Current Trends in Natural Sciences
Vol. 11, Issue 22, pp. 320-327, 2022
https://doi.org/10.47068/ctns.2022.v11i22.037
Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521
Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

THE INFLUENCE OF THE APPLICATION OF SOME NEW TYPES OF CALCAREOUS AMENDMENTS ON SOYBEAN PRODUCTION AND QUALITY, IN THE CONDITIONS OF SCDA PITEȘTI IN 2021

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Current Trends in Natural Sciences

Abstract
Given the importance of soybeans, both in our country and in the world, it is necessary to expand the areas in different environment. In the conditions of the clay-illuvial soils of the station, the promotion of soybeans involves first of all the restoration of the culture medium and the chemical properties, considering the acid reaction which is totally unsuitable for the roots of the plant. To this end, an experience has been set up to promote the latest amendments based on calcium carbonate approved by us. Thus, the experiment promoted agrocalcium products - based only on $CaCO_3$ and doloflor with $CaCO_3$ and MgO (magnesium oxide). From the obtained results it was found that compared to the unfertilized control, the soybean plants produced total biomass of 9-11 t/ha, the biomass of the pods between 5,5-7,4 t/ha (over 60%) and the biomass of the grains between 3- 4,3 t/ha (over 30%). From a qualitative point of view, the Raluca TD soybean variety contained in the grains 36% protein, 25% oil, 6% fiber at a grain humidity of less than 10%. The data obtained showed a good adaptability of the new soybean variety in the conditions of the station.

Keywords: $CaCO_3$, correlations, plant biomasses, soybean.

1. INTRODUCTION

Soybean (*Glycine max*. (L) Merril pro syn. G. *angustifolia* Miq., G. *gracilis* Skvort, G. *hispida* (Moench) Maxim) (Hymowitz & Newell, 1981) is one of the most important protein and oil plants (Corke & Wrigley, 2004) at the global level (Conner et al., 2004).

Known for a very long time (Mureșeanu & Cătinaș, 1994; Mureșeanu et all, 1999), soybean has outstanding agronomic and culinary qualities (Endres, 2001; Heuzé et all, 2017; Hu et all, 2019). Thus, the plant has active ingredients, mainly protein (36%) and vegetable oil (20%) in the largest quantities compared to other crops. The difference of 44% is represented by carbohydrates (30%), water (9%) and ash (5%). At the same time, soybeans contain significant amounts of phytic acid, a wide range of minerals (iodine, calcium, iron, and potassium), B vitamins (B1 - thiamine, B2 - riboflavin, B6 - pyridoxine), and enzymes (lipoxidase, urease, lipases, amylase). The quality and stability of soybean oil is mainly determined by five predominant fats, namely acids: palmitic, stearic, oleic, linoleic and linolenic. Thus, the plant, in a relatively long period of vegetation fixes atmospheric nitrogen (N_2) (a feature common to all species of the family *Fabaceae*), structures and enriches the soil in nitrates (NO_3^-), directly assimilable and ensures adequate crop rotation. Atmospheric nitrogen fixation is based on the activity of symbiotic bacteria of the *Bradyrhizobium*

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type, with which N_2 is converted into ammonia, by a path of the type: a) $N_2 + 8H^+ + 8e = 2NH_3 + H_2$ and then in assimilable form expressed by the ion of ammonium; b) $NH_3 + H^+ = NH_4^+$. In nodules the bacterium produces amino acids with which proteins are formed. After harvesting the plants, the remaining nodules in the soil decompose, and the accumulated amino acids are also converted biologically into nitrates (NO_3^-). They become available for wheat plants, which usually follow in crop rotation.

In order for the plant to be able to capitalize on its genetic potential, it needs precipitation in larger quantities, especially when filling the grain. That is why in favorable years, the plants ensure their need for rainwater, and in other situations, the level of production is decreasing.

Raluca TD is a semi-early variety (maturity group 0) registered in 2019 at S.C.D.A. Turda. The plant has a medium height (76-116 cm), insertion height (14-26 cm), semi-erect port, compact bush, reddish pubescence. The leaf is medium green with sharp oval leaflets, purple flowers. The bean has a flattened spherical shape, yellow color, dark brown hilum. It has very good resistance to falling, shaking, manna (*Peronospora manshurica*), bacterial burn (*Pseudomonas glycinea*), the common red spider (*Tetranychus urticae*) and good resistance to white rot of the stem (*Sclerotinia sclerotionum*).

