V - DISCUSSION OF RESULTS

Tomato varieties grown in U.A.R. are all introduced varieties adapted to local conditions. In the last few years, an expansion was noticed in tomato acreage as a result of the increased local consumption and the extension in exportation to other countries. This called the attention of tomato breeders to search for better yielding varieties resistant to Fusarium wilt, which is considered one of the most determinating factors to tomato crop.

The aim of the present work is to study the mode of inheritance of reaction to Fusarium wilt disease in crosses including the three resistant varieties Red Cherry, San Marzanc (belonging to L. pimpinellifolium) and American (a selection from an interspecific cross between L. esculentum x L. pimpinellifolium) and the three susceptible varieties Pearl Harbor (L. pimpinellifolium), Pearson 107 and Orange (L. esculentum). The work was also extended to include studies on the inheritance of some qualitative characters namely fruit shape, flesh colour and the association between fruit shape and number of locules per fruit. Furthermore, the inheritance of some quantitative characters as fruit size,plant height and ascorbic acid content in fruits was studied.

Reaction to Fusarium wilt :

This character was studied in eight crosses including six varieties. These crosses were arranged into three groups according to their reaction to wilt;resistant x resistant, resistant x susceptible and susceptible x susceptible crosses.

1. The first group of crosses; resistant x resistant, was represented by the cross American x San Marzano. The F_1 plants were resistant, and the F_2 segregants were divided into resistant and susceptible types, fitting the trihybrid ratio 57 resistant : 7 susceptible. This ratio indicated that these two varieties differed in three pairs of genes. The variety American was suggested to carry a dominant gene (R) for resistance and the other resistant variety San Marzano carried another two dominant genes (R_2 , R_3) having a complementary effect, which was clearly noticed later on in the cross San Marzano x Pearson 107 belonging to the second group discussed below.

2. The second group; resistant x susceptible, was represented by five crosses, San Marzano (resistant) x Pearl Harbor, American (resistant) x Orange, Red Cherry (resistant) x Orange, San Marzano x Pearson 107 and Red Cherry x Pearl Harbor. The F_1 plants were resistant in

the first three crosses and were susceptible in the other two crosses, San Marzano x Pearson 107 and Red Cherry x Pearl Harbor. The F_2 plants in the cross San Marzano x Pearl Harbor segregated into the ratio 9 resistant : 7 susceptible, indicating the presence of two dominant complementary genes (R_2 , R_3) for resistance in San Marzano, while the other variety Pearl Harbor carried their recessive alleles (r_2 , r_3) for susceptibility. In the second cross American x Orange, the F_2 segregation showed a dihybrid ratio of 12 resistant : 4 susceptible. This ratio indicated the presence of two pairs of gene difference between the parents. The variety American was previously suggested to carry the gene (R) for resistance and the variety Orange was assumed to carry a dominant gene (S_1) for susceptibility hypostatic to (R) as will be shown later on. The double recessive alleles (rs) showed susceptible individuals. The F_2 plants in the third cross Red Cherry x Pearl Harbor fitted a monohybrid ratio of 3 resistant : 1 susceptible, showing the presence of one pair of gene difference between parents. The variety Red Gherry may be suggested to possess the gene (R_1) for resistance, while Pearl Harbor carried the recessive allele (r_1) for susceptibility.

The monohybrid segregation with dominance of resistance was previously reported by Bohn and Tucker (1940) in an accession of L. pimpinellifolium, Foster and Walker (1947) in crosses including the variety Red Currant, and Hutton et al.(1947) in the cross L. pimpinellifolium x Marglobe. Young and Mac Arthur (1947), Dennett (1950), and Henderson and Winstead (1961); the three authors postulated the gene (I) for immunity to Fusarium wilt (race 1). Paddock (1950) postulated the gene (T) for Fusarium immunity. Recently in Japan, Suzuki et al.(1962) suggested a single major gene for resistance to Fusarium wilt in six tomato hybrids with some other modifiers, a result which also agreed with the present work.

In the fourth cross Red Cherry x Orange, F_1 plants were susceptible and F_2 population was classified into a dihybrid ratio of 13 susceptible : 3 resistant. This F_2 ratio suggested that the gene (R_1) possessed by Red Cherry for resistance was hypostatic to a dominant gene for susceptibility (S_1) carried by the variety Orange. The genotype (R_1S_1) was susceptible and the recessive alleles (r_1s_1) caused also susceptibility. The F_2 plants in the fifth cross San Marzano x Pearson 107 segregated into the tetrahybrid ratio 199 susceptible : 57 resistant, showing a difference in four pairs of genes. Two of these genes (R_2R_3) were previously suggested for San Marzano, showing a complementary effect for resistance while the other two genes were proposed to be carried by the other susceptible parent Pearson 107. One of these genes was postulated (R_1) for resistance hypostatic to another gene (S_2) for susceptibility. The gene (S_2) appeared also to be epistatic over the complementary effect of genes (R_2 and R_3) when present together giving susceptibility.

