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AMMI MODEL IN THE ANALYSIS OF GENOTYPE BY ENVIRONMENT INTERACTION OF CONVENTIONALLY AND ORGANICALLY GROWN ONION

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This study was aimed to assess the stability of direct yield components (bulb weight and number plot^{-1}) and other yield contributing characteristics (bulb diameter, height and index, neck diameter and length, plant height, emergence and vegetation period) in five commercial onion cultivars grown in conventional and organic environments, by employing additive main effect and multiplicative interaction (AMMI) statistical model in data analysis. The two-year field trial organized in complete randomized blocks included the plots maintained in four regimes: mineral fertilization (conventional), without fertilization, fertilization with farmyard manure and with bacterial fertilizer (organic). Each treatment by year combination was considered as an environment. Analysis of variance of AMMI model calculated for the investigated traits showed that all sources of variation (genotypes, environments, genotype by environment interaction) were highly significant. The largest proportions of the total sum of squares were encompassed by environments, except for emergence and bulb index with the pronounced effect of genotypes (67.26 and 52.54%, respectively) and neck length with the genotype by environment interaction amounting 44.59%. Generally, the effects of the interactions were in the common range. The AMMI model with two axes was concluded as the best model for the investigated traits. Onions grown in conventional system outperformed the organic ones. However, good performance of the genotypes was accompanied with low stability across the environments and vice versa. Therefore breeding programs intended to develop cultivars adapted to alternative production

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systems should rely on the experiments set in the corresponding environments that include various combinations of genotypes and agro-technical procedures based on the principles of organic agriculture.

Keywords: AMMI analysis, genotype by environment interaction, onion, organic agriculture

INTRODUCTION

Onion (*Allium cepa* L.) is a plant species of great nutritive and economic significance. It is the second most cultivated vegetable in the world, with approximately 4 million ha of the occupied area and annual harvested yield of 80 million tons. In Serbia, the crop is grown on about 5 thousand ha and the total production amounts to 37 tons. Besides for the distinctive flavor and technological properties making the vegetable essential in cuisines of many nations and regions all over the world, onion is also valued as potentially beneficial to human health. On the other hand, the raised public awareness of the importance of the overall environmental protection and therefore the quality of the consumed food has led to the increased demand for the food coming from the sources other than the conventional, which are traditionally associated to intensive use of synthetic fertilizers and pesticides. Consequently, together with other forms of sustainable production, organic agriculture emerged as an environmentally friendly source of high quality food.

However, despite of the increasing demand for organically produced food; the crop areas maintained by the principles of the production system are still comparatively small, both in the region and in the world. For example, organic crops account for approximately 5.7% of the total agricultural area of the European Union. The differences among the member countries are still pronounced; ranging from only 0.3 and 0.8% in Malta and Bulgaria to even 18.6% in Austria. Organically maintained crops in Serbia occupy 0.15% of the total agricultural land. One of the most important causes for the modest proportion of organically cultivated land is often substantially lower crop yield, when compared to the yield from conventional farming systems. As an illustration, the average yields of the organic onion grown in an agriculturally developed Netherlands reach only 50-60% of the conventional. This is primarily related to comparatively low nitrogen input, differences between conventional and organic systems in terms of nitrogen availability throughout the season, difficulties in coping with weeds and diseases. In addition, the great majority of the onion cultivars grown by the principles of organic agriculture are developed in and attended for the conditions of intensive production. At the moment there is no organic onion cultivar, which emphasize the need for detail analysis of the performance of the available material in the conditions of organic farming (GRIFFITHS *et al.*, 2002; OSMAN *et al.*, 2008; PAVLOVIĆ *et al.*, 2011; BRDAR-JOKANOVIĆ *et al.*, 2012; LAMMERTS VAN BUEREN *et al.*, 2012; DŽIGURSKI *et al.*, 2013; KOCIĆ-TANACKOV *et al.*, 2013; MAGGIO *et al.*, 2013; EUROSTAT, 2014; MINISTRY OF AGRICULTURE AND ENVIRONMENT, 2014; FAO, 2015; RZS, 2015; VLAJIĆ *et al.*, 2015).

