GENETIC VARIABILITY AND CORRELATION STUDIES IN PUMPKIN

(*Cucurbita moschata* Poir)

BY

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "GENETIC VARIABILITY AND CORRELATION STUDIES IN PUMPKIN (*Cucurbita moschata* Poir)" is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellanikkara,
9th August, 1979.

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CERTIFICATE

Certified that this thesis is a record of research work done independently by Shri. Gopalakrishnan, P.K. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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

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C O N T E N T S

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

INTRODUCTION

I N T R O D U C T I O N

Significant break through in the genetic improvement of cereal crops especially wheat, paddy and maize has been achieved through adoption of scientific plant breeding principles. Crops with higher harvest index and photosynthetic efficiency have been bred to meet the manyfold human requirements. The development of crop ideotypes in wheat, maize and soy bean is considered milestones in the overall crop improvement programmes. The attainment of self sufficiency in cereal food production in India stands as an eloquent testimony to the great plant breeding achievements.

There remains an immense need to improve a large array of crops which are left unexploited and unimproved. Vegetables in general and cucurbits in particular are the crops where sufficient attention has not been paid for their improvement. The lack of attention given in our country for the improvement of cucurbitaceous vegetables like cucumber, bitter gourd, snake gourd and ash gourd looks rather paradoxical when we know that these crops are originated in this very land. Pumpkin (Cucurbita moschata Poir) is yet another crop

where practically not much work seems to have been done for its improvement in India. Introduced to our country from the South American centre of crop origin by foreign navigators and emissaries, pumpkin is grown throughout the length and breadth of India. It is an important cucurbitaceous vegetable of tropics cultivated for its mature fruit. The 'pepo' forms an ingredient of cattle feed in some countries. The young leaves, flowers and fruits are rich in carotene. Importance of pumpkin as a potential supplier of carotene has not been fully appreciated even now. Medicinal uses of pumpkin to reduce tape worm infection and its use as a diuretic are yet to be explored on a larger scale. Yield in pumpkin remains low due to a conglomeration of reasons, both genetic and environmental. Poor genetic stocks, inadequate and improper management practices and incidence of many parasitic and non-parasitic diseases especially, yellow vein mosaic disease, are the main causes for the low productivity. For the development of high yielding carotene packed pumpkin varieties which can entrap the abundantly available tropical solar energy, a need based crop improvement programme has to be drawn up.

Success of any plant breeding programme primarily

depends on the extent of available variability. In selecting a plant or a type, one should be reasonably sure that there is good chance of the superiority of selection being inherited by the progenies. This can be ascertained by partitioning the total variability into heritable and non-heritable components with the aid of suitable genetic parameters. The choice of breeding method either selection or hybridization depends on the extent of heritability of the character under improvement. Selection of basic parental materials with maximum genetic divergence is of utmost importance to develop transgressive segregants. The extent of variability that would be available in the subsequent cycles of selection also depends on the extent of genetic divergence of the basic parents involved in the hybridization.

Yield in pumpkin is a complex character and as such may be an artifact. There may or may not be any genes for yield <u>per se</u> but genes for the components of yield whose interaction results in the ultimate expression of yield. This implies the importance of selection of appropriate component character(s) whose selection would result in the improvement of yield. Selection of component characters may or may not be

more efficient than selection for complex character *per se* but this has to be worked out and proved.

A review of literature indicated that only a meagre work has been attempted in pumpkin along these directions. Hence the evaluation of available germplasm in this regard is highly necessary and the present investigations were undertaken with the following objectives.

1. To catalogue the available pumpkin genotypes surveyed and collected from different parts of Kerala.

2. To estimate the extent of available variability with respect to yield, length of main vine, weight of first mature fruit and their possible components, carotene content and other chemical constituents.

3. To estimate heritability and estimate of genetic advance in the next generation of selection for different quantitative characters.

4. To estimate the extent of relationship, if any, among fruit yield, length of main vine and weight of first mature fruit and their possible components and carotene content and other chemical constituents.

5. To determine the direct and indirect effects of

component characters on yield, length of main vine, weight of first mature fruit and carotene content using path coefficient analysis.

6. To find out the efficiency of selection through discriminant function over straight selection or vice-versa.

7. To constellate the available genotypes using metroglyphs.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Success of any crop improvement programme depends largely on the extent and availability of genetic variation. Breeding methods like hybridisation, mutation, polyploidisation and disruptive selection are aimed at creating desirable recombinants *a priori* to any further crop improvement programme. Selection *per se* does not create any further variability but operates on the available variability to screen out desirable segregants. In a selection programme the genetic advance which would be expected in the next cycle of selection, depends on heritability of the character under improvement and the extent of available variability. The synthesis of desirable transgressive segregants through hybridisation and consequent selfing depends on the extent of divergence of parental genotypes, involved in the initial hybridisation. This makes abundantly clear that information regarding variability, heritability, inter-relation among characters, extent of genetic divergence among genotypes are pre-requisite for any crop improvement programme.

Eventhough the information on variability studies are abundant in many vegetable crops, the amount of work done on cucurbits in generally and pumpkin in particular are very limited and scanty. The available literature on the variability studies of cucurbits are reviewed under the following heads.

A. Information on genetic variability.

B. Information on heritability and genetic advance.

C. Information on correlations among polygenic characters.

D. Information on direct and indirect effects of character components on complex characters.

E. Information on relative efficiency of selection through discriminant function over straight selection or vice-versa.

F. Information on genetic constellation of genotypes.

A. Information on genetic variability

No information is available on the extent of genetic variability in pumpkin. Kubiaki and Walczak (1976) reported large differences within and between varieties with respect to β carotene content in 19 varieties belonging to Cucurbita pepo, Cucurbita maxima and Cucurbita moschata. The variety Golden Delicious (Cucurbita maxima) recorded the highest carotene content.

Thakur and Nandpuri (1974) studied the extent of genetic variability in 2> varieties of watermelon (Citrullus vulgaris Schrad). They reported significant differences among the varieties for yield/plant, fruit weight, fruits/plant, fruits free from blossom end rot, days taken to first picking, length of vine, branches/plant, sex ratio, total soluble solids, seeds/kg of fruit weight and 100-seed weight. Phenotypic coefficient of variation was the maximum for seeds/kg of fruit weight (41.31) and it was the minimum for days to first picking (6.46). The coefficients of genotypic variation also had the same trend. Vashista et al.,(1975) observed variability in seed characters of watermelon. Data on seed length, seed width, 100-seed weight and seed colour indicated considerable variability for all the above seed characters.

Miller and Quisenberry (1976) reported that variance was primarily due to additive gene action for early flowering in cucumber (Cucumis sativus L.). Partial dominance type of gene action for early flowering and low nodal position of the first female flower were also observed.

Kalyanasundaram (1976) evaluated three muskmelon (*Cucumis melo* L.) varieties - Annamalai, Hara Madhu and Arka Rajhans - and observed significant differences among the three varieties for branches/plant, hermaphrodite flowers/vine, per cent of hermaphrodite flower production, fruit weight, fruits/plot, fruit cavity diameter, flesh thickness and seeds/fruit. However, the variances for days to maturity from the time of anthesis, fruit yield and total soluble solids were not significantly different among the varieties. Singh *et al.*,(1976) found that the additive component of total genetic variance was high for days to opening of the first female flower, picking maturity, fruits per vine and total soluble solids. Dominance component of genetic variance was high for fruit weight, flesh thickness and total yield in muskmelon.

Srivastava and Srivastava (1976) studied variability in 10 lines of bitter gourd (*Momordica charantia* L.) and observed significant differences for all the characters except for male flowers/plant. The highest genotypic coefficient of variation (37.45) was observed for fruits/plant followed by yield/plant (g.c.v. = 32.13) and weight of fruit (g.c.v. = 30.02). Male flowers/plant

had the lowest genotypic coefficient of variation (g.c.v. = 11.47). Singh et al., (1977) studied 20 bitter gourd varieties grown during the rainy season of 1974. High genotypic coefficient of variability was observed for yield, fruits/plant and fruit length. Ramachandran (1978) worked on 25 bitter gourd types. The 25 types he studied were significantly different for all the 21 characters studied, primary branches/plant, length of main vine, node at which first female flower appeared, days to opening of the first female flower, female flowers/plant, per cent of female flowers, days to picking maturity, yield/plant, fruits/plant, fruit weight, length of fruit, girth of fruit, flesh thickness, seeds/fruit, 100-seed weight, T.S.S, vitamin C content, protein content, phosphorus content, potassium content and iron content. The highest estimates of phenotypic and genotypic coefficient of variability were observed for yield/plant (39.88 and 39.82 respectively). Vitamin C content, iron content and fruits/plant had high phenotypic and genotypic coefficients of variation well above 30%. The lowest estimates of variability were observed for girth of fruit (p.c.v.= 7.77; g.c.v.= 7.07).

Joseph (1978) studied on variability in 25 snake gourd (Trichosanthes anguina L.) types with respect to 21 characters, days to male flower anthesis, days to female flower anthesis, node at which first female flower appeared, female flowers/plant, length of main vine, primary branches/plant, fruits/plant, yield/plant, days to maturity, length of fruit, girth of fruit, average fruit weight, flesh thickness, seeds/fruit, 100-seed weight, vitamin C content, crude fibre, crude protein, ash content, phosphorus and potassium contents. The 25 snake gourd types differed significantly with respect to all the 21 characters studied.

B. Information on heritability and genetic advance

Kubiaki and Walesak (1976) studied variability and heritability of carotene content in a few Cucurbita spp. The β carotene content and T.S.S. in Cucurbita spp. recorded high heritability estimates. The inbred lines developed through selfing and selection, recorded 70%, 50% and 20% more β carotene when the parental populations were Melonowa Zolta, Golden Delicious and Nagydobos Sutolok respectively.

Suzuki (1938) reported high estimates of heritability for seed size, T.S.S. content and fruit weight, and intermediate values for leaves/plant, days to first male flower anthesis and rind thickness in watermelon. Thakur and Nandpuri (1974) reported a heritability estimate of 92.92% for 100-seed weight and 84.97% for seeds/kg of fruit in watermelon. The minimum heritability estimate of 25.95% was observed for branches/plant. The maximum genetic advance was observed for seeds/kg of fruit weight (83.75%) resulting from the highest variability estimate associated with higher estimate of heritability. The lowest estimate of genetic advance was observed for days to first picking (5.78%) resulting from lower estimates of heritability and variability. Brar and Nandpuri (1978) conducted genetic analysis of yield and fruit number in watermelon. Heritability in broad sense was observed medium (48.92%) and in narrow sense quite low (23.64%) for the character yield. This indicated that in watermelon yield is a complex character more influenced by environment. The heritability in broad sense was higher (72.29%) and heritability in narrow sense was medium (66.90%) for fruit number, indicating

the major role of genotypic and additive genetic variance in the inheritance of fruit number.

Miller and Quisenberry (1976) working on cucumber reported that days to opening of the first female flower was controlled by relatively a few genes and heritability for this trait was moderately high. Mc Creight (1977) studied heritability estimates of fruit sugar concentration in a population of 501 cucumber introductions and commercial varieties. Narrow sense estimate of heritability calculated through half sib family variance method was observed to be 0.03 and after correction for genotypic x environmental interaction, worked out to be 0.05. The heritability estimate calculated through parent offspring regression analysis was found to be 0.04. The expected genetic gain in altering sugar concentration per cycle of half sib progeny testing was observed 0.21 mg reducing sugar per gram fresh weight. Smith and Lower (1977) estimated heritability and variance components for yield in pickling cucumber. Heritability estimated for commercial value and fruit number, calculated from full sib families, grown in two replicates and environments, were 0.14% and 0.22% respectively.

Panwar et al., (1977) studied 40 varieties of sponge gourd (Luffa cylindrica Roem.) to estimate heritability, and expected genetic advance. Fruit length and days to flower had higher estimates of heritability and expected genetic advance.

Srivastava and Srivastava (1976) reported that fruits/plant had the highest estimate of genetic advance (71.73%) resulting from the highest estimate of variability (g.c.v. = 37.45%) and heritability (99.31%) in bitter gourd. Male flowers/plant recorded the lowest estimate of genetic gain (16.73%) due to the lowest genotypic coefficient of variation (11.47%) and heritability (49.93%). High heritability associated with moderate variability resulting in high genetic gain was observed for fruit weight, yield/plant and length of fruit. Singh et al.,(1977) observed high estimate of heritability and expected genetic advance for fruit yield, fruits/plant and fruit length in bitter gourd. Ramachandran (1978) reported that heritability in broad sense was quite high for all the 21 characters he studied in bitter gourd except seeds/fruit. Fruits/plant had the highest heritability of 99.80% which was closely

followed by yield/plant (99.74%) and vitamin C content (99.63%). The lowest heritability was in seeds/fruit (43.37%). Genetic advance estimated as per cent of mean was found to be highest for yield/plant (81.93%) followed by vitamin C content (70.72%), fruits/plant (64.3%), female flowers/plant (53.5%) and iron content (51.8%). The study indicated that by selecting five per cent superior and elite plants from the available population yield could be improved upto 81.93% over the base mean. High variability associated with high heritability resulting in high expected genetic advance was observed for yield, vitamin C content, fruits/plant, female flowers/plant, iron content and phosphorus content. The heritability estimates were observed to be higher for days to opening of the first female flower, per cent of female flowers, girth of fruit and 100-seed weight but the genetic gain was observed low due to low estimate of variability for the above characters. Seeds/fruit had only a low estimate of genetic gain resulting from low heritability estimate and low variability.

Joseph (1978) studied in detail the heritability and expected genetic advance for 21 characters in snake gourd. Heritability in the broad sense was found to

be quite high for most of the characters. Length of the fruit had the highest heritability of 99.19% which was closely followed by girth of fruit (98.60%) and vitamin C content (97.59%). Yield/plant had comparatively a low estimate of heritability (45.90%). The lowest heritability estimate was recorded for fruits/plant (21.20%). Highest genetic advance as per per cent of mean was observed for ash content (56.92%) followed by crude protein content (55.52%), phosphorus content (55.12%), female flowers/plant (47.62%), fruit weight (46.77%) and vitamin C content (41.39%). The expected genetic advance as per cent of mean was 435.66 for fruit yield. The characters, ash content, crude protein, phosphorus content, female flowers/plant, weight of individual fruit and vitamin C content had higher estimate of genetic advance resulting from higher estimates of heritability and variability.

C. Information on correlations among polygenic characters

Khanna et al., (1969) worked out extent of correlation between T.S.S. and vitamin C content in 10 varieties of watermelon. They observed positive and significant correlation (r = 0.84) between T.S.S.

content and vitamin C content. Tikka et al., (1974) reported that yield was positively correlated with main shoot length, number of primary laterals, number of days to first female flower opening and average fruit weight in 10 varieties of watermelon.

Carlson (1962) reported that length of fruit was positively correlated with average fruit weight in cucumber. Large fruited varieties were generally observed to have poorer fruit set than those with small fruits. Molocojedova (1962) reported that the correlation between fruit yield (weight and number) and the proportion of marketable fruits were positive and significant in cucumber. Ramalao (1975) observed that the pistillate flowers/plant was positively correlated, phenotypically and genotypically, with fruit number but negatively with fruit weight, length and fruit set in cucumber. The occurrence of pistillate flowers on the main stem was also found to be negatively correlated with total fruit yield, number of fruits, fruit weight and fruit length. Mc Creight et al., (1978) reported highly significant correlation between total carbohydrate concentration and reducing sugar content ($r = 0.97$) in pickling cucumber. The reducing sugar

content was neither correlated with fruit fresh weight (r = 0.40) nor with commercial fruit size (r = 0.52).

Shamburaj (1973) reported that seeds/pod, pod weight and pod length were significantly and positively correlated with yield/plant in ridge gourd(Luffa acutangula Roxb.).

Panwar et al., (1977) observed significant positive correlation between yield and fruits/plant and significant negative association between yield and days to flower and age of the edible fruit in 40 varieties of sponge gourd.

Bohn and Andrews (1939) observed positive correlation between fruit diameter and flesh thickness, fruit diameter and cavity size in muskmelon. They reported that selection for small cavity size alone would lead to reduced fruit size and flesh thickness. Lucille et al., (1939) found high positive correlation between refractive index, a measure of total soluble solids, and vitamin C content in 16 American varieties of muskmelon. Khanna et al., (1969) also observed significant positive correlation (r = 0.85) between total soluble solids and vitamin C content in muskmelon varieties. Kalyanasundaram (1976) reported significant positive correlation of fruit weight with diameter, size, and flesh thickness of fruit, and blossom scar with both size and flesh thickness in

muskmelon. Size of fruit cavity had positive association with fruit diameter but had no relation with flesh thickness. Soluble solid content was negatively correlated with fruit weight and seeds/fruit. Dalgit Singh and Nandpuri (1978) observed that days to fruit maturity was positively correlated with days to opening of first female flower, total soluble solids, fruit weight, and total yield/plant in muskmelon. Phenotypically, T.S.S. content showed significant positive correlation with fruit weight and total yield/plant. The fruit weight was positively correlated with flesh thickness and total yield/plant. Flesh thickness was positively correlated with total yield both at genotypic and phenotypic levels.

Srivastava and Srivastava (1976) reported that the genotypic correlation coefficients were higher than phenotypic correlation coefficients among different pairs of characters in bitter gourd. Fruit yield/plant was found positively associated with female flowers/plant (r_g = 0.87), fruits/plant (r_g = 0.86) and lateral branches/plant (r_g = 0.59). Female flowers and lateral branches/plant were found positively associated with fruits/plant. Days to first female flower opening was

observed negatively correlated with fruits/plant and female flowers/plant, but positively with fruit weight. Fruit weight had negative genotypic correlation with fruits/plant. Ramachandran (1978) in a detailed study on bitter gourd found that phenotypic and genotypic correlations for any pair of characters were of comparable magnitude. Yield/plant was highly correlated with length of main vine, weight of fruit, length of fruit, fruits/plant, female flowers/plant and primary branches/plant. Characters exhibiting significant association with yield/plant, had showed high genotypic and phenotypic intercorrelation among themselves which indicated that primary branches/plant, length of main vine, female flowers/plant, fruits/plant, fruit weight and fruit length could be simultaneously improved in bitter gourd.

Joseph (1978) also observed higher values of genotypic correlation coefficients than the corresponding phenotypic values among the characters he studied in snake gourd. Fruit yield was highly associated with primary branches/plant (r_g = 0.82), days to opening of the first female flower (r_g = 0.75),

average weight of fruit (r_g = 0.77), length of fruit (r_g = 0.76), days to first female flower anthesis (r_g = 0.75) and girth of fruit (r_g = 0.68). The biochemical traits did not show any significant intercorrelation. Thamburaj et al., (1978) reported significant positive correlation between fruit length and weight of fruit (r = 0.67). Negative but non-significant correlations existed between girth and weight of fruit (r = -0.14). The association between length of fruit and girth of fruit was negative and significant (r = -0.63).