3. The third group including susceptible x susceptible varieties, was represented by two crosses; Pearl Harbor x Orange and Pearson 107 x Orange. The F_1 plants of both crosses were also susceptible, but they differed in F_2 behaviour. The F_2 population of the first cross Pearl Harbor x Orange showed no segregation and all plants were susceptible as was expected according to their previously proposed genotypes for susceptibility. The variety Orange possessed the dominant gene (S_1) for susceptibility while the variety Pearl Habor contained the recessive allele (s_1) for susceptibility also, and thus no segregation for resistance was noticed which ascertained the previous assumptions for genes suggested from other crosses including these two parents. However, in the F_2 of the second cross Pearson 107 x Orange, some

resistant plants appeared giving trihybrid ratio of 61 susceptible : 3 resistant. This showed that these two parents differed in three pairs of genes. The variety Pearson 107 was previously proposed to carry the two genes (R_1S_2), where (S_2) proposed for susceptibility was epistatic to (R_1) for resistance, and the variety Orange carried the gene (S_1) for susceptibility which showed also to be epistatic to (R_1).

Inheritance of fruit shape :

Fruit shape was considered by some geneticists as a qualitative character among whom were; Lindstrom (1927), Zielinski (1948), Dennett(1952), Butler (1952) and Fryxell (1954). Other workers treated fruit shape as a quantitative character affected by several genes, among whom could be mentioned; Groth (1912), Warren (1924), Lindstrom (1927), Powers (1939), Larson (1941) and Jenkins (1951). It was also known that fruit shape is greately affected by number of locules per fruit as reported by most of the above authors. This review showed a rather confusing behaviour for the character. In the present study fruit shape was treated as a qualitative character in F_1, F_2 and Bc_1 of ten crosses including the seven tomato varieties representing different fruit shapes and locule numbers. These crosses were grouped into four categories; roundish oblate bilocular x oval bilocular, roundish oblate bilocular x round multilocular, roundish oblate bilocular x roundish oblate bilocular and round multilocular x oval bilocular. In these groups fruit shape was studied in association with number of locules, overlooking the linkage which was previously reported between them as it was difficult to get clear segregation, if the two traits were treated seperately. For accurate classification of fruit shape, the shape index method adopted by **Bergh** (1957) was used.

1. The first group; i.e., roundish oblate bilocular x oval bilocular was studied in four crosses; Pearson 107 x San Marzano (oval), Pearl Harbor x San Marzano, Genome x San Marzano and Red Cherry x San Marzano. The F_1 plants in the first two crosses carried roundish bilocular fruits, and were slightly elongated as compared to its roundish oblate fruited parent in the second cross (Pearl Harbor x San Marzano), giving nearly pear shape . The F_2 plants segregated into the dihybrid ratio 13 roundish bilocular fruits as in Pearl Harbor in addition to round fruit types : 3 oval bilocular fruits as in the variety San Marzano. This round type of fruit shape appeared in this segregation might be explained as due to effect of modifying genes present in each of the two roundish oblate fruited varieties, Pearson 107 and Pearl

Harbor. Modifiers for fruit shape were suggested before by Jenkins (1951) in some crosses between tomato varieties from a World collection. The appearance of the pear shape F_1 fruits in the second cross showed incomplete dominance of roundish oblate fruit shape. The intermediate shape found in F_1 of the second cross was observed by Larson (1941) in nineteen tomato hybrids. The obtained F_2 dihybrid ratio suggested two pairs of gene interaction for fruit shape in these two crosses. The roundish oblate fruited parents, Pearson 107 and Pearl Harbor might carry the dominant gene (E) for equatorial diameter expansion of fruit, epistatic over another dominant gene (P) for polar diameter expansion carried by the oval bilocular fruited parent San Marzano. The presence of bilocular fruit in both parents may be due to the presence of a dominant gene (Lc) present in common in each one. The two varieties Pearson 107 and Pearl Harbor would therefore carry the genetic constitution ([illegible] p Lc) and San Marzano (e P Lc). These results were ascertained by the backcrosses of F_1 to both parents, giving no segregations in Bc_1 when F_1 was crossed to the roundish oblate fruited parent either Pearson 107 or Pearl Harbor, and giving a ratio of 2 roundish oblate and round : 2 oval in the other backcross to San Marzano. The interpretation of fruit shape inheritance by assuming two genes governing growth directions for fruit development one for polar and another for equatorial expansion, was previously proposed by Lindstrom (1927) and Houghtaling (1935) and Yeager(1937), suggested another gene (o) affecting elongation of ovary after anthesis. The same explanation was mentioned by Zielinski (1948) and Jenkins (1951).

