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INFLUENCE OF IRRIGATION, FERTILIZATION AND GENOTYPE, ON CONTENT OF LECITHIN AND AMINO ACIDS ON SOYBEANS, IN THE CONDITIONS OF TRANSYLVANIA

Laura Cristina Luca[1], Emil Luca[2], Simona Bârsan[1], Ancuţa Ivan[1], Marcel Dîrja[2], Păuniţa Boancă[2], Adela Hoble[2]

[1] Research Institute for Analytical Instrumentation Cluj-Napoca, Romania, Donath Street, no. 67 400293 Cluj-Napoca, Romania. E-mail: laura_c_luca@yahoo.com; laura.luca@icia.ro

[2] University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Calea Manastur, 3-5, 400372 Cluj-Napoca, Romania

ABSTRACT

This paper presents the results of researches regarding the influence of some technology elements on the lecithin and amino acids content at the irrigated soybean crop, in the Transylvania area conditions, between 2009 and 2014. As a result of the research, it was shown that irrigation and fertilization applied to the soybean crop had great influence on the content of lecithin and amino acids. Of the three varieties tested on the content of vitamins, the best results were obtained at the varieties Felix and Eugen created at ARDS Turda.

Key words: irrigation, fertilization, genotype, soybean, lecithin content, amino acids.

INTRODUCTION

The evolution of human society has generated, especially in recent decades, the most diverse problems, including a major one - nutrition. Because of the explosive growth of the world population, an increase of the food efficiency of the crop production that is obtained in a more intensive agriculture is naturally required (Cociu et al., 2010, 2011; Popović et al., 2013; Luca, 2012, 2013).

Soybean is one of the plants with broad applications that can provide future solutions for food, but also for issues regarding energy resources (Niţă, 2004, 2006, Mureşanu et al., 1999).

Soybean is the first in the group of vegetables used for beans due to the high content of protein, fat, lecithin, vitamins and enzymes. It is very hard to find another plant that, within such a short growing season, is able to synthesize such a large amount of valuable substances (Peñas et al., 2011; Coreţchi et al., 2014).

In addition to the many uses in the field of energy, food industry and animal husbandry, soybean has therapeutic-curative effects, and especially preventive ones, having a good influence on the human body (Cregan et al., 1999; Popovic et al., 2013; Cociu et al. 2013).

Given the importance of the soybean crop prospects and the perspectives that this culture can have in the Transylvanian Plain conditions, the authors initiated, together with the staff from the disciplines from the Department of Science and Land Measurements from the University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, a series of experiences that bring new technological solutions for the area, for the soybean crop. The experiences organized in the Viişoara – Turda area, Cluj County, between 2009 and 2014, were analysed both for quantity and quality, with a particular emphasis on lecithin and amino acids content in soybeans, in relation to the irrigation regime, crop management and genotypes (Cociu, 2010; Giosan et al., 1986; Muresanu, 2003; Luca et al., 1999, 2008; Popovic, 2010).

MATERIAL AND METHODS

During the experiments organized at Viişoara – Turda, between 2009 and 2014, three soybean varieties, belonging to the genus

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Glycine max. (L.) Merril and widely grown in the Plains of Transylvania were studied: Onix, Eugen and Felix. All three varieties were created at the Agricultural Research and Development Station Turda.

Onix variety, registered in 2002, is one of the most important achievements of the Agricultural Research and Development Station Turda in soybean improvement.

Eugen variety was also registered in 2002 and its genealogy is Maple Arrow x Evans. It represents significant progress in soybeans improvement, demonstrating both the possibility of increasing the production potential in the group of early maturity and increasing the insertion point of the first basal pods at a level that avoid losses at harvest.

The third studied variety was Felix, registered in 2005, representing the most recent variety bred at the Agricultural Research and Development Station of Turda.

Experiments presented in this paper were placed in an experimental field of Viişoara area – Turda, Cluj County, on a fertile and uniform land.

The design of the trials was split plot, with three replications (n = 3), the number of the tested variants being 18 (v = 2 x 3 x 3).

