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PECULIARITIES OF THE LENTIL PRODUCTIVITY FORMATION UNDER THE USE OF NITROGEN-FIXING AND PHOSPHATE-MOBILIZING MICROORGANISMS

Abstract. Research goal. To study the peculiarities of lentil productivity formation under the effect of nitrogen-fixing and phosphate-mobilizing microorganisms in the Forest-Steppe of Ukraine. **Methods.** Field, laboratory, and statistical. **Results**. The maximum number and weight of active nodules on the lentil roots were formed in the stage of bean filling when the plant's need for nitrogen was the highest. Seed inoculation with formulation Rizohumin contributed to a 5.3 times increase in the number of active nodules in the budding stage, 4.5 times in the flowering stage, and 3.8 times in the bean-filling stage compared to the control treatment. The best indicators of active symbiotic potential demonstrated the treatment with seed inoculation with Rizohumin and the use of phosphate-mobilizing formulation Polymixobacterin and Azohran B in combination with foliar dressing using Alga 600. In the same treatments, in the flowering stage, the maximum content of leghemoglobin in the fresh mass of nodules (5.58 and 5.50 mg/g) was obtained. In the flowering stage, plants formed the maximum leaf area (40 300 m^2/ha) in the treatments with Rizohumin, Azogran B, and Alga 600. When using a combination of Rizohumin, Polymixobacterin and Alga 600, 128.0 kg/ha of nitrogen, 43.4 kg/ha of phosphorus, and 60.8 kg/ha of potassium was needed for yield formation. At the same time, under the joint application of Rizohumin, Azorgan B and Alga 600, the need was 118.0 kg/ha, 40.0 kg/ha, and 56.0 kg/ha, respectively, which corresponded to the maximum indicators of the nutrient uptake in the experiment. The use of Rizohumin + Azogran B + +Alga 600 resulted in the lentil yield of 1.79 t/ha; whereas in the treatments with Rizohumin + Polymixobacterin + +Alga 600, the maximum yield was obtained (1.95 t/ha).

Key words: lentils; seed inoculation; tuber bacteria; leghemoglobin; symbiotic potential.

Introduction. Lentil belongs to crops with quite high drought and cold resistance and good adaptability to growing in temperate climates [1]. However, existing standpoints on the inexpediency of fertilization do not allow attaining the maximum realization of the crop biological potential [2]. Apart from this, it should be noted that growing eco-lentil requires minimal use of mineral fertilizers and other synthetic agrochemicals [3].

Neglecting the basic biological requirements of the crop eventually leads to unstable productivity, significant influence of uncontrolled growing factors, etc. Thus, if one does not take into account the factors of demand for lentil seeds, in Ukraine, in 2017, the crop occupied 8 300 hectares with the average yield of 1.4 t/ha, in 2018, 24 500 hectares with a yield of 0.8 t/ha, and 2019, 7 300 hectares in yield of 1.07 t/ha [4].

The importance of using nutrients for the formation of the crop unit of legumes grows with the fact that they require much more than cereals. Despite the demand for the availability of nutrients in the soil, mineral fertilizers are not often used in legumes, because under favourable conditions of symbiosis (pH 6–7, sufficient supply of phosphorus, potassium, magnesium, boron, molybdenum, the availability of specific strains of nodule bacteria, optimal soil moisture) lentil can uptake up to 160 kg/ha of nitrogen during vegetation [5].

However, in practice, due to the influence of adverse conditions, the activity of symbiosis weakens, and only 20–60 kg of nitrogen per hectare is fixed. Such differences between optimal conditions are often caused by increased soil acidity, lack of moisture, nutrients or soil-specific microorganisms, etc. [6].

The nitrogen problem is inseparably linked to the availability of phosphorus to plants since plants in the first half of the vegetation season use most of the phosphorus. Besides, phosphorus in the soil is relatively low-mobile compared to other nutrients. For example, phosphorus compounds can be absorbed by root hairs from a distance of 2–4 mm, while nitrogen and potassium can be absorbed from a minimum distance of 15 mm and NO_3 even from a distance of 40 mm [7].

