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# Study on the effect of the green manure application on soil fertility

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# Study on the effect of the green manure application on soil fertility

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**Abstract.** The natural soil and climatic conditions of green manure crops are taken into account. It is important to choose the types suitable for growing them for different purposes (as a main, repeated crop, animal feed, mulching), to increase the yield and quality of green manure crops, to achieve high green biomass by using optimal seeding periods and rootstock thicknesses. One of the urgent tasks is to carry out research in the priority areas such as increasing the soil fertility and cotton yield by crushing the cultivated green biomass and spreading it evenly on the field, plowing it into the soil at different times and depths. In order to increase soil fertility, the use of pure bean and colza and their mixtures as green manure has increased. The percentage of macroaggregates in the driving layer before the first irrigation increased by 13.0–13.45% compared to the control, and by 16.55–17.4% before the last irrigation. As a result, the volume mass of the soil is reduced to 0.02-0.04 g/cm$^3$, and the amount of nitrogen, phosphorus ($P_2O_5$) and exchangeable potassium ($K_2O$) in the form of ammonium ($N\text{-}NH_4$) and nitrate ($N\text{-}NO_3$) in the soil is lower than in the control-green manure and caused a slight increase compared to the option.

## 1. Introduction

Cultivation of green manure crops improves soil water and air regimes. This situation is especially evident when crops with spikes are grown, because of the stiffness and softness of the roots, it “splits” the soil into small pieces. This water has a positive effect on slow-draining, compacted heavy soils. In light loamy soils, green manure crop cover acts as a “living mulch”, preventing nutrient leaching from top to bottom. Therefore, in such soils, if green manure crops are ground in autumn, and in spring they are plowed with green mass and ground, they perform a sanitary role in the soil and protect plants from diseases and pests [1].

According to the results of the experiment conducted by Kenjaev [2], the percentage of macrostructural aggregates with a size of 5-0.25 mm at the beginning of cotton vegetation after sideration increased by 5.31-8.55% when sideration was used compared to the control. Also, the relationship between the formation of structure, the spreading of plant roots into the soil and the amount of humus in the soil has been shown in the literature [3-7].

In addition to macrostructured aggregates, microstructured aggregates < 0.25 mm in size have a specific role in soil fertility. A favorable proportion of these aggregates in the soil structure ensures high crop yields in Central Asian (gray) soils, but air exchange is impaired in soils with a large amount of < 0.25 mm microstructured aggregates. Such soils quickly dry out, and when they dry, they become compacted and become lumpy [8].

Soil structure is one of the important agronomic properties that determine soil fertility and crop yield. Issues such as physical properties of the soil, tillage measures, water-weather regimes of the soil, general fertility and their influence on the productivity of plants have been thoroughly studied by Uzbek and international scientists. In the short-row cotton-cereal rotation, the application of green manure crops to the fields freed from cotton in the fall period and its effect on soil fertility have not been sufficiently studied.

## 2. Materials and Methods

The cultivation of green manure crops, their analysis and observation were carried out based on manuals such as "Methodology for conducting field and vegetative experiments with fodder crops" [9], chemical composition of green manure crops "Methods of biochemical research of plants" [10].

In the experiment, methodological manuals "Methods of agrochemical, agrophysical and microbiological research in irrigated cotton areas" [11] and "Methods of agrochemical research" [12] were used to perform agrochemical, agrophysical and microbiological analysis.

In the experiment, the following agrophysical analyzes were carried out: the mechanical composition of the soil according to Kachinsky; macro and microstructure of the soil (%) at the beginning and end of the cotton vegetation after green manures by sieving, weighing and counting from the 0-20 and 20-40 cm layers in 4 repetitions of each option; water-resistant aggregates of the soil (%) in 4 repetitions of each option in the 0-20 and 20-40 cm layers and at the beginning and end of cotton vegetation by the Savvinov method; volume mass of the soil (g/cm$^3$) after green manure during cotton vegetation period before the first and last watering from 0-20 and 20-40 cm layers in 4 repetitions by Kachinsky method; specific mass of the soil (g/cm$^3$) after green manure during cotton vegetation period before the first and last irrigation from 0-20 and 20-40 cm layers in 4 repetitions by pycnometer method; soil porosity (%) by calculation according to soil volume mass and specific mass before the first and last irrigation during cotton vegetation after green manure; soil moisture (%) was determined by drying and weighing in a thermostat for 6 hours at 105 $^0$C, before plowing green manures, before the first and last watering of cotton during the growing season in 0-20 and 20-40 cm layers in 4 replications of each option. Also, by calculation, the soil moisture reserve (mm) was determined according to the above layers [13].

