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Trait associations in onion grown under organic and mineral fertilization

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Abstract: The aim of this two-year field study was to investigate the effects of different nutrient regimes on the interrelationships of onion (*Allium cepa* L.) yield and yield contributing characteristics (bulb weight, number of bulbs plot^{-1}, plant height and number of days from sowing to emergence). The experiment involved five onion cultivars grown in conventional (mineral fertilization) and organic (unfertilized, bacterial fertilizer, farmyard manure) production systems. The trait associations were studied using two-dimensional biplot. The applied treatments affected all the traits investigated and those effects were stable across the growing seasons. Consistently positive correlations that have been found among yield, bulb weight, number of bulbs plot^{-1} and plant height imply the conclusion that taller plants perform better in all nutrient regimes. Early emergence correlated positively with yield only in favorable (mineral and bacterial fertilizer) environments. The close position of the two favorable entities on the biplot imply the possibility of achieving high and stable onion yields by applying an appropriate organic amendment.

Key words: onion, organic fertilizers, trait associations, biplot

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Introduction

Both fresh and proceeded, onion (*Allium cepa* L.) represents an important ingredient of everyday human diet. In Serbia, the great majority of the 19 000 ha occupied by the onion crops are still conventionally maintained. However, the consumers and producers have become more interested in organic farming of the vegetable, especially for the crops attended for fresh consumption. Besides for extending the knowledge on organic agricultural practice (the use of appropriate fertilizers, coping with weeds etc.) that has gained in importance, the special attention should be paid to the choice of the cultivars suitable for this type of growing. Because there is no organic onion cultivar recognized in our country, the production relies on those selected in and for conventional farming systems. Those cultivars do not necessarily perform satisfactory in organic conditions; therefore, they should be tested for yield response to low input situation in order to choose the best-performing and recommend them to the producers (Lammerts van Bueren *et al.* 2005, Osman *et al.* 2008, Berenji 2009, Stat. god. Srb. 2010, Vlahović *et al.* 2010, Zdravković *et al.* 2010, Brdar-Jokanović *et al.* 2011).

The next step would be breeding onion cultivars attended specifically for organic production. The same as for conventional breeding, the best-performing candidates should be crossed in order to choose the offspring with the highest yielding potential in organic production systems. However, there is an open question if the certain traits that are proved to be yield-predictive in conventional environments can be used for the same purpose in organic environments (Kristensen and Ericson 2008). Therefore, both yield and potentially yield-predictive traits should be investigated in both environments.

This study was conducted in order to investigate the effects of mineral and organic nutrient regimes on the relationships among onion yield and other traits of agronomical importance.

Materials and methods

Two-year (2009, 2010) field trial including five commercial onion cultivars (Jasenički crveni, Jasenički žuti, Majski srebrnjak, Holandski žuti and Zlatno gnezdo) has been set at the Institute for Vegetable Crops, Smederevska Palanka, Serbia (44°22' N, 20°57' E, elevation 121 m). The trial was complete randomized block designed, with three replications. It included control (unfertilized-UNF), treatment with mineral fertilizer (NPK) and two treatments with organic amendments (farmyard manure-MAN and bacterial fertilizer-BACT). The application of NPK (15 % N, 15 % P_2O_5 and 15 % K_2O) and

farmyard manure was performed prior to sowing, at the rates of 500 kg ha^{-1} and 45 t ha^{-1}, respectively. Bacterial fertilizer 'Slavol', Agrounik d.o.o., Belgrade (*Bacillus megaterium, Bacillus licheniformis, Bacillus suptilis, Azotobacter chrocoocum, Azotobacter vinelandi, Derxia* sp.) was applied foliar, twice during each year, at the three-leaf stage. Pesticides used in conventional agriculture were applied to NPK plots, while the unfertilized control and treatments were kept free from weeds by hand-weeding. The plots were irrigated as needed.

The main plots included three 5 m long rows, with intra and inter row spacing of 10 and 20 cm, respectively. The trial was sowed on 23rd and 25th March and harvested on 15th July and 8th August for 2009 and 2010 growing seasons, respectively. Meteorological data are given in Figure 1. The both seasons were characterized by higher temperatures andprecipitation in comparison to long-term average.

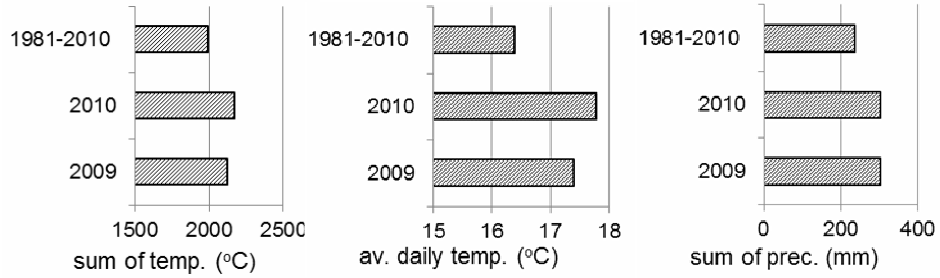

Figure 1. Meteorological data for onion growing seasons (2009, 2010, long-term average, Smederevska Palanka, March 20th-July 20th)

Emergence (number of days from sowing to emergence), plant height (cm), bulb weight (g), number of bulbs $plot^{-1}$ and yield (kg $plot^{-1}$) were recorded and analyzed. The samples consisted of 30 plants per plot.

