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Željko LAKIĆ, Ljubiša ŽIVANOVIĆ, Slobodan POPOVIĆ[1]

PRODUCTIVITY OF SPRING FORAGE PEA *(PISUM SATIVUM)* IN DIVERGENT AGROECOLOGICAL CONDITIONS

SUMMARY

Spring forage pea varieties represent a broad source of genes for the desirable properties, especially those related to abiotic and biotic stress, that can be inserted into the existing varieties. Studies showed that a variety-line-hybrid had the greater impact on the expression of production and morphological traits in relation to the vegetation period. The factor of years did not had the same impact on the expression of each production and morphological traits.

Statistically significant impact on the plant height had the genotype and genotype x year interaction. It was noticed that this phenotypical characteristic vary in a wide range between 71.00 cm in Baccara genotype to 146 cm in Saša genotype.

The genotype and genotype x year interaction had a statistically significant impact on the pod length. Studies showed that the genotype and G x Y interaction had a statistically significant impact on the seed yield per plant. Baccara genotype had a statistically significant higher average seed yield per plant compared to the line L-CC.

The correlative relation of production and morphological traits has manifested in varying degrees. Strong positive correlation was recorded between the grain weight per plant and pod length (r = 0.53 **), then between the grain weight and pod weight per plant (r = 0.87 **), and grain weight and pod length (r = 0.47*).

The wide mutual variability of the most important characteristic may be extremely beneficial for the existing varieties, due to the narrow genetic base.

Keywords: *Fabaceae*, spring forage pea, plant breeding, production and morphological traits, correlation.

INTRODUCTION

Annual legumes are important, both in the terms of yield and quality as well as the protection of agroecological system: improvement of the soil physical, chemical and biological properties, fertilizer costs reduction, nutrient leaching prevention, moisture storage, erosion prevention, reduction of pesticide use and environmental protection; preservation of soil and water quality and thus

[1]Željko Lakić (corresponding author: zeljko_lakic@inecco.net) PI Agricultural Institute of Republic of Srpska, Knjaza Miloša 17, Banja Luka, BOSNIA AND HERZEGOVINA; Ljubiša Živanović University of Belgrade Faculty of Agriculture, Nemanjina 6, Zemun, SERBIA, Slobodan Popović JKP "Gradsko Zelenilo" Novi Sad, Sutjeska 2, Novi Sad, SERBIA
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human health. Despite a prominent character the annual forage plants are grown on relatively small areas in the agroecological conditions of Bosnia and Herzegovina. Annual forage plants have a long cultivation tradition in Bosnia and Herzegovina, where they represent an indispensable supply source of the quality forage and concentrated animal feed for livestock production.

The most important annual forage legumes are forage pea (*Pisum sativum* L.) and common vetch (*Vicia sativa* L.), followed by broad bean (*Vicia faba* L.), hairy vetch (*Vicia villosa* Roth), Pannonian vetch (*Vicia pannonica* Crantz), ervil (*Vicia ervilia* (L.) Willd.) and grass pea (*Lathyrus sativus* L.), then narbon vetch (*Vicia narbonensis* L.), white lupine (*Lupinus albus* L.), blue lupine (*Lupinus angus - tifolius* L.) and cowpea (*Vigna unguiculata* (L.) Walp.), with high potential for intensive cultivation (Mihajlović et al., 2006b). Annual forage legumes have a multiple purpose and are grown for green fodder, hay, fodder meal, grain and straw, with the note that beans and other legumes can also be used for grazing. In the production great losses of pea yield are occurring due to biotic and abiotic stresses, which requires to direct selection towards the creation of varieties with an improved stress tolerance mechanism (Saha and Vandemark, 2012). The breeding of forage pea includes three basic directions: breeding for fodder yield; breeding for seed yield and for the yield of fodder and seed. Methods of breeding for forage pea yield are the pedigree method, bulk method and backcross method. Success of a breeder in the new pea varieties creation, that aims to increase seed yield, depends a lot on the starting material variability as well on the success in the improvement of quantitative and qualitative properties and their mutual interaction (Tiwari and Lavanya, 2012). For the successful breeding work and the creation of new varieties, one of the requirement is the starting material variability. However, if the selection goes in the direction towards certain traits, and if these traits have a high variability and heritability, it is important that they are in the preferred correlative relation with seed yield (Lakić et al., 2013).