*In agrochemical analyses:* the amount of humus in the soil according to Tyurin; total nitrogen, phosphorus and potassium according to Maltsev and Gritsenko; amount of nitrogen in the form of nitrate according to Granwald-Lyaju; the amount of nitrogen in ammonium form in Nessler's reagent; mobile phosphorus and exchangeable potassium were determined according to Machigin.

*Statistical analysis* of experimental results was performed according to Dospekhov [14].

The field experiments were carried out in the conditions of the old irrigated, mechanical composition of medium loam, volume mass of 1.26 g/cm$^3$ in the plowed layer, typical gray soil with a porous structure of the Botany educational and scientific center of NUUz. The experiment was carried out in 4 variants, 3 replicates in one layer, according to the following system, i.e. variants - 1-control-without green manure, 2-bean, 3-colza, and 4-bean+colza. The surface of each plot was 240 m$^2$ (length 50 m and width 4.8 m), the area to be considered was 120 m$^2$.

To study the effectiveness of green manure crops in cotton cultivation, after harvesting the cotton crop, the selected field was watered and prepared for planting in the fall (on October 10). Maintenance of green manure crops was carried out according to existing recommendations [15].

As green manure crops, long-day autumn colza and leguminous bean plants, including bean Asia-2001 and biological autumn Loris varieties of colza, were selected for the experiment as green manure crops, which are somewhat cold-resistant and have high biomass accumulation. As a green manure crop, bean - 40 kg/ha, colza - 13 kg/ha separately and their mixtures were sown by hand spreading, reducing it to half. Colza seeds were planted at a depth of 1.5–2 cm, and bean seeds were planted at a depth of 6–7 cm. After planting, it was irrigated at the rate of 500-600 m$^3$/ha.

Nitrogen fertilizer was spread at 50 kg/ha in two periods with the help of NRU-1.5 fertilizer spreader, when the plant height was 8-10 cm and it was about to enter the intensive growth phase. After putting the fertilizer on the ground, it was watered at the rate of 700-800 $m^3$/ha. In autumn, irrigation was carried out every 17-20 days in October-November, and 20-25 days in March-April.
Burying the green biomass produced by green manure crops into the ground, crushing Colza and their mixtures during the flowering-fruiting phases with a heavy disk harrow (BDT-2.2) and burying it in a double-layer plow (PD-3-35) work was done. The effect of green manures on soil properties was studied.

## 3. Results and Discussion

Soil structure is one of the important agronomic properties that determine soil fertility and crop yield. Although issues such as physical properties of the soil, tillage measures, water-weather regimes of the soil, fertility in general and their effect on the productivity of plants have been thoroughly studied by Uzbek and foreign scientists, but in the conditions of meadow-alluvial soils of Samarkand province (Uzbekistan), short-rotation cotton-grain rotation The work on burying the biomass produced as a result of the maintenance of green manure crop types in the autumn periods in the fields freed from cotton and its effect on soil graininess has hardly been studied.
According to the work program, after green manure in spring, at the beginning and end of the cotton vegetation, samples were taken from the 0-20 cm and 20-40 cm layers of the soil from the experimental field, and the aggregate fractions were analyzed.
In the experiment, the highest (19.55-18.65%; 23.55-21.45%) percentage of large-sized (> 10 mm) megastructure aggregates in the 0-20 cm and 20-40 cm soil layers at the beginning and end of cotton vegetation control-green was observed in the variant without manure, and the lowest indicator compared to the control was recorded in colza and bean+colza variants, the amount of > 10 mm aggregates was 2.5-2.6%; 4.05 - 4.65% and 6.4 - 5.45%; It was noted that it was 6.3-6.0% less or relatively less in the bean variant.
Also, at the beginning and end of cotton vegetation, the amount of macrostructured aggregates (10-0.25 mm) in the 0-20 cm layer of the soil decreased from 60.15% to 54.20% in the control variant. In the options where green manures were used, their share increased by 9.9-13% compared to the control option. In this case, it was noted that its highest indicator is in the bean+colza variant, and relatively high indicator is in the colza variant (Table 1).
The percentage of macrostructured aggregates with a size of 10-0.25 mm in the 20-40 cm layer of the soil was different from that in the 0-20 cm layer, and it was 62.50% in the control option without green manure, while in the options with green manures, this indicator was 71.85-74.05% respectively. Its share in the 20-40 cm soil layer was higher in the bean+colza option.