The data was processed by analysis of variance in order to confirm significant genotype-environment (GE) interactions as a precognition for employing biplot analysis (Yan and Tinker 2006). Pearson's correlation coefficients among the traits were calculated. The constructed trait association by environment biplot represents the visual description of those relationships in different environments and facilitates their interpretation. R software (R Development Core Team 2008) was used for the statistical analysis.

Results and Discussion

Bulb weight and number of bulbs plot^{-1} are the two components that define onion (*Allium cepa* L.) yield. As in other agricultural plants, the performance of the yield components depends on a number of genetic and environmental factors, such as temperature, humidity, the available nutrients, efficacy of pest and weed control. In addition, other traits, such as number of days from sowing to emergence, vegetation period, plant height, bulb diameter, neck length and diameter, may affect yield components and consequently yield. Hence the other agronomical traits are under the influence of environmental factors too, it is logical that a change in external conditions may affect them and lead to decreased or increased yield. The effects of different nutrient regimes and other environmental factors on onion and garlic have been noticed by Kumar *et al.* (2007), Gaviola and Lipinski (2008) and Yassen and Khalid (2009). Since among the listed traits, besides of yield components, emergence and plant height have been defined as characteristics that directly influence onion yield under different nutrient regimes, this study was aimed to get further inside in their interrelationships.

The associations among a number of traits are routinely investigated by calculating Pearson's coefficients of correlation. However, when it comes to experiments that include multiple treatments, genotypes and/or seasons, numerous coefficients are often difficult to interpret. The associations of the particular traits in different environments can be visualized and studied using two-dimensional biplots. The procedure has become often employed by agronomists when analyzing multiple genotypes, environments and/or traits (Yan and Tinker 2006). Significant GE interaction (from analysis of variance) that is the first precognition for employing the analysis was found for all five studied onion traits. The highest yield was obtained from NPK-fertilized plots, followed by the yield from plots treated with bacterial fertilizer. The lowest yield was noted for manure (data not shown). In addition, rank changes of the onion cultivars in the treatments have been noticed for all traits investigated. As an illustration, the differences among the cultivars in plant height attributed to differences in nutrient regimes are depicted in Figure 2.

When it comes to interrelationships of the analyzed traits in the four nutrition regimes, twenty six positive and three negative Pearson's correlation coefficients have been calculated for the two-year averages (Table 1.).

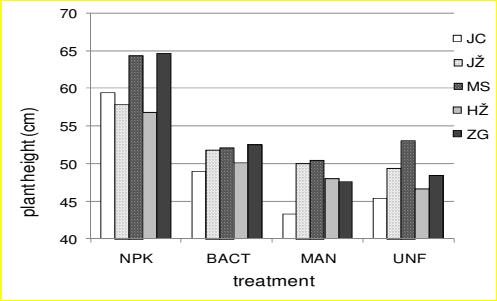

Figure 2. Rank of onion cultivars (JC-Jasenički crveni, JŽ-Jasenički žuti, MS-Majski srebrnjak, HŽ-Holandski žuti, ZG-Zlatno gnezdo) on fertilizer treatments (NPK-mineral, BACT-bacterial, MAN-manure, UNF-unfertilized) concerning plant height.

Table 1. Pearson's correlation coefficients among onion yield, (Y), bulb weight (BW), number of bulbs plot^{-1} (NB), plant height (PH), and number of days from sowing to emergence (EM), two-year average.

a) Mineral fertilization (above diagonal) and without fertilization (below diagonal)

Traits	**Y**	**BW**	**NB**	**PH**	**EM**
Y		0.70**	0.78**	0.75**	-0.61**
BW	0.70**		0.32	0.79**	-0.04
NB	0.78**	0.54**		0.54**	-0.83**
PH	0.76**	0.69**	0.65**		-0.36*
EM	0.13	0.38*	0.22	0.01	

b) Bacterial fertilizer (above diagonal) and farmyard manure (below diagonal)

Traits	Y	BW	NB	PH	EM
Y		0.83**	0.69**	0.57**	-0.24
BW	0.45*		0.55**	0.64**	-0.20
NB	0.58**	0.61**		0.57**	0.08
PH	0.73**	0.71**	0.80**		0.19
EM	0.06	0.65**	0.22	0.38*	

*, ** significant at the 0.05 and 0.01 levels of probability, respectively

The constructed two dimensional trait association by environment biplot (Figure 3) facilitates the interpretation of this data. Each treatment in each year was considered as a separate entity, accordingly environment. Principal components 1 and 2 in the biplot explained 84.7 and 9.2 of the variation,

respectively. The very acute angles between individual treatments corresponding to the two years (e.g. 10 NPK and 09 NPK) indicate that the effects of the treatments were stable across the onion growing seasons. The close position of NPK and BACT treatments imply the possibility of achieving high and stable onion yields by applying an appropriate organic amendment. NPK and MAN treatments were the most informative for discriminating the cultivars.

