THE INFLUENCE OF THE MATERNAL FACTOR ON THE EFFECTS OF GENE INVOLVED IN THE CONTROL OF QUANTITATIVE CHARACTERS IN TOMATO

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Abstract. According to contemporary bibliographical sources, the maternal factor has an important role in resetting the genetic formulas underlying the phenotypic manifestation of quantitative characters, but the mechanisms of phenomenon, at the moment, are quite uncertain. By researching the influence of the maternal factor on the effects of gene involved in the control and heritability of biological characters and productivity of tomato it was found that the maternal factor strongly influenced the level, the orientation and the variance of gene effects which control the quantitative characters of the tomato fruit. Changing the level of the heritability coefficient in a broad sense in reciprocal crosses reveals the influence of the maternal factor on the rate of participation of the genotype in the formation of phenotype quantitative character and its hereditary transmission capacity.

Keywords: maternal effect, tomato, epistasis, heritability.

Rezumat. Influenţa factorului matern asupra efectelor genice implicate în controlul unor caractere cantitative la tomate. Conform surselor bibliografice contemporane, factorul matern deţine un rol important în resetarea formulelor genetice care stau la baza manifestării fenotipice a caracterelor cantitative, însă mecanismele fenomenului, la moment, sunt destul de incerte. Prin cercetarea influenţei factorului matern asupra efectelor genice implicate în controlul şi heritabilitatea unor caractere biologice şi de productivitate la tomate s-a constatat că factorul matern a influenţat puternic nivelul, orientarea şi varianţa efectelor genice care controlează caracterele cantitative ale fructului de tomate. Schimbarea nivelului coeficientului de heritabilitate în sens larg în încrucişările reciproce, relevă influenţa factorului matern asupra ratei de participare a genotipului în formarea fenotipului caracterului cantitativ şi capacităţii de transmitere ereditară a acestuia.

Cuvinte cheie: efect matern, tomate, epistazie, heritabilitate.

INTRODUCTION

The redistribution epigenetic of gene expression is manifested through various actions and interactions of gene (HOLLAND, 2001). The epistasis or interaction between non-allelic genes has long been recognized as having fundamental importance for the understanding of the structure and realization of the function of the genetic pathways and evolutionary dynamics of complex genetic systems. The development of functional genomics and the emergence of systemic concepts in biology, as well as the skills of determining the genetic basis of evolution starting from specific molecular changes is a new approach to the importance of research of gene interactions for genesis and functionality of a unified system of control of quantitative characters (PHILLIPS, 2008). Underestimating these effects may lead to the simplification of the models of describing the heritability of complex characters (CARLBORG & HALEY, 2004) and creating impediments in the efforts to detect loci quantitative characters. Epistasis between the loci contributes significantly to the variance of quantitative characters, and, in particular, to the determination of the genetic architecture of complex characters (COREȚCHI, 2013).

It is recognized that the level of variability of the phenotype can be caused not only by genotype and the ambient environment, but also by maternal effects – particularly important for the evolution and adaptability of organisms to environmental conditions.

Maternal effects can contribute considerably to increase the variance of several characters, in particular, if they manifest the stages of early ontogenetic. Elucidating how the epistasis may result from maternal effects may contribute to understanding the role of these gene effects in evolutionary processes. At the same time, mother- descendant interactions may lead to the appearance of the epistasis in the genotype through various biochemical or physiological ways (WOLF, 2000).

The research goal was to elucidate the influence of the maternal factor on the effects of gene involved in the formation and heritability of quantitative characters in tomato (*Solanum lycopersicum* L.).

MATERIAL AND METHODS

Three combinations of reciprocal hybrids belonging to F_1 and F_2 generations, derivatives from 4 varieties of tomatoes - Gloria, Jubiliar, Atlasnâi, Zastava were used as research material as they present many characters.

There were analysed the following biological indices: the number of seeds per fruit, fruit mass (g), fruit length and diameter (mm), pericarp and mesocarp thickness (mm), number of seminal lodges, plant height (cm); of productivity: mass (g) and number of fruit per plant.

The influence of the maternal factor was determined based on of reciprocity effect (r_e) according to the formula proposed by the author (REINHOLD, 2002).

The actions and interactions of gene were established and calculated by the model proposed by GAMBLE (1962). The coefficient of heritability in broad sense (H) was established after Warner (BOROJEVIC, 1990). The statistical processing of data was performed in STATISTICA 7 software package.

