ORIGINAL SCIENTIFIC PAPER

Quantitative Performances of Recently Developed OS-Soybean Elite Lines in Maturity Group I

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SUMMARY

This paper presents an evaluation of the agronomic and breeding values of recently developed soybean (*Glycine max* (L.) Merr.) lines maturity group (MG) I within soybean breeding program at the Agricultural Institute Osijek. Thirty two soybean genotypes (30 elite breeding lines and two control cultivars) were studied in a field experiment conducted on the experimental field of the Institute during period from 2002 to 2004 to determine the grain yield and grain quality (protein and oil content) potential as well as stability and adaptability of these lines. The obtained results of statistical analysis (ANOVA, LSD-test, stability parameters: S^2_{GxE} and b_i) indicated significant differences in level and stability of grain yield and grain quality as well as adaptability of genotypes. Higher average grain yield was obtained for the lines in comparison with average grain yield of control cultivars. According to analysis of stability and adaptability of genotypes, tested genotypes were classified in three groups. There were: stable genotypes with wide-general adaptability, unstable genotypes adapted to low-yielding environments and unstable genotypes adapted to high-yielding environments. Among 32 tested genotypes, 22 genotypes are stable in grain yield, 20 genotypes are stable in protein content and 17 genotypes are stable in oil content in grain. The best elite lines in level and stability of grain yield, protein content and oil content in grain as well as in adaptability are: OS-L-36/01, OS-L-18/01, OS-L-12/01, OS-L-10/01 and OS-L-39/00. These results suggest on achieved genetic advance in yield potential of new elite soybean lines. Thereby, the best recently developed soybean elite breeding lines into MG I represent good genetic background for further improving soybean production in Croatia. At the same time, these genotypes may be utilized as a source of better yields potential in breeding programs.

KEY WORDS

soybean (*Glycine max* (L.) Merr.); maturity group I; grain yield, grain quality, stability, adaptability

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Received: February 15, 2005

INTRODUCTION

The breeding work on soybean (*Glycine max* (L.) Merr.) at the Agricultural Institute Osijek primarily has focused on permanently development high-yielding and high-quality soybean cultivars in the frame of maturity groups (MGs) 00 to II (focus on MGs 0 and I) which likewise characterized stability in principal agronomic traits and adaptability on different environmental conditions of soybean production regions in Croatia. The result of continued and intensive breeding work is genetic improvement of cultivars which significantly contributes to the increasing and improving of soybean production in the country (Vratarić and Sudarić, 2000). Genetic improvement of grain yield is concerned with two parameters: genetic potential and stability over environment. Yield stability is controlled by the complex responses to and interactions with the environment (Blum, 1985). Differential genotypic responses to variable environmental conditions especially associated with changes in ranks of genotypes, limit accurate yield estimates and identification of superior, stable genotypes. Interpretation of genotypes performance, evaluated in a broad range of environments, is always affected by genotype x environment interaction-GEI (Crossa et al., 1991). GEI and its effect on the predictability of future genotype performance is the essence of the concept of trait stability (Sneller et al., 1997, 1999; Piepho, 1999). Cultivar stability, as related to interactions between genotype and environment, can be described in two components: linear response to environmental yields potential and deviations from that response. Preferred genotypes generally show GEI variances, above average response to environmental yield potential and lower deviations from the expected response within a target production region (Kang, 2002). Further, a genotype that has stable trait expression across environments contributes little to GEI variance and its performance should be more predictable from the main effects of genotypes and environments than the performance of an unstable cultivar (Sneller et al., 1997). Understanding GEI is essential to developing optimal yield evaluation and selection procedures (Sneller et al., 1999). In order to assessment the agronomic value of new developed soybean elite breeding lines considering both level and stability trait and adaptability, it's necessary to carry out testing of selected genotypes (new promising lines in comparison with commercial cultivars-standards) over a wide range of variable environments. Testing done in one environment provides only limited information. Multienvironment testing makes it possible to identify genotypes with specific adaptation as well as those with broad adaptation, which will not be possible from testing in a single environment. Broad adaptation provides stability against the variability inherent in an ecosystem, but specific adaptations may provide a significant yield advantage in particular environments (Wade et al., 1999). Identification of the most stable soybean cultivars for a given environment is important for recommendation the adequate cultivars for commercial production and as selection criteria which will give the better results for improving grain yield in soybean.

