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Content

YIELD-RELATED TRAITS IN A COLLECTION OF 'TREŠNJEVAC' BEANS (*Phaseolus vulgaris* L. forma *versicolor*)

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Abstract

In order to facilitate the selection of high-yielding 'trešnjevac' bean variety adapted to Serbian agro ecological conditions, local populations and a foreign (control) variety have been examined in terms of several traits of agronomic importance. Significant variability was found among the tested accessions and between the two seasons of experiment in terms of all investigated traits. Yield per plant correlated positively to pod weight, seed weight, number of seeds per plant, number of seeds per pod and number of pods per plant. Out of 13 examined populations, six over-yielded check variety in both seasons. The population with high and the most stable yield (P-36, 22.2 g/plant) would be a valuable starting material for breeding 'trešnjevac' bean variety.

Key words: local populations, 'trešnjevac' bean, yield

Introduction

As an important source of nutrients in human diet, dry bean (*Phaseolus vulgaris* L.) is grown on 25-30 million hectares worldwide, with annual production of 21-23 million tons. It is the third most important food legume crop in the world, following only soybean and peanut. In Serbia dry beans occupy approximately 20 thousand hectares. The average annual production for both pure and interplanted crops is 43 thousand tons, which does not fully meet the needs of the local population.

Although more than twenty high-yielding and high-quality dry bean varieties have been developed at Institute of Field and Vegetable Crops from Novi Sad and Institute for Vegetable Crops from Smederevska Palanka, a significant part of Serbian dry bean crops are still domestic, local populations. This is especially true for beans intended for producer's own consumption or for selling in local markets. The fact that the producers frequently choose local populations over commercial varieties imply the specific requirements of consumers, but also the possibility that at least a part of this material perform better than commercial varieties in terms of important traits; primarily quality, tolerance to abiotic and biotic stress, and yield. In addition, Serbian

commercial varieties are mostly white-seeded and seeds of certain types, such as two-colored 'trešnjevac', are not available on the market. Although seed color and shape do not affect dry bean nutritional composition, they represent basic market characteristic. Therefore, the collected local populations of 'trešnjevac' should be evaluated in field trials in order to distinguish the superior ones that could be included in breeding programs (Vasić, 2004; Gonzáles *et al*., 2006; Vasić et al., 2007; Stat. Yearb. Serb., 2012; Kahraman and Önder, 2013; FAOSTAT, 2014).

The purpose of this study was to investigate the collection of 'trešnjevac' dry bean local populations in terms of yield and several traits of agronomic importance. The results should facilitate the selection of high-yielding variety adapted to Serbian agro ecological conditions.

Material and methods

This study comprised 13 'trešnjevac' type dry bean local populations (P-2, P-11, P-18, P-19, P-20, P-29, P-34, P-36, P-62, P-69 and P-92 collected in Vojvodina, P-86 from south Serbia and P-93 from Bosnia) and one variety (P-74, Butmirski trešnjo, old cultivar from Bosnia and Herzegovina). The accessions are part of the joint dry bean collection founded by Institute for Vegetable Crops, Smederevska Palanka and Institute of Field and Vegetable Crops, Novi Sad.

The trial was conducted during two growing seasons (2010, 2011) at the experimental field of the Institute for Vegetable Crops, Smederevska Palanka, Serbia (44^o 22' N, 20^o 57' E, elevation 121 m). The soil type is vertisol. The trial was set in complete randomized blocks, with three replications. The main plot consisted of three 1 m long rows; with intra and interspacing of 5 and 70 cm, respectively. Sowing and harvest were performed at regular dates. The official weather data (Republic Hidrometeorological Service of Serbia) covering the two seasons are given in Table 1.

Table 1. Weather data for dry bean growing seasons (April – July) of 2010, 2011 and the corresponding long-term averages (Smederevska Palanka, Serbia)

Parameter	2010	2011	2004-2013
Average daily temperature (^{o}C)	18.1	18.2	18.4
Minimum temperature (^{o}C)	1.0	0.1	-3.4
Maximum temperature (^{o}C)	34.2	38.7	44.9
Sum of temperatures (^{o}C)	2208.6	2223.3	2245.3
Sum of precipitation (mm)	373.6	197.6	251.8

The following traits were analyzed: yield per plant (g), plant height (cm), the first pod height (cm), weight of vegetative plant parts (g), pod weight (without seeds, g), 1000 seed weight (g), number of seeds per plant, number of seeds per pod and number of pods per plant.

