NARDI FUNDULEA, ROMANIA
www.incda-fundulea.ro

ROMANIAN AGRICULTURAL RESEARCH, NO. 33, 2016
Print ISSN 1222-4227; Online ISSN 2067-5720

VARIABILITY OF YIELD AND CHEMICAL COMPOSITION IN SOYBEAN GENOTYPES GROWN UNDER DIFFERENT AGROECOLOGICAL CONDITIONS OF SERBIA

Vera Popovic[1*], Mladen Tatic[1], Vladimir Sikora[1], Jela Ikanovic[2], Gordana Drazic[3], Vojin Djukic[1] Bozo Mihailovic[4], Vladimir Filipovic[5], Gordana Dozet[6], Ljiljana Jovanovic[4], Petar Stevanovic[2]

[1] Institute of Field and Vegetable Crops, Maksima Gorkog St. 30, Novi Sad, Serbia
[2] University of Belgrade, Faculty of Agriciculture, Nemanjina 6, ZemunBelgrade, Serbia
[3]University of Singidunum, Faculty of Applied ecology, Futura, Danielova 32, Belgrade, Serbia
[4]University of Montenegro, Faculty of Economy and Rectorat, Jovana Tomasevica 37, Podgorica, MNO
[5]Institute for Medicinal Plant Research ″Dr Josif Pancic″, T. Koscuska 1, 11000 Belgrade, Serbia
[6]University of Megatrend, Faculty of Biofarming, Marsala Tita 39, 34000 Backa Topola, Serbia
*Corresponding author. E-mail: bravera@eunet.rs

ABSTRACT

Study of the interaction between genotype (G) and year (Y) provides good estimates of genotypes breeding values. In order to investigate the main effects of G, Y and G x Y interactions on yield and quality components of NS soybean genotypes, an experiment with genotypes of different maturity groups was carried out during three-year period. The average yield for all genotypes was 4,716 kg ha^{-1}. Genotype, year and interaction G x Y had statistically significant effect on the yield, $p<0.05$, $p<0.01$. The highest grain yields per unit area had, on an average, was recorded in genotype Venera (4,962 kg ha^{-1}), significantly higher than genotype Vojvodjanka (4,522 kg ha^{-1}), $p<0.05$. The highest yield stability was recorded by genotypes of MG 0.

The average protein content of all examined genotypes was 37.60%. Year, genotype and G x Y interaction had statistically significant effects on protein content. Genotype Galina had on an average the highest protein content (38.11%), significantly higher than genotypes Trijumf, Valjevka and Venera, $p<0.05$. Significantly higher protein content was achieved during 2008 and 2009 compared with 2010, $p<0.05$, $p<0.01$. Average protein yield for all genotypes was 1,711 kg ha^{-1}. The highest protein yields had genotype Venera, significantly higher than genotype Vojvodjanka, $p<0.05$. The average oil content for all examined genotypes was 21.51%. The most favorable year for oil synthesis in the test period was 2008 (22.41%). Statistically significantly higher oil content was recorded in 2008 (22.41%) compared to 2010 (20.22%) and significantly higher than in 2009 (21.89%), $p<0.05$. Genotype Valjevka (21.78%) had on average significantly higher oil content than genotype Trijumf, $p<0.05$. The average oil yield for all genotypes was 1,014 kg ha^{-1}. On average the highest oil yield was recorded in genotype Venera. The yield was negatively statistically significant correlated with protein content, highly negatively significant correlated with air temperature and positively significant correlated by protein yield, oil yield and precipitation.

The goal of the breeder was to create highly productive soybean varieties, followed by quality grain. This research can constitute the basis for further soybean breeding.

Key words: soybean, agro ecological factors, yield, quality characteristics.

INTRODUCTION

From a little-known plant that had been cultivated in the early twentieth century in a few countries, soybean (*Glycine max* (L.) Merr.) became one of the most widely grown field crop in the world at the end of the *20*th century (Miladinovic et al., 2008). In recent years, 90% of world production was concentrated in a few countries (USA, Brazil, Argentina, China, India). Areas and yields (and hence production) have registered growth tendency in recent years, at home and abroad (Popovic, 2010). Contribution of Europe to world soybean production ranges from 1 to 2% and the plant is important only in some countries of the continent (France, Italy, Romania, Serbia, Croatia, Russia, and Ukraine). In Serbia, from 2001 to 2011, soybean acreage has increased, and in 2010

Received 21 September 2014; accepted 10 December 2015; First online: February, 2016. DII 2067-5720 RAR 2016-167

reached a record of 170,359 ha. Average yield in 2010 was 3.17 t ha^{-1} (Popovic et al., 2011, 2013). The breeding progress is the most notably reflect ed in protein content which was increased in open field and laboratory for our varieties. We also did research on nitrogen metabolism in soybean, and quality increasing of soybean oil (Miladinovic et al., 2008).

In previous work on soybean breeding at Institute of Field and Vegetable Crops, most attention was paid on yield increasing and stability, respectively on the creation of varieties adaptable on different agro-ecological growing conditions and on protein content increasing, conducted on the open field and laboratory, as well as nitrogen metabolic activities testing and improving of oil quality (Evans and Fischer, 1999, Miladinovic et al, 2008).

