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STABILITY OF EARLINESS OF AUTOCHTHONOUS POPULATION OF *PHLEUM PRATENSE* L.

SUMMARY

Phleum pratense (L.) is perennial grass. The aim of this paper was to determine the stability of maturing time of germplasm population *Phleum pratense* L. 20 autochthonous populations of *Phleum pratense* L., originating in western Serbia. Significant differences between the examined populations were determined by analysis of variance. It is evident that the year had a statistically significant influence on the tested parameter in the population of PP20. The start time for maturing for all populations was, on average, 57.49 days for the first study year and 61.31 days for the second year studied. Stability of the examined values for the panicle forming start time, between years, was noted, $C_v = 5.86\%$. The highest stability by years, was tested at population PP10 ($C_v = 1.63\%$).

The coefficient of variation for the length of panicle for all populations was $C_v = 19.15\%$. The statistically significantly better productive properties were at the late populations of PP20 (17.08 cm), PP16 (17.08 cm), PP4 (12.77 cm) and PP9 (12.11 cm) compared to other tested populations.

Populations PP20, PP16, PP4 and PP9 have a good basis and can serve as good material for further breeding programs.

Keywords: autochthon populations, *Phleum pratense* L., stability, maturing time

INTRODUCTION

Timothy - *Phleum pratense* (L.) is an important pasture species in many cool-temperate regions of the world, particularly those with cold winters and moist summers. The plant timothy originated in Europe but it was first valued as pasture grass in the United States. It is valued for hay as it retains good feed quality even when seed heads are present. When compared with the commonly used grasses, such as perennial ryegrass, timothy is late flowering, tending to head 6–10 weeks later than ryegrass. It has less production in winter, but commences spring growth early, giving it a long period with high quality leafy pasture. Commercial cultivars are usually hexaploid, with a chromosome number of 42, but diploid, tetraploid and octoploid forms also occur (Neilson and Nath

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1961, cited Charlton and Stewart, 2000). Timothy cultivars can be classified according to flowering time, with early cultivars developing seed heads around early December and late cultivars have heading around late December. Early-flowering cultivars are usually more erect and have less densely tiller than ones of later-flowering, with a greater tendency to produce flower heads in late summer. Pastures of timothy frequently provide advantages in quality and appearance of animal over those of perennial ryegrass, and this is largely explained by four following factors:

a) Compared to perennial ryegrass, later flowering of timothy's grass, postpones decline in feed quality (which is associated with emergence of seed head), allowing digestibility levels to be maintained from October to December, over a longer period than ryegrass.

b) Timothy decline in feed quality as seed heads develop is less than in perennial ryegrass and its reproductive tillers remain green longer and continue to accumulating carbohydrates, even after the seed matures. Timothy hay, cut at this mature stage, is, therefore of superior feed quality than those made from perennial ryegrass. c) Timothy, as an endophyte-free grass, is superior than endophyte-infected perennial ryegrass pastures, and this difference is more pronounced during summer and autumn, particularly when conditions become dry (Charlton and Stewart, 2000). Authors reported that Timothy prefers moist soils of moderate to high fertility, a soil pH of 5.5– 7.0 and is only slightly less tolerant of soil with aluminium than perennial ryegrass. d) Drought tolerance: Timothy has roots that are shallower and more sensitive to drought, than perennial ryegrass. Timothy responds well to irrigation in drier regions.

Timothy is an important fodder in the regions where the climate in the cultivation season is wet and not too hot. In our country, these areas are over 600-800 m above sea level where Timothy achieved a 10 t ha⁻¹ of dry matter in two to three mowing. The crude protein content ranges from 14-17% (Tomić and Sokolović, 2007). High energy value of entire plant and grain is being excellently supplemented with high protein content of alfalfa, why those two feeds are regularly combined in cattle diet - TMR – total mixed ratio, (Dewhurst, 2013, Dubljević et al, 2016). Timothy has a low field emergence capacity, which can result from a large sensitivity of husked seeds to environmental factors but also from a strong response to allelopathic compounds released by other grass species during germination (Lipińska 2006). Too large seed density increases competition and makes emergences difficult, and also reduces the survival rate of seedlings (Martyniak 2005, Szczepanek and Katańska-Kaczmarek, 2012).

