybrids respectively as compared with parental mean and better parent.

9. Fifty seven hybrids increased the total yield over their parental average and thirty one hybrids over their better parent. The increase was recorded upto 126.16 per cent in the former case and upto 75.45 per cent in the later case. A reduction in total yield was also, however, recorded in three hybrids only over their better parent while none was significantly inferior over parental mean. The maximum average yield of 87.094 kg per plant was recorded in hybrid C-20R.

10. Partial dominance was indicated for the characters, the number of days taken to open the first female flower, number of fruits, weight of fruit and T.S.S. while for yield complete dominance was indicated.

11. Recessive alleles were more frequent than the dominant alleles in the number of days taken to open the first female flower, weight of fruit, and T.S.S. while for the number of fruits, recessive alleles were slightly frequent than dominant alleles. In case of total yield the proportion of recessive and dominant alleles were almost equal.

12. The asymmetry of distribution of genes with positive and negative effects was observed in all the characters except the total yield in which these were in almost equal proportion.

13. The positive and negative significant coefficients of correlation between parental order of dominance and parental measurements for the number of days taken to open the first female flower and total yield respectively, indicated that negative genes i.e. for earliness and higher yield were mostly dominant.

14. The epistasis probably of complementary type was found in all the characters except in weight of the fruit and P.S.S. where additive gene effect was observed.

15. The significant g_1 effect was recorded in parents P-3, P-1, P-10, P-8, P-2 and P-7 for higher number of days taken to open the first female flower, and P-5, P-6, P-9 and P-4 for early opening of the first female flower. P-6, P-5, P-9, P-10 showed significant positive g_1 effect for number of fruits while negative g_1 effect was observed in P-1, P-3, P-7, P-2, P-8 and P-4. In case of fruit weight P-3, P-1, P-2, P-10 and P-7 had significant positive g_1 effect while the other had negative effect.

Significant positive g_i effect was shown by the parents P-2, P-6, P-1, P-5 and P-10 while others showed negative effects for T.S.S. In yield the maximum g_i effect was shown by P-3 followed by P-2, P-1 and P-10

16. Significant specific combining ability effect for all the characters were observed except that of T.S.S.

17. Reciprocal effect was found to be significant for all the characters except number of fruits.

18. The plants with dark green skin coloured fruits were completely dominant over the plants with light green fruits and that the parents differed by one pair of genes.

19. The plants with dark green striped fruits were completely dominant over non-striped fruits and that the parents differed by one pair of genes.

20. The dark green skin coloured fruits and striped fruits were inherited independently and there was no linkage. The genes for these traits were situated on different chromosomes.

21. The red flesh colour was completely dominant over yellow flesh and the differences were due to single pair of genes.

22. Cannery yellow flesh was completely dominant over the pink flesh and the parent differed by one pair of genes.

23. Black seed colour was completely dominant over dark brown, red and dark orange yellow seed colour. These characters differed by one pair of genes.

24. Dark brown seed colour was completely dominant over red and dark orange yellow seed colour and the characters differed by single pair of genes.

25. The dark orange yellow seed colour was completely dominant over red and the differences were due to single pair of genes.

26. The ~~large~~ *Small* seed size was completely dominant over ~~small~~ *large* size and that the parent differed by one pair of genes.

27. The plants with long fruits were incompletely dominant over round fruited plants and that the parent differed by one pair of genes.

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APPENDIX I

Covariance matrix (after Hayman, 1954 a)

	D	P	H₁	H₂	h²	E
D	n^5+n^4	$2n^5+2n^4-4n^3$	$n^5+3n^4-2n^3$	$2n^4$	$4n^3-4n^2$	$-n^4$
P	$2n^5+2n^4-4n^3$	$4n^5+20n^4-16n^3+16n^2$	$2n^5+22n^4-16n^3+8n^2$	$4n^4-8n^3$	$8n^3-24n^2+16n$	$-2n^4+4n^3$
H₁	$n^5+3n^4-2n^3$	$2n^5+20n^4-16n^3+8n^2$	$n^5-41n^4-12n^3+4n^2$	$22n^4-4n^3$	$12n^3-20n^2+8n$	$-3n^4+2n^3$
H₂	$2n^4$	$4n^4-8n^3$	$22n^4-4n^3$	$36n^4$	$8n^3-8n^2$	$-2n^4$
h²	$4n^3-4n^2$	$8n^3-24n^2+16n$	$12n^3-20n^2+8n$	$8n^3-8n^2$	$16n^4+16n^2-32n+16$	$-4n^3+4n^2$
E	$-n^4$	$-2n^4+4n^3$	$-3n^4+2n^3$	$-2n^4$	$-4n^3+4n^2$	n^4

Note: With common multipliers s^2/n^5

Var. $(D-H_1) = 4(9n^2-2n+1)\, s^2/n^3$