Research Regarding the Chemical Fertilizers Effects on Physiological Indices and Protein at Soybean (*Glycine max L. Merr.*)

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Abstract
In this experiment we studied the influence of chemical fertilizers on physiological indices and the amount of protein in two soybean varieties, Atlas and Hodgson. Researches has been carried out between 2017-2019 at Didactic Station of BUASMV Timișoara with different doses of chemical fertilizers. Observations and measurements were made on plant physiology and yield characteristics. The process of accumulation of dry substances in different organs of the plant during the vegetation period is dependent to the effectiveness of fertilization. The dynamics of the total water content in the plant and especially its modification under the influence of chemical fertilizers is of interest for the appreciation of the process of formation of dry substances, respectively of agricultural harvest. In both varieties between the experimental and the control variant, significant differences appeared in all followed indicators, the most favorable variant being \( N_{45}P_{63}K_{45} \).

Superior results were registered at Atlas, better adapted to the ecological conditions of the reference area. Fertilizers are decisive factors in the increase of yield and the quantity of protein, although this plant has the capacity to supply some of the necessary nitrogen with bacterial symbionts. High doses of phosphorus did not produce higher yields compared to moderate ones.

Keywords: leaf area, dry matter, soybean, plant height

Introduction
One of the most important cultures for the mankind due to its high content in protein substances is considered the soybean culture which contains over 40% and 17-25% oil. The soybean culture gained an important position among the most important cultures through its nutritive value (Hartman et al., 2011). The soybean culture playing also an important role in culture rotation and it can be used as source of oils, as forage, protein source and row matter for a series of industries (Dobrei et al, 2004; Mahna, 2005).

Soybean is traditionally cultivated in calcareous soils in arid and semi-arid regions, being one of the most important leguminous crops for human nutrition; the agronomical importance of soybean (*Glycine max L.*) is linked to its high protein content (25%-29%). Soybean seeds are a
source of protein and oil for human nutrition and a source of soybean meal for livestock feed. In 2006 and 2007 the soybean protein meal and soybean oil accounted for 69% and 30% of the world’s supply of protein meal and edible oil (Dalshad et al., 2013).

Since the earliest practice of agriculture the leguminous have been consumed by humans and have been used both for their medicinal, cultural as well as nutritional properties, providing an important source of protein and oil, which can also be converted into bio-diesel (Libault et al., 2010). Legumes and cereals are the two most important plant foods to human’s (Graham and Vance, 2003), within Glycine max L. is the highest produced leguminous crop. The major contributor to the world’s food supply is the soybean crop (Kumagai and Sameshima, 2014; Janagard et al., 2013). Besides the importance, there are many factors that influence seed physiological potential of soybeans such as vigor and germination (viability) which are the theoretical capacity of seeds to express their vital functions under both favorable and unfavorable environmental conditions (Filho, 2015; Lee et al., 2013). Soybean growth, development and yield depend on genetic potential of a cultivar and its interaction with the environment (Carvalho et al., 2017; Souza et al., 2015).

For many years soybean has been a valuable crop plant, due to the high nutritional value of its beans. However, it is characterized by unstable and variable yields, due to its diverse climatic requirements (Cho et al., 2002; Von Richthofen, 2006a; Von Richthofen, 2006b). During the growing season, physiological processes occurring in the plant may have a considerable influence on plant productivity (Amanullah et al., 2011; Thompson et al., 1995).

This research was conducted to investigate the influence of different doses of chemical fertilizers on some soybean physiological indices.

**Materials and methods**

Researches were carried out within 2017-2019. The biological material tested was represented by two varieties, namely Atlas and Hodgson. Atlas - is native to Romania, created at S.C.C.P.T. Fundulea. Depending on the vegetation period it is an early variety, requiring 1150-1250°C. The plants have a branched stem with a waist between 80-100 cm, the leaves have ovate - lanceolate leaflets, the flowers are grouped in racemes, white, with gray-colored brushes. The pods are brown in color and the seeds and hilum are yellow. The insertion height of the first pod is 12-15 cm. The weight of thousand berry is between 130-200 g, the protein content is 41.1-42.3%, and the oil content is 18.9-19.6%. The production capacity is between 2000-3500 Kg/ha (Pîrșan, 1998).