Metric properties (yield and grain quality) are polygenically inherited and strongly influenced by environmental factors. When the plant population shows phenotypic variability of some quantitative trait, the expressed variability is attributed to genetic differences and / or different environmental impacts. Genetic factors of varieties are an important factor that affects the chemical composition of the grain, but these properties are under the strong influence of the environment, about 50% (Brumm and Hurburgh, 2002).

We definitely cannot predict the external conditions for seed production in a certain area because it is necessary to monitor the variation of external factors and their impact on the physiological processes that determine the quality of the seeds (Popovic, 2010, Popovic et al., 2013). Climate of Serbia is characterized by excessive and uneven distribution of rainfall per year, especially during the growing season, leading to instability in the production of soybeans.

Knowledge of climate changes, and drought, influences and planning of adequate response are the biggest challenges today. Climate changes and drought occurrence can modify the conditions for soybean plants development. These modifications can be mitigated by finding appropriate adaptation measures, usage of cultural practices and breeding programs. The most important adaptation measures are earlier sowing, irrigation introducing, regionalization and selection of tolerant soybean varieties adapted to different climates.

The aim of this paper is determination of productivity and stability of examined varieties grain yield and quality.

MATERIAL AND METHODS

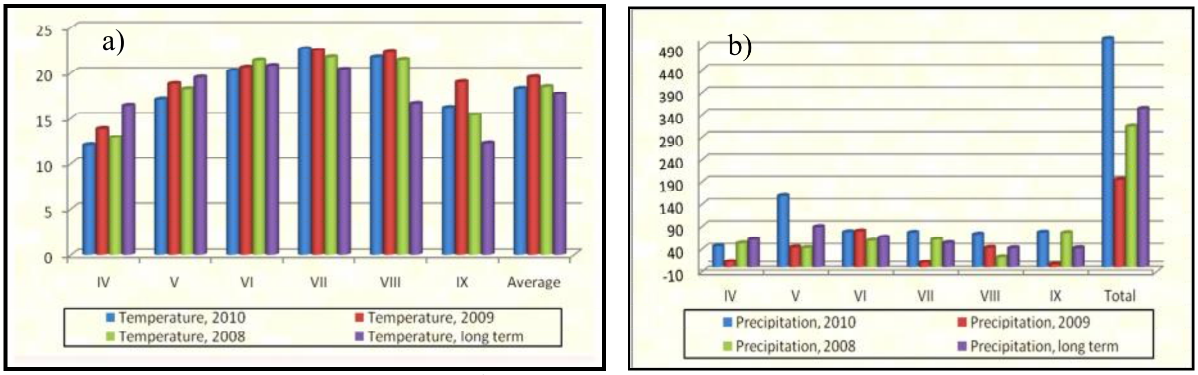
Study area and soil analysis

This study was conducted over a three-year period (2008, 2009 and 2010) in Sremska Mitrovica region, Serbia (44° 58′ 21″ N 19° 36′ 26″ E, 100 m asl.), on a humogley and meadow black soil, at location 80-200 m a.s.l. The municipality has a moderate continental climate, characterized by warm and dry summers, moderate winters and rainy transitional seasons (late fall and late spring).

Environmental conditions (weather and soil)

Meteorological data were taken from the Meteorological station in Sremska Mitrovica. Temperature in long-term average for Sremska Mitrovica has been 18.48^{o} C, Graph 1a.

Mean monthly temperature in 2008 was 18.51^{o}C. During growing period in 2009 mean monthly temperature was 19.51^{o}C which exceeded average in 2008 and 2010 by 1^{o}C and 0.88^{o}C (Graph 1a). Precipitation quantity during soybean growing period in long time period was 353 mm, and in 2008 was 313.1 mm. Precipitation quantity during soybean growing period in 2009 was 194.5 mm, which was by 154 mm less than long-term average for Sremska Mitrovica. In humid 2010 precipitation quantity was 509.5 mm (Graph 1b) (Popovic et al., 2013, 2014a, 2014b, 2015a, 2015b). Meteorological data recorded high variability during year (Popovic et al., 2013; Bran et al., 2008, Vrandecic et al, 2014).



Graph 1. Average temperature (^{o}C, a) and precipitation sum (mm, b), Serbia, 2008-2010

Experimental design

Soybean experiment was conducted in Sremska Mitrovica, in the village of Kukujevci in 2009 and in the village of Lacarak in 2008 and 2010. The 2009 trial was carried out on meadow black soil lows in humus, calcareous and moderately alkaline, moderate in P_2O_5 and rich in K_2O. The 2008 and 2010 trial was carried out on marshy black soil lows in humus, highly calcareous, moderately alkaline, and moderate in P_2O_5 and in 2010 high in K_2O. The trials were set up as randomized block design in three replicates with five NS soybean varieties of different maturity groups: Valjevka and Galina (0 MG) and Venera, Trijumf and Vojvodjanka, II MG (Popovic et al., 2012, 2013, 2014a, 2014b, 2015a, 2015b).

Soybean was planted on April 17, 2008, April 14, 2009, and April 25, 2010 on a basic plot size of 10 m^2 with maize as the preceding crop. Plant density for 0 maturity group varieties was 500,000 plants ha^{-1} and for MG II 400.000 plants ha^{-1}. Before planting, soybean seeds were inoculated with microbiological preparation NS-Nitragin. Standard soybean cultivation practices were applied during growing period.