The aim of this study was to identify and compare the stability of the maturing time of germplasm population and panicle length of 20 populations germplasm *Phleum pratense* L. originating in western Serbia.

MATERIAL AND METHODS

The study was based on a field experiment, established at Rađevo Selo (233 m.n.v.), (Valjevo, Western Serbia), in the leached soil, in period 2008-2010.

The type of soil on which the experiment was performed was slightly acidic (pH 5.9%), medium fertility, with humus content of 3.59%. The randomized split-plot design was used in three replications. The area of plots was 10 m². Sowing of seeds, collected from autochthonous populations, was carried out on October 13, 2008. Tested were 20 autochthonous populations of *Phleum pratense* L., from the area of Western Serbia, Kolubara district, which belongs to the mountainous area and vary in the length of the vegetation period. Tested populations was: PP1, Bobova (453 m.n.v.); PP2, Gornje Leskovice (747 m.n.v.); PP3, Donje Leskovice (747 m.n.v.); PP4, Krčmar (650 m.n.v.); PP5, Bratačić (351 m.n.v.); PP6, Gornji Lajkovac (525 m.n.v.); PP7, Golubac (373 m.n.v.); PP8, Lopatanj (392 m.n.v.); PP9, Planinica (559 m.n.v.); PP10, Pričević (298 m.n.v.); PP11, Lelić (329 m.n.v.); PP12, Struganik (575 m.n.v.); PP13, Sušica (535 m.n.v.); PP14, Suvodanje (543 m.n.v.); PP15, Komirić (283 m.n.v.); PP16, Rožanj (973 m.n.v.); PP17, Gunjaci (395 m.n.v.); PP18, Skadar (530 m.n.v.); PP19, Popučke (161 m.n.v.); PP20, Carina (742 m.n.v.). Kolubara district extends in the north-western part of Serbia and covers an area of 2474 km². During the vegetation, the time of the start of panicle forming was monitored, while at the end of the vegetation, at the stage of maturity, from each repetition, 10 plants were taken for morphological analysis of the panicle length of the 20 population of timothy. The time of reaching a maturity for harvesting was different in individual years of the study. The obtained results were analysed statistically for the split-plot design, and the significance of differences was determined using StatSoft, at the significance level $p = 0.05$.

Meteorological data

Meteorological data were recorded throughout the entire experiment by a meteorological station (Valjevo, Serbia). The average temperature, in the first year, was 11.79°C and total precipitation was 709.80 mm and during the second year average temperature was 12.02°C while the total precipitation was 651.1 mm.