Hodgson - is originally from the USA, having as genitors the varieties Corsoy - Lincoln x Richland x PL 180-501, belonging to the immaculate variety. Depending on the vegetation period it is semi-late, requiring 1350-1450°C. It has a height of 70-90 cm, the flowers are purple, the pods color is brown, the seeds yellow, the hilum are spotted yellow and the pubescence is gray. The insertion height of the first pod is 12-15 cm. The vegetation period is between 115-134 days, the weight of thousand berry = 120-180 g, hecrotitre mass = 70-76 Kg, the protein content is 38-42% and in oil 18-24%. It is a variety sensitive to drought, very sensitive to the pod burning, sensitive to manna and root rot. The production capacity is between 1600-2500 Kg/ha in non-irrigated culture and 2500-3500 Kg/ha in irrigated culture (Bîlteanu, 1998).

Experiments on the influence of chemical fertilizers on physiological indices and soybean production have been conducted in the field, so that the physiological processes are completely and accurately surprised. The varieties were placed in a comparative culture, using the method of subdivided plots with three repetitions. Experimental field was plowed during autumn and further processed 2 times with combiner in the spring. Sowing date was in the second decade of April, when soil temperatures were 7-8°C. The experimental variants consisted in different doses of chemical fertilizers, namely: \( V_{0}N_{0}P_{0}K_{0}, V_{45}N_{45}P_{45}K_{45}, V_{81}N_{81}P_{81}K_{81} \) Fertilizer rates were split in 2 phases, at the sowing date (1/2 of ratio) and the second one when foliage was well developed (1/2 of ratio).

To express the moments of determination and the phenological stages of development of soybean plants, we used the decimal unit coding system B.B.C.H. (Bayer; BASF; Giba-Geigy; Hoechst).
This code is used internationally for identifying and expressing the stage of plants development (Dobrei et al., 2004). During the experiments we made determinations regarding: waist of plants (cm) - determined by biometric measurements; leaf surface (cm²/plant) - determined by the leaf parameter method using the correction coefficient; the amount of dry matter accumulated (%); grain production (kg/ha). The size of the plants was determined by biometric measurements in different phenological phases: in the beginning of the growth of the vegetative mass (22-25 BBCH scale), the end of the growth of the vegetative mass (49 BBCH scale) and during the fructification period (70-75 BBCH scale). The foliar surface of the plant expressed by the sum of the all leaf surfaces, is a physiological index that characterizes both the growth of the plant and its photosynthetic capacity.

As regards the determination of the leaf surface in soybeans, the following linear equation applies:

\[
S = S_1 + S_2 + S_3
\]

where:

- \( S \) – total leaf area (cm²);
- \( S_1 \), \( S_2 \), \( S_3 \) – the surface of folioles (cm²).

\[
S = K * L * l
\]

where:

- \( K \) = 0.668 for the central foliole,
- \( 0.751 \) for the side foliole,
- \( L \) – the length of foliole (cm),
- \( l \) – the maximum width of foliole (cm) [8].

The determination of the percentage of dry matter was performed using Kern thermo-balance. The Kjeldahl method was used to determine the crude protein. The crude protein represents the totality of the organic substances with nitrogen, of which are the proteins and the non-protein nitrogenous substances (alkaloids, pigments with nitrogen, complex lipids, amides and so on). The crude protein content is calculated by the total organic nitrogen content of the plant.

\[
\text{Crude protein content} = \frac{\text{Total Nitrogen} \times 6.25}{\text{g}}
\]

Total Nitrogen (%) = \( \frac{\left( V_1 f_1 - V_2 f_2 \right) \times 0.0014 \times 100}{g} \)

- \( V_1 \) – the volume of 0.1n sulfuric acid in which ammonia was captured;
- \( f_1 \) – the normality factor of the sulfuric acid 0.1n;
- \( V_2 \) – the amount of NaOH 0.1n used to titrate the analyzed sample (ml);
- \( f_2 \) – the normality factor of NaOH 0.1n;
- 0.0014 – factor for converting sulfuric acid 0.1n into grams of nitrogen;
- \( g \) – weight of the weighed substance (g);
- 100 – factor for percentage reporting.

Crude protein content is determined as follows:

\[
\% \text{Crude protein} = \% \text{Total Nitrogen} \times 6.25
\]

Directing the growth of soybean plants in height present a great practical importance, because the pods are formed at the nodes. The more nodes the plant has, more number of pods that can be formed on the stalk. The number of seeds in the pods, the size and weight of the beans, the number of fertile pods are important factors that contribute to the harvest formation (Baia, 1970). It is well known that under the influence of nitrogen fertilizers, all crop plants as well as weeds in crops grow high and have rich foliage. Following the influence of fertilizers with N, P, K on some morphological characteristics in soybean, among which the height of the plants, it is found that this is greater than in the control, in all the variants that have been fertilized with nitrogen, besides phosphorus and potassium (Popescu, 1972).