In the third cross Genome x San Marzano and the fourth cross Red Cherry x San Marzano the F_1 plants were roundish oblate fruited, indicating the dominance of this fruit shape. The F_2 plants in these two crosses segregated according to a monohybrid segregation of 3 roundish oblate: 1 oval. The backcrosses showed a ratio of 1 roundish oblate : 1 oval shape when F_1 was backcrossed to variety San Marzano and no segregation in the other Bo_1 to either Genome or Red Cherry, which verified the F_2 conclusion. The variety Genome was considered to carry the dominant gene (E), besides the other two genes (P and Lc) for roundish oblate shape. The same genes were also suggested for Red Cherry. The other variety San Marzano was previously proposed to possess the genes (o P Lc) and thus difference was only in gene (E).

The monohybrid segregation for fruit shape was also observed by Lindstrom (1927) between oval x (round or oblate fruit shape), Jenkins (1951) in similar fruit shapes and Butler (1952) who designated gene (el) for elongated fruits.

2. The second group roundish oblate bilocular x round multilocular fruited crosses was studied in four crosses; (Pearson 107, Pearl Harbor, Red Cherry and Genome) x Orange (multilocular). The F_1 plants in all these crosses were roundish oblate bilocular fruited, showing the dominance of both roundish oblate and bilocular characters. This observation was in agreement with that reported by Price and Drinkard (1908), Yeager (1937) and Powers and Locke (1949) who showed dominance of bilocular fruits over more loculed fruits (lc). Salib (1965) showed that few number of locules in Red Currant and Genome was dominant over large number in Pritchard,Marglobe and Earliana and was controlled by one major gene. The F_2 population in the two crosses Pearson 107 x Orange and Pearl Harbor x Orange showed a dihybrid ratio of 3 oblate fruited plants : 13 roundish oblate and round fruited plants. With regard to number of locules, segregation did not fit a clear Mendelian ratio. The backcrosses of F_1 to the roundish oblate parent showed no segregation for roundish oblate shape, while in the other backcross a ratio of 3

roundish oblate and round : 1 oblate was clearly observed. These results verified the F_2 dihybrid ratio, and the hypothesis suggested for gene interaction. The varieties Pearson 107 and Pearl Harbor were proposed to carry the genes (E p Lc), while the round multilocular variety Orange carried all the recessive alleles (e p lc), To explain the above F_2 and Bc_1 segregations, it was assumed that gene (lc) in the recessive condition modified the roundish oblate fruit shape caused by (E) in the absence of (P) to give oblate instead of roundish oblate shape. Moreover, the genes (lc, e, p) gave round fruits as in the parental variety Orange. This result fairely agreed with that of Yeager (1937) who described the different developmental processes of fruit shape from anthesis to maturity . He suggested that the recessive gene (lc) for multilocules when associated with gene (o) produced a phenotypically round tomatoes.

The modification of fruit shape due to change in gene action of locule number from dominant to recessive condition was noticed by Zielinski (1948). He showed that fruit shape was determined by two sets of mutually antagonistic size factors, namely general size genes primarily affected longitudinal growth, besides genes which partially determine increase in locule number.

Jenkins (1951), suggested that the increase in locule size was due to the accumulation of many gene mutants, the bulk of which were recessive. Thus the basic oval shape with only tow locules was modified by additional mutant genes for locule number giving pear shape and an increase in number of locules, resulted in an increase in the equatorial diameter to give kidney shape. This increase in number of locules was sometimes due to a single recessive gene in some crosses and to numerous modifying genes in others.

In the third and fourth crosses, Red Cherry x Orange and Genome x Orange, there was a trihybrid ratio of 6 oblate : 49 roundish oblate and round : 9 oval fruited plants, indicating three pairs of gene difference between parents. The backcross of F_2 to Red Cherry or Genome parents gave roundish oblate fruits only, while in the backcross to Orange, a segregation of 2 oblate : 5 roundish oblate and round : 1 oval fruit shape was obtained, which confirmed the F_2 observations. Both varieties Red Cherry and Genome were previously suggested to carry the genes(E P Lc) while Orange possessed the recessive alleles (e p lc),which explained this segregation also. The segregation in these two crosses revealed the effect of each gene and its interaction with other genes.

The oblate shape appeared in the presence of genes (E and lc), where (lc) acted as a modifier for flattening the roundish oblate to oblate shape. At the same time, the presence of gene (P) for polar expansion and gene (Lc) for bilocules, in the absence of the dominant gene (E) for equatorial expansion, gave the oval shape. Furthermore, the presence of both genes (P and lc) for polar expansion and multilocules, in the absence of gene (E), gave oblate fruit shape also as in (E p lc) case. This trihybrid ratio for fruit shape was in agreement with that reported by Powers (1939) in the cross *L. esculentum* var. **Johannisfeuer** (multilocular) x *L. pimpinellifolium* var. Red Currant (few loculed).

3. The third group between roundish oblate bilocular x roundish oblate bilocular fruits was represented by the cross Pearl Harbor x Pearson 107. The F_1 fruits were also roundish oblate bilocular as their parental varieties, and F_2 showed also no segregation. This result may suggest that both parental varieties; Pearl Harbor and Pearson 107, might carry similar genetic constitutions, This suggestion agreed with the results of other crosses confirming the given genotypic composition (E p Lc). However, the other cross belonging to this group between the two roundish oblate parents Red Cherry x Genome was not studied

to realize the identity of their proposed genetic constitution (E P Lc), which needs further work.