The objective of this study was to test yield potential and stability of grain yield, protein and oil content in the grain and adaptability level of recently developed own soybean elite lines (MG I) in comparison with standard cultivars. The obtained results should be provide useful information about values of new promising lines from both aspects agronomic and breeding and thus enable selection the best lines for submission to the Cultivar Recognition Commission of the Republic of Croatia.

MATERIAL AND METHODS

The research was conducted at the experimental field of the Agricultural Institute Osijek (Osijek, Croatia) over period from 2002 to 2004 year. Experimental material was involved 32 genotypes MG I (30 elite breeding lines and 2 standards). Tested elite breeding lines have developed from different hybridizations within the Institute's soybean breeding program (therein ensure level of genetic variability) and derived from preliminary trials in 2000 and 2001 year as better material in relation to parental components on the basis of their quantitative performances. Control cultivars ('Ika', 'Tisa') are released cultivars (cvs.) of the Institute and leading cultivars as regards grain yield and surfaces in commercial soybean production in Croatia. Cultivar 'Ika' is recognized in Hungary, too. Field trials were designed as a randomized complete block (RCBD) in four replications on basic plot of 10 m^2. The experimental plots were sown by precise planting machine in optimal time for soybean. Currently accepted levels of management and cultural practices for soybean were applied each year in trial. Plots were harvested with small plot harvest combine, when genotypes reached the full harvest maturity. After harvesting, grain yield from each plot was weighed and converted into t/ha on standard of 13% seed moisture content. Grain quality traits: protein and oil content (% in absolutely dry matter of grain-ADM) were determined from the average sample of grain for each genotype by Infratec 1241 Analyzer.

The acquired experimental data for grain yield, protein and oil content in grain were processed by analysis of variance (ANOVA). Least Significant Difference (LSD) test was applied to examine the statistical significance of differences for the analyzed traits among genotypes, experimental years and interaction between genotype and environment. Different experimental years were treated as different environments. By ANOVA is proved the presence

Table 1. Monthly mean air temperatures (^{0}C) and monthly total precipitation (mm) per years during soybean growing seasons, 2002-2004 and perennial average for period 1971-2000, Osijek (Croatia)

Month	Air temperature (°C)				Precipitation (mm)			
	1971-2000	2002	2003	2004	1971-2000	2002	2003	2004
April	11.2	11.5	11.5	11.4	51.0	57.6	9.1	122.0
May	16.7	19.1	20.5	15.4	59.2	155.6	43.2	63.3
June	19.6	22.1	24.7	19.8	82.0	48.1	25.3	88.4
July	21.3	23.0	22.9	22.1	66.3	84.6	70.3	58.4
August	20.8	20.9	24.6	21.4	61.9	79.3	23.4	104.9
September	16.5	16.0	16.7	15.8	51.0	74.8	49.3	44.7
October	11.1	11.6	9.7	9.7	55.9	58.1	145.4	145.4
Total					427.3	558.1	366.0	627.1