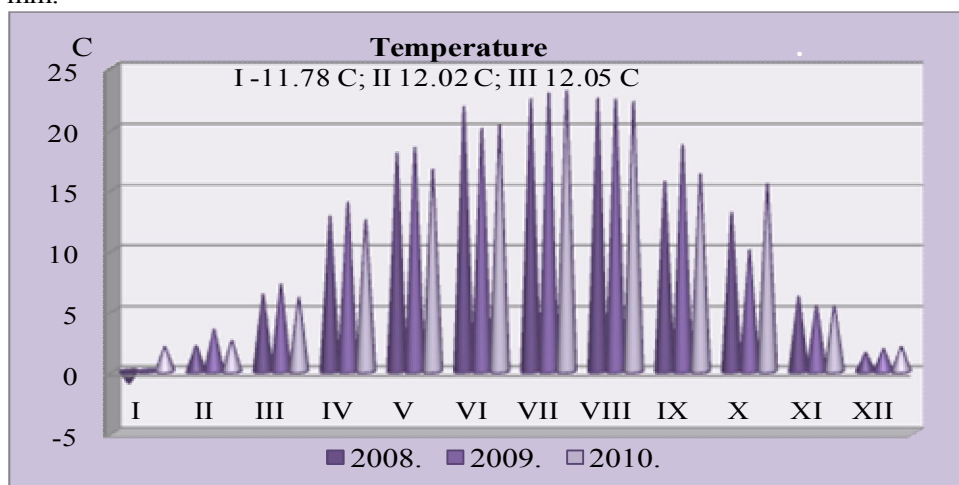


Figure 1. Monthly air temperature average (°C), Valjevo, Serbia

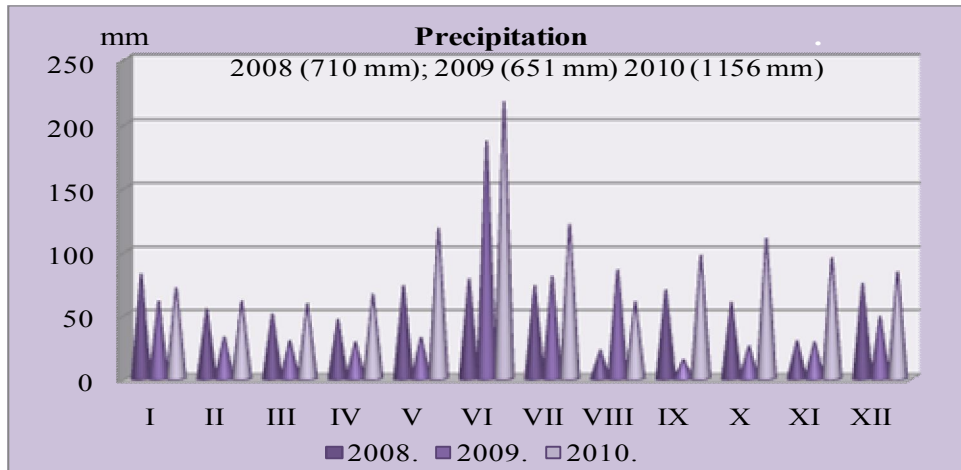


Figure 2. Total precipitation (mm), b, Valjevo, Serbia

During the third year of the average temperature amounted to 12.05°C while the total precipitation was 1156.20 mm (Figure 1 and 2). Meteorological conditions are unpredictable and variable (Popovic, 2010; 2015; Popovic et al., 2015, 2016a, 2016b). The biomass production reduces with increasing in water deficit stress; nonetheless, in major of cases, the tolerant genotypes had less reduction in biomass than ones susceptible under stress caused by drought (Salem, 2003). Water lack stress reduced not only biomass production, but also inhibited partition of photo-assimilates within the plants (Bota et al., 2004).

RESULTS AND DISCUSSION

Table 1 shows the descriptive statistics of the studied properties of the *Phleum pratense* L. populations for the examined years. The population, the year and interaction of the investigated factors, had statistical significance for the tested parameters, ($p < 0.05$). The populations had been statistically significantly different. The interaction of the examined factors for the tested parameter were statistically significant ($p < 0.05$). In the second experimental year, a statistically significantly higher difference was made between the value of the tested parameter, compared to the first study year, ($p < 0.05$), tab. 1. Population PP19, PP15, PP11 and PP5 was the shortest time for beginning of panicle forming, while the populations, PP16 and PP9 (67.82 and 63.35) had later beginning of panicle forming, Table 1, Figure 3.

The stability of the examined values for the start time of the creation of panicle between years was noted, $C_v = 5.86\%$. The variability of the examined values within the year for the start time of the creation of panicle varied from $7.35\% < C_v < 10.94\%$.

The coefficient of variation for the start time of panicle forming was ranged in the interval of $1.63\% < C_v < 10.41\%$, Table 1.

Table 1. Start time of the creation of panicle, a., and panicle length, cm, of *Phleum pratense* L.

