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AGROBIOLOGICAL RESPONSE OF EARLY POTATO BREEDING LINES AND VARIETIES IN BIOLOGICAL PRODUCTION

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Abstract

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Studies on the agro biological response of five early potato varieties and breeding lines have been conducted at four different systems for organic production during the period 2008-2010 on the experimental plots of the Maritsa Vegetable Crops Research Institute, Plovdiv. The main role of the genotype in determining important morphological and economic characteristics of early potato varieties and breeding lines grown under different systems for organic production was proven and it was identified a suitable starting material for organic breeding in this culture. Varieties Nadezhda, Ivertse and E 1026 combining relatively high productivity level (over 2000 kg.da^{-1}) and specific insusceptibility to late blight (*Phythophtora infestans*), early blight (*Alternaria solani*), bacterial leaf spot and Colorado beetle (*Leptinotarsa decemlineata*), are described with complex value in organic potato production. The obtained initial results give reason to consider that there are opportunities for the development of organic production of early potatoes in Bulgaria, as all genotypes included in the study (except E 766) realized yield over 1500 kg.da^{-1} at least one of the tested production systems.

Key words: potato, organic production, yield, diseases, pests

Introduction

The organic food and farming sector is very dynamic, and it is showing rapid growth and constant development, both which need to be supported by the availability of new technologies (Willer and Kilcher, 2011). Research needs depend upon the evolution of the sector and in particular upon factors like diversification of production, new marketing possibilities but also changes in/updating of the relevant legislation (Karova et al., 2011).

Among the various issues in the European Action Plan for Organic Food and Farming, it is important to mention the strengthening of the research on organic agriculture and production methods, with a view to facilitating the expansion of the organic farming sector, and also to increase its production capacity (Karova, 2011).

To achieve this, organic farming relies on a number of objectives and principles, as well as common practices designed to minimize the human impact on the environment, while ensuring the agricultural system operates as naturally as possible (Seyfang, 2006).

Typical organic farming practices include: wide crop rotation as a prerequisite for an efficient use of on-site resources (Grandy et al., 2002), very strict limits on chemical synthetic pesticide and synthetic fertilizer use, livestock antibiotics, food additives and processing aids and other inputs (Hiiesaar et al., 2009), absolute prohibition of the use of genetically modified organisms (Parrott and Marsden, 2002), taking advantage of on-site resources, such as livestock manure for fertilizer or feed produced on the farm (Saucke and Doring, 2004), choosing plant and animal species that are resistant to disease and adapted to local conditions (Finckh et al., 2006), raising livestock in free-range, open-air systems and providing them with organic feed, using animal husbandry practices appropriate to different livestock species (Hovi et al., 2003).

The purpose of this study was to determine the agrobiological response of potato varieties and breeding lines grown in different systems for organic production.

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Materials and Methods

During the period 2008-2010 four different systems (variants) for organic production of potato were studied:

1) growing plants in natural soil fertility without using plant-protection products;

2) growing plants by fertilization with organic products authorized for use in organic production without the use of biopesticides for plant protection;

3) growing in natural soil fertility using biopesticides for plant protection;

4) growing plants by fertilization with organic products authorized for use in organic production and use of biopesticides for plant protection;

The control variant of the experiment is conventional production – growing through the use of herbicides, mineral fertilization and plant protection with chemical fungicides and insecticides.

The fertilization rates with biohumus have been determined in agrochemical laboratory of the Maritsa Vegetable Crops Research Institute. Specification of fertilizer rates was made according to the reserves of soil nutrient substances and the biological requirements of early potato.

The experiments were conducted in the experimental plots of the Maritsa Vegetable Crops Research Institute-Plovdiv, Bulgaria with five early potato accessions: varieties Ivertse and Nadezhda, and breeding lines E 766, E 1205 and E 1026 on an area of 500 m^2. The genotypes were grown by technology for early field production with planting date 1-5 March in planting scheme 75/25 cm and harvesting 1-10 June. The experiments were performed by block method with five accessions in five variants.

Before the blossoming stage of the second and the fourth variants fertilization was conducted using biohumus within a rate of 750-800 L.da^{-1}. The plant protection of the third and the fourth variants was carried out by applying biopesticides: Piros 0.08% (a. i. pirethrin), Bioneem Plus 0.25% (a. i. azadirachtin), Neem Azal T/S 0.3% (a. i. azadirachtin) and bio fungicide Timorex 1% (extract from *Melaleuca alternifolia*).

Observations for recording of the response to phytopathogenic and entomogenic factors of biotic stress were made during the vegetation period. The degree of infestation by pathogens causing early blight (*Alternaria solani*), late blight (*Phytophthora infestans Mont*) and bacterial leaf spot, and the average population density of larvae and adults of Colorado potato beetle *(Leptinotarsa decemlineata* Say*)* were recorded.