In order to prevent negative effects of weeds, the trials were treated in the phase of 2-3 well-developed leaf blades with herbicides: Pulsar 40 1 L/ha + Harmony 8 g/ha in 2008 and 2009, and Acetogal 1.8 l/ha + Mistral 0.35 kg/ha in 2010. Crops were harvested mechanically on September 7, 2008, September 4, 2009 and September 24, 2010. Yield was measured after harvest and average samples were taken from each trial replicate to determine oil and protein content in grain (Popovic et al., 2013, 2014a, 2014b, 2015a, 2015b). Chemical composition in soybean genotypes - total oil and protein content in grain was determined by infrared spectroscopy technique on the apparatus PERTEN DA 7000 (NIR/VIS Spectro-photometer) by applying non-destructive method.

Statistical Analysis

The results were used to calculate the usual indicators of descriptive and analytical statistics of STATISTICA 12 for Windows: average values, error of the (arithmetic) mean and standard deviation. Significance of differences between the calculated mean values of the analyzed factors (year and genotype) was tested by two-factorial analysis of variance (Maletic, 2005, Mihailovic, 2008):

$$y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk}$$

i=1,2, j=1,2,...,5, k=3

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

Grain yield

Soybean yield is the most important trait in soybean breeding; it is a polygenic character, and largely depends on both the genetic resources and agro ecological factors (Miladinovic et al., 2008; Popovic et al., 2013a, 2013b, 2015a).

Looking at the average of the examined soybean genotypes yield in 2008, 2009 and 2010, evidently average yields among years were statistically highly significantly different ($p<0.01$). The year had statistically significant effect on the grains yield level. In 2010 and 2008, on average, for all tested genotypes, highly statistically significantly higher yields were recorded (5,204 kg ha^{-1} and 5,015 kg ha^{-1}), compared with 2009 (3,929 kg ha^{-1}), $p<0.01$ (Table 1, Graph 2).

The average yield for all genotypes was 4,716 kg ha^{-1}. 0 MG genotypes - Valjevka and Galina recorded greater yield stability, as compared to genotypes of MG II. Genotypes Trijumf and Venera recorded the highest yield variation (CV=23.17%, CV=22.77%). Standard Error for average yield, for all genotypes, was 113 (Table 1).

The highest grains yield per unit area had on average genotypes Venera (4,962 kg ha^{-1}), Valjevka (4,761 kg ha^{-1}), Galina (4,677 kg ha^{-1}) and Trijumf (4,659 kg ha^{-1}). Genotype Vojvodjanka recorded significantly lower yield compared to genotype Venera (Table 1).

Table 1. Grain yield (kg ha^{-1}) and soybean stability (%)

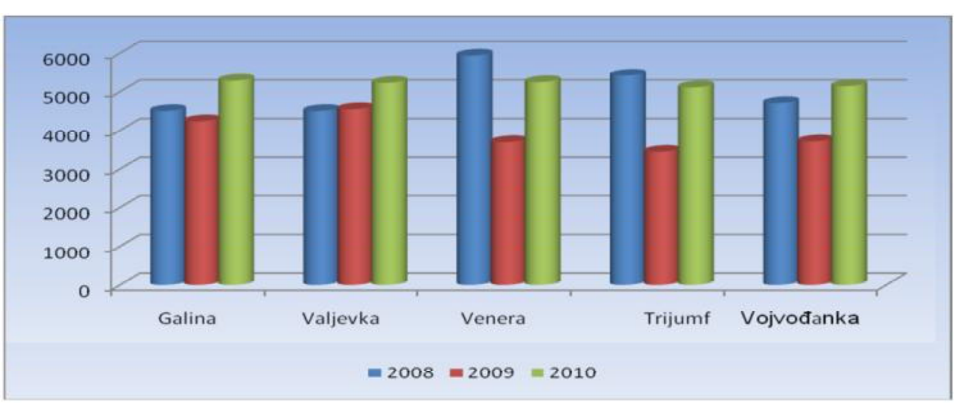
No.	Genotype (A)	Yield, kg ha^{-1} Year (B)			Average (A)	Rang	Std. Error	Stability
		2008	2009	2010	2008-2010			CV, %
1.	Galina	4,503	4,240	5,288	4,677	3	212	11.66
2.	Valjevka	4,505	4,551	5,229	4,761	2	154	7.77
3.	Venera	5,940	3,696	5,249	4,962	1	337	23.17
4.	Trijumf	5,419	3,447	5,112	4,659	4	378	22.77
5.	Vojvodjanka	4,710	3,713	5,143	4,522	5	235	16.22
Average (B)		5,015	3,929	5,204	4,716	-	113	12.81

Indicator	LSD-test	G	Y	G x Y
Yield	0.05	340	264	590
	0.01	458	355	794

Interaction of G x Y had a significant effect on the yield, $p<0.05$, $p<0.01$. Genotype Venera had in 2008 significantly higher yield compared with all genotypes tested in the period 2008-2009, $p<0.05$, $p<0.01$. In 2009 genotype Venera had significantly lower yield compared with all genotypes tested, except for genotypes Galina in 2009, Trijumf in 2009 and Vojvođanka in 2009.

Genotype Trijumf had a significantly lower yield in 2009 compared to all tested genotypes in the study period, 2008-2010, except for genotypes Vojvodjanka and Venera in 2009. Genotype Venera had a lower yield in 2009 than the standard II MG, genotype Vojvodanka (Table 1).

Venera, Trijumf, Galina, Valjevka and Vojvodjanka genotypes achieved significantly higher yields in 2010 compared to all genotypes in the 2008 and 2009, except for Venera and Trijumf genotypes in 2008, $p<0.05$, $p<0.01$ (Table 1).



