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QUALITY PARAMETERS AND GRAIN YIELDS OF SOYBEAN VARIETIES PRODUCED AT ARDS TURDA: A CHEMOMETRIC APPROACH

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Abstract

*The main purpose of this study was to determine the quality parameters and grain yields of twenty soybean varieties created at Agricultural Research and Development Station Turda (ARDS)**:** Diamant, Perla, Safir, Granat, Eugen, Onix, Felix, Darina TD, Cristina TD, Mălina TD, Carla TD, Larisa, Caro TD, Ilinca TD, Bia TD, Ada TD, Teo TD, Miruna TD, Nicola TD and Felicia TD. Field trials were carried out in the experimental field of the ARDS Turda, based on a randomized complete block design with three replications, using plots of 10 m^2. The varieties were characterized by: dry weight, ash, proteins, lipids, total carbohydrates, total carotenoids, plants' height, insertion height of basal pods, grain yield and thousand kernels' weight. Analytical determinations were performed using oven drying (for moisture), furnace ashing (for ash), Soxhlet extraction (for total lipids), Kjeldahl method (for total proteins), UV-VIS spectrophotometry (for total carotenoids); the total carbohydrate content was assessed by difference. A chemometric evaluation of the obtained results was carried out, highlighting similarities between the studied varieties and pointing up those ones with the best scores for quality parameters.*

Key words*: soybean seeds, quality, chemometry.*

INTRODUCTION

The current interest in soybean (*Glycine max* (L.) Merr.) is motivated by its high nutritional value, especially with respect to their protein and amino acids' content (Mello Filho et al., 2004; Specht et al., 1999). Soybean is a leading crop, grown worldwide as the most important source of vegetable protein known to mankind (30-49%) and oil (~20%); it is one of the cheapest and convenient sources of protein available, particularly in developing countries (Idrisa et al., 2010; Jiang et al., 2018). Soybean seeds contain proteins that include all the essential amino acids, besides valuable fatty acids (Clemente & Cahoon, 2009; Goldflus et al., 2006; Karr-Lilienthal et al., 2004; Liu, 1997; Lombardi et al, 2013).

The soybean breeding program from the Agricultural Research and Development Station (ARDS) Turda had as a priority the creation of early, productive varieties with good yield stability, well adapted to the pedo-climatic conditions of the area. Particular attention was paid to increased resistance to the main stress factors, increased availability to mechanized harvesting and quality (Mureşanu & Mărginean 2011; Mureşanu & Mărginean 2011a).

The results of the works carried out within the Soybean Breeding Program at ARDS Turda have been materialized by recording 20 early and very early soybean varieties during 1987-2017; most of the varieties were created and registered after 2000, 13 out of them being registered in the last 7 years (Mureşanu et al, 2017). Seventeen of these are registered in The Romanian Official Catalogue of Crop Plant Varieties.

From a morphological point of view, Turda soybean varieties are characterized by gray or red pubescence, violet or white flower, and different colors of hilum (grey, yellow, black and different shade of brown). Cristina TD, Caro TD, Larisa, Ilinca TD, Ada TD, Darina TD are varieties with high yield and also a very good stability of the yield. Until now, Cristina TD is considered the most valuable creation regarding yield; in the trial organized at Agricost Brăila, Insula Mare a Brăilei it

reached 4779 kg/ha. It should note the production potential of the Ada TD variety, which in irrigation conditions reached 5703 kg/ha in Mircea Vodă testing center, in 2015 (Mureşanu et al, 2016). All the Turda soybean varieties but especially Ilinca TD, Miruna TD, Nicola TD, Darina TD, Ada TD and Teo TD have high insertion of the basal pods (over 19 cm), being suitable for mechanized harvest.

In Europe there is an increasing interest for conventional soybean (Dima, 2018). At Freising, in 2013, the European soybean breeders established new direction for their breeding programs namely the creation of new varieties with specific destination: human consumption, animals feeding and oil derivatives. Selection of the appropriate variety is a very important task and needs to be taken seriously since it directly influences yields and also the seed quality.

In this context, the quality parameters of plant raw material are important issues for both breeding programs and food processors, due to their impact on the quality of the end-products; hence, they are important criteria for selection of appropriate genotypes for specific consumer's preferences. Since in the last years, consumers are becoming increasingly aware of the health benefits of soybean, there is a growing interest in breeding programs directed towards the improvement of taste, functional characteristics and health benefits (Gandhi, 2009; Lagos & Stein, 2017; Mihalache, 2006).

The main purpose of this study was to assess the quality parameters and grain yields of the soybean varieties produced at ARDS Turda in the conditions of the year 2018, then to perform a chemometric evaluation of the obtained results in order to highlight similarities between the studied varieties.