Phosphorus is often present in the form of unavailable to plants compounds. To illustrate, the main source of phosphorus to plant is anions of orthophosphoric acid ($H_2PO_4^-$, HPO_2^{4-} and PO_4^{3-}), but plants can partially absorb poly- and metaphosphates and some organic phosphorus compounds. Plants best absorb $H_2PO_4^-$, anions, and worse HPO_2^{4-}. Anion PO_4^{3-} is unavailable to plants, it is used only by certain legumes, buckwheat and some other plants [8].

The use of the inoculants of nitrogen-fixing and phosphate-mobilizing microorganisms is addressed to solve the problem of the lack of essential nutrients for lentil plants. However, in the technology of inoculation itself, there are also unexplored issues. For example, when combining two inoculants (phosphate-mobilizing and nitrogen-fixing) the positive effect of one of them can be blocked by the negative influence of the other because there can be a competition between biological agents.

Therefore, the study of the peculiarities of the use of inoculants of nitrogen-fixing and phosphate-mobilizing microorganisms and foliar feeding for lentil and revealing their role in the formation of lentil productivity is essential.

The **research goal** was to study the peculiarities of lentil productivity formation under the effect of applied nitrogen-fixing and phosphate-mobilizing microorganisms in the Forest-Steppe of Ukraine.

Methods and materials. The study was carried out in the zone of sufficient soil moisture with the average annual rainfall from 600 to 620 mm and an average annual temperature of 7.8°C (Uladivske-Liulyntsi Research Breeding Station). The soil for the experiment was chernozem with the following agrochemical characteristics: pH_{Salt} of 6.0, humus content of 3.72 %, nitrogen content of 120 mg/kg, mobile phosphorus content of 194 mg/kg, and potassium content of 104 mg/kg.

The weather conditions in the years of the experiment were generally favourable for plant growth and development. Thus, the greatest precipitation amount during lentil vegetation was observed in 2018 with 360.6 mm, and in 2019 with 316 mm, while the least was in 2017 with 283.1 mm.

The layout of the experiment is given in Table 1. For the experiment domestic lentil variety 'Antonina' was used. The experiment was carried out in a randomized plot design with four replications in plots of an area of 25 m^2.

Lentil seeds were treated with inoculants before sowing, then with growth stimulants in the budding stage at the doses recommended by the manufacturer. To avoid the negative interference of microorganisms, they were introduced separately: phosphate-mobilizing bacteria in the row zone to the depth of lentil seed burying, while the nitrogen-fixing bacteria were used to inoculate seeds.

Biophosphorin (Azogran B) contains live cells and spores of *Bacillus megaterium* strain LZ 20 with a titer of 1x109 CFU/ml and metabolism products. This bacterial strain can convert hard-to-reach phosphorus and potassium compounds into easily digestible by plant forms.

Polymixobacterin contains a bacterium strain *Paenibacillus polymyxa* KV that can produce organic acids and enzyme phosphatase, which provides dissolution of difficult to dissolve mineral and organic soil phosphates.

Rizohumin contains a suspension of *Rhizobium leguminosarum* (first component) nodule bacteria and a solution of physiologically active substances of biological origin (auxins, cytokinins, amino acids, humic acids), microelements in chelated form, and macroelements in the start concentrations.

The ALGA 600 biostimulant contains the following seaweed extracts: *Sargassum*, a source of alginic acid and cytokinins; *Laminaria*, a source of laminarin polysaccharide; *Ascophyllum Nodosum*, a source of alginic acid, mannitol and phytohormones.

The number and weight of nodules on the root system of plants were determined according to Volkohon [10]. The content of leghemoglobin in the nodules was evaluated by the method of Posypanov [11].

Results and discussion. Seed inoculation affected the number and weight of active nodules on the root system of lentil plants (table 1).

Table 1 – The number of active nodules on the lentil roots and their wet weight (per plant) as affected by the components of the agricultural technology, the average for 2017/19