Graph 2. Grain yield (kg ha^{-1}) of NS soybean

Genotype Galina had a significantly lower yield in 2008 and 2009 compared genotypes Valjevka in 2010, Galina in 2010, Trijumf in 2008, 2009 and 2010, Vojvodjanka in 2010 and Venera in 2008 and 2010 (Table 1).

The study of the interaction between the genotype (G) and year (Y) provides good estimates of breeding genotype value. To cope with unpredictable environmental conditions, the emphasis was on stable varieties creating, suitable for growing in different environmental conditions. Resistance to diseases and pests and tolerance on stress can be seen as a stability factor (Miladinovic et al., 2008). The most suitable genotypes for examined growing region were Venera, Valjevka, Galina and Trijumf.

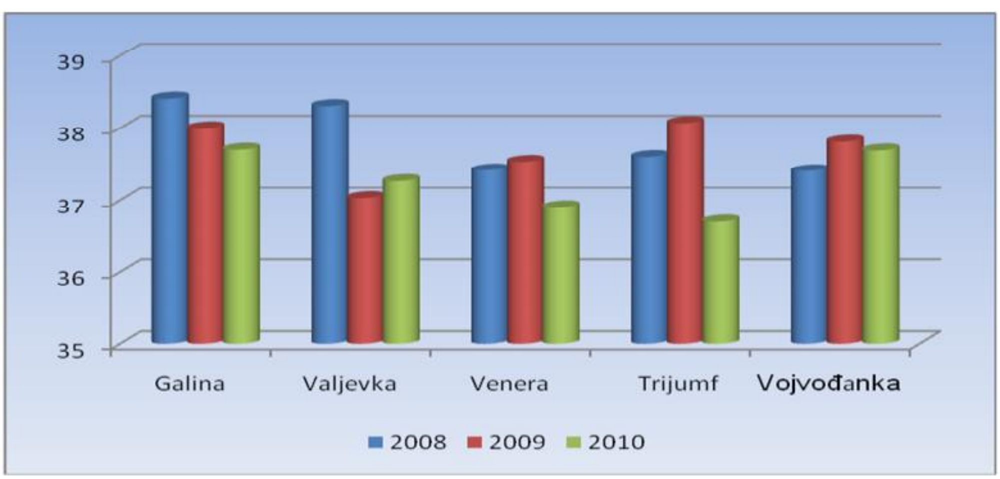
Protein content

The average protein content in all examined genotypes was 37.60%. A statistically significantly higher content of protein had, on average, genotype Galina (38.11%) compared to genotypes Valjevka, Venera and Trijumf, $p<0.05$, $p<0.01$. The highest stability of the protein content had genotypes Vojvodjanka, Venera and Galina (CV=0.56%, CV=0.88 %, CV=0.93 %) (Table 2, Graph 3). Standard Error for average protein content, for all genotypes, was 0.10 (Table 3).

Table 2. The protein content in soybean grain (%) and stability (%)

No.	Genotype (A)	Protein content, %			Average (A)	Rang	Std. Error	Stability
		Year (B)						CV, %
		2008	2009	2010	2008-2010			
1.	Galina	38.40	38.00	37.70	38.11*	1	0.27	0.93
2.	Valjevka	38.30	37.03	37.26	37.54	3	0.23	2.35
3.	Venera	37.41	37.53	36.90	37.28	5	0.16	0.88
4.	Trijumf	37.60	38.07	36.70	37.45	4	0.22	1.86
5.	Vojvodjanka	37.40	37.81	37.69	37.64	2	0.17	0.56
Average (B)		37.87	37.69	37.25	37.60	-	0.10	0.97

Indicator	LSD-test	G	Y	G x Y
Protein content	0.05 0.01	0.52 0.70	0.40 0.54	0.90 1.21



Graph 3. Protein content (%) of NS soybean

2008 was the most favorable year for protein synthesis. Statistically highly significantly higher protein content was recorded in 2008 (37.87 %) and 2009 (37.69%) compared with 2010 (37.25%). The highest protein content in 2008 had genotypes

Galina (38.40%) and Valjevka (38.30%) and significantly higher compared to genotypes Vojvodjanka and Trijumf, $p<0.05$ (Table 2, Graph 3).

Studied factors - year, genotype and G x Y interaction had statistically significant effect on protein content, $p<0.05$, $p<0.01$. The highest stability of the protein content had genotypes from MG II - Vojvodjanka and Venera (CV=0.56 %, CV=0.88 %) (Table 2).

Protein yield

Average proteins yield for all genotypes was 1,771 kg ha^{-1}. The highest stability of protein yield had Valjevka and Galina genotypes (CV=7.89%, CV=11.07%) (Table 3).