From a genetic point of view (Mureșeanu et all, 2016), soybeans show a high polymorphism. Of these, *Glycine max* (L.) Merril has a characteristic of 2n = 2x = 40.

From a botanical point of view, soybeans produce 2-4 grains in the pod, rarely more, these having a globular shape, 5-11 mm in diameter, and the colors have various shades between green, yellow, brown and black.

Calcium carbonate is the salt of calcium and carbonic acid, being a white solid with the chemical formula $CaCO_3$. Ca's nature reserves originate in a multitude of minerals and rocks, the decomposition of which is relatively complex. In the case of white luvosoil there is a dynamic equilibrium between the Ca forms, equilibrium constantly shifted either towards or adsorption of clay particles, or for consumption by plants and leaching. However, the absolute amounts of Ca in luvosoil are insufficient for plant growth. The calcium here is unable to contribute to and maintain proper degrees of base saturation of soil colloids. Under these conditions, exchangeable Al^{3+} ions dominate the clay exchange sites, contributing to the excessive acidity of the soil, which results in soluble Al^{3+}, which is toxic to most plants. Calcite (dolomitic) amendments are administered to correct the Ca deficiency. Calcification reduces the activity or solubility of aluminum (Al) and manganese (Mn), increasing the pH which has a positive effect on the amount of nitrogen released into the soil. Soil treatment with amendments also becomes a larger reservoir for essential plant nutrients, allowing a smaller amount of fertilizer to be used.

For the study of the variability of some morphological characters for the new cultivated soybean varieties, the following were determined: plant biomass, pod biomass, grain biomass and Mass of one Thousand Grains (MTG).

2. MATERIALS AND METHODS

This paper presents data obtained in 2021, in the pedoclimatic conditions of the station, located in the High Plain of Pitesti. The soil in which the experimental field was located is a stagnant white luvosoil, with an acidic pH (5.3), a clay structure (clay content below 30%), poorly supplied with nitrogen (Nt = 0.130%) and phosphorus (P = 33 mg/kg), moderately supplied with potassium (K = 89 mg/kg) and a humus content in the arable horizon of 2.26%. The Raluca TD soybean variety was grown in non-irrigated crops. The cultivation technology used was the one recommended by the

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station. The culture was placed in the experimental field according to the method of subdivided plots into 3 repetitions. The surface of the variant was 40 m² (5 m long x 8 m wide).
The experimental factors are as follows:
- A factor with graduations: A1 – control without $CaCO_3$;
  A2 – Powder of the Agrocalcium 2.5t/ha;
  A3 – Powder of the Doloflor 2.5 t/ha;
  A4 – Granules of the Doloflor 2.5 t/ha;
- B factor with graduations: B1 – unfertilized;
  B2 – chemically fertilized ($N_{40}P_{40}$);
  B3 – chemically fertilized ($N_{80}P_{80}$).

The product Agrocalcium had a content of 93% $CaCO_3$, and the product Doloflor had a content of 65% $CaCO_3$ and 31-32% MgO.
The following biometric determinations were made on soybean plants:
- total biomass (or total s.u.)
- pod biomass
- grain biomass
- Mass of a Thousand Grains (MTG).

Regarding the quality indices of the grains, we analyzed the following parameters:
- crude protein (%)
- oil (%)
- fiber (%)
- moisture (%)

The quality analysis of soybeans was performed using the Infracmatic IM 9500 Plus analyzer. The data obtained were statistically processed by analyzing the variance (Anova test) and by studying the correlations expressed by Excel graphs. For the data obtained, the variability coefficients were also calculated.