RESULTS AND DISCUSSION

The research of the parental effects has demonstrated the differentiated contribution of maternal factors depending on the character and combination. The most pronounced influence of the maternal form on the effects of gene was manifested in the combination of Gloria x Jubiliar (G x J)/Jubiliar x Gloria (J x G) for the characters fruit length (1), index fruit (2), pericarp thickness (3), number of seminal lodges (4), fruit mass (5) and number of fruit per plant (6) (GRIGORCEA et al., 2014).

Choosing the variety Jubiliar as maternal form, with the above indices of the mentioned characters compared with variety Gloria, contributed to the increase of the average in the population F_2 Jubiliar x Gloria with 8.3; 4.6; 8.9; 7,7; 30.0 and 24.0%, respectively, for 1, 2, 3, 4, 5, 6 (Table 1).

Table 1. Phenotypic effects and genetic mechanisms of the combination Jubiliar x Gloria.

No.	Character	The report of means F_2 J x G/ F_2 G x J, %	Genetic mechanisms
1	Fruit length	8 .3	Reorientation epistasis *dd* from negative to positive
2	Index fruit	4 .6	-"-
3	Pericarp thickness	8 .9	-"-
4	Number of seminal lodges	7 .7	Increasing the level of positive to the epistasis *dd*.
5	Fruit mass	30 .0	Increasing the level of positive to the epistasis *ad*; Reorientation epistasis *dd* from negative to positive.
6	Number of fruit per plant	25 .0	Reorientation epistasis *dd* from negative to positive.

Thus, one of the important genetic mechanisms, which induces the increase or the decrease of the quantitative characters – biological and productivity of tomatoes, consists in the influence of the maternal factor on epistasis *ad* and/or *dd* involved in the control and heritability characters.

The calculation of the average gene effects for the combinations Gloria x Jubiliar, Gloria x Atlasnâi, Gloria x Zastava (1 x 2) and Jubiliar x Gloria, Atlasnâi x Gloria, Zastava x Gloria (2 x 1) has shown that the direction of the crossover strongly influenced the level, orientation and variance of gene effects, which controls the quantitative characters of tomato fruit, less, however, being influenced the number of seminal lodges (Table 2).

Table 2. The influence of the maternal factor on the actions and interactions of gene involved in controlling quantitative characters of tomato fruit.

Cross	a	d	aa	ad	dd
Fruit mass					
1 x 2	-26 .8	23 .4	-6 .2	203 .4	-16 .7
2 x 1	-5 .0	-112 .9	-104 .6	226 .8	46 .1
Pericarp thickness					
1 x 2	-0 .5	3 .6	2 .9	16 .5	-8 .5
2 x 1	-0 .3	-6 .9	-7 .5	16 .7	8 .8
Mesocarp thickness					
1 x 2	-5 .1	1 .31	-11 .1	118 .4	5 .0
2 x 1	-1 .5	-14 .1	-17 .2	122 .8	-0 .2
Number of seminal lodges					
1 x 2	-0 .6	-1 .9	-1 .7	12 .3	3 .8
2 x 1	-0 .4	-6 .5	-4 .8	12 .5	6 .3
Number of seeds per fruit					
1 x 2	-0 .3	10 .6	-27 .0	196 .3	-12 .0
2 x 1	42 .7	24 .3	24 .2	239 .3	-114 .0
Fruit length					
1 x 2	6 .1	17 .3	17 .4	148 .9	-53 .9
2 x 1	-9 .0	-35 .4	-42 .1	133 .8	57 .8
Fruit diameter					
1 x 2	-0 .6	-2 .2	-7 .6	147 .9	-4 .2
2 x 1	-1 .7	3 .1	-4 .9	146 .7	2 .9
Fruit index					
1 x 2	0 .07	0 .16	0 .30	3 .01	-0 .76
2 x 1	-0 .20	-0 .71	-0 .66	2 .74	0 .90

From the practical point of view is important to elucidate the manner how the gene effects, particular or in association, contribute to increase or diminution of the character of interest. Thus, it has been proceeded to cluster analysis in order to determine the degree of association of the average character in F_2 population with gene effects involved in the formation of phenotype. Thus, according to the dendrogram of distribution, in all cases, the average F_2

presented high associative connection with epistasis *ad*, and for such characters as number of seminal lodges, fruit mass, number of fruit per plant – and with epistasis *dd* (Fig. 1), which reveals their major involvement in the formation of the genetic potential to the population F_2 (GRIGORCEA, 2014).