**Table 1.** Effect of green manure on the formation of soil aggregates (% of soil mass), 2019 – 2020.

| Experience options | Soil layer, cm | Aggregate size, mm | | | | | |
|---|---|---|---|---|---|---|---|
| | | at the beginning of the cotton vegetation | | | at the end of the cotton vegetation | | |
| | | >10 | 10-0.25 | <0.25 | >10 | 10-0.25 | <0.25 |
| Control-without green manure | 0 – 20 | 19.55 | 60.15 | 20.3 | 23.55 | 54.2 | 22.25 |
| | 20 – 40 | 18.65 | 62.5 | 18.85 | 21.45 | 55.0 | 23.55 |
| Bean | 0 – 20 | 17.25 | 70.25 | 12.5 | 19.2 | 69.75 | 11.05 |
| | 20 – 40 | 17.05 | 71.85 | 11.1 | 17.6 | 70.55 | 11.85 |
| Colza | 0 – 20 | 17.05 | 71.4 | 11.55 | 17.15 | 70.5 | 12.35 |
| | 20 – 40 | 16.05 | 72.6 | 11.35 | 16.0 | 71.2 | 12.8 |
| Bean+colza | 0 – 20 | 15.5 | 73.15 | 11.35 | 17.25 | 70.75 | 12.0 |
| | 20 – 40 | 14.0 | 74.05 | 11.95 | 15.45 | 72.4 | 12.15 |

In general, when various crops were planted for the purpose of green manure, the proportion of macrostructured aggregates of 10-0.25 mm size increased in the tillage layer, and water-resistant aggregates were formed. The reason is that soil particles combine with organic humus to form structural soil aggregates. It is known that the quality of granules is determined by their water resistance and mechanical strength.

In field experiments, the amount of < 0.25 mm microstructured aggregates in the 0-20 cm layer of the soil at the beginning of the cotton vegetation was 11.35-20.30%, and at the end of the cotton vegetation was 12.0-22.25%. In this case, it was found that its share was relatively small in the bean+colza option. Also, in the 20-40 cm layer of the soil, at the beginning and end of the cotton vegetation, microstructured aggregates < 0.25 mm are 11.35-18.85 according to options; 12.15-21.55%, and under the influence of green manures, their amount increased by only 0.75-1.45% at the end of the growing season compared to the beginning of the growing season, while it was found that it increased by 4.70% in the control-green manure option.

In addition, from the studied fractions, microstructured aggregates with a size of <0.25 mm were more abundant in the upper layers of the soil at the beginning of the vegetation, but by the end of the vegetation, on the contrary, it was found in the analyzes that they were formed more in the lower layer than in the upper layers. This indicator was especially high in the control-green manure-free option. This situation is explained by the fact that as a result of irrigation, microstructured aggregates are washed into the lower layers of the soil and form a colloid mass.

In the conditions of meadow-alluvial soils of Samarkand region, planting beans and colza in their pure state and mixed with colza and using them as green manure has a positive effect on soil fertility and improves its structure. As a result, the plants will grow and develop better, creating a higher yield and increasing the profitability of the field. Also, in order to determine the effect of green manures on the volume mass (density) of the soil, samples were taken and analyzed from the 0-20 and 20-40 cm layers of the soil.

After green manure, before the first and last irrigation of cotton, the volume and mass change was observed in the soil tillage (0-40 cm) layer. In field conditions, soil volume mass was determined by taking an undisturbed soil sample from the driving layer using a cylinder. The results of determining the volume mass of the soil driving layer are described in Table 2.

Before the first irrigation of cotton in 0-20 and 20-40 cm soil layers in options using green manure, its bulk mass is 0.03-0.05 g/cm$^3$ and 0.02-0.04 g/cm$^3$ less than in the option without green manure. It can be seen that the volume mass was larger in the lower 20-40 cm layer compared to the surface 0-20 cm layer. A decrease in volume mass in the tillage layer compared to the control-green manure-free option (0.05 and 0.04 g/cm$^3$) was observed in the options planted mixed with bean+colza as green manure. Before the last irrigation, the amount of volume and mass in the plowing layer of the soil (0-20 and 20-40 cm) is 0.02-0.03 g/cm$^3$ when beans and colza are planted with green manure; It was found that it decreased by 0.03 g/cm$^3$ (Table 2).

