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Original scientific paper

ASSESSMENT OF YIELD AND YIELD STABILITY OF NEW PERSPECTIVE PEPPER BREEDING LINES WITH CONICAL SHAPE

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The main goal of the present study was to estimate new perspective Bulgarian conic lines pepper about yield and stability of the yield with purpose to be presented for Government variety testing and to been included in new breeding programs. Three years experiments were carried out in Experimental fields of Agricultural University, Plovdiv, Bulgaria with eight new perspective consolidated hybrids of sweet pepper. Typical Bulgarian variety Kurtovska kapia 1619 was used as a standard. The plants were grown according to the conventional technology for middle early field production for South Bulgarian condition. Four harvests were done – one of green fruits and three of red ripening fruits. The total yield, weight and length of fruit were determined. The stability of yield (Ysi) by the methods Kang was calculated. The lines with the highest yield were Doux Marconi Rouge x Kapia 1300 F_8 and Doux Marconi San Semences x Kalinkov 800/7 F_7 with productivity of 5034.1 kg/da and 4881.3 kg/da respectively. The index of yield stability was highest 7+ about following breeding lines Doux Marconi San Semences x Kalinkov 800/7 F_7 and Kapia 1300 x Doux d'Espagne F_9. The lines Doux Marconi Rouge x Kapia 1300 F_8, Doux Marconi San Semences x Kalinkov 800/7 F_7 and Doux Marconi Rouge x Kapia 1300 F_7 are suitable to be included in new selection programs for more successfully breeding.

Key words: adaptability, index of stability, Kang (YSi), productivity, selection

INTRODUCTION

The stability of yield is a complex index about adaptability of given genotype and its ability to develop a higher productivity potential through better use of natural resources and climate conditions. Based on the yield stability index and rank-sum the most stable genotypes

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with high productivity can be identified (FARSHADFAR *et al.,* 2011). MEKBIB (2003) reported that stability can be grouped into three groups according to the knowledge generated by stability index. The yield is a sign which is controlled by a complex polygenic system and strong varies depending on the environmental conditions, therefore establishment of phenotypic stability is of paramount importance to their successful implementation. Higher variety phenotypic productive stability, which is result of it genetic peculiarity and also of environmental condition, indicate their better adaptability and steady manifestation of their indexes and less marked genotype-environmental interaction. The changes of environmental factors, during important organogenesis stages and phases of genetics development of plant, caused changes in specters of locus, determining quantitative plant indexes and yield respectively (RACHOVSKA *et al.*, 2011). Establishment of adaptability and yield stability of varieties and breeding lines is very important for the relationship between genotype and climatic conditions and hence the behaviors of these genotypes in different years, locations and growing seasons (CARBONELL and POMPEU, 2000).

CARBONELL and ANTONIO (2001) emphasized that the experimental coefficient of variation is widely used for statistical evaluation of different genotypes. In this sense availability of varieties with weaker deviation from the average of the genotype is a prerequisite for their successful inclusion in breeding programs (DIMOVA and PETROVSKA, 2010).

The main goal in vegetable growing is to achieve maximum productivity in different environmental conditions. Furthermore through implementation of specific agri-technology practices (HAYTOVA and BABRICOV, 2006; HAYTOVA and GERGOVA, 2011; CHOLAKOV, 2003; CHOLAKOV 2009; VLAHOVA *et al.* 2010, CHOLEVA *et al.*, 2010), high productivity potential and better adaptability are achieved manly through targeted breeding activity. In Bulgaria the pepper population is characterized with wide diversity of varieties, form, shape of fruit and cultivars (TODOROVA 2011; TODOROVA and PEVICHAROVA, 2012). The breeding programs in this crop are primarily aimed to increasing the productivity and to creation of varieties with sustainable manifestation of signs and with high adaptability (TODOROVA *et al.*, 2004; TODOROVA *et al.*, 2011). The main parameters and statistical interdependences that are responsible about formation of pepper seed yield have been established (PANAYOTOV *et al*., 2010)

One of the most accurate and widely applied methods about estimation of yield stability is a parameter of KANG (1993) – Ysi. Through it is established summary information about yield as well as stability of it expressed in changes of climatic conditions (RACHOVSKA *et al.*, 2002).

The main goal of this study was to assessment new perspective pepper breeding lines by yield, yield stability and stability of some important morphological signs with aim propose them for Government variety testing and for successful inclusion in new breeding programs.