MATERIALS AND METHODS

Biological material

The seeds used in this study were produced at ARDS Turda in 2018, twenty early and very early soybean varieties being evaluated: Diamant, Perla, Safir, Granat, Eugen, Onix, Felix, Darina TD, Cristina TD, Mălina TD, Carla TD, Larisa, Caro TD, Ilinca TD, Bia TD, Ada TD, Teo TD, Miruna TD, Nicola TD and Felicia TD. Field trials were based on a randomized block design with three replications with the harvested plot of 10 m^2; each soybean variety was sowed on two rows of 12 m length and 50 cm distance between rows. At the end of the growing period 10 plants/ variety were analyzed for height and for insertion of the basal pods. The plots were harvested at the end of September 2018 with a Wintersteiger Classic Plot Combine (Wintersteiger AG, Austria); the thousand kernel weight (TKW) was determined using a Sadkiewicz Seed Counter (Sadkiewicz Instruments, Bydgoszcz, Poland) and a KERN 573-34 NM analytical balance (Kern & Sohn GmbH, Bahlingen-Frommern, Germany); the results are the average of 100 seeds counted and weighed in 8 replications.

Sampling and sample processing

Average representative samples of soybean seeds were collected from each variety; they were milled using a WZ-1 laboratory mill (Sadkiewicz Instruments, Bydgoszcz, Poland) the resulted powder being used for next analytical steps after a weighing step, using a Kern ABT-220-5DM analytical scale (Kern & Sohn GmbH, Bahlingen-Frommern, Germany).

Analytical determinations

Proximate composition of seeds was accomplished according to AOAC methods (Latimer, 2012); all determinations were accomplished in triplicates and mean values were reported. The dry matter content was determined by drying using a SLW 53 programmable forced air convection oven (POL-EKO-Aparatura, Wodzisław Śląski, Poland). The ash content was established by calcination at 550°C in a Nabertherm B180 muffle furnace (Nabertherm GmbH, Lilienthal, Germany). The protein content was determined using the Kjeldahl method: about 0.5 g of samples were weighed and transferred into 250 mL digestion tubes, where 20 mL of concentrated sulfuric acid (Chempur, Piekary Śląskie, Poland) and two tablets of Kjeltabs CX catalysts (each containing 5 g K_2SO_4 and 0.5 g $CuSO_4$. $5H_2O$ - Gerhardt, Koenigswinter, Germany) were added, digestion being therefore achieved for three hours, at 400°C using a Turbotherm TT 265 digestion unit connected with a Turbosorg Tur/K scrub unit

(both from Gerhardt (Koenigswinter, Germany). The digested samples were treated with 32% sodium hydroxide (Chempur, Piekary Śląskie, Poland) and the resulted ammonia was distilled in a Vapodest 30S device (Gerhardt, Koenigswinter, Germany) in a known volume of standardized 0.1 N sulfuric acid. The nitrogen content was determined by titration with a standardized 0.1 N NaOH solution using a classic burette; the titration's endpoint was established using as indicator a mixture of five parts of bromocresol green and one part of methyl red (both from Sigma Aldrich). The crude protein content was estimated by multiplying the nitrogen content with the conversion factor 6.25. The total fat content was determined using the Soxhlet method, in a Det Gras N6p system (JP Selecta, Barcelona, Spain); after the recovery stage, the aluminium bakers were transferred in an SLW 53 drying oven (POL-EKO-Aparatura, Wodzisław Śląski, Poland), where they were kept at 105°C for one hour; after cooling, the final weighing was carried out on a Kern ABT-220-5DM analytical scale (Kern&Sohn GmbH, Bahlingen-Frommern, Germany). The total carbohydrates' content was assessed by difference: (dry matter - protein - fat - ash), this including the polyglucides from starch and fibres.

The total carotenoid content was determined by UV-VIS spectrophotometry, after extraction of about 0.5 g sample with 15 ml ethanol (Merck KGaA Darmstadt, Germany), on an Arex magnetic stirrer (Velp Scientifica, Italy), at 40°C, for 30 min, at 150 rpm. The resulted suspensions were transferred in 15 ml Falcon centrifuge tubes, and then centrifuged at 5000 rpm for 10 minutes on a Hettich Universal 320 (Hettich, Germany). The volumes of supernatants were measured and the absorbances of the extracts were measured at 450 nm using a T80+ UV/VIS Spectrophotometer (PG Instruments Ltd, Leicestershire, UK). The total carotenoid content was calculated based on the formula:

$$TC = \frac{A.V.10}{2500.m} \quad [mg/kg]$$

where: A - recorded absorbance; V - volume [ml]; m - sample weight [g] (Britton et al., 1995).