The variants resulting from the combinations of the three studied factors were: Factor A, Irrigation regime, with two graduations: a_1 – non irrigated, a_2 – irrigated at 50% active moisture range (IUA); Factor B, Fertilization, with three graduations: b_1 – basic fertilization, b_2 – basic fertilization + additional fertilization, b_3 – organic fertilization and Factor C, genotype.

During the experimental period, rigorous tests and observations were carried out for: *meteorological parameters* – temperature, precipitation, solar radiation, other observations; *soil parameters* – soil type, specific physical and hydro indexes; *plant parameters* – the date of the main phenophases, the date for maintenance works, plant disease and pest resistance, grain yield, etc.

Quality analyses were performed at the Research Institute for Analytical Instrumentation, ICIA Subsidiary, Cluj-Napoca. In addition to the usual tests, regarding the protein content of the soybean samples belonging to the variants tested at Viişoara – Turda, the content in lecithin and amino acids was determined.

In order to determine the amino acids and lecithin content, the LC-MS-MS AGILENT 1200, with mass spectrometer Applied Biosystem 3200 Qtrap method was used.

RESULTS AND DISCUSSION

Results on the lecithin content in soybeans, in the Viişoara – Turda area conditions

The lecithin content of soybean represents one of the key parameters for the production of beans, from the point of view of areas of application, use and therefore price. The results related to the lecithin content of soybean (%) for each variant of the tests are presented in Figure 1.

The content of lecithin of the Onix variety ranged between 0.38 and 0.42% (in case of non-irrigation and basic fertilization of the crop) and from 0.45 to 0.55% (under irrigation and additional or organic fertilization of the crop). Considering as control the grain yield achieved in experimental variant a_1 x b_1 x c_1, containing 0.38% lecithin, the best result was obtained in the experimental variant a_2 x b_3 x c_1 - containing 55% lecithin, which represents a relative increase of 44.7%. The obtained results recommend this variant as the optimal for Transylvania, in order to achieve a high content of lecithin.

Both the irrigation applied and the fertilization (graduations b_2 and b_3), led to an increase in the content of the lecithin in soybean. Thus, compared to the control variant a_1 x b_1 x c_2 (0.35%), the best results were recorded in the experimental variants a_2 x b_2 x c_2 and a_2 x b_3 x c_2 (0.52%), which represented an increase of 48.5%. The performances of the Eugen variety for the lecithin content ranged between 0.35 and 0.42% (non-irrigation and basic fertilization conditions of the crop) and 0.46 to 0.52% under irrigation and additional and organic fertilization of the crop.

Considering as control the experimental variant a_1 x b_1 x c_3 (0.28%), through the

applied irrigation and fertilization regimes, the experimental variant a_1 x b_3 x c_3 (0.50%) recorded an increase of 78.5% in lecithin content, recommending this variant as optimal for Felix variety. Felix variety's lecithin content was situated in the range of 0.28 to 0.40% (non-irrigated variant, but basic fertilized during the growing season) and, respectively, from 0.38 to 0.50% (by applying irrigation and additional and organic fertilization of the crop during the growing season).

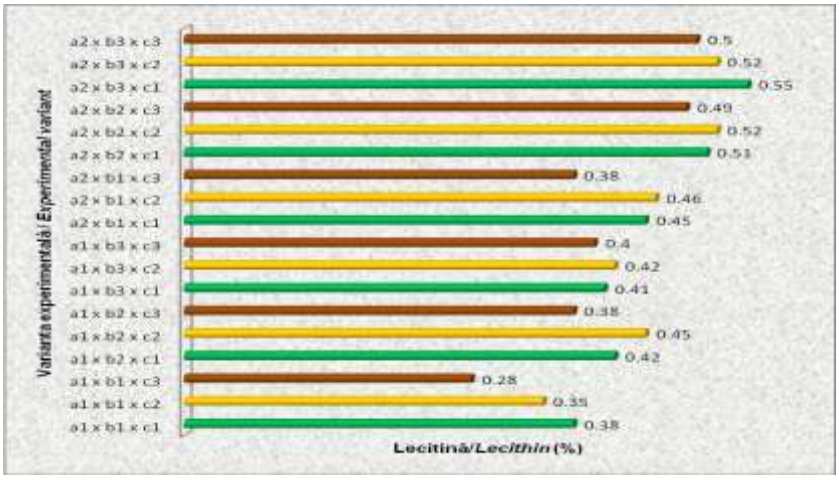

Figure 1. Lecithin content (%) of soybean, recorded in the conditions of Viişoara – Turda

Results on the amino acid content in soybeans, in the Viişoara – Turda area conditions

Soy is the plant that provides proteins that contain all the essential amino acids, which makes extremely necessary their determination in order to characterize the quality of the soybean crop production. The results regarding the DL alanine content in the soybean culture are shown in Figure 2.