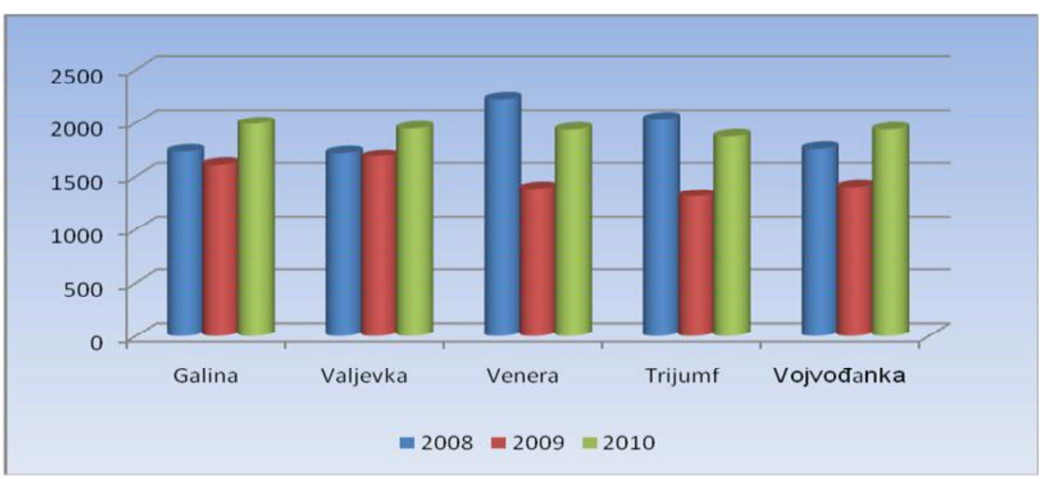
Table 3. Protein yield (kg ha^{-1}) in soybean grain and stability (%)

No.	Genotype (A)	Protein yield, kg ha^{-1}			Average (A)	Rang	Std. Error	Stability
		Year (B)						
		2008	2009	2010	2008-2010			CV, %
1.	Galina	1,739	1,605	1,993	1,779	3	73	11.07
2.	Valjevka	1,724	1,686	1,947	1,786	2	55	7.89
3.	Venera	2,220	1,386	1,937	1,848	1	124	22.95
4.	Trijumf	2,037	1,311	1,875	1,741	4	114	21.89
5.	Vojvodjanka	1,763	1,403	1,938	1,701	5	86	16.03
Average (B)		1,896	1,478	1,938	1,771	-	41	14.36

Indicator	LSD-test	G	Y	G x Y
Protein yield	0.05 0.01	118 160	92 123	205 277

The highest protein yield, on average, had Venera genotype (1,848 kg ha^{-1}) and significantly higher than Vojvodjanka genotype (1,701 kg ha^{-1}), (Table 3, Graph 4). Standard Error for average protein yield, for all genotypes, was 41 (Table 3).

The highest protein yield was recorded in 2010. Year and G x Y interaction had a statistically significant effect on protein yield, $p<0.05$, $p<0.01$. Statistically significantly higher protein yield was recorded in 2010 and 2008 (1,938 kg ha^{-1} and 1,896 kg ha^{-1}) compared to 2009 (1,478 kg ha^{-1}). The highest protein yield had genotype Venera in 2008 (2,220 kg ha^{-1}) and statistically significantly higher than all other genotypes. Genotype Galina (1,993 kg ha^{-1}) had significantly higher protein yield in relation to genotype Trijumf in 2010 (1,875 kg ha^{-1}), $p<0.05$ (Table 3, Graph 4).



Graph 4. Protein yield (kg ha^{-1}) of NS soybean

Oil content

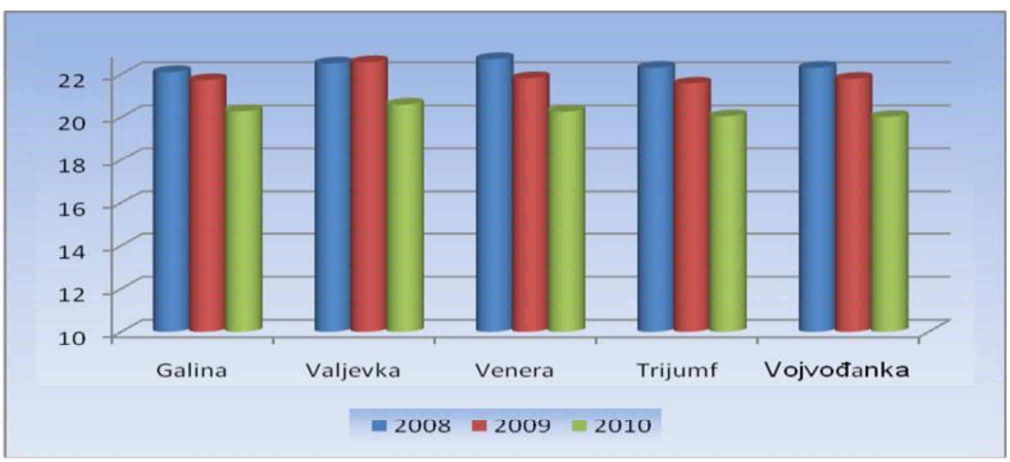
The average oil content for all genotypes was 21.51%. Effects of examined factors - year, genotype and G x Y interactions were statistically significant. The highest oil content, on average, had genotype Valjevka (21.78%), significantly higher compared with genotype Trijumf (21.32%). The highest content of oil per year had genotypes Venera (22.70%) in 2008 and Valjevka in 2008 and 2009 (22.50%, 22.56%). The highest stability of oil had genotype Galina from MG 0 (CV=4.50 %) (Table 4, Graph 5). Standard Error for average oil content, for all genotypes, was 0.15 (Table 4).

The most favorable year for oil synthesis was 2008 (22.41%). Statistically significantly higher oil content was achieved in 2008 (22.41%) compared with 2010 (20.22%) and significantly higher than in 2009 (21.89%), $p<0.05$, $p<0.01$. Genotype Valjevka (20.59%) had significantly higher oil content than genotypes Trijumf and Vojvodjanka in 2010, $p<0.05$ (Table 4).

