STUDY OF INHERITANCE OF SOME QUANTITATIVE TRAITS IN TOMATO

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Abstract. Data are given on the degree of dominance and heterotic effect in 12 intraspecific tomato hybrids F_1 for the length of vegetation period, height of the main stem, number of fruiting branches, number of set fruits on the first two bunches, average fruit weight, and productivity. As a result of the conducted studies, there have been distinguished heterotic hybrids for all studied traits; however, hybrid combinations E 90/7 x Gusar, Kal. J. TNM x Saladette, Katerina x Sanmark are of the main interest as positive heterosis was observed in all their traits. Hybrid combinations with positive heterosis in such traits as: number of fruits in plant, fruit weight, pericarp thickness and number of loculi are also of practical interest. Hybrid combinations with negative heterosis are of some interest for the selection for early ripeness. These were Onix x Saladette, Narvik x Zastava, Kal. J. TNM x Saladette, Nistru x Onix, Katerina x Dana, Katerina x Sanmark. It was found that trait total yield was manifested according to positive overdominance type in 8 of 12 hybrid combinations.

Keywords: dominance, heterotic effect, tomato hybrids, breeding.

Rezumat. Studiul eredităţii unor caractere cantitative la tomate. Sunt prezentate datele despre gradul de dominanţă şi efectul heterozis la 12 combinaţii hibride intraspecifice F_1 de tomate, pentru caracterele: lungimea perioadei de vegetaţie, înălţimea plantei, numărul de ramuri roditoare, numărul de fructe din primele două inflorescenţe, greutatea medie a fructului, productivitatea. În urma investigaţiilor, s-au depistat hibrizi care manifestă heterozis pentru toate caracterele studiate, dar interes deosebit prezintă combinaţiile hibride E 90/7 x Gusar, Kal. J. TNM x Saladette, Katerina x Sanmark care au manifestat heterozis pozitiv pentru toate caracterele evaluate. Interes practic prezintă de asemenea combinaţiile hibride cu efect heterozis pozitiv pentru caracterele: numărul de fructe per plantă, masa fructului, grosimea pericarpului, numărul de loji seminale. Pentru ameliorarea precocităţii prezintă interes combinaţiile hibride cu heterozis negativ. Acestea au fost Onix x Saladette, Narvic x Zastava, Kal. J. TNM x Saladette, Nistru x Onix, Katerina x Dana, Katerina x Sanmark. S-a constatat că 8 din cele 12 combinaţii hibride manifestă supradominanţă pozitivă pentru caracterul recolta totală.

Cuvinte cheie: dominaţie, efect heterozis, hibrizi de tomate, ameliorare.

INTRODUCTION

Being an important vegetable crop, tomato is widely cultivated worldwide. A number of useful elements present in its fruits makes favourable prerequisites for various use of this crop. Wide use of the crop is determined by its high taste and nutritional properties. Tomato fruits are used fresh, boiled, fried and canned. They are widely used for preparation of pastas, sauces, juices and powders.

Many authors highlight that the study of inheritance type and heterotic effect of some agronomic traits is significant for the acceleration of the selection process (BAKULINA, 1970; GUSEVA, 1989; GRATI & GRATI, 1997; ZHUCHENKO et al., 1973; DROGIN, 1977; KUZEMENSKIY, 2004; MAMEDOV & PYSHNAYA, 1996; SKVORTSOVA et al., 1997; TITOK, 2002). It is known that heterosis is manifested in higher viability of plants, fast adaptation to changing environmental conditions, accelerated growth and development, earlier ripeness and higher productivity, increased resistance to diseases (ZHUCHENKO et al., 1973; ZHUCHENKO, 1980; YIORDANOV, 1987). Explanation lies in the fact that heterotic hybrids unlike parental forms have higher energy potential and possibilities for its implementation due to the elimination of many repressing factors at different levels of gene expression (TITOK, 2002).

Many of the agronomic traits of tomato are quantitative traits therefore careful attention is paid to the question of their variability and inheritance, mostly for the preparation of selection-and-genetic programs and successful conduction of the selection process. The specificity of quantitative trait study determined by multiple factors requires certain methods of statistical analysis of experimental data: determination of coefficient of variation, type of inheritance in hybrids F_1 for degree of dominance, and coefficient of inheritance.