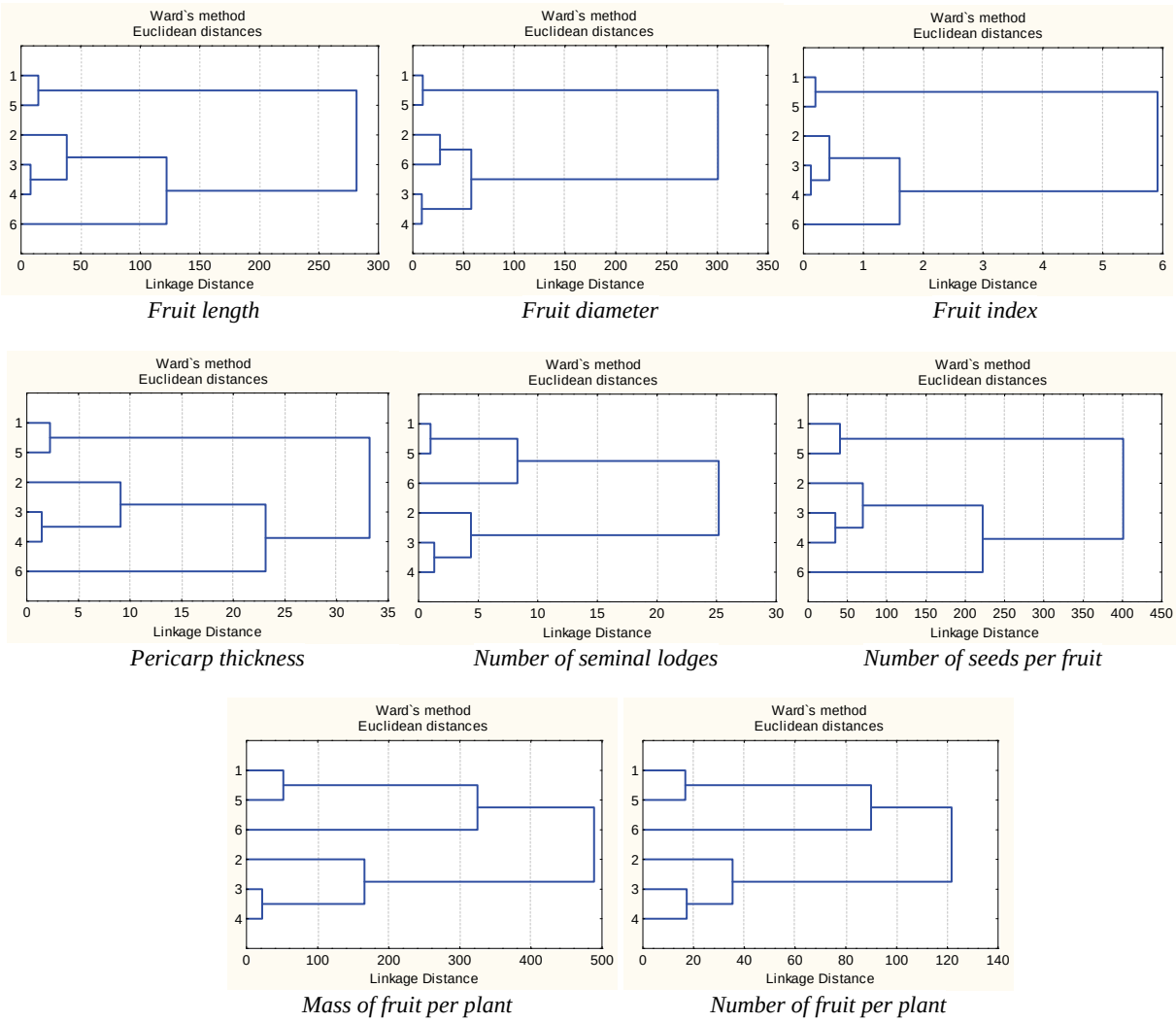

Figure 1. The dendrogram of the distribution of the mean population F_2 and gene effects involved in the control of some quantitative characters of tomato
Legend: 1 – mean in population F_2, 2 – *a*, 3 – *d*, 4 – *aa*, 5 – *ad*, 6 – *dd*

The influence of the maternal factor on the actions and interactions of gene was reflected on the capacity of inheritance of characters (Table 3).