D. Information on direct and indirect effects of character components on complex characters

Tikka et al., (1974) employed path coefficient analysis in watermelon to find out the direct and indirect effect of yield components on fruit yield/plant. Days to first female flower anthesis and average fruit weight were observed to have the highest direct effect on yield.

Srivastava and Srivastava (1976) reported that female flowers/plant had the maximum direct effect on yield (2.75) followed by fruits/plant (0.90) and lateral branches/plant (0.89) in bitter gourd. The indirect

effects of other characters towards yield were mainly through lateral branches/plant, fruits/plant and female flowers/plant. Fruits/plant also had high indirect contribution towards yield through weight of fruit. Ramachandran (1978) observed that fruit weight, fruits/plant and length of main vine had high positive direct effects on yield (0.55, 0.40, 0.30 respectively). Primary branches/plant, female flowers/plant and fruit length were found to have negative direct effects on fruit yield.

Joseph (1978) utilized path coefficient analysis to find out direct and indirect effects of components on fruit yield in a closed system of "cause and effect" factors. Weight of individual fruit, fruit girth, fruits/plant and node at which the first female flower appeared had high direct effects on fruit yield. The path analysis of fruits/plant and its components indicated that female flowers/plant exerted moderate positive direct effects on fruits/plant and thereby on yield. Among the different components of weight of individual fruit, girth of fruit exerted the maximum direct effect followed by 100-seed weight. He concluded that weight of individual fruit, girth of fruit, fruits/plant

and node at which first female flower appeared were the most important characters contributing to yield in snake gourd.

No information is available in pumpkin on yield and yield contributing characters, length of main vine and its components, weight of first mature fruit and its components and carotene content and other chemical constituents.

E. Information on relative efficiency of selection through discriminant function over straight selection or vice-versa

No work seems to have been done in cucurbits to estimate the efficiency of selection through discriminant function over straight selection for complex characters.

F. Information on genetic constellation of genotypes

Ramachandran (1978) attempted constellation of bitter gourd genotypes through metroglyphs. He also studied genetic divergence using Mahalonobis D^2 statistic for eight quantitative characters, primary branches/plant, length of main vine, days to opening of the first female flower, female flowers/plant, fruits/plant, weight of individual fruit, length of fruit and yield/plant. The 25 types differed significantly for the characters he

studied and were grouped into 10 clusters based on the magnitude of D^2 values. Considerable diversity within and between clusters were noted. Length of main vine, fruits/plant, weight of individual fruit and yield/plant were the important factors contributing to divergence.

Joseph (1978) utilised metroglyphs to group snake gourd genotypes into distinct groups which are similar within groups and dissimilar between groups.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present studies were conducted during 1978-79 (October-February) at the Instructional Farm of the College of Horticulture, Kerala Agricultural University, Vellanikkara. This station is located at an altitude of 23 metres above M.S.L. and is situated between 10°32" N. latitude and 76°16" E. longitude. Geographically it falls in the humid tropical climatic zone. The meterological data for the season under experimentation are presented in Appendix-1.

A. Experimental materials

The experimental materials consisted of 18 pumpkin genotypes collected from different parts of Kerala State and maintained in the department of Olericulture, College of Horticulture, Kerala Agricultural University. The genotypes were diverse in their genetic make up. The source and morphological description of the genotypes are presented in Table 3.1.

Table 3.1. Source and morphological description of 18 pumpkin genotypes

Acc.No.	Place of collection	Vigour of the plant	Presence of white spots on the leaves	Fruit character			
				Shape	Size	Colour of immature fruit	Furrow
C.M.1	Palghat	Vigorous	Present	Conical	Large	Green	Deep
C.M.2	Trichur	Less vigorous	Present	Flat round	Medium	Green	Deep
C.M.3	Calicut	Less vigorous	present	Round	Medium	Green	Shallow
C.M.4	Trichur	Moderately vigorous	Present	Flat round	Medium	Green with white patches	Shallow
C.M.5	Trichur	Moderately vigorous	Present	Flat round	Medium	Green	Shallow
C.M.6	Trichur	Moderately vigorous	Present	Round	Medium	Green	Shallow
C.M.7	Thriprayar	Moderately vigorous	Present	Round	Medium	Green	Shallow
C.M.8	Palghat	Vigorous	Absent	Long oval	Small	White	Shallow
C.M.9	Trichur	Moderately vigorous	Present	Flat round	Medium	Green	Deep
C.M.10	Thriprayar	Moderately vigorous	Present	Flat	Big	White	Shallow

Table 3.1. Contd.

Acc.No.	Place of collection	Vigour of the plant	Presence of white spots on the leaves	Fruit character			
				Shape	Size	Colour of immature fruit	Furrow
C.M.11	Trichur	Moderately vigorous	Present	Long oval	Big	Green	Shallow
C.M.12	Cannanore	Less vigorous	Present	Flat round	Medium	Green	Shallow
C.M.13	Trichur	Vigorous	Present	Flat round	Big	Green	Shallow
C.M.14	Trichur	Vigorous	Present	Round	Big	Green	Shallow
C.M.15	Cannanore	Less vigorous	Present	Flat round	Small	Green	Shallow
C.M.16	Calicut	Moderately vigorous	Present	Oval	Medium	Green	Shallow
C.M.17	Trichur	Vigorous	Present	Round	Large	Green	Shallow
C.M.18	Calicut	Moderately vigorous	Absent	Round	Small	White	Shallow

B. Experimental methods

The 18 pumpkin genotypes were grown in a randomised block design with three replications. There were three plants/genotype/replication. The spacing adopted was 1.5 m between plants and width of each block was kept at 8 m.

Three seeds were sown in each pit and only one plant was retained after thinning. During the cropping period various cultural operations and prophylactic plant protection measures were adopted as recommended by the Kerala Agricultural University (Anon. 1978).

C. Plant characters studied

The entire population was considered for taking observations and the average of each type in each replication was taken for further analysis. The quantitative and qualitative characters studied were as follows:

1. Earliness

a. Days to first female flower anthesis.

b. Days to first male flower anthesis.

c. Node at which the first female flower appeared.

d. Node at which the first fruit is retained.

2. Vegetative characters.

a) Length of main vine (m)

b. Nodes on main vine.

c. Primary branches/plant.

d. Thick branches/plant. Branches having a diameter of 10 mm or more were arbitrarily fixed as thick branches.

e. Internodal length (cm). Length of 6^{th}, 7^{th}, 8^{th}, 9^{th} and 10^{th} internodes were measured and averaged.

f. Internodal circumference (cm). Circumference of 6^{th}, 7^{th}, 8^{th}, 9^{th}, and 10^{th} internodes were measured and averaged.

g. Leaves/plant.

h. Leaf area/plant (m^2). The 'paper weight method' was used to measure the leaf area. Ten leaves were plucked randomly from each plant and circumferences of these ten leaves were marked on uniformly weighing paper using ink. The paper equivalent to the area of leaves was cut and weighed. The area of paper for unit gram weight was initially determined and then

the total leaf area/plant was calculated by multiplying the mean area of one leaf with the number of leaves/ plant.

3. Flower and fruit characters.

a. Male flowers/plant.

b. Female flowers/plant.

c. Per cent of female flowers.

d. Average fruit weight (kg).

e. Weight of first mature fruit (kg).

f. Fruits/plant.

g. Per cent of fruit set.

h. Circumference of fruit (cm).

i. Length of fruit (cm).

j. Fruit shape index. This was calculated as the ratio of fruit length to fruit diameter.

k. Flesh thickness (cm).

l. Seeds/fruit.

m. 100-seed weight (g).

n. Fruit yield/plant (kg)

4. Qualitative characters of fruit.

a. Protein content - The nitrogen content of the dried fruit flesh was estimated using the Microkjeldahl method (A.O.A.C, 1960). The nitrogen content was

multiplied by 6.25 to obtain the protein content and expressed as per cent of dry weight.

b. Phosphorus content - This was estimated colorimetrically using the vanadomolybdo-phosphoric yellow colour method in nitric acid system (Jackson, 1973) and expressed as per cent of dry weight.

c. Potassium content - Potassium in an aliquot of the triple acid extract of the sample was determined using flame photometer (Jackson, 1973) and expressed as per cent of dry weight.

d. Calcium content - Per cent of calcium in the dried sample was estimated by versene titration method (Jackson, 1973).

e. Total soluble solids (T.S.S) - The T.S.S. content of the fruit was estimated by using Abbe refractometer.

f. Carotene content - The carotene content of dried sample was estimated using spectrophotometer after extracting the carotene with water saturated n-butyl alcohohol (A.O.A.C, 1960) and expressed as per cent of dry weight.

The fruit characters viz., circumference of fruit, length of fruit, fruit shape index, flesh

thickness, seeds/fruit, 100-seed weight, and the qualitative characters viz., protein content, phosphorus content, potassium content, calcium content, total soluble solids and carotene content were recorded/estimated from the first mature fruit.

D. Statistical analysis.

The details of the statistical analysis followed in the present experiment are as follows.

1. Analysis of variance.

Before proceeding with the detailed statistical analysis of the plant characters, the data were analysed for the analysis of variance as described by Ostle (1966) for a randomised block design. The model utilised in the analysis of this design is.

$$Y_{ij} = \mu + b_i + t_j + e_{ij}, \quad \begin{matrix} i = 1, \ldots\ldots\ldots 3 \\ j = 1, \ldots\ldots\ldots 18 \end{matrix}$$

Where, Y_{ij} = Performance of j^{th} genotype in i^{th} block;

μ = general mean;

b_i = true effect of i^{th} block,

t_j = true effect of j^{th} genotype and

e_{ij} = random error.

Restrictions are $\sum_{i=1}^{r} b_i = 0$ and $\sum_{j=1}^{t} t_j = 0$.

The actual break up of the total variance into variances due to replications, genotypes and error and their expectations are given in Table 3.2.

1. Estimation of variability, heritability and genetic advance.

Variability existing in the fruit yield and yield contributing characters, length of main vine and its contributing components, weight of first mature fruit and its possible components and carotene content and other chemical constituents were estimated as suggested by Burton (1952). The formulae used in the estimation of variability at genotypic, phenotypic and environmental levels are given below:

a. Genotypic coefficient of variation (g.c.v) =

$$\frac{\text{Genotypic standard deviation}}{\text{Mean of the character under study}} \times 100$$

b. Phenotypic coefficient of variation (p.c.v) =

$$\frac{\text{Phenotypic standard deviation}}{\text{Mean of the character under study}} \times 100$$

c. Environmental coefficient of variation (e.v) =

$$\frac{\text{Environmental standard deviation}}{\text{Mean of the character under study}} \times 100$$

d. Standard error of mean =

$$\frac{\text{Environmental standard deviation}}{(\text{Number of replications})^{\frac{1}{2}}}$$

Table 3.2. Analysis of variance and covariance of the design

Sources of variation	d.f.	Mean squares			
		Variance analysis		Covariance analysis	
		Observed	Expected	Observed	Expected
Total	53				
Between replications	2	M_1		MP_1	
Between genotypes	17	M_2	Error variance + number of replications x genotypic variance	MP_2	Error covariance + number of replications x genotypic covariance
Error	34	M_3	Error variance	MP_3	Error covariance

The above estimates - genotypic, phenotypic and environmental standard deviations - were obtained by solving the following equations from the respective analysis of variance table for different characters.

M_3 = Error variance

M_2 = Error variance + number of replications x genotypic variance.

$$\text{Genotypic variance} = \frac{M_2 - M_3}{\text{Number of replications}}$$

Phenotypic variance = Genotypic variance + Error variance.

e. Heritability - Heritability in the broad sense was estimated by the formula suggested by Burton and Devane (1953).

$$h^2 (b) = \frac{\text{Genotypic variance}}{\text{Phenotypic variance}}$$

f. Expected genetic advance - The expected genetic advance of the available germplasm at 5% intensity of selection was calculated using the formulae suggested by Lush (1949) and Johnson et al., (1955) using the constant 'i' as 2.06 as given by Allard (1960).

$GA = h^2 \times \sigma p \times i$ where,

σp refers to phenotypic standard deviation and 'i' to intensity of selection.

3. Estimation of correlation.

Correlation between yield and its components, length of main vine and its components, weight of first mature fruit and its components, and carotene content and other chemical constituents were calculated at genotypic and phenotypic levels as given by Searle (1961).

a. Genotypic correlation between characters x and y

$$r_{xy}(g) = \frac{Cov_{xy}(g)}{(Var._x(g) \cdot Var._y(g))^{\frac{1}{2}}}$$

b. Phenotypic correlation between characters x and y

$$r_{xy}(p) = \frac{Cov_{xy}(p)}{(Var._x(p) \cdot Var._y(p))^{\frac{1}{2}}}$$

where, $Cov_{xy}(g)$, $Cov_{xy}(p)$, denote genotypic and phenotypic covariances respectively between characters x and y. $Var._x(g)$, $Var._x(p)$ denote genotypic and phenotypic variances for character 'x' and $Var._y(g)$ and $Var._y(p)$ denote genotypic and phenotypic variances respectively for character 'y'. The phenotypic correlation coefficients were tested for significance.

4. Path coefficient analysis.

Fruit yield was considered as the effect factor in a closed system of "cause and effect" variables,

the causal variables being days to first female flower anthesis, days to first male flower anthesis, length of main vine, female flowers/plant, average fruit weight, weight of first mature fruit and fruits/plant.

The length of main vine was considered as the effect factor in a similar closed system of "cause and effect" variables, the causal variables being the node at which first female flower appeared, node at which first fruit is retained, nodes on main vine, primary branches/plant, thick branches/plant, internodal length, internodal circumference, leaves/plant and leaf area/plant.

The weight of first mature fruit was considered as the effect factor in a similar closed system of "cause and effect" variables, the causal variables being circumference of fruit, length of fruit, flesh thickness, seeds/fruit, 100-seed weight and carotene content.

The carotene content was also considered in a similar closed system of "cause and effect" variables, where the causal variables are the contents of protein, phosphorus, potassium, calcium, carotene and total soluble solids of fruit flesh.

The estimates of direct and indirect effects in such a closed system of variables were calculated by the path coefficient analysis as suggested by Dewey and Lu (1959). The following set of simultaneous equations were formed and solved for estimating the various direct and indirect effects.

$$r_{1y} = P_{1y} + r_{12} P_{2y} + r_{13} P_{3y} + r_{14} P_{4y} + \cdots\cdots + r_{1k} P_{ky}$$

$$r_{2y} = P_{2y} + r_{21} P_{1y} + r_{23} P_{3y} + r_{24} P_{4y} + \cdots\cdots + r_{2k} P_{ky}$$

$$r_{3y} = P_{3y} + r_{31} P_{1y} + r_{32} P_{2y} + r_{34} P_{4y} + \cdots\cdots + r_{3k} P_{ky}$$

$$r_{4y} = P_{4y} + r_{41} P_{1y} + r_{42} P_{2y} + r_{43} P_{3y} + \cdots\cdots + r_{4k} P_{ky}$$

$$\vdots$$

$$r_{ky} = P_{ky} + r_{k1} P_{1y} + r_{k2} P_{2y} + r_{k3} P_{3y} + \cdots\cdots + r_{k(k-1)} P_{(k-1)y}.$$

where, r_{1y} to r_{ky} denote coefficient of correlation between independent characters 1 to k and dependent character y. r_{12} to $r_{k(k-1)}$ denote coefficient of correlation between all possible combinations of independent characters; and P_{1y} to P_{ky} denote direct effects of characters 1 to k on character y.

The above equations can be written in a matrix form shown as.

$$
\begin{array}{ccccc}
A & & B & & C \\
\begin{pmatrix} r_{1y} \\ r_{2y} \\ r_{3y} \\ r_{4y} \\ \vdots \\ r_{ky} \end{pmatrix} & = & \begin{pmatrix} 1 & r_{12} & r_{13} & r_{14} \cdots\cdots r_{1k} \\ & 1 & r_{23} & r_{24} \cdots\cdots r_{2k} \\ & & 1 & r_{34} \cdots\cdots r_{3k} \\ & & & 1 \quad \cdots\cdots r_{4k} \\ & & & \vdots \\ & & & 1 \end{pmatrix} & \begin{pmatrix} P_{1y} \\ P_{2y} \\ P_{3y} \\ P_{4y} \\ \vdots \\ P_{ky} \end{pmatrix}
\end{array}
$$

The genotypic path coefficients were obtained by replacing the corresponding elements in A and B matrices by genotypic correlation coefficients.

Residual factor (P_{xy}) which measures the contribution of rest of the characters not considered in the causal scheme was obtained as given below.

Residual factor (x), $P_{xy} = (1-R^2)^{\frac{1}{2}}$

where $R^2 = \sum_{i=1}^{k} P_{iy}^2 + 2 \sum_{\substack{i=1 \\ i \neq j \\ i < j}}^{k} P_{iy} P_{jy} r_{ij}$

5. Estimation of Selection indices.

A series of select on indices were obtained by discriminant function analysis using different combination of component characters. The component

characters were days to first female flower anthesis, length of main vine, thick branches/plant, leaf area/ plant, average fruit weight and flesh thickness. These characters were selected based on the relative magnitude of positive direct effects on fruit yield/ plant. The statistical method suggested by Robinson et al., (1951) was used for constructing selection indices and computing genetic advance. The set of simultaneous equations, solved to obtain weights in the selection index based on yield and the independent component characters were

$$b_1t_{11} + b_2t_{12} + b_3t_{13} + \ldots\ldots + b_kt_{1k} + b_yt_{1y} = g_{1y}$$

$$b_1t_{21} + b_2t_{22} + b_3t_{23} + \ldots\ldots + b_kt_{2k} + b_yt_{2y} = g_{2y}$$

$$b_1t_{31} + b_2t_{32} + b_3t_{33} + \ldots\ldots + b_kt_{3k} + b_yt_{3y} = g_{3y}$$

$$\vdots$$

$$b_1t_{k1} + b_2t_{k2} + b_3t_{k3} + \ldots\ldots + b_kt_{kk} + b_yt_{ky} = g_{ky}$$

where, t_{kk} and t_{km} represent phenotypic variance and covariance respectively and b_k is the unknown weight. g_{km} and g_{kk} are genotypic covariance and variance respectively.

Genetic advance by descriminant function,

$$GA\ (D) = i\ (\Sigma b_k\ g_{ky})^{\frac{1}{2}}$$

where, 'i' stands for intensity of selection when top 5% of the population is selected (2.06).

Genetic advance by straight selection for yield,

$$GA\ (S) = i.\ \frac{g_{yy}}{(t_{yy})^{\frac{1}{2}}}$$

The relative efficiency of selection through discriminant function over straight selection was calculated as suggested by Paroda and Joshi.(1970).

Relative efficiency over straight selection =

$$\frac{GA\ (D) - GA\ (S)}{GA\ (S)} \times 100$$

6. Analysis of genetic divergence through metroglyph method

Anderson (1957) proposed this method to study the pattern of morphological variation in parents and hybrids. In the present study 18 genotypes were analysed in a replicated trial and the measurements on various characters were recorded. From the data mean tables were prepared where, each value was the mean over replications.

Two most variable characters were selected, one of

them was taken along the x-axis and the other on the Y-axis. The means of Y values were plotted against the means of X values for each genotype. A particular genotype was thus represented by a glyph on the graph.