Breeding for the fodder yield is the oldest direction in pea breeding that is aimed on the creation of a winter and spring varieties of the great potential for high-quality and stable yields of green fodder and hay, with the possibility to be used as green manure. The most important forage pea agronomic traits are the tall plants, moderate stem number, increased proportion of leaf in plant mass and satisfactory seed yield. Winter forage pea variety Pešter from Novi Sad is characterized by the fodder yield of 45 to 50 t ha^{-1} and about 10 t ha^{-1} of dry fodder matter (Mihajilović et al., 2007b). Pea breeding for the seed yield is usually focused on the creation of varieties with a good potential for high and stable yields of grain that is rich in proteins and have the reduced anti-nutritional ingredients content. In this breeding direction, the most significant characteristics are considered to be a shortened growing period, uniformly ripening, increased tolerance to lodging, increase in the number of knuckles in lower stem part and the introduction of genes for afila leaf type (af Tl). Biological nitrogen fixation efficiency depends on the strain type of nitrogen fixing bacterias, varieties, followed by the interaction between different strains and varieties, environmental factors and technological practices. After photosynthesis, biological nitrogen fixation in leguminous plants can be considered the most important biological process on earth. The ability of nitrogen fixation is underutilized by the developing countries, but also by developed countries, as reflected on the excessive nitrogen fertilizers dependence in agriculture (Abi-Ghanem et al. 2014). In the European Union of the total cultivated land in different countries, fodder legumes are making 1-7%, which is certainly small compared to non-EU countries with 15-25%. One way to increase the areas in Europe is to intensify the work on selection in terms of the genotype creation that is tolerant to pedoclimatic or stress conditions, particularly diseases. As one of the measures for increasing the areas under annual fodder legumes in EU is the production subsidization per area unit (Mihajilović et al., 2009). In order to intensify livestock production and to obtain high yields with good quality, special attention should be given to the selection of appropriate assortment with short growing season, as well as to sowing, and above all to the seed quantity and sowing period. During the preliminary tests, NS spring pea cultivars Partner, Kristal and Dukat, had the average yields of about 5 t ha^{-1}, with a prominent early maturity (Mihajilović et al., 2007b). However, the yield and quality achieved in micro trials points to the fact that this plant species is unduly neglected.

The morphological description and general assessment of future parents is as important as its interaction with the environment (Popović et al., 2012a, 2012b, 2016a). The climate change impacts on agriculture are the result of a series of complex interactions with other environmental, social, economic and political factors and are mainly related to the biological effects on crop yields, as well as the resulting impacts on outcomes including prices, production, and consumption (Nelson et al., 2009). Therefore, the objective of this study was to determine the morphological diversity of pea genotypes, and to valorize the value of morphological characteristics and analyzes based on them, or to examine the productivity of facultative pea varieties.

MATERIALS AND METHODS

Parental varieties and their hybrids are shown on the experimental field of the PI Agricultural Institute of Republic of Srpska in Delibašino Selo during the years 2014 and 2015. The sowing was done in March. For the sowing 80 viable seeds per m^2 was used. Plot size was 2.5 m^2 (2 x 1.25m). Row spacing of 12.5 cm x 8 cm. Depth of sowing 4-5 cm. The number of repetitions (blocks) is 4. The basic fertilization during the preparation for sowing amounted to 350 kg/ha of NPK 8:24:24. Fertilization with 100 kg/ha of KAN 27% N in the phase of plant growth and development. Treatment against weeds (with herbicide) after sowing and before germination (Zanat - active ingredient pendimethalin). The dose of 5 l/ha - in 5 liters of water 50 ml of herbicide Zenit for 100 m^2. Treatment with Galbenon herbicide (a.i. bentazon 480 g/l) 3.5 l/ha (in pea upgrowth 8- 10 cm). Treatment with insecticides against pests (weevil) at the blooming and flowering stage - systemic insecticide (Decis - a.i. deltamethrin 25 g/l, Perfekthion - a.i. dimethoate) at a concentration of 0.15-0.20%.

Nitrogen fertilization lead to a significant increase in dry matter yield, however, it reduced the value of the achieved yield and increase in the yield per unit of added nitrogen (Bijelić et al, 2016).

Parallel to the spring sowing all hybrids (crossbreeds) of F3 and F4 generations are sown in the first week of October in 2014 and 2015 as winter peas. In this study data are processed for F3 and F4 generation of spring forage pea. Of the each variety/hybrid 10 plants per replication were annually analyzed.

For breeding the following population of spring fodder pea were used:

1. Saša – variety created in the Agricultural Institute of Republic of Srpska in 1990. Designated for the combined use of fodder and grain.

2. Baccara – French variety of spring forage pea intended for the seed production.

3. Line L-CC – forage pea line originating from North America. It has pink-purple flowers. Line L-CC is facultative.

This study is processing the following hybrids (crossbreeds):

1. Line L-CC x Baccara; 2. Baccara x Line L-CC; 3. Saša x Line L-CC; 4. Baccara x Saša

Analysis of the following morphological and productive parameters was conducted: 1. plant height (cm); 2. legume length (cm); 3. legume weight without grain (g); 4. grain weight (g); seed yield per plant (g).