Values of heritability coefficient reveal that the phenomenon depends on the character, combination and crossing direction. In all cases, the reciprocal crosses have determined changes in the level of heritability coefficient, which reveals the importance of correct choice of components of hybridization as maternal or paternal form to streamline donors of certain qualities.

Table 3. Heritability coefficient of tomato fruit characters on the reciprocal combinations.

No.	Combination	Fruit mass	Pericarp thickness	Mesocarp thickness	Number of seminal lodges	Number of seeds per fruit	Fruit length	Fruit diameter	Number of fruit per plant
1	Gloria x Jubiliar	0 .50	0 .43	0 .17	0 .35	0 .43	0 .49	0 .66	0 .28
2	Jubiliar x Gloria	0 .65	-0 .21	0 .59	0 .87	0 .01	0 .64	0 .50	0 .26
3	Gloria x Atlasnâi	0 .61	-0 .19	0 .47	0 .25	0 .43	0 .65	0 .75	0 .31
4	Atlasnâi x Gloria	0 .63	-0 .05	0 .70	0 .36	0 .69	0 .17	0 .09	0 .61
5	Gloria x Zastava	0 .04	0 .24	0 .05	0 .12	-0 .04	0 .14	0 .36	0 .45
6	Zastava x Gloria	0 .26	0 .01	0 .24	0 .27	0 .33	0 .08	0 .49	0 .28

Therefore, the maternal factor is involved in the control of the morphobiologic characters of fruit and productivity elements by regulation/reset actions (*additive, dominant*) and interactions (*additive x additive, additive x dominant and dominant x dominant*) gene (GRIGORCEA, 2014).

CONCLUSIONS

1. Based on reciprocal hybrids, it was found that maternal factors determine the level and direction (+/-) of gene effects involved in the control of biological characters and productivity of tomato, these effects depending largely on the combination and character.
2. The basic genetic mechanisms of the influence of the maternal factor involved in the formation of phenotypes with high indices in F_2 segregating population consisted in the degree and mode of manifestation – differentiated or associated gene interactions.
3. Changing the level of heritability coefficient in a broad sense in reciprocal crosses reveals the influence of the maternal factor on the rate of participation of the genotype in the formation of phenotype quantitative character and its hereditary transmission capacity.

REFERENCES

BOROJEVIC S. 1990. *Principles and Methods of Plant Breeding*. Edit. Academy-Verlag. Berlin. 368 pp.

CARLBORG Ö. & HALEY C. 2004. Epistasis: Too often neglected in complex trait studies? *Nature Reviews Genetics.* **5**: 618-625.

COREȚCHI LIUBOV. 2013. Controlul genetic al interacţiunii culturilor leguminoase cu fitopatogenii. Chişinău. 47 pp.

GAMBLE E. E. 1962. Gene effects in corn (*Zea mays* L.). I. Separation and relative importance of gene effects for yield. *Canadian Journal of Plant Science*. **42**: 339-348.

GRIGORCEA S. 2014. *Influenţa factorului matern asupra rezistenţei la patogenii fungici şi elementelor de productivitate la tomate* (*Solanum lycopersicum*). Ph. D. Thesis, Institute of Genetics, Physiology and Plant Protection of the Academy of Sciences of Moldova: Chişinău. 37 pp.

GRIGORCEA SOFIA, LUPASCU GALINA, MIHNEA NADEJDA. 2014. Maternal factor role in the genetic control of some fruit characteristics and productivity of tomato plants. *Collection of scientific papers "Vegetable breeding and seed production"* Moscow. 2014. 234 pp. [In Russian].

HOLLAND J. B. 2001. Epistasis and plant breeding. *Plant Breeding Reviews*. U. S. Departament of Agriculture. Nord Carolina State. **21**: 27-92.

PHILLIPS P. C. 2008. Epistasis - the essential role of gene interactions in the structure and evolution of genetic systems. *Nature Reviews Genetics. https://scholar.google.com/citations? view_op=view_citation&hl=en&user= JbH6mVkAAAAJ&citation_for_view=JbH6mVkAAAAJ:9yKSN-GCB0IC*. **9**(11): 855-867. Accesed February, 2015.

REINHOLD K. 2002. Maternal effects and the evolution of behavioural and morphological characters: a literature review indicates importance of extended maternal care. *Journal of Heredity*. **93**(6): 400-405.

WOLF J. B. 2000. Gene interactions from maternal effects. *Evolution.* http://www.ncbi.nlm.nih.gov/pubmed/11209768. **54**(6): 1882-1898. (Accesed February, 2015).

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