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Adaptability and stability of standard yield in production of certified seeds from Bulgarian potato varieties

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Abstract

The experiment was performed in the Maritsa Vegetable Crops Research Institute, Plovdiv and Experimental station, Samokov during the period 2009-2011. The aim of this study was to evaluate the adaptability and stability of standard yield in production of certified seeds from four Bulgarian potato varieties. Three factors field experiment was set with 12 combinations to established effect of the factors - fertilization rate, planting density and term of leaf striping on the standard yield of the seed fractions in varieties Rozhen, Perun, Kalina and Bor. It was established that varieties Bor, Perun and Kalina are described with a complex value, combining high level, relatively stability and adaptability of standard yield in change of the environmental conditions in the variant including higher level of nitrogen and potassium fertilization, higher planting density and earlier term of leaf striping. High level of stability and adaptability, but lower productivity is recorded in variety Rozhen in the variant including fertilization rate N_{16} P_{14} K_{18}, higher planting density and later term of leaf striping.

Keywords: *Solanum tuberosum* L, potato, certified seeds, adaptability, stability, yield

Introduction

Because of climate change, the reduction of arable land, increasing population, and frequent occurrence of natural disasters, food security has become a crucial issue (Wang, 2008). To face this situation, increased food supply has become a priority in the world's development agenda. In terms of nutritional value, adaptability to diverse environments and yield potential, the potato is a preferred crop (Nakitandwe et al., 2006). According to FAO statistics, out of the four major food crops (rice, wheat, potato and maize), the potato has the best potential for yield increases.

Potato yield is determined both by the crop *per se* and the environment (Vayda et al., 1994; Jovović et al., 2012). The former can be defined as internal causes including genetic identity, health and physiology. The latter are external factors that consist mainly of temperature, light, nutrition and water (Pereira et al., 2008). The genotype determines tuber number, tuber size and yield potential for any given cultivar (Nacheva, 2006). Then, the performance of yield is largely influenced by the health status of seed tubers and plants. Since some external factors (such as light and temperature) cannot be controlled, we can only adjust the inputs of nutrition and water by appropriate fertilizer application and irrigation (Liu et al., 2009).

The present study aimed to evaluate the adaptability and stability of standard yield in production of certified seeds from four Bulgarian potato varieties.

Materials and Methods

The investigation was carried out at Maritsa Vegetable Crops Research Institute, Plovdiv and at Experimental station, Samokov during the period 2009-2011. Four Bulgarian potato varieties (Perun, Rozhen, Kalina and Bor) were evaluated.