The original experimental data are processed, analyzed and evaluated using the following mathematical and statistical methods: factor impact on the plant characteristics (variance analysis) and correlation analysis of plant characteristics with the use of the statistical package STATISTICA 12 for Windows. Applied mathematical and statistical methods for the experimental data processing, analysis and evaluation of the research results enabled the correct understanding of all results. Significance was calculated based on LSD test for probability levels 0.05% and 0.01%. Relative dependence was defined by method of correlation analysis and stability tested traits determined by the coefficients of variation (%).

RESULTS AND DISCUSSION

Soil conditions

At the experimental field of the Agricultural Institute of Republic of Srpska in Delibašino Selo, where the experiment was established, dominant soil type was a valley-brown soil on alluvial substrate of the river Vrbas. By the mechanical composition soil belongs to the group of a clay loam. The surface structure layer of this soil type is crumbly. The results of chemical analysis of arable soil layer on which the experiment was set up are shown in Table 1.

In terms of pH, the soil is alkaline, and by humus content it belongs in soil types with low humus content (1.9%). The availability of easily accessible phosphorus is good (20.3 mg/100g), while the presence of potassium in the soil is moderately with 16.1 mg/100 g of soil. Based on these results it can be concluded that the soil intended for the experiment is suitable for the cultivation of forage pea.

Table 1. Results of chemical analysis of arable soil layer

Depth (cm)	Humus %	pH in H_2O	pH in KCl	P_2O_5 mg/100g of soil	K_2O mg/100g of soil
0-30	1.9	7.9	6.9	20.3	16.1

Meteorological conditions

Weather conditions are unpredictable and variable (Popović, 2010, 2015a). Meteorological data recorded high variability during year (Bran et al., 2008, Popović et al., 2012a; 2015b; 2016a; 2016b; 2017; Glamočlija et al, 2015; Jankovic et al, 2015; 2016; Sikora et al, 2015; 2016; Marišovà et al, 2017). For the analysis of weather conditions the data from meteorological station in Banja Luka were used (Table 2). Winter period in the both years of testing was warmer compared to the multi-year average. The average multi-year temperature was 11.1^{o}C, and during the vegetation period 13.4^{o}C. The total precipitation amount in the vegetation period (III-VI) during the years from 1961-2014 was 376.0 l/m^2. The average temperatures in both years of testing, during the vegetation period, were higher compared to the multi-year average. In the first year of testing the precipitation amount during the vegetation period was higher by 244.0 l/m^2 compared to the multi-year average. During the vegetation period in the year 2015 rainfall amounts to 311.2 l/m^2, which is for 64.8 l/m^2 less precipitations compared to the multi-year average.

Table 2. Average temperatures (^{o}C) and precipitations (l/m^2) for Banja Luka, B&H

Year	**Temperature/ precipitation**	**Month**												**Average total**
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
2014	Temperature (^{o}C)	5.6	6.5	9.6	13.1	15.8	20.3	21.7	20.6	16.4	13.5	8.9	4.0	13.0
	Precipitation (l/m^2)	52	74	91	214	218	97	139	276	284	117	42	83	1,687
2015	Temperature (^{o}C)	3.4	2.4	7.3	11.8	17.4	20.9	25.2	24.0	18.3	11.5	7.1	3.2	12.7
	Precipitation (l/m^2)	111.2	91.1	79.0	54.1	117.6	60.5	20.5	22.8	75.0	142.7	85.7	8.1	868.3
1961-2014	Temperature (^{o}C)	0.2	2.0	6.7	11.3	16.1	19.6	21.3	20.8	16.3	11.3	6.4	1.5	11.1
	Precipitation (l/m^2)	70	64	78	90	98	110	91	86	96	80	93	91	1.043

Research showed that on the tested parameters a statistically significant impact had the genotype and hybrids, and genotype x year interaction.

Plant height

It was noticed that this phenotypic characteristic vary in a wide range between 71.00 cm in genotype Baccara to 146 cm in genotype Saša (Tab. 3).

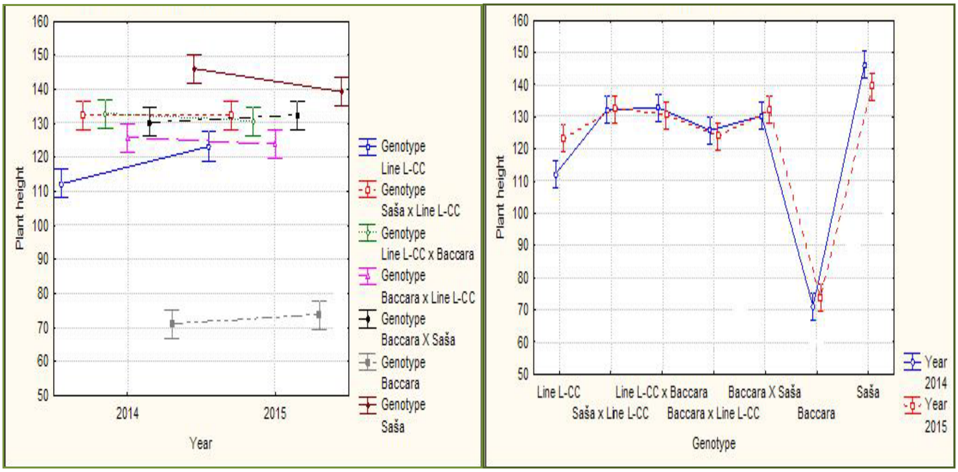
Table 3. Morphological and productive traits of tested pea varieties