Table 4. Oil content (%) in soybean grain and stability (%)

No.	Genotype (A)	Oil content, %			Average	Rang	Std. Error	Stability
		Year (B)						
		2008	2009	2010	2008-2010			CV, %
1.	Galina	22.10	21.73	20.28	21.42	4	0.30	4.50
2.	Valjevka	22.50	22.56	20.59	21.78	1	0.38	5.12
3.	Venera	22.70	21.82	20.26	21.60	2	0.40	5,72
4.	Trijumf	22.30	21.57	20.05	21.32	5	0.34	5.38
5.	Vojvodjanka	22.30	21.79	20.02	21.43	3	0.34	5.60
Average (B)		22.41	21.89	20.22	21.51	-	0.15	5.39

Indicator	LSD-test	G	Y	G x Y
Oil content	0.05 0.01	0.40 0.54	0.31 0.42	0.69 0.93



Graph 5. Oil content (%) of NS soybean

Oil yield

The average oil yield for all genotypes was 1,014 kg ha^{-1}. The highest average yield of oil had genotype Venera (1,073 kg ha^{-1}), significantly higher than genotype Galina, $p<0.05$ (Table 5, Graph 6).

In all tested genotypes - genotype, year, and interaction G x Y had a statistically significant effect on oil yield, $p<0.05$, $p<0.01$. Statistically significantly higher oil yields were achieved in 2008 and 2010 (1,124 kg ha^{-1} and 1,056 kg ha^{-1}) compared to 2009 (862 kg ha^{-1}), $p<0.01$ (Table 5, Graph 6).

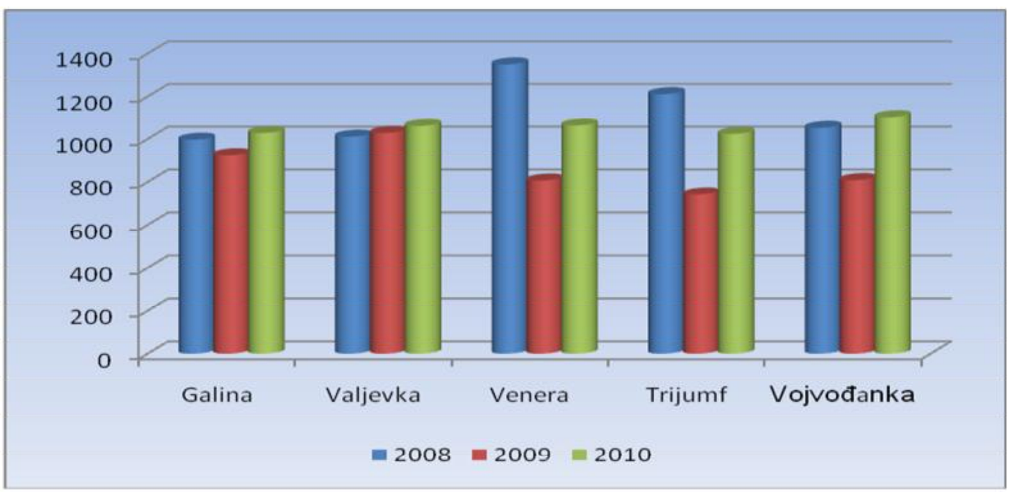
Statistically significantly higher oil yield was achieved in 2008 (1,124 kg ha^{-1}) compared with 2009 (862 kg ha^{-1}), $p<0.01$. Genotype Venera (1,350 kg ha^{-1}) had significantly higher oil yield than genotypes Galina, Valjevka and Vojvodjanka in 2008 and 2009, $p<0.01$ (Table 5).

The highest oil yields stability had genotypes of MG I, Valjevka and Galina (CV=2.46%, CV=5.37%). Standard Error for average oil yield, for all genotypes, was 25 (Table 5).

Table 5. Oil yield (kg ha^{-1}) in grain of soybean and stability (%)

No.	Genotype (A)	Oil yield, kg ha^{-1} Year (B)			Average	Rang	Std. Err.	Stability
		2008	2009	2010	2008-2010			CV, %
1.	Galina	997	925	1,028	983	5	38	5.37
2.	Valjevka	1,011	1,028	1,061	1,034	2	21	2.46
3.	Venera	1,350	807	1,063	1,073	1	80	25.30
4.	Trijumf	1,211	742	1,024	993	3	69	23.79
5.	Vojvodjanka	1,052	809	1,104	988	4	58	15.93
Average (B)		1,124	862	1,056	1,014	-	25	13.41

Indicator	LSD-test	G	Y	G x Y
Oil yield	0.05 0.01	88 118	68 92	152 205



Graph. 6. Oil yield (kg ha^{-1}) of NS soybean

Interdependance of yield, chemical composition, temperatures and precipitation

The average yield in the tested period was statistically significantly negatively correlated with protein content (r=-0.43), and had a highly significant negative correlation with temperatures (r=-0.75). The yield was positively highly significantly correlated with the yield of oil and protein (r=0.93, r=0.99) and precipitation (r=0.65), and positively nonsignificantly correlated with the oil content (r=0.18) (Table 6).