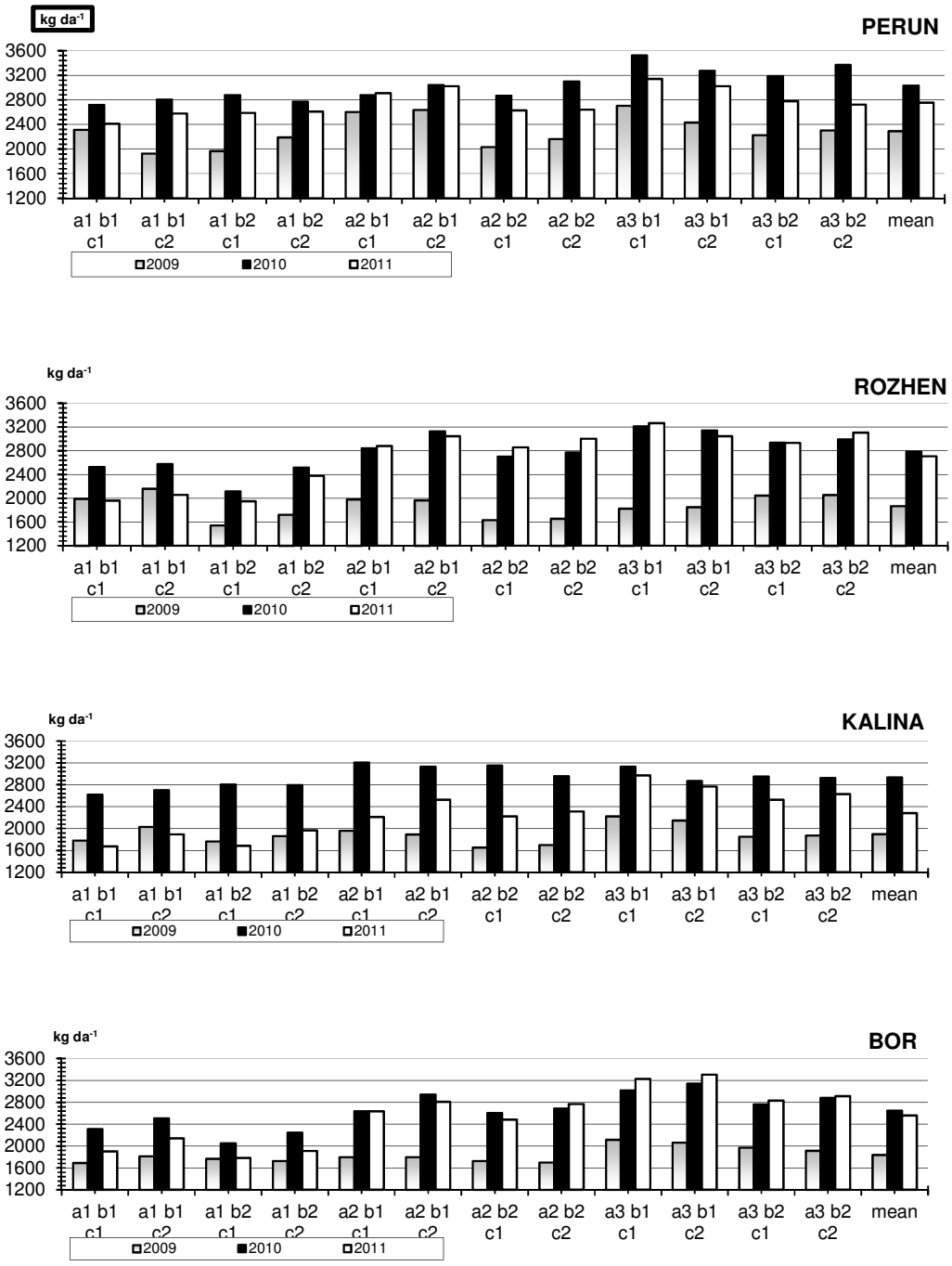

Figure 1. Standard yield in the production of certified potato seeds

Table 1. Two-way analysis of variance of standard yield in the production of certified potato seeds

Variety		Source of variation			
		Years (Y)	Combinations (C)	Interaction (Y x C)	Error
Perun	Mean square	1887278***	1266418***	986610***	66992
	Influence (%)	8.1	29.9	46.5	
Rozhen	Mean square	12368755***	941229***	1608271***	109204
	Influence (%)	30.1	12.6	43.0	
Kalina	Mean square	13233952***	567040**	1417166***	96227
	Influence (%)	35.6	8.4	42.1	
Bor	Mean square	9387388***	1212762***	734278***	224363
	Influence (%)	25.9	18.4	22.3	

*** p<0.001%

Three factors field experiment from 3 x 2 x 2 type i.e. 12 combinations was set for study of the factors having effect on the yield of certified potato seeds. The influence of fertilization rate, planting density and term of leaf striping was established in these combinations.

Factor A – Fertilization rate

Degrees: a_1 - N_{16} P_{14} K_{18} a_2 - N_{18} P_{14} K_{18} a_3 - N_{18} P_{14} K_{22}

Factor B – Planting density

Degrees: b_1- 18 cm b_2 – 22 cm

Factor C – Term of leaf striping

Degrees: c_1 - 20 days after mass blossoming c_2 - 30 days after mass blossoming

Field experiment was set in 4 replications at 75 cm distance between the rows on 8 m^2 experimental plot. The planting was made in the beginning of May with seed and in Experimental station in Samokov. The experiments were conducted according to the agricultural practices adopted for potato growing in mountain conditions. The character standard yield was recorded in harvesting of the variants from each plot as the requirements of the Regulation № 16/30.05.2008 concerning the size of potato seeds (diameter from 2.5 to 6 cm). Two factor analysis (Lakin, 1990) was carried out and the parameter of stability b_i (Eberhart and Russell, 1966) and index of total adaptation x_i - b_i (Valchinkov, 1990) were established. Genotypes with coefficient b_i>1.2 are described with low stability, in 0.8>b_i<1.2 the level of stability is average and the genotypes with coefficient b_i<0.8 are defined as stable ones. When b_i=0 – absolute stability i.e. the studied character has one and the same manifestation in all growing conditions of the variety.