The other characters were represented by rays on the glyph, the rays for the same character having the same position on each glyph.

The range of variation in each character was represented by different length of rays ie. a genotype having low values for the character will have a smaller ray and so on. Thus the length of the ray is either short, medium or long depending on the magnitude of values.

RESULTS

R E S U L T S

The data collected from the present experiment were statistically analysed and the results are presented under the following heads:

A. General analysis of variance, estimation of variability, heritability, genetic advance, correlation and path coefficient analysis for yield and its components.

B. General analysis of variance, estimation of variability, heritability, genetic advance, correlation and path coefficient analysis for the length of main vine and its components.

C. General analysis of variance, estimation of variability, heritability, genetic advance, correlation and path coefficient analysis for the weight of first mature fruit and its components.

D. General analysis of variance, estimation of variability, heritability, genetic advance, correlation and path coefficient analysis for carotene content and other chemical constituents.

E. Relative efficiency of selection through discriminant function over straight selection or vice-versa.

F. Constellation of pumpkin genotypes through metroglyphs.

A. General analysis of variance, estimation of variability, heritability, genetic advance, correlation and path coefficient analysis for yield and its components

1. General analysis of variance.

The partitioning of total variance into its three components in a randomised block design set up indicated that the 18 pumpkin genotypes were significantly different for yield and its 10 component characters viz., days to first female flower anthesis, days to first male flower anthesis, length of main vine, male flowers/plant, female flowers/plant, per cent of female flowers, average fruit weight, weight of first mature fruit, fruits/plant and per cent of fruit set (Table 4.1). The results showed that there were inherent and statistically significant differences among the genotypes for all the 11 characters.

Table 4.1 General analysis of variance for yield and its components

Sources of variation	d.f.	M.S.										
		Days to first female flower anthesis	Days to first male flower anthesis	Length of main vine(m)	Male flowers/ plant	Female flowers/ plant	% of female flowers	Average fruit weight (kg)	Weight of first mature fruit (kg)	Fruits/ plant	% of fruit set	Fruit yield/ plant (kg)
Replications	2	1.50	0.56	0.48	27.86	0.23	0.17	0.22	0.04	0.02	3.65	0.92
Genotypes	17	30.03**	38.22**	5.60**	15799.43**	32.35**	35.85**	17.53**	18.93**	3.79**	177.98**	29.69**
Error	34	0.98	1.32	0.32	45.39	0.28	0.27	1.25	0.53	0.10	16.14	1.19

** Statistical significance at 1% probability level (p = 0.01)

2. Estimation of variability, heritability and genetic advance.

The extent of variability present in the 18 pumpkin genotypes with respect to yield and its 10 component characters was measured in terms of range, mean and its standard error and coefficients of variation at genotypic, phenotypic and environmental levels (Table 4.2). Considerable variation for all the characters under study was observed. The range for days to first female flower anthesis varied from 45 days after sowing in C.M. 7 to 57 days in C.M. 8. The length of main vine ranged from 4.75 m in C.M. 15 to 9.63 m in C.M. 8. Female flowers/plant ranged from 3.33 in C.M. 15 to 16.28 in C.M. 8. The range for average fruit weight varied from 1.21 kg. in C.M. 18 to 9.95 kg. in C.M. 11. Number of fruits/plant varied from 1.33 in C.M. 10 to 5.67 in C.M. 8. The range for fruit yield/plant varied from 5.45 kg. in C.M. 18 to 16.10 kg. in C.M. 17. The genotype C.M. 14 closely followed C.M. 17 in yield, with 15.38 kg./ plant (Plates 2, 3 and 4).

The maximum value of genotypic coefficient of variation was observed for male flowers/plant (56.23)

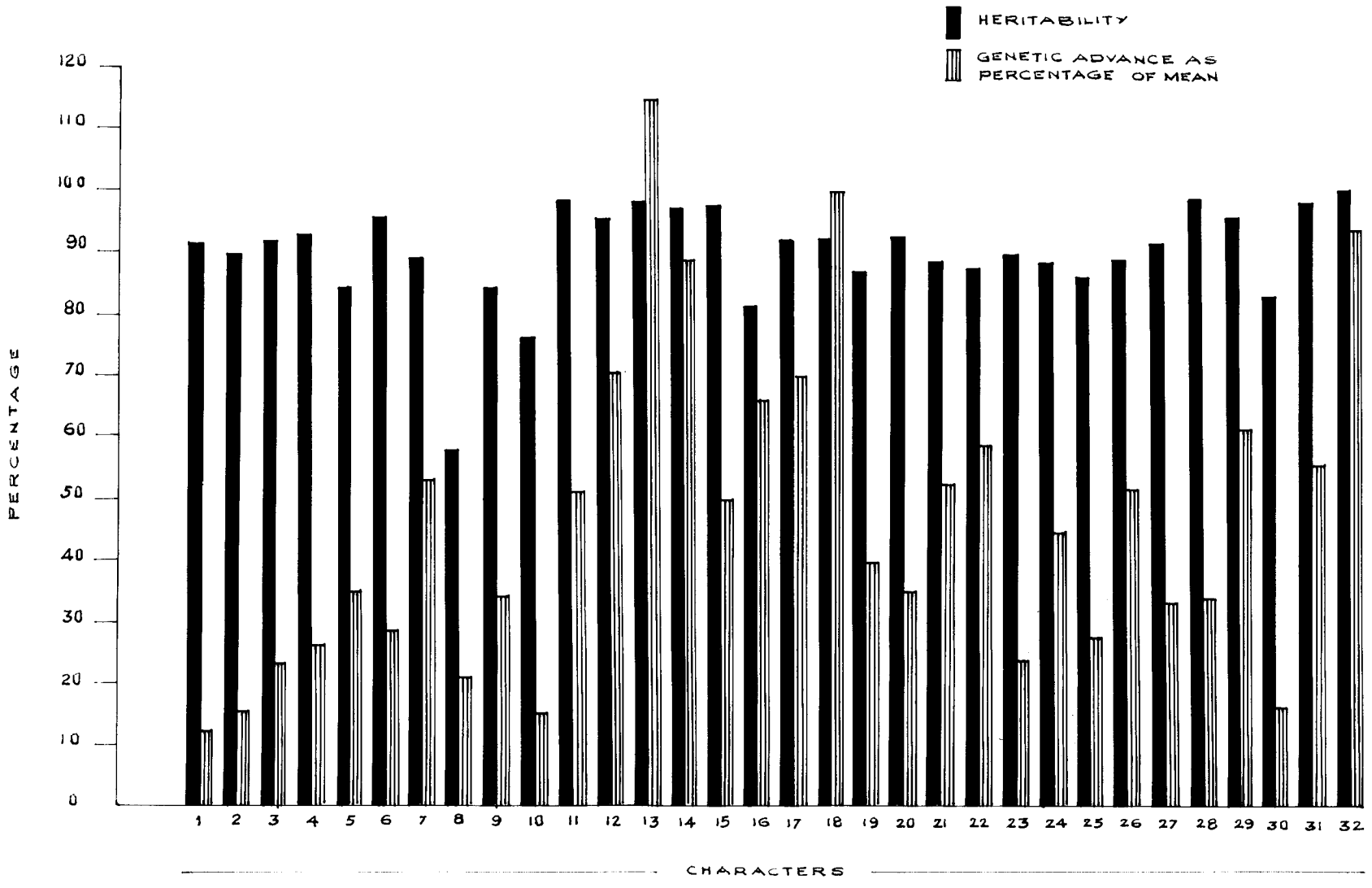
Table 4.2 Range, mean, genotypic (g.c.v.), phenotypic (p.c.v.) and environmental (e.c.v.) coefficients of variation, heritability and expected genetic advance for yield and its components.

Characters	Range	Mean ± S&m	g.c.v.	p.c.v.	e.c.v.	Heritability(%)	G.A.	G.A. as % of mean
Days to first female flower anthesis	45.33 - 57.00	50.22 ± 0.57	6.20	6.50	1.97	90.80	6.12	12.19
Days to first male flower anthesis	37.57 - 56.00	47.74 ± 0.66	7.35	7.73	2.41	90.30	6.87	14.39
Length of main vine (m)	4.75 - 9.63	7.14 ± 0.33	18.58	20.22	7.98	84.45	2.52	35.31
Male flowers/plant	56.23 - 383.67	128.89 ± 3.89	56.23	56.47	5.23	99.14	148.64	115.33
Female flowers/plant	3.33 - 16.28	7.49 ± 0.30	43.65	44.22	7.08	97.45	6.65	88.79
Per cent of female flowers	8.20 - 19.40	14.08 ± 0.30	24.47	24.75	3.69	97.77	7.02	49.88
Average fruit weight (kg)	1.21 - 9.95	6.12 ± 0.65	38.06	42.21	18.27	81.28	4.34	70.89
Weight of first mature fruit (kg)	1.85 - 9.95	7.01 ± 0.42	35.34	36.84	10.41	92.05	4.89	69.78
Fruits/plant	1.33 - 5.67	2.20 ± 0.17	50.32	52.28	14.55	92.67	2.20	99.82
Per cent of fruit set	19.62 - 49.66	33.53 ± 2.32	21.90	24.97	11.99	76.97	13.28	39.61
Fruit yield/plant	5.45 - 16.10	11.42 ± 0.63	26.99	28.63	9.55	88.84	5.98	52.36

Fig. 1 Heritability and expected genetic advance as per cent of mean.

1. Days to first female flower anthesis.
2. Days to first male flower anthesis.
3. Node at which the first female flower appeared.
4. Node at which the first fruit is retained.
5. Length of main vine.
6. Nodes on main vine.
7. Primary branches/plant.
8. Thick branches/plant.
9. Internodal length.
10. Internodal circumference.
11. Leaves/plant.
12. Leaf area/plant.
13. Male flowers/plant.
14. Female flowers/plant.
15. Per cent of female flowers.
16. Average fruit weight.
17. Weight of first mature fruit.
18. Fruits/plant.
19. Per cent of fruit set.
20. Circumference of fruit.
21. Length of fruit.
22. Fruit shape index.
23. Flesh thickness.
24. Seeds/fruit.
25. 100-seed weight.
26. Fruit yield/plant.
27. Protein (%).
28. Phosphorus(%).
29. Potassium (%).
30. Calcium (%).
31. T.S.S. (%).
32. Carotene (%).

FIG. 1. HERITABILITY AND EXPECTED GENETIC ADVANCE AS PERCENTAGE OF MEAN.



followed by fruits/plant (50.32). The lowest value of genotypic coefficient of variation was recorded for days to first female flower anthesis (6.20). The highest heritability estimate of 99.14% was obtained for male flowers/plant followed by per cent of female flowers (97.77%) and female flowers/plant (97.45%) (Fig.1). The lowest heritability estimate of 76.97% was noted for per cent of fruit set. Fruit yield/plant had moderate estimates of heritability (88.84%) and variability (g.c.v. = 26.99). The highest value of genetic advance as per cent of mean was observed for male flowers/plant (115.33) followed by fruits/plant (99.82). Days to first female flower anthesis recorded the lowest estimate of genetic advance as per cent of mean (12.19). Fruit yield/plant had an expected genetic advance of 52.36% in the next generation of selection when the intensity of selection was 5%.

3. Correlation among yield and its components.

Length of main vine, average fruit weight and weight of first mature fruit were significantly and positively correlated with fruit yield/plant (r_p= 0.47;

0.74 and 0.65 respectively) (Table 4.3). Fruits/plant had negative association with fruit yield/plant, though the estimate of correlation was not significant (r_p = -0.35). Female flowers/plant and days to first female flower anthesis had no correlation with fruit yield/plant (r_p = -0.03 and 0.05 respectively). Length of main vine was positively correlated with female flowers/plant (r_p = 0.49). Male flowers/plant was negatively correlated with average fruit weight (r_p = -0.49). Female flowers/plant had positive correlation with number of fruits/plant (r_p = 0.52). Average fruit weight was positively correlated with weight of first mature fruit (r_p = 0.83) and negatively correlated with number of fruits/plant (r_p = -0.76).

4. Path coefficient analysis.

The direct effects of the component characters on fruit yield/plant, length of main vine, weight of first mature fruit and carotene content of fruit are presented in Figure 2.

The genotypic correlations among yield and its eight component characters were partitioned into its different components, to find out the direct and indirect

Table 4.3 Genotypic (r_g) and phenotypic (r_p) correlations among yield and its components in pumpkin.

Characters	Days to first male flower anthesis	Length of main vine	Male flowers/ plant	Female flowers/ plant	Average fruit weight	Weight of first mature fruit	Fruits/ plant	Fruit yield/ plant
Days to first female flower anthesis	0.64 (0.62**)	0.25 (0.24)	0.05 (0.04)	0.29 (0.27)	0.05 (0.05)	-0.02 (-0.01)	0.17 (0.17)	0.05 (0.07)
Days to first male flower anthesis		0.56 (0.51**)	-0.44 (-0.42)	0.36 (0.34)	0.25 (0.22)	0.32 (0.29)	-0.03 (0.001)	0.26 (0.26)
Length of main vine			0.19 (0.18)	0.54 (0.49*)	0.18 (0.14)	0.22 (0.18)	0.33 (0.31)	0.54 (0.47*)
Male flowers/ plant				0.14 (0.15)	-0.53 (-0.49*)	-0.51 (-0.48*)	0.71 (0.69**)	-0.29 (-0.28)
Female flowers/ plant					-0.17 (-0.16)	-0.32 (-0.30)	0.53 (0.52*)	0.03 (0.03)
Average fruit weight						0.97 (0.83**)	-0.77 (-0.76**)	0.80 (0.74**)
Weight of first mature fruit							-0.79 (-0.73**)	0.73 (0.65**)
Fruits/plant								-0.40 (-0.35)

*p = 0.05 **p = 0.01

Figures within paranthesis indicate phenotypic correlation coefficients.

contribution of component characters on fruit yield (Table 4.4) (Fig.3). The eight component characters alone and in combinations contributed more than 78% of the variability in fruit yield/plant (R^2= 0.7899). Length of main vine had the maximum direct effect (1.46) on fruit yield/plant followed by average fruit weight (1.33). Weight of first mature fruit had a negative direct effect on fruit yield (-0.93) though the total correlation with fruit yield was positive and significant (r_g= 0.73). The highly significant positive correlation between weight of first mature fruit and fruit yield resulted from the high positive indirect effects on fruit yield through average fruit weight and male flowers/plant. The negative correlation between fruits/plant and fruit yield/plant resulted from the high negative indirect effect of fruits/plant on fruit yield via. the character average fruit weight (-1.02). Male flowers/plant and days to first male flower anthesis had high negative direct effects on yield (-1.09 and -1.21 respectively).

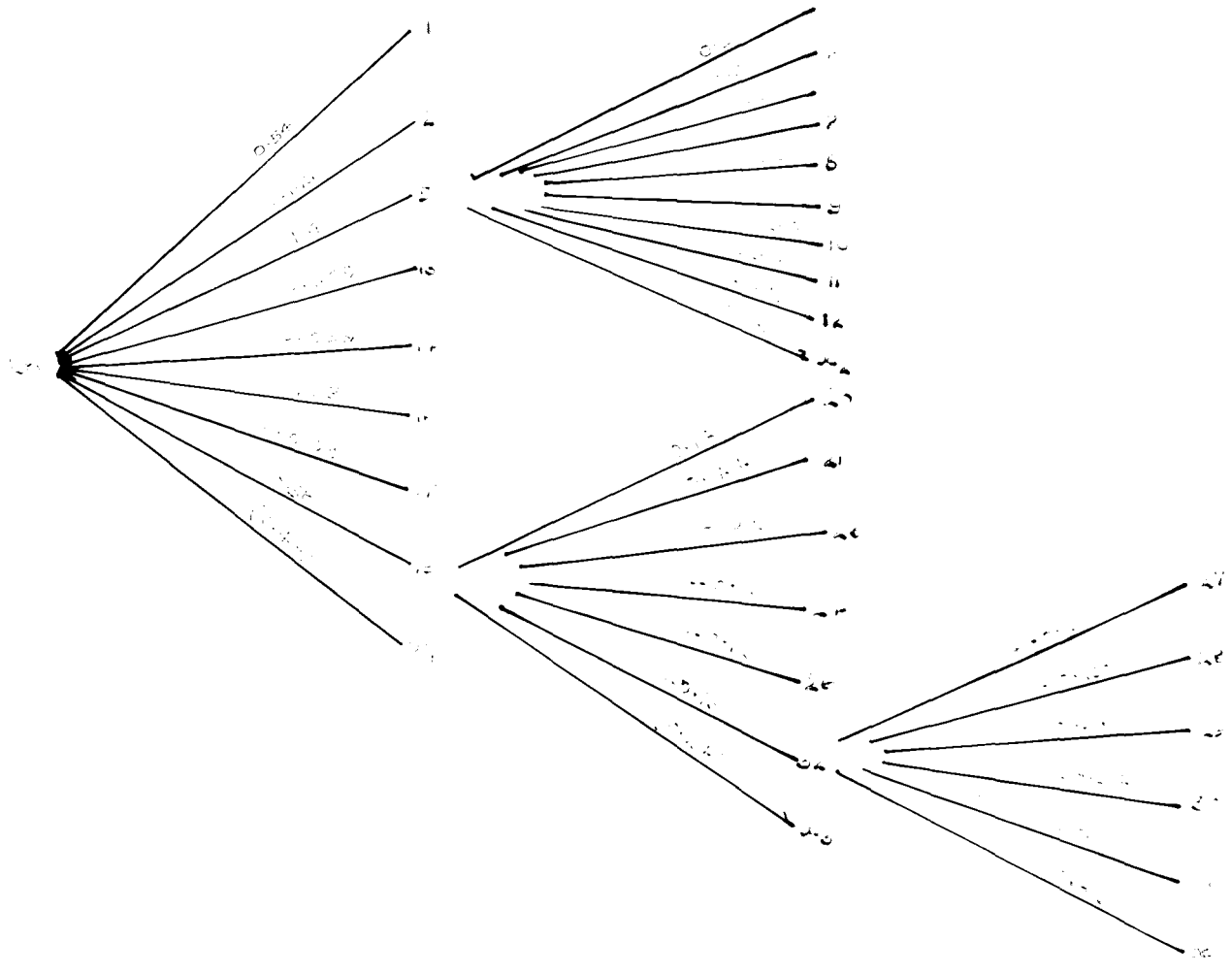
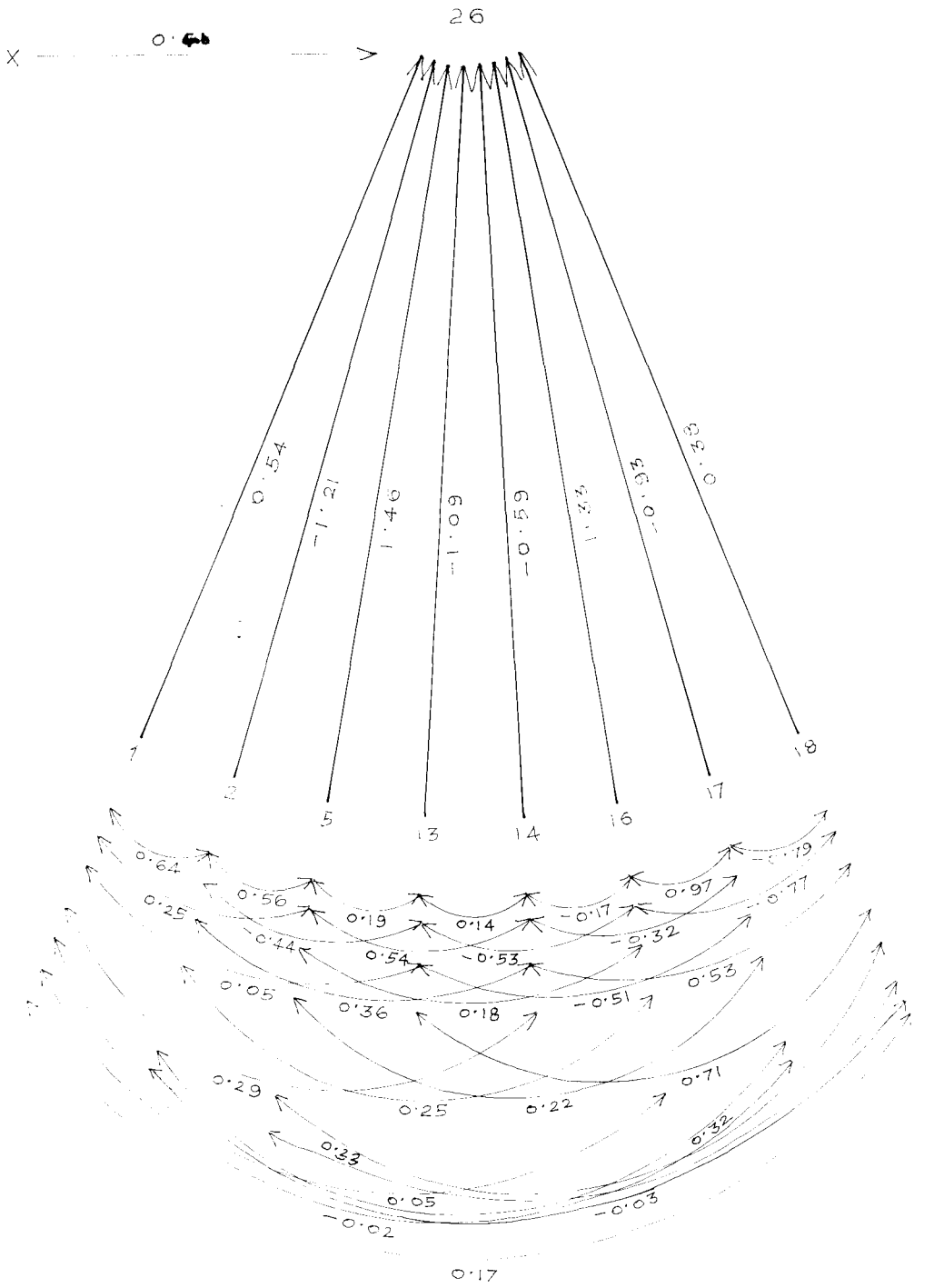