For this experiment, the variant made with graduations a_1 x b_1 x c_1 was chosen as control. The content of the DL alanine in the control variant was 3.13 x 10^4 mg/kg. The application of irrigation and fertilization during the crop's growth led to an increased content of this amino acid; thus, in non-irrigation conditions, the highest value was obtained with graduation a_2 x b_2 x c_1 – 3.33 x 10^4 mg/kg. The content of DL alanine varied from 4.15 x 10^4 mg/kg (in the control variant a_1 x b_1 x c_2) to 4.21 x 10^4 mg/kg in the case of b_2 fertilization, both under non-irrigation conditions. If the application of irrigation and fertilization was simultaneous, DL alanine content varied from 4.28 x 10^4 mg/kg (in the variant a_2 x b_1 x c_2), to the highest value for a_2 x b_2 x c_2 (4.39 x 10^4 mg/kg).

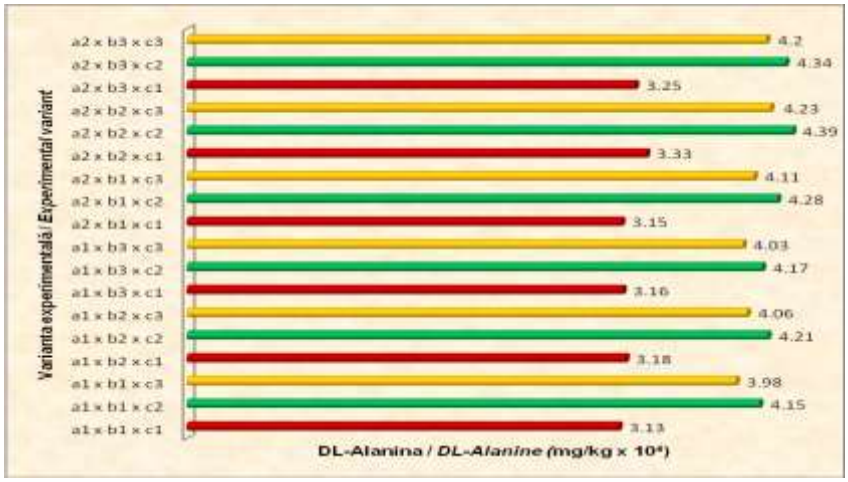

Figure 2. DL alanine content in soybeans, recorded in the conditions of Viişoara – Turda

Compared to the control variant a_1 x b_1 x c_3, with a content of 3.98 x 10^4 mg/kg, the highest value of this amino acid for the variety Felix was recorded for the experimental variant a_2 x b_2 x c_3 – 4.23 x 10^4 mg/kg.

Figure 3 shows the results obtained for the determination of DL tyrosine in the soybeans grains. For the Onix variety, a content of 1.32 x 10^4 mg/kg DL tyrosine for the chosen control variant (graduation a_1 x b_1 x c_1) was determined. The application of irrigation and fertilization determined variations of this parameter, recording the highest value for experimental variation a_2 x b_2 x c_1 – 1.49 x 10^4 mg/kg, meaning an increased percentage of 12.9%. Compared to the control value recorded in the experiment, graduation a_1 x b_1 x c_2 – 2.35 x 10^4 mg/kg, irrigation and fertilization applied during the growing season resulted in an increase of 14.1% (graduation a_2 x b_2 x c_2 – 2.68 x 10^4 mg/kg).

The control variety had a similar pattern with the Onix variety, not registering differences between values obtained in DL tyrosine. Under non-irrigation conditions, but under application of fertilization (with the two graduations), DL tyrosine ranged from 2.55 x 10^4 mg/kg (a_1 x b_1 x c_3 - control) to 2.63 x 10^4 mg/kg (a_1 x b_2 x c_3). Application of irrigation leads to higher values of this amino acid. Values in the range 2.59 x 10^4 mg/kg (a_2 x b_1 x c_3) – 2.68 x 10^4 mg/kg (a_2 x b_2 x c_3) were obtained.