**Table 2.** Effect of green manure on soil volume mass, g/cm$^3$ (2019 – 2020)

| Experience options | In early spring | | During the growth period of cotton | | | |
|---|---|---|---|---|---|---|
| | | | Before the first irrigation | | Before the last irrigation | |
| | Soil layer, cm | | | | | |
| | 0 – 20 | 20 – 40 | 0 – 20 | 20 – 40 | 0 – 20 | 20 – 40 |
| Control-without green manure | 1.35 | 1.37 | 1.37 | 1.38 | 1.38 | 1.39 |
| Bean | 1.33 | 1.35 | 1.34 | 1.36 | 1.36 | 1.38 |
| Colza | 1.33 | 1.34 | 1.34 | 1.35 | 1.36 | 1.37 |
| Bean+colza | 1.32 | 1.34 | 1.33 | 1.35 | 1.35 | 1.37 |

Thus, in the option without control-green manure, before the first and last irrigation of cotton, the volume mass increases in the driving layer, while in the options with green manure, it was found to decrease compared to the control.

During the growing period of cotton, before the last irrigation, the increase in the driving layer was observed in the control option (1.38 and 1.39 g/cm$^3$), and it was found to be the least when it was used as green manure mixed with colza. Before the last watering, the lowest volume mass (1.38 g/cm$^3$) was observed when the bean was planted as green manure (Table 2).

Further statistical analysis determined the relationship between soil volumetric mass and green manure biomass. It turned out that the correlation is weak (R=0.94) (Figure 1).

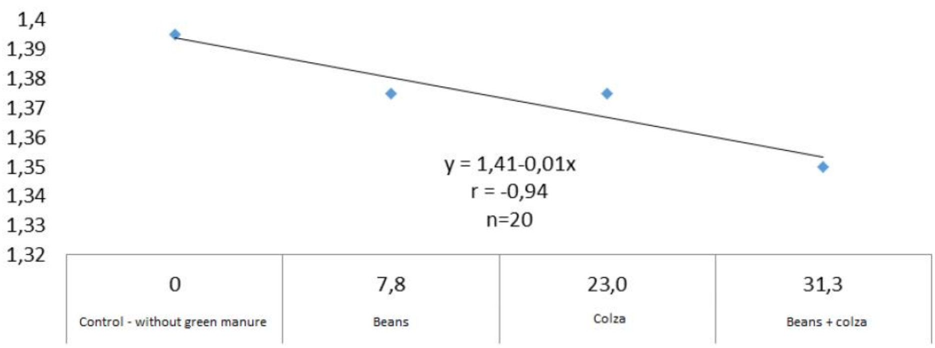


**Figure 1.** Dependence of soil volume mass on biomass of green manure crops

Statistical analysis of data allows obtaining objective information for the process. In general, when the bean for green manure was planted in its pure form and the bean with colza, the volume mass in the driving layer decreased the most compared to the control option, and it was observed that it was almost unchanged due to irrigation. When green manure is used, it was found that the volume mass in the driving layer is reduced by 0.05-0.04 g/cm$^3$. It was noted that when green manure was used, a density favorable for good growth and branching of cotton roots was created.

The change of the general physical properties of the soil, in turn, had its effect on its water physical properties, including the soil moisture (0-40 cm) during the experiment. determined before the increase. These indicators are presented in Table 3. It was found out from the conducted analyzes that green manures had a significant effect on soil moisture.