MATERIALS AND METHODS

Field trial and yield establishment. Competition variety experiments were carried out in the Experimental field of Department of Horticulture and of Department of Genetic and breeding at the Agricultural University of Plovdiv, Bulgaria in 2010-2012 years with new promising hybrids pepper lines. Eight conical shape pepper lines, consolidated in the referred generation from F_7 to F_9, are results from hybridisation between varieties Kurtovska kapia 1619, Kapia 1300, Kalinkov 800/7, Zlaten medal 7, Doux d'Espagne, Doux Marconi Geonet, Doux Marconi Rouge and Doux Marconi San Semences, as follows:

- Breeding line 200051-10 - Kapia 1300 x Doux d'Espagne F_8;
- Breeding line 200049-10 - Kapia 1300 x Doux d'Espagne F_9;

- Breeding line 200056-10 - Doux Marconi Rouge x Kapia 1300 F_7;
- Breeding line 200055-10 - Doux Marconi Rouge x Kapia 1300 F_8;
- Breeding line 200040-10 – Zlaten medal 7 x Doux Marconi Geonet F_7;
- Breeding line 200022A-10 - Doux Marconi Geonet x Kurtovska kapia 1619 F_8;
- Breeding line 200074-10-Doux Marconi Geonet x Kurtovska kapia 1619 F_7;
- Breeding line 20007A-10 - Doux Marconi San Semences x Kalinkov 800/7 F_7.

For the sake of brevity further in the text the breeding lines are mentioned with those numbers. As a standard (control) variety was used Bulgarian variety Kurtovska kapia 1619. Variety testing experiments were carried out in four replications, with experimental plot from 7.4 m^2. The plants were grown by the conventional technology for middle early field production in South Bulgaria. One harvest of green fruit and three harvest of ripening fruits were done. Total yield was established. In stage of full botanical maturity weight of fruit and length of fruit on 20 fruits taken randomly from each replication were measured.

Statistical analyses. Dispersion analysis of the results was accomplished by the methods described by FOWEL and COHEN (1992), DIMOVA and MARINKOV (1999). Parameters of phenotypic stability (Ysi) of yield, weight and length of fruit were determined by the methods of KANG (1993), applying computer program IPCSSVKYSI (International Program for Calculating Shuklas Stability Index (Ysi)), developed from KANG and MAGARI (1995).

RESULTS AND DISCUSSION

Estimation of the genotypes phenotypic stability can be searched after establishing of the significant differences between genotypes as well as between environmental conditions and of interaction between them. The results from dispersion analyses of the investigation breeding pepper lines are shown in Table 1. Availability of reliable differences between years of the experiments and of the interaction genotype - environmental was established. Proven interaction between genotype - environmental indicate that gradation of the breeding lines has changed depending on the environmental condition during the years. The obtained results about proven influence of the years as well as genotype - environmental, with aim to include these lines in breeding work, are a prerequisite to determine the parameter of yield stability (RACHOVSKA *et al.*, 2002). Taking into account the climatic conditions is a datum for the full and proper consideration to the different selection patterns (CARBONELL *et al*., 2004). The author emphasizes that the statistical methodology have been used for various crops to evaluate genotype behaviors in different environments. By applying of the index of stability and tracking of interaction between genotype and environmental conditions are essential for more accurate assessment of the breeding lines (SHOWEMIMO, 2007).

The data for productivity of breeding pepper lines (Table 2) described that all of them exceeded standard variety Kurtovska kapia 1619. The highest differences were reported in lines 200055-10 (Doux Marconi Rouge x Kapia 1300), 20007A-10 (20007A-10 Doux Marconi Geonet x Kurtovska kapia) and 200056-10 (Doux Marconi Rouge x Kapia 1300), as in both of them as a mail parent participated variety Kapia 1300. The index of stability YS(i) varied in widely limits from -9 to 7+. These lines have demonstrated high levels of stability. The highest value of YS(i) 7+ was accounted about line 20007A-10, which also was with very high productivity. The same value was calculated in line 200049-10. This denotes that these two lines are with bigger adaptability, their realized potential is comparatively sustainable and that they can develop its productivity in greater variation of environmental conditions. From point of

view of breeding they are also with high efficiency and are appropriate as a parent's component in future breeding program. The line with the highest yield 200055-10 also was with high stability - YS(i) 4+. Line 200056-10, despite lower stability index YS(i) 2+, on the base of its significantly high yield also recommended for inclusion in future selection. As a complex assessment by average level of expression of given sign and degree of its stability is possible to apply the index of Kang (YSi). In this scope is also applied the rang methods, through which can be achieved combination of dispersion of environment with experimental data in a total rank (YSi), serving as a criteria in breeding work with these lines. This is also a good means about breeding assessment for inclusion and use of the relevant genotypes in the process of variety creating (DIMOVA and PETROVSKA, 2010).