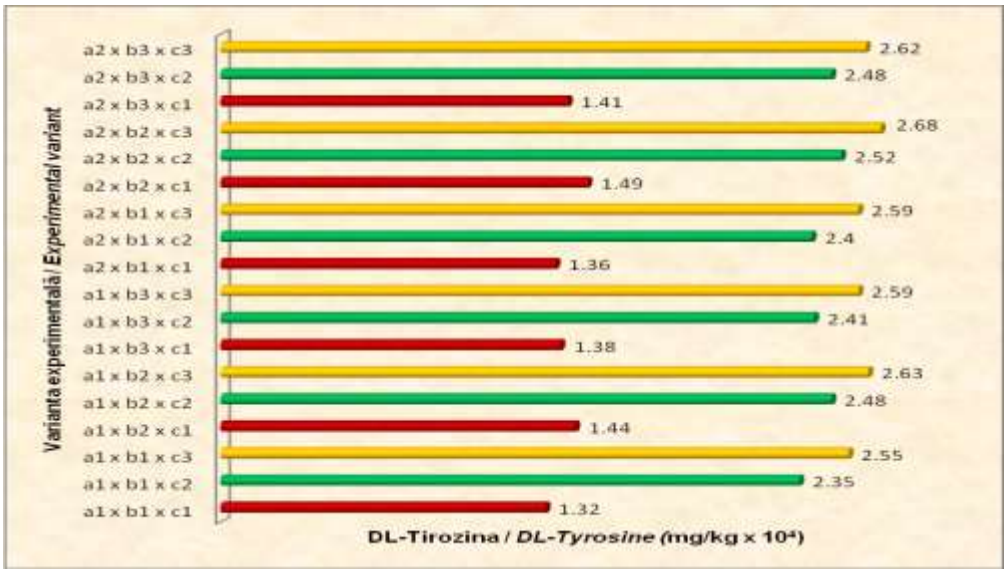

Figure 3. DL tyrosine content in soybeans, recorded in the conditions of Viişoara – Turda

The results registered in the DL histidine content in the soybean for variants tested under the conditions of Viişoara – Turda are graphically shown in Figure 4.

DL histidine content in the grains of Onix variety recorded a value of 0.29 x 10^4 mg/kg for the control variant a_1 x b_1 x c_1. Through irrigation and fertilization during the growing season, a higher content of this amino acid was obtained. The best results were obtained for the variants a_1 x b_2 x c_1 – 0.38 x 10^4 mg/kg (increase of 31.0%) and, respectively, a_2 x b_2 x c_1 – 0.42 x 10^4 mg/kg (an increase of 44.8%).

Compared to the control variant a_1 x b_1 x c_2, through irrigation and fertilization, significant variations in the DL histidine content were obtained. The variations were in the range of 0.85 x 10^4 mg/kg (control) and 0.95 x 10^4 mg/kg (a_2 x b_2 x c_2), meaning an increase of 11.8%.

Felix variety had a similar behaviour as Eugen variety, with small variations of the registered values. Thus, for the control variant (a_1 x b_1 x c_3), a value of 0.77 x 10^4 mg/kg was recorded, the highest value being obtained for graduation a_2 x b_2 x c_3 – 0.86 x 10^4 mg/kg, meaning an increase percentage of 11.6%.