Data were processed by analysis of variance. Basic statistic parameters (mean, minimum, maximum values and coefficients of variation), as well as Pearson's correlation coefficients were calculated. The calculations were performed using Statistica 12 software package (StatSoft, Tulsa, OK, USA).

Results and discussion

Statistically significant differences in terms of all the investigated traits were found among the tested 'trešnjevac' dry bean accessions (Table 2). The highest variation was noted for pod weight and yield per plant (54.2 and 48.6%, respectively), while the first pod height, number of seeds per pod, plant height and 1000 seed weight varied in significantly lower range (19.9, 23.4, 23.9 and 26.8%, respectively). Comparatively low coefficients of variation were reported for the

same traits investigated in a three-year field trial comprising collection of 129 dry bean accessions of different types (Vasić, 2004).

Table 2. Basic statistic parameters and LSD test for the investigated traits in fourteen 'trešnjevac' dry bean accessions, two-year averages. CV – coefficient of variation

Trait	Mean	Min	Max	CV (%)	$LSD_{0.05}$	$LSD_{0.01}$
Yield per plant (g)	15.3	7.3	23.0	48.6	5.3	7.4
Plant height (cm)	49.0	38.0	71.1	23.9	6.9	9.6
The first pod height (cm)	22.4	18.3	26.2	19.9	5.4	7.6
Weight of vegetative plant parts (g)	8.1	4.7	14.3	44.3	4.3	5.9
Pod weight (g)	5.2	3.1	8.8	54.2	3.9	5.4
1000 seed weight (g)	404.0	302.8	503.8	26.8	82.9	115.0
Number of seeds per plant	37.2	19.5	49.2	33.8	8.3	11.4
Number of seeds per pod	3.6	2.0	4.3	23.4	1.8	2.5
Number of pods per plant	10.3	8.5	13.1	31.3	3.7	5.2

Table 3. Pearson's coefficients of correlation for the investigated 'trešnjevac' dry bean traits

Traits	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Yield per plant (1)	1.00	0.32	-0.29	0.16	0.86**	0.77**	0.88**	0.66**	0.84**
Plant height (2)		1.00	0.24	0.51**	0.30	0.09	0.22	-0.03	0.47*
First pod height (3)			1.00	0.31	-0.22	-0.43*	-0.36	-0.41*	-0.32
Weight of veg. parts (4)				1.00	0.38*	0.04	-0.08	-0.25	0.25
Pod weight (5)					1.00	0.72**	0.64**	0.50**	0.82**
1000 seed weight (6)						1.00	0.52**	0.48**	0.61**
No of seeds per plant (7)							1.00	0.68**	0.80**
No of seeds per pod (8)								1.00	0.52**
No of pods per plant (9)									1.00

As for the mean values of yield per plant and traits directly related to yield (1000 seed weight, number of seeds per plant, number of pods per plant), the analyzed accessions performed better than the mentioned collection, probably due to the fact that the latter consisted of a large number of accessions differing in seed coat color, shape and chemical composition, growth habit etc. Plant height was in the range of most widely grown Serbian cultivars (Vasić *et al.,* 1999), while the first pod height mean value of 22.4 cm meets the requirements of mechanized harvesting (Zdravković *et al.,* 2005). Number of seeds per pod (3.6) was not significantly different from the value of 3.2 reported by Vasić (2004), implying high stability of the trait.

In addition, Pearson's correlation coefficients were calculated among the investigated traits in order to analyze their interrelationships and to identify those with the strongest effects on yield (Table 3). Positive correlations of yield per plant and number of seeds per plant, number of seeds per pod and number and weight of pods per plant are in accordance to the results of Vasić (2004). However, the yields of 'trešnjevac' beans analyzed in this study, as well as the yield of commercial Serbian varieties in general (Vasić *et al.,* 1997) correlate positively to 1000 seed weight, whereas this correlation was negative in the study comprising large number of accessions differing in morphology and origin. According to Vasić (2004), the discrepancy is due to the requirements of the local market which demands high-yielding varieties with large seeds. In addition, the interrelationships among the mentioned traits were generally positive. Yield per plant was not significantly related to plant and the first pod height, implying the possibility for

breeding high-yielding 'trešnjevac' varieties of different growth types. However, the first pod height correlated negatively to the majority of the traits directly related to yield, which should be taken into account in further research. In a study performed by Önder *et al*. (2013) yield was negatively affected by both first pod and plant height.