The growth dynamics of the leaf surface and the surface of all the leaves on a plant are physiological indices of great importance for the assessment of the physiological activity of the plants (Baia, 1970). The total surface of the leaves on a plant is a morphological index with special importance, since it gives indications on the photosynthetic potential of the respective plants. It has been found that this index can be managed through the plant fertilization, as it is an important leverage to direct photosynthesis and thereby production. The total leaf area per hectare depends not only on the foliage surface of a plant, but also on the number of plants per hectare. The number of plants per hectare can also be controlled by sowing more or less grains per square meter, respectively by the amount of seed that is applied per hectare (Baia, 1974).

All data analysis were done by ANOVA test followed by t test.

Results and discussions

The first observations regarding the size of the plants were made during the growth phase of the vegetative mass. In this phase, the minimum length was recorded for both varieties in the unfertilized control variant (Figure 1), while the rest of the varieties that benefited from fertilizers had higher values. The highest waist was recorded
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in both Atlas and Hodgson, in the V2 variant of 16.1 + 0.71 cm, respectively 15.9 + 1.16. The differences between these values and the control are 2.14 for Atlas and 2.7 for Hodgson. V3, which benefited from a surplus of phosphorus, did not show higher increases than in the case of V2, but on the contrary slightly lower. Phosphorus is taken in the highest amount in the grain formation phase (phase 6-7) (Bortolon et al., 2018; Mitran et al., 2018; Syers et al., 2008). The element intensifies the process of cell division by accelerating through this action the growth of organs, but especially of the roots. It stimulates flowering, accelerates fruit ripening, seed formation and ripening.

The following observations on the size of the plants were made at the end of the vegetative mass growth (Figure 2), when the waist approaches the maximum size. In this phenophase the way of staggering between the variants was identical to the previous observations, but, the differences between the variants and the control are greater. The maximum differences were registered in the case of variant 2, (6.26 in Atlas and 5.05 in Hodgson).

During the flowering period (Figure 3) in the Atlas variety, the size of the plants was between 87.70 + 1.02 cm in the control and 96.40 + 1.02 cm in the V2. Variants 2 and 3, which benefited from higher doses of phosphorus, registered towards control variant, a difference in size of more than 8 cm. In the Hodgson variety, in this phenophase, the size of the plant had lower values than at the Atlas variety.
The final observations regarding the size of plants were made during the fructification period (Figure 4). Compared to the flowering period, the plant's waist recorded values only 2 - 3 cm larger, which shows that most of the assimilated after flowering were directed for the formation and growth of the seeds. The method of grading the experimental variants was identical to the one from the beginning of the observations, which demonstrates the importance of fertilizers for plant growth in all phases of vegetation.

At Hodgson variety, in the first vegetation phases, the differences between variants in absolute values are still small, due to the low vegetative mass. The minimum leaf area was 66.21 + 1.83 cm² per plant at control and 102.15 + 5.39 cm² at V₂. At the Atlas variety, compared to Hodgson, the leaf surface recorded slightly higher values, ranging from 64.82 + 3.03 cm² in the control and 120.70 + 4.63 in V₂ (Figure 5).

At the end of the vegetative mass growth period, leaf surface value approached the maximum one having values far superior to the previous phenophase. In the Atlas variety, the foliar surface per plant had values between 368.75 + 4.87 cm² in the unfertilized variant and 539.21 + 17.10 cm² in V₂, this exceeding the control with 46%. V₁ and V₂ had values close to 473.61 + 12.60 cm², respectively 477.93 + 20.50. In the case of Hodgson variety, the leaf surface recorded slightly higher values than the Atlas variety, ranging from 391.35 + 11.23 cm² at V₂ and 642.52 + 14.44 at V₂. In the case of this variety, the differences from the control were greater, being between 192.74

Figure 3. Plants height during flowering (cm)

Figure 4. Plants height during fructification (cm)
cm² at V₁ and 251.17 cm² at V₂. In percentages, the variants exceed the control with values of 49.25 to 64.18%. (Figure 6).