The study was undertaken to assess the stability of bulb weight and number plot^{-1} as the most important yield components, as well as several other yield contributing characteristics of commercial onion cultivars grown in conventional and organic environments, by employing additive main effect and multiplicative interaction (AMMI) statistical model in data analysis. The results should help onion breeders to establish selection strategy in the experiments set with the aim to improve productivity in organic environments.

MATERIALS AND METHODS

Five onion genotypes (cultivars Jasenički crveni, Jasenički žuti, Majski srebrnjak, Holandski žuti and Zlatno gnezdo) were sown in the two-year (2009, 2010) complete randomized block designed and replicated field experiment set at the Institute for Vegetable Crops, Smederevska Palanka, Serbia. The experiment included conventionally and organically grown onion. Conventional plots were maintained in a manner which is common in the region, i.e. fertilized with NPK (500 kg ha^{-1}, prior to sowing) and treated with pesticides as needed. Organic plots were in three variants: unfertilized, fertilized with fully decomposed farmyard manure (45 t ha^{-1}, prior to sowing) and with bacterial fertilizer (*Bacillus megaterium*, *Bacillus licheniformis*, *Bacillus suptilis*, *Azotobacter chrocoocum*, *Azotobacter vinelandi*, *Derxia* sp., applied foliar twice throughout the growing season). Organic plots were kept free from weeds by hand-weeding, and all plots were irrigated as needed. Sowing and harvest were performed at optimal times (March, July). Main plot was of 2 m^2 surface, consisting of 3 rows, spaced 20 cm and long 5 m. Soil type was vertisol. Weather data was collected from the station located near the plots. The seasons in which the experiment was conducted were characterized by higher sums of temperatures and precipitation, in comparison to long-term averages (not shown).

The following traits were analyzed in the samples of 30 plants per plot: bulb weight (g), number of bulbs $plot^{-1}$, bulb diameter (cm), bulb height (cm), bulb index, neck diameter and length (cm), plant height (cm), emergence (accumulated growing degree days from sowing to emergence, gdd) and vegetation period (gdd from emergence to maturity). Growing degree days are the sums of the average daily temperatures for the corresponding periods.

The results were processed by additive main effect and multiplicative interaction (AMMI) analysis, with each year by treatment combination being considered as an environment. The model is based on the number of axes of the main components and it is displayed graphically in the form of biplots. AMMI1 biplot is comprised from the main effects shown on the abscissa and the first principal component shown on the ordinate, while AMMI2 biplot illustrates the first (PC1) and second (PC2) principal component ratio (GAUCH, 2006; GAUCH *et al.*, 2008). In order to range the genotypes with respect to stability, AMMI stability values (ASV) were calculated (PURCHASE *et al.*, 2000) according to the formula:

$$ASV = \sqrt{\left[\frac{SSPC1}{SSPC2} \quad (\text{value PC1})\right]^2 + [\text{value PC2}]^2}$$

SS – sum of squares

The calculations were performed using R software, 2.15.2 version (R DEVELOPMENT CORE TEAM, 2005).