The characters recorded in harvesting of the variants from each plot are the following: weight of one standard tuber (g), tubers number per cluster (standard, non-standard and total), standard, non-standard and total yield (kg.da^{-1}), and percentage standard produce were established.

The obtained data were mathematically processed by two-way analysis of variance (Lakin, 1990).

Results and Discussion

Significant differences in the characters of the morphological and economic description are registered in the organic production of early potato varieties and breeding lines (Table 1).

Average value characterizing number of standard tubers per plant is assessed with amplitude of variation from 3.6 (Ivertse, natural soil fertility without plant protection) to 7.7 (Nadezhda, conventional production - control). The maximal mean value (6.0 tubers) is recorded in Nadezhda as the varying is in a relatively narrow range from 7.7 in conventional production to 5.2 tubers in natural soil fertility without plant-protection. In this system of organic production all varieties and breeding lines form the smallest number of standard tubers (average 4.2). The number of standard tubers is larger average with one tuber (5.0 to 5.2) in the other three systems of organic production. In all lines and varieties maximum expression of the trait is observed in conventional production (6.5 tubers). The greatest variation in the number of standard tubers is recorded in E 1026 with minimum 4.2 and maximum 7.1.

The trend is remained in great degree in total number of tubers per plant. The ranking of the variants in the progression is: natural soil fertility without plant protection (5.5), natural fertility and protection with biopesticides (6.1), fertilization with biohumus and protection with biopesticides (6.4), fertilization with biohumus without plant protection (6.5) and conventional production (8.5). The highest total number of tubers is characterized variety Nadezhda (8.0). In all lines and varieties maximum expression of the trait is observed in conventional production.

The variation of the average tuber weight in the studied variants is from 52 g (E 1205, natural fertility without plant protection) to 90 g (Ivertse, conventional production). Maximum value for whole experiment (71 g) was recorded in conventional production, but the line E 1205 formed slightly larger tubers in a natural fertility and protection with biopesticides and E 1026 and Nadezhda – in the organic production, including fertilization with biohumus and protection with biopesticides.

Standard yield is characterized by a minimum value of 1060 kg.da^{-1} (E 1205, natural fertility without plant protection) and a maximum of 2841 kg.da^{-1} (E 1026, conventional production). Compared to conventional production (2568 kg.da^{-1}) in genotypes grown under natural fertility without

Table 1
Morphological and economic characteristics of early potato genotypes grown in conditions of biological production

Character	Variety Line	Natural fertility without plant protection	Fertilization with biohumus without plant protection	Natural fertility and protection with biopesticides	Fertilization with biohumus and protection with biopesticides	Conventional production	Average
Standard tuber number per plant	E 766	4.3	5.1	5.2	4.3	6.6	5.1
	E 1205	3.8	5.2	4.7	5.4	5.4	4.9
	E 1026	4.2	5.2	5.7	5.2	7.1	5.5
	Ivertse	3.6	4.6	4.4	5.0	5.5	4.6
	Nadezhda	5.2	5.8	5.2	6.1	7.7	6.0
	mean	4.2	5.2	5.0	5.2	6.5	5.2
Non standard tuber number per plant	E 766	1.4	1.4	1.0	1.2	1.2	1.2
	E 1205	1.4	1.5	1.4	1.6	2.6	1.7
	E 1026	1.3	1.3	0.9	1.0	1.8	1.3
	Ivertse	0.8	0.6	0.7	0.7	1.1	0.8
	Nadezhda	1.8	2.0	1.2	1.6	3.4	2.0
	mean	1.3	1.4	1.0	1.2	2.0	1.4
Total tuber number per plant	E 766	5.6	6.5	6.2	5.5	7.8	6.3
	E 1205	5.2	6.6	6.1	6.9	8.0	6.6
	E 1026	5.5	6.5	6.6	6.2	8.9	6.7
	Ivertse	4.4	5.2	5.1	5.7	6.7	5.4
	Nadezhda	7.0	7.9	6.4	7.7	11.2	8.0
	mean	5.5	6.5	6.1	6.4	8.5	6.6
Average tuber weight, g	E 766	53	60	69	68	75	65
	E 1205	52	56	57	55	54	55
	E 1026	70	74	65	75	70	71
	Ivertse	83	75	79	69	90	79
	Nadezhda	66	66	67	67	65	66
	mean	65	66	67	67	71	67
Standrd yield, $kg.da^{-1}$	E 766	1392	1720	2043	1633	2779	1913
	E 1205	1060	1651	1401	1681	1619	1482
	E 1026	1599	2121	2122	2164	2841	2169
	Ivertse	1685	1922	1917	1950	2829	2060
	Nadezhda	1927	2132	1944	2209	2774	2197
	mean	1533	1909	1885	1927	2568	1964
Total yield, $kg.da^{-1}$	E 766	1483	1832	2136	1719	2872	2008
	E 1205	1170	1752	1504	1802	1804	1606
	E 1026	1708	2225	2201	2257	2972	2273
	Ivertse	1759	1976	2004	2010	2935	2137
	Nadezhda	2054	2304	2051	2356	2990	2351
	mean	1635	2018	1978	2029	2714	2074
% standard produce	E 766	91.4	90.2	93.6	92.5	96.8	92.9
	E 1205	84.9	90.3	90.7	89.4	87.2	88.5
	E 1026	85.1	88.6	93.5	94.3	94.6	91.2
	Ivertse	94.2	97.8	96.2	97.0	96.8	96.4
	Nadezhda	87.8	88.6	92.3	91.0	91.0	90.1
	mean	88.7	91.1	93.3	92.8	93.3	91.8