**Table 3**. Effect of green manure on soil moisture, % (2019-2020)

| Experience options | Before plowing green manures Nov 18-24 | | During the growth period of cotton | | | |
|---|---|---|---|---|---|---|
| | | | Before the first irrigation June 9-12 | | Before the last irrigation Sep 2-5 | |
| | Soil layer, cm | | | | | |
| | 0 – 20 | 20 – 40 | 0 – 20 | 20 – 40 | 0 – 20 | 20 – 40 |
| Control-without green manure | 17.9 | 20.1 | 19.8 | 20.5 | 17.9 | 19.4 |
| Bean | 20.7 | 24.05 | 20.1 | 25.4 | 18.6 | 20.8 |
| Colza | 20.5 | 25.4 | 20.1 | 25.9 | 19.3 | 24.1 |
| Bean+colza | 21.05 | 26.3 | 21.4 | 25.9 | 19.7 | 24.5 |

During the cotton growth period, before the first watering, compared to the control option without green manure, moisture (0-20 cm and 20-40 cm) in the driving layer is 0.3-1.6% and 0.7-1.8% higher in the options with green manures. it happened. Also, higher humidity (21.4-25.9%) was noted when beans were planted mixed with Colza as compared to the control-green manure-free variant.

Even before the last watering of cotton, it was found that the humidity was the highest (19.7-24.5%) when the green manure was planted as a crop mixed with colza in the plow layer (0-20 cm and 20-40 cm). Relatively high humidity was observed in colza variant (19.3-24.1%).

In the driving layer of the soil, the moisture content before the last irrigation increased by 0.7 and 1.4% in the bean variant compared to the control-green manure variant. In the bean version, the soil moisture is 18.6%, corresponding to the layers; It was observed to be 20.8%, which is much lower than other green manures (Table 3).

When green manure is used, the accumulation of organic mass in the soil leads to the acceleration of microbiological activity, and as a result, it leads to an increase in organic humus in the soil and the preservation of moisture at an optimal level.

In general, in our study, when green manure was cultivated, beans were mixed with colza and colza was planted pure, it was observed that the humidity was the highest in the first and last irrigation layer of cotton, and it was favorable for cotton cultivation. In particular, it was found that the ability to retain moisture in the soil is high when beans are planted mixed with colza and colza alone and used as green manure.

Since the 20s of the last century, many activities have been conducted in Uzbekistan to change soils under the influence of irrigation, and to increase their productivity. According to the data obtained in the experiment, it was observed that the amount of humus decreased from year to year in the option without green manure. The use of different green manure crops had a positive effect on the amount of humus.

Among the green manures, when green manure was used as a crop mixed with bean rape, it had a positive effect on the amount of humus in the soil compared to the use of other green manure crops. It was observed in the option of planting green manure as a mixture of bean + colza, and it was noted that the amount of humus in the soil was high. At the same time, all green manure crop biomass had a positive effect on maintaining soil humus content when green manure was applied. As a result, the biomass rotted in a short period of time, the amount of humus in the soil increased by 0.005-0.006%, total nitrogen by 0.010-0.013%, total phosphorus by 0.019-0.027%, and potassium by 0.160-0.200% in 2 years.

Also, the amount of nitrogen in the form of ammonium (May) increased by 10.3-15.3 mg/kg compared to the control (19.3 mg/kg) at the beginning of the growing season, especially by June, when the highest value returned in all options.

The use of green manures increased the amount of nitrogen in ammonium form in the soil, but even in these options, its amount was the lowest in the flowering phase of the plant, which is related to the rapid assimilation of nutrients. In this case, when green manure crops were applied in a mixed manner, they had almost the same effect. However, due to the presence of leguminous crops in the mixture of green manures, their effect lasted for a long time.

In the options where green manures were used in a mixed form, the amount of nitrogen in the form of ammonium was slightly higher during the flowering and fruiting phases of cotton than in the options where green manures were used in pure form. The amount of nitrogen in the form of ammonium was 34.6 mg/kg on May 1, 41.3 mg/kg on June 1, 40.3 mg/kg on July 1, and 37.4 mg/kg on August 1 in the bean+colza option (Table 4).

**Table 4.** Effect of green manure on the amount of ammonium nitrogen in the soil, mg/kg (2019 – 2020)

| # | Experience options | $N\text{-}NH_4$, mg/kg | | | |
|---|---|---|---|---|---|
| | | **May 1** | **June 1** | **July 1** | **August 1** |
| 1. | Control-without green manure | 19.3 | 29.8 | 28 | 26.05 |
| 2. | Bean | 29.6 | 37.8 | 35.1 | 33.3 |
| 3. | Colza | 30.15 | 38.5 | 37.5 | 35.0 |
| 4. | Bean+colza | 34.6 | 41.3 | 40.3 | 37.4 |

The next indicator of our statistical analysis is the correlative relationship between the amount of N-$NH_4$ in the soil and the biomass of green manure crops, which is R=0.91 and obeys the equation u=a+$b_x$ (Figure 2).