During the flowering period (Figure 7), Atlas variety recorded a leaf area of 603.41 + 10.44 cm² per plant at V₀ and 822.21 + 11.78 at V₂. Variants 1 and 3 had values very close to each other, slightly lower than the maximum variant. The differences between control and the other variants increased compared to the previous phenophase, which shows that during the flowering period the role of the macro-elements for the vegetative mass growth and the production is very important. In the case of Hodgson variety, the values of leaf surface at all

**Figure 5.** Evolution of leaf surface at the beginning of vegetative mass growth (cm² / plant)

**Figure 6.** Evolution of leaf surface at the end of vegetative mass growth (cm² / plant)

**Figure 7.** The evolution of the leaf surface during the flowering phenophase (cm²/plant)
variants were lower than those of Atlas variety, although in the previous phase they were higher. It follows that between the phenophase 49 (the end of vegetative mass growth) and 50-55 (flowering), Atlas variety made better use of the fertilizers, which materialized through a larger leaf surface. The differences between fertilized variants and control variant, in the case of Hodgson variety, are smaller in both, absolute and percentage values. The biggest difference was for the case of $V_2$ variant of 32.34%, followed by $V_3$ - 22.19% and $V_1$ with 18.06%.

In the fructification phenophase (Figure 8), last one in which observations were made regarding the leaf surface, it had the highest values. At Atlas variety, the maximum leaf area was in the case of variant 2 of $954.24 + 14.52 \text{ cm}^2$ per plant, value close to the maximum ones cited by the specialized literature, for this variety (Borcean and Borcean, 2003; Pîrșan, 1998). The variants that benefited from fertilizers exceeded the control with percentages between 23.97 and 31.79%. At Hodgson variety leaf surface had slightly lower values than Atlas variety, although this variety is semi-late and should logically have higher values than Atlas. The explanation could be given by the fact that the Atlas variety is a Romanian variety better adapted to the pedo-climatic conditions in this part of the country. Smallest leaf area recorded was in the case of the control by $688.92 + 9.09 \text{ cm}^2$ per plant.

Observations were made regarding the dry matter content of soybean plants in two different vegetation phenophases, before flowering and then when filling the seed.

In the pre-flowering phenophase, Atlas variety recorded on average 16.32% dry matter in root, 14.53% in stem and 16.01% in leaf, the difference being given by the water content. Regarding the experimental variants, the lowest content in dry matter in all the organs of analyzed plants was in the case of the control with 16.01% in root, 14.31% in stem and 15.72% in leaf. The variants that benefited from fertilizers registered higher values that increased with the fertilizer dose, the maximums being at $V_3$ of 16.53% in root, 14.71% in stem and 16.21% in leaf (Tab. 1).

<table>
<thead>
<tr>
<th>Variant</th>
<th>Dry matter content (%)</th>
<th>Diff. from Control (DM, %/pl.)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Root</td>
<td>Stem</td>
<td>Leaf</td>
</tr>
<tr>
<td>$V_0$ - N, P, K</td>
<td>16.01</td>
<td>14.31</td>
<td>15.72</td>
</tr>
<tr>
<td>$V_1$ - N, P, K</td>
<td>16.26</td>
<td>14.47</td>
<td>15.96</td>
</tr>
<tr>
<td>$V_2$ - N, P, K</td>
<td>16.49</td>
<td>14.62</td>
<td>16.15</td>
</tr>
<tr>
<td>$V_3$ - N, P, K</td>
<td>16.53</td>
<td>14.71</td>
<td>16.21</td>
</tr>
<tr>
<td>Average</td>
<td>16.32</td>
<td>14.53</td>
<td>16.01</td>
</tr>
</tbody>
</table>

DL 5% (p<0.05)* - 0.16 1% (p<0.01)** - 0.29 0.1% (p<0.001)*** - 0.79
Regarding the average dry matter content per plant, it was 15.35% at V₁, 15.56 at V₂, 15.75 at V₃ and 15.82% at V₄. The differences between the variants and control ranged between 0.21% at V₁ and 0.47 at V₄. These differences have statistical coverage, significant at V₁ and distinctly significant at V₂ and V₄.

At Hodgson variety (Tab. 2), the concentrations in dry matter had values very close to Atlas variety, but slightly lower; 16.05% in root, 14.16% in stem, 15.31% in leaf, with an average/plant of 15.17%. The way of grading of variants from control was the same as with the previous variety. Differences registered are 0.3% at V₁, 0.52% at V₂ and 0.56% at V₄ being statistically ensured also at this variety.