The protein content was negatively significantly correlated with protein yield (r=0.33) and with precipitation (r=0.30) and nonsignificantly negatively correlated with oil content (r=0.16). The protein content was nonsignificantly positively correlated with temperatures (r=0.15) (Table 6).

Table 6. Correlations for tested parameters, 2008-2010

Parameter	Yield	Protein content	Oil content	Protein yield	Oil yield	Temperature	Precipitation
Yield	1.00	-0.43*	0.18 ns	0.99**	0.93**	-0.75**	0.65**
Protein content	-0.43*	1.00	-0.16 ns	-0.33*	-0.37*	0.15ns	-0.30*
Oil content	0.18 ns	-0.16 ns	1.00	-0.16 ns	0.12 ns	0.40*	-0.75**
Protein yield	0.99**	-0.33*	-0.16 ns	1.00	0.93**	-0.76**	0.64**
Oil yield	0.93**	-0.37*	0.12 ns	0.93**	1.00	-0.61**	0.40*
ns – not significant; *and ** significant at $p<0.05$ and $p<0.01$;							

The oil content was nonsignificantly negatively correlated with protein yield (r=0.16) and positively nonsignificantly correlated with oil yield (r=0.12) (Table 6).

The oil content was highly significantly negatively correlated with precipitation (r=0.75) and positively significantly correlated with temperatures (r=0.40).Protein yield showed positively highly significantly correlation with oil yield (r=0.93) and precipitation (r=0.64) (Table 6).

Protein and oil yield was in negative highly significantly correlation with temperatures (r=0.76, r=0.61). Oil yield was positively highly significantly correlated with precipitation (r=0.40) (Table 6).

Protein yield was positively highly significantly correlated with precipitation (r=0.64) while the oil yields were positively significantly correlated with precipitation (r=0.40) (Table 6).

The average yield in the 2008 was statistically significantly negatively correlated with protein content (r=-0.58), and positively highly significantly correlated with the yield of oil and protein (r=1.00) and the oil content (r=0.52) (Table 7). The protein content was negatively significantly correlated with protein yield (r=0.51) and with oil yield (r=0.58) and non-significantly negatively correlated with oil content (r=0.32). The oil content was non-significantly negatively correlated with protein content (r=0.32) and showed positively significantly correlation with protein yield (r=0.51) and with oil yield (r=0.60) (Table 7).

Protein and oil yield was in negatively highly significantly correlation with protein content (r=0.51, r=0.58). Oil yield showed positively highly significantly correlation with oil content (r=0.60) and with protein yield (r=0.99) (Table 7).

Table 7. Correlations for tested parameters, 2008

Parameter	Yield	Protein content	Oil content	Protein yield	Oil yield
Yield	1.00	-0.58*	0.52*	1.00**	1.00**
Protein content	-0.58*	1.00	-0.32 ns	-0.51*	-0.58*
Oil content	0.52*	-0.32 ns	1.00	0.51*	0.60*
Protein yield	1.00**	-0.51*	-0.51*	1.00	0.99**
Oil yield	1.00**	-0.58*	0.60*	0.99**	1.00
ns – not significant; *and ** significant at $p<0.05$ and $p<0.01$;					

The average yield in the 2009 was statistically significantly negatively correlated with protein content (r=-0.63), and positively highly significantly correlated with the yield of oil and protein (r=0.99) and the oil content (r=0.53) (Table 8).

The protein content was negatively significantly correlated with protein yield (r=0.54) and with oil yield and with oil content (r=0.68) (Table 8).

The oil content was significantly negatively correlated with protein content (r=0.68) and positively significantly correlated with oil yield (r=0.65) (Table 8).

Protein yield was positively significantly correlation with protein content (r=0.54) and positively significantly correlation with oil yield (r=0.97) (Table 8).

Protein and oil yield was in negatively highly significantly correlation with protein content (r=0.54, r=0.68).

Oil yield was positively significantly correlation with oil content and was positively highly significantly correlation with protein yield (r=0.97) (Table 8).

Table 8. Correlations for tested parameters, 2009

Parameter	Yield	Protein content	Oil content	Protein yield	Oil yield
Yield	1.00	-0.63*	0.53*	0.99**	0.99**
Protein content	-0.63*	1.00	-0.68*	-0.54*	-0.68*
Oil content	0.53*	-0.68**	1.00	0.48 ns	0.65**
Protein yield	0.99**	-0.54*	-0.48 ns	1.00	0.97**
Oil yield	0.99**	-0.68*	0.65*	0.97**	1.00
ns – not significant; *and ** significant at p<0.05 and p<0.01;					

The average yield in the 2010 was statistically nonsignificantly negatively correlated with protein content (r=-0.21), and positively highly significantly correlated with the yield of oil and protein (r=0.96, r=0.70), Table 9.

The oil content was significantly positively correlated with oil yield (r=0.54). Protein yield was positively significantly correlation with oil yield (r=0.67) (Table 9).

Protein and oil yield was in negatively nonsignificantly correlation with protein content (r=0.54, r=0.68). Oil yield was positively significantly correlation with oil content and was positively highly significantly correlation with protein yield (r=0.67) (Table 9).