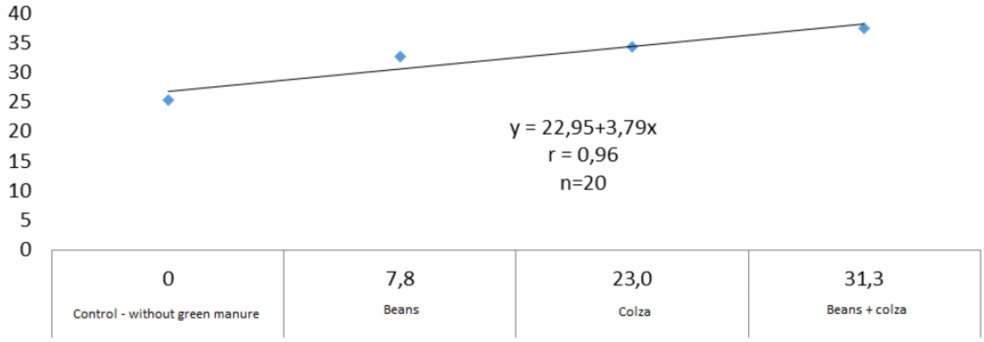


**Figure 2.** Dependence of the amount of N-$NH_4$ in the soil on the biomass of green manure crops (August 1)

Therefore, the combined use of green manure crops increases the amount of nitrogen in the form of ammonium in the soil and creates the most favorable nutritional regime for the growth of cotton. Such changes can also be seen in the nitrogen in the form of nitrate in the soil.

**Table 5.** Effect of green manure on the amount of nitrogen in the form of nitrate in the soil, mg/kg (2019 – 2020)

| # | Experience options | N-$NO_3$, mg/kg | | | |
|---|---|---|---|---|---|
| | | **May 1** | **June 1** | **July 1** | **August 1** |
| 1. | Control-without green manure | 16.75 | 20.15 | 18.75 | 17.95 |
| 2. | Bean | 31.05 | 37.15 | 35.75 | 34.15 |
| 3. | Colza | 33.45 | 39.75 | 39.45 | 37.05 |
| 4. | Bean+colza | 37.15 | 42.65 | 41.75 | 40.65 |

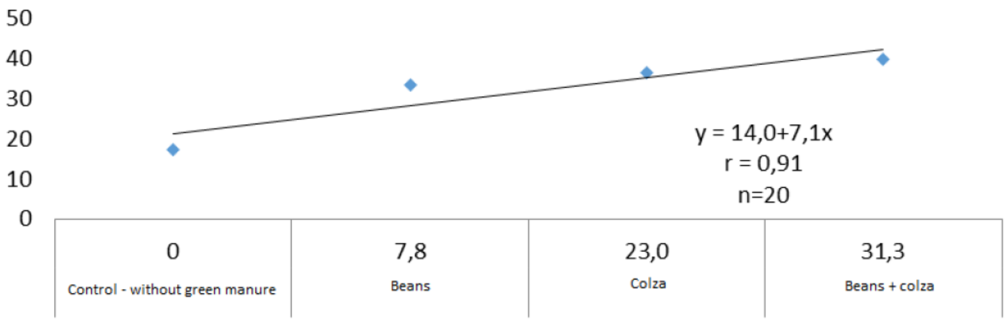


**Figure 3.** Amount of N-$NO_3$ in the soil green manure crops dependent on biomass (August 1)

In our research, it was found that the amount of nitrogen in the form of nitrate in the soil is the same as the amount of nitrogen in the form of ammonium. However, in the control-green manure-free option, the amount of nitrogen in the form of ammonium and nitrate changed according to the same law, that is, it increased from spring to summer until the cotton ginning period. Then, going to the phases of flowering and fruiting, their quantity decreased significantly. By the end of the growth period, the amount of nitrogen in the form of nitrate decreased somewhat. As a result of the use of green manures, changes in these laws were observed. Green manures prevented the decrease of nitrogen content in the form of nitrate in the soil in the middle of the growing season of cotton. In particular, intercropping of bean and colza resulted in significantly higher nitrogen content in the form of nitrate in the soil than the control throughout the growing season of cotton. According to the analysis, the amount of nitrogen in the form of nitrate is 16.75 mg/kg in the control-green manure-free version of the experiment on May 1; 20.15 mg/kg on June 1; 18.75 mg/kg on July 1; and on August 1 was 17.95 mg/kg. Besides, 31.05 and 33.45 mg/kg on May 1, respectively, in bean and colza variants planted as green manure; 37.15 and 39.75 on June 1; 35.75 and 39.45 on July 1; and, on August 1, it was 34.15 and 37.05 mg/kg (Table 5).