RESULTS AND DISCUSSION

Bulb weight and the realized bulb set per unit area are the components that directly determinate onions yield, implying the importance of the traits for both breeders and producers (PAVLOVIĆ *et al.*, 2015). According to the analysis of variance of AMMI model for onion bulb weight and number $plot^{-1}$ harvested from the conventionally and organically maintained plots in the two-year field trial, all sources of variation were highly significant (Table 1, 2). The largest proportion of the total sum of squares referred to the environments (89.91 and 53.49% for bulb weight and number $plot^{-1}$, respectively), which was somewhat expected since the applied treatments represent extremely different variants of fertilization; on the other hand, all the analyzed genotypes are widely grown cultivars adapted to local agro-ecological conditions. The effect of the genotype by environment interaction accounted for 5.67 and 15.52% of the total sum of squares, falling in the range commonly reported for multi-environment yield trials of various agricultural plants. Similarly to the results obtained for the main yield components, all sources of variation from AMMI model ANOVA performed for the other analyzed traits of agronomic importance were highly significant (Table 3); however their proportion in the total sum of squares differed for the individual traits. Vegetation period, bulb diameter, neck diameter, bulb height and plant height were primarily influenced by the environments (in the range from 99.25 to 77.67%, respectively), while the largest proportion of the total sum of squares for emergence and bulb index (67.26 and 52.54%, respectively) accounted for the genotypes. Accordingly, the effects of the production systems on onions were more pronounced in later phases of plant development. Despite of the significant environmental effects on both bulb height and diameter; bulb index, as an important cultivar characteristic, remained preserved in different production systems. The genotype by environment interaction encompassed the largest proportion of the total sum of squares for neck length (44.59%), and the smallest (0.20%) for vegetation period. Both traits are recognized as important by organic breeders and growers, since longer onion neck length contributes to earliness which is a desirable onion trait (TIEMENS-HULSCHER *et al.*, 2006; BABIĆ *et al.*, 2010; MARJANOVIĆ-JEROMELA *et al.*, 2011; BOSE *et al.*, 2014; MIROSAVLJEVIĆ *et al.*, 2014).

Table 1. The analysis of variance of the AMMI model for bulb weight of conventionally and organically grown onion

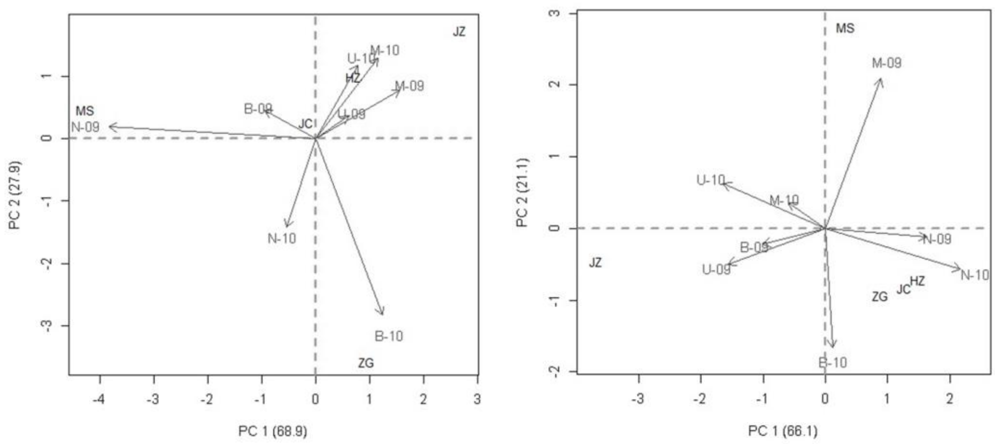
Source of variation	Df	Sum of squares	Sum of squares (%)	Mean squares	F-ratio
Genotypes (G)	4	1,730.00	3.02	432.50	53.27**
Environments (E)	7	51,445.00	89.91	7,349.30	427.42**
Interaction G by E	28	3,246.00	5.67	115.90	14.28**
Replications	16	275.00	0.48	17.20	2.12ns
PC1	10	2,237.32	68.93	223.73	27.56**
PC2	8	905.94	27.91	113.24	13.95**
PC3	6	89.88	2.77	14.98	1.84ns
PC4	4	12.80	0.39	3.20	0.39ns
PC5	2	0.00	0.00	0.00	0.00ns
Error	64	520.00	0.91	8.10	-
Total	119	57,216.00	-	-	-

Df – degrees of freedom; ns, ** – insignificant, significant at the 0.01 level of probability, respectively