of interaction genotype x environment (GEI), what enable statistical analysis of stability and adaptability. Stability analysis of grain yield and grain quality as well as adaptability of tested materials were performed by combination of two parameters within agronomic concept of stability: S^2_{GxE} – portion of GEI variance of each genotype to total variance of GEI (Plasteid and Peterson, 1959) and b_i – regression coefficient (Finlay and Wilkinson, 1963). According to Plasteid and Peterson's method, if GEI portion of single genotype in total GEI (S^2_{GxE}) is less, stability of genotype is higher and inverse. Regression coefficient represents specific reaction of genotype on environmental conditions. Genotypes characterized with b_i around 1.0 are stable in all environments and have wide-general adaptability, respectively. Values $b_i > 1.0$ indicate on the under-average of stability and adaptability on high-yielding environments, while values $b_i < 1.0$ indicate on the above-average of stability and adaptability to low-yielding environments. According to Lin et al. (1986) the stability statistics applied in this study represents the Type 2 concept of stability: A genotype is considered to be stable if its response to environments is parallel to the mean response of all genotypes in the trial. If agronomic stability is demonstrated for a wide range of environments, a genotype is defined as having general or wide adaptation. On the contrary, if agronomic stability is manifest over a limited range, a genotype has specific or narrow adaptation. Estimated parameters were enabled grouping tested materials in consideration on genetic potential and stability of grain yield, protein and oil content in grain as well as level of adaptability.

The soil type at the experimental site was classified as an eutric cambisol. The chemical soil properties were: pH 7.00 (H_2O); humus 1.83%; N_{org20} 2.34 mg/100g of soil; K_{20} 13.46 mg/100g of soil; P_{20} 3.39 mg/100g of soil (according to EUF method). Meteorological data (monthly mean air temperature and monthly total precipitation) for the investigated period (2002-2004) over soybean growing season at location Osijek are presented in Table 1.

RESULTS AND DISCUSSION

Grain yield (t/ha)

The average grain yield of tested genotypes throughout experimental years and in 3-years average with results of statistical analysis are summarized in Table 2. From tabulated data, visibly is that exist statistical significant differences in grain yield among tested genotypes in each experimental year and as well as in overall mean, implying on differences in genetic background of this trait within experimental material. On the basis of the 3-years average, among 30 tested promising lines, only five lines (OS-L-41/01, OS-L-11/00, OS-L-36/01, OS-L-40/00, OS-L-19/00) had statistical significant higher ($P \leq 0.01$) grain yield than control cultivar 'Ika', while in relation to another control cultivar 'Tisa', all tested lines were had higher grain yield at level $P \leq 0.05$. Furthermore, a variation in the average grain yield was existed among experimental years, regardless of genotypes, what could be connected with differences in the climatic conditions over experimental years. Thus, during soybean vegetation in 2002 and 2004, the climatic conditions were more favorable for soybean growth and development than in 2003 (Table 1). It was resulted significantly ($P \leq 0.01$) lower grain yield in 2003 (4.25 t/ha) in relation on both 2002 (4.81 t/ha) and 2004 (4.89 t/ha) year. GEI was statistical significant, what indicated on differential genotypes expression across years, respectively on the reaction of genotype (genetic factor) on changing environmental conditions during soybean vegetation throughout experimental years. In general, the obtained results about grain yield variability have confirmed the well-known fact that the grain yield has depended considerably of genetically potential, but which has modified under impact of environmental factors and environmental growing conditions are reflected on the genotypic value, respectively (Vratarić et al, 1998, 2003; Sudarić et al., 2001, 2003; Yan and Rajcan, 2002, 2003).

The yield performances consist of yield level and yield stability. Breeders search genotypes that show

Table 2. Mean values, stability and adaptability of tested soybean genotypes in grain yield, 2002-2004, Osijek (Croatia)