Table 4.4 Direct and indirect genotypic effects of eight component characters on fruit yield in pumpkin

Characters	r_g*	Direct effect (P_{iy})	Indirect effect via. character							
			Days to first female flower anthesis	Days to first male flower anthesis	Length of main vine	Male flowers/ plant	Female flowers/ plant	Average fruit weight	Weight of first mature fruit	Fruits/ plant
Days to first female flower anthesis	0.05	0.54	-	-0.77	0.36	-0.05	-0.17	0.06	0.02	0.06
Days to first male flower anthesis	0.26	-1.21	0.35	-	0.83	0.48	-0.21	0.34	-0.30	-0.01
Length of main vine	0.54	1.46	0.13	-0.68	-	-0.21	-0.32	0.23	-0.20	0.12
Male flowers/ plant	-0.29	-1.09	0.02	0.54	0.28	-	-0.08	-0.71	0.48	0.27
Female flowers/ plant	0.03	-0.59	0.16	-0.44	0.79	-0.15	-	-0.23	0.29	0.20
Average fruit weight	0.30	1.33	0.03	-0.31	0.26	0.58	0.10	-	-0.89	-0.29
Weight of first mature fruit	0.73	-0.93	-0.01	-0.39	0.32	0.56	0.17	1.28	-	-0.30
Fruits/ plant	-0.40	0.38	0.09	0.03	0.49	-0.77	-0.31	-1.02	0.73	-

*r_g = Genotypic correlation coefficients between fruit yield and its components.

FIG. 3 PATH DIAGRAM INDICATING DIRECT AND INDIRECT EFFECTS OF THE POSSIBLE COMPONENTS ON FRUIT YIELD / PLANT



→ PATH COEFFICIENTS	13 MALE FLOWERS / PLANT
r(g)	14 FEMALE FLOWERS / PLANT
1 DAYS TO FIRST FEMALE FLOWER ANTHESIS.	16 AVERAGE FRUIT WEIGHT
2 DAYS TO FIRST MALE FLOWER ANTHESIS.	17 WEIGHT OF FIRST MATURE FRUIT
5 LENGTH OF MAIN VINE	18 FRUITS / PLANT
	26 FRUIT YIELD / PLANT

B. General analysis of variance, estimation of variability, heritability, genetic advance, correlation and path coefficient analysis for length of main vine and its components

1. General analysis of variance.

Observations on length of main vine and its nine component characters viz., node at which the first female flower appeared, node at which the first fruit is retained, number of nodes on main vine, primary branches/plant, thick branches/plant, internodal length, internodal circumference, leaves/plant and leaf area/plant were subjected to analysis of variance to test the significance of differences among the genotypes in respect to these polygenic characters. Highly significant differences were observed among the 18 pumpkin genotypes for all the characters studied (Table 4.5).

2. Estimation of variability, heritability and genetic advance.

Node at which the first female flower appeared ranged from 18.33 in C.M. 3 to 28.78 in C.M. 8 (Table 4.6). Node at which the first fruit was retained varied from 19.22 in C.M. 3 to 31.0 in C.M. 18. Nodes on main vine

Table 4.5 General analysis of variance for length of main vine and its components

Sources of variation	d.f.	M.S.									
		Node at which first female flower appeared.	Node at which first fruit is retained	Nodes on main vine	Primary branches/ plant	Thick branches/ plant	Internodal length (cm)	Internodal circumference (cm)	Leaves/ plant	Leaf area/ plant (m^2)	Length of main vine (m)
Replications	2	0.03	2.05	2.48	0.02	0.05	0.01	0.12	22.91	0.15	0.48
Genotypes	17	21.30**	34.57**	234.85**	8.16**	0.80**	15.09**	0.33**	10238.78**	21.56**	5.60**
Error	34	0.60	0.80	3.31	0.31	0.16	0.92	0.03	60.24	0.40	0.32

**p = 0.01

Table 4.6 Range, mean, genotypic (g.c.v.) phenotypic (p.c.v.) and environmental (e.c.v.) coefficients of variation, heritability and expected genetic advance for length of main vine and its components.

Characters	Range	Mean ± SEm	g.c.v.	p.c.v.	e.c.v.	Heritability (%)	G.A.	G.A. as % of mean
Node at which the first female flower appeared	18.33 - 28.78	22.26 ± 0.45	11.80	12.30	3.46	92.06	5.19	23.31
Node at which the first fruit is retained	19.22 - 31.00	24.22 ± 0.52	13.85	14.34	3.67	93.37	6.68	27.58
Nodes on main vine	44.22 - 81.33	62.21 ± 1.05	14.12	14.42	2.93	95.89	17.72	28.49
Primary branches/plant	3.78 - 10.22	5.97 ± 0.32	27.09	28.67	9.38	89.26	3.16	52.91
Thick branches/plant	1.33 - 4.00	3.34 ± 0.22	13.87	18.21	11.98	57.97	0.71	21.26
Internodal length (cm)	8.18 - 17.95	12.13 ± 0.56	17.92	19.58	7.91	83.72	4.10	33.80
Internodal circumference(cm)	3.38 - 4.51	3.84 ± 0.10	8.26	9.48	4.43	75.91	0.57	14.83
Leaves/plant	111.67 - 343.00	231.86 ± 4.48	25.12	25.34	3.35	98.26	118.95	51.30
Leaf area/plant (m^2)	2.82 - 12.38	7.52 ± 0.36	25.30	36.29	8.51	94.59	5.32	70.71
Length of main vine	4.75 - 9.63	7.14 ± 0.33	18.58	20.22	7.98	84.45	2.52	35.31

ranged from 44.22 in C.M. 16 to 81.33 in C.M. 17. The range for thick branches/plant varied from 1.33 in C.M. 16 to 4.0 in C.M. 12 and C.M. 17. Leaves/plant varied from 111.67 in C.M. 15 to 343.0 in C.M.8. Leaf area/plant ranged from 2.82 m^2 in C.M. 15 to 12.38 m^2 in C.M. 14.

Maximum variability was observed for primary branches/plant (g.c.v. = 27.09) followed by leaf area/plant (g.c.v. = 25.30) and leaves/plant (g.c.v. = 25.12). The lowest value of genotypic coefficient of variation was observed for internodal circumference (8.25). For all the characters studied phenotypic coefficients of variation were higher than the corresponding genotypic coefficients of variation.

Leaves/plant had the highest value of heritability (98.26%) followed by nodes on the main vine (95.89%). The lowest heritability value of 57.97% was observed for thick branches/plant. Leaf area/plant recorded the highest value of expected genetic advance in the next generation of selection (70.71%). Leaves/plant recorded a moderate genetic advance of 51.30% though the heritability estimate was 98.26%. The moderate

value of genetic advance as per cent of mean for leaves/plant resultedfrom a moderate value of phenotypic coefficient of variation (25.34). Length of main vine had only a low expected genetic advance (35.31%) resulting from low variability (g.c.v.=18.58) and moderate estimate of heritability (84.45%).

3. Correlation among length of main vine and its components.

Nodes on main vine, primary branches/plant, leaves/plant and leaf area/plant were positively correlated with the length of main vine (r_p= 0.60, 0.61, 0.85 and 0.78 respectively) (Table 4.7). Leaves/plant had positive correlations with nodes on main vine (r_p= 0.52), primary branches/plant (r_p= 0.71), thick branches/plant (r_p= 0.53), internodal length (r_p= 0.54) and leaf area/plant (r_p= 0.77). Internodal circumference of vine appeared to have no significant relationship with any of the other nine characters studied. Node at which the first female flower appeared had high positive correlation with node at which first fruit was retained (r_p= 0.75) but had no significant correlation with other characters. Primary branches/plant was positively correlated with internodal length (r_p= 0.62).

Table 4.7 Genotypic (r_g) and phenotypic (r_p) correlations among length of main vine and its components.

Characters	Node at which first fruit is retained	Nodes on main vine	Primary branches/ plant	Thick branches/ plant	Internodal length	Internodal circumference	Leaves per plant	Leaf area/ plant	Length of main vine
Node at which first female flower appeared	0.76 (0.75**)	-0.20 (-0.19)	0.29 (0.27)	0.24 (0.17)	0.002 (0.004)	0.21 (0.22)	0.11 (0.10)	0.04 (0.03)	0.14 (0.15)
Node at which first fruit is retained		-0.10 (-0.08)	0.15 (0.14)	0.48 (0.33)	-0.19 (-0.16)	0.07 (0.09)	0.28 (0.27)	0.45 (0.41)	0.28 (0.30)
Nodes on main vine			0.40 (0.36)	0.31 (0.23)	0.015 (0.024)	0.05 (0.06)	0.53 (0.52*)	0.36 (0.34)	0.63 (0.60**)
Primary branches/ plant				0.35 (0.37)	0.70 (0.62**)	0.28 (0.23)	0.76 (0.71**)	0.40 (0.36)	0.67 (0.61**)
Thick branches/ plant					0.24 (0.18)	-0.21 (-0.09)	0.71 (0.53*)	0.55 (0.40)	0.42 (0.36)
Internodal length						0.28 (0.27)	0.58 (0.54*)	0.36 (0.32)	0.48 (0.41)
Internodal circumference							0.21 (0.19)	0.25 (0.24)	0.32 (0.30)
Leaves/ plant								0.79 (0.77**)	0.93 (0.85**)
Leaf area/ plant									0.86 (0.78**)

*p = 0.05 **p = 0.01; Figures within parenthesis indicate phenotypic correlation coefficients.

4. Path coefficient analysis.

Leaves/plant had the maximum positive direct effect on length of main vine (2.34) followed by internodal length (0.77) (Table 4.8) (Fig.4). Primary branches/plant, thick branches/plant, internodal circumference and leaf area/plant had negative direct effects on length of main vine though they are positively correlated with length of main vine. The correlation between thick branches/plant and length of main vine was positive (r_g= 0.42), but its direct effect was negative (-1.39). The positive correlation resulted from its positive indirect effects via.,all other characters except via.,primary branches/plant and leaf area/plant. The nine component characters directly and indirectly via., other component characters explained 79.73% of the variations in length of main vine (R^2 = 0.7973).

C. General analysis of variance, estimation of variability, heritability, genetic advance, correlation and path coefficient analysis for weight of first mature fruit and its components

1. General analysis of variance.

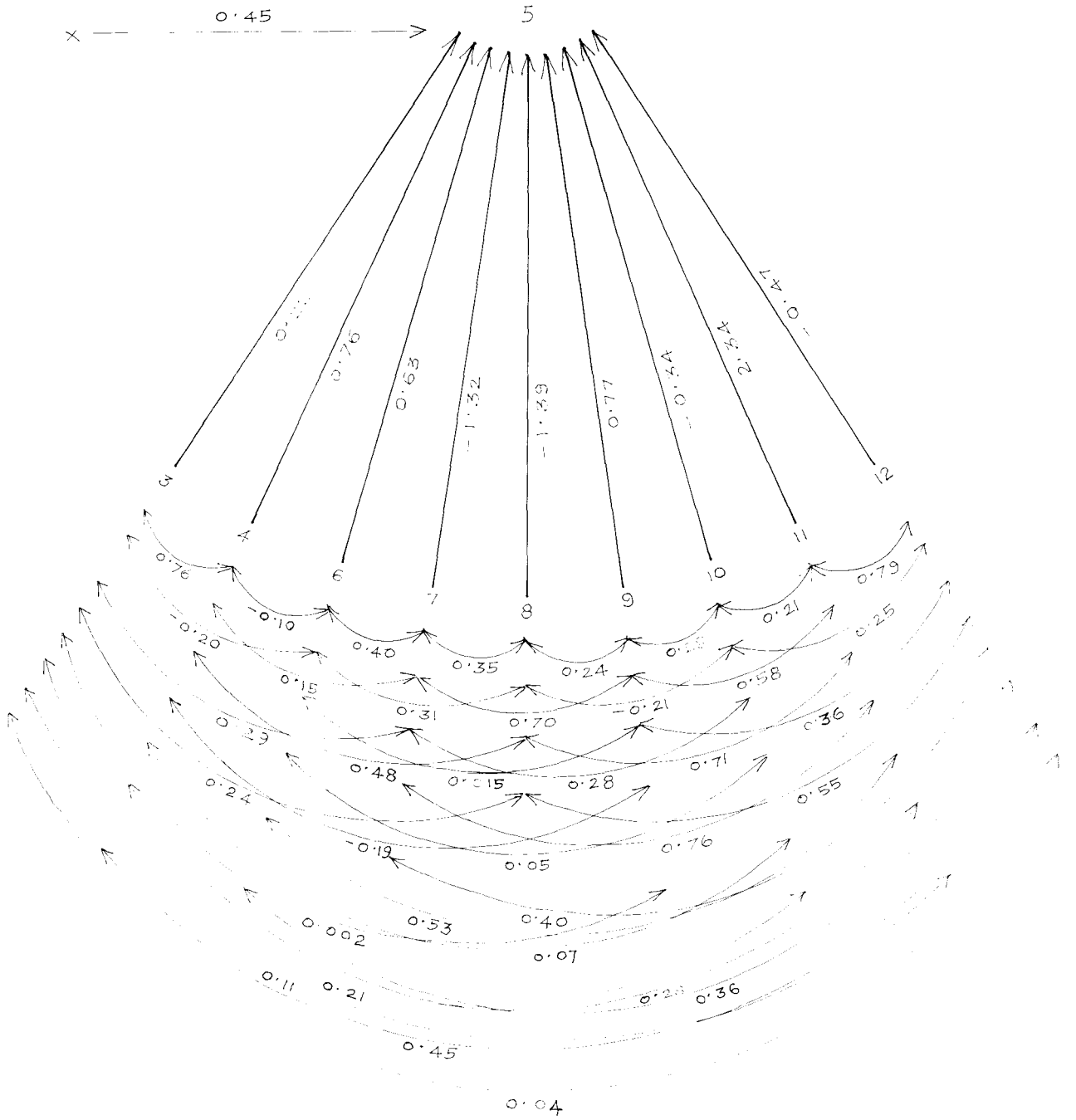
Weight of first mature fruit was considered as a

Table 4.8 Direct and indirect genotypic effects of nine component characters on length of main vine in pumpkin.

Characters	r_g^*	Direct effect (P_{iy})	Indirect effect via. character: Node at which first female flower appeared	Node at which first fruit is retained	Nodes on the main vine	Primary branches/ plant	Thick branches/ plant	Internodal length (cm)	Internodal circumference (cm)	Leaves/ plant	Leaf area/ plant (m^2)
Node at which first female flower appeared	0.14	0.22	-	0.58	-0.12	-0.38	-0.33	0.001	-0.07	0.26	-0.02
Node at which first fruit is retained	0.28	0.76	0.17	-	-0.06	-0.20	-0.67	0.15	-0.03	0.66	-0.21
Nodes on main vine	0.63	0.63	-0.04	-0.07	-	-0.53	-0.43	0.01	-0.02	1.25	-0.17
Primary branches/ plant	0.67	-1.32	0.06	0.11	0.25	-	0.48	0.54	-0.09	1.79	-0.19
Thick branches/ plant	0.42	-1.39	0.05	0.37	0.19	-0.46	-	0.18	0.07	1.66	-0.26
Internodal length	0.48	0.77	0.0004	-0.15	0.01	-0.92	-0.33	-	-0.09	1.35	-0.17
Internodal circumference	0.32	-0.34	0.05	0.06	0.03	-0.37	0.30	0.22	-	0.49	-0.12
Leaves/plant	0.93	2.34	0.03	0.21	0.33	-1.00	-0.98	0.45	-0.07	-	-0.37
Leaf area/plant	0.86	-0.47	0.01	0.34	0.23	-0.53	-0.76	0.28	-0.08	1.86	-

* r_g = Genotypic correlations between length of main vine and its components.