4. The fourth group of crosses between round multilocular x oval bilocular varieties exemplified by a single cross; American x San Marzano. The F_1 plants tended to be roundish fruited, having a slight elongation to give nearly pear shaped fruits. The F_2 population showed three types fitting the dihybrid ratio of 1 oblate multilocular : 12 roundish oblate and round (bilocular and multilocular) : 3 oval bilocular, indicating the presence of two pairs of gene difference between parents.

It was noticed from that F_2 segregation in this cross and other crosses that the oval fruit shape was always bilocular and never observed to have multilocules. This observation was also reported by Dennett (1952), that non-ovate fruits were multilocules, while ovate fruits always had few locules.

The backcross of F_1 to the round multilocular fruited variety American segregated to the ratio; 2 roundish oblate : 2 round either(bilocular or multilocular) Progenies of the other backcross to the oval fruited parent San Marzano segregated into the ratio 2 roundish oblate fruited plants: 2 oval fruited plant, ascertaining

F_2 results. The variety San Marzano was previously shown to carry genes (e P Lc), and the variety American was proposed to have genes (E P **lc**).

Association between fruit shape and number of locules :

Tests for association between fruit shape recorded as shape index and locule number in the same fruits showed significant association in five crosses. This result indicated constant association between fruit shape and number of locules.

This association between these two characters was reported by many workers among whom Crane (1915), Lindstrom (1928), Houghtaling (1935), Yeager (1937), Morgando (1948) and Zielinski (1948). Dennett (1952) detected linkage relations between gene (O) for fruit shape and gene (lc) for locule number in L. esculentum in linkage group I, situated at a distance about 40% cross-over units.

This high recombination value may be regarded as nearly independent segregation between the gene or genes for number of locules (lc) and gene (o) for fruit shape. It may also be suggested that this weak association was present also between gene (lc) and one of the other fruit shape genes on chromosome I probably (P), but not the other gene (E) located on other chromosomes or the vice versa.

Inheritance of fruit colour :

This character was studied in six crosses between red and orange fruited varieties. These crosses was grouped into two groups; red flesh colour x red flesh colour and red flesh colour x orange flesh colour.

1. The first group red x red varieties, consisted of one cross. The F_1, F_2 and Bc_1 progenies showed red flesh coloured fruits. This indicates that all parents possessed similar genes for flesh colour or at least might carry a gene in common for red colour.

2. The second group, red flesh colour x orange flesh colour was represented by five crossès between the red varieties (Red Cherry, Pearl Harbor, American, Pearson 107 and Genome) and the orange fleshed variety Orange. The F_1 in all these five crosses carried red flesh coloured fruits, showing that this colour behaved as a dominant character over orange colour or (tangerine). The complete dominance of red flesh colour over tangerine was reported before by many authors among whom could be cited Mac Arthur (1934), Bourdouil (1935) in crosses between red and yellow coloured fruits, Fleming and Mayers (1937) in the crosses Golden Dwarf x Connecticut Orange

and Connecticut Orange x Burpe (red). The same conclusion was reached by Le Rosen et al. (1941), Zechmeister et al. (1941), Zechmeister and Went (1948) in crosses between tangerine and red tomato varieties. Kohler et al. (1947) suggested complete or partial dominance of factors for red flesh colour, and Forlani (1951) reported that red flesh was dominant to yellow. However, Lasley and Lesely (1946), suggested that orange flesh colour was dominant over the red flesh colour in crosses between L. esculentum and L. hirsutum due to the presence of at least three genes whose dominant alleles inhibit the formation of pigments specially lycopene. This observation contradicted the present findings in crosses between L. esculentum x L. pimpinellifolium or within varieties of the first species only. The F_2 plants of the first and fourth crosses Red Cherry x Orange and Pearson 107 x Orange segregated into the dihybrid ratio 9 red : 7 orange, suggesting two complementary genes interacting for the red colour. The backcross of F_1 to Orange gave the ratio 3 orange : 1 red verifying the F_2 results for complementary genes. From these ascertained results it can be assumed that the varieties Red Cherry and Pearson 107 would carry the two complementary genes (R_1R_2) for red colour whose effect was epistatic over a third dominant gene (T) for tangerine colour. This result agreed with that reported by Fleming and Mayers (1937) in the cross Golden Dwarf x Connecticut Orange and Jenkins and Mackinney (1953) who obtained a similar ratio of 9 red : 7 other shades (yellow, tangerine and yellow-tangerine). F_2 of the second cross Pearl Harbor x Orange showed a clear segregation to the ratio 15 red : 1 orange illucidating the presence of two duplicate genes for red colour. The backcross of F_1 to the parent Orange confirmed this F_2 segregation giving the ratio 3 red: 1 orange.