No.	Variety-line-hybrid	Year	Plant height (cm)	Pod lenght (cm)	Pod mass per plant (g)	Grain weight (g)	Seed yield per plant (g)
1.	Baccara	2014	71.00	6.62	1.56	1.29	8.02
		2015	73.70	6.58	1.45	1.25	7.35
		Average	72.35	6.60	1.50	1.27	7.68*
2.	Saša	2014	146.00	6.47	0.99	0.81	6.69
		2015	139.00	6.35	1.16	0.96	6.23
		Average	142.70	6.41	1.08	0.88	6.46
3.	Line L-CC	2014	112.20	6.13	1.00	0.82	4.70
		2015	123.20	6.26	1.24	1.01	5.31
		Average	117.70	6.19	1.12	0.92	5.01-
4.	Line L-CC x Baccara	2014	132.80	7.55	1.71	1.39	6.97
		2015	130.60	7.00	1.43	1.16	6.31
		Average	131.70	7.28	1.57	1.28	6.64
5.	Baccara x Line L-CC	2014	125.80	6.41	1.28	1.16	7.09
		2015	124.00	6.33	1.26	1.09	7.14
		Average	124.90	6.37	1.27	1.26	7.12
6.	Saša x Line L-CC	2014	132.20	6.54	1.29	1.08	6.20
		2015	132.40	7.07	1.37	1.10	6.07
		Average	132.30	6.81	1.33	1.09	6.14
7.	Baccara x Saša	2014	130.30	7.20	1.57	1.09	6.84
		2015	132.20	6.75	1.35	1.08	6.62
		Average	131.25	6.98	1.46	1.09	6.73
Average		2014	121.48	6.70	1.34	1.09	6.65
		2015	122.20	6.62	1.32	1.095	6.43
		X	121.84	6.66	1.33	1.09	6.54

Parameter		Genotype	Year	G x Y
Plant height	LSD 0.5	4.163	2.221	5.898
	0.1	5.450	2.917	7.722
Pod lenght	0.5	0.323	0.169	0.449
	0.1	0.423	0.229	0.588
Pod mass per plant	0.5	0.152	0.081	0.214
	0.1	0.198	0.106	0.281
Grain weight	0.5	0.139	0.073	0.194
	0.1	0.182	0.096	0.253
Seed yield per plant	0.5	0.679*	0.367*	0.956
	0.1	0.889	0.401	1.252

The genotype and genotype x year interaction had a statistically significant effect on the plant height (Table 3).

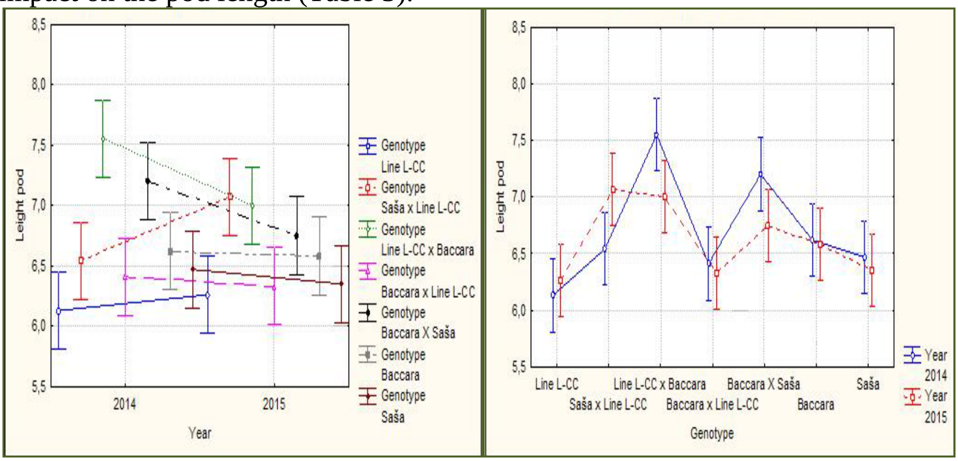
In the year 2015 pea plants were higher (122.2 cm) compared to the year 2014 (121.5 cm), but the difference was not statistically significant. Saša genotype had the greatest plant height in 2014 (146 cm), while the lowest plants had Baccara genotype (71 cm).