The purpose of these studies was to determine the degree of dominance and heterosis effect for some quantitative traits in hybrids F_1 obtained as a result of intervarietal crossing of varieties of different ecological origin for the prediction of the efficacy of further selection process.

MATERIAL AND METHODS

The material for the study included 12 hybrid combinations of tomato and their parental forms. All parental forms present a determinate growth, while Burnley Metro presents an indetermined growth. Field experiments were designed as three repetitions in randomized blocks in transplanted culture. The scheme of planting in greenhouse was 7 x 10 cm, and scheme of planting of transplant seedlings in the field was 70 x 30 cm. Transplant seedlings were planted in the second decade of May. Harvesting was many-fold (4-6). Tomatoes were cultivated and grown in accordance with the technology approved in the Republic of Moldova (YERSHOVA, 1978). The degree of trait dominance (h_p) was evaluated as per Brubaker (BRUBAKER, 1966). The heterosis effect magnitude (MPH) was determined as per Lamkey, Edwardes (LAMKEY & EDWARDS, 1999), using equation MPH = (F_1-P) / P, where F_1 is the mean value of trait in hybrid F_1, P is the mean value of trait of both parents. The heterosis index was determined as the ratio of hybrid F_1 trait

to the mean value of trait in parental forms. Phenological observations and relevant measurements of plants and their organs were made in the field during the vegetation period.

The obtained experimental data were subjected to statistical analysis using Statistica 7 software package.

Agronomic parameters included length of vegetation period, height of the main stem, number of fruiting branches, number of set fruits on the first two bunches, fruit weight, and productivity.

The type of inheritance of traits that determine the rate of passing through phenological phases is very significant for the creation of varieties with different ripeness and especially with early ripeness. The development and magnitude of early ripeness trait is controlled by respective genes expressing certain effect.

RESULTS AND DISCUSSIONS

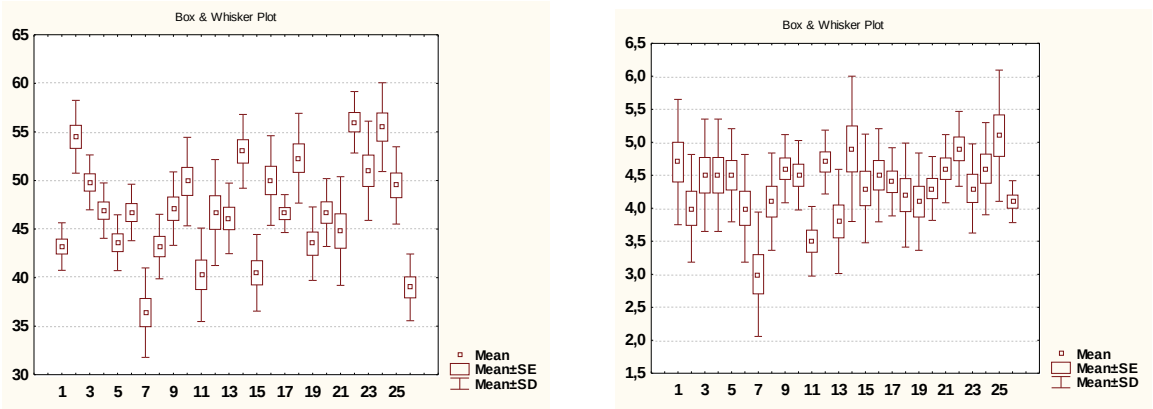
As a result of our studies, significant varietal differences in the degree of manifestation of early ripeness trait were revealed. Data in Table 1 show significant varietal diversity in the duration of "seedlings-blossom" period. Earlier blossoming was observed in the varieties Costral and Dana (61 days), and the latest was observed in the varieties Narvik (75 days) and E 90/7 (74 days). The data on the phenotypic variation of "blossom-ripening" phenophase duration allows stating that this period is also very changeable. The shortest *blossom-fruit ripening* period was found in the variety E 90/7 (38 days), and the longest one was in the variety Saladette (54 days).