Based on the data of Figure 3, it is known that the correlation between the mobile nitrate nitrogen in the soil and the biomass of green manure crops corresponds to R=0.88.

The use of green manures in a mixed form had a stronger effect on the amount of nitrogen in the form of nitrates in the soil than in their pure form. Application of bean mixed with colza as green manure significantly increased $N\text{-}NO_3$-nitrogen in the soil, providing the highest content in the soil in this option, that is, they accelerated the assimilation of nitrogen mineralization in the soil by plants.

It was found that in the control-green manure-free version of the experiment, the amount of mobile phosphorus was less than in the other versions. In the options where green manures were used, it was noted that its amount increases during the growing season. In June, the amount of mobile phosphorus in the soil was at its maximum. By the end of the growing period of cotton, the amount of mobile phosphorus in the soil was lower than in other periods. The use of green manures increased the absorption of mobile phosphorus in the soil by plants.

**Table 6.** Effect of green manure on the amount of mobile phosphorus in the soil, mg/kg (2019 – 2020)

| # | Experience options | $P_2O_5$, mg/kg | | | |
|---|---|---|---|---|---|
| | | **May 1** | **June 1** | **July 1** | **August 1** |
| 1. | Control-without green manure | 21.3 | 23.7 | 20.8 | 18.9 |
| 2. | Bean | 33.3 | 35.4 | 35.2 | 32.6 |
| 3. | Colza | 35.3 | 38.1 | 35.9 | 33.1 |
| 4. | Bean+colza | 38.4 | 41.4 | 39.3 | 36.4 |

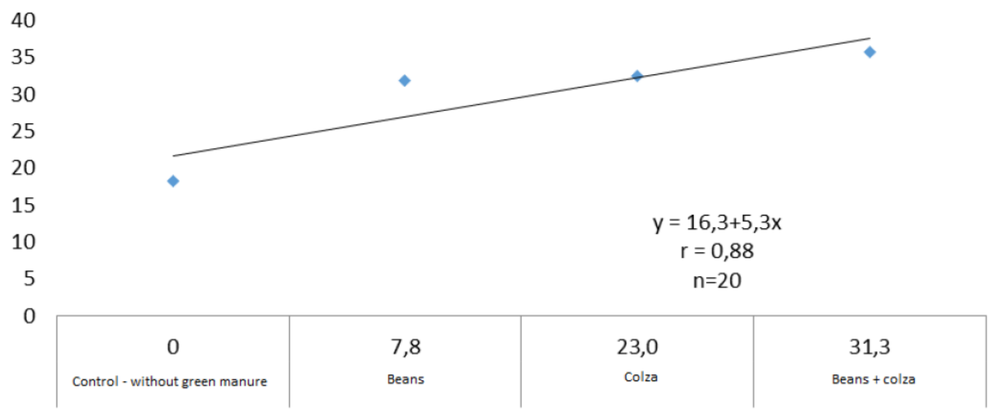


**Figure 4.** Dependence of the amount of $P_2O_5$ in the soil on the biomass of green manure crops

In the experiment, the amount of mobile phosphorus in the control version was 21.3 mg/kg on May 1; 23.70 mg/kg on June 1; 20.8 mg/kg on July 1; and on August 1 was 18.9 mg/kg. 33.3, 35.4, 35.2, and 32.6 mg/kg, respectively, in the bean variant used as green manure; 35.3, 38.1, 35.9, and 33.1 mg/kg in the colza option, 38.4, 41.4, 39.3, and 36.4 mg/kg in the mixed option (bean+colza) was found (Table 6).

It turns out that the correlation between the amount of $P_2O_5$ in the soil and the biomass of green manure crops is high, R=0.88. It can be concluded that the amount of mobile phosphorus in the soil indicates that green manure crop biomass increased the amount of mobile $P_2O_5$ (Figure 4). Therefore, green manures increase the mobilization of mobile phosphorus in meadow-alluvial soils.