Genotype		Year			Mean value (t/ha)	* S^2_{GxY}	* b_i
		2002	2003	2004			
Stable genotype, wide-general adaptability							
1	OS-L-41/01	5.25	4.92	5.10	5.09	12045	1.007
2	OS-L-36/01	5.15	4.70	5.05	4.96	12008	1.002
3	OS-L-40/00	5.08	4.55	5.18	4.94	12100	0.991
4	OS-L-19/00	5.07	4.60	5.12	4.93	12097	0.990
5	OS-L-53/01	5.10	4.66	5.00	4.92	12100	0.986
6	OS-L-7/01	4.98	4.53	5.07	4.86	12045	1.009
7	OS-L-18/01	4.87	4.60	4.95	4.81	12004	0.997
8	OS-L-25/00	5.00	4.57	4.86	4.81	12045	0.990
9	OS-L-62/01	4.80	4.55	4.97	4.77	12108	0.992
10	OS-L-12/01	4.95	4.15	5.10	4.73	12083	0.993
11	OS-L-3/01	4.86	4.35	4.92	4.71	12090	0.984
12	OS-L-21/01	4.82	4.35	4.97	4.71	12103	1.008
13	OS-L-44/01	4.83	4.25	5.00	4.69	12102	0.994
14	OS-L-10/01	4.90	4.10	4.95	4.65	12067	0.990
15	OS-L-17/00	4.92	4.00	4.86	4.60	12077	0.991
16	OS-L-38/01	4.78	4.00	4.92	4.57	12092	0.990
17	OS-L-21/01	4.73	4.12	4.86	4.57	12086	1.005
18	Ika	4.48	4.10	5.06	4.55	12086	0.997
19	OS-L-16/01	4.66	3.95	4.88	4.50	12010	0.987
20	OS-L-39/00	4.63	4.15	4.72	4.50	12028	0.995
21	OS-L-51/00	4.52	4.05	4.78	4.45	12100	1.006
22	Tisa	3.94	3.65	4.10	3.90	12090	0.995
Unstable genotype, adapted to low-yielding environments							
1	OS-L-28/01	4.76	3.98	4.90	4.55	12153	0.899
2	OS-L-33/01	4.65	4.00	4.75	4.47	12102	0.876
3	OS-L-49/01	4.58	3.87	4.65	4.37	12212	0.880
4	OS-L-13/00	4.32	3.96	4.68	4.32	12143	0.883
5	OS-L-9/00	4.42	3.96	4.50	4.29	12237	0.876
6	OS-L-50/01	4.50	4.00	4.36	4.29	12228	0.896
Unstable genotype, adapted to high-yielding environments							
1	OS-L-11/00	5.30	4.65	5.17	5.04	12196	1.110
2	OS-L-23/01	5.05	4.22	5.12	4.80	12143	1.112
3	OS-L-4/01	5.00	4.28	4.96	4.75	12166	1.098
4	OS-L-47/01	4.90	4.20	5.10	4.73	12182	1.086
Overall mean		4.81	4.25	4.89	4.65	12104	0.988
$LSD_{genotype\ (A)}$	0.05	0.405	0.433	0.368	0.372		
	0.01	0.478	0.518	0.415	0.407		
$LSD_{year\ (B)}$	0.05				0.312		
	0.01				0.400		
$LSD_{A \times B}$	0.05				0.582		
	0.01				0.615		

* S^2_{GxY} – interaction share of some genotype in total genotype x year interaction; b_i – regression coefficient

a stable, high yield over years and locations (Kang, 2002). The estimates of stability have derived from an analysis of GEI (Hill et al., 1998). According to Fernandez (1991), the significant GEI have resulted from changes in the magnitude of the differences among genotypes in different environments or from changes in relative ranking of the genotypes. If no GEI are present, the average difference among genotypes evoked by phenotypes in different environment is constant.

Results of stability analysis for grain yield at this study indicated on differences in stability and adaptability among tested genotypes and thereby genotypes were classified in three groups (Table 2). The first group involves 20 promising lines and both standards, which characterized lower single value S^2_{GxY} than average value S^2_{GxY} for trial and b_i around 1.0. Regarding to obtained stability estimates, these genotypes could be considered as stable in grain yield and as broad adaptable ones. It means that theirs grain yield will not considerably vary through changing environmental conditions. Respectively, these genotypes will give satisfactory grain yield in different environmental conditions, what is very important positive characteristic of any genotypes from aspect of production. The others 10 tested promising lines were had higher single value S^2_{GxY} in relation to average value S^2_{GxY} and classified as unstable in grain yield. Among them, six lines (OS-L-28/01, OS-L-33/01, OS-L-49/01, OS-L-13/00, OS-L-9/00, OS-L-50/01) were had value of $b_i<1.0$ what indicated on the above-average of stability and adaptability on low-yielding environments. It implies that the average grain yield of these lines could be on the same level with the overall average or higher of it in low-yielding environments, while in high-yielding environments, grain yield could be in rang of the overall average or lower of it. Four tested lines (OS-L-11/00, OS-L-23/01, OS-L-4/01, OS-L-47/01) were characterized by values of $b_i>1.0$ or the under-average of stability. These lines will have the average grain yield on the same level with the average of all tested genotypes or higher of it in high-yielding environments, whereas in low-yielding environments, their grain yield will be on the same level of the overall average or lower of it. This type of genotype's reaction on environmental changes is classified as adaptability on high-yielding environments.