Table 1. Degree of dominance and heterosis effect for the duration of the vegetation period trait and its phenophases in tomato hybrids F_1.

Hybrid combinations	Seedlings – blossom			h_p	MPH	Blossom – ripening			h_p	MPH	Vegetation period			h_p	MPH
	P_1	P_2	F_1			P_1	P_2	F_1			P_1	P_2	F_1		
Onix x Saladette	71	64	62	-1.6	-7.8	42	54	50	0.33	4.2	111	117	111	-1.0	-2.6
Katerina x Burnley Metro	70	67	69	0.33	0.7	47	44	44	-1.0	-3.2	116	110	112	-0.33	-0.9
E 90/7 x Gusar	74	61	67	-0.08	-0.7	38	42	45	2.5	12.5	111	102	111	1.0	4.2
Narvik x Zastava	75	64	61	-1.5	-12.2	47	48	50	5.0	5.2	121	111	110	1.2	-5.2
Kal. J. TNM x Saladette	67	64	62	-2.3	-5.3	50	54	50	-1.0	-3.8	116	117	111	-11.0	-4.7
Katerina x Zastava	70	64	62	-1.7	-7.5	47	48	50	5.0	5.3	116	111	111	-1.0	-0.9
Nistru x Onix	64	71	61	-1.8	-9.6	49	42	50	1.3	9.9	111	111	110	0	-2.2
E 90/7 x Kredo	74	68	61	-3.3	-14.1	38	45	51	2.7	22.8	111	112	111	-1.0	-0.4
Katerina x Dana	70	61	62	-0.78	-5.3	47	42	42	-1.0	-5.6	116	102	103	-0.86	-5.5
Katerina x Sanmark	70	68	62	-7.0	-10.1	47	50	51	1.7	5.1	116	117	111	-11.0	-4.7
E 90/7 x Costral	74	62	75	1.2	10.3	38	42	44	2.0	10.0	111	103	118	2.75	10.3
Nistru x Saladette	64	64	62	0	3.1	49	54	56	1.8	8.7	111	117	117	1.0	2.6

The results of our studies of the dominance degree and heterosis for the trait *vegetation period* and its phenophases revealed significant variability – from negative to positive overdominance (Table 1). Hybrid combinations with negative heterosis are of certain interest for early ripeness selection. Six such hybrids were found: Onix x Saladette, Narvik x Zastava, Kal. J. TNM x Saladette, Nistru x Onix, Katerina x Dana, Katerina x Sanmark.

The study results allowed reveal significant varietal differences in the degree of manifestation of the traits *height of the main stem* and *quantity of fruiting branches* (Fig. 1). Stunt varieties included Saladette and Gusar; their height was 36.4 cm, 40.3 cm, respectively. The height of the main stem of other varieties was over 43.0 cm (Fig. 1 A). This parameter varied in hybrid combinations from 39.0 cm to 56.0 cm. Stunt hybrid combinations were Nistru x Saladette (39.0 cm) and Onix x Saladette (40.5 cm).



A B

Figure 1. Variability of traits: *height of the main stem* (A) and *number of fruiting branches* (B).

1. Nistru; 2. Katerina; 3. Narvik; 4. Onix; 5. Kal.J.TNM; 6. E 90/7; 7- Saladette; 8. Zastava; 9. Kredo; 10. Burnley Metro; 11. Gusar; 12 Dana.; 13. Sanmark; 14. Costral ; 15. Onix x Saladetete; 16. Katerina X Burnley Metro; 17. E 90/7 x Gusar; 18. Narvic x Zastava; 19. Kal.J.TNM x Saladette; 20. Katerina x Zastava; 21. Nistru x Onix; 22. E 90/7 x Kredo; 23. Katerina x Dana; 24. Katerina x Sanmark; 25. E 90/7 x Costral; 26. Nistru x Saladette

The original forms also were different in the number of fruiting branches (Fig. 1 B). Lower values were found in the varieties Saladette, Gusar and Sanmark (3.0-3.8). This parameter varied in other genotypes within the range of 4.0 to 4.9 cm, in hybrid combinations it varied from 4.1 to 5.1 cm.