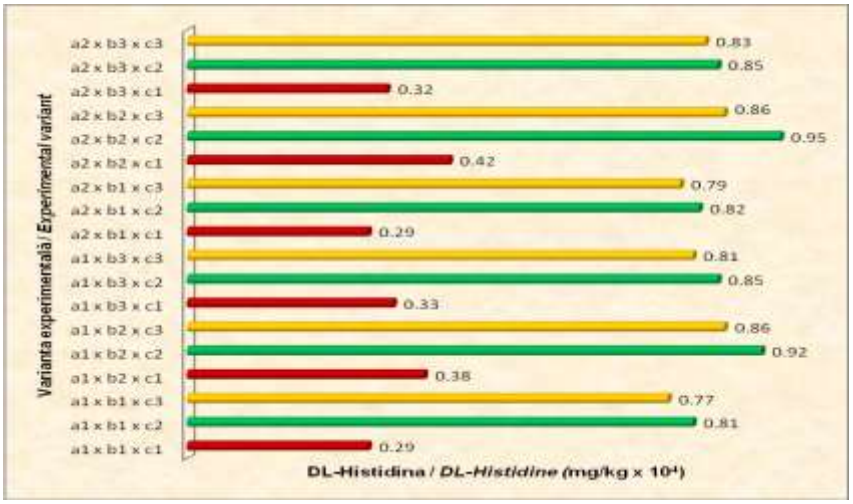

Figure 4. DL histidine content in soybeans, recorded in the conditions of Viişoara – Turda

Figure 5 shows the results recorded on the content of glutamic acid determined in soybeans in the Viişoara – Turda area.

The Onix variety recorded, for the control variant (a_1 x b_1 x c_1), a glutamic acid content of 6.01 x 10^4 mg/kg. Through crop irrigation and fertilization, this parameter registered a slight increase, the best results being obtained for the experimental variant a_2 x b_2 x c_1 – 6.11 x 10^4 mg/kg, meaning an increase of 1.7%. As compared to the defined control variant, a_1 x b_1 x c_2 (21.58 x 10^4 mg/kg), Eugen variety had an increase of the glutamic acid content for the experimental variant a_2 x b_2 x c_2 (21.78 x 10^4 mg/kg), considered as the optimal one among the experimental variants.

As compared to the control variant (a_1 x b_1 x c_3 – 23.68 x 10^4 mg/kg), Felix variety presented a similar pattern with Eugen variety. The best results were achieved by graduation a_2 x b_2 x c_3 – 23.82 x 10^4 mg/kg, obtained by irrigation and fertilization of the b_2 type crop.

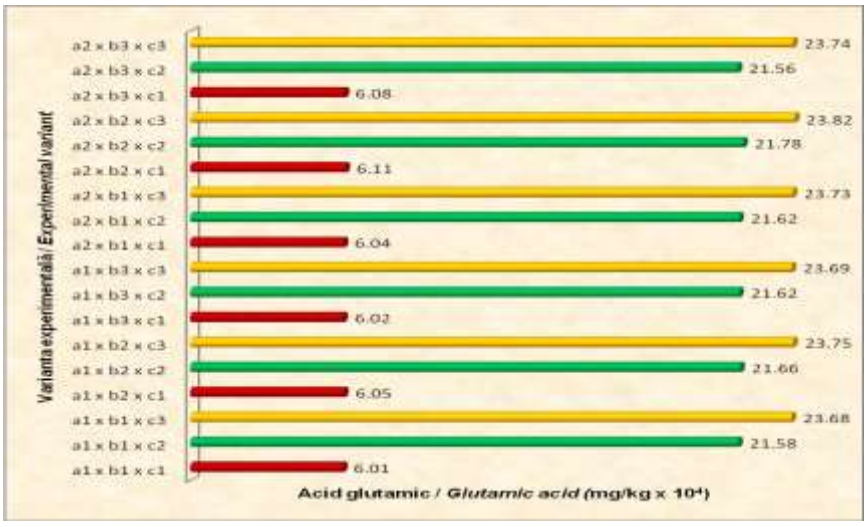

Figure 5. Glutamic acid content in soybeans, recorded in the conditions of Viişoara – Turda

Figure 6 shows the results recorded on the content of DL phenylalanine, determined in the soybeans of the culture carried out in conditions of Viişoara – Turda area.

As compared to the selected control variant, the graduation a_1 x b_1 x c_1 containing 1.48 x 10^4 mg/kg, the irrigation and fertilization of the crop determined an increase of the DL phenylalanine amino acid. The best results were achieved by the experimental variants a_1 x b_2 x c_1 – 1.54 x 10^4 mg/kg (4.1%) and a_2 x b_2 x c_1 – 1.61 x 10^4 mg/kg (8.8%). As compared to the control variant (a_1 x b_1 x c_2 – 5.66 x 10^4 mg/kg), the

irrigation and fertilization led to obtaining higher values of the DL phenylalanine content. The best result was given by the a_2 x b_2 x c_2 variant - 5.68 x 10^4 mg/kg.

