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MORPHOLOGICAL AND GENETIC VARIATION IN THE HYBRID DERIVATIVES OF OXHEART AND ANOBIK TOMATO CROSS

M.A. HOSSAIN[1], M.R.I. KHAN AND M.A.Q. SHAIKH

Institute of Nuclear Agriculture, Mymensingh, Bangladesh

Abstract

Morphological variation in the F_1 and F_2 progenies of the cross between 'Oxheart' and 'Anobik' tomatoes were studied. The Oxheart is a tall, indeterminate, large fruited variety and the Anobik is a dwarf, determinate, small fruited mutant. The F_2 progeny produced 6 type of plants: 2 parental types and 4 recombinants viz. determinate-medium, determinate-wilty, indeterminate-Anobik and indeterminate-medium. The tall plant type of Oxheart was found to be dominant over the dwarf plant type of Anobik. Recombinant leaf types were found to be associated with the recombinant plant types. The F_2 progeny showed 4 type of fruits including 2 recombinants. The small fruit of Anobik was found to be partially dominant over the large fruit of Oxheart. Fruit yield/ plant was 31% higher in the F_1 than the average of the two parents. Among the parents, F_1 and F_2s, the highest fruit yield was obtained from the determinate-medium plant type ; the latter was considered to be superior for its medium height and orderly determinate fashion of growth.

Introduction

Tomato as an introduced crop in the Asian region has now generated much interest in the development of good adaptable types. Knowledge of the various morphological characters and their inheritance patterns are essential for the researchers working in tomato improvement projects. A crossing programme was, therefore, undertaken between the variety Oxheart and the mutant Anobik for studying the inheritance pattern, morphological variation and selecting desirable plant types with higher yield and better quality fruits. The inheritance patterns of the qualitative characters have already been reported (Khan *et al.* 1981). The objective of this work was to investigate the variation in the different morphological characters of the progenies and their various associations with the plant types.

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1. Department of Crop Botany, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Material and Methods

The tomato mutant Anobik is characterized by a dwarf and determinate plant with short internodes, broad leaves and small fruits. It was obtained from a local cultivar through gamma-irradiation (Rahman *et al.* 1975). Oxheart is a commercial variety of indeterminate habit and is popular for its good quality fruits.

Anobik (P_1), Oxheart (P_2), reciprocal crosses ($P_1 \times P_2$, $P_2 \times P_1$), their F_2 and backcrosses (B_1 and B_2) were planted in a randomized block design with 5 replications at a planting distance of 75 cm × 75 cm. The plant population comprised 1050 plants of F_2 and 95 plants of each of P_1, P_2, F_1 and backcrosses. Three-week old seedlings were transplanted at the INA field in November, 1978. Fertilizer at the rate of 20 kg N, 40 kg P, and 8 kg K per acre were applied in 3 instalments.

Six different morphological groups of plants were found in the F_2 population. Data on different morphological characters were recorded from 25 plants from each group taking 5 plants at random from each of the replication. Duncan's multiple range test were carried out on some of the important characters to ascertain the actual differences between groups and to compare them with their parents and F_1s.

Results and Discussion

Plant type

Large variations in the morphological traits of the F_2 plants were noticed. Groups on the basis of their important morphological characters were made as in Fig. 1 and the representative photographs are shown in Fig. 2. The groups were named as follows:

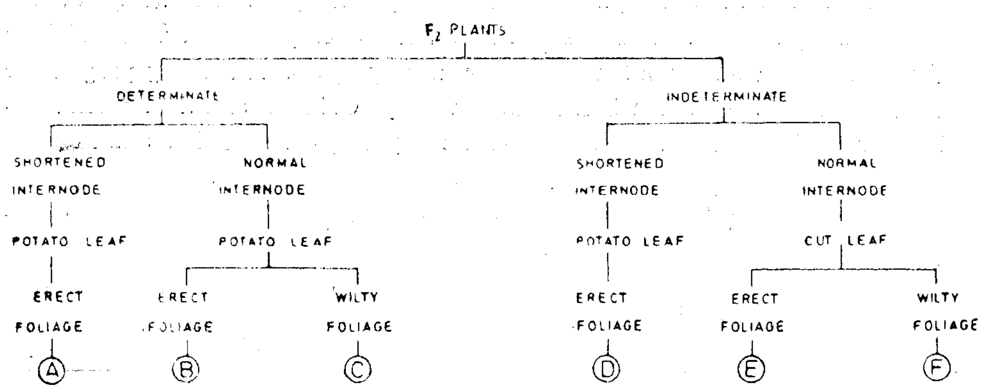

Fig. 1. Grouping of F_2 plants on the basis of their important morphological characters.