3. RESULTS AND DISCUSSIONS

1. The influence of climatic factors on soybean products

In terms of climate, S.C.D.A. Pitesti is located in a temperate-continental climate zone. Temperatures and rainfall recorded between March and September 2021 show influence of environmental factors on soybean plants.
The climatic conditions during the experimentation period (figure 1 and figure 2) were different, both in terms of the min of temperatures, and also of the amounts of precipitation recorded from one month to another. There were periods with temperatures above the multiannual average (June, July, August and September) and precipitation amounts above the multiannual average (March and May).
In the first period of vegetation, the temperatures were close to normal, after which in the summer the monthly values exceeded by 2-3ºC, over normal. During the soybean vegetation period, it accumulated 1509.3ºC active temperatures (Σtn> 10ºC) and 2949.3ºC active temperatures (Σtn> 0ºC).
In the precipitation regime, it was found that in the first period of March the values were almost double compared to normal, which contributed to the increase of the water supply in the soil. Under these conditions, the plants sprouted and went through the first phenophases very well. It was followed by 2 months of rainfall close to normal and in June there was an excess of rain. Very favorable conditions were found for this period, namely for flowering and the formation of the first

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pods. In the summer months and the beginning of autumn, the water deficit from precipitation was permanently accentuated until the end of the vegetation period. Against this dry background it was found that the last flowers on the top of the plants aborted and the youngest pods no longer formed berries. During the bean filling period, the plants did not benefit from sufficient rainfall due to drought. However, the water supply in the soil, which is favorable for the growth and development of soybean plants, has ensured average to good yields.

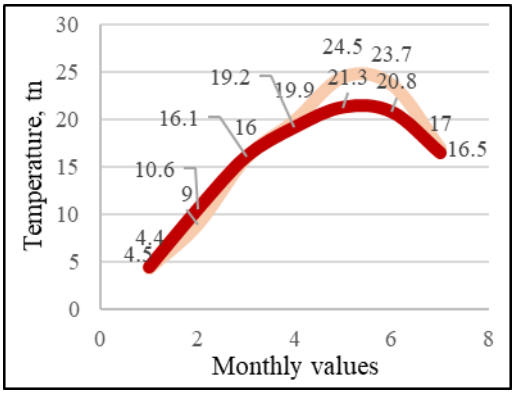

Figure 1 - Thermal regime in soybean crop

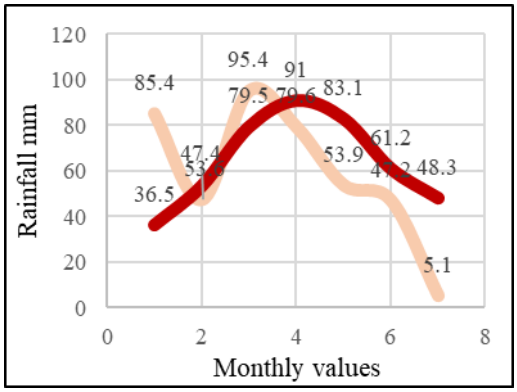

Figure 2 - The rainfall regime in soybean cultivation

1-March; 2-April; 3-May; 4-June; 5-July; 6-August; 7-September

2. Soybean plant biomass structure

The experiment included grouped variants in the experimental system with subdivided plot, so we will analyze each factor in turn and their interaction.

Regarding factor A (types of amendments), it had total biomass productions between 10.19 t/ha and 10.95 t/ha, without statistical differentiation (table 1). Pod biomass was between 6.56 t/ha and 7.01 t/ha, also with insignificant differences between variants. However, the variant with Doloflor granules was noted, with an increase in pod biomass of 0.45 t/ha. The average of grain production was between 3.44 t/ha and 4.16 t/ha. There were no significant differences between the variants. On the other hand, in the product of Doloflor granules, 0.72 t/ha of grains were formed in addition to the other variants. From the analysis of the Mass of one Thousand Grains (MTG), the values obtained ranged between the limits of 118.44 g in the control and 123.44 g in the case of the product Agrocalcium powder. The difference is close to the lower limit of significance. Of the total soybean plant biomass obtained according to the type of amendment, pods accounted for between 61.64% and 64.37% percentages, considered important for the crop area. Grain biomass (production) represented from the total soybean biomass between 33.48% in the control version and 37.99% in the version with Doloflor granules. Considering the analysis of A factor, it was found that the Raluca TD soybean variety produced an average biomass of 10.68 t/ha, of which 6.75 t/ha represented the pods (63.23%) and the grains 3, 77 t/ha, namely 35.29%.

Regarding chemical fertilization (B factor), it was found that between the three levels of the total biomass of the plants was obtained over 10 t/ha, with very small and insignificant differentiations (table 2). The production of pods was between 6.58 t/ha and 6.90 t/ha with maximum differences of 0.32 t/ha without statistical assurance. The grain production was between 3.71 t/ha in the control variant and 3.78-3.83 t/ha in the chemically fertilized variants. There were no significant differences

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between variants. Mass of one Thousand Grains (MTG) had very good average values, namely between 115.83 g and 121.25 g. There were no significant differences between the variants.