Results of stability analysis of tested genotypes in grain yield have indicated on high agronomic and breeding values of 20 new soybean elite breeding lines, particularly lines OS-L-41/01, OS-L-36/01, OS-L-40/00 and OS-L-19/00 which have had, beside stability and broad adaptability, significantly higher ($P\leq0.01$) grain yield than control cultivar 'Ika'. High agronomic values of tested lines are confirmation of achieved genetic improvement in grain yield within Institute's soybean breeding program. These elite lines represent good genetic background for further improving soybean production in Croatia. Furthermore, these genotypes may be utilized as a source of better yields potential in breeding programs.

Protein content in grain (% in ADM)

Soybean is the most important source of edible high-quality vegetable protein in the world today. Wilson (2004) reports that range of protein concentration in seed of soybean lines is 34.1 to 56.8% of seed dry mass, but in the average, the seeds of modern cultivars contain about 40-41% protein. Due to negative correlation between grain yield and protein content, the quantity and quality of protein has remained unchanged in soybean cultivars for the past 70 years (Wilcox and Guodong, 1997). Progress has been made with possibilities in overcoming inverse relationships between grain yield and protein content (Wilcox and Cavines, 1995; Wilcox and Kinney, 1999; Chung et al., 2003).

At the present study, the average protein content in grain of 32 tested genotypes across three experimental years and in the overall average of study with obtained results of statistical analysis are summarized in Table 3. From the obtained results, obviously is that protein content in grain is highly variable depending of tested genotypes, experimental years and interaction genotype x year. Across all experimental years, among 30 tested promising lines, 12 lines had statistical significant higher ($P\leq0.05$) protein content in grain in relation to control cultivar 'Ika' and 17 lines (level of $P<0.05$) in relation to control cultivar 'Tisa'. Statistical significant differences among tested genotypes in each of experimental years as well as in 3-years average indicated first of all on the existence of genetic variability for protein content in grain within tested materials. Apart from genetic differences, protein content in grain was also affected by various climatic conditions during soybean growing season (Table 1), what is evidently from considerable differences among the average values of protein content in grain per experimental years. Different environmental conditions throughout the study affected on the protein content in grain of each tested genotypes, thereby GEI at each genotype was significant ($P\leq0.01$). These results correspond with findings by similar study (Helms and Orf, 1998; Vratarić et al., 1999, 2002; Vollman et al., 2000; Fasoula et al., 2004) which announced that the level of protein content in soybean grain is depended of genetic factor, environmental variables and interaction between genotype and environment. Besides the increasing protein content in soybean grain, phenotypic stability of percentage protein is another important factor to consider in breeding higher protein cultivars.

The stability analysis for protein content in grain in this study was showed that tested genotypes were differed in stability and adaptability of this trait (Table 3). Among 32 tested genotypes, 18 promising lines and both control cultivars were classified as genotypes with stable protein content in grain and wide adaptability due to lower single value of S^2_{GxY} than the average value of S^2_{GxY} and value of b_i around 1.0. These results have allowed the further explanation that protein content in grain of these genotypes will not considerably varied in different environmental conditions, what is very favorable from a practical viewpoint. The others 12 tested promising lines were classified as unstable in this trait (single S^2_{GxY} is higher than average S^2_{GxY}), suggesting that protein content in grain of these lines will considerably varied with changing environmental conditions. Likewise, unstable lines were differed in reaction on the environmental changes. Therein, five tested lines (OS-L-19/00, OS-L-38/01, OS-L-7/01, OS-L-62/01, OS-L-21/01) with value $b_i<1.0$ were the above-average of stability in protein content in grain. Consequently, their protein content in grain will be in unfavorable environments on the same level with the overall average of trials or higher of that and in the favorable environments their protein content is in the rang of the overall average or lower of that. Seven tested lines (OS-L-41/01, OS-L-17/00, OS-L-40/00, OS-L-25/00, OS-L-16/01, OS-L-23/01, OS-L-3/01) were had values $b_i>1.0$ or the under-average of stability,