Table 1. Analysis of variance about yield of pepper breeding lines

№	Source of variance	Fg	SQ	S^2	F
1	General	26	6.606835	-	-
2	Genotypes	8	2.067869	2584836	1.0508393ns
3	Environments	2	1.797149	89855744	84.40353**
4	Interaction	16	2.741818	1713636	16.09627**
5	Heterogeneity	8	1.075968	1344960	0.645897ns
6	Residual	8	1.66585	2082313	19.55962**
7	Pooled error	48	-	106461.7	

Some of the tested lines are characterized with lower productivity in comparison with other studied genotype as well as with lower stability. Zero or negative values of YS(i) were established, in 200051-10 and Kurtovska kaipa and for 200040-10, 200022A-10 and 200074-10 respectively. The standard variety Kurtovska kaipa 1619 compared with tested lines was with lower yield and index of stability.

Table 2. Evaluation of pepper breeding lines by yield stability

Breeding lines	Yield kg/da	Range of yield	Coefficient of yield	Coefficient of range	Stability variance	Stability Rating	Index YS(i)
200051-10	4107.7	5	-1	4	484711.9	-4	0+
200049-10	4269.8	6	1	7	14103.39	0	7+
200056-10	4822.5	7	3	10	1654965	-8	2+
200055-10	5034.1	9	3	12	3763739	-8	4+
200040-10	4012.4	3	-1	2	3404728	-8	-6
200022A-10	4089.7	4	-1	3	5169472	-8	-5
200074-10	3604.3	2	-3	-1	736279.6	-8	-9
20007A-10	4881.3	8	3	11	404466.1	-4	7+
Kurtovska kapia 1619	3587.0	1	2	3	200795.5	-3	0

Besides productivity the tested eight perspective pepper breeding lines were analyzed additionally by the indexes weight and length of fruit. From the data obtained about dispersion

analyses of fruit weight (Table 3) can be seen, that effect of genotype and influence of environmental during the years and interaction between them were proved. The data presented in Table 4 indicate that each genotype were with higher weight towards the standard variety. The highest values were measured about 200022A-10 (132,5 g), 200040-10 (98.10 g) and for 200056-10 (97.77 g). Line 200022A-10 emerges with biggest weight of fruit, but at the same time with highest level of expression of this sign 8+. This determines it's as a very perspective for breeding goals. With high YS(i) were characterized also lines 200074-10 and 200055-10.

Table 3. Analysis of variance about fruit weight of pepper breeding lines

№	Source of variance	Fg	SQ	S^2	F
1	General	26	27997.36	-	-
2	Genotypes	8	20530.27	2566.238	8.00137**
3	Environments	2	2335.406	1167.703	15.31615**
4	Interaction	16	5131.688	320.7305	4.206853**
5	Heterogeneity	8	734.2212	91.77765	0.1669646ns
6	Residual	8	4397.466	549.6833	7.209907**
7	Pooled error	48	-	76.24	-

Table 4. Evaluation of pepper breeding lines by stability of fruit weight

Breeding lines	Weight (g)	Range of weight	Coefficient of weight	Coefficient of range	Stability variance	Stability Rating	Index YS(i)
200051-10	88.44	5	-1	4	431.5011	-8	-4
200049-10	78.77	2	-2	0	28.38179	0	0
200056-10	97.77	7	1	8	1045.828	-8	0
200055-10	86.32	4	-1	3	34.70432	0	3
200040-10	98.10	8	1	9	760.2817	-8	1
200022A-10	132.55	9	3	12	269.345	-4	8
200074-10	90.55	6	-1	5	156.8951	0	5
20007A-10	78.33	1	-3	-2	157.6238	0	-2
Kurtovska kapia 1619	79.44	3	-2	1	2.128639	0	1

About morphological sign, length of fruit, very good statistical significant between tested eight perspective pepper lines also was established. STOFFELLA *et al.* (2005) also reported that pepper cultivars vary to stability of yield and fruit size or adaptability to diverse environments. Therefore, through stability analyses, breeders can identify cultivars and select advanced breeding lines that express adaptability for yields or fruit size to diverse environmental conditions or cultural practices for inclusion in future breeding programs. The influence of environmental and interaction environmental-genotype also were with high evidence (Table 5). On this base the results were analyzed for stability of expression of the trait length of fruit (Table 6). With the exception of line 200049-10 all investigated genotype were with bigger length than standard. The highest values were recorded in line 200051-10 (17,55 cm) and of 20007A-10 (16,71 cm). The highest stability in expression of this trait was determined in line 200051-10

(12+). It could be noted that newly breeding lines characterized with low level of expression of trait. All of these demonstrated their limited adaptability concerning length of fruit and its strong variation from environmental conditions.