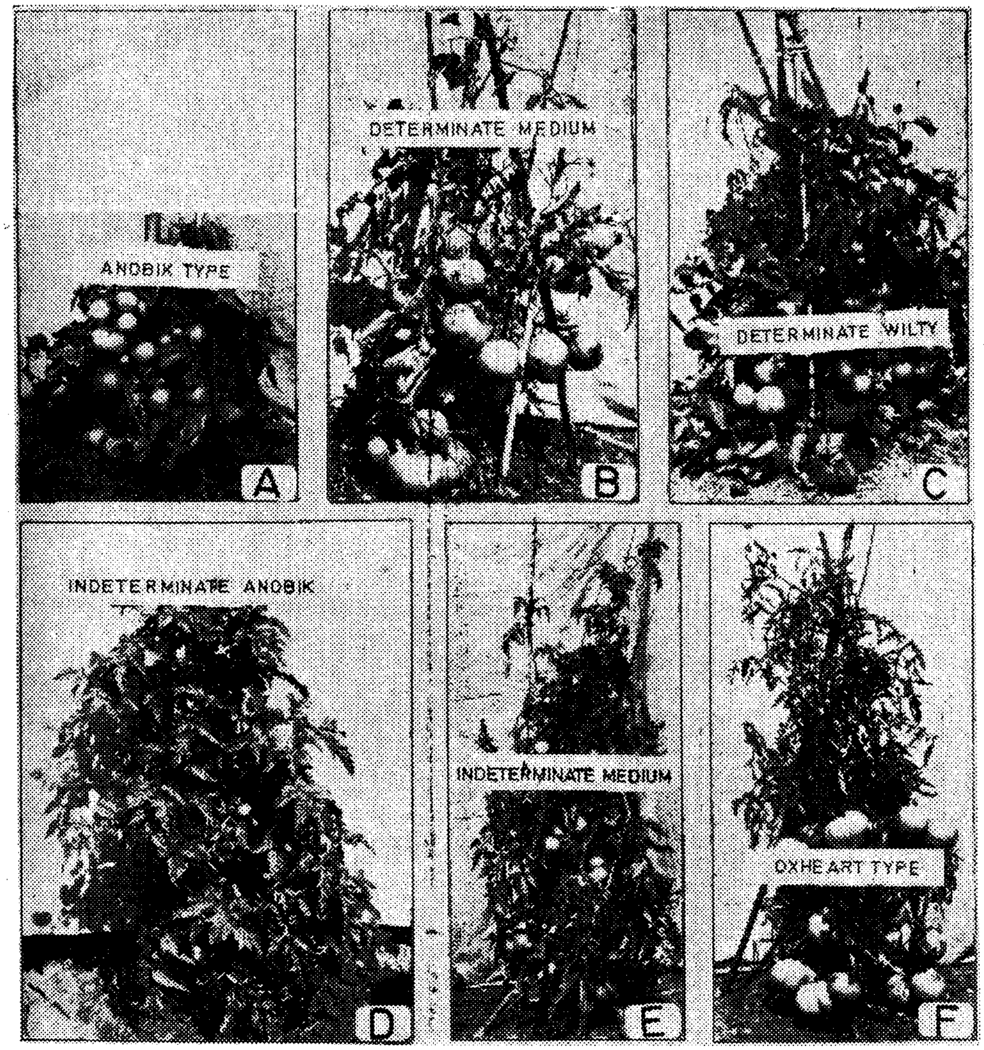

Fig. 2. Various plant types observed in F_2 progenies.

A Anobik type	D Indeterminate-Anobik type
B Determinate-medium type	E Indeterminate-medium type
C Determinate-wilty type	F Oxheart type

The groups A and F are parental types and groups B, C, D and E are the recombinant types.

Plant height and stem characteristics

The Oxheart parent was 156 cm tall and was 4 times taller than the Anobik parent. There was much variation in plant height among the different type of F_2 plants (Fig. 3, Table 1). F_1 plants were similar to those of the Oxheart

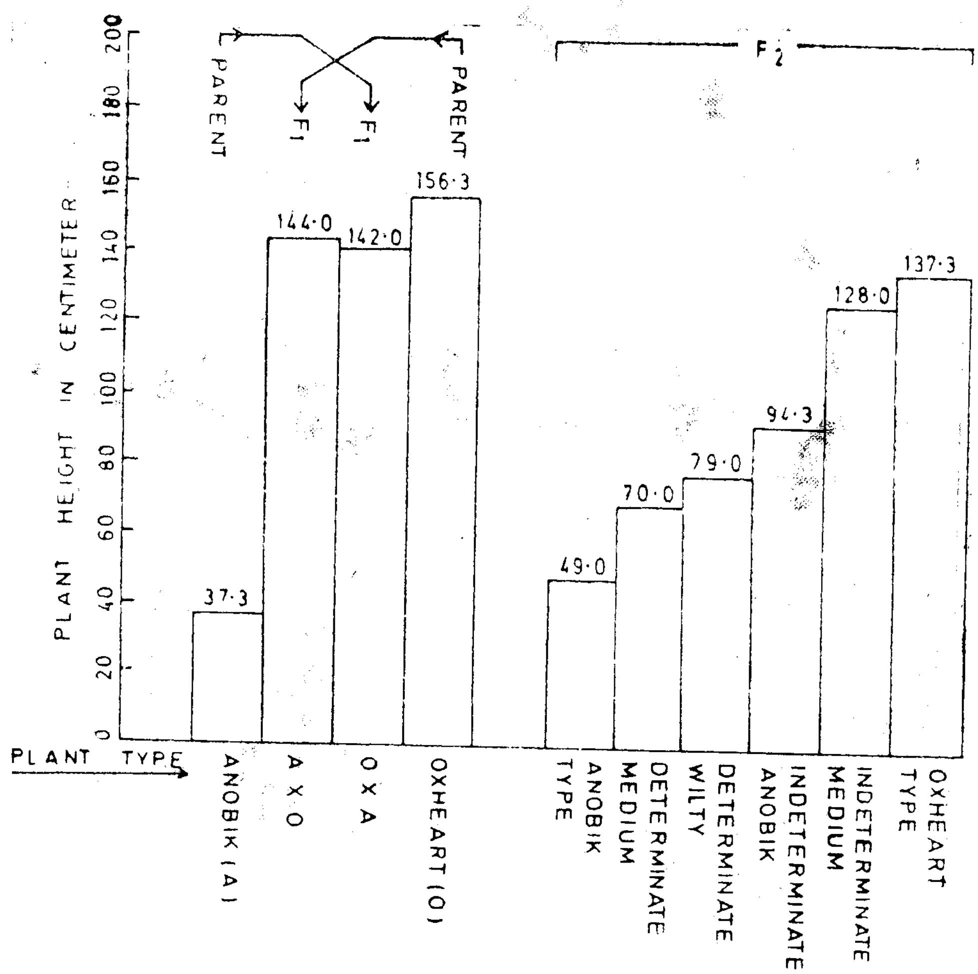

Fig. 3. Variation in plant height among parents, F_1 and F_2 populations.