Table 3. Mean values, stability and adaptability of tested soybean genotypes in protein content in grain, 2002-2004, Osijek (Croatia)

Genotype		Year			Mean value (% in ADM)	$*S^2_{GxY}$	$*b_i$
		2002	2003	2004			
Stable genotype, wide-general adaptability							
1	OS-L-39/00	41.37	41.83	42.49	41.90	8097	1.012
2	OS-L-21/01	41.53	41.70	42.38	41.87	8109	0.976
3	OS-L-12/01	40.72	41.17	41.98	41.29	8119	1.002
4	OS-L-28/01	40.23	41.35	41.48	41.12	8125	0.954
5	OS-L-50/01	40.66	41.00	41.35	41.00	8120	0.915
6	OS-L-10/01	41.00	40.82	41.11	40.98	8113	1.007
7	OS-L-51/00	40.21	40.79	41.44	40.81	8117	0.958
8	OS-L-49/01	40.93	40.23	41.03	40.73	8119	0.965
9	OS-L-53/01	40.45	40.72	40.66	40.61	7965	0.932
10	OS-L-18/01	40.42	39.77	40.96	40.38	8104	1.004
11	OS-L-9/00	40.23	39.78	40.72	40.24	8033	0.967
12	OS-L-44/01	39.57	40.43	40.70	40.23	8076	0.935
13	OS-L-4/01	40.23	39.84	40.59	40.22	8120	0.934
14	OS-L-36/01	40.08	39.95	40.53	40.19	8115	0.987
15	OS-L-33/01	39.58	40.25	40.70	40.18	8093	0.931
16	OS-L-11/00	39.53	40.11	40.82	40.15	8104	0.992
17	Ika	39.94	39.23	40.35	39.84	8120	1.003
18	OS-L-13/00	39.76	39.41	40.28	39.82	8116	0.949
19	Tisa	39.38	39.67	40.11	39.72	8123	1.012
20	OS-L-47/01	39.12	39.50	39.79	39.47	8111	0.976
Unstable genotype, adapted to low-yielding environments							
1	OS-L-19/00	39.13	39.43	40.38	39.65	8153	0.875
2	OS-L-38/01	39.53	39.12	40.00	39.55	8136	0.845
3	OS-L-7/01	38.94	39.28	39.70	39.31	8151	0.884
4	OS-L-62/01	38.66	39.25	39.91	39.27	8173	0.824
5	OS-L-21/01	38.76	39.45	39.30	39.17	8165	0.796
Unstable genotype, adapted to high-yielding environments							
1	OS-L-41/01	40.73	41.08	42.42	41.41	8275	1.010
2	OS-L-17/00	40.23	41.35	41.78	41.12	8167	1.133
3	OS-L-40/00	39.37	40.12	40.73	40.07	8148	1.153
4	OS-L-25/00	39.53	40.02	40.16	39.90	8138	1.167
5	OS-L-16/01	39.63	39.06	40.71	39.80	8172	1.186
6	OS-L-23/01	39.53	39.17	40.37	39.69	8155	1.105
7	OS-L-3/01	38.71	39.47	39.79	39.32	8200	1.128
Overall mean		39.93	40.13	40.77	40.28	8126	0.985
$LSD_{genotype\ (A)}$	0.05	0.422	0.504	0.515	0.417		
	0.01	0.512	0.611	0.610	0.510		
$LSD_{year\ (B)}$	0.05	0.565					
	0.01	0.604					
$LSD_{A x B}$	0.05	0.642					
	0.01	0.718					

* S^2_{GxY} – interaction share of some genotype in total genotype x year interaction; b_i – regression coefficient

what indicated that these genotypes are sensitive to environmental change. In reference to, these genotypes could be given higher protein content in environments that favor the expression of this character and lower in unfavorable environmental conditions than the overall average.