Population	2009	2010	\bar{X}	σ	Cv	2009	2010	\bar{X}	σ	Cv
	Start time of the creation of panicle, days					Panicle length, cm				
PP1	59.06	60.96	60.01	0.95	2.23	9.16	12.04	10.60	1.44	19.21
PP2	61.93	63.80	62.87	0.94	2.10	10.13	13.26	11.70	1.57	18.92
PP3	58.26	61.73	60.00	1.74	4.09	10.36	13.60	11.98	1.62	19.12
PP4	60.90	62.56	61.73	0.83	1.90	11.33	14.20	12.77	1.43	15.89
PP5	56.73	58.30	57.52	0.78	1.93	7.90	10.78	9.34	1.44	21.80
PP6	61.56	63.36	62.46	0.90	2.04	9.96	11.14	10.55	0.59	7.90
PP7	56.73	59.70	58.22	1.48	3.61	8.26	11.26	9.76	1.50	21.73
PP8	57.96	61.60	59.78	1.82	4.31	7.80	10.62	9.21	1.41	21.65
PP9	61.36	65.33	63.35	1.99	4.34	10.50	13.71	12.11	1.61	18.75
PP10	52.73	53.96	53.35	0.61	1.63	6.60	9.70	8.15	1.55	26.89
PP11	55.70	59.93	57.82	2.12	5.17	7.00	10.21	8.61	1.61	26.38
PP12	61.66	63.90	62.78	1.12	2.52	9.80	12.68	11.24	1.44	18.12
PP13	60.06	63.40	61.73	1.67	3.82	8.70	11.50	10.10	1.40	19.60
PP14	61.10	63.73	62.42	1.31	2.98	9.60	12.83	11.22	1.62	20.36
PP15	51.40	53.36	52.38	0.98	2.65	6.23	9.16	7.70	1.47	26.92
PP16	69.43	66.20	67.82	1.62	3.36	15.33	18.83	17.08	1.75	14.49
PP17	58.70	61.86	60.28	1.58	3.71	9.70	12.80	11.25	1.55	19.48
PP18	61.46	63.83	62.65	1.18	2.67	9.53	12.63	11.08	1.55	19.78
PP19	50.43	54.13	52.28	1.85	5.21	5.63	8.63	7.13	1.50	29.75
PP20	55.76	64.63	60.19	6.27	10.41	15.53	18.63	17.08	1.55	12.83
Average	58.64	61.31	59.40	1.59	5.86	9.45	12.41	10.93	1.48	19.15
CV	7.35	10.94	7.82	-	-	27.04	21.41	23.76	-	-

Tested parameters	LSD	Genotype	Year	Genotype x Year
Start time of the creation of panicle	0.5	1.006	0.319	1.425
	0.1	1.335	0.423	1.891
Panicle length	0.5	0.383	1.211	0.541
	0.1	0.508	1.606	0.718

The investigated populations statistically significantly differed by the length of the panicle. In the second experimental year, a statistically significantly higher value of the panicle length was achieved, compared to the first test year, ($p < 0.05$), tab. 1. The interaction of the examined factors for the tested parameter was statistically significantly different ($p < 0.05$). PP19, PP15, PP10, PP11 and PP5 had the shortest panicles while the longest had populations PP20 (17.08 cm), PP16 (17.08 cm), PP4 (12.77 cm) and PP9 (12.11 cm), Table 1, Figure 3.

The variability of panicle length, within the year, was $21.41\% < C_v < 27.04\%$. The coefficient of variation for the panicle length for all populations, between

the examined years, was 19.15%. The variability was at an interval of 7.90% <Cv <29.75%, Table 1.