parent in height indicating that Anobik was a recessive mutant for this character. The indeterminate character was dominant over the determinate. When the indeterminate growth habit was inherited along with the Anobik plant type, the plants became taller and turned indeterminate-Anobik type having leaves similar

Table 1. Plant height and stem characteristics of Parents, F_1 and F_2 plants

Varieties/ groups	Plant height (cm)	Primary branch		Internode length (cm)		Diameter (cm)		Branch angle with main axis (degrees)
		Number	Length (cm)	Main axis	Primary branch	Main axis	Primary branch	
Anobik parent	37.3g*	6.7b	21.0g	2.1h	3.0f	0.9d	0.7d	57.7h
Oxheart parent	156.3a	6.4c	77.0a	5.3a	6.4a	1.2bc	0.8c	87.3a
O×A (F_1)	142.0b	6.4c	74.3a	5.1b	6.4a	1.1cd	0.7d	76.7c
A×O (F_1)	144.0b	6.7b	76.3a	5.1b	6.3ab	1.2bc	0.8c	74.0d
Anobik type (F_2)	49.0f	6.1d	28.7f	2.6g	4.7e	1.2bc	0.8c	60.3g
Determinate-medium type (F_2)	70.0e	5.8e	36.3e	3.1f	5.6c	1.2bc	0.9b	65.7e
Determinate-wilty type (F_2)	79.0e	4.9f	45.3d	3.5d	6.3ab	1.1cd	0.7d	67.3e
Inderminate-Anobik type (F_2)	94.3d	7·0a	58.3c	3.3e	5.1d	1.5a	1.0a	62.0f
Indeterminate-medium type (F_2)	128.0c	6.9ab	69.7b	4.8c	6.2b	1.4ab	1.0a	63.3f
Oxheart type (F_2)	137.3bc	6.4c	74.3a	4.9c	6.3ab	1.1cd	0.7d	85.0b

*Figures followed by letters in common are not significantly different at the 1% level of probability to that of Anobik parent. Indeterminate-Anobik and Anobik type plants possessed shortened internodes with broader leaflets which made these plants bushy in appearance.

All the F_1 and F_2 plants showing Oxheart characters possessed longer primary branches and weak stems and thus required much support for cultivation. Anobik and indeterminate-Anobik type (Fig. 2A, 2D) were characterized by stout stems and branches having smaller angles with the main stem. On the other hand, determinate-medium type plants (Fig. 2B) had greater height, longer internode length and wider angle of primary branches with the main axis than those of the Anobik types which made the plants well-spread. The determinate-wilty type plants (Fig. 2C) had weak stem and narrow leaves. Although height and appearance were similar to that of Oxheart, the indeterminate-medium type plants (Fig. 2E) were stronger than those of the Oxheart type (Fig. 2F) and remained erect with minimum support. The erectness and wilty habit are thought to have been inherited from the Anobik and Oxheart parents respectively.

Leaf type

Each group of F_2 plants showed representative leaf types and six different type of leaves were easily identifiable. The leaf type of the corresponding

Fig. 4. Parental and recombinant type of leaves: A. Anobik type B. Determinate-medium C. Determinate-wilty, D. Indeterminate-Anobik, E. Indeterminate-medium F. Oxheart type.

plant groups have been denoted by the same letters of the respecitve plant groups and are shown in Fig. 4. It was observed that the other plant characters such as growth habit, determinate or indeterminate and presence or absence of dwarfness had marked influence on the leaf type.

All parts of the leaf such as petiole, blade, stalk of leaflets, rachis etc. of the Oxheart leaves (Fig. 4F) were longer than those of the Anobik (Fig. 4A). In Oxheart type of leaves, the margin of leaflets was deeply serrated, sometimes reaching the rachis, whereas in Anobik type leaflets the serration was almost absent or superficial. The number of larger leaflets (length above 6.0 cm), medium leaflets (length 2.5 cm - 6.0 cm) and smaller leaflets (length below 2.5 cm) in Oxheart were 8, 9 and 12 respectively whereas in Anobik it was 5, 2 and 1 respectively. For these characters the Anobik leaves had similarity with those of potato. The leaflets of Anobik plants (Fig. 4A) were thicker than those of Oxheart, arranged closely, making overlapping of the leaflets whereas in Oxheart, the leaflets were numerous and were scattered throughout the long rachis making it very irregular in shape (Fig. 4F). The surface of the indeterminate-Anobik leaflets (Fig. 4D) was very wrinkled and wavy whereas in the determinate-medium type leaflets (Fig. 4B), it was almost plain. The indeterminate-medium leaves were similar to those of Oxheart (Fig. 4F) in appearance but some what stout and shorter indicating that they possessed more sclerenchymatous tissues in vascular bundles which might have been inherited from the Anobik parents. The F_1 plants had leaves similar to those of Oxheart indicating that this leaf type was dominant over the Anobik leaf type. The wilty habit of leaves in the determinate-wilty type (Fig. 4C) indicates that it might have been inherited from the Oxheart type.