Graph 1. The impact of genotype x year interaction on forage pea plant height

Saša genotype had a statistically significant higher average plant height (142 cm) compared to other tested genotypes, while a statistically significant lower plants had the genotype Baccara (72.4 cm) in regard to other tested genotypes and hybrids (Table 3, Graph 1).

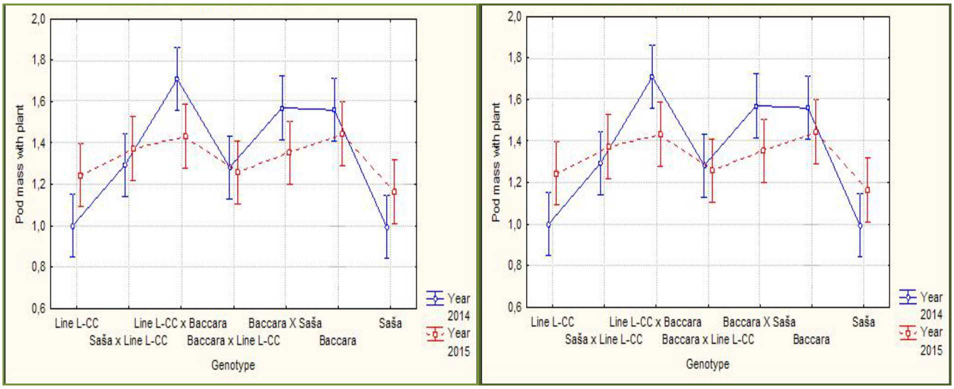
Pod length. Genotype x year interaction had a statistically significant impact on the pod length (Table 3).



Graph 2. The impact of genotype x year interaction on forage pea pod lenght

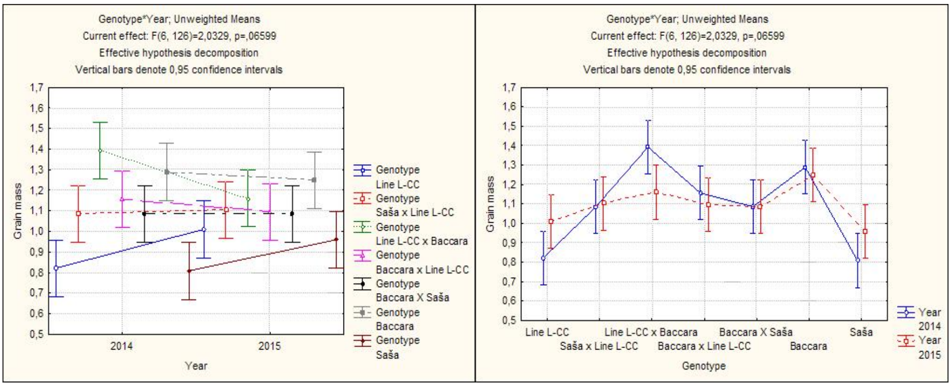
In the year 2014 plants had the longer pods (6.70 cm) compared to the year 2015, but the difference was not statistically significant. The highest average pod length had the hybrid Line L-CC x Baccara (7.55 cm) in 2014. The hybrid Line L-CCxBaccara had on average a statistically significant greater pod length compared to other tested genotypes, except hybrid Baccara x Saša (Tab.3, Graph 2).

Pod mass per plant was a statistically significant dependent on the genotype and genotype x year interaction (Table 3). Over the years there was no statistically significant difference in the average pod mass. The highest average pod mass had the hybrid Line L-CC x Baccara (1.71 g) in 2014. The hybrid Line L-CC x Baccara had a statistically significant greater average pod mass compared to the Line L-CC, hybrid Saša x Line CC and genotype Saša (Table 3, Graph 3).



Graph 3. The impact of G x Y interaction on forage pea pod mass per plant

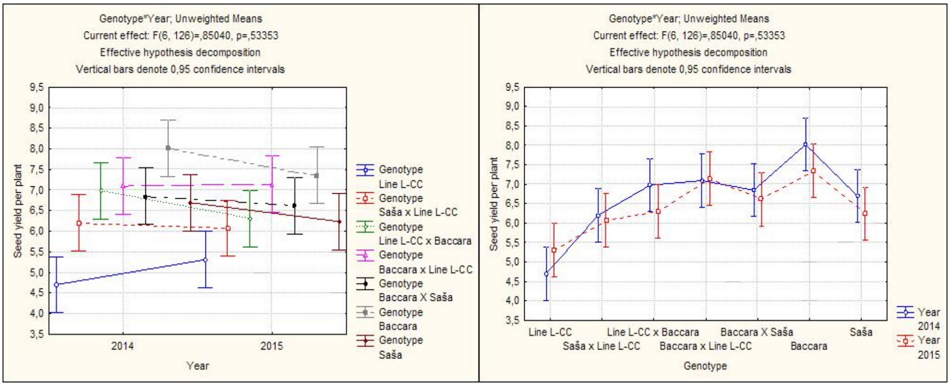
Grain weight was a statistically significant dependent on the genotype and genotype x year interaction (Table 3).