Table 5. Analysis of variance about fruit length of pepper breeding lines

№	Source of variance	Fg	SQ	S^2	F
1	General	26	544.4883	-	-
2	Genotypes	8	485.814	60.72675	21.92648**
3	Environments	2	14.36133	7.180664	10.73343**
4	Interaction	16	44.31299	2.225893	4.139853**
5	Heterogeneity	8	17.80714	3.313231	0.6718193ns
6	Residual	8	26.50585	0.669	4.952512**
7	Pooled error	48			

Table 6. Evaluation of pepper breeding lines by stability of fruit length

Breeding lines	Length (cm)	Range of length	Coefficient of length	Coefficient of range	Stability variance	Stability Rating	Index YS(i)
200051-10	17.55	9	3	12	1.767739	0	12+
200049-10	10.72	1	-3	-2	2.370086	-4	-6
200056-10	11.27	2	-3	-1	1.376103	0	-1
200055-10	11.38	4	-3	1	4.341825	-8	-7
200040-10	11.60	5	-3	2	0.6303912	0	2
200022A-10	12.77	6	-1	5	3.226588	-4	1
200074-10	11.33	3	-3	0	1.933845	0	0
20007A-10	16.71	8	3	11	8.622952	-8	3+
Kurtovska kapia 1619	15.02	7	3	10	6558342	0	10+

CONCLUSION

Applying of the index YS(i) allows for further comprehensive assessment of newly pepper breeding lines as regards the expression of their signs and of its adaptability to environmental conditions, which provide the necessary information about effectiveness of their inclusion in future breeding programs.

With the highest productivity, high stability and increased adaptability to environmental conditions are identified breeding lines 200055-10 (Doux Marconi Rouge x Kapia 1300 F_8) and 20007A-10 (Doux Marconi San Semences x Kalinkov 800/7 F_7). The lowest is adaptability and productivity in lines 200074-10 (Doux Marconi Geonet x Kurtovska kapia 1619 F_7) and 200040-10 (Zlaten medal 7 x Doux Marconi Geonet F_7).

Regarding the stability and adaptability of fruit weight promising for inclusion in new breeding programs are lines 200022A-10 Doux Marconi Geonet x Kurtovska kapia 1619 F_8) and 200074-10 (Doux Marconi Geonet x Kurtovska kapia 1619 F_7), while regarding length of fruit is also line 200051-10 (Kapia 1300 x Doux d'Espagne F_8).

With comparatively good features and perspective opportunities for presenting of Government variety testing and for inclusion as source material for breeding of pepper are determined lines 200055-10 (Doux Marconi Rouge x Kapia 1300 F_8), 20007A-10 (Doux Marconi San Semences x Kalinkov 800/7 F_7) and also line 200056-10 (Doux Marconi Rouge x Kapia 1300 F_7).

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PROCENA PRINOSA I STABILNOSTI PRINOSA NOVIH PERSPEKTIVNIH SORTI PAPRIKE KONUSNOG OBLIKA

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Izvod

Multidisciplinarni pristup demostriran u okviru ovog rada predstavlja prva istraživanja na crnom boru koje u direktnu vezu dovodi zavisnost genotipa i uslove sredine ispoljene kroz fitocenološku pripadnost. U radu su izvršena multidisciplinarna istraživanja (genetička i fitocenološka) 4 populacije crnog bora (*Pinus nigra* Arnold) u zapadnoj i centralnoj Srbiji. Izvršena je analiza PCR amplifikacija genomske DNA sa 14 RAPD primera, od čega je 10 polimorfno. Korišćene su tri vrste koeficienata genetičke sličnosti, *Jaccard*, *Dice* and *Socal and Michener*. Dobijeni dendogrami (NTSYS) diferenciraju na najvećoj genetičkoj distanci populaciju crnog bora na Šarganu u odnosu na ostale populacije Crni Vrh, Goč i Studenica. Fitocenološke analize su vršene po metodi *Braun-Blanquet* i tom prilikom je utvrđeno da populacija crnog bora na Šarganu gradi zajednicu crnog bora sa crnjušom (*Erico-Pinetum gocensis*), a ostale populacije formiraju zajednice crnog bora sa uskolisnom šaškom (*Seslerio rigidae-Pinetum gocensis*). Dobijenih rezultata korišćenjem genetičke analize (PCR) i analize fitocenološke pripadnosti dali su isti međupopulacioni raspored.

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