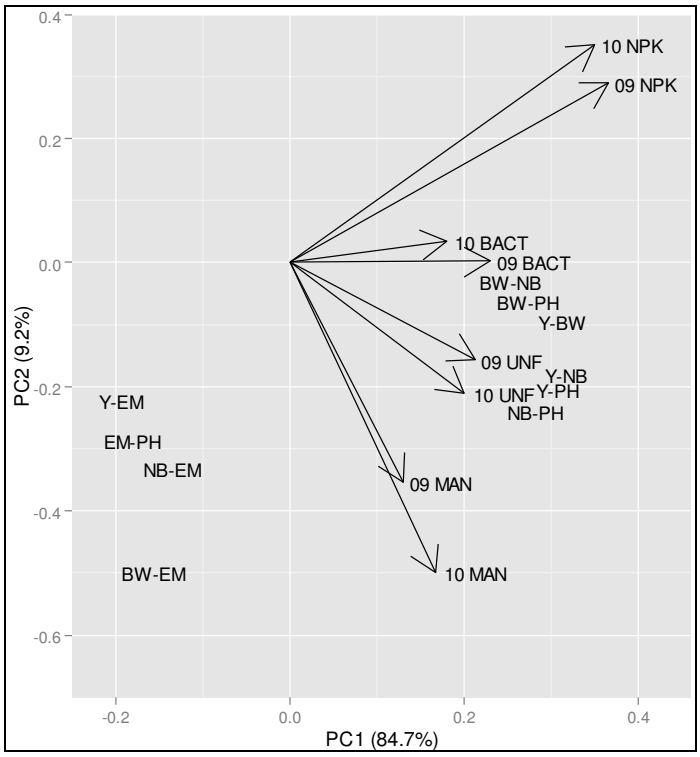

Figure 3. Trait association by environment biplot. Traits: yield (Y), bulb weight (BW), number of bulbs plot^{-1} (NB), plant height (PH), number of days from sowing to emergence (EM). Environments: mineral fertilizer in 2009 and 2010 (09 NPK, 10 NPK), bacterial fertilizer (09 BACT, 10 BACT), farmyard manure (09 MAN, 10 MAN) and without fertilization (09 UNF, 10 UNF).

Positive correlations were found among yield, bulb weight, number of bulbs plot^{-1} and plant height in all treatments. Similar results have been reported by Aliyu *et al.* 2007, Islam *et al.* 2007 and Degewione *et al.* 2011, while Golani *et*

al. (2006) found negative effect of plant height on yield. The associations were stronger in the cases of BACT and UNF. However, the associations between number of days from sowing to emergence and other investigated traits were altered across the treatments: negative for NPK and BACT, and positive for MAN. In the case of UNF, emergence was slightly negatively correlated only to yield and plant height. Arin *et al.* (2011) also noted the effects of different treatments on onion seed emergence period and ratio. Therefore, taller plants perform better in both mineral and organic nutrient regimes, while earlier emergence correlates positively with yield in favorable (NPK, BACT) environments only.

Conclusion

High and stable onion yields may be achieved by application of appropriate onion fertilizers. The most informative treatments for discriminating the cultivars are mineral fertilizer (the most favorable nutrient regime) and farmyard manure (the least favorable regime). Taller plants are desirable in all nutrient regimes, while lower number of days from sowing to emergence correlates positively with yield only in favorable environments.

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KORELACIJE SVOJSTAVA CRNOG LUKA PRI ORGANSKOM I MINERALNOM REŽIMU ISHRANE

- originalni naučni rad -

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Rezime

Dvogodišnji poljski ogled je postavljen sa ciljem ispitivanja uticaja različitih režima ishrane na odnose između prinosa crnog luka (*Allium cepa* L.) i svojstava koja se dovode u vezu sa prinosom (masa lukovice, broj lukovica parceli^{-1}, visina biljke, broj dana od setve do nicanja). U ogled je bilo uključeno pet sorti crnog luka, gajenih u konvencionalnom (mineralno đubrivo) i organskom (bez đubrenja, mikrobiološko đubrivo, stajnjak) sistemu proizvodnje. Veze između svojstava su tumačene na osnovu dvodimenzionalnog biplota. Primenjeni tretmani su ispoljili značajan uticaj na sva proučavana svojstva i efekti ovih tretmana su bili stabilni u obe sezone. Pozitivne korelacije koje su utvrđene između prinosa, mase lukovice, broja lukovica parceli^{-1} i visine biljke upućuju na zaključak da biljke sa većom visinom daju bolje prinose pri svim režimima ishrane. Ranije nicanje je bilo u pozitivnoj korelaciji sa prinosom jedino pri povoljnijim (mineralno i mikrobiološko đubrivo) režimima ishrane. Bliska pozicija ova dva režima ishrane na biplotu upućuje na zaključak da se stabilan i visok prinos crnog luka može postići primenom odgovarajućih organskih đubriva.

Ključne reči: crni luk, organska đubriva, korelacije, biplot.