Table 1. Influence of the type of amendment (A factor) on soybean yield

A factor	Plant biomass, t/ha	%	Pods biomass, t/ha	%	Grain biomass, t/ha	%	MTG, gr
Check plot	10.69	100.00	6.59	61.64	3.58	33.48	118.44
Powder of the Agrocalcium	10.90	100.00	6.86	62.93	3.92	35.96	123.44
Powder of the Doloflor	10.19	100.00	6.56	64.37	3.44	33.75	112.55
Granules of the Doloflor	10.95	100.00	7.01	64.01	4.16	37.99	121.33
LSD 5% *LSD 1%* *LSD 0,1%*	*1.370* *2.075* *3.337*		*1.321* *2.001* *3.217*		*0.807* *1.223* *1.966*		*5.628* *8.526* *13.705*

Table 2. The influence of chemical fertilization (B factor) on soybean yield

B factor	Plant biomass, t/ha	%	Pods biomass, t/ha	%	Grain biomass, t/ha	%	MTG, gr
Check plot	10.68	100.00	6.79	63.57	3.71	34.73	121.25
$N_{40}P_{40}$	10.85	100.00	6.90	63.59	3.83	35.29	119.75
$N_{80}P_{80}$	10.51	100.00	6.58	62.60	3.78	35.96	115.83
LSD 5% *LSD 1%* *LSD 0.1%*	*1.950* *2.687* *3.693*		*1.420* *1.957* *2.690*		*0.848* *1.168* *1.606*		*8.670* *11.946* *16.421*

The interaction of the two factors (table 3) showed that the total biomass production was between 9.44 t/ha and 11.67 t/ha. No significant differences were found between the values obtained.
The biomass of pods formed was between 5.56 t/ha and 7.52 t/ha, and the differences were also insignificant (table 3). In terms of percentage, the pods represented between 58.58% in the control and 65.92% in the variant only with powder of the Agrocalcium. Grain production was between 2.97 t/ha and 4.26 t/ha, also with no differences. In terms of percentage, the grains represented between 31.29% in the control and 38.9% in the case of the granules of the Doloflor amendment. The Mass of one Thousand Grains (MTG) was between 110.67 g and 128 g with slight significant differences. On the whole experiment, the biomass of soybean plants produced on average 10.68 t/ha, of which 6.75 t/ha represented pods (63.20%), grains 3.77 t/ha (35.32%). From the data it is observed that the Raluca TD variety cultivated in the experiment had high levels of production in all 3 components, which demonstrated a good adaptability in the station.
Statistical indices were obtained by processing strings according to the formula $1/n-1*[(\Sigma x^2)-\Sigma x^2/n]$ (table 4). Thus, the average protein content was 35.5 with a variability of 3.75%. The oil content averaged 25.1 with a variability of 1.09%. These data show that the Raluca TD variety grown in the experiment had active content (protein and oil) at a good to very good level. Also, the moisture content of 8.5% with a variability of 2.18% shows that soybeans have been harvested at full maturity.

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Table 3. The interaction between amendment and chemical fetilization over soybean yield

A factor	B factor	Plant biomass, t/ha	%	Pods biomass, t/ha	%	Grain biomass, t/ha	%	MTG, gr
Check plot	0	9.49	100.00	5.56	58.58	2.97	31.29	117.33
	$N_{40}P_{40}$	11.67	100.00	7.52	64.43	4.10	35.13	124.67
	$N_{80}P_{80}$	10.93	100.00	6.69	61.20	3.68	33.66	113.33
Powder of the Agrocalcium	0	10.80	100.00	7.12	65.92	4.11	38.05	128.00
	$N_{40}P_{40}$	10.97	100.00	6.76	61.62	3.71	33.81	122.67
	$N_{80}P_{80}$	10.95	100.00	6.71	61.27	3.94	35.98	119.67
Powder of the Doloflor	0	11.51	100.00	7.37	64.03	3.52	30.58	116.00
	$N_{40}P_{40}$	9.63	100.00	6.13	63.65	3.35	34.78	111.00
	$N_{80}P_{80}$	9.44	100.00	6.19	65.57	3.46	36.65	110.67
Granules of the Doloflor	0	10.95	100.00	7.12	65.02	4.26	38.90	123.67
	$N_{40}P_{40}$	11.16	100.00	7.19	64.42	4.18	37.45	120.67
	$N_{80}P_{80}$	10.75	100.00	6.75	62.79	4.05	37.67	119.67
Mean		10.68	-	6.75	63.20	3.77	35.32	118.93
LSD 5% *LSD 1%* *LSD 0.1%*		*3.168* *4.464* *6.388*		*2.506* *3.567* *5.198*		*1.532* *2.183* *3.188*		*13.715* *19.278* *27.461*