The variety Pearl Harbor was suggested to carry the two duplicate factors (R_3 and R_4) for red colour epistatic over the dominant gene (T) which was previously supposed to be present in the variety Orange. The F_2 plants in the third cross American x Orange was distributed into the trihybrid ratio 36 red : 21 orange : 7 yellow showing three pairs of gene difference, with complementary effect (36 red : 28 non-red). The backcross progenies of F_1 to Orange gave the ratio 6 orange : 2 red, as expected for complementary gene action. The variety Orange was previously suggested to carry the dominant gene (T) for orange colour, the variety American probably carried the two dominant complementary genes

(R_1R_2) for red colour found in Red Cherry and Pearson 107 or other genes, epistatic over (T). Each of these two genes (R_1 or R_2) when existed in presence of the recessive gene (t); i.e., (R_1 r_2t) and (r_1 R_2t) as well as the triple recessive (r_1 r_2t) gave yellow flesh colour. The segregation obtained in this cross revealed the presence of gene (T) for orange colour whose effect masked the yellow flesh colour caused by either gene (R_1) or (R_2) only and disappeared in the presence of red colour caused by the two complementary genes (R_1R_2) together. This interpretation agreed with the previous literature reviewed by most of tomato geneticists, considering yellow colour as recessive and orange or red colour as dominant. Among those authors the following could be cited, Le Rosen <u>et al</u>. (1941). Zechmeister and Went (1948), Lincoln and Porter (1950) and Forlani(1951). Jenkins and Mackinney (1955), described new recessive genes for yellow shades as apricot, yellow-apricot and tangerine-apricot which were suggested to be present at different loci. The dominant orange colour gene (T), was recently reported by Chmielewski(1963). However, Jenkins and Mackinney (1953), proposed a dominant gene(T) for yellow tomatoes and another dominant gene (R) for tangerine colour both of which gave red flesh colour, while the double recessive (rt) gave yellow-tangerine colour. This postulation did not contradict the present observations, inspite of the difference in phenotypes. The F_2 in the fifth cross Genome x Orange fitted the dihybrid ratio of 12 red : 3 orange : 1 yellow, showing two pairs of genes difference. The backcross of F_2 to Orange segregated into two equal types in the ratio 2 red : 2 orange, ascertaining F_2 results. The variety Genome was proposed to carry the gene (R_5) for red colour which was epistatic to the gene (T) carried by Orange and resembled the duplicate genes (R_3 R_4) in their effect. The yellow colour appeared also in this cross in the double recessive type (r_5t), ascertaining the previously mentioned assumptions. The genetic analysis presented for this character is compatable with the biochemical analysis of fruit components especially lycopene and carotenoid contents previously reported, by Kohler _et al._ (1947), Zechmeister and Went (1948), Lincoln and Porter (1950), Denisen (1951), Soost (1956) and Tomes _et al._ (1958). Table (13), shows the genotypes of the parental varieties with regard to Fusarium reaction and the Qualitative characters studied.

Inheritance of fruit size :

This character was studied in eight crosses including seven varieties exhibiting different fruit sizes. Parental varieties were classified for fruit size according to their fruit weight into three classes, small,medium and large. Crosses were arranged into four categories small x medium fruit, small x large fruit, medium x large fruit and large x large fruit, and were studied in F_1 and F_2 generations.

1. The first group small x medium fruit crosses, was represented by the cross Red Cherry (small) x Orange (medium). The parental distributions were widely separated and F_1 characters fall between the two parental ranges. The F_2 characters showed a continuous curve which covered only the smaller fruited parent, and extended beyond the range of the large fruited parent. The F_1 mean was nearly equal to F_2 mean and the calculated F_1 arithmetic mean, indicating absence of dominance with a slight tendency towards small fruit weight.

The nature of gene action was nearly additive since both F_1 and F_2 means were more closer to the arithmetic mean rather than the geometric mean. The observed partial dominance of small fruit weight of F_1, was reported by Lindstrom (1935), Powers (1941), Larson et al (1944), Griffing (1953) and Salib (1965). However, Perry(1915) Frimmel(1922) and Larson (1941) observed absence of dominance.

The number of genes were estimated to be 3 pairs by Castle-Wright and Wright's formulae and (1-2) pairs with some minor genes on the basis of Mendelian principles. These results were comparable to that reported by Butler (1941) who suggested (2-5) pairs of genes, and Fogle and Currence (1950) who reported three pairs of genes in the cross. Ting Ten x Stemeless Penne Orange.

Heritability values for fruit size were 62.12%, 87.03% and 92.41% using three different formulae, which indicated that selection may be generally effective for heavy fruits.