FIG. PATH DIAGRAM INDICATING DIRECT AND INDIRECT EFFECTS OF THE POSSIBLE COMPONENTS ON LENGTH OF MAIN VINE



- PATH COEFFICIENTS
- r(g)
- 3 NODE AT WHICH FIRST FEMALE FLOWER APPEARED
- 4 NODE AT WHICH FIRST FRUIT IS RETAINED
- 5 LENGTH OF MAIN VINE
- 6 NODES ON MAIN VINE
- 7 PRIMARY BRANCHES/PLANT
- 8 BRANCHES/PLANT
- 9 INTERNODAL LENGTH
- 10 INTERNODAL CIRCUMFERANCE
- 11 LEAVES/PLANT
- 12 LEAF AREA/PLANT

function of circumference of fruit, length of fruit, fruit shape index, flesh thickness, seeds/fruit, 100-seed weight and carotene content. The 18 genotypes were significantly different among themselves for the above characters (Table 4.9). The differences were significant even at 1% level of probability.

2. Estimation of variability, heritability and genetic advance.

The weight of first mature fruit ranged from 1.85 kg. in C.M. 18 to 9.95 kg. in C.M. 17 (Table 4.10). The first mature fruit of C.M. 14 had a weight of 9.36 kg. The circumference of fruit varied from 44.67 cm in C.M. 18 to 113.07 cm in C.M. 9. Flesh thickness ranged from 2.85 cm in C.M. 8 to 4.30 cm in C.M. 14. Carotene content ranged from 0.132% in C.M. 15 to 0.527% in C.M. 18. The line C.M. 10 had flat fruit shape (fruit shape index = 0.60) while the lines C.M. 6 and C.M. 5 had round fruit shape (fruit shape index = 0.99 and 1.11 respectively) and C.M. 11 had long fruit shape (fruit shape index = 1.47) (Plates 5 to 11).

Table 4.9 General analysis of variance for weight of first mature fruit and its components

Sources of variaton	d.f.	M.S.							
		Circum-ference of fruit (cm)	Length of fruit (cm)	Fruit shape index	Flesh thick-ness (cm)	Seeds/ fruit	100-seed weight (g)	Carotene (%)	Weight of first mature fruit (kg)
Replica-tions	2	9.11	0.18	0.002	0.01	4138.74	0.25	0.00001	0.04
Genotypes	17	781.92**	140.66**	0.29**	0.61**	25974.48**	21.59**	0.02**	18.93**
Error	34	18.83	5.34	0.01	0.02	1018.33	1.03	0.00002	0.53

*p = 0.05 **p = 0.01

Table 4.10 Range, mean, genotypic (g.c.v.), phenotypic (p.c.v.) and environmental (e.c.v.) coefficients of variation, heritability and expected genetic advance for weight of first mature fruit and its components.

Characters	Range	Mean ± SEm	g.c.v.	p.c.v.	e.c.v.	Heritability (%)	G.A.	G.A. as % mean
Circumference of fruit (cm)	44.67 - 113.07	91.24 ± 2.51	17.48	18.12	4.76	93.11	31.70	34.75
Length of fruit (cm)	12.17 - 38.71	24.63 ± 1.33	27.27	28.83	9.38	89.42	13.09	53.13
Fruit shape index	0.60 - 1.47	0.95 ± 0.06	32.12	34.48	14.74	86.74	0.56	59.13
Flesh thickness (cm)	2.85 - 4.30	3.67 ± 0.10	12.10	12.75	3.81	90.05	0.88	24.00
Seeds/fruit	225.00 - 536.67	412.53 ± 18.42	22.11	23.42	1.04	89.09	177.34	44.99
100-seed weight (g)	11.67 - 24.75	18.33 ± 0.59	14.28	15.31	5.51	86.90	5.02	27.54
Carotene (%)	0.132- 0.527	0.192± 0.003	46.14	46.20	1.65	99.76	0.18	93.75
Weight of first mature fruit (kg)	1.85 - 9.95	7.01 ± 0.42	35.34	36.84	10.41	92.05	4.89	69.78

Carotene content had the maximum value of expected genetic advance as per cent of mean (93.75) resulting from the highest heritability estimate (99.76%) associated with the highest genotypic coefficient of variation (g.c.v. = 46.14). The low value of genetic advance as per cent of mean in case of flesh thickness (24.00) resulted from a low value of variability (g.c.v. = 12.10). Weight of first mature fruit had a moderate estimate of genetic advance as per cent of mean (69.73%) resulting from higher estimates of heritability (92.05%) and genotypic coefficient of variation (g.c.v. = 35.34). The lowest heritability was observed for fruit shape index (86.74%).

3. Correlation among weight of first mature fruit and its components.

Weight of first mature fruit was positively correlated with circumference of fruit (r_p = 0.73), length of fruit (r_p = 0.50), flesh thickness, (r_p= 0.87) and seeds/fruit (r_p= 0.61) (Table 4.11). It had a negative association with carotene content though the correlation was non-significant. Fruit shape index was independent of weight of first mature

Table 4.11 Genotypic (r_g) and phenotypic (r_p) correlations among weight of first mature fruit and its components.

Characters	Length of fruit (cm)	Fruit shape index	Flesh thickness (cm)	Seeds/ plant	100-seed weight (g)	Carotene (%)	Weight of first mature fruit (kg)
Circumference of fruit (cm)	-0.03 (-0.03)	-0.63 (-0.59**)	0.84 (0.78**)	0.39 (0.35)	0.02 (0.01)	-0.02 (-0.02)	0.75 (0.73**)
Length of fruit (cm)		0.75 (0.76**)	0.31 (0.30)	0.49 (0.45)	0.46 (0.42)	-0.26 (-0.25)	0.57 (0.50*)
Fruit shape index			-0.30 (-0.27)	0.12 (0.12)	0.26 (0.23)	-0.10 (-0.09)	-0.05 (-0.09)
Flesh thickness (cm)				0.71 (0.62**)	0.34 (0.29)	-0.28 (-0.26)	0.94 (0.87**)
Seeds/ fruit					0.30 (0.28)	-0.41 (-0.39)	0.67 (0.61**)
100-seed weight (g)						-0.51 (-0.47*)	0.38 (0.34)
Carotene (%)							-0.34 (-0.33)

*p = 0.05 **p = 0.01; Figures within parenthesis indicate phenotypic correlation coefficients.

fruit. The 100-seed weight apparently had no relationship with other characters except a negative correlation with carotene content (r_p = -0.47). There was positive correlation between circumference of fruit and flesh thickness (r_p = 0.78). The positive correlation between flesh thickness and seeds/fruit was quite obvious in the genotypes under study (r_p = 0.62).

4. Path coefficient analysis.

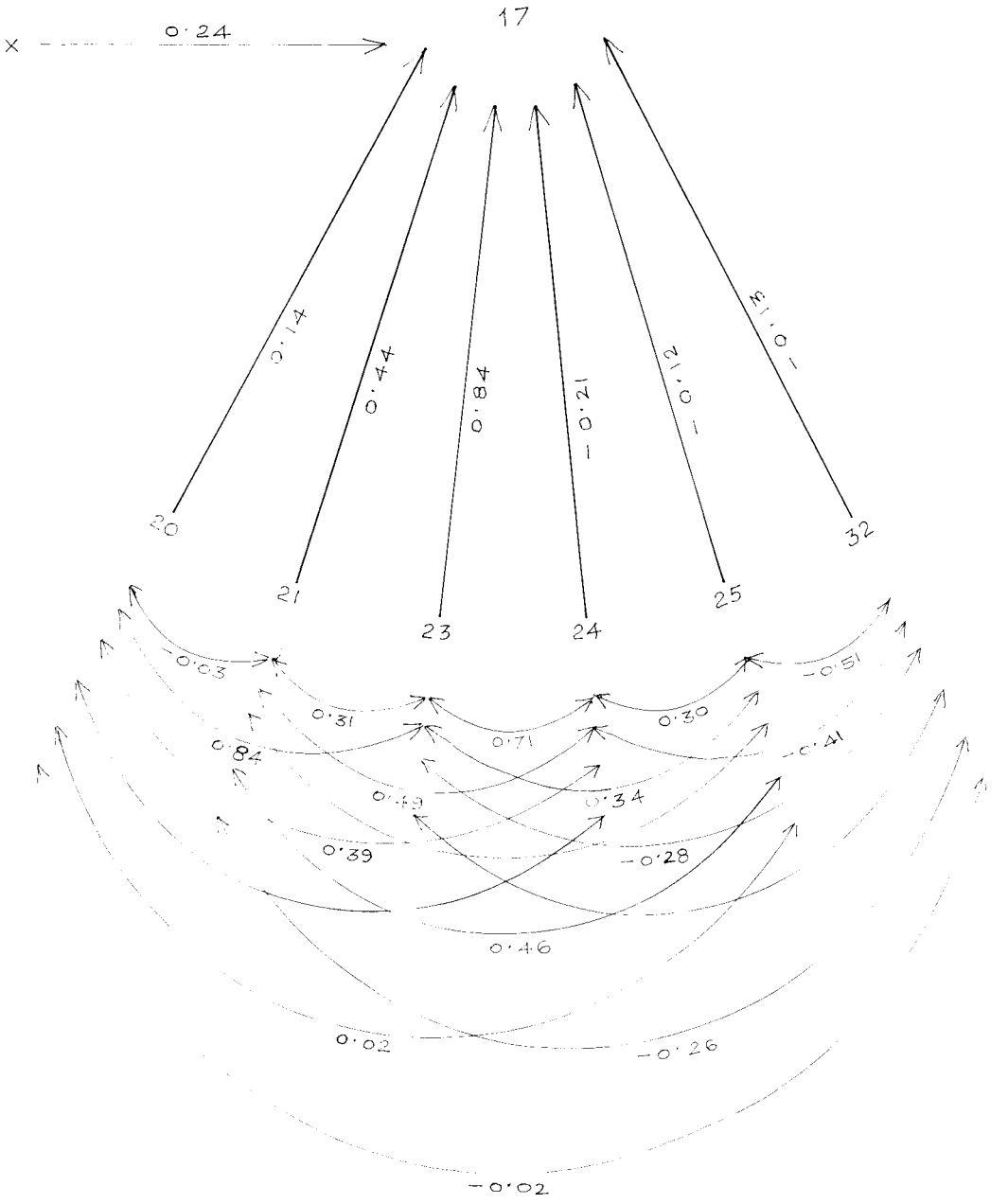
When the weight of first mature fruit was considered as a function of circumference of fruit, length of fruit, flesh thickness, seeds/fruit, 100-seed weight and carotene content, the component characters explained 94.03% variation in the weight of first mature fruit (R^2 = 0.9403). Flesh thickness had the maximum value of positive direct effect on weight of first mature fruit (0.84) (Table 4.12) (Fig.5). Circumference of fruit, though having a correlation of 0.75 with weight of first mature fruit, had only a marginal value of 0.14 as direct effect. Seeds/ fruit had a negative direct effect on weight of first mature fruit, though the total correlation was positive. Hundred-seed weight and carotene content also had

Table 4.12 Direct and indirect genotypic effects of six component characters on weight of first mature fruit in pumpkin.

Characters	r_g*	Direct effect (P_{iy})	Indirect effect via character: Circumference of fruit (cm)	Length of fruit (cm)	Flesh thickness (cm)	Seeds/ fruit	100-seed weight (g)	Carotene content ( )
Circumference of fruit (cm)	0.75	0.14	-	-0.01	0.70	-0.08	0.002	0.003
Length of fruit (cm)	0.57	0.44	-0.004	-	0.26	-0.1	-0.05	0.03
Flesh thickness (cm)	0.94	0.84	0.11	0.14	-	-0.15	-0.04	0.04
Seeds/Fruit	0.67	-0.21	0.05	0.21	0.60	-	-0.04	0.05
100-seed weight (g)	0.38	-0.12	0.003	0.20	0.28	-0.06	-	0.07
Carotene content (%)	-0.34	-0.13	-0.003	-0.11	-0.23	0.08	0.06	-

* r_g = Genotypic correlation coefficients between weight of first mature fruit and its components.

FIG. 3 PATH DIAGRAM INDICATING DIRECT AND INDIRECT EFFECTS OF THE POSSIBLE COMPONENTS ON WEIGHT OF FIRST MATURE FRUIT.



PATH COEFFICIENTS

$r_{(g)}$

17 WEIGHT OF FIRST MATURE FRUIT.

20 CIRCUMFERANCE OF FRUIT

21 LENGTH OF FRUIT

23 FLESH THICKNESS

24 SEEDS/FRUIT

25 100 SEED WEIGHT

32 CAROTENE (%)

negative direct effects on weight of first mature fruit.

D. General analysis of variance, estimation of variability, heritability, genetic advance, correlation and path coefficient analysis for carotene content and other chemical constituents

1. General analysis of variance.

All the 18 pumpkin genotypes were significantly different among themselves for protein, phosphorus, potassium, calcium, T.S.S. and carotene contents (Table 4.13).

2. Estimation of variability, heritability and genetic advance.

The protein content on dry weight basis ranged from 5.26% in C.M. 11 to as high as 9.49% in C.M. 15 (Table 4.14). Phosphorus content ranged from as low as 0.348% in C.M. 11 to as high as 0.675% in C.M. 14. Potassium content ranged from 1.38% in C.M. 9 to 3.75% in C.M. 18. Calcium varied from 0.427% in C.M. 8 to 0.6% in C.M. 4. Total soluble solids ranged from 4.39% in C.M. 18 to 12.78% in C.M. 8.

Potassium content had a higher estimate of

Table 4.13 General analysis of variance for carotene content and other chemical constituents.

Sources of variation	d.f.	M.S. Protein (%)	Phosphorus (%)	Potassium (%)	Calcium (%)	T.S.S. (%)	Carotene (%)
Replications	2	0.03	0.00003	0.002	0.00009	0.09	0.00001
Genotypes	17	4.69**	0.02**	1.07**	0.006**	10.19**	0.02**
Error	34	0.12	0.00009	0.01	0.00003	0.08	0.00002

**p = 0.01

Table 4.14 Range, mean, genotypic (g.c.v.), phenotypic (p.c.v.) and environmental (e.c.v.) coefficients of variation, heritability and expected genetic advance for carotene content and other chemical constituents.

Characters	Range	Mean ± SEm	g.c.v.	p.c.v.	e.c.v.	Heritability (%)	G.A.	G.A. as % of mean
Protein (%)	5.26 - 9.49	7.41 ± 0.20	16.66	17.31	4.72	92.54	2.45	33.08
Phosphorus (%)	0.348 - 0.675	0.474 ± 0.005	16.40	16.52	2.11	98.61	0.16	33.76
Potassium (%)	1.38 - 3.75	1.93 ± 0.058	30.67	31.27	5.18	96.44	1.20	62.11
Calcium (%)	0.427 - 0.600	0.518 ± 0.01	8.78	9.35	3.34	88.18	0.09	17.38
T.S.S. (%)	4.39 -12.78	6.67 ± 0.16	27.53	27.86	4.20	97.66	3.77	55.93
Carotene (%)	0.132 - 0.527	0.192 ± 0.003	46.14	46.20	1.65	99.76	0.18	93.75

genetic advance (62.11%) among the chemical constituents, resulting from higher estimates of heritability(96.44%) and phenotypic coefficient of variation (31.23). Calcium content had the lowest estimate of genetic advance as per cent of mean (17.38%) resulting from a very low phenotypic coefficient of variation (9.35) though heritability estimate was 88.18%, which was also the lowest among the chemical constituents. Protein content and phosphorus content had moderate values of genetic advance as per cent of mean (33.08 and 37.76 respectively).

3. Correlation among carotene content and other chemical constituents.

The correlations among carotene, phosphorus, calcium and T.S.S. contents were not significant (Table 4.15). A positive correlation was observed between potassium and carotene contents (r_p = 0.72). The T.S.S. content had negative relationship with phosphorus, potassium, calcium and carotene contents but the values were not significant.

4. Path coefficient analysis.

The potassium content had the maximum direct effect on carotene content (Table 4.16) (Fig.6). The

Table 4.15 Genotypic (r_g) and phenotypic (r_p) correlations among carotene content and other chemical constituents.

Characters	Phosphorus (%)	Potassium (%)	Calcium (%)	T.S.S. (%)	Carotene (%)
Protein (%)	0.28 (0.28)	0.32 (0.32)	-0.28 (-0.25)	0.05 (0.06)	0.15 (0.14)
Phosphorus (%)		0.38 (0.37)	-0.16 (-0.16)	-0.11 (-0.11)	0.23 (0.23)
Potassium (%)			0.47 (0.44)	-0.31 (-0.29)	0.74 (0.72**)
Calcium (%)				-0.47 (-0.43)	0.30 (0.28)
T.S.S. (%)					-0.35 (-0.34)

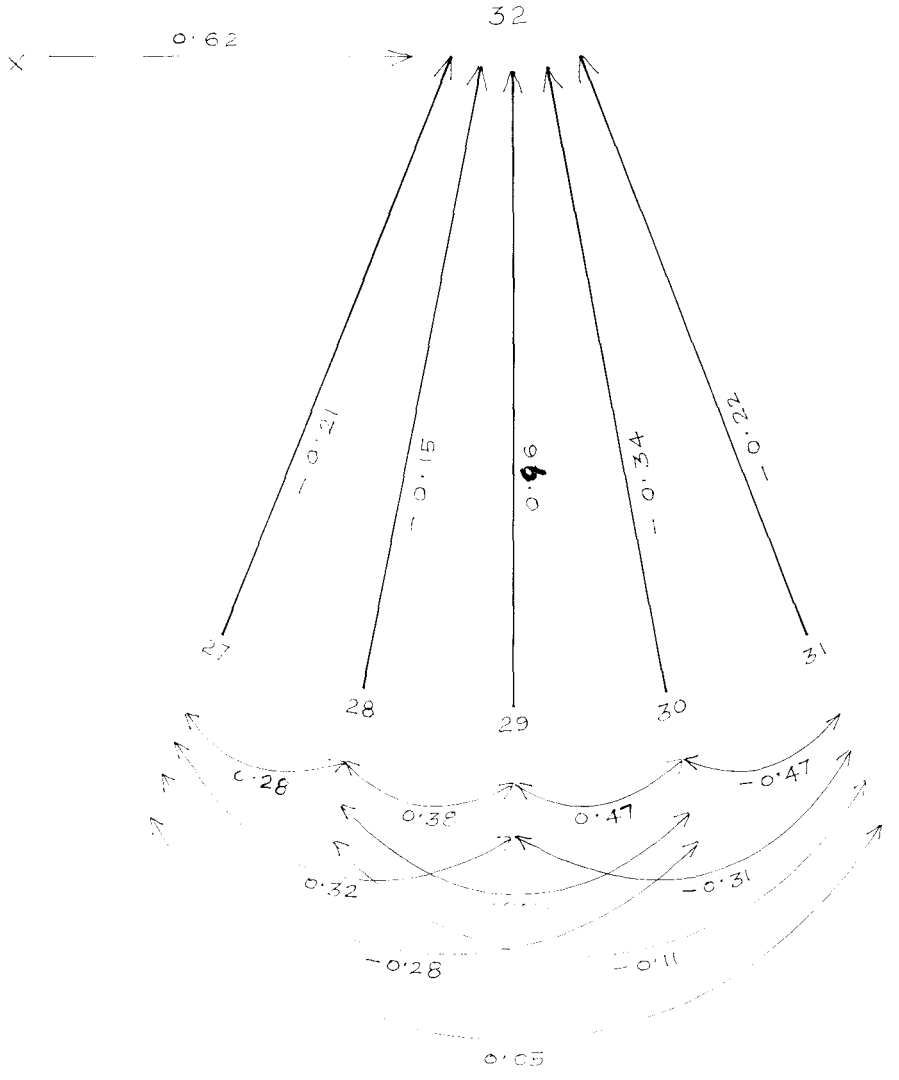
**p = 0.01; Figures within parenthesis indicate phenotypic correlation coefficients.