Results and Discussion

The studied potato varieties differ significantly in standard yield over the years, the combinations of fertilization rate, planting density and term of leaf striping and genotypes (Figure 1). In the period of investigation their potential of standard seed productivity was with amplitude of variation from 1544 kg da^{-1} (Rozhen, 2009 in the variant N_{16} P_{14} $K_{18,}$ 22 cm distance in the row and term of leaf striping 20 days after mass blossoming) to 3521 kg da^{-1} (Perun, 2010 in the variant including higher level of nitrogen and potassium fertilization, higher planting density and earlier term of leaf striping). During 2009 the greatest expression of the character was recorded in Perun (2707 kg da^{-1}) in the variant N_{18} P_{14} $K_{22,}$ 18 cm distance in the row and term of leaf striping 20 days after mass blossoming. The variety keeps its rank in this combination as regardless of the changes in the environmental conditions. It maintain comparatively high and constant yield within 2707-3520 kg da^{-1}. The variety Rozhen was described with wider amplitude of variation (1544-3265 kg da^{-1}) being as a result of the different combinations of factors fertilization rate, planting density and term of leaf striping and different combinations of the meteorological elements during the period of examination. Relatively high variability as a result of the different combinations of studied factors was also recorded both in Kalina (1662-3204 kg da^{-1}) and Bor (1692-3306 kg da^{-1}), which standard yield has increased almost two times in the variants including higher level of nitrogen fertilization and higher planting density.

Table 2. Yield stability and adaptability in the production of certified potato seeds

Variety	Combinations	Yield (kg da^{-1})	Stability parameter (b_i)	Index of total adaptability (x_i - b_i)
PERUN	a_1 b_1 c_1	2482	0.509	1.973
	a_1 b_1 c_2	2438	1.207	1.231
	a_1 b_2 c_1	2477	1.237	1.240
	a_1 b_2 c_2	2524	0.789	1.735
	a_2 b_1 c_1	2798	0.418	2.380
	a_2 b_1 c_2	2899	0.575	2.324
	a_2 b_2 c_1	2509	1.144	1.365
	a_2 b_2 c_2	2635	1.244	1.391
	a_3 b_1 c_1	3122	0.982	2.140
	a_3 b_1 c_2	2910	1.147	1.763
	a_3 b_2 c_1	2730	1.281	1.449
	a_3 b_2 c_2	2800	1.382	1.418
ROZHEN	a_1 b_1 c_1	2159	0.333	1.826
	a_1 b_1 c_2	2263	0.217	2.046
	a_1 b_2 c_1	1869	0.566	1.303
	a_1 b_2 c_2	2206	0.831	1.375
	a_2 b_1 c_1	2567	0.992	1.575
	a_2 b_1 c_2	2711	1.274	1.437
	a_2 b_2 c_1	2398	1.285	1.113
	a_2 b_2 c_2	2477	1.376	1.101
	a_3 b_1 c_1	2767	1.590	1.177
	a_3 b_1 c_2	2678	1.919	0.759
	a_3 b_2 c_1	2638	1.000	1.638
	a_3 b_2 c_2	2720	1.114	1.606
KALINA	a_1 b_1 c_1	2025	0.772	1.253
	a_1 b_1 c_2	2208	0.706	1.502
	a_1 b_2 c_1	2084	1.076	1.008
	a_1 b_2 c_2	2207	0.935	1.272
	a_2 b_1 c_1	2458	1.231	1.227
	a_2 b_1 c_2	2517	1.158	1.359
	a_2 b_2 c_1	2340	1.439	0.901
	a_2 b_2 c_2	2322	1.183	1.139
	a_3 b_1 c_1	2777	0.704	2.073
	a_3 b_1 c_2	2596	0.737	1.859
	a_3 b_2 c_1	2443	1.010	1.433
	a_3 b_2 c_2	2477	0.954	1.523
BOR	a_1 b_1 c_1	1968	0.583	1.385
	a_1 b_1 c_2	2153	0.699	1.454
	a_1 b_2 c_1	1866	0.224	1.642
	a_1 b_2 c_2	1961	0.493	1.468
	a_2 b_1 c_1	2356	1.083	1.273
	a_2 b_1 c_2	2517	1.415	1.102
	a_2 b_2 c_1	2270	1.074	1.196
	a_2 b_2 c_2	2386	1.323	1.063
	a_3 b_1 c_1	2837	0.960	1.877
	a_3 b_1 c_2	2788	1.284	1.504
	a_3 b_2 c_1	2520	1.227	1.293
	a_3 b_2 c_2	2571	1.269	1.302