Oil content in grain (% in ADM)

The quantity of oil content in soybean grain has varied, depending of genotypes and environment, from 12 to 24% on a moisture free-basis, while commercial cultivars have 20-22%, usually (Wilson, 2004). For the past 70 years, the quantity of oil in soybean grain has remained unchanged in commercial soybean cultivars (Wilcox and Guodong, 1997), similar as at protein content. Nowadays, much more efforts in soybean breeding have been made on increasing quantity and improving quality of soybean oil and related studies have been well reviewed by Wilson (2004).

Results of the average oil content in grain of 32 tested genotypes per experimental years and in the overall average of study as well as results of LSD-

Table 4. Mean values, stability and adaptability of tested soybean genotypes in oil content in grain, 2002-2004, Osijek

Genotype		Year			Mean value (% in ADM)	*S^2_{GxY}	*b_i
		2002	2003	2004			
Stable genotype, wide-general adaptability							
1	OS-L-19/00	22.96	22.72	23.14	22.94	9004	0.954
2	OS-L-12/01	22.69	22.96	22.82	22.82	9010	0.966
3	OS-L-41/01	22.40	23.17	22.80	22.79	8994	1.003
4	OS-L-18/01	22.18	23.14	22.45	22.59	8990	0.993
5	OS-L-38/01	22.42	22.39	22.65	22.49	8986	0.995
6	OS-L-40/00	22.13	22.48	22.56	22.39	8984	0.981
7	OS-L-7/01	22.00	22.72	22.33	22.35	8996	1.026
8	OS-L-36/01	22.15	22.55	22.30	22.33	9008	0.982
9	OS-L-16/01	22.18	22.55	22.20	22.31	9000	1.004
10	OS-L-10/01	22.17	22.38	22.30	22.28	8981	0.946
11	OS-L-28/01	22.17	23.14	21.41	22.24	8962	0.983
12	OS-L-13/00	22.12	22.17	22.26	22.18	8900	0.993
13	OS-L-39/00	22.08	22.31	22.01	22.13	9003	1.003
14	OS-L-21/01	21.86	22.70	21.45	22.00	8984	1.014
15	Ika	21.86	22.17	21.75	21.93	8955	0.965
16	OS-L-25/00	21.18	21.96	21.99	21.71	9002	0.982
17	Tisa	21.52	21.90	21.40	21.61	8984	0.993
Unstable genotype, adapted to low-yielding environments							
1	OS-L-47/01	21.87	22.20	22.04	22.04	9026	0.882
2	OS-L-62/01	21.40	22.70	21.90	22.00	9045	0.885
3	OS-L-51/00	22.02	22.22	21.40	21.88	9073	0.873
4	OS-L-9/00	21.47	22.36	21.30	21.71	9042	0.894
5	OS-L-33/01	21.36	21.80	21.48	21.55	9035	0.872
6	OS-L-50/01	21.22	21.35	21.37	21.31	9063	0.854
Unstable genotype, adapted to high-yielding environments							
1	OS-L-53/01	22.04	22.38	22.22	22.21	9038	1.118
2	OS-L-49/01	21.63	22.43	22.08	22.05	9028	1.125
3	OS-L-44/01	22.05	22.40	21.79	22.08	9104	1.119
4	OS-L-11/00	22.05	22.02	21.95	22.01	9038	1.115
5	OS-L-3/01	21.54	22.71	21.69	21.98	9033	1.104
6	OS-L-23/01	21.60	22.59	21.71	21.97	9024	1.109
7	OS-L-17/00	22.10	22.30	21.43	21.94	9058	1.117
8	OS-L-4/01	21.56	21.90	21.72	21.73	9020	1.186
9	OS-L-21/01	21.44	21.42	21.86	21.57	9014	1.104
Overall mean		21.92	22.38	21.99	22.10	9012	1.004
$LSD_{genotype (A)}$	0.05	0.396	0.362	0.407	0.376		
	0.01	0.425	0.410	0.482	0.416		
$LSD_{year (B)}$	0.05				0.265		
	0.01				0.318		
$LSD_{A x B}$	0.05				0.433		
	0.01				0.507		