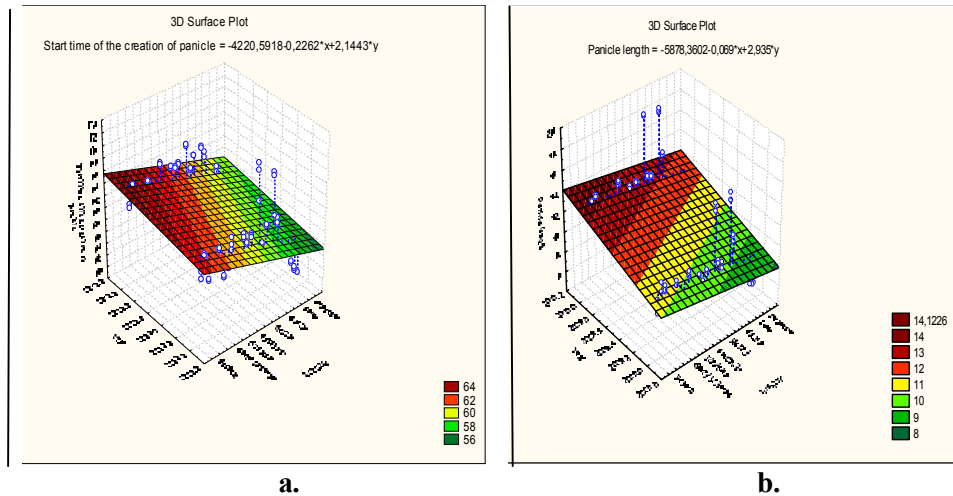


Figure 3. Start time of the creation of panicle, a., and panicle length, cm, of *Phleum pratense* L.

The statistically significantly better productive properties were at the late populations PP20 (17.08 cm), PP16 (17.08 cm), PP4 (12.77 cm) and PP9 (12.11 cm) compared to other tested populations, Table 1, Figure. 3.

Populations PP20, PP16, PP4 and PP9 have a good basis and can serve as good material for further breeding work.

According to Kryzeviciene [2000] higher yields of timothy seeds can be obtained in early cultivars. According to Rutkowska and Dębska-Kalinowska [1989], early cultivars of grasses form more fertile shoots in comparison to the late ones. This results from a fast rate of development in the year of foundation and forming autumn shoots with a larger number of leaves, which has a significant effect on seed yield in the next growing season. Schöberlein [1987] indicated that at a larger number of leaves on autumn shoots the ears of timothy were longer and heavier. Optimal supply of plants with water, nutrients and in access of light.

Correlations of studied features

The results of relative dependence of examined indicators of *Phleum pratense* (L.) population were presented by Pearson's correlation coefficient and shown in Table 2. The panicle length has a positive non-significant correlation with start time of the creation of panicle ($r=0.36^{ns}$), Table 2.

Based on the obtained value and also by the appropriate choice of selection methods, we can see that excellent genotypes (PP20, PP16, PP4 and PP9) are available to us for a successful selection process in order to obtain new varieties of *Phleum pratense* (L.).

The efficiency of selection and breeding depends on the present genetic variation in the initial breeding material.

Table 2. The correlation of tested components

Parameters	Panicle length	Start time of the creation of panicle
Panicle length	1.00	0.36 ^{NS}
Start time of the creation of panicle	0.36 ^{NS}	1.00
^{NS} Stat. non significant		

Kryzeviciene [2000] indicate that the yield of an early cultivar of timothy was 3.5 times higher than that of the semi-early and late cultivars. Also, Furuya et al. [1996] report that early cultivars are more productive in growing for seeds. Varied assessment of the reproductive abilities of early cultivars of timothy in the present experiment and other studies does not give the grounds for making conclusions concerning seed productivity only on the basis of ears of grass and maturing times.

SWOT analysis of national breeding programs showed, their strengths are reach gene pool, and traditional selection methods. Institution network in range of zones, varieties adaptation especially in low, and average income segments;, intellectual property IP rights similarity to European ones, and others are also strengths. Weaknesses are old infrastructure and equipment's; limited access to modern technologies; autocratic management; poor breeders motivation etc. Opportunities are possible collaboration development; trailing in different climate zones; seed market potential growth, etc. Realty as subject of raiders attacks; agricultural policy unpredictability; “dyeing” some breeding programs due to cost; erosion of genetic resources; mutual sanctions; availability of know-how and hi-tech in breeding are threats (Goncharov, 2016). Climatic changes increase the level of investment needs required to reach food security mainly via crop breeding (Goncharov, 2016; Capone et al., 2016).