Inflorescence

Inflorescence was compound cymose in both parents as well as in the progenies. In the Anobik type, the inflorescence was scorpioid (Fig. 5F) and in Oxheart it was mostly helicoid (Fig. 5A, C and E) but in few cases it was mixed (helicoid-scorpioid, Figs. 5B, D). Scorpioid type of inflorescence was rarely branched whereas the helicoid types were almost always branched. Floral leaves were found on the inflorescence of Oxheart type plants but this was absent in Anobik type. Thirty inflorescence of Oxheart parent possessed the floral leaves (Table 2). Presence of floral leaves diminished gradually in plants showing closer and closer relation to the Anobik character. Again, the leaf or leaflets on the inflorescence were found to vary greatly in shape and size as shown in Fig. 5. The length of Oxheart inflorescence was 16.9 cm whereas it was only 7.1 cm in Anobik plant (Table 2). The longer inflorescence of the Oxheart parent was dominant over the short ones of Anobik. The F_1s and the various groups of F_2 populations showed greater

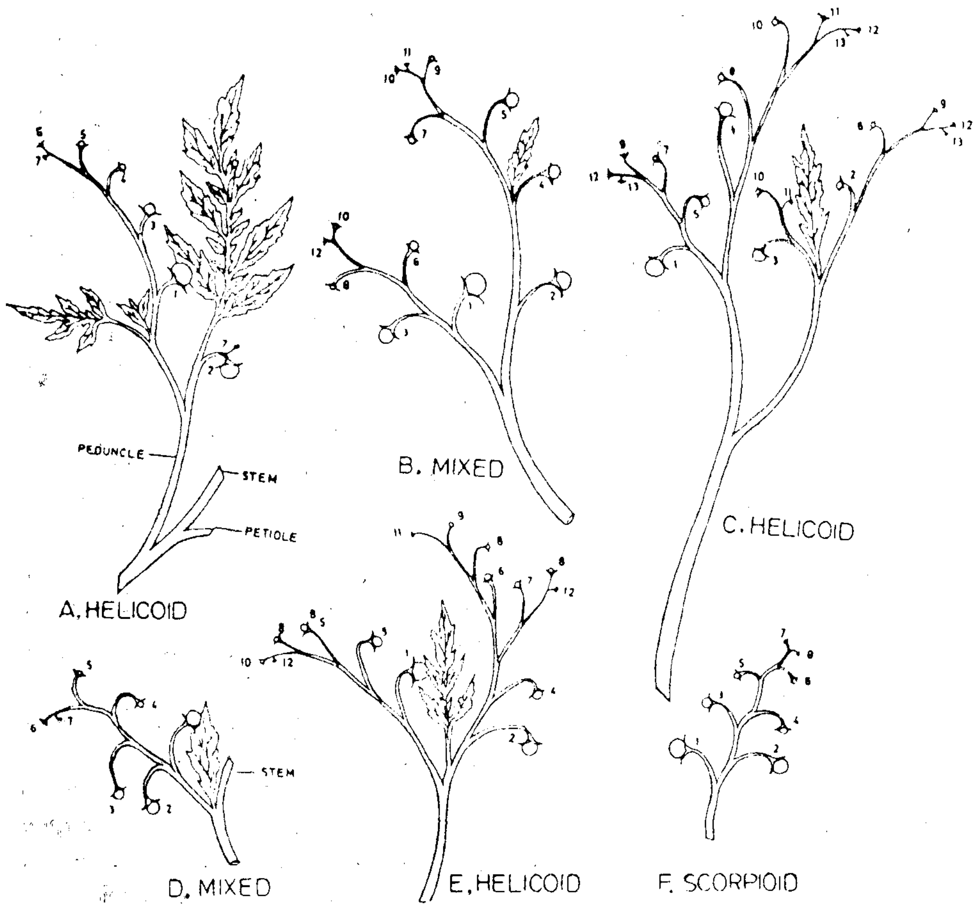

Fig. 5. Different positions of leaf, leaflets and shoots on helicoid and mixed type of cymose inflorescences but absent on scorpioid type. The number indicates the order of blooming of the flowers.

number of inflorescence/plant than those of the parents (Table 2). The Oxheart plants bore maximum percentage of abortive flowers whereas those of the Anobik parent had the minimum (Table 2). The F_2 recombinants possessed more or less equal number of abortive flowers except the Anobik type, but there was ample variation among themselves in the total number of flowers. Any plant having a higher total number of flowers would then have a higher

Table 2. Characteristics of inflorescence in parents, F_1 and F_2 plants

Varieties/ groups	Type of inflorescence	% inflorescence having leaf/ leaflet on it	Length of inflorescence (cm)	No. of inflorescence/ plant	No. of flowers/ inflorescence	% abortive flowers
Anobik parent	Scorpioid*	0	7.1 g**	28 de	5.9 d	66
Oxheart parent	Helicoid & mixed	30	16.9 a	24 g	9.0 a	89
O×A (F_1)	Helicoid & mixed	10	15.0 c	30 cd	9.2 a	82
A×O (F_1)	Helicoid & mixed	10	14.9 c	30 cd	9.4 a	82
Anobik type (F_2)	Scorpioid	0	7.3 g	27 ef	5.9 d	66
Determinate medium type (F_2)	Scorpioid	5	8.9 c	40 a	6.1 cd	80
Determinate Wilty type (F_2)	Scorpioid helicoid & mixed	8	11.4 d	36 b	6.2 cd	81
Indeterminate Anobik type (F_2)	Scorpioid	0	8.1 f	29 de	6.8 bc	79
Indeterminate medium type (F_2)	Scorpioid	7	8.7 e	31 c	7.4 b	82
Oxheart type (F_2)	Helicoid & mixed	26	15.7 b	26 fg	9.2 a	85

* Scorpioid = Scorpioid type of cymose inflorescence
Helicoid = Helicoid type of cymose inflorescence
** Figures followed by letters in common are not significantly different at 1% level of probability.

number of fertile flowers and consequently a higher number of fruits. Therefore, a higher initial number of flowers might be a criterion of selection for a higher number of fruits.