Table 4.16 Direct and indirect genotypic effects of other chemical constituents on carotene content in pumpkin.

Characters	r^*_g	Direct effect (P_{ij})	Indirect effect via. character				
			Protein (P_{iy})	Phosphorus (%)	Potassium (%)	Calcium (%)	T.S.S. (%)
Protein (%)	0.15	-0.21	-	-0.04	0.31	0.10	-0.01
Phosphorus (%)	0.23	-0.15	-0.06	-	0.36	0.05	0.03
Potassium (%)	0.74	0.96	0.07	-0.06	-	-0.16	0.07
Calcium (%)	0.30	-0.34	0.06	0.02	0.45	-	0.10
T.S.S. (%)	-0.35	-0.22	-0.01	0.02	-0.30	0.16	-

*r_g = Genotypic correlation coefficients between carotene content and other chemical constituents.

FIG. 6 - PATH DIAGRAM INDICATING DIRECT AND INDIRECT EFFECTS OF OTHER CHEMICAL CONSTITUENTS ON CAROTENE CONTENT.



→ PATH COEFFICIENTS	29 POTASSIUM (%)
↷ r(g)	30 CALCIUM (%)
27 PROTEIN (%)	31 T.S.S.
28 PHOSPHORUS (%)	32 CAROTENE (%)

other chemical constituents, protein, phosphorus, calcium and T.S.S. had negative direct effects on carotene content. The five chemical constituents explained only 61.45% of the variation in carotene content (R^2 = 0.6145).

E. Relative efficiency of selection through discriminant function analysis over straight selection or vice-versa

Genetic advance through discriminant function analysis was estimated considering yield and its six components, days to first female flower anthesis, length of main vine, thick branches/plant, leaf area/plant, average fruit weight and flesh thickness (Table 4.17). Genetic advance through straight selection of yield *per se* was observed superior than selection through discriminant function, considering all permutations and combinations of six component characters. The genetic advance through discriminant function analysis by taking days to first female flower anthesis was 94.85% lesser than genetic advance that would have been obtained if selection were made based on yield *per se*. When selection was made based on days to first female flower anthesis and flesh thickness the genetic advance obtained was 2.18%

Table 4.17 Selection indices and relative efficiency of selection through discriminant function over straight selection.

Discriminant function equations	G.A. through straight selection.	G.A. through discriminant function.	Relative efficiency.
Straight selection for fruit yield/plant	5.98	5.98	0.00
$Y = -0.057\ x_1 + 0.203\ x_2 + 0.691 x_3 + 0.370\ x_4 + 0.479\ x_5 + 1.448\ x_6$	5.98	5.61	-6.19
$Y = -0.076\ x_1 + 0.220\ x_2 + 0.733\ x_3 + 0.416\ x_4 + 0.677\ x_5$	5.98	5.56	-7.02
$Y = -0.020\ x_1 + 0.073\ x_2 + 0.635\ x_3 + 0.394\ x_4 + 3.70\ x_6$	5.98	5.43	-9.20
$Y = -0.069\ x_1 + 0.678\ x_2 + 0.861\ x_3 + 0.501\ x_5 + 1.920\ x_6$	5.98	5.48	-8.36
$Y = -0.043\ x_1 + 0.235\ x_2 + 0.411\ x_4 + 0.467\ x_5 + 1.550\ x_6$	5.98	5.55	-7.19
$Y = -0.045\ x_1 + 0.714\ x_3 + 0.453\ x_4 + 0.459\ x_5 + 1.480\ x_6$	5.98	5.60	-6.36
$Y = 0.160\ x_2 + 0.656\ x_3 + 0.377\ x_4 + 0.458\ x_5 + 1.574\ x_6$	5.98	5.59	-6.52
$Y = -0.053\ x_1 - 0.186\ x_2 + 0.767\ x_3 + 0.793\ x_4$	5.98	4.47	-25.25
$Y = -0.098\ x_1 + 0.784\ x_2 + 0.948\ x_3 + 0.778\ x_5$	5.98	5.39	-9.87
$Y = -0.031\ x_1 + 0.574\ x_2 + 0.813\ x_3 + 4.313\ x_6$	5.98	5.28	-11.71
$Y = -0.063\ x_1 + 0.256\ x_2 + 0.463\ x_4 + 0.679\ x_5$	5.98	5.50	-8.03
$Y = -0.064\ x_1 + 0.759\ x_3 + 0.507\ x_4 + 0.660\ x_5$	5.98	5.55	-7.19

Table 4.17 contd...

Discriminant function equations	G.A. through straight selection	G.A. through discriminant function	Relative efficiency.
$Y = 0.163\ x_2 + 0.689\ x_3 + 0.431\ x_4 + 0.673\ x_5$	5.98	5.54	-7.36
$Y = -0.008\ x_1 + 0.106\ x_2 + 0.431\ x_4 + 3.743\ x_6$	5.98	5.38	-10.03
$Y = -0.016\ x_1 + 0.644\ x_3 + 0.424\ x_4 + 3.676\ x_6$	5.98	5.43	-9.20
$Y = 0.060\ x_1 + 0.630\ x_3 + 0.400\ x_4 + 3.710\ x_6$	5.98	5.44	-9.03
$Y = -0.053\ x_1 + 0.787\ x_2 + 0.488\ x_5 + 2.121\ x_6$	5.98	5.39	-9.87
$Y = -0.002\ x_1 + 1.294\ x_3 + 0.389\ x_5 + 2.894\ x_6$	5.98	5.19	-13.21
$Y = 0.638\ x_2 + 0.822\ x_3 + 0.476\ x_5 + 2.080\ x_6$	5.98	5.46	-8.70
$Y = 0.201\ x_2 + 0.415\ x_4 + 0.451\ x_5 + 1.645\ x_6$	5.98	5.54	-7.36
$Y = -0.028\ x_1 + 0.509\ x_4 + 0.442\ x_5 + 1.693\ x_6$	5.98	5.53	-7.53
$Y = 0.681\ x_3 + 0.444\ x_4 + 0.445\ x_5 + 1.578\ x_6$	5.98	5.59	-6.52
$Y = -0.092\ x_1 + 0.924\ x_2 + 1.253\ x_3$	5.98	3.52	-41.14
$Y = -2.405\ x_1 + 0.220\ x_2 + 0.842\ x_4$	5.98	3.69	-38.29
$Y = -0.084\ x_1 + 0.917\ x_2 + 0.797\ x_5$	5.98	5.28	-11.71
$Y = -0.017\ x_1 + 0.680\ x_2 + 4.445\ x_6$	5.98	5.20	-13.04

Table 4.17 contd...

Discriminant function equations	G.A. through straight selection.	G.A. through discriminant function.	Relative efficiency.
$Y = 0.360\ x_1 + 0.750\ x_3 + 0.710\ x_4$	5.98	4.52	-24.42
$Y = -0.033\ x_1 + 1.547\ x_3 + 0.816\ x_5$	5.98	4.98	-16.72
$Y = 0.020\ x_1 + 1.202\ x_3 + 4.700\ x_6$	5.98	5.06	-15.39
$Y = -0.048\ x_1 + 0.572\ x_4 + 0.659\ x_5$	5.98	5.48	-8.36
$Y = -0.002\ x_1 + 0.476\ x_4 + 3.709\ x_6$	5.98	5.38	-10.03
$Y = 0.041\ x_1 + 0.339\ x_5 + 3.477\ x_6$	5.98	4.95	-17.20
$Y = -0.224\ x_2 + 0.737\ x_3 + 0.802\ x_4$	5.98	4.45	-25.59
$Y = 0.738\ x_2 + 0.902\ x_3 + 0.777\ x_5$	5.98	5.36	-10.37
$Y = 0.558\ x_2 + 0.797\ x_3 + 4.335\ x_6$	5.98	5.28	-11.71
$Y = 0.206\ x_2 + 0.474\ x_4 + 0.675\ x_5$	5.98	5.48	-8.36
$Y = 0.100\ x_2 + 0.431\ x_4 + 3.747\ x_6$	5.98	5.38	-10.03
$Y = 0.752\ x_2 + 0.469\ x_5 + 2.242\ x_6$	5.98	5.38	-10.08
$Y = 0.715\ x_3 + 0.500\ x_4 + 0.660\ x_5$	5.98	5.53	-7.53
$Y = 0.633\ x_3 + 0.421\ x_4 + 3.689\ x_6$	5.98	5.43	-9.20

Table 4.17 contd...

Discriminant function equations	G.A. through straight selection	G.A. through discriminant function.	Relative efficiency.
$Y = 1.292\ x_3 + 0.389\ x_5 + 2.898\ x_6$	5.98	5.19	-13.21
$Y = 0.502\ x_4 + 0.434\ x_5 + 1.653\ x_6$	5.98	5.53	-7.53
$Y = -0.073\ x_1 + 1.105\ x_2$	5.98	3.20	-13.04
$Y = -0.015\ x_1 + 1.981\ x_3$	5.98	2.47	-58.70
$Y = -0.048\ x_1 + 0.783\ x_4$	5.98	4.37	-26.92
$Y = 0.013\ x_1 + 0.860\ x_5$	5.98	4.58	-23.41
$Y = 0.058\ x_1 + 5.029\ x_6$	5.98	5.85	-2.18
$Y = 0.879\ x_2 + 1.209\ x_3$	5.98	3.47	-41.97
$Y = -0.180\ x_2 + 0.849\ x_4$	5.98	4.38	-26.76
$Y = 0.872\ x_2 + 0.795\ x_5$	5.98	5.25	-12.21
$Y = 0.669\ x_2 + 4.455\ x_6$	5.98	5.24	-12.38
$Y = 0.701\ x_3 + 0.713\ x_4$	5.98	4.43	-25.92

Table 4.17 contd...

Discriminant function equations	G.A. through straight selection.	G.A. through discriminant function.	Relative efficiency.
$Y = 1.518\ x_3 + 0.814\ x_5$	5.98	4.96	-17.06
$Y = 1.221\ x_3 + 4.693\ x_6$	5.98	5.06	-15.39
$Y = 0.563\ x_4 + 0.659\ x_5$	5.98	5.47	-8.53
$Y = 0.475\ x_4 + 3.710\ x_6$	5.98	5.38	-10.03
$Y = 0.349\ x_5 + 3.426\ x_6$	5.98	4.95	-17.22
$Y = 0.046\ x_1$	5.98	0.308	-94.85
$Y = 1.065\ x_2$	5.98	3.17	-46.99
$Y = 1.968\ x_3$	5.98	2.47	-58.70
$Y = 0.775\ x_4$	5.98	4.36	-27.09
$Y = 0.861\ x_5$	5.98	4.58	-23.41
$Y = 5.022\ x_6$	5.98	4.83	-19.23

x_1 = Days to first female flower anthesis.

x_2 = Length of main vine.

x_3 = Thick branches/plant.

x_4 = Leaf area/plant.

x_5 = Average fruit weight.

x_6 = Flesh thickness.

lesser than that would have been obtained if selection was made based on yield per se only.

F. Constellation of pumpkin genotypes through metroglyphs.

The 18 genotypes were pictorially represented through metroglyphs (Fig. 7, 8, 9 and 10).

FIG 8 CONSTELLATION OF 18 PUMPKIN GENOTYPES BASED ON YIELD AND ITS COMPONENTS THROUGH METROGLYPHS.