The solutions were prepared using bidistilled water, obtained in a GFL 2104 system (GFL Gesellschaft fur Labortechnik, Burgwedel, Germany).

Data analysis

The data matrix was prepared and processed in Excel (Microsoft, USA), then chemometric analysis was performed using MatLab (The Mathworks, USA) after mean center preprocessing.

RESULTS AND DISCUSSIONS

The studied soybean varieties are tall or very tall, with high insertion of the basal pods (Table 1). In natural conditions, they had a good or very good tolerance to specific diseases and pests. Agat, Safir, Eugen, Onix, Felix, Carla TD and Bia TD are typical early soybean varieties, while the other eleven tend to approach the maturity group 0. Onix and Felix varieties are the most cultivated, being preferred by farmers for high ecological plasticity; Felix and Cristina TD are recommended for food industry, while Caro TD is the new control variety used by Romanian State Institute for Variety Testing and Registration.

The experimental data are summarized in Table 1, highlighting genotypes with the maximum values for the studied parameters: Perla - with maximum values for dry matter (94.29%), lipids (18.38 g/100 g DW) and yield (3467 kg/ha), Safir - with the highest protein content (42.76 g/100 g DW), Nicola TD - with the maximum total carotenoid content (16.19 mg/100 g DW) and total carbohydrate content (36.51 g/100 g DW), Darina TD - with the highest ash content (5.80 g/100 g DW) and height (157 cm) and Teo TD with the maximum insertion (23 cm).

Principal component analysis (PCA) was based on seven variables (concentrations of proteins, carotenoids, carbohydrates, lipids, dry matter and ash), leading to a model which expose a close correlation between the yield (P) and the content of lipids (Lip), while explaining 57.39% of variance (Figure 1).

The scores' plot of the PCA model reveals three classes (Figure 2), confirmed by cluster analysis (Figure 3): one consisting from genotypes with high protein content (the blue

one, with Onix, Felix, Eugen and Bia TD), a second joining genotypes higher in carbohydrates (the orange one, with Miruna TD, Nicola TD, Felicia TD, Ilinca TD and Mălina TD) and a third one containing the biggest number of the studied genotypes, characterized by intermediate values for the studied parameters (the red one, with Diamant, Agat, Darina TD, Cristina TD, Larisa, Caro TD, Bia TD, Ada TD and Teo TD).

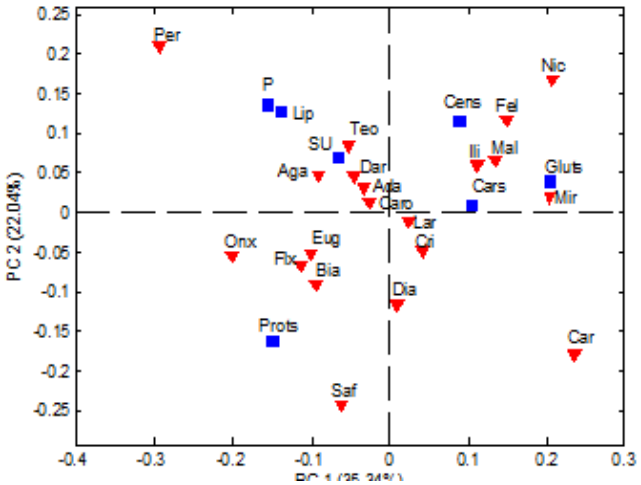

Figure 1. Biplot for the experimental dataset (P - yield, Lip - lipids, SU - dry matter, Prots - protein content, Cens - ash, Cars- total carotenoids, Gluts - total carbohydrates)

Several genotypes are much dissimilar from the described clusters: thus, Carla TD has the lowest lipid content from all, Safir has both the highest protein content and the smallest ash content, while Perla is an outlier of this model, being outside the border corresponding to the 95% confidence interval due to its exceptional yield, combined with the maximum dry weight and maximum lipid content.