The length of the flower, calyx, corolla and androecium in flowers producing the F_1 fruit types were intermediate between the parental types. This indicates that these characters are quantitatively inherited and, therefore, no dominance of the parents was observed. The flowers giving rise to intermediate type of fruits had shorter length of all these floral parts than those resulting in the elongated type of fruits. No appreciable variation could be detected in the characters such as length of gynoecium and height of ovary. The diameter of ovary was similar in the flowers of the Anobik, F_1 and F_2 recombinant type fruits but it was bigger in the flowers giving rise to Oxheart type of fruits.

Rick and Dempsey (1969) found that the length of androecium and gynoecium varies in different varieties which influences the type of pollination. In Oxheart the length of gynoecium is shorter than that of androecium thus facilitating self-pollination but since Anobik has comparatively longer gynoecium a reverse case may happen. This might have caused a low incidence of cross-pollination.

Fruit characters

Oxheart and Anobik type of fruits are distinctly different. The Anobik types are small and round shaped, whereas the Oxheart types are large and heart-shaped (Fig. 6). The fruits of F_2 plants varied for shape and size ; 2 recombinant types *viz.* elongated and ovate shapes were noted. However, slight variations in shape were also found among fruits of each parent especially in the Oxheart type. Depending on the shape and size, the fruits of the F_2 progeny were grouped as follows: (1) Anobik type (2) Oxheart type (3) Intermediate (ovate) type and (4) Elongated type (Fig. 6). The number of fruits/bunch as well as their number/plant was the highest in the Anobik type, followed by the F_1 type. It was the lowest in the Oxheart type. The Oxheart type of fruits were the largest and those of Anobik type were smallest. Weight of the fruit was highest in the Oxheart type followed by those of the other two recombinant types of the F_2 progeny. The persistent calyx was shorter and stout in the Anobik type of fruits but it was longer and narrower in other type of fruits.

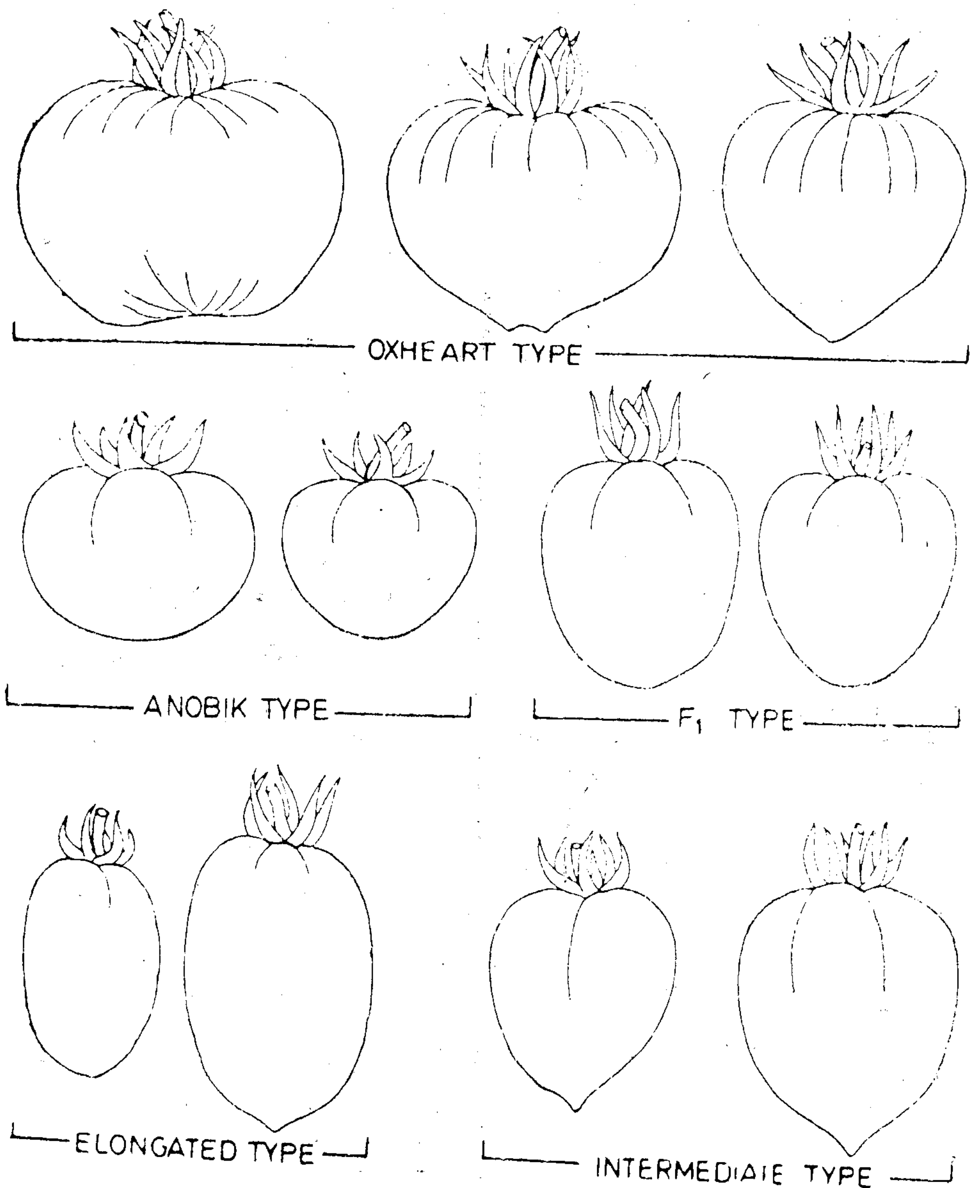

Fig. 6. Fruit types observed in the F_1 and F_2 progenies. Anobik type and Oxheart type fruits reveal the exact shapes of their parents.