Table 9. Correlations for tested parameters, 2010

Parameter	Yield	Protein content	Oil content	Protein yield	Oil yield
Yield	1.00	-0.21 ns	0.42 ns	0.96**	0.70**
Protein content	-0.21 ns	1.00	-0.05 ns	-0.08 ns	-0.16 ns
Oil content	0.42 ns	-0.05 ns	1.00	0.42ns	0.54*
Protein yield	0.96**	-0.08 ns	-0.42 ns	1.00	0.67*
Oil yield	0.70**	-0.16 ns	0.54*	0.67*	1.00
ns – not significant; *and ** significant at p<0.05 and p<0.01;					

Similar results were reported in the researches of Chung et al. (2003) and Popovic et al. (2013, 2015).

Investigated factors and G x Y interaction are the basis for the further soybean breeding.

CONCLUSIONS

Following conclusions can be drawn on the bases of this research results:

– The highest average grain yield, protein yield and oil yield, on average, had genotype Venera (4,962 kg ha^{-1} and 1,848 kg ha^{-1} and 1,073 kg ha^{-1}) significantly higher than genotype Vojvodjanka ($p < 0.05$).

– The most suitable genotypes for examined growing region were Venera, Valjevka, Galina and Trijumf.

– The interaction of the investigated factors (year x genotype) shows a statistically significant effect on yield in soybean, suggesting that the studied factors mutually reinforce their effects ($p < 0.05$).

– In humid 2010, on average, significantly higher grain yields per unit area were obtained, while 2009 recorded significantly lower yield ($p < 0.01$).

– The most favorable year for protein and oil synthesis was 2008, the year with temperatures and precipitation on the level of the long-term average for the tested site.

– The average yield in the test period was statistically significantly negatively correlated with protein content and highly significantly negative correlated with temperatures.

– The yield was positively highly significantly correlated with the protein yields and oil yields (r=0.99**, r=0.93**) and rainfall (r=0.65**).

– The oil content was in negatively highly significantly correlation with rainfall (r=0.75**) and significantly positively correlated with temperatures (r=0.40*).

– This research can be the basis for the further soybean breeding.

Acknowledgements

Experiment needed for this work is part of the projects: TR 31022, TR 32078 and TR 16610021 financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

REFERENCES

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.

Brumm, J..T., and Hurburgh, C.R., 2002. *Quality of the 2002 soybean crop from the United States*. American Soybeans Associacion Quality Mission to Asia, December 13, 2002.

Chung, J.H.L, Barka Staswick, P.E., Lee, D.J., Gregan, P.B., Shoemaker, R.C., Specht, J.E., 2003. *The seed protein, oil and yield QTL on soybean linkage group I.* Crop Sci., 43: 1053-1067,

Evans, L.T., Fischer, R.A., 1999. *Yield potential: Its Definition, Measurement, and Significance.* Crop Sci., 39: 1544-1551

Glamoclija, D.J., Jankovic, S., Popovic, V., Filipovic, V., Kuzevski, J., Ugrenovic, V., 2015. *Alternative crops in conventional and organic growing system.* Monograph, IPN Belgrade, 1-355; 20-40. ISBN 978-86-81689-32-5

Maletic, R., 2005. *Statistics*. Faculty of Agriculture, Zemun, Belgrade, Serbia

Mahailovic, B., 2008. *Marketing.* Faculty of Economy, Podgorica, Montenegro

Miladinovic, J., Hrustic, M., Vidic, M., 2008. *Soybean*. Institute of Field and Vegetable Crops, Novi Sad and Sojaprotein, Bečej, AMB Graphics, Novi Sad., pp 510.

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

Popovic, V., Vidic, M., Glamoclija, Dj., Tatic, M., Vučkovic, S., Ikanovic, J., 2011. *Effect of meteorological conditions on the production of NS soya bean seed.* Economics of agriculture, Belgrade, EP 2011, (58) 2: 323-331.

Popovic, V., Malesevic, M., Miladinovic, J., Maric, V., Zivanovic, Lj., 2013. *Effect of agroecological factors on variations in yield, protein and oil contents in soybean grain.* Romanian Agricultural Research, Romania, 30: 241-248. DII 2067-5720. RAR 2013-30.

Popović, Vera, Vidić, M., Vojislav, Mihailovic, Ikanović, Jela, Đekić, Vera, Ilic, A. (2014a). *Genotype x environment interaction between yield and quality components of soybean [Glycine max].* "Agriculture and Forestry", Podgorica, 60, 2: 33-46.

Popovic, V., Tatic, M., Djekic, V., Dozet, G., Djukic, V., Grahovac, N., 2014b. *Stability of soybean yield and quality components*. AJAR – African Journal of Agricultural Research, 8 (45): 5651-5658. DOI 10.5897/AJAR 12.1146

Popovic, V., Vidic, M., Ikanovic, J., Djekic, V, Filipovic, V., Kolaric, Lj., Cobanovic, L., 2015a. *Productive characteristics of soybean in agroecological conditions of Sremska Mitrovica, Serbia.* Agriculture and Forestry. Podgorica, 61, 1: 67-75.

Popovic, V., Vidic, M., Vučkovic, S., Ikanovic, J., Drazic, G., Djekic, V., Filipovic, V., 2015b. *Determining genetic potential and quality components of NS soybean cultivars under different agroecological conditions.* Romanian Agricultural Research, 32: 1-8. DII 2067-5720 RAR 2015-32.

Vrandečić K., Jug D., Ćosić J., Stošić M., Poštić J., 2014. *The impact of tillage and fertilization on soybean grain infection with fungi.* Romanian Agricultural Research, Nardi Fundulea Romania. NO. 31, 139-145. www.incda-fundulea.ro DII 2067-5720 RAR 2014-310