Breeding of perennial grasses, in our conditions, is primarily directed towards increasing yields or maintaining stable yields with quality improvement. Selection in a given direction is done for creating the varieties with different maturing and which are intended for different forms of exploitation (Vučković *et al.*, 2007; Babić *et al.* 2015; Vasileva and Vasilev, 2012, 2017, Janković *et al.*, 2017). Seed is a key factor of agricultural prospects, as other agricultural inputs efficacy depends on them in a big scale. Appropriate seeds quality is required to meet the demand of diverse climate conditions and cropping systems. Sustainable agricultural production depends on adapted varieties flow, crops production and efficient channels of quality seeds supply to the farmers (Alabushev, 2010; Goncharov, 2013).

New domestic varieties in Serbia have good chances to be distributed in other republics of the cis cue to similarity of geographical, cultural and economic conditions.

CONCLUSIONS

Timothy is an important pasture species in cool-temperate regions of the world, with cold winters and moist summers.

Variance analysis showed significance for all tested properties. The year, population and interaction of the examined factors had a statistically significant influence on the tested parameters .

The stability of the values for the start time of the creation of panicle, between years, $C_v = 5.86\%$ was noted.

The coefficient of variation for the panicle length for all populations was $C_v = 19.15\%$. The statistically significantly better productive properties were at late populations of PP20 (17.08 cm), PP16 (17.08 cm), PP4 (12.77 cm) and PP9 (12.11 cm) compared to other tested populations.

The panicle length has a positive non-significant correlation with start time of its creation ($r=0.36^{ns}$).

Populations PP20, PP16, PP4 and PP9 have a good basis and can serve as good material for further breeding work.

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REFERENCES

- Alabushev A. 2010. Gureeva A., Raeva S., Current situation and prospects of development cereals seeds in Russia. Grain husbandry of Russia. № 6(12). P. 13-16.
- Babić S., Sokolović D., Radović J., Anđelković S., Lugić Z., Jevtić G. Anđelković B. 2015. Genetic diversity of wild populations of Timothy – *Phleum pratense* (L.). XX Conference on Biotechnology. Čačak, Serbia, 20. (22), 105-109.
- Bota, A.J., Medrano, H. and Felxas, J. 2004. Is photosynthesis limited by decreased rubisco activity and RuBP content under progressive water stress? New Phytol. 162: 671-681.
- Capone R., El Bilali H., Debs Ph., Bottalico F. 2016. Relations between food and nutrition security, diets and food systems. Agriculture & Forestry, Vol. 62, 1: 49-58, 2016, Podgorica
- Charlton J.F.L. and Stewart A.V. 2000. Timothy – the plant and it use New Zeland Farms. Proceedings of the New Zealand Grassland Association 62: 147–153 (2000)