The study of the trait *height of the main stem* demonstrated that 3 hybrids F_1 of 12 hybrid combinations had positive overdominance with the degree of dominance from 1.24 in hybrid Katerina x Sanmark to 90.0 in E 90/7 x Kredo. At that, heterosis in these combinations was 10.34-19.5% (Table 2).

The manifestation of heterosis in tomato yield is possible under favourable combination of the following traits in hybrid: *number of fruiting branches, number of fruits in the plant* and their average weight. The parameter *number of fruiting branches* was inherited in hybrids according to the positive overdominance type (1.0…7.0) and negative dominance (-0.05). There have been identified 6 hybrids with positive overdominance. Data given in Table 2 show that the heterotic effect largely depends on specific properties of the parental forms. The highest heterosis for the number of fruiting branches was observed in the combinations E 90/7 x Gusar (18.92), Katerina x Sanmark (17.95), E 90/7 x Costral (15.9), E 90/7 x Kredo (15.29), Onix x Saladetete (14.67%).

According to many researchers (AVERCHENKOVA, 1981; GRATI et al., 2008; DROGIN, 1977; KUZEMENSKIY, 2004; MAMEDOV. & PYSHNAYA, 1996), heterosis in yield is mostly manifested as a result of the increase of the number of fruits in plant. Hybrids were obtained, in which heterosis was manifested both in the increased number of fruits in plant and fruit weight (GVOZDENKO, 1971; OGANISYAN, 1970). The studies conducted by Kuzemenskiy [16] showed that the increase in the number of fruits had the prevailing influence on the increase of yield in hybrids F_1 even with simultaneous heterosis in fruit weight. The degree of dominance for the number of fruits on the first bunch varied from 0.8 to 13. 11 combinations showed positive overdominance except for Katerina x Zastava. 10 combinations showed positive overdominance in the number of set fruits on the second bunch, except for the combinations E 90/7 x Costral and Katerina x Danna, where the degree of dominance was 0.83 and 0.86, respectively. According to our data, the highest heterotic effect for the number of fruits on the first bunch was manifested in seven combinations of crossing and it was 15.79% in Katerina X Burnley Metro and up to 28.2% in the hybrid Narvic x Zastava. It should be noted that more pronounced positive heterosis in the *number of fruits on the second bunch* was found in all combinations. The results of the study of dominance and heterotic effect of trait *number of fruits in plant* indicate high selective value of the studied hybrids.

Table 2. Characteristics of intervarietal tomato hybrids F_1 by manifestation of heterosis and inheritance of some traits.

Hybrid combinations	Height of the main stem, cm		Number of fruiting branches		Number of fruits			
					First bunch		Second bunch	
	h_p	MPH	h_p	MPH	h_p	MPH	h_p	MPH
Onix x Saladetete	-0,14	-1,7	0,73	14,67	2,0	17,78	10,0	28,6
Katerina X Burnley Metro	-0,96	-4,21	1,0	5,88	2,0	15,79	3,8	40,42
E 90/7 x Gusar	0,91	6,64	3,5	18,92	1,67	5,49	2,33	10,45
Narvic x Zastava	1,76	12,47	-0,5	-2,32	1,83	28,2	4,33	23,64
Kal.J. TNM x Saladette	0,97	8,75	0,47	9,33	4,6	24,73	3,0	24,32
Katerina x Zastava	-0,54	-6,24	7,0	8,64	0,8	10,0	1,5	24,0
Nistru x Onix	-0,14	0,45	0,0	0,0	7,0	24,7	4,0	21,05
E 90/7 x Kredo	90,0	19,15	1,86	15,29	2,0	8,69	19,0	29,23
Katerina x Dana	0,1	0,79	-0,14	-1,15	1,15	18,07	0,86	21,43
Katerina x Sanmark	1,24	10,34	7,0	17,95	13,0	18,31	2,43	34,7
E 90/7 x Costral	-0,05	-0,3	1,4	15,9	3,0	6,67	0,83	13,16
Nistru x Saladette	-0,23	-2,0	0,29	6,49	4,2	22,58	2,67	21,62

The results of our studies with regard to the degree of dominance of the trait *average fruit weight* showed intermediate dominance in 6 combinations and positive overdominance in 5 combinations.