Table 2. The analysis of variance of the AMMI model for number of bulbs plot^{-1} of conventionally and organically grown onion

Source of variation	Df	Sum of squares	Sum of squares (%)	Mean squares	F-ratio
Genotypes (G)	4	2,060.10	21.35	515.01	49.04**
Environments (E)	7	5,160.20	53.49	737.18	45.74**
Interaction G by E	28	1,497.00	15.52	53.46	5.09**
Replications	16	257.90	2.67	16.12	1.54ns
PC1	10	989.36	66.09	98.94	9.42**
PC2	8	315.59	21.08	39.45	3.76**
PC3	6	125.26	8.37	20.88	1.99ns
PC4	4	66.81	4.46	16.70	1.59ns
PC5	2	0.00	0.00	0.00	0.00ns
Error	64	672.10	6.97	10.50	-
Total	119	9,647.30	-	-	-

Df – degrees of freedom; ns, ** – insignificant, significant at the 0.01 level of probability, respectively



A) B)

Figure 1. AMMI2 biplot of five onion genotypes across eight environments, for bulb weight (a) and number plot^{-1} (b)

Genotypes: JC – Jasenički crveni, JZ – Jasenički žuti, MS – Majski srebrnjak, HZ – Holandski žuti, ZG – Zlatno gnezdo; Environments: N-09 and N-10 – mineral fertilizer in 2009 and 2010, U-09 and U-10 – unfertilized, M-09 and M-10 – manure, B-09 and B-10 – bacterial fertilizer

Table 3. Sums of squares (SS) and F-ratios from the AMMI model analysis of variance, for the yield-related traits in onion cultivars grown in conventional and organic systems

		Bulb diameter		Bulb height		Bulb index		Neck diameter	
Source of variation	Df	SS (%)	F-ratio	SS (%)	F-ratio	SS (%)	F-ratio	SS (%)	F-ratio
Genotypes (G)	4	1.12	30.46**	9.43	315.84**	52.54	1,832.55**	6.92	202.29**
Environments (E)	7	95.78	1,181.27**	81.99	1,104.05**	20.86	300.41**	82.82	1,469.82**
Interaction G by E	28	2.32	9.00**	7.93	37.92**	26.08	130.28**	9.55	40.71**
Replications	16	0.19	1.26ns	0.17	1.42ns	0.15	1.39ns	0.24	0.96ns
PC1	10	52.94	13.34**	80.80	85.80**	88.87	324.13**	74.89	85.36**
PC2	8	27.63	8.74**	12.91	17.13**	8.70	39.48**	15.80	22.56**
PC3	6	13.37	5.61**	3.92	6.94**	1.87	11.48**	6.91	13.13**
PC4	4	6.06	3.77**	2.37	6.28**	0.56	5.47**	2.40	6.76**
PC5	2	0.00	0.00ns	0.00	0.00ns	0	0.00ns	0.00	0.00ns
Error	64	0.59		0.48		0.37		0.48	
Total	119	100.00		100.00		100.00		100.00	

		Neck length		Plant height		Emergence		Vegetation period	
Source of variation	Df	SS (%)	F-ratio	SS (%)	F-ratio	SS (%)	F-ratio	SS (%)	F-ratio
Genotypes (G)	4	21.31	312.15**	11.63	189.88**	67.26	367.66**	0.47	124.96**
Environments (E)	7	32.29	124.02**	77.67	601.99**	21.68	74.40**	99.25	9,988.96**
Interaction G by E	28	44.59	93.09**	9.42	21.97**	7.46	5.83**	0.20	7.40**
Replications	16	0.66	2.17*	0.30	1.20ns	0.67	0.91ns	0.02	1.50ns
PC1	10	54.78	142.75**	52.06	32.02**	63.11	10.30**	90.98	18.86**
PC2	8	34.56	112.72**	26.00	19.99**	23.84	4.86**	7.51	1.95ns
PC3	6	8.45	35.89**	17.83	18.27**	11.79	3.21**	1.07	0.37ns
PC4	4	2.21	15.43**	4.11	6.32**	1.26	0.51ns	0.44	0.23ns
PC5	2	0.00	0.00ns	0.00	0.00ns	0.00	0.00ns	0.00	0.00ns
Error	64	1.15		0.98		2.93		0.06	
Total	119	100.00		100.00		100.00		100.00	