Graph 4. The impact of genotype x year interaction on forage pea grain weight

Over the years there was no statistically significant difference in the average grain weight. The highest average grain weight had the hybrid Line L-CC x Baccara (1.39 g) in 2014. The hybrid Line L-CC x Baccara and Baccara genotype had a statistically significant higher average grain weight compared to other tested genotypes (Table 3, Graph 4).

Seed yield is beside quality the most important indicator of the variety value (Mihajlović et al. 2009). Studies showed that the genotype and interaction of tested factors had a statistically significant impact on the seed yield per plant (Table 3). In the year 2014 a larger average grain yield per plant was achieved (6.65 g) compared to the year 2015, but the difference was not statistically significant. The highest average seed yield per plant had the genotype Baccara (8.02 g) in 2014. Baccara genotype had a statistically significant higher average seed yield per plant (7.68 g) compared to the Line L-CC, while the Line L-CC had a significantly significant lower seed yield per plant (5.01 g) compared to other tested genotypes (Table 3, Graph 5).



Graph 5. The impact of GxY interaction on forage pea seed yield per plant

Correlations of tested parameters

Correlation analysis results of tested parameters are given in Table 4. For the morphological and production traits correlation analysis shows a very different result values of the correlation connection between production and morphological traits. Strong positive correlation dependence was recorded between the grain weight per plant and pod length (r = 0.53 **), then between the grain weight and pod mass per plant (r = 0.87 **), and grain weight and pod length (r = 0.47 *), Table 4.

Seed yield per plant was in a significant positive correlation with the grain weight (r = 0.29 *), pod length (r = 0.24 *), pod mass per plant (r = 0.23 *), and in the negative correlation with plant height (Table 4). The positive insignificant correlation was achieved between plant height and pod length (r = 0.08), Table 4.

Spring forage pea varieties represent a broad source of genes for the desirable properties, especially those related to abiotic and biotic stress, that can be inserted into the existing varieties. The wide mutual variability of the most important characteristics can be very useful for the existing varieties. For the demonstration of production and morphological traits in some cases the variety-line-hybrid have a greater impact, and in other cases the vegetation period. The factor of years did not had the same impact on the expression of each production and morphological traits. Togay et al., (2008) stated that the number of pods per plant and pod mass are in a positive high significant correlation with the seed yield.

Table 4. Correlations between tested parameters

Variable	Pod lenght	Grain weight	Pod mass per plant	Plant height	Seed yield per plant
Pod lenght	1.00	0.47*	0.53**	0.08^{ns}	0.24*
Grain weight	0.47*	1.00	0.87**	-0.26*	0.29*
Pod mass per plant	0.53**	0.87**	1.00	-0.20^{ns}	0.23*
Plant height	0.08	-0.26*	-0.20^{ns}	1.00	-0.20^{ns}
Seed yield per plant	0.24*	0.29*	0.23*	-0.20^{ns}	1.00
ns – not significant; *and ** significant at p<0.05 and p<0.01;					

Morphological markers are used for the description of a newly created varieties characteristics in order to conduct testing of distinctiveness, uniformity and stability (DUS). The main disadvantages of morphological markers are their paucity and the impact of environmental factors, as well as the development phase of plant. However, despite these limitations morphological markers were and still are highly useful in the plant breeding.

Thus, for example, resistance to lodging is a quantitative characteristic of pea, and it is related to the morphological characteristics such as root, stem hardness, height, leaf type, but as such it can be masked by an impact of the environment. In the modern pea breeding the choice of parents is based on a molecular level based diversity.

CONCLUSION

According to the results of conducted research, the following can be concluded:

For the demonstration of production and morphological traits in some cases the variety-line-hybrid has a greater impact, and in other cases the vegetation period. The factor of years did not have the same impact on the expression of each production and morphological traits.

The genotype and genotype x year interaction had a statistically significant impact on the plant height. Saša genotype had the greatest plant height in 2014 (146 cm), while the lowest plants had Baccara genotype (71 cm).

Genotype x year interaction had a statistically significant impact on the pod length. The hybrid Line L-CC x Baccara had on average a statistically significant greater pod length compared to all tested genotypes, except hybrid Baccara x Saša.