* S^2_{GxY} – interaction share of some genotype in total genotype x year interaction; b_i – regression coefficient

test and stability analysis are given in Table 4. From presented results, obvious are significant differences in oil content in grain among tested genotypes across experimental years and in 3-years average, what have suggested on genetic diversity within experimental material. Comparing average values of this trait, evidently is that among 30 tested promising lines, 9 lines had statistical significant ($P \leq 0.05$) higher oil content in grain in relation to control cultivar 'Ika' and 20 lines (on level $P \leq 0.05$) than control cultivar 'Tisa'. Besides genetic factor, environmental factors were affected on the value of oil content in grain, too. Favorable climatic conditions for oil synthesis were in 2003 year (Table 1), what were resulted considerably ($P \leq 0.01$) the higher oil percentage in that year (22.38% in ADM) in relation to 2002 (21.92%) and 2004 (21.99%), respectively. The GEI was significant on level $P \leq 0.01$ for all tested genotypes, what indicated on the variations of oil content in grain within each genotype under environmental influence. The summarized and analyzed data for oil content in grain indicated that phenotypic variability of this trait is caused by genotype variability, environmental variability and variability of GEI. These results corresponded with results of similar investigations reported by Vratarić et al., 1999, 2002, 2003; Ustun et al., 2001; Chen and Nelson, 2004.

According to obtained results of stability analysis for oil content in grain, apparently that to exist the differences in stability and adaptability among tested genotypes, grouping them in three groups. The first group of genotypes (15 promising lines and 2 standards) characterized lower single values of S^2_{GxY} than average value of S^2_{GxY} in trials and value b_i about 1.0. These assessments have indicated on oil content stability of these genotypes over different environmental conditions. Into group of unstable genotypes belongled 15 lines. These lines were had single values S^2_{GxY} higher than the average values S^2_{GxY} of trials, what indicated on considerably variation in this trait affected by environmental factors. Furthermore, these genotypes were differed in reaction on the environmental change. Thus, 6 lines were had b_i<1.0 or the above-average of stability in oil content in grain. It means that these cultivars will have higher oil content in grain than the average value in low-yielding environments. The others 9 unstable lines were characterized b_i>1.0 or the under-average of stability. Therefore, these lines will have higher oil content than the average value in favorable environments, while in unfavorable environments theirs oil content will be under of the average and due to classified as narrow adaptable on high-yielding environments.

CONCLUSION

This study has provided an evaluation of the agronomic and breeding values of recently developed soybean OS-elite breeding lines (30) in comparison with two commercial cultivars (as a control cultivar) within MG I. It was found that tested genotypes significantly differed in level of grain yield, protein and oil content in grain and in stability of these quantitative characters as well as adaptability. The average grain yield, protein and oil content in grain were higher in tested lines in relation to control cultivars. Stability analysis has demonstrated that, among 32 tested genotypes, fairly stability and wide adaptability had 22 genotypes in grain yield, 20 genotypes in protein content and 17 genotypes in oil content in grain. The others tested genotypes were unstable in grain yield and grain quality and had narrow (specific) adaptability. The best tested elite breeding lines, which had at the same time high and stable grain yield, protein content and oil content in grain as well as wide-general adaptability are following lines: OS-L-36/01, OS-L-18/01, OS-L-12/01, OS-L-10/01 and OS-L-39/00. These data indicate on achieved genetic advance in grain yield and grain quality of domestic soybean lines within MG I. Consequently, this is important for further improving soybean production in Croatia as well as further breeding procedure using these lines as parental components.

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