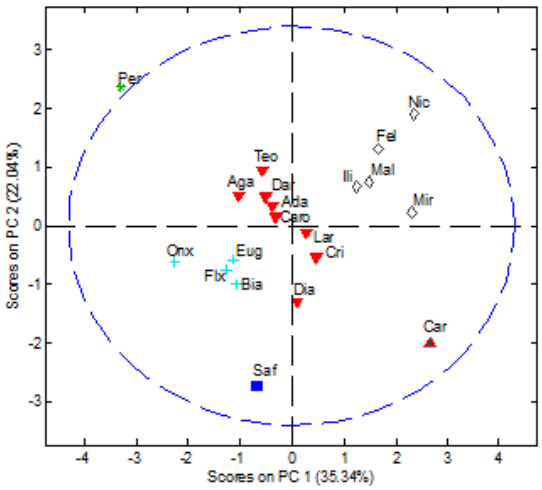

Figure 2. Score's plot for the PCA model

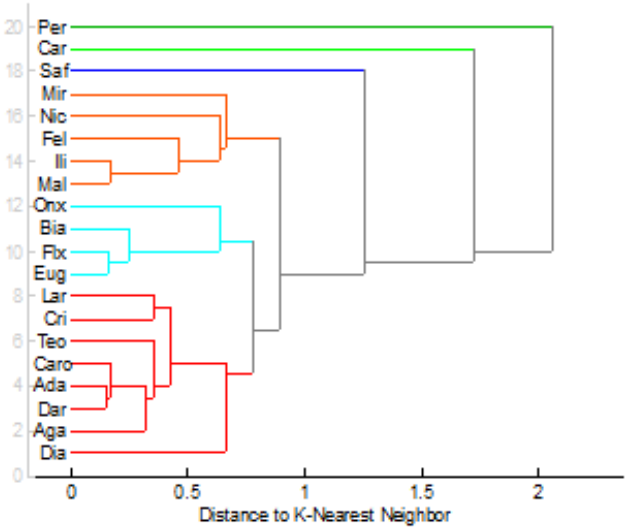

Figure 3. Dendrogram obtained for the PCA model (K-Nearest Neighbour method)

Table 1: Experimental data obtained for soybean genotypes from RDSA Turda

Genotype	Dry matter [%]	Lipids [g/100 g DW]	Proteins [g/ 100 g DW]	Total carotenoids [mg/kg DW]	Ash [g/100 g DW]	Total carbohydrates [g/100 g DW]	Yield [kg/ha]	TKW [g]	Height [cm]	Insertion [cm]
Diamant	93.83	14.48	41.55	10.81	5.69	32.11	2214	161	-	-
Perla	**94.29**	**18.38**	40.37	10.04	5.73	29.81	**3467**	144	95	13
Agat	94.24	16.50	39.12	8.62	5.15	33.48	2560	152	-	-
Safir	93.97	15.31	**42.76**	13.28	4.70	31.21	1905	142	-	-
Eugen	94.20	16.04	40.82	13.65	4.63	32.72	2679	157	121	14
Onix	94.01	18.28	41.08	13.51	4.56	30.09	2565	129	137	16

Felix	93.66	17.35	40.61	11.77	5.07	30.63	2492	158	125	16
Darina TD	93.67	17.62	39.66	12.82	**5.80**	30.59	2508	150	**157**	19
Cristina TD	93.89	15.22	40.44	13.02	5.63	32.60	2285	152	126	15
Malina TD	94.17	17.07	37.53	15.20	5.45	34.12	1874	125	118	15
Carla TD	93.84	12.07	40.10	12.06	5.47	36.20	1838	**164**	124	16
Larisa	93.98	15.99	39.20	12.44	5.19	33.60	2355	148	131	16
Caro TD	93.88	17.02	39.65	14.10	5.30	31.91	2500	133	137	16
Ilinca TD	93.76	16.72	37.80	14.08	5.62	33.62	2278	151	153	21
Bia TD	93.73	16.82	41.27	12.91	5.15	30.49	2419	138	135	17
Ada TD	93.81	16.11	39.92	13.02	5.52	32.26	2831	150	149	20
Teo TD	93.86	18.06	38.84	13.36	5.47	31.50	2577	145	148	**23**
Miruna TD	93.77	16.23	37.20	15.08	5.47	34.87	1941	**164**	126	17
Nicola TD	94.04	16.28	35.77	**16.19**	5.48	**36.51**	2497	160	128	16
Felicia TD	93.87	15.56	36.49	11.12	5.60	36.23	2545	149	152	21

CONCLUSIONS

The obtained results for soybean cultivars created at ARDS Turda have identified valuable genotypes that can be used successfully in the crossing program for creating new varieties that align with the European soybean objectives.

Turda soybean varieties came forward with a high insertion of the basal pods, Teo TD being representative for this character (23 cm). The highest genotype in 2018 was Darina TD (157 cm), the biggest yield was obtained by Perla variety (3467 kg/ha) and TKW reached the value of 164 g (Carla TD and Miruna TD).

Nine out of twenty varieties had the protein content higher than 40 g/ 100 g DW, Safir variety obtaining the highest value for this quality parameter (42.76 g/100 g DW). For improving oil content, varieties with fat content higher than 18 g/100 g DW can be used: Perla, Onix and Teo TD. The sweetest varieties proved to be Nicola TD, Felicia TD and Carla TD, all with the total carbohydrate content higher than 36 g/100 g DW.

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