Pod mass per plant was a statistically significant dependent on the genotype and genotype x year interaction. The hybrid Line L-CC x Baccara had a statistically significant greater average pod mass compared to the Line L-CC, hybrid Saša x Line CC and genotype Saša.

Grain weight was a statistically significant dependent on the genotype and genotype x year interaction. The hybrid Line L-CC x Baccara and Baccara genotype had a statistically significant higher average grain weight compared to all tested genotypes.

Studies showed that the genotype and interaction of tested factors had a statistically significant impact on the seed yield per plant. Baccara genotype had a statistically significant higher average seed yield per plant compared to the Line L-CC.

The correlation link between morphological and production traits has manifested in the different time and level. For the dependent variable characteristic of total seed number per plant the independent variable characteristics (plant height, pod length, pod weight without grain, grain weight and seed weight per plant) provided a high determination in the years of research and in all seven tested pea genotypes-lines-hybrids.

Strong positive correlation dependence was recorded between the grain weight per plant and pod length (r = 0.53 **), then between the grain weight and pod mass per plant (r = 0.87 **), and grain weight and pod length (r = 0.47 *).

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REFERENCES

Abi-Ghanem, R., Bodah, E. T., Wood, M., Braunwart , K. 2013. Potential Breeding for High Nitrogen Fixation in Pisum sativum L.: Germplasm Phenotypic Characterization and Genetic Investigation. American Journal of Plant Sciences, Vol.4 No.8, 1597-1600.

Al Lawati, A.H, Pierce, C.A, Murray, L.W, Ray, I.M., 2010. Combining ability and heterosis for forage yield among elite alfalfa core collection accessions with different fall dormancy responses. Crop Sci. 50: 150-158.

Bijelić, Z., Tomić, Z., Mandić, V., Ružić-Muslić, D., Krnjaja, V., Vučković, S., Simić, A., 2016. The efficiency of nitrogen from fertilizer in lucerne cultivated as a pure sward or as a mixture with grasses. Romanian Agricultural Research, No. 33, 227-234.

Bran, M., Dobre, I., Stefan, M. Bobac, D., Papuc, C.M., 2008. Long-term development of agriculture in micro-area „Dobrotfor-Pojorâta”. Romanian Agricultural Research, 25: 97-105.

Ikanović, J., Popović, V., Janković,S., Živanović, Lj., Rakić, S., Dončić, D. (2014): Khorasan wheat population researching (*Triticum Turgidum,*sp. *Turanicum*

(McKEY) in the minimum tillage conditions**.** Genetika, Belgrade, 46 (1), p.105-115.

Jankovic, S., Ikanovic, J., Popovic, V., Rakic, S., Pavlovic, S., Ugrenovic, V., Simic, D, Doncic, D. (2015): Morphological and productive traits of spelt wheat – Triticum spelta L. "Agriculture and Forestry", Podgorica, Vol. 61, 2, 173-182.

Jankovic, S., Popovic, V., Ikanovic, J., Rakic, S., Kuzevski, J., Gavrilovic, M., 2016. Productivity traits of rye (Secale cereale), Khorasan wheat (Triticum turgidum, ssp. Taranicum MCKEY) and quinoa (Chenopodium quinoa Willd) grown on degraded soil. Nardi Fundulea, Romanian Agricultural Research, No. 33.

Lakić, Ž, Soković, D., Babić, B., Vojin, S., Ikanović, J., Veljovic, J., Balalić, I. 2013.. Genetic variabilyty of seed yield and seed components of autochthonous *Lolium perenne* L. populations. Genetika, Vol. 45. No. 2, 553-556.

Marišovà, E., Milovanović, J., Đorđević, S., Jerekovà, Z., Dražić, G., Hauptvogl, M., Prčik, M., Mariš, M., Kortla, M., Fandel, P., Ilkova, Z., Gaduš, J., Popović, V., Ikanović, J., Živanović, Lj., Radojević, U., Kovàčik, M., Mandalovà, K., 2016. Agro-energy for sustainable agriculture and rural development. Monograph. Good practices from Slovakia-Serbia bilateral cooperation. 1-291.

Mihailovic, B., 2008. Marketing. Faculty of Economy, Podgorica, Montenegro.

Mihailović, V., Mikić, A., Ćupina, B., Katić, S., Karagić, Đ., Pataki, I., Erić, P. 2006. Yield and for age yield com po nents in win ter vetch cultivars. Grass land Sci ence in Eu rope, 11: 255-257. 204

Mihailović, V., Mikić, A., Katić, S., Milić, D., Vasiljević, S., Pataki, I.,Ćupina, B. 2007. Directions and recent achieve ments in breeding annual forage and grain legumes in Serbia. Proceedings of the COST Action 852 Final Meeting Quality Legume-Based Forage Systems for Contrasting Environments, Gumpenstein, Austria, 27-30.