During the growth period, the amount of exchangeable potassium in the soil in the control-green manure-free variant of the experiment significantly decreased by July 1. By June, it was found that the amount of exchangeable potassium in the soil is the highest. At the end of the growing season, exchangeable potassium content was observed to be the same as May 1 (Table 7).

**Table 7.** Effect of green manure on exchangeable potassium content in soil, mg/kg (2019 – 2020)

| # | Experience options | Amount of exchangeable potassium, mg/kg | | | |
|---|---|---|---|---|---|
| | | May 1 | June 1 | July 1 | August 1 |
| 1. | Control-without green manure | 231 | 252 | 236 | 231 |
| 2. | Bean | 318 | 331 | 316 | 316 |
| 3. | Colza | 341 | 366 | 346 | 341 |
| 4. | Bean+colza | 346 | 381 | 361 | 356 |

Green manure had a stronger effect on soil exchangeable potassium content when applied as a mixture than when applied alone, and soil exchangeable potassium content was the highest.

It was determined from the obtained information that the dependence of the amount of $K_2O$ in the soil on the biomass of green manure crops is very high (R=0.94). Green manure crops increase the mobile (water-soluble and exchangeable) form of potassium.

This is expected, because the organic mass of green manure crops partially proofs the soil environment, resulting in more exchangeable potassium going into solution. Also, a certain amount of potassium falls with green manure crops. Because potassium accumulates a lot in the young cells of the plant (Figure 5).

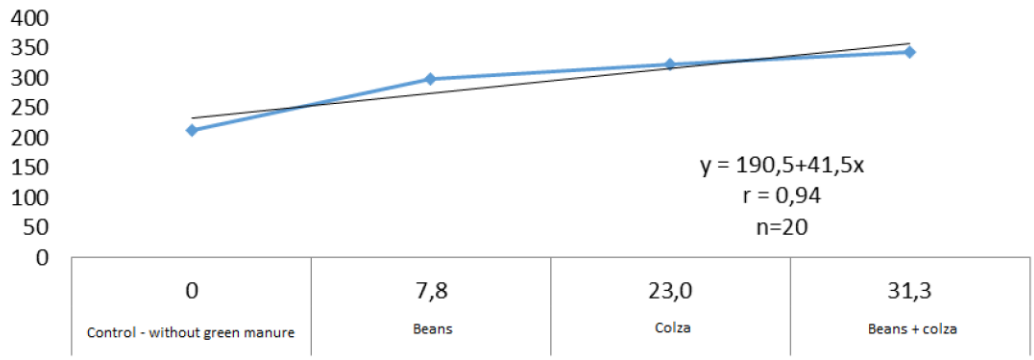


**Figure 5.** Dependence of the amount of $K_2O$ in the soil on the biomass of green manure crops

In conclusion, green manure applied to cotton-free fields in a short-rotation field significantly increased the movement and uptake of humus and mobile nutrients in the soil. It is also explained by the increase in microbiological activity in the soil as a result of the increase in the amount of nutrients in the soil, especially when used in a mixed form.

## 4. Conclusions

1. In the fall (October 10), bean in pure state as green manure to fields freed from cotton; when colza and bean+colza are planted and cared for, the biomass yield is 31.38 tons/ha in the bean+colza variant, 23.12 tons/ha in the rape variant, and 7.81 tons/ha in the bean variant, and the highest biomass yield

indicator is bean+colza was observed in the variant. The resulting biomass is crushed as green manure and buried in the soil at the beginning of April.
2. The percentage of macroaggregates in the driving layer before the first irrigation of cotton increased by 13.0-13.45% compared to the control, and by 16.55-17.4% before the last irrigation. As a result, the volume mass of the soil decreased from 0.02 g/cm to 0.04 g/cm$^3$. This had a positive effect on the improvement of soil water-physical properties and high soil fertility.
3. Accumulation of organic matter due to the green manures used in the soil of the study area, their decay under the influence of microorganisms, their mineralization and their transition to a mobile form. As a result, it was found that the amounts of nitrogen, phosphorus ($P_2O_5$) and exchangeable potassium ($K_2O$) in the form of ammonium ($N-NH_4$) and nitrate ($N-NO_3$) in the soil slightly increased compared to the control-green manure-free option.

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