The interaction was further partitioned into principal components, of which the first two were highly significant for both analyzed direct yield components. In addition, since the sums of squares of the first two PCs encompassed 96.84 and 87.17% of the total (for bulb weight and number plot-^{1}, respectively), the model with two axes was concluded as the best model. For the same reason, the same model was the best for other traits of agronomic importance, although in most cases more than two principal components were highly significant (GAUCH, 2006; YAN *et al.*, 2007; GAUCH *et al.*, 2008). The first two components, i.e. the interaction, are graphically displayed as AMMI2 model biplots (Figure 1). Biplot methods are commonly used for visualizing the response of the genotypes to multiple treatments and seasons (YAN and TINKER, 2006; GIREK *et al.*, 2015; SIKORA *et al.*, 2016; BRDAR-JOKANOVIĆ *et al.*, 2017). Genotypes and environments of the same sign of the same principal component (eider positive or negative) are positively associated; vice versa, the opposite sign implies the negative interaction. The position close to the biplot origin indicates high stability. As depicted for bulb weight; out of five onion genotypes analyzed, only Jasenički crveni expressed high bulb weight stability across the range of organic and conventional fertilizer treatments applied in the two years of the experiment, while all other cultivars exhibited narrower adaptability to particular environments. However, the mentioned stable genotype coincidently had the lowest bulb weight, while the genotype Majski srebrnjak which achieved the highest bulb weight in the trial ranged the lowest with the respect to stability. Concerning the number of bulbs plot^{-1}, Zlatno gnezdo, Holandski žuti and Jasenički crveni were of similar however not particularly high stability, while the remaining two genotypes were even less stable (Table 4). Similar ranking of genotypes in terms of means and stability was noted for the majority of the investigated traits of agronomic importance. On the average of eight traits, Majski srebrnjak and Jasenički žuti had the highest mean, and the lowest stability values. Vice versa, Jasenički crveni and Holandski žuti were of the lowest means and highest stability (Table 5). The phenomenon is common and it was reported for the yields and yield-related traits of many agricultural plants (e.g. GIREK *et al.*, 2013; LAKIĆ *et al.*, 2015).

Table 4. Means, AMMI stability values and ranking orders of stability for onion bulb weight (g) and number plot^{-1} – Genotypes

Genotype	Bulb weight		PC1	PC2	ASV	
	Mean	Rank			Value	Rank
Jasenički crveni	43.57	5	-0.1363	0.2809	0.44	1
Jasenički žuti	45.00	3	2.7355	1.7709	6.98	4
Majski srebrnjak	54.00	1	-4.2854	0.5064	10.60	5
Holandski žuti	44.50	4	0.7392	1.0267	2.09	2
Zlatno gnezdo	48.06	2	0.9470	-3.5850	4.28	3
Genotype	No of bulbs plot^{-1}		PC1	PC2	ASV	
	Mean	Rank			Value	Rank
Jasenički crveni	72.50	5	1.2554	-0.7779	4.01	3
Jasenički žuti	79.04	3	-3.7448	-0.4907	11.75	5
Majski srebrnjak	84.75	1	1.2858	-0.7400	4.10	4
Holandski žuti	77.54	4	0.2996	2.8544	3.00	2
Zlatno gnezdo	81.92	2	0.9040	-0.8458	2.96	1

PC1, PC2 – first and second principal components; ASV – AMMI stability values

Table 5. Ranking orders of means and AMMI stability values for onion traits of agronomic importance – Genotypes