plant protection is recorded average 1000 kg lower productivity (1533 kg.da^{-1}). Despite those conclusion varieties Nadezhda, Ivertse and E 1026 even in this simple system of organic farming are characterized by a standard yield higher than average yield for the country. Listed genotypes are with relatively high and stable values of this character in the other three types of organic production with a standard yield of 1917 to 2841 kg.da^{-1}.

Total yield varies from 1170 kg.da^{-1} (E 1205 natural fertility without the protection of plants) to 2990 kg.da^{-1} (Nadezhda, conventional production). The results obtained in different varieties and production systems follow the trend outlined in the analysis of standard yield. In all studied varieties and breeding lines maximum yield was recorded in conventional production.

The average percentage of standard produce is characterized by amplitude variation from 84.9% to 97.8%. Lower values are registered in the systems without plant protection. There are no significant differences (Table 2 and Table 3) in mean values of the character between the two systems for organic production with biopesticides for plant protection and conventional production. The variety Ivertse is distinguished with the highest (96.4%) and relatively stable percentage of standard produce.

The response of variety to the phytopathogenic and entomogenic factors of biotic stress is read in the conditions of the experiment (Table 4). The results obtained for the index of infestation by late blight (*Phytophthora infestans*) demonstrate a slight development of this pathogen (0.3-5.8%). Relatively higher values are recorded in E 1205. In the organic systems with biopesticides protection minimum values were recorded in breeding lines E 766, E 1026 and variety Ivertse that identify them as suitable for growing in organic potato production.

In the vegetation period was observed relatively stronger development of early blight (*Alternaria solani*). In conventional production, this pathogen infestation is in the weakest in line E 766 and Ivertse. In organic production systems in all genotypes were reported two to three time's higher index of damage. However, in both systems, including biopesticides protection index of damage in Nadezhda, Ivertse and E 766 does not exceed 10%, making them relatively suitable for organic production.

Results for degree of infestation with bacterial leaf spot showed very weak development of the pathogen (average 1.2%). Line E 766 had no symptoms of the disease in any of the tested systems, and Nadezhda and E 1026 - with a very low degree of damage whose values are in the range from 0 to 2.5%.

The population density of Colorado potato beetle larvae ranged from 0.5 (Ivertse) to 21.9 (E 766) number per plant. In the production systems including the use of biopesticides the mean value is 6.9, while in those without protection of plants is more than twice higher (15.5 to 17.2). Minimum values in systems including the use of biopesticides (less than 6 numbers per plant) were recorded in the E 1026, Nadezhda and Ivertse.

Amplitude of variation of the population density of adults of Colorado beetle is in the range from 0 to 1.8 numbers per plant. Systems without biopesticides differ with relatively

Table 2
Two-factorial analysis of variance of morphological and economic characters

Sources of variation	Standard tuber number per plant	Non-standard tuber number per plant	Total tuber number per plant	Average tuber weight, g	Standard yield, kg.da^{-1}	Total yield, kg.da^{-1}	% standard produce
Genotype (G)	4.5*	3.3**	13.2**	1173**	1276124***	1285157**	63*
Version (V)	9.9**	2.2*	19.1**	74	2106848***	2316469***	23
G x V	0.6	0.4	1.0	99	122789	115225	6

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Table 3
Influence of the variation factors on morphological and economic characters

Sources of variation	Standard tuber number per plant	Non-standard tuber number per plant	Total tuber number per plant	Average tuber weight, g	Standard yield, kg.da^{-1}	Total yield, kg.da^{-1}	% standard produce
Genotype (G)	10.7	19.0	14.8	18.3	16.6	16.8	13.4
Version (V)	23.8	12.8	21.4		27.4	30.3	
G x V							

Table 4
Evaluation of agrobiological response of potato varieties and lines to biotic stress