The calculation of heterosis effect showed that the mean parental value of fruit weight in the studied combinations was higher than that in all combinations except for Katerina x Zastava, where it was at its level. It should be noted that heterosis magnitude of the studied trait was within 4.1 to 15.6 in the majority of combinations except for E 90/7 x Gusar that had the most pronounced heterotic effect in this parameter – 40.05%.

Table 3. Degree of dominance and heterosis for fruit weight and productivity in tomato hybrids F_1.

S/N	Hybrid combinations	Fruit weight	h_p	MPH	Yield, t/ha	h_p	MPH
1	Onix x Saladette	81.5±2.81	0.92	15.6	57.14	0.08	1.9
2	Katerina x Burnley Metro	127.4±7.12	5.0	4.1	64.15	-3.69	-19.0
3	E 90/7 x Gusar	154.2±13.14	3.22	40.05	68.83	0.44	10.0
4	Narvik x Zastava	149.2±9.37	0.15	2.9	109.3	6.28	43.2
5	Kal..J. TNM x Saladette	72.2±2.33	0.1	1.69	77.14	3.56	60.2
6	Katerina x Zastava	120.8±5.01	-0.03	-0.08	95.58	5.31	22.1
7	Nistru x Onix	76.0±3.94	0.55	11.45	71.69	1.19	15.5
8	E 90/7 x Kredo	135.2±4.71	5.56	11.46	84.15	- 0.3	-3.4
9	Katerina x Dana	137.0±6.61	1.57	7.78	80.52	1.74	19.0
10	Katerina x Sanmark	139.6±7.64	2.08	8.9	91.43	16.82	23.5
11	E 90/7 x Costral	100.1±6.0	0.16	4.93	79.77	2.84	5.4
12	Nistru x Saladette	57.2±2.37	0.39	1.6	63.66	2.60	32.6

Many plant breeders have studied the type of manifestation of tomato total yield trait in F_1. The analysis of literature data (9, 6, 16) showed prevailing overdominance for this trait in F_1. Our studies confirmed that this trait is manifested according to the positive overdominance type in the majority of hybrid combinations (8 of 12), negative overdominance was found only in one combination Katerina x Burnley Metro, and intermediate dominance was found in combinations Onix x Saladette, E 90/7 x Gusar and E 90/7 x Kredo.

As to the magnitude of heterosis effect for productivity, there are different data in literature. The majority of authors reported that the increase in yield in heterotic tomato hybrids averages between 20% and 50%. According to our data, positive heterosis for hybrids F_1 obtained as a result of intervarietal crossing was 1.9%....60.2%. The manifestation of heterosis in the total yield was more pronounced in hybrid combinations Kal. J. TNM x Saladette, Narvik x Zastava, where yield increase was 60.2% and 43.2%, respectively. It should be noted that the combinations Narvik x Zastava, Nistru x Onix, Katerina x Dana combine high productivity and early ripeness that is of special interest for further selection process.

CONCLUSIONS

1. As a result of the conducted studies we succeeded in selecting heterotic hybrids for all studied traits; however hybrid combinations E 90/7 x Gusar, Kal. J. TNM x Saladette, Katerina x Sanmark are of special interest due to the positive heterosis for all traits. Hybrid combinations with positive heterosis for the number of fruits in plant, fruit weight, pericarp thickness and number of loculi are also of practical interest.
2. Specificity of the type of inheritance of quantitative traits in F_1 is observed in tomato. Hybrid combinations with negative heterosis are important for early ripeness selection. These were Onix x Saladette, Narvik x Zastava, Kal. J. TNM x Saladette, Nistru x Onix, Katerina x Dana, Katerina x Sanmark.
3. It was revealed that the trait *total yield* was manifested according to the positive overdominance type in 8 of 12 hybrid combinations, negative overdominance was observed only in one combination - Katerina x Burnley Metro, and intermediate dominance was found in the combinations Onix x Saladette, E 90/7 x Gusar and E 90/7 x Kredo.