Trait	Means					ASV				
	JC	JZ	MS	HZ	ZG	JC	JZ	MS	HZ	ZG
Bulb diameter	3	5	1	2	4	1	5	3	2	4
Bulb height	4	1	2	5	3	3	2	5	1	4
Bulb index	4	1	2	5	3	2	3	5	1	4
Neck diameter	4	3	1	5	2	1	2	4	3	5
Neck length	2	3	1	5	4	3	4	5	2	1
Plant height	5	3	1	4	2	3	5	4	2	1
Emergence	3	1	5	2	4	2	5	4	1	3
Vegetation period	3	5	1	4	2	5	4	2	3	1
Average ranking	4	2	1	5	3	2	4	5	1	3

ASV – AMMI stability values; JC – Jasenički crveni, JZ – Jasenički žuti, MS – Majski srebrnjak, HZ – Holandski žuti, ZG – Zlatno gnezdo

Table 6. Means, AMMI stability values and ranking orders of stability for onion bulb weight (g) and number plot^{-1} – Environments

Environment	Bulb weight		PC1	PC2	ASV	
	Mean	Rank			Value	Rank
B-09	41.81	4	-1.0565	0.5033	2.66	4
B-10	46.28	3	1.3688	-3.1465	4.62	7
M-09	27.81	7	1.7383	0.8685	4.38	6
M-10	36.42	5	1.2862	1.4361	3.49	5
N-09	72.22	2	-4.2539	0.2037	10.51	8
N-10	88.91	1	-0.6072	-1.5781	2.18	2
U-09	26.85	8	0.6689	0.4049	1.70	1
U-10	35.91	6	0.8553	1.3082	2.48	3
Environment	No of bulbs plot^{-1}		PC1	PC2	ASV	
	Mean	Rank			Value	Rank
B-09	80.93	4	-1.1240	-0.2461	3.53	3
B-10	85.80	2	0.1283	-1.8507	1.89	1
M-09	68.00	8	0.9889	2.3221	3.87	4
M-10	74.93	6	-0.6519	0.4049	2.08	2
N-09	89.13	1	1.8091	-0.1307	5.67	6
N-10	83.73	3	2.4165	-0.6365	7.60	8
U-09	73.80	7	-1.7416	-0.5573	5.49	5
U-10	76.87	5	-1.8253	0.6944	5.76	7

PC1, PC2 – first and second principal components; ASV – AMMI stability values; N-09 and N-10 – mineral fertilizer in 2009 and 2010, U-09 and U-10 – unfertilized, M-09 and M-10 – manure, B-09 and B-10 – bacterial fertilizer

Concerning bulb weight, the acute angle noticeable between the conventional treatments means the similarity in the trait expression in the two years of the experiment, indicating significant role of optimizing mineral fertilization in the formation of yield components and therefore the stable yield (KUMAR *et al.*, 2007; GAVIOLA *and* LIPINSKI, 2008). The vector angles between the organic treatments allocated in the upper right positive quadrant were also acute implying similarity in the bulb weights of the onions from the unfertilized and manure-fertilized plots. On the other hand; the obtuse angles between the conventional and the organic treatments refer to the significantly different bulb weights. The exception was bacterial treatment which was more similar to the conventional in both years of the experiment. However, bacterial treatments applied in the two consecutive years were not associated. As expected, the highest bulb weight was measured from the plots fertilized with conventional mineral fertilizer, while the bulbs from unfertilized plots performed the poorest (Table 6). Similarly low bulb weights noted for the unfertilized and plots fertilized with farmyard manure might be related to the specifics of the dynamics of nitrogen release from the organic fertilizers (HEINZE *et al.*, 2011; LAMMERTS von BUEREN *et al.*, 2012), which requires the modifications in terms of both agricultural practices and timing of their implementation (LEE, 2010; VIDIGAL *et al.*, 2010; LEE *et al.*, 2014). Bulb weights measured from the organic plots with foliar applied bacterial fertilizer were significantly higher, however still not in the range of the conventional. The number of bulbs plot^{-1} was to a greater extent influenced by the applied treatments, and to a lesser extent by the season in which the experiment was conducted (Table 6, Figure 1). Although the differences among the treatments were not as pronounced as for the bulb weight, the highest number of bulbs plot^{-1} was also obtained from the conventional and plots treated with bacterial fertilizer.