Character	Variety Line	Natural fertility without plant protection	Fertilization with biohumus without plant protection	Natural fertility and protection with biopesticides	Fertilization with biohumus and protection with biopesticides	Conventional production	Average
Index of damage of late blight, %	E 766	0.3	1.5	1.8	1.8	1.5	1.4
	E 1205	1.8	5.8	2.0	4.5	3.5	3.5
	E 1026	1.5	4.5	1.8	2.0	2.8	2.5
	Ivertse	2.8	0.5	3.5	3.0	1.0	2.2
	Nadezhda	3.0	2.0	1.0	4.8	0.8	2.3
	mean	1.9	2.9	2.0	3.2	1.9	2.4
Index of damage of early blight, %	E 766	10.7	10.2	8.8	9.3	3.7	8.5
	E 1205	15.2	13.8	12.8	15.2	6.2	12.6
	E 1026	13.8	14.5	12.0	12.5	5.3	11.6
	Ivertse	9.5	8.5	9.5	8.2	3.7	7.9
	Nadezhda	10.0	10.2	10.0	9.7	4.7	9.0
	mean	11.8	11.4	10.7	11.0	4.7	9.9
Index of damage of bacterial leaf spot, %	E 766	0.0	0.0	0.0	0.0	0.0	0.0
	E 1205	3.8	2.5	1.0	2.0	2.0	2.3
	E 1026	2.5	0.0	0.0	2.0	0.0	0.9
	Ivertse	2.5	1.0	2.0	2.0	0.0	1.5
	Nadezhda	2.5	1.5	0.0	2.0	0.0	1.2
	mean	2.3	1.0	0.6	1.6	0.4	1.2
Population density of larvae of Colorado beetle	E 766	21.9	22.5	12.5	13.3	0.8	14.2
	E 1205	12.9	14.9	7.8	8.4	0.6	8.9
	E 1026	11.4	11.5	4.4	3.8	0.6	6.3
	Ivertse	14.9	16.4	5.3	4.1	0.5	8.2
	Nadezhda	16.4	20.8	4.6	5.2	0.9	9.6
	mean	15.5	17.2	6.9	6.9	0.7	9.4
Population density of adult of Colorado beetle	E 766	1.4	1.8	0.4	0.5	0.0	0.8
	E 1205	1.1	1.4	0.6	0.5	0.0	0.7
	E 1026	1.0	1.0	0.1	0.1	0.0	0.4
	Ivertse	0.7	0.3	0.4	0.0	0.1	0.3
	Nadezhda	0.9	1.0	0.7	0.4	0.0	0.6
	mean	1.0	1.1	0.4	0.3	0.0	0.6

Table 5
Two-factorial analysis of variance of agrobiological response to biotic stress

Sources of variation	Index of damage of late blight, %		Index of damage of early blight, %		Index of damage of bacterial leaf spot, %		Population density of larvae of Colorado beetle		Population density of adult of Colorado beetle	
	Mean square	Influence	Mean square	Influence	Mean square	Influence	Mean square	Influence	Mean square	Influence
Genotype (G)	8.9*	11.8	65.1		10.2***	41.1	128*	8.6	0.7	
Version (V)	5.8		130.9		8.7***	34.8	700***	47.1	3.4***	32.7
G x V	5.4*	28.3	2.6		1.5		16*	4.3	0.2	

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

higher values. In variants including the use of biopesticides the number of adults in any of the tested varieties and lines does not exceed unit.

Differences in the expression of studied morphological and economic characters are mainly due to different hereditary potential of potato varieties and breeding lines (Tables 2, 3 and 5). The influence of genotype is determinative for the observed differences in the percentage of standard produce and average tuber weight and with the strongest effect on the number of non standard tubers and degree of infestation with bacterial leaf spot.

The influence of systems for production is determinative for the different manifestations in population density of adults of Colorado potato beetle and with the strongest effect on number of standard tubers, total number of tubers, total and standard yield, and population density of Colorado potato beetle larvae. Interaction of genotype with production system has been proven only for index of infestation by late blight (*Phytophthora infestans*) and average population density of larvae of Colorado beetle.

Conclusions

The main role of the genotype in determining important morphological and economic characteristics of early potato varieties and breeding lines grown under different systems for organic production was proven and it was identified a suitable starting material for organic breeding in this culture.

Varieties Nadezhda, Ivertse and E 1026 combining relatively high productivity level (over 2000 kg.da^{-1}) and specific insusceptibility to late blight (*Phythophtora infestans*), early blight (*Alternaria solani*), bacterial leaf spot and Colorado beetle (*Leptinotarsa decemlineata*), are described with complex value in organic potato production.

The obtained initial results give reason to consider that there are opportunities for the development of organic production of early potatoes in Bulgaria, as all genotypes included in the study (except E 766) realized yield over 1500 kg.da^{-1} at least one of the tested production systems.

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