REFERENCES

AVERCHENKOVA Z. 1981. Specificity of heterosis manifestation in tomato. *Advanced technology of vegetable crop growing*. Moscow: 72-77.

BRUBAKER D. 1966. *Agricultural genetics*. Moscow. 223 pp.

BAKULINA V. 1970. *Regarding the study of some agronomic traits of tomato fruits*: author's abstract of thesis of the candidate of agricultural sciences: 06.01.05. Moscow. 12 pp.

GVOZDENKO T. 1971. *Tomato selection under the conditions of low-lying Karabakh and Apsheron*: author's abstract of thesis of the candidate of agricultural sciences: 06.01.05. Baku. 29 pp.

GRATI M., MIHNEA N., JAKOTA A., GRATI V. 2008. Heterosis in tomato hybrids F_1 for the main agronomic traits. *Current tendencies in selection and seed farming of vegetable crops. Traditions and perspectives. I International Fundamental and Applied Sciences Conference (4-6 august 2008.* Moscow. **2**: 202-206.

GUSEVA L. 1989. *Methods of tomato selection for intensive technologies*. Edit. „Ştiinţa". Chişinău. 223 pp.

GRATI V. & GRATI M. 1997. Combinability of some promising forms of tomato. *Heterosis in agricultural plants.* Moscow: 100-101.

DASKALOV H., MIKHOV A., MINKOV I. 1987. *Heterosis and its use in vegetable growing*. "Kolos". Moscow. 64 pp.

YERSHOVA V. 1978. *Cultivation of tomato in open ground.* Edit. „Ştiinţa". Chişinău. 280 pp.

DROGIN M. 1977. *Initial material for evenly ripening tomatoes suitable for mechanical harvesting under the conditions of the Lower Volga Region*: author's abstract of thesis of the candidate of agricultural sciences: 06.01.05. Kharkov. 22 pp.

ZHUCHENKO A., ADRIUSCHENKO V., KOROL M. 1973. *Variability and inheritance of agronomic traits in tomato*. Chişinău. Edit: Kartea Moldoveneaska. 632 pp.

ZHUCHENKO A. 1973. *Tomato genetics*. Edit. „Ştiinţa". Chişinău. 662 pp.

ZHUCHENKO A. 1980. *Ecological genetics of cultivated plants (adaptability, recombinogenesis, agrobiocenosis.* Edit. „Ştiinţa". Chişinău. 587 pp.

YIORDANOV M. 1987. Tomato heterosis. *Heterosis*. Moscow: 239-253.

KUZEMENSKIY A. 2004. *Selection and genetic studies of tomato mutant forms*. Kharkov. Magda LTD. 391 pp.

MAMEDOV M. & PYSHNAYA O. 1996. Selection for early ripened heterotic hybrids F_1 of sweet pepper. *Selection of vegetable crops and gourds for heterosis*. Kharkov: 26-28.

MAMEDOV M., PIVOVAROV V., PYSHNAYA O. 2002. *Selection of tomato, pepper and eggplant for adaptability*. M. 442 pp.

OGANISYAN R. 1970. *Use of tomato heterosis under the conditions of Martuninskiy region in the Armenian Soviet Socialist Republic*: author's abstract of thesis of the candidate of agricultural sciences: 06.535, Yerevan. 32 pp.

SKVORTSOVA R., GURKINA L., MAMEDOV M. 1997. Specifics of heterosis manifestation in tomato hybrids of the first generation for early ripeness and resistance to phytophthora strains. *Heterosis in agricultural plants*. International Symposium Moscow: 144-150.

TITOK V. 2002. Bioenergetic basis of heterosis in agricultural plants. Genetics and selection in the XXI century. *Materials of the 8th meeting of geneticists and plant breeders of the Republic of Belarus.* Minsk: 163-165

LAMKEY K. & EDWARDS I. 1999. The quantitative genetics of heterozis. *Genetics and Exploitation of Heterozis in crops*. USA. Madison. **1**: 31-48.

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Received: March 28, 2014
Accepted: May 18, 2014