2. The second group of crosses including small x large fruited varieties was represented by four crosses, Red Cherry x San Marzano, Red Cherry x Pearl Harbor, Red Cherry x Genome and Pearson 107 x American. The first cross Red Cherry x San Marzano, showed intermediate distribution of F_1 population between both parental limits and a continuous distribution in F_2 generation slightly touching the high limit of the small fruited parent, and completely covering the large fruited parent. The F_1 mean was less than the arithmetic mean, and the F_2 observed mean was nearly close to the F_1 mean, indicating partial dominance of small fruit weight. The F_2 observed mean was approximately equal to the geometric

mean, and the F_1 mean was also more closer to the geometric than the arithmetic mean, both observations indicated that the nature of gene action was cumulative in this cross. Perry (1915) found that fruit size in F_1 resembled the geometric mean of the parental sizes when one parent was much smaller than the other. Many other workers reported also cumulative effect of genes in tomato fruit size among whom could be mentioned Groth (1914,1915), Frimmel (1922), Mac Arthur and Butler(1938), Charles and Smith (1939), Butler (1941), Mac Arthur (1941), Powers (1942) and Larson _et al_.(1944).

The estimated number of genes were (5-6) pairs using the two mentioned formulae, and three pairs of major genes on Mendelian basis accompanied by other minor genes. Similar estimations for fruit size genes were recorded by other workers; 4 pairs by Perry (1915), and (2-5) pairs by Butler (1941).

Heritability values for fruit size were estimated as 83.31%, 88.33% and 96.91% by the three formulae. These high heritability values indicated that selection could be practised for this character, and were in agreement with the estimations of Griffing (1953) obtaining 97.30% for fruit weight.

The second cross Red Cherry x Pearl Harbor showed in F_1 a narrow range of only two class centers, with a mean of much lower value than the arithmetic mean of both parents. The F_2 distribution was continuous but was not sufficient to recover the parental types,owing to the presence of several genes. The observed F_1 mean was about (13.79 gms.) less than the arithmetic mean indicating partial dominance of small fruit size. The observed F_1 mean was more closer to the geometric than the arithmetic mean. The F_2 mean was nearly equal to the calculated geometric mean, indicating that gene action was multiplicative in nature. The partial dominance of smaller fruit size with cumulative effect was previously cited by Powers (1942) Griffing (1953) and other workers.

The number of genes involved were estimated as (9.99) pairs by Castle-Wright formula, (11.59) pairs by Wright's formula, and comparable number on Mendelian basis. This estimation agreed with that reported by Griffing (1953) who suggested a large number of gene pairs, and Bianchi (1954) who suggested (14-15) pairs.

Heritability estimates were 89.12%, 91.49% and 79.98% using the three different formulae, showing effectiveness of selection in such cases. This conclusion agreed with that of Griffing (1953).

The third cross Red Cherry x Genome showed an intermediate distribution of F_1 plants and a continuous distribution of F_2 plants closer to the smaller fruited parent and beyond the range of the large fruited parent. The F_1 and F_2means suggested incomplete dominance of smaller fruit size over larger fruit sizes, and gene action was cumulative in nature. These results agreed with those reported by several authors mentioned before.

The number of genes estimated in this cross were very large, approaching (25.47) pairs by Castle-Wright formula, and (32.70) pairs by Wright's formula. This estimated high number, is compatible with F_2 segregation since no segregates were observed within the range of the large fruited parent. This result was also reported by Griffing (1953) and Bianchi (1954).

Estimations for heritability values were 79.93% , 83.45% and 70.45%, showing the effectiveness of selection for larger fruit size.

The fourth cross Pearson 107 x American showed an intermediate mean for F_1 plants and continuous distribution for F_2 population covering the ranges of both parents. The calculated arithmetic mean of F_1 was higher than the observed mean, indicating incomplete dominance of smaller size. The F_1 and F_2 means were closer to the geometric means than the arithmetic means, exhibiting cumulative gene action.

The number of genes estimated by Castle-Wright and Wright's formulae were (1.11 and 1.51) pairs respectively, showing the existence of (1-2) pairs of genes. Mendelian principle indicated the presence of at least two pairs of genes, assuring the above estimations. This gene estimation agreed with that reported by Butler(1941) introducing (2-5) pairs.

The heritability values were 96.48%, 83.81% and 90.26% which is extremely high to permit successful selections for this character.

3. The third group of crosses between medium and large fruited varieties was exemplified by the cross Orange x Genome. The F_1 distribution occupied nearly the same classes of the smaller parent, while F_2 distribution was continuous covering the ranges of both parents. The calculated arithmetic mean of F_1 plants was higher than the obtained F_1 mean, showing partial dominance of smaller fruit size or nearly complete dominance of this character. The nature of gene action could not be determined in this cross, since the F_1 mean was lower than both arithmetic and geometric means, while F_2 mean was nearly

equal to both of them but more closer to geometric mean. However, gene action could be considered to be more cumulative than additive in this cross.

The number of genes difference between parents was estimated to be (0.75 and 1.02) pairs by Castle-Wright and Wright's formulae, showing one pair of gene difference. Mendelian principles suggested the presence of one pair of major genes. This simple mode of inheritance was not reported before, but Lindstrom (1935) stated that some of the quantitative genes for fruit size and shape in tetraploid tomatoes appeared to behave like qualitative.

The heritability was computed by the three mentioned formulae, showed to be high reaching the values (93.09%, 84.81 and 88.33%), which ascertain the possibility of selection for large fruit size in tomato.