Data on different fruit setting habits of the parents, F_1 and F_2 progenies are presented in Fig. 7. Number of Oxheart type fruit was the highest in the first cluster and the number of such fruits gradually diminished to nearly zero in the 7th cluster. Almost the same trend was observed with the intermediate type of fruit. In all other types, the first cluster bore a smaller

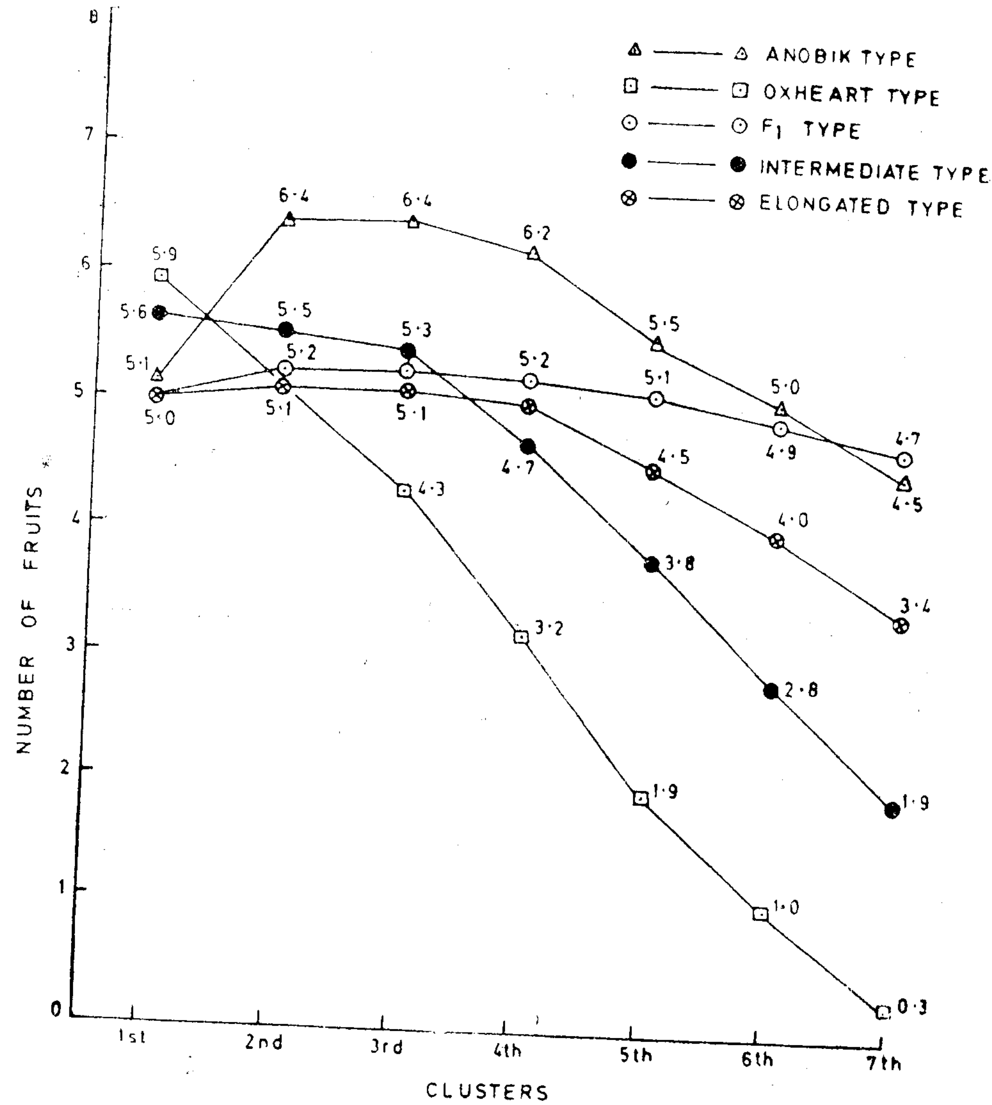

Fig. 7. Setting habit of different type of fruits from the lst to the 7th cluster.

number of fruits than the second and the third cluster. This trend was more pronounced in the case of Anobik type. Variation in the number of fruits in different clusters was minimum in the case of F_1 plants. However, the number of fruits in various clusters was found to be associated with the fruit types but not with the plant types.

The frequency of different plant types bearing different types of fruits is shown in Fig. 8. The Anobik type of plants never bore Oxheart type of fruits and the Oxheart type of plants never bore Anobik type of fruits. Besides these, all the plant types in the F_2 bore all the 4 types of fruits (Table 3). The Anobik type of fruits was found to be partially dominant over the Oxheart type. Butler (1973) also found that the smaller fruit was dominant over the larger one. Moreover, the stoutness observed in the plants bearing Anobik