Table 4. Statistical indices obtained in the analysis of grain quality

Statistical indices	Determined characteristics			
	Protein	Oil	Fiber	Moisture
Mean, $\bar{x}$	35.5	25.1	5.8	8.5
Variance, s^2	0.70	0.07	0.01	0.10
Standard deviation, s	0.84	0.27	0.12	0.31
LSD 5% *LSD 1%* *LSD 0.1%*	*1.848* *2.609* *3.727*	*0.594* *0.838* *1.197*	*0.264* *0.372* *0.532*	*0.682* *0.962* *1.375*
Coefficient of variation, CV %	3.75	1.09	2.37	2.18

3. Correlations between the soybean characters

The correlations were obtained from the average values on each repetition. The correlation between plant weight and pod weight is very significant positive and this shows that in the conditions in which 10.7 t/ha of total biomass were produced, of which the biomass of pods represented 6.75 t/ha on average (figure 3). Similarly, it can be expressed in the correlation between the total biomass and the grain biomass formed (3.77 t/ha on average) (figure 4).

A positive but less increasing correlation was obtained between total biomass and MTG, given that soybeans have a more stable grain weight character. This is the genetic characteristic of the plant at the moment when it insures its descendants (figure 5). The correlation between pod weight and grain weight is as high (very significant positive) as in previous biomass correlations (figure 6).

And in these two correlations the results are very significant positive, given the MTG character which is less changeable (figure 7 and figure 8).

All correlations between the production elements are very significant positive, which means that the Raluca TD variety expressed high values in the experiment (table 5). The data show that this variety has shown adaptability characteristics in the conditions of the station.

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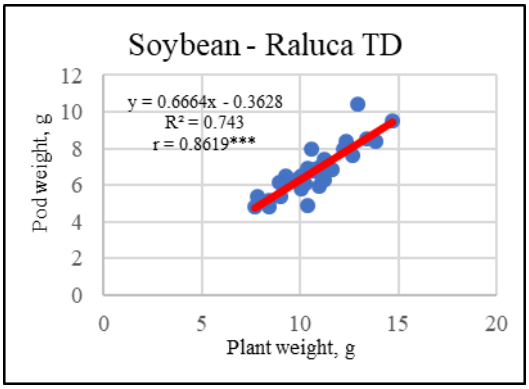