4. The fourth group large x large fruit crosses was represented by the two crosses San Marzano crossed with each of the two varieties Pearl Harbor and Genome. The F_1 plants showed a peculiar shift in its range which extended from (14-26) grams while the parental ranges were (34-38) grams for San Marzano and (42-58) grams for Pearl Harbor. The F_1 mean was accordingly beyond both

parental means. Most of the F_2 distribution covered the range of F_1 plants, while only four individuals fall within the range of the comparatively small fruited parent and 2 plants in the first class center of the comparatively large fruited parent. This behaviour in F_1 was previously recorded and interpreted by Powers (1944,1945) as negative heterosis or over dominance of small fruit weight. Lindstrom (1926) attributed this phenomenon to the influence of dominance of small fruit size genes. The F_1 mean was greatly lower than either arithmetic or geometric means, while the F_2 mean was closer to its geometric mean than its arithmetic mean, showing nearly cumulative action of genes.

The number of genes estimated by Castle-Wright and Wright's formulae were (0.87 and 5.36) pairs of genes respectively. This large difference between the two estimations may be attributed to the effect of negative heterosis in F_1. On the basis of Mendel's principle(3-4) pairs of genes were estimated. This Mandelian estimation agreed with the number of genes obtained by Wright's formula, which might explain the absence of recovery of large fruited types in this large F_2 population. This estimated number of genes for fruit size, agreed with that reported by Perry (1915) in the cross Red Currant x

Yellow Pear suggesting four pairs, Butler (1941) suggesting five pairs in some crosses and Powers et al. (1950) suggesting six pairs of genes.

Heritability values were 58.97%, 79.29% and 73.43% for fruit weight in this cross. It was noticed that these values were comparatively smaller than the previously estimates in other crosses, but still high enough to permit the effectiveness of selection for fruit size.

In the cross San Marzano x Genome the F_1 plants showed also the same phenomenon for overdominance of the smaller fruit size. The F_2 mean was higher than the comparatively smaller fruited parent mean, and the calculated F_1 arithmetic mean. This observation showed that the negative effect of heterosis in F_1 did not continue in F_2, however, some F_2 plants were distributed beyond the lower limit of the smaller fruited parent. This distribution may be caused by transgressive gene interaction in both parents. The nature of gene action was determined as cumulative from the F_1 behaviour, since the F_1 mean was closer to the geometric mean than the arithmetic mean. However, in F_2 the difference between the observed mean and either the arithmetic or geometric means was quite small to determine directly the nature of gene action.

The number of genes involved in this cross was estimated to be (0.36 and 0.43) pairs respectively by the two mentioned formulae. This result showed one pair of gene difference between parents, which was also verified by applying Mendelian principles. It might be suggested that both parents may carry similar genes for fruit size and differed only in certain modifying genes.

The heritability values were 95.32%, 63.57%, 91.47% showing the effectiveness of selection for fruit size.

Inheritance of plant height :

Plant height was studied in two crosses belonging to the groupe short x long stem. The first cross Pearl Harbor x Orange represented two widely separated varieties with regard to stem length. F_1 plants fall within the range of the long stem variety Orange and even exceeded its range by one class, representing complete dominance of long stem with heterosis effect. The F_2 distribution was continuous and covering the ranges of both parents. The dominance of long stem was previously reported by Powers (1941) in F_1 of three crosses with their means exceeding those of the parents, considering this phenomenon as a result of heterosis. Dokić(1954) and Gaafar (1962) reported the dominance of tall stem in tomato.

The nature of gene action was mostly multiplicati since both F_1 and F_2 means were closer to the geometric mean rather than the arithmetic mean. Gaafar (1962), pointed out that the nature of gene action could not be determined in the cross Stoner's Exhibition x Pearl Harbor.

The number of genes for plant height in this cross was estimated as 0.90 pairs by Castle-Wright and 2.07 pairs by Wright's formula . On the basis of Mendel's principles, (1-2) pairs of genes were suggested which agreed with Wright's formula deductions, since heterosis affected the Castle-Wright formula. These results agreed with those of Capinpin and Cauton(1948) and Gaafar (1962), both suggested one pair of genes for plant height.

The heritability values were 71.04%, 91.66% and 72.8% computed by three different methods of estimations, showing the effectiveness of selection for plant height. These estimations agreed with that reported by Gaafar (1962), averaging 71.4% for plant height.

The second cross American x San Marzano showed an intermediate F_1 mean between their parental means, with a slight increase than the F_1 calculated arithmetic mean, indicating partial dominance of long stalks of San Marzano. The F_2 population covered the ranges of both parents, but showed a lower mean than F_1 falling within the range of the short stalked parent. This partial dominance of tall stem agreed with the findings of Powers (1941).

The nature of gene action could not be determined, since the F_1 mean was beyond both arithmetic and geometric means, as well as the F_2 mean was much lower than both F_2 calculated means. The same situation was also met by Gaafar (1962) in the cross Stoner's Exhibition x Pearl Harbor.