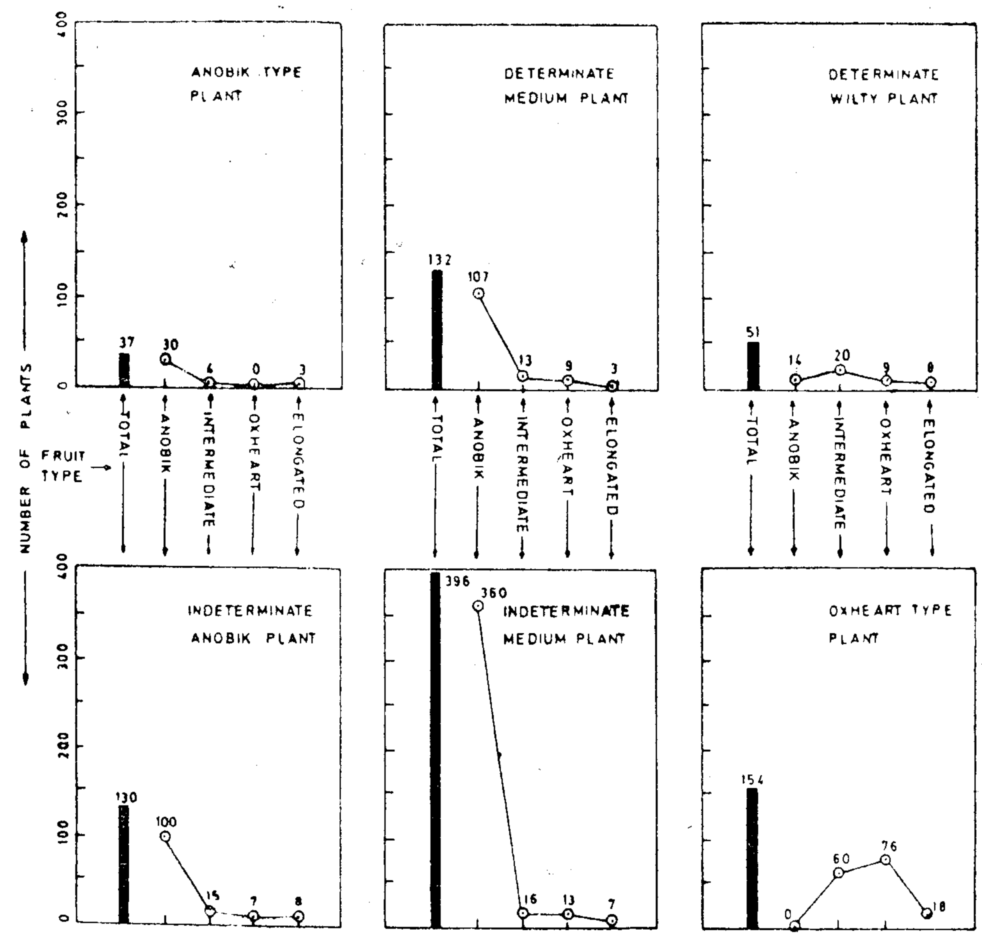

Fig. 8. Total number of plants of different F_2 groups and their distribution in bearing the different type of fruits.

type of fruits was thought to have been inherited from Anobik plant and it was associated with the Anobik type of fruit-setting.

Although the number of flowers/inflorescence was smaller in Anobik than that of Oxheart, the number of effective fruit bunches/plant as well as fruits/bunch were higher in the former than in the latter (Table 3). This resulted in an increase of the total number of fruits/plant in Anobik (56.0) over that of Oxheart (22.9). The F_1s had more flowers like the Oxheart parent and at the same time, these bore a greater number of effective fruit bunches/plant like that of Anobik. Among the parental, F_1 and F_2 plants, the determinate-medium ones bore the highest number of fruits.

Large variations were recorded for fruit dimension in the parents and progenies (Table 3). The height and diameter of fruits in Oxheart were 6.1 and 6.5 and in Anobik, 4.1 and 4.2 respectively. Although the fruit size was larger in Oxheart, total yield was higher in Anobik due to the greater number of fruits. The fruit demension of the F_1 was closer to that of Anobik. As the number of fruits/plant in the F_1 was closer to and the fruit size was larger than that of Anobik, the total yield/plant was much higher (31%) in the F_1s than in both parents. Some of the F_2 plants produced the largest fruits. Determinate-medium plants had the highest total yield of fruits/plant when the plant bore only the Oxheart type of fruits (Table 3). Heterosis in tomato yield was reported by Williams and Gilbert (1960) and this was in conformity with the findings of the present investigation.

In conclusion, it can be stated that a great deal of variation in different morphological characters was observed. The parents were divergent for most of the characters and the progenies of the F_2 population segregated in various combinations. Although closer to those of Oxheart in appearance, the indeterminate-medium plants were closer to Anobik in respect of stoutness type and the number of fruits; the fruit-setting habit and wilty behaviour of the determinate-wilty type of plants might have been inherited from the Oxheart parent. Although the F_1 plants showed similarity in appearnace with Oxheart they were not significantly different from those of Anobik in respect of the number of fruit bunches and the number of fruits/plant. However, among the progenies and parents, the determinate-medium type of plant was found to be superior for its better fruit bearing capacity. This type of plant was stout, medium in size, and grew in an orderly determinate fashion and had higher yield capacity.