According to the results discussed by several authors (YASSEN and KHALID, 2009; FAROOQ *et al.*, 2015), carefully balanced combination of the type and the dose of organic fertilizer, the applied agro-technical procedures and the choice of the genotypes generally adapted to local climate, soil and other environmental conditions results in the organic onion that over-yields the conventional. The results of our investigation, especially those concerning various onion performances and the stability of these performances across the analyzed production systems, indicate that the high-yielding genotypes that are adapted to and bred for conventional environments may prove to be inferior when grown organically. In order to approximate yields of organic onions to those grown conventionally, a special attention should be paid to optimize organic onion fertilization. Therefore onion breeding programs intended to develop cultivars adapted to alternative production systems should be based on comprehensive analyses of the performances of a number of genotypes grown in complex experiments that include various combinations of sowing dates, fertilizing regimes, times of their application and other agro-technical practices relying on the principles of organic agriculture.

CONCLUSIONS

All sources of variation in AMMI model ANOVA were highly significant. For majority of the investigated onion traits the largest proportion of the total sum of squares encompassed to environments. The exceptions were emergence and bulb index, with pronounced effect of genotypes; and neck length, with pronounced effect of genotype by environment interaction. The best model was the AMMI model with two axes. Good onion performance was generally accompanied with low stability across the analyzed production systems. Hence the breeding programs intended to develop cultivars adapted to organic production regimes should be based on the experiments set in the corresponding environments including various combinations of genotypes and agro-technical procedures.

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AMMI MODEL U ANALIZI INTERAKCIJE GENOTIPA I SREDINE KOD KONVENCIONALNO I ORGANSKI GAJENOG CRNOG LUKA

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Izvod

Istraživanje je sprovedeno sa ciljem procene stabilnosti direktnih komponenti prinosa (mase lukovice i broja lukovica parceli^{-1}) i svojstava koja ispoljavaju uticaj na prinos (prečnik, visina i indeks lukovice, prečnik i dužina lažnog stabla, visina biljke, nicanje, dužina vegetacije) kod pet komercijalnih sorti crnog luka gajenih u konvencionalnom i organskom režimu, primenom AMMI statističkog modela kod analize podataka. Dvogodišnji poljski ogled organizovan po slučajnom blok sistemu je postavljen u četiri varijante: mineralno đubrenje (konvencionalna), bez đubrenja, stajnjak i mikrobiološko đubrivo (organske). Analizom varijanse AMMI modela je utvrđeno da su kod ispitivanih svojstava svi izvori variranja (genotipovi, uslovi sredine, interakcija genotipova i sredina) visoko značajni. Najveći deo ukupne sume kvadrata se odnosio na uslove sredine, osim kod nicanja i indeksa lukovice gde su najizraženiji bili efekti genotipova (67,26 i 52,54%, po redosledu) i dužine lažnog stabla gde je suma kvadrata interakcije genotipova i sredina iznosila 44,59%. Generalno, efekat interakcije je bio u uobičajenom rangu. Zaključeno je da je za ispitivana svojstva AMMI model sa dve ose najbolji model. Luk gajen u konvencionalnom sistemu nadmašio je organski. Međutim, poželjna ekspresija svojstava genotipova nije bila stabilna u svim uslovima sredine. Stoga oplemenjivački programi koji za cilj imaju razvoj sorti namenjenih alternativnim sistemima proizvodnje treba da budu zasnovani na eksperimentima postavljenim u uslovima sredine koji podrazumevaju raznovrsne kombinacije genotipova i agrotehničkih procedura baziranih na principima organske poljoprivrede.

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