Mihailović, V., Pataki, I., Mikić, A., Katić, S.,Vasiljević, S., Karagić, Đ., Milić, D. 2009. A new generation of NS forage crop cultivars. Institute of Forage and Vegetable Crops, Novi Sad, 46, 199-205.

Nelson, G.C, Rosegrant, M.W., Koo, J., Robertson, R., Sulser, T., Zhu, T., Ringler, Claudia, Msangi, S., Palazzo, A., Batka, M., Magalhaes, M., Valmonte-Santos, R., Ewing, Mandy and Lee, D., 2009. Climate Change Impact on Agriculture and Costs of Adaptation. International Food Policy Research Institute, Food Policy Report, Washington, 30 p. DOI: 10.2499/0896295354

Popovic, V., 2010. Influence of agro-technical and agro-ecological practices on seed production of wheat, maize and soybean. Doctoral thesis, University of Belgrade, Faculty of Agriculture in Zemun, 20-35.

Popovic, V., Vidic, M., Jockovic, Dj., Ikanovic, J., Jaksic S., Cvijanović G., 2012a. Variability and correlations between yield components of soybean [Glycine max (L.) Merr.]**.** Genetika, Belgrade, Vol. 44, No.1, 33-45.

Popovic, V., Jaksic, S,, Glamoclija, DJ., Djekic, V., Grahovac, N., Mickovski Stefanovic, V. 2012b. Variability and correlations between soybean yield and quality components. Romanian Agricultural Research, Romania. No. 29, 131-138.

Popovic, V., Miladinovic, J., Vidic, M., Vučkovic, S., Ikanovic, J., Drazic, G., Djekic, V., Filipovic, V., 2015a. Determining genetic potential and quality components of NS soybean cultivars under different agroecological conditions. Romanian Agricultural Research, 32: 35-42. DII 2067-5720 RAR 2015-32.

Popović, V., 2015b. The concept, classification and importance of biological resources in agriculture. Editor. Milovanovic & Đorđević: Conservation and enhancement of biological resources in the service of ecoremediation**.** Monograph. Futura. Belgrade. ISBN 978-86-86859-41-9; 1-407. 29-51.

Popovic, V., Tatic, M., Sikora, V., Ikanovic, J., Drazic, G., Djukic, V., Mihailovic, B., Filipovic, V., Dozet, G., Jovanovic, Lj., Stevanovic, P., 2016a. Variability of yield and chemical composition in soybean genotypes grown under different agroecological conditions of Serbia. Romanian Agricultural Research, No. 33, 29-39. DII 2067-5720 RAR 2016-167.

Popović, V., Vidic, M., Ikanovic, J., Djekic, V., Filipovic, V., Tabakovic, M., Veselic, J. (2016b): Soybean oil yield as affected by the growing locality in agro-climatic divergent years. "Agriculture and Forestry" - Podgorica, Vol.62, 1, 217-225.

Popovic, V., Sikora, V., Ugrenovic, V., Filipovic V. (2017). Status of buckwheat (*Fagopyrum esculentum*) production in the worldwide and in the Republic of Serbia Book. Chapter 9. In. Rural Communities in the Global Economy. Beyond The Classical Rural Economy Paradigms Authors. NICOLAE I., DE LOS RIOS I. AND VASILE A.J. NOVA SCIENCE PUBLISHERS, USA. 178-198.

Statistica 12.0, StatSoft. University Licence, Institute of Field and Veget.Crops, Serbia.

Saha, G.C., Vandemark, G.J., 2012. Evaluation of Expression Stability of Candidate References Genes among Green and Yellow Pea Cultivars (*Pisum sativum* L.) Subjected to Abiotic and Biotic Stress. American J. Plant Sciences, 3, 2, 235-242.

Sikora V., Berenji J., Popović Vera, Brdar Jokanović M., Maksimović L. (2015): Accumulation and distribution of NPK in above ground parts of grain sorghum and maize in intensive production. Vol. 61. Issue 1: 223-230.

Sikora, V., Popovic, V., Zoric, M., Latkovic, D., Filipovic, V., Tatic, M., Ikanovic, J. (2016). An agro-technological characterization of south-eastern european broomcorn landraces. Pak. J. Agri. Sci., Vol. 53 (3), 567-576;

Tiwari, G., Lavanya, G. R., 2012. Genetic Variability, Character Association and Component Analysis in F4 Generation of Forage pea (Pisum sativum var.arvense L.). Karnataka Journal of Agricultural Sciences, 25, 173-175.

Togay, N., Togay, Y., Yildirim, B., Dogan, Y., (2008). Relationships between yield and some yield components in pea (*Pisum sativum* ssp arvense L.) genotypes by using correlation and path analysis. African J. of Biotechnology, 7(23): 4285-4287.