The number of genes obtained by using Castle-Wright and Wright's formulae was estimated as (0.53 and 0.59) pairs respectively. This meant that one pair of genes was responsible for this character. The same deduction was reached in F_2 data by using Mendelian principles, in addition to some other minor modifying genes.

The heritability values obtained by using the three formulae were (66.59%, 92.89%, and 74.58%), showing high values sufficient for effective selection, confirming the view of Gaafar (1962).

Inheritance of ascorbic acid content :

This character was studied in fruits of the cross Pearson 107 x San Marzano. Pearson 107 is rich in vitamin C content with a range of (52-60 mg.), while the variety San Marzano is rather poor in this vitamin with a range of (20 - 28 mg.). Vitamin C content of F_1 fruits fall between these two extremes, ranging from (36-44 mg.) and thus showing no dominance. The F_2 distribution of Vitamin C content showed a wide range from (20-28mg.), covering both parental extremes. F_2mean was higher than both arithmetic and geometric, showing partial dominance of high vitamin C content. The nature of gene action was rather additive than cumulative, since the F_1 mean was equal to the arithmetic F_1 mean and the F_2 mean was closer to the arithmetic F_2 mean than the geometric mean. The intermediate value of ascorbic acid in F_1,was previously reported by Rynard and Margaret (1942) and Murphy and Mildred (1951). However Walkof and Hyde(1955) noticed incomplete dominance for high vitamin C values in the cross Morden Wo 24 MD X Early Lethbridge.

The number of genes estimated by using Castle-Wright and Wright's formulae were (0.71) and (0.86) pairs respectively, which coincide, with that estimated by using Mendelian principles.

It could be deduced from these results that this character is simple in its inheritance, inspite of the continuity of its distribution in F_2 generation. This result agreed with that previously reported by Walkof and Hyde (1955), who found a bimodal curve in F_2 typical to 3:1 ratio, in the cross Morden Wo 24 MD x Early Lethbridge. However, Currence _et_ _al_. (1951) suggested three pairs of genes; two major genes and one minor gene controlling ascorbic acid content in the cross Tiny Tim x Stemless Penn orange, using Powers Partitioning method of analysis.

Heritability estimates for this character were 92.71%, 93.43% and 93.25%, being very high and suggesting the possibility of increasing vitamin C contents by selection. This idea was also proposed by Marx (1951)who showed that vitamin C content could be raised by selection. Schultz and Kelly (1952) showed that inspite of the negative correlation between fruit size and ascorbic acid content, individual with relatively high ascorbic acid content and large fruit size, could be selected by breeders.

Table 13 : The genetic consititution of parental varieties for Fusarium-reaction and qualitative characters studied.

Variety	Type	Reaction to Fusarium wilt	Qualitative characters	
			Fruit shape	Fruit colour
1 - Red Cherry	P.	Resistant	Roundish oblate	Red
	G.	r $R_1r_2r_3$ s_1s_2	E P Lc	R_1R_2 T
2 - San Marzano	P.	Resistant	Oval	---
	G.	r r_1 R_2R_3 s_1s_2	e P Lc	---
3 - Pearl Harbor	P.	Susceptible	Roundish oblate	Red
	G.	r $r_1r_2r_3$ s_1s_2	E p Lc	R_4 R_5 T
4 - American	P.	Resistant	Round.	Red
	G.	R $r_1r_2r_3$ s_1s_2	E P lc	R_1 R_2 t
5 - Genome	P.	---	Roundish oblate	Red
	G.	---	E P Lc	R_3 t
6 - Pearson 107	P.	Susceptible	Roundish oblate	Red
	G.	r R_1 r_2r_3 s_1s_2	E p Lc	R_1R_2 T
7 - Orange	P.	Susceptible	Round	Orange
	G.	r $r_1r_2r_3$ S_1 s_2	e p lc	$r_1r_2r_3r_4r_5$ T

P. = Phenotype G. = Genotype

VI - SUMMARY

1. The present investigations represent an attempt to study the genetic behaviour of the reaction to Fusarium wilt, as well as some other qualitative and quantitative characters in some Tomato crosses grown in the three successive years (1964,1965,1966).

2. The study was based on the data of F_1 , F_2 and Bc_1 progenies of **fourteen** crosses including seven varieties of tomatoes; Red Cherry, San Marzano, Pearl Harbor, American, Genome, Pearson 107 and Orange.

3. The inheritance of Fusarium wilt was studied in eight crosses including the resistant varieties Red Cherry, San Marzano and American. The F_1 plants showed dominance of resistance in all crosses including the variety American, and dominance of susceptibility in crosses including the varieties Red Cherry and San Marzano. The F_2 and Bc_1 generations showed that this character was controlled by four dominant genes for resistance and two dominant genes for susceptibility. The genes suggested for resistance were (R) in the variety American and was epistatic to gene (S_1) for susceptibility in Orange, gene(R_1) in Red Cherry and the two complementary genes (R_2, R_3)