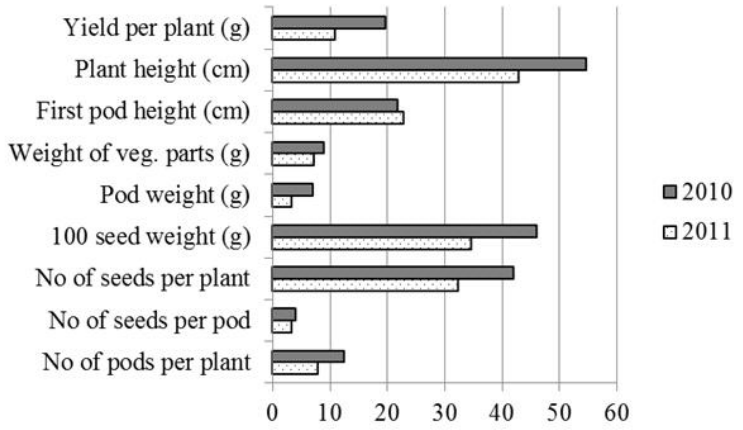

Figure 1. The average effect of the season on the investigated 'trešnjevac' dry bean traits

The average effect of the seasons in which the experiment has been conducted on the investigated traits is depicted in Figure 1. The analyzed 'trešnjevac' beans performed significantly better in 2010 than in 2011 growing season in terms of all investigated traits, except the first pod height which was slightly increased in the unfavorable season. Since the average daily temperature and sum of temperatures in both 2010 and 2011 fell in the range of long-term averages (Table 1), the poor performance in 2011 is probably due to the low sum of precipitation. In addition, maximum daily temperatures were 4.5 ^{o}C higher in the unfavorable than in the favorable season. The highest seasonal effect was noted for pod weight, yield per plant and number of pods per plant, respectively. Seasonal variation in dry bean yield and several other traits was also reported by Shenkut and Brick (2003).

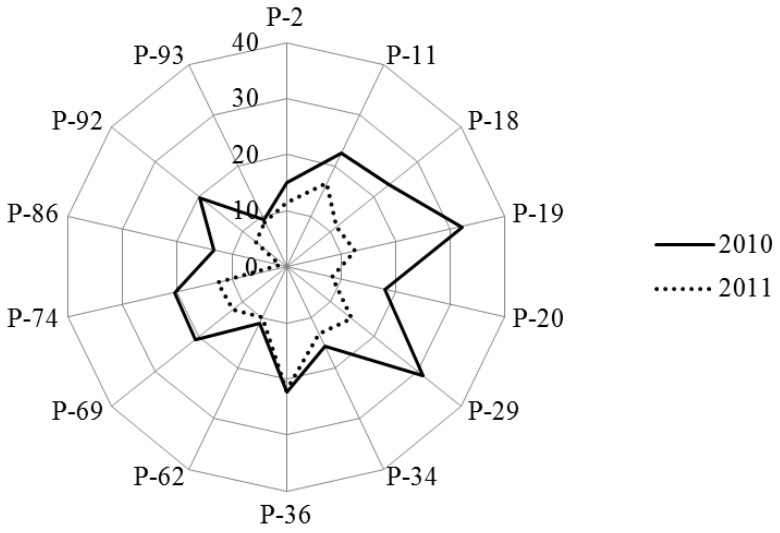

Figure 2. Yield per plant (g) in the analyzed 'trešnjevac' dry bean accessions

Yield per plant of the particular accessions grown in the two seasons of the experiment is shown in Figure 2. Out of thirteen examined populations, six (P-11, P-18, P-19, P-29, P-36 and P-69) over-yielded check variety (P-74, Butmirski trešnjo), implying wide possibilities for developing new 'trešnjevac' cultivar adapted to local environment. The highest average yields are noted for accessions P-29, P-19 and P-36 (23.0, 22.3 and 22.2 g/plant, respectively). However, the yield of the agricultural plants should be both high and stable across environments, therefore only P-36 is recommended for further research. Since the two seasons of the investigation differed in terms of precipitation, yield stability of the particular accessions might be used as a starting point for breeding for drought tolerance.

Conclusions

Significant variability was found among the tested fourteen 'trešnjevac' dry bean accessions and between the two seasons of experiment in terms of all investigated traits. Yield per plant correlated positively to pod weight, seed weight, number of seeds per plant, number of seeds per pod and number of pods per plant. Six populations over-yielded check variety, implying the possibility for developing new 'trešnjevac' dry bean cultivar. The population with high and the most stable yield (P-36, 22.2 g/plant) would be a valuable starting material for further research. Yield stability of the analyzed accessions might be considered in breeding for drought tolerance.

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