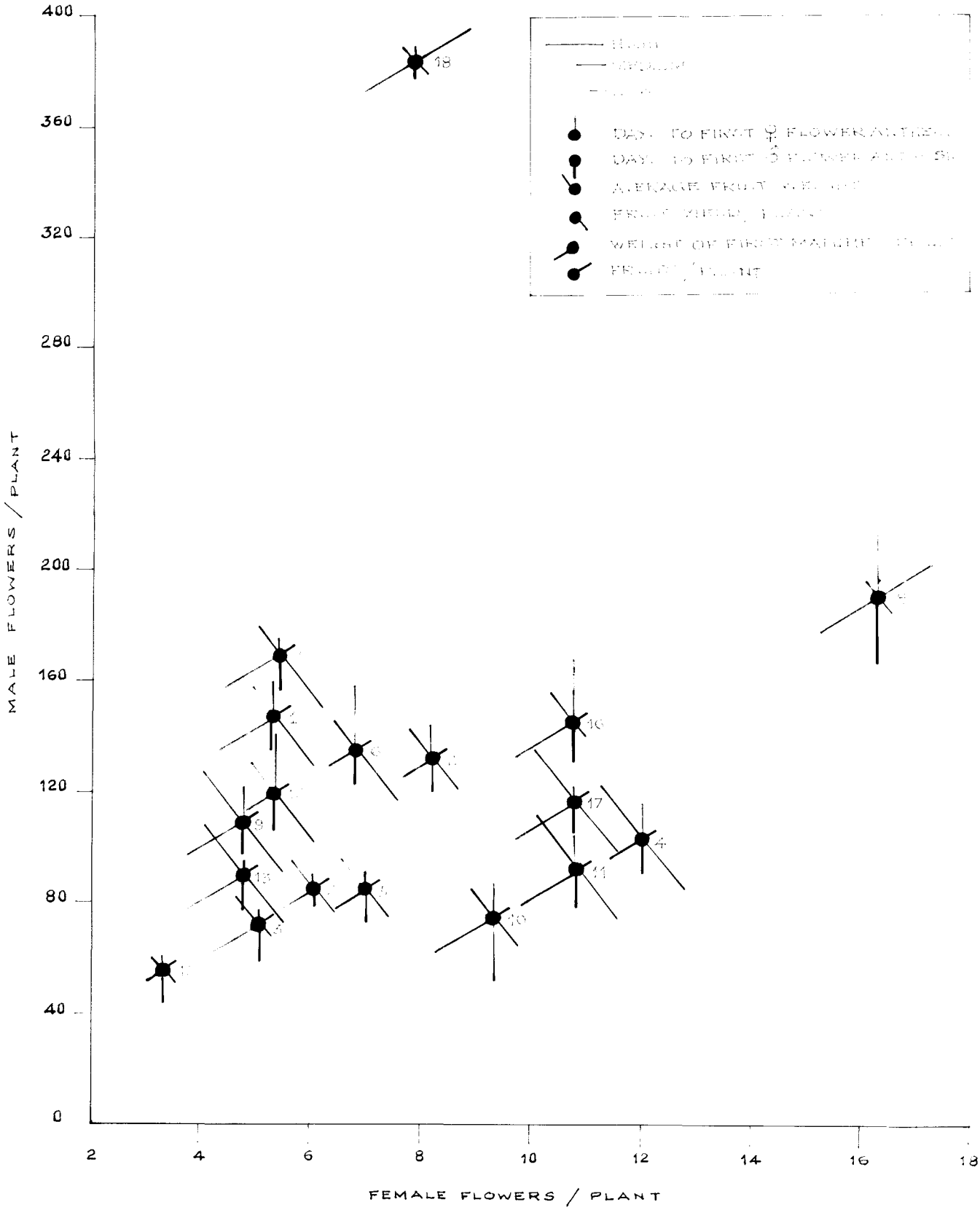


FIG. 3. CONSTELLATION OF 18 PUMPKIN GENOTYPES BASED ON LENGTH OF MAIN VINE AND ITS COMPONENTS THROUGH METROGLYPH

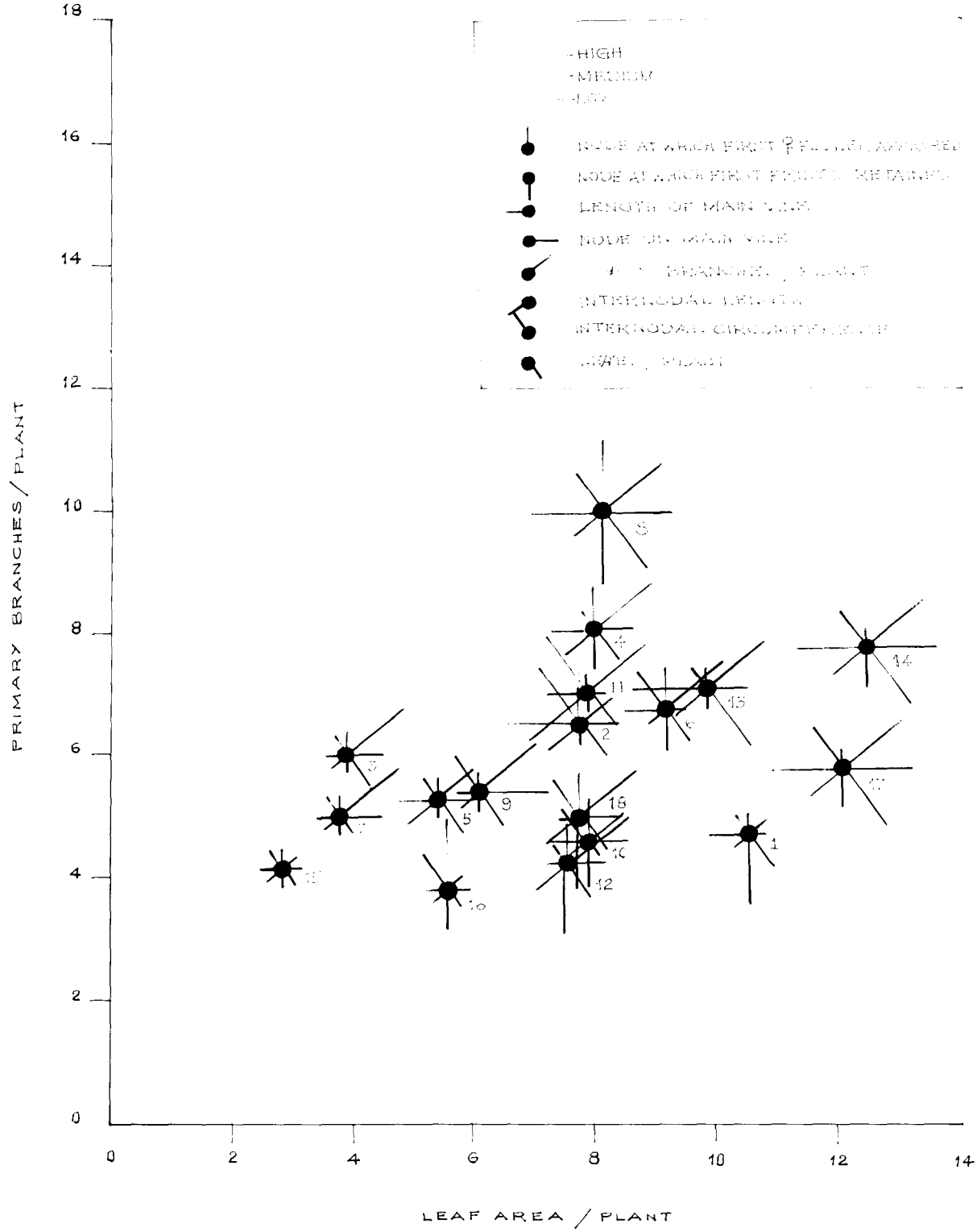


FIG. 4 CONSTELLATION OF 18 PUMPKIN GENOTYPES BASED WEIGHT OF FIRST MATURE FRUIT AND ITS COMPONENTS THROUGH METROGLYPH

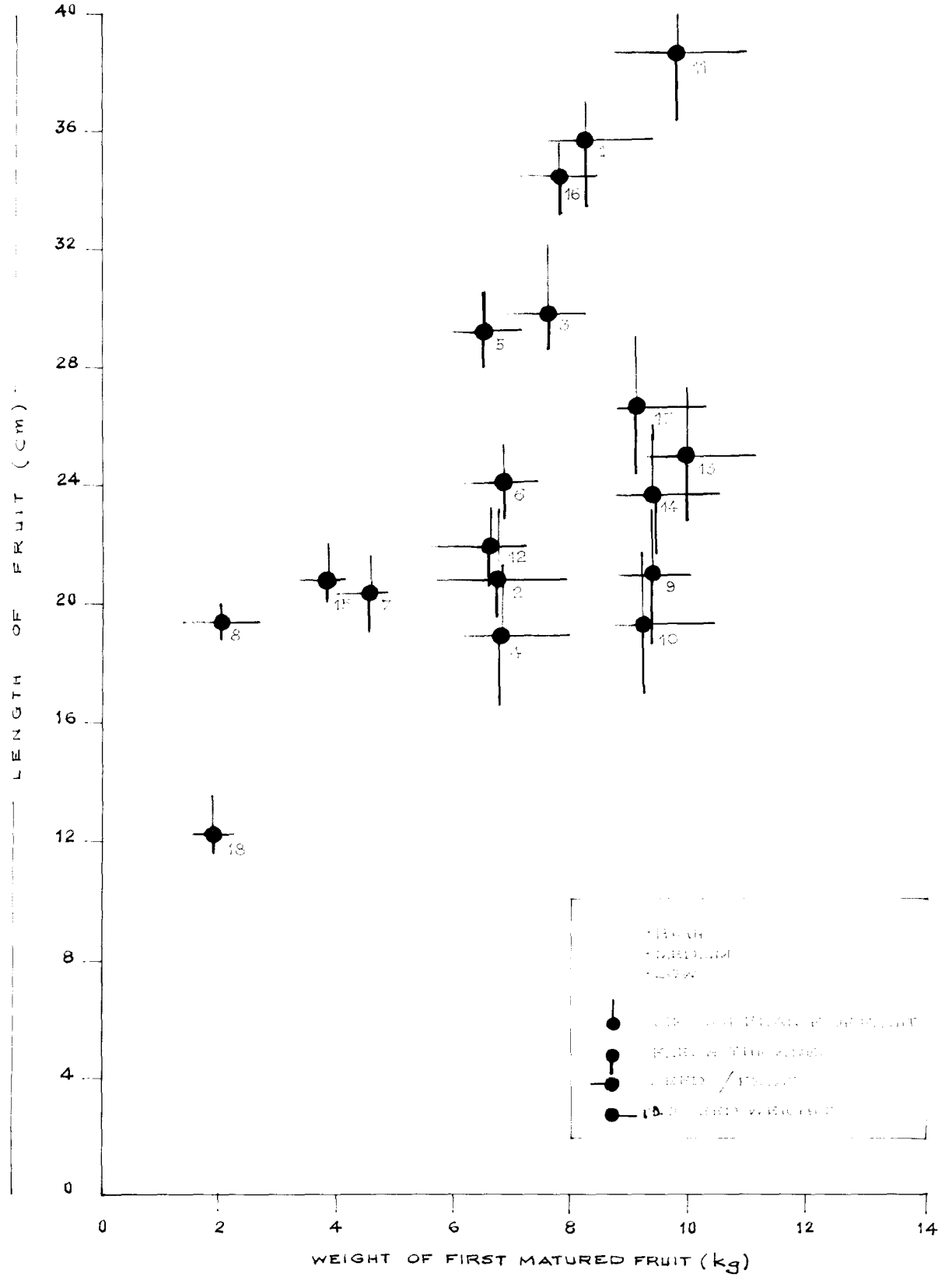
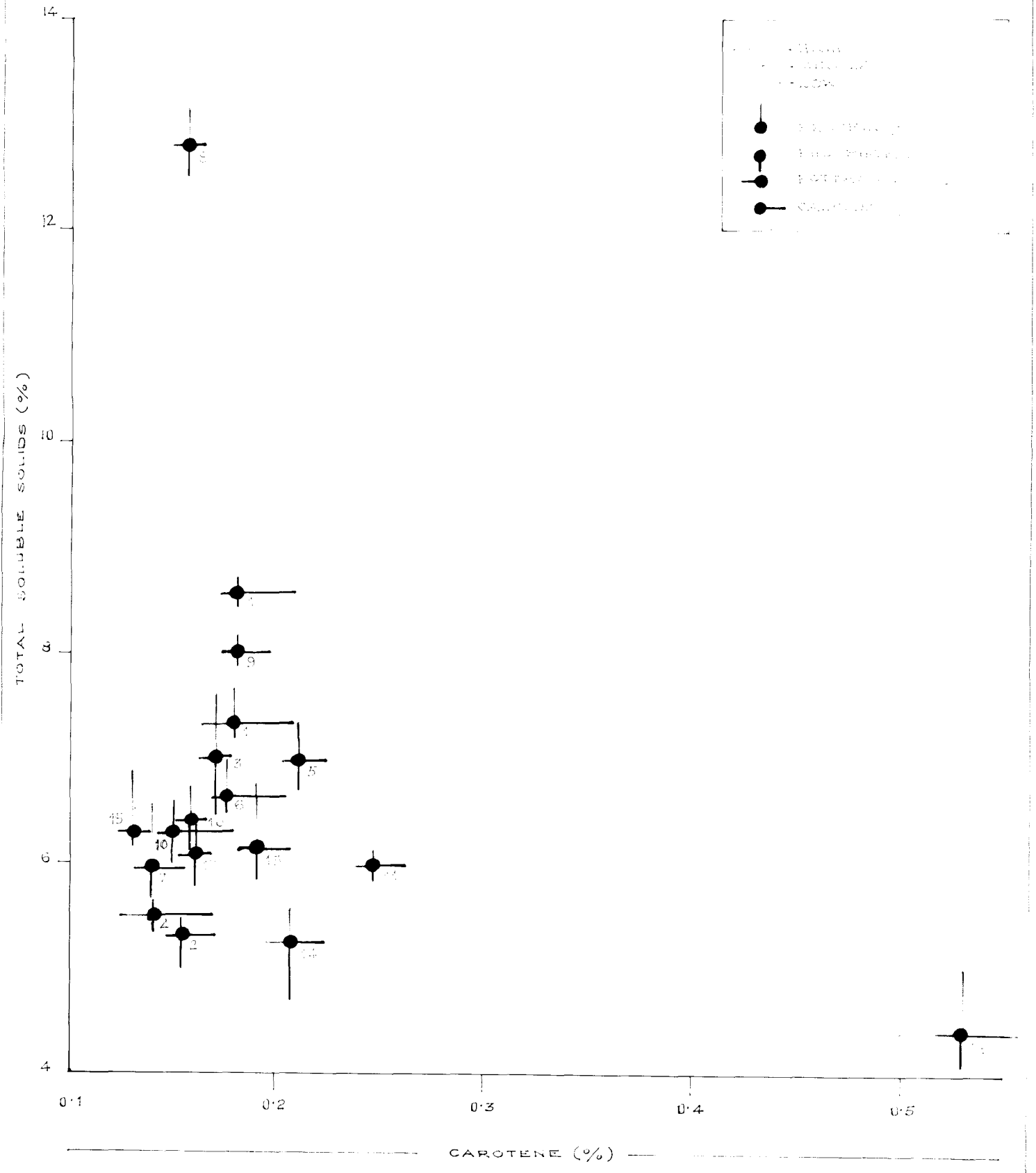


FIG. 1. CONSTELLATION OF 18 PUMPKIN GENOTYPES BASED ON CAROTENE CONTENT AND OTHER CHEMICAL CONSTITUENTS THROUGH METROGLYPHS.



DISCUSSION

D I S C U S S I O N

The development of elite crop genotypes and the genetic upgrading of economic crops generally follow two pathways. The first is production breeding and the second is "defect elimination" breeding or resistance breeding. Production breeding and resistance breeding go side by side in a "symbiotic" fashion. Production breeding with which we are mainly concerned is usually followed for evolving varieties or improving the existing varieties. The varieties thus synthesised should have better genetic capabilities to use more nutrients and to entrap and convert more solar energy into the ultimate harvestable form.

The basic information, a breeder usually requires, a priori to production breeding in a particular crop species is the extent of variability present in the available germplasm. Information on heritability and estimates of genetic advance that could be obtained in next cycle of selection are vital to decide the appropriate method of crop breeding. Knowledge on the association among polygenic characters would enable

the breeder to locate a character(s) whose selection would automatically result in the progress of characters which are positively correlated and would result in regress of characters which are negatively correlated. A thorough understanding of genetic diversity is a pre-requisite for the production of transgressive segregants in pedigree method, bulk population method or even in a heterosis breeding programme.

The present investigations basically deal with obtaining relevant genetic information a priori to production breeding in a number of pumpkin genotypes. The results obtained are discussed in the ensuing pages.

The 18 pumpkin genotypes were observed to be significantly different for yield and its component characters viz., days to first female flower anthesis, days to first male flower anthesis, length of main vine, male flowers/plant, female flowers/plant, per cent of female flowers, average fruit weight, weight of first mature fruit, fruits/plant and per cent of fruit set. The higher level of significance of the

differences among genotypes indicated that the differences were due to genetic reasons. In the 18 genotypes studied, average fruit weight ranged from 1.21 kg. in C.M. 18 to 9.95 kg. in C.M. 11. The variability for fruit yield/plant ranged from 5.45 kg. in C.M. 18 to 16.10 kg. in C.M. 17; the line C.M. 14 being second to C.M. 17 with 15.38 kg/plant. This indicated the availability of enough variability in the population under study. The investigations by Thakur and Nandpuri (1974) in watermelon, Srivastava and Srivastava (1976) and Ramachandran (1978) in bitter gourd and Joseph (1978) in snake gourd had shown that a wide range of variation was present for most of the characters considered in those crops. It was observed that in the present material male flowers/plant had the maximum genotypic coefficient of variation (56.23) followed by fruits/plant. The highest heritability estimate of 99.1% was also observed for male flowers/plant. This resulted in the highest value of genetic advance as per cent of mean for male flowers/plant followed by fruits/plant. Srivastava and Srivastava (1976) in bitter gourd also observed highest estimate of genetic advance for fruits/plant. The selection of plants based on yield

per se gave an expected genetic advance of 52.36% in the next cycle of selection when the intensity of selection was 5%.

Selection for yield per se may not be effective since implicitely or explicitely "there may not be genes for yield per se but rather for the various components, the multiplicative interaction of which results in the artifact of yield" (Grafius, 1956). For a rational approach to the improvement of yield, therefore, it would be desirable to have some knowledge on the association between different yield components and their relative contribution to yield. A knowledge of such relationship is essential if selection for the simultaneous improvement of yield components and in turn, yield to be effective. But selection based on simple correlation without taking into consideration the interaction between component characters may sometimes prove misleading. Average fruit weight was observed to be positively correlated with weight of first mature fruit and also with fruit yield/plant. The path coefficient analysis indicated that length of main vine and average fruit weight had the maximum direct effect on fruit yield/plant. This leads us to

consider length of main vine and average fruit weight as more important component characters of yield. This obviously leads for the selection of plants with higher avera e fruit weight and having longer length of main vine for higher yield. It was also interesting to note the existance of a negative but non-significant association between number of fruits/plant and fruit yield/plant in the 18 pumpkin genotypes under study. Likewise the female flowers/plant had no correlation with fruit yield/plant. This is quite contrary to the observations made by Panwar **et al.**, (1977) in sponge gourd, where he observed positive correlation between number of fruits/plant and yield. Srivastava and Srivastava (1976) also observed positive correlation between fruit yield/plant and female flowers/plant. Similar observations were made by Ramachandran (1973) in bitter gourd and Joseph (1978) in snake gourd. This aberrant behaviour in pumpkin needs further physiological studies for a detailed understanding of the relationship among fruit yield and its components especially, female flowers/plant and fruits/plant. The physiological sink in pumpkin is yet to be defined.

Studies conducted recently by Agarwal (1978) in okra and Mehra (1978) in tomato indicate the importance of actually calculating the value of expected genetic advance through selection of component characters and through direct selection. In the present study it was observed that the genetic advance obtained in fruit yield/plant by selecting average fruit weight alone was 23.14% lesser than that obtained through a straight selection programme. The present study proved conclusively the efficiency of straight selection of yield per se over selection based on component characters alone or in combinations. The superiority of straight selection over selection through discriminant function analysis has been pointed out by Mehra in tomato (1978).

The highly significant differences among the 18 genotypes for length of main vine and its components are in agreement with the findings of Ramachandran (1978) in bitter gourd and Joseph (1978) in snake gourd. Leaf area/plant has a high heritability estimate accompanied by high genetic gain which may be due to additive gene effects. This shows that there is sufficient scope for the improvement of this character.

Leaves/plant eventhough having a high heritability estimate, the expected genetic advance as per cent of mean is found to be low which may be attributed to the action of non-additive genes which includes dominance and epistasis (Panse, 1957). Hence selection has limited scope for improving leaves/plant. However, leaves/plant has high positive direct effect on length of main vine which shows the importance of this character towards improving the length of main vine.

The weight of first mature fruit determined major portion of the ultimate total yield. It ranged from 1.85 kg. in S.A. 18 to 9.95 kg. in S.A. 17. Among the component characters of weight of first mature fruit, flesh thickness has the maximum value of positive direct effect. Dalgit Singh and Nandpuri (1978) in muskmelon also observed the high positive relationship between flesh thickness and fruit weight. Circumference of fruit, though having a correlation of 0.79 with weight of first mature fruit, had only a marginal value of 0.14 as direct effect. Path analysis indicated that selection of plants with more flesh thickness and length of fruit would apparently result in selection of plants with more weight of first mature fruit.

The improtance of pumpkin as a possible supplier of carotene has not been much emphasized. The present study also brought out considerable variability in pumpkin genotypes with respect to carotene content. Kubiaki and Kalezak (1976) also reported considerable variability with respect to carotene content in different Cucurbita spp. Carotene content ranged from 0.132% in C.M. 15 to 0.927% in C.M. 18. It had the maximum value of expected genetic advance as per cent of mean (93.75) resulting from the highest heritability estimate (9.76) associated with the highest genotypic coefficient of variation (46.14). This indicated sufficient scope in the material under study for selecting genotypes with high carotene content. The T.S.S. content was observed to have a negative association with carotene content. The potassium content was observed to have maximum genotypic correlation and maximum positive direct effect on carotene content. The role of potassium nutrition in the possible enhancement of carotene content in pumpkin genotypes needs further study for confirmation.

The genotypic correlation coefficients among fruit yield/plant, length of main vine, weight of first

mature fruit and carotene content and their respective possible components were observed to be greater than the corresponding phenotypic correlation coefficients except in few cases. This is in agreement with the reports of Thakur and Nandpuri (1974) in watermelon, Srivastava and Srivastava (1976) and Ramachandran (1973) in bitter gourd. Kaloonar (1960) worked out a relationship between phenotypic, genotypic and environmental correlations. He proposed the equation $r_{xy}(p) = \sqrt{h_x^2 \cdot h_y^2} \cdot r_{xy}(g) + \sqrt{e_x^2 \cdot e_y^2} \cdot r_{xy}(e)$ where, h_x^2 and h_y^2 refer to heritability estimates of the characters x and y respectively. $e_x^2 = \sqrt{1 - h_x^2}$ and $e_y^2 = \sqrt{1 - h_y^2}$ and $r_{xy}(p)$, $r_{xy}(g)$ and $r_{xy}(e)$ stand for phenotypic, genotypic and environmental correlation coefficients respectively between characters x and y. In the present study heritability estimates in broad sense were found high for most of the polygenic characters. This resulted in higher estimate of genotypic correlation coefficients than the phenotypic correlation coefficients.

To sum up, the 13 pumpkin genotypes exhibited considerable variability with respect to many of the polygenic characters studied. Length of main vine and

average fruit weight were observed as the most important component characters deciding the total fruit yield. The aberrant behaviour in pumpkin in terms of negative association between fruit yield/ plant and number of fruits/plant and female flowers/ plant needs much physiological studies for appropriate explanation. There is sufficient scope to improve the pumpkin genotypes for higher carotene content through simple selection methods like mass selection. The role of potassium nutrition to enhance carotene content in pumpkin also requires a detailed investigation. The present study could isolate the lines C.M. 17 and C.M. 14 as high yielders (16.10 kg. and 15.38 kg. fruit yield/plant respectively) having desirable characters such as longer main vine, higher fruit weight, large number of leaves/plant and fruits with high flesh thickness.

SUMMARY

S U M M A R Y

Eighteen pumpkin (*Cucurbita moschata* Poir) genotypes were grown in a randomised block design with three replications during September - February (1978-79) at the Instructional Farm, College of Horticulture, Kerala Agricultural University, Vellanikkara.

2. The experiment was conducted to measure the extent of variability, relationship among fruit yield/plant, length of main vine and weight of first mature fruit and their components. The carotene content and other chemical constituents present in the 18 genotypes were also estimated to find out the extent of variability and correlation among themselves. The correlations were partitioned into the direct and indirect effects of components on fruit yield/plant, length of main vine, weight of first mature fruit and carotene content. The efficiency of selection through discriminant function, if any, over straight selection was also ascertained. The genotypes were pictorially represented through metroglyphs.

3. Fruit yield/plant considered as a function

of days to first female flower anthesis, days to first male flower anthesis, length of main vine, female flowers/plant, per cent of female flowers, average fruit weight, weight of first mature fruit, fruits/plant and per cent of fruit set. The 18 genotypes were significantly different for yield and its 10 component characters.

4. Considerable variability existed for yield and its ten component characters. The range for fruit yield/plant varied from 3.45 kg. in C.M. 18 to 16.10 kg. in C.M. 17. The maximum value of genotypic coefficient of variation was observed for male flowers/plant followed by fruits/plant. The highest heritability estimate of 99.14% was observed for male flowers/plant followed by per cent of female flowers and female flowers/plant. The lowest heritability estimate of 76.97% was observed for per cent of fruit set. Male flowers/plant were observed to have the highest value of genetic advance in the next cycle of selection. Fruit yield/plant had an expected genetic advance of 52.32% in the next generation of selection, when intensity of

selection was 5%.