The irrigation and fertilization applied during the growing season determined an increase in the content of DL phenylalanine, as compared to the control variant (a_1 x b_1 x c_2), from 6.21 x 10^4 mg/kg to 6.28 x 10^4 mg/kg (a_2 x b_2 x c_3). The two varieties, Felix and Eugen, had a similar behaviour.

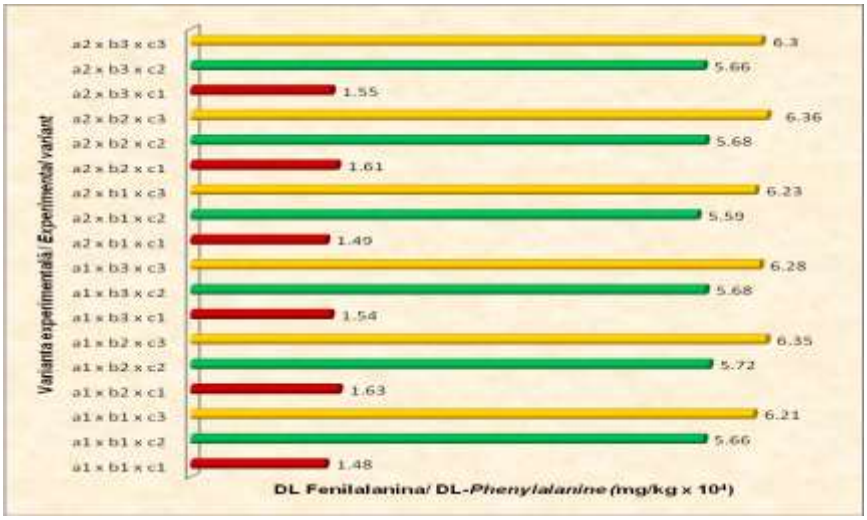

Figure 6. DL phenylalanine content in soybean, recorded in the conditions of Viişoara – Turda

The results obtained on the content of aspartic acid the conditions of Viişoara – Turda, are presented in Figure 7.

Considering as control the experimental variant the graduation a_1 x b_1 x c_1, with 1.62 x 10^4 mg/kg aspartic acid value, through irrigation and fertilization applied to the crop, variations of the contents of this amino acid were registered. Thus, under non-irrigation conditions, but applying type b_2 (a_1 x b_2 x c_1) fertilization, a content of 1.69 x 10^4 mg/kg was registered.

Compared to the control a_1 x b_1 x c_2 (5.29 x 10^4 mg/kg), the application of irrigation and fertilization led to small increases in the content of this amino acid, the highest value recorded being 5.39 x 10^4 mg/kg, obtained with graduation a_2 x b_2 x c_2.

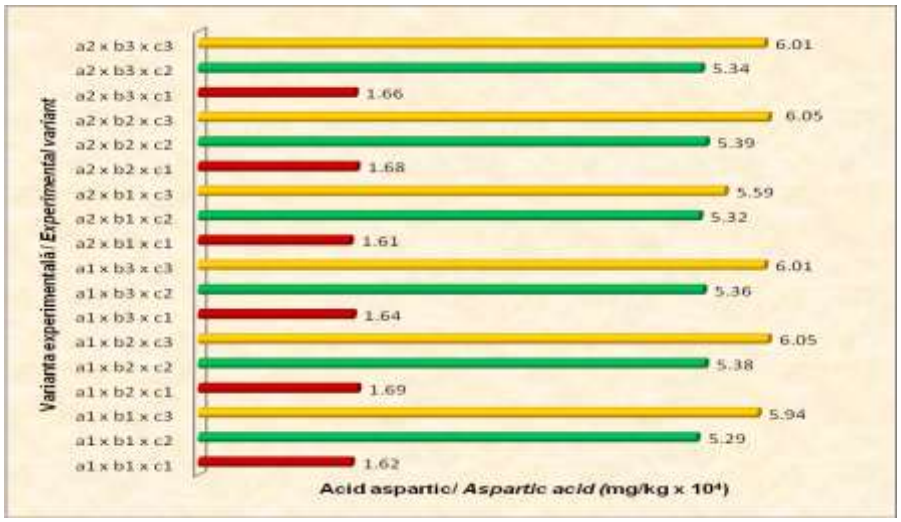

Figure 7. Aspartic acid content in soybeans, recorded in the conditions of Viişoara – Turda

Felix variety had a behaviour similar with Eugen variety. As compared with the control variant (5.94 x 10^4 mg/kg), the highest value was 6.05 x 10^4 mg/kg, determined by the application of the b_2 type fertilization, under irrigation and non-irrigation conditions.