In the filling the seed phenophase was register a higher content of dry matter at both varieties compared with previous phenophase in which we made observations. At Atlas variety, the average dry matter content was: 28.48% in root, 23.58% in stem, 24.67% in leaf, with an average/plant of 25.14%. All fertilized variants registered superior values compared with control, the maximums being at V₁ of 28.96% in root, 23.84% in stem, 25.09% in leaf, with an average per plant of 25.96%. The differences from the control were between 0.22% at V₁ and 0.82 at V₄, being statistically ensured (Tab. 3).

In the case of Hodgson variety, the situation was similar, content in the dry matter being higher than before the flowering, and the experimental variants had an identical positioning as the Atlas variety. If we compare the varieties between them, the Hodgson variety, also records at this phenophase of the vegetation, slightly lower values of Atlas variety, the averages being 28.02% in root, 23.17% in stem, 24.27% in leaf and 25.15% - compared to whole plant (Tab. 4). In all fertilized variants, the differences between these and the control are statistically covered.

Figure 10 shows the results regarding the production obtained per hectare. Due to symbiosis with nitrogen fixing bacteria, soybeans provide most of the nitrogen needed in this way. Application of balanced doses of chemical fertilizers has led to significant increases in production.

At Atlas variety, the average production was 2144.5 Kg/ha. The V₀ (control) variant that did not benefit from fertilizers achieved the lowest production of 1470 Kg / ha. Large yields of 2542 Kg / ha in V₂ and 2491 in V₄ show that in soybean cultivation with total or partial nitrogen supply, phosphorus and potassium administration is extremely important. From a statistical point of view, differences registered in these two variants had a very distinct significance.

**Table 2.** Dry matter content at Hodgson variety (before flowering)

<table>
<thead>
<tr>
<th>Variant</th>
<th>Root (%)</th>
<th>Stem (%)</th>
<th>Leaf (%)</th>
<th>Average/plant (%)</th>
<th>Diff. from Control (DM, %/ pl.)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>V₀-N_P_Kₐ</td>
<td>15.73</td>
<td>13.97</td>
<td>14.79</td>
<td>14.83</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>V₁-N_P_Kₐ</td>
<td>16.06</td>
<td>14.16</td>
<td>15.15</td>
<td>15.13</td>
<td>0.30</td>
<td>*</td>
</tr>
<tr>
<td>V₂-N_P_Kₐ</td>
<td>16.18</td>
<td>14.23</td>
<td>15.63</td>
<td>15.35</td>
<td>0.52</td>
<td>**</td>
</tr>
<tr>
<td>V₃-N_P_Kₐ</td>
<td>16.22</td>
<td>14.27</td>
<td>15.67</td>
<td>15.39</td>
<td>0.56</td>
<td>**</td>
</tr>
<tr>
<td>Media</td>
<td>16.05</td>
<td>14.16</td>
<td>15.31</td>
<td>15.17</td>
<td>0.34</td>
<td>-</td>
</tr>
</tbody>
</table>

DL 5% (p<0.05)* - 0.19 1% (p<0.01)** - 0.37 0,1% (p<0.01)** - 0.96

**Table 3.** Dry matter content at Atlas variety (filling seed)

<table>
<thead>
<tr>
<th>Variant</th>
<th>Root (%)</th>
<th>Stem (%)</th>
<th>Leaf (%)</th>
<th>Average/plant (%)</th>
<th>Diff. from Control (DM, %/ pl.)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>V₀-N_P_Kₐ</td>
<td>28.03</td>
<td>23.17</td>
<td>24.23</td>
<td>25.14</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>V₁-N_P_Kₐ</td>
<td>28.16</td>
<td>23.52</td>
<td>24.42</td>
<td>25.36</td>
<td>0.22</td>
<td>*</td>
</tr>
<tr>
<td>V₂-N_P_Kₐ</td>
<td>28.78</td>
<td>23.79</td>
<td>24.97</td>
<td>25.85</td>
<td>0.71</td>
<td>**</td>
</tr>
<tr>
<td>V₃-N_P_Kₐ</td>
<td>28.96</td>
<td>23.84</td>
<td>25.09</td>
<td>25.96</td>
<td>0.82</td>
<td>**</td>
</tr>
<tr>
<td>Media</td>
<td>28.48</td>
<td>23.58</td>
<td>24.67</td>
<td>25.57</td>
<td>0.43</td>
<td>-</td>
</tr>
</tbody>
</table>

DL 5% (p<0.05)* - 0.16 1% (p<0.01)** - 0.41 0.1% (p<0.001)** - 1.17
Hodgson variety recorded an average production of 1923.75 kg/ha, slightly lower than the Atlas variety, although it is apart of other maturity group. At this variety, the minimum production was also at control variant with 1323 Kg/ha (Figure 10).