Morphological characters of the progenies following hybridization between a mutant and a variety of tomato and an interspecific cross involving

Table 3. Fruit bearing habit of the parents, F_1 and F_2 plants

Plant type / Characters	Fruit type 2	Anobik parent 3	Oxheart parent 4	O×A (F_1) 5	A×O (F_1) 6	Anobik (F_2) 7	Deteminate medium (F_2) 8	Determinate wilty (F_2) 9	Indeterminate Anobik (F_2) 10	Indeterminate medium (F_2) 11	Oxheart (F_2) 12
Number of fruits bunch/plant		10.1 abc**	6.6 e	11.0 a	11.0 a	10.3 abc	10.7 ab	9.6 c	9.8 bc	10.5 abc	7.0 e
Number of fruits/ bunch	Ak**	5.5	0.0	—	—	5.6	6.0	6.0	6.0	6.0	0.0
	Ox	0.0	3.8	—	—	0.0	4.0	3.3	3.0	3.0	4.0
	Int	0.0	0.0	—	—	0.0	4.2	4.1	4.0	4.0	4.8
	Elong	0.0	0.0	—	—	0.0	4.0	5.0	4.0	4.3	5.0
	F_1t	—	—	5.0	5.0	—	—	—	—	—	—
Number of fruits/ plant	Ak	56.0	0.0	—	—	57.2	66.0	59.0	61.1	63.0	0.0
	Ox	0.0	22.9	—	—	0.0	33.0	28.1	29.0	30.0	25.8
	Int	0.0	0.0	—	—	0.0	38.2	36.5	36.8	37.7	37.3
	Elong	0.0	0.0	—	—	0.0	42.0	42.4	37.2	37.8	41.5
	F_1t	—	—	51.2	51.6	—	—	—	—	—	—
Average weight of fruit (g)	Ak	39.7	—	—	—	42.2	46.9	46.1	43.5	45.4	—
	Ox	—	94.5	—	—	—	97.8	92.3	86.7	90.1	93.1
	Int	—	—	—	—	—	66.7	64.3	62.3	65.6	70.3
	Elong	—	—	—	—	—	63.4	62.5	53.5	55.1	62.0
	F_1t	—	—	56.1	56.0	—	—	—	—	—	—

Contd.

1	2	3	4	5	6	7	8	9	10	11	12
Total yield/ plant (kg)	Ak	2.22	—	—	—	2.41	3.09	2.71	2.65	2.86	—
	Ox	—	2.16	—	—	—	3.22	2.59	2.51	2.70	2.40
	Int	—	—	—	—	—	2.54	2.34	2.29	2.47	2.62
	Elong	—	—	—	—	—	2.66	2.65	1.99	2.08	2.57
	F_1t	—	—	2.87	2.89	—	—	—	—	—	—
Height of fruit (cm)	Ak	4.1	—	—	—	4.3	4.8	4.7	4.3	4.5	—
	Ox	—	6.1	—	—	—	6.2	6.3	6.1	6.1	6.1
	Int	—	—	—	—	—	6.0	6.0	5.9	5.9	6.1
	Elong	—	—	—	—	—	6.9	7.1	6.5	6.6	7.2
	F_1t	—	—	5.1	5.0	—	—	—	—	—	—
Diameter of fruit (cm)	Ak	4.2	—	—	—	4.4	5.0	4.8	4.5	4.5	—
	Ox	—	6.5	—	—	—	6.6	6.5	6.4	6.4	6.5
	Int	—	—	—	—	—	5.2	5.0	5.0	5.1	5.4
	Elong	—	—	—	—	—	5.3	5.4	5.1	5.1	5.6
	F_1t	—	—	4.9	4.8	—	—	—	—	—	—

AK =Anobik type of fruit, Ox = Oxheart fruit, Int = Intermediate type of fruit, Elong = Elongated type of fruits
F_1t = F_1 type fruit.
** Figures followed by letters in common are not significantly different at the 1% level of probability.

tomato were studied by Mihailov and Popova (1970) and Vorobeva (1976) respectively. In the present work, variation in morphological characters of the parents and progenies and their various combinations have been described. An extensive study on the inheritance of size and shape of tomato fruit was conducted by MacArthur and Butler (1938). They found that of the two genetic factors, one governs the cell division and the other the expansion of cells and they together were responsible for the appearance of the heterozygous combination of fruits. Khan *et al.* (1981) found that the fruit length and breadth are controlled by separate gene systems, thus making various combinations.

From this study it becomes clear that recombination of various fruit types with different plant types are possible. Analysis of morphological data as have been presented in this work might be of value to breeders in recombining characters for obtaining the desired plant type. On the basis of the characters studied and their association, it has been possible to select a few desirable plant types with increased yield/plant and better quality fruits.

References

Butler, L. 1973. Tomato fruit size segregation in F_2 selections. Genetics **74** (2, 11) : S36 (Abst.).

Khan, M. R. I., S. Khanum, M. A. Q. Shaikh and A. K. Kaul. 1981. Genetic studies in tomato (*Lycopersicon esculentum* Mill.). 1. Some qualitative characters. Bangladesh J. Bot. **10**(2): 157-163.

MacArthur, J. W. and L. Butler. 1938. Size inheritance and geometric growth processes in the tomato fruit. Genetics **23**: 253-268.

Mihailov, L. and D. Popova. 1970. Morpholgical and genetic studies of spontaneous tomato mutant. Comptes Rendus de l' Academic des Sciences Agric. Bulgarie. **3** (4): 355-359.

Rahman, M. M., M. A. Mansur and A. Rahman. 1975. Evolution of tomato mutants resistant to bacterial wilt. Annual Report. 1971-73, Institute of Nuclear Agriculture Mymensingh, Bangladesh. pp. 15-16.

Rick, C. M. and W. H. Dempsey. 1969. Position of the stigma in relation to fruit-setting of the tomato. Bot. Gaz. **130** : 180-186

Vorobeva, G. A. 1976. Morphological and biological features in the F_2 of *Lycopersicon esculentum* Mill. × *Solanum pennelli* Corr. Trudy po prikladnoi Botanike genet. Selek. **58** (1) : 94-109. (Russian, English summary).

Williams, W. and N. Gilbert. 1960. Heterosis and inheritance of yield in the tomato. Heredity **14** : 133-149.