Figure 3 - Correlation between plant weight and pod weight

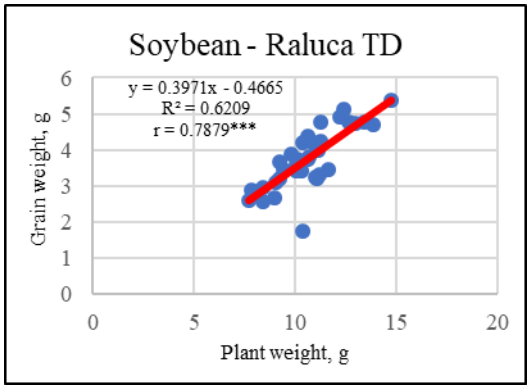

Figure 4 - Correlation between plant weight and grain weight

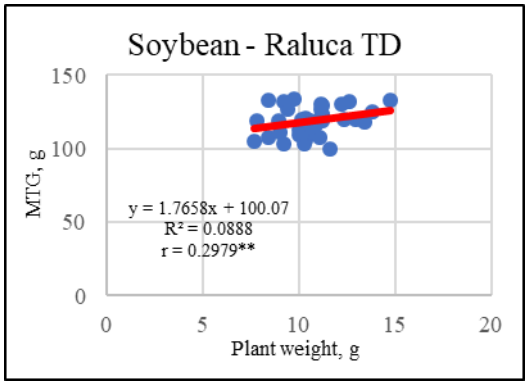

Figure 5 - Correlation between plant weight and MTG

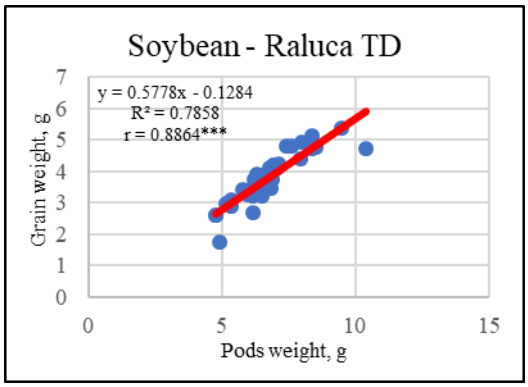

Figure 6 - Correlation between pod weight and grain weight

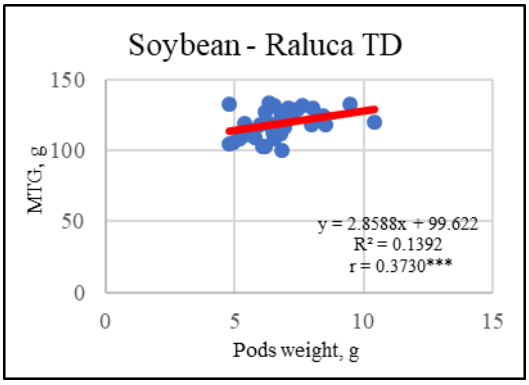

Figure 7 - Correlation between pod weight and MTG

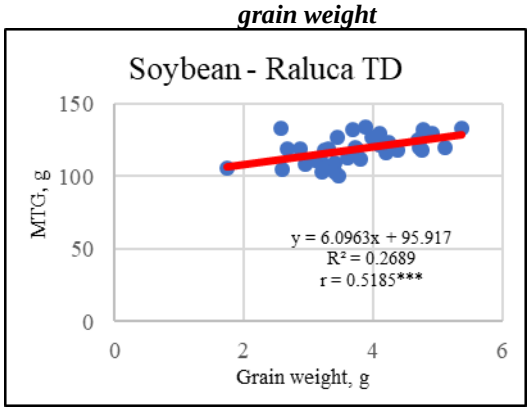

Figure 8 - Correlation between grain weight and MTG

Table 5. Correlations or connections between determined characters

	Plant weight, gr	Pods weight, gr	Grain weight, gr	MTG, gr
Plant weight, gr	1	0.8619***	0.7879***	0.2979**
Pods weight, gr		1	0.8864***	0.3730***
Grain weight, gr			1	0.5185***
MTG, gr				1
LSD 5% = 0.190	LSD 1% = 0.250		LSD 0.1% = 0.320	

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4. CONCLUSIONS

Given the expansion of soybean crop in our country, we need to promote the latest genetic creations with high production potential and increased adaptability. However, in the conditions of acidic soils in the station, it is necessary to correct the acidic reaction of the soil, so that the plants develop their root system in the best possible (optimal) conditions. From the data obtained, the Raluca TD variety showed that in the variants with types of calcareous amendments, the soil was improved and thus the plants responded very favorably to the culture medium in which the acid reaction was corrected. Biomass production in variants is considered good. Thus, the total soybean biomass increased from 9.5 t/ha in the control variant to 11.67 t/ha in a chemically fertilized variant.

The pod biomass was between 5.56 t/ha and 7.52 t/ha and the grain biomass was between 2.9 t/ha and 4.18 t/ha. The distribution of biomass formed showed a proportion of 65% - 66% in the case of pods and between 33% - 39% in the case of grains. At the same time, the Mass of one Thousand Grains (MTG) was relatively high for the growing conditions created (113 g and 128 g).

The correlations obtained between the production elements were all very significant positive. At the same time, there were favorable elements for the quality of the grains, made up of 35% - 36% protein, 25% - 26% oil, 5% - 6% fiber and 8% - 9% moisture.

From this practical point of view, the experiment showed that soybeans for grains can also show an increased adaptability to the conditions in the station.

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