Based on these results, we can say that by applying moderate doses of nitrogen and especially doses of phosphorus and potassium, soybean production can greatly increase depending on the climatic conditions and the technological level applied. Fertilizing substances are crucial for obtaining high yields, even for leguminous plants.

Regarding the crude protein content, there are some differences between varieties. Thus, Atlas variety showed a higher protein content compared to the Hodgson variety. Among the variants, V₂ was noted with an amount of 40.92% at Atlas and 38.54% at Hodgson. The unfertilized variant (V₀) shows the lowest crude protein content (35.49%) and total nitrogen (5.68%) in Atlas and 33.66% protein with 5.38% total nitrogen in Hodgson variety (Figure 11). The protein content of seeds in both analyzed varieties increased progressively, with increased levels of nitrogen up to 45 kg/ha, phosphorus 63 kg/ha and potassium 45 Kg/ha. The increase of protein content of soybean with the increasing nitrogen level has also been reported in different studies (Boroomandan et al., 2009; Morshed et al., 2008).

The content of soybeans in total nitrogen and protein substances is influenced, within the limits of genetic potential, by the supply of soil with nitrogen. The two ways of supplying soybean plants with nitrogen (absorption of nitrates from the soil and bacterial fixation of atmospheric nitrogen) complement each other. Nitrogen is indispensable for the plant in the first phenophases of vegetation.

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**Table 4. Dry matter content at Hodgson variety (filling seed)**

<table>
<thead>
<tr>
<th>Variant</th>
<th>Dry matter content (%)</th>
<th>Diff. from Control (DM. %/ pl.)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Root</td>
<td>Stem</td>
<td>Leaf</td>
</tr>
<tr>
<td>V₀-N-P-K₀</td>
<td>27.64</td>
<td>22.87</td>
<td>23.76</td>
</tr>
<tr>
<td>V₁-N-P-K₀</td>
<td>28.06</td>
<td>23.03</td>
<td>24.11</td>
</tr>
<tr>
<td>V₂-N-P-K₀</td>
<td>28.17</td>
<td>23.35</td>
<td>24.56</td>
</tr>
<tr>
<td>V₃-N-P-K₀</td>
<td>28.21</td>
<td>23.42</td>
<td>24.62</td>
</tr>
<tr>
<td>Media</td>
<td>28.02</td>
<td>23.17</td>
<td>24.27</td>
</tr>
</tbody>
</table>

DL 5% (p<0.05)* - 0.12 1% (p<0.01)** - 0.33 0.1% (p<0.001)*** - 0.98

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**Figure 10. Soybean production (kg/ha)**
until the symbiosis between roots and bacteria Bradyrhizobium japonicum occurs. On soils well supplied with phosphorus, potassium, sulfur, calcium, molybdenum, magnesium, cobalt and under optimum humidity conditions, the efficiency of bacteria is higher (Handi, 1982; O’Hara, 2001; Weisany at al., 2013).

Excess phosphorus leads to stagnation of the growing plant and reduced plant productivity. Thanks to the synergistic action with nitrogen and potassium, the production is increased.

The size of soybean plant is a specific hereditary character of each variety, which can be influenced by the pedo-climatic conditions and the culture technology. The leaf surface was also specific to each variety, but it is also under the influence of climatic, pedological and technological conditions.

Conclusions

By applying moderate doses of fertilizer, for all variants, differences were observed compared to the control, with \( V_2 \) registering the highest waist. The most intense growth rate was recorded between phenophases 49 and 50-55, after which the rate of growth reduces its intensity, but retains its ascending character until fructification when maximum values are recorded for all variants. Application of fertilizers has led to increase in content of dry substance, by intensifying and making the metabolism more efficient. Chemical fertilizers have a decisive influence of the in increasing of the soybean yield. High doses of phosphorus did not produce higher yields compared with moderate doses. The application of balanced doses of chemical fertilizers \((N_{45}P_{63}K_{45})\) has led to significant increases in protein. Superior results were registered at Atlas, better adapted to the ecological conditions of the reference area.

References