5. Length of main vine, average fruit weight and weight of first mature fruit were significantly and positively correlated with fruit yield/plant. Fruits/plant had a negative association with fruit yield/plant. Female flowers/plant had no correlation with fruit yield/plant.

6. Length of main vine appeared to have the maximum direct effect on fruit yield/plant followed by average fruit weight. Selection of plants with more average fruit weight and length of main vine was observed not as effective as straight selection of plants based on yield per se.

7. Length of main vine was considered as a function of nine components, node at which the first female flower appeared, node at which the first fruit is retained, nodes on main vine, primary branches/plant, thick branches/plant, internodal length, internodal circumference, leaves/plant and leaf area/plant. The 18 genotypes were significantly different for length of main vine and its nine components.

8. Among the possible components of length of main vine the maximum variability was observed for primary branches/plant followed by leaf area/plant. The highest value of heritability was noted for leaves/plant followed by nodes on the main vine. Leaf area/plant recorded the highest value of genetic advance in the next generation of selection. The high genetic advance results from higher estimates of heritability as well as phenotypic coefficient of variation.

9. Length of main vine was observed positively correlated with nodes on main vine, primary branches/plant, leaves/plant and leaf area/plant. Leaves/plant had the maximum positive direct effect on length of main vine followed by internodal length.

10. Weight of first mature fruit was considered as a function of circumference of fruit, length of fruit, fruit shape index, flesh thickness, seeds/fruit, 100-seed weight, and carotene content. The 18 genotypes were significantly different for the above characters.

11. The weight of first mature fruit ranged from 1.85 kg. in C.M. 18 to 9.95 kg. in C.M. 17. Among the chemical constituents carotene content had the maximum value of expected genetic advance as per cent of mean resulting from the highest heritability estimate associated with the highest genotypic coefficient of variation. There remains immense scope for improving pumpkin for higher carotene content.

12. The flesh thickness appeared to have the maximum value of positive direct effect on weight of first mature fruit. Circumference of fruit had only a marginal value of 0.14 as direct effect on weight of first mature fruit.

13. The 18 pumpkin genotypes were observed significantly different among themselves for protein, phosphorus, potassium, calcium, T.S.S. and carotene contents. The protein content ranged from 5.26% on dry weight basis in C.M. 11 to as high as 9.49%, in C.M. 15. The significant correlation between potassium content and carotene content indicates the possible use of a higher potassium nutrition in

increasing carotene content in pumpkin. This requires further work for confirmation.

14. A discriminant function analysis was carried out to estimate the efficiency of selection through discriminant function over straight selection of fruit yield/plant per se. Genetic advance through straight selection for yield/plant per se was higher than that calculated by discriminant function considering all combinations of component characters viz., days to first female flower anthesis, length of main vine, thick branches/plant, leaf area/plant, average fruit weight and flesh thickness.

15. The 18 pumpkin genotypes were pictorially represented through metroglyphs.

The results obtained in the present study are adequately discussed and its implication in vegetable breeding elucidated.

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Appendix 1. Meterological data during the cropping period (Week wise)

Days			Temperature(°C)		Humidity (%)		Rainfall in mm. (Total)
			Maximum	Minimum	Morning	Evening	
22-10-78	to	28-10-78	31.7	23.8	86	68	13.6
29-10-78	to	4-11-78	31.0	23.6	87	74	47.4
5-11-78	to	11-11-78	28.6	22.9	92	75	124.4
12-11-78	to	18-11-78	32.2	22.7	87	55	0.0
19-11-78	to	25-11-78	31.5	21.0	83	52	19.3
26-11-78	to	2-12-78	30.8	22.9	80	54	23.8
3-12-78	to	9-12-78	31.0	24.0	73	59	0.0
10-12-78	to	16-12-78	30.9	24.5	75	56	0.0
17-12-78	to	23-12-78	31.0	23.3	73	51	0.0
24-12-78	to	31-12-78	30.0	23.3	82	65	42.9
1--1-79	to	7--1-79	31.0	22.5	74	47	0.0
8--1-79	to	14--1-79	31.0	22.5	74	47	0.0
15--1-79	to	21--1-79	32.2	22.0	83	54	0.0
22--1-79	to	28--1-79	32.6	23.9	79	51	0.0
29--1-79	to	4--2-79	33.9	22.4	89	49	0.0
5--2-79	to	11--2-79	34.1	23.1	79	45	0.0
12--2-79	to	18--2-79	33.4	22.9	85	52	17.9
19--2-79	to	25--2-79	32.9	23.7	93	62	4.1
26--2-79	to	4--3-79	33.8	23.3	75	48	3.2

*Source: Meteorological observatory, District Agricultural Farm, Mannuthy.

Appendix 2. Mean performance of 18 pumpkin genotypes with respect to 32 characters

Acc.No.	Days to first female flower anthesis	Days to first male flower anthesis	Node at which first female flower appeared	Node at which the first fruit is retained	Length of main vine	Nodes on main vine	Primary branches/ plant	Thick branches/ plant	Internodal length (cm)
C.M. 1	48.67	50.56	21.00	28.11	7.60	56.11	4.67	3.33	11.41
C.M. 2	48.23	51.78	23.00	23.11	8.10	68.67	6.45	2.67	12.42
C.M. 3	47.53	47.22	18.33	19.22	5.98	63.50	6.11	3.56	11.40
C.M. 4	47.03	49.89	24.78	26.67	6.98	62.33	8.11	3.89	14.10
C.M. 5	46.90	47.78	20.22	20.22	6.49	61.67	5.28	3.11	13.29
C.M. 6	48.20	53.33	22.23	26.33	7.03	55.56	6.78	3.44	11.42
C.M. 7	43.57	45.33	20.55	20.67	5.79	66.33	5.00	3.11	10.86
C.M. 8	56.00	57.00	28.78	29.00	9.63	71.33	10.22	3.67	14.53
C.M. 9	48.33	51.11	21.22	21.78	6.38	69.45	5.33	3.45	10.04
C.M.10	51.67	50.22	22.99	24.33	7.41	60.33	4.55	2.56	10.65
C.M.11	47.57	51.55	21.33	21.56	6.77	49.78	7.00	3.22	17.95
C.M.12	46.90	53.66	24.44	27.33	6.35	59.67	4.33	4.00	11.57
C.M.13	49.23	48.22	21.22	21.78	8.08	58.22	7.11	3.56	14.21
C.M.14	48.57	48.00	20.00	24.56	9.31	74.33	7.78	3.56	13.63
C.M.15	45.90	47.67	20.22	20.67	4.75	56.44	4.22	2.00	9.73
C.M.16	49.00	55.45	25.78	26.33	5.89	44.22	3.78	1.33	10.56
C.M.17	48.57	48.67	19.34	23.33	9.57	81.33	5.78	4.00	12.35
C.M.18	37.57	46.56	25.22	31.00	6.37	60.44	5.00	3.67	8.18
C.D. (5%)	1.91	1.64	1.27	1.48	0.94	3.02	0.93	0.65	1.59

Appendix 2 contd...

ACC.No.	Internodal circumference (cm)	Leaves/ plant	Leaf area/ plant (m^2)	Male flowers/ plant	Female flowers/ plant	% of female flowers	Average fruit weight (Kg)	Weight of first mature fruit(Kg)
C.M. 1	3.54	256.11	10.46	148.07	5.33	10.71	6.59	8.21
C.M. 2	4.44	238.62	7.74	133.53	8.22	13.83	6.40	6.58
C.M. 3	3.41	224.00	3.78	74.90	5.00	14.53	4.55	7.53
C.M. 4	3.61	233.43	7.94	103.33	12.00	18.87	7.46	6.80
C.M. 5	3.66	208.45	5.34	86.00	7.00	15.33	5.87	6.51
C.M. 6	4.07	254.11	9.06	135.27	6.77	12.65	6.39	6.79
C.M. 7	3.45	173.00	3.72	86.20	6.00	15.93	4.59	4.58
C.M. 8	4.06	343.00	8.04	189.10	16.28	16.32	1.52	2.01
C.M. 9	4.11	200.78	6.02	110.77	4.67	11.68	8.67	9.40
C.M.10	3.89	182.33	7.80	75.23	9.33	19.40	6.92	9.29
C.M.11	4.51	244.44	7.84	92.53	10.83	18.90	9.95	9.77
C.M.12	3.38	226.46	7.47	120.57	5.33	11.87	6.23	6.58
C.M.13	3.59	291.22	9.80	91.67	4.77	12.87	9.63	9.12
C.M.14	3.79	299.54	12.38	169.77	5.44	10.19	6.41	9.36
C.M.15	3.70	111.67	2.82	56.23	3.33	16.61	3.22	3.95
C.M.16	3.92	156.53	5.50	145.43	10.78	8.65	6.36	7.87
C.M.17	4.08	321.67	12.0	117.67	10.83	16.81	8.23	9.95
C.M.18	3.99	208.11	7.71	383.67	7.83	8.20	1.21	1.85
C.V.(5%)	0.30	12.86	1.05	11.17	0.88	0.86	1.85	1.21

Appendix 2. contd...

ACC.No.	Fruits/ plant	% of fruit set	Circumference of fruit (cm)	Length of fruit (cm)	Fruit shape index	Flesh thick-ness (cm)	Seeds/ fruit	100-seed weight (g)
C.M. 1	2.11	40.02	85.52	35.86	1.40	3.86	535.00	16.44
C.M. 2	1.67	26.67	96.00	21.34	0.74	3.65	533.27	20.68
C.M. 3	1.89	37.71	93.33	29.82	1.33	3.44	390.50	17.76
C.M. 4	1.78	22.63	103.33	18.13	0.62	4.10	536.70	19.20
C.M. 5	2.00	32.42	86.44	29.75	1.11	3.49	417.50	18.22
C.M. 6	2.00	33.25	86.92	24.29	0.99	3.58	407.43	18.78
C.M. 7	2.44	36.37	85.00	20.44	0.85	3.37	272.90	20.09
C.M. 8	5.67	36.17	44.67	19.45	1.36	2.85	369.77	16.56
C.M. 9	1.55	35.19	113.07	20.95	0.61	4.22	432.50	18.64
C.M.10	1.33	22.19	106.50	19.29	0.60	4.03	434.83	18.23
C.M.11	1.44	19.62	84.83	38.71	1.47	3.98	488.33	24.75
C.M.12	2.11	38.86	88.67	22.07	0.79	3.66	264.67	20.84
C.M.13	1.44	33.37	112.89	25.08	0.73	4.16	439.17	16.33
C.M.14	2.45	41.28	108.05	23.82	0.71	4.30	475.73	17.98
C.M.15	1.78	33.70	74.06	20.79	0.88	2.91	314.10	18.20
C.M.16	1.44	38.04	85.44	34.50	1.39	3.63	432.17	19.92
C.M.17	2.00	25.53	101.67	26.91	0.76	3.87	456.00	15.68
C.M.18	4.56	49.66	85.83	12.17	0.70	2.89	225.00	11.67
C.D.(5%)	0.52	6.66	7.19	3.83	0.20	0.24	52.89	1.68

Appendix 2. contd...

AC.C.No.	Fruit yield/ plant (Kg)	Protein (%)	Phosphorus (%)	Potassium (%)	Calcium (%)	T.S.S. (%)	Carotene (%)
C.M. 1	14.20	7.31	0.447	2.25	0.600	7.33	0.176
C.M. 2	11.32	5.56	0.478	1.38	0.533	5.39	0.155
C.M. 3	7.98	9.12	0.571	2.13	0.480	7.00	0.168
C.M. 4	13.22	5.80	0.431	2.38	0.600	5.50	0.143
C.M. 5	11.75	7.07	0.521	2.13	0.507	7.00	0.211
C.M. 6	12.78	7.92	0.356	2.06	0.560	6.67	0.174
C.M. 7	11.12	8.70	0.478	1.42	0.493	6.00	0.139
C.M. 8	8.61	7.94	0.468	1.50	0.427	12.78	0.154
C.M. 9	12.96	6.16	0.453	1.38	0.520	8.00	0.180
C.M.10	9.20	7.19	0.471	1.59	0.560	6.28	0.150
C.M.11	14.21	5.26	0.348	1.38	0.507	5.00	0.249
C.M.12	12.91	6.40	0.446	2.13	0.520	8.55	0.182
C.M.13	13.79	8.52	0.474	1.46	0.507	6.17	0.191
C.M.14	15.38	7.92	0.675	2.50	0.507	5.82	0.207
C.M.15	5.64	9.39	0.371	1.96	0.480	6.33	0.132
C.M.16	8.96	6.77	0.478	1.42	0.467	6.33	0.154
C.M.17	16.10	7.43	0.522	1.96	0.480	6.11	0.161
C.M.18	15.45	8.76	0.543	3.75	0.573	4.39	0.527
C.D.(5%)	1.81	0.58	0.020	0.19	0.030	0.47	0.007

Plate I. A general view of the **experimental field.**

Plate II. Field performance of pumpkin genotype C.M. 18.


CM18

Plate III. Field performance of pumpkin genotype C.M. 17.

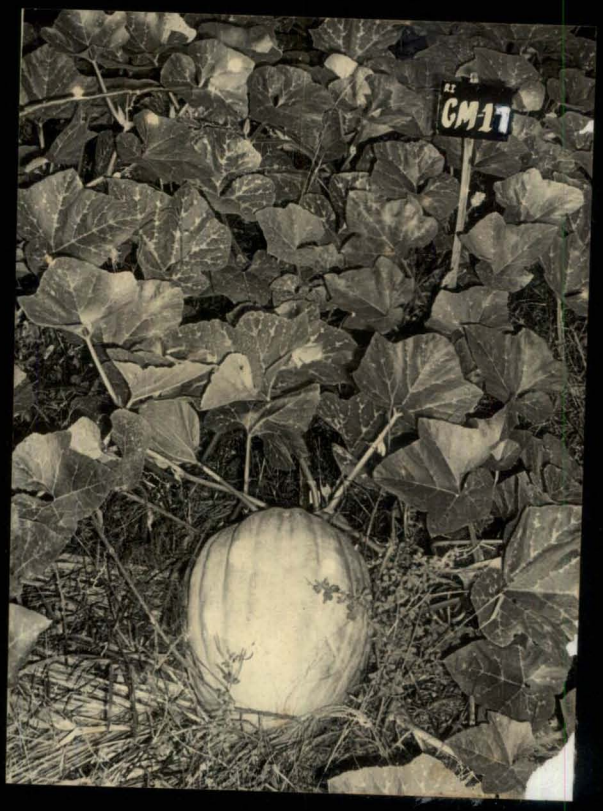

GM-17

Plate IV. Field performance of pumpkin genotype C.M. 14.


THUMP

Plate V. Fruit characters of different pumpkin types
(C.M. 1, C.M. 2 & C.M. 3)

Plate VI. Fruit characters of different pumpkin types
(C.M. 4, C.M. 5 & C.M. 6)


CM-1
RI
CM-2
RI
CM-3


RI
CM-4
RI
CM-5
RI
CM-6

Plate VII. Fruit characters of different pumpkin types
(C.M. 7, C.M. 8 & C.M. 9)

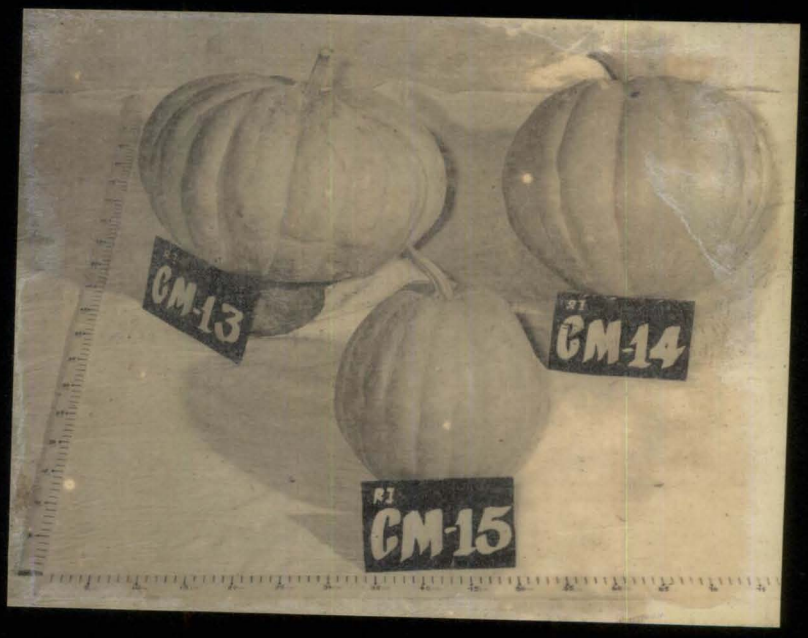
Plate VIII. Fruit characters of different pumpkin types
(C.M. 10, C.M. 11 & C.M. 12)


RI
CM-7
RI
CM.8
RI
CM-9


RI
CM-10
RI
CM-11
RI
CM 12

Plate IX. Fruit characters of different pumpkin types
(C.M. 13, C.M. 14 & C.M. 15)

Plate X. Fruit characters of different pumpkin types
(C.M. 16, C.M. 17 & C.M. 18)


CM-13
CM-14
CM-15


CM-16
CM-17
CM-18

GENETIC VARIABILITY AND CORRELATION STUDIES IN PUMPKIN

(*Cucurbita moschata* Poir)

BY

GOPALAKRISHNAN, T. R.

ABSTRACT OF A THESIS

Submitted in partial fulfilment of the

requirement for the degree of

Master of Science in Horticulture

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COLLEGE OF HORTICULTURE

Vellanikkara, Trichur.

1979

A B S T R A C T

Eighteen diverse pumpkin genotypes were grown in a randomised block design with three replications during 1978-79 at the Instructional Farm of College of Horticulture, Vellanikkara to estimate the extent of genetic variability, association among polygenic characters and its partition into direct and indirect effects. A discriminant function analysis was also carried out to find out the efficiency, if any, of selection through discriminant function over straight selection or vice-versa.

The 18 genotypes were significantly different for the 32 polygenic characters studied. The genotypes C.M. 17 and C.M. 14 emerged as high yielders with other desirable qualities (16.10 kg. and 15.38 kg. fruit yield/plant respectively). Selection of plants considering yield per se was observed to be efficient than selection of component characters.

Fruit yield/plant was positively correlated with length of main vine, average fruit weight and weight of first mature fruit. Leaves/plant and internodal length had maximum direct effects on length

of main vine. Weight of first mature fruit was positively correlated with flesh thickness and circumference of fruit. Number of female flowers/ plant and number of fruits/plant had no correlation with fruit yield/plant. This aberrant behaviour requires further physiological studies to define the physiological sink in pumpkin.

The line C.M. 18 is observed to contain the maximum amount of carotene (0.527%) among the 18 genotypes studied. The carotene content was observed rather independent of fruit yield/plant.