Two factor analysis of variance was carried out in order to be distinguished the reasons for the observed phenotypic variability. The results were shown in Table 1. Data from the analysis show, that the differences in expression of the standard seed productivity are due mainly to the interaction between years and combination of the factors fertilization rate, planting density and term of leaf striping. The conditions of the year of variety Perun, although being proven, are assessed with smaller burden (8.1%). In the others three varieties their effect varies in the range between 25.9 and 35.6%. The influence of the factors fertilization rate, planting density and term of leaf striping is characterized by an amplitude of 8.4% (Kalina) to 29.9% (Perun). The interaction years x combination has the strongest influence on standard yield of varieties Perun, Rozhen and Kalina (42.1-46.5%). The high significance of this factor ($p<0.001\%$) shows, that the genotypes react in a different way to the changes in environmental conditions, which is a prerequisite for evaluation of their phenotypic stability (Table 2).

According to the biological conception ($b_i = 0$) (Becker and Leon, 1988) variety Perun ($b_i = 0.418$) possess the highest stability in the variant including higher level of nitrogen fertilization, higher planting density and earlier term of leaf striping, variety Rozhen ($b_i = 0.217$) - in the variant N_{16} P_{14} K_{18}, 18 cm distance in the row and term of leaf striping 30 days after mass blossoming, Kalina ($b_i = 0.704$) - in the variant including higher level of nitrogen and potassium fertilization, higher planting density and earlier term of leaf striping and Bor ($b_i = 0.224$) in the variant N_{16} P_{14} K_{18}, 22 cm distance in the row and term of leaf striping 20 days after mass blossoming. The values of their regression coefficients are smaller than 1, which is an indication that these varieties in their respective combinations distinguish with relatively constancy of yield in unfavourable conditions of growing. The structural model of Lidanski and Vasileva (1995) differentiates different combination of factors fertilization rate, planting density and term of leaf striping, included in the study, in 3 classes by average level of stability. Variety Perun ($b_i = 1.382$) is characterized with lest stability in the variant including higher level of nitrogen and potassium fertilization, 22 cm distance in the row and term of leaf striping 30 days after mass blossoming, variety Rozhen ($b_i = 1.919$) – in the variant including higher level of nitrogen and potassium fertilization, 18 cm distance in the row and term of leaf striping 30 days after mass blossoming, Kalina ($b_i = 1.439$) - in the variant including higher level of nitrogen fertilization, 22 cm distance in the row and earlier term of leaf striping and Bor ($b_i = 1.415$) in the variant N_{18} P_{14} K_{18}, higher planting density and term of leaf striping 30 days after mass blossoming. The values of the regression coefficients in these combination are greater than 1.2, which shows that regardless of their relative weaker potantial of productivity in optimal conditions of growing it is possible these varieties to give considerable higher yields.

The greatest adaptability of the character was recorded in Perun (2.380) in the variant including higher level of nitrogen fertilization, higher planting density and earlier term of leaf striping, Kalina (2.073) and Bor (1.877) - in the variant including higher level of nitrogen and potassium fertilization, higher planting density and earlier term of leaf striping. High level of adaptability (2.046) and stability, but lower productivity was recorded in variety Rozhen in the variant including fertilization rate N_{16} P_{14} K_{18}, higher planting density and later term of leaf striping.

Conclusion

Bulgarian varieties Bor, Perun and Kalina are described with a complex value, combining high level, relatively stability and adaptability of standard yield in change of the environmental conditions in the variant including higher level of nitrogen and potassium fertilization, higher planting density and earlier term of leaf striping.

High level of stability and adaptability, but lower productivity is recorded in variety Rozhen in the variant including fertilization rate N_{16} P_{14} K_{18}, higher planting density and later term of leaf striping.

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