- Goncharov, S. 2016. Cereals breeding & seed business in Russia: Current development and prospects. *Agriculture and Forestry*, 62 (1): 99-107. DOI: 10.17707/AgricultForest.62.1.12
- Goncharov S. 2013. Competiveness of national breeding programs. *Herald of VSAU.V 2(37).P.* 176-183.
- Dewhurst, R.J. 2013. Milk production from silage: comparison of grass, legume and maize silages and their mixtures. *Agricultural and Food Science*, 22 : 57-69.
- Dubljević, R., Đorđević, N., Mitrović, D. 2016. The influence of inoculation on chemical composition, quality and proteolysis in silages made from whole maize plant and alfalfa. *Agriculture and Forestry*, 62 (1): 279-285. DOI: 10.17707/AgricultForest.62.1.31
- Furuya M., Shmokoji H., Nakazumi H., Fujii H., 1986. Cultivar variation in seed yield and correlated characters in *Phleum pratense* L. *Grass. Sci.* 42(3), 255-259.
- Janković V., Vučković S., Živanović LJ., Ikanović J., Popović V., Tabaković M., Simić D. 2017. Variability of earliness of autochthonous populations *Phleum pratense* (L.). VIII International Agriculture Symposium "AGROSYM 2017", Jahorina, 5-8 October 2017, Bosnia and Herzegovina, 110-111.
- Kryzeviciene A., 2000. *Zemdirbyste, Makslo Darbai. Lietuvos Zemdirbystes Institutas, Akademija Lithuania* 69, 132-147.
- Lipińska M., 2006. Kiełkowanie nasion i wzrost siewek wybranych gatunków traw w warunkach oddziaływania blastokolin kiełkujących nasion traw [Seed germination and seedling growth of selected grass species in conditions of action of blastocolins of grass germinating seeds]. *Acta Agrobot.* 59(2), 253-262 [in Polish].
- Martyniak D., 2005. Wpływ ilości wysianych nasion na obsadę i plonowanie odmian gazonowych kostrzewy czerwonej (*Festuca rubra* L.) w uprawie na nasiona. *Biul. IHAR 237/238*, 259-267. [in Polish].
- Popović V. 2010. Agrotechnical and agroecological effects on wheat, corn and soybean seeds production. Doctoral dissertation, University of Belgrade, Faculty of Agriculture, Zemun, 55-66.
- Popović V. 2015. The concept, classification and importance of biological resources in agriculture. Editor. Milovanovic Jelena, Đorđević Slađana: Conservation and enhancement of biological resources in the service of eco-remediation. Monograph. Belgrade. ISBN 978-86-86859-41-9; 29-51. 1-407.
- Popovic V., Miladinovic J., Vidic M., Vuckovic S., Drazic G., Ikanovic J., Djekic V., Filipovic V. 2015. Determining genetic potential and quality components of NS soybean cultivars under different agroecological conditions. *Rom. Agric. Res.*, No.32, 35-42.
- Popovic V., Tatic M., Sikora V., Ikanovic J., Drazic G., Djukic V., Mihailovic B., Filipovic V., Dozet G., Jovanovic LJ. 2016a. Variability of yield and chemical composition in soybean genotypes grown under different agroecological conditions of Serbia. *Romanian Agric. Research*, 33, 29-39.
- Popović V., Vidic M., Ikanovic J., Djekic, V., Filipovic V., Tabakovic M. 2016b. Soybean oil yield as affected by the growing locality in agro-climatic divergent years. *Agriculture and Forestry.* 62, 1, 217-225.

- Rutkowska B., DĆbska-Kalinowska Z., 1989. Rozwój pĆdów generatywnych gatunków i odmian traw w zaleĪnoŹci od uwilgotnienia gleby [Development of fertile shoots of grass species and cultivars depending on soil moisture]. *Biul. Oceny Odm.* 27, 69-79 [in Polish].
- Salem, M. 2003. Response of durum and bread wheat genotypes to drought biomass and yield components. *Asian J. Plant Sci.* 2:290-93.
- Schöberlein W., 1987. Correlations between the phase of development of some perennial grass species in autumn and seed yield characteristics in the following year. *Int. Seed Conf.*, Tune, 1-9.
- StatSoft, Inc. 2012. Statistica for Windows. Tulsa, StatSoft
- Szczepanek M., Katańska-Kaczmarek A., 2012. Response of timothy (*Phleum pratense* L.) cultivars to growing in diversified row spacing. *Acta Sci. Pol., Agricultura* 11 (2) 2012, 63-72.
- Tomić Z., Sokolović D. 2007. Breeding of perennial grasses – methods, criteria and results in Serbia. *Proceedings of the Institute of Vegetable and Crops, Novi Sad*, 44, 1, 51-59.
- Vasileva V. and Vasilev E. 2012. Study on Productivity of some Legume Crops in Pure Cultivation and Mixtures. *Agriculturae Conspectus Scientificus.* 77 (2): 91-94.
- Vasileva V. and Vasilev E. 2017. Utilization efficiency of nitrogen and phosphorus and their response on dry mass accumulation in different forage mixtures. *Grassland Science in Europe*, 22: 449-453.
- Vučković S., I., Prodanović S., Ćupina B., Źivanović T., Vojin S., Jelaćić S. 2007. Morphological and Nutritional Properties of Birdsfoot Trefoil (*Lotus corniculatus* L.) Autochthonous Populations in Serbia and Bosnia and Herzegovina. *Genetic Resources and Crop Evolution* 54(2):421-428 · DOI: 10.1007/s10722-006-0004-6