Figure 8 shows the values obtained for the glycine content in soybeans, determined under Viişoara – Turda area conditions. Considering as control the experimental variant with the graduation a_1 x b_1 x c_1 that had a determined glycine content of 0.14 x 10^4 mg/kg, the application of fertilization and irrigation determined higher values of this amino acid. The highest recorded values were 0.29 x 10^4 mg/kg (a_1 x b_2 x c_1) and 0.23 x 10^4 mg/kg (a_2 x b_2 x c_1). Irrigation and fertilization applied on the soybean crop of Eugen variety led to an increased glycine content. Eugen variety registered variations on the glycine content in the range of 0.21 x 10^4 mg/kg (control variant (a_1 x b_1 x c_2) to 0.29 x 10^4 mg/kg (a_1 x b_2 x c_2), under non-irrigation conditions, but with applied fertilizer, and from 0.16 x 10^4 mg/kg (a_2 x b_1 x c_2) to 0.29 x 10^4 mg/kg (a_2 x b_2 x c_2), under irrigation, by applying fertilizer.

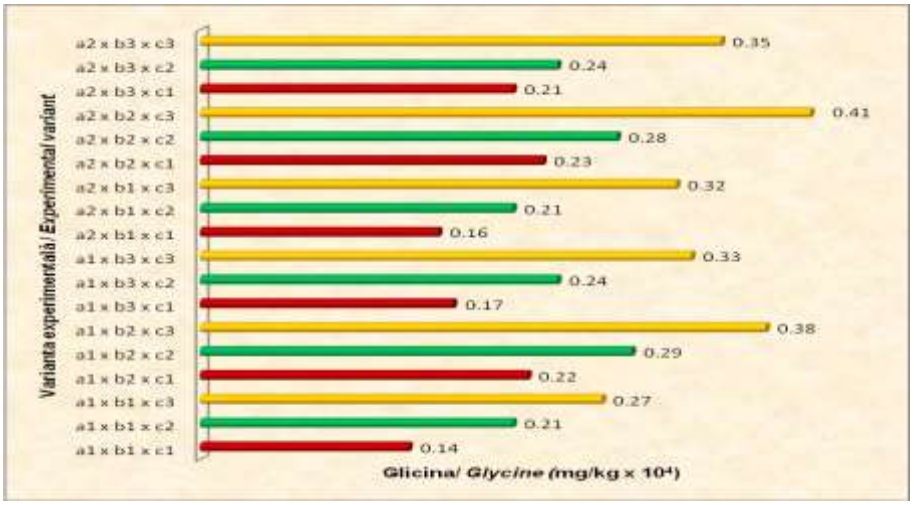

Figure 8. Glycine content in soybeans, recorded in the conditions of Viişoara – Turda

In the variety Felix, as compared to the control variant (a_1 x b_1 x c_3 – 0.27 x 10^4 mg/kg), irrigation and fertilization led to an increase of the parameter, the highest obtained value being registered by the variant a_2 x b_2 x c_3 – 0.41 x 10^4 mg/kg.

CONCLUSIONS

Considering as control the grain yield achieved in the experimental variant a_1 x b_1 x c_1 containing 0.38% lecithin, the best result was obtained for the experimental variant a_2 x b_3 x c_1 –lecithin content of 0.55 %, which represents a relative increase of 44.7%.

As for Felix variety, considering as control the experimental variant a_1 x b_1 x c_3 (0.28%), through irrigation and applied fertilization, in the experimental variant a_1 x b_3 x c_3 (0.50%), a lecithin content increase of 78.5% was recorded, recommending this as the best option for Felix variety.

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