Seed inoculation	Introduction in the row	Foliar dressing	Phenological stage					
			Budding		Flowering		Bean filling	
			the number of active nodules	wet weight of active nodules	the number of active nodules	wet weight of active nodules	the number of active nodules	wet weight of active nodules
Without inoculation	Control (without application)	No foliar dressing	4.0	6.8	7.1	27.2	8.8	36.9
		Alga 600	4.0	6.7	7.2	27.1	9.2	36.8
	Polymixobacterin	No foliar dressing	4.2	6.6	7.9	29.2	10.0	39.8
		Alga 600	3.8	6.8	7.3	26.3	9.3	36.0
	Biophosphorin (Azogran B)	No foliar dressing	3.9	6.7	6.9	26.3	9.1	36.0
		Alga 600	4.0	6.7	7.3	27.5	9.7	37.4
Rizohumin	Control (without application)	No foliar dressing	21.4	3.5	30.8	218.9	34.0	267.3
		Alga 600	20.4	33.1	33.4	230.2	35.8	278.8
	Polymixobacterin	No foliar dressing	20.9	34.6	32.4	238.6	35.8	289.2
		Alga 600	20.7	34.2	34.9	246.6	36.5	293.9
	Biophosphorin (Azogran B)	No foliar dressing	21.7	34.4	31.6	235.3	35.1	283.1
		Alga 600	20.7	33.8	34.4	238.4	36.2	288.3
$LSD_{0.05}$			1.1	1.6	1.8	2.3	2.5	4.4

Control treatments without seed inoculation with Rizohumin had rather modest indicators of colony formation by nitrogen-fixing nodule bacteria. Thus, in the budding stage, on average, the number of nodules per plant was 4.0, with the average wet mass of 6.7 g/plant. At the same time, in the treatments with inoculation with Rizohumin, in this stage, the number of nodules was 5.3 times higher, and their wet weight was 5.1 times higher than in the control treatments. Similar trends in the formation of the nodule bacteria colonies remained through the vegetation period, with the treatments with seed inoculation being significantly different from the control ones.

In the flowering stage, the number of active nodules per plant in the Rizohumin inoculated treatments of the experiment was 30.8–34.9, with their wet weight ranging from 218.9 to 246.6 g/plant. The maximum indices of the number and weight of active nodules on the roots of lentil were in the stage of bean filling when the plant's need for nitrogen was the highest.

Concerning the influence of other experimental factors on the state of the symbiotic apparatus of lentil, in the treatments with Polymixobacterin and Azogran B, the number and wet weight of active nodules in the budding stage were higher than in the control treatment, but their deviations were within the experimental error. This can be explained by the sufficient availability of phosphorus in the soil at the beginning of the growing season. However, in the flowering, the number of nodules per plant for the use of phosphate-mobilizing formulations was higher by 1.6 and 0.8 g/plant and their wet weight was higher by 19.6 and 16.4 g/plant, respectively than in respective control treatments. Similarly, we observed an increase in the number of active nodules and their wet weight in the flowering and bean-filling stage with foliar dressing using Algae 600. Therefore, the provision of optimal conditions for the growth and development of lentil plants affects the formation of nodule bacteria colonies on their roots.

However, the calculation of these indicators is not enough to understand the processes of symbiotic nitrogen fixation as a whole, and therefore the efficiency of nodule bacteria colonies is determined in terms of the total and active symbiotic potential (table 2).

Table 2 – The total and active symbiotic potential of lentil (1 000 kg·day/ha) as affected by the components of the agricultural technology, the average for 2017/19

Seed inoculation	Introduction in the row	Foliar dressing	Interstage period			
			Budding – flowering		Flowering – bean filling	
			total symbiotic potential	active symbiotic potential	total symbiotic potential	active symbiotic potential
Without inoculation	Control (without application)	No foliar dressing	33.2	20.0	89.5	51.8
		Alga 600	33.4	19.9	98.8	56.4
	Polymixobacterin	No foliar dressing	34.3	21.6	92.8	57.1
		Alga 600	34.2	19.7	101.0	55.7
	Biophosphorin (Azogran B)	No foliar dressing	34.7	20.1	94.7	52.1
		Alga 600	34.4	20.5	101.9	58.2
Rizohumin	Control (without application)	No foliar dressing	214.8	191.2	493.6	442.0
		Alga 600	221.3	200.8	551.1	504.5
	Polymixobacterin	No foliar dressing	227.2	206.9	521.8	479.7
		Alga 600	241.3	221.1	597.9	553.3
	Biophosphorin (Azogran B)	No foliar dressing	224.0	203.7	511.9	469.6
		Alga 600	228.3	208.3	567.9	523.8

In the treatments without inoculation with Rizohumin, in the interstage period of budding–flowering, the total symbiotic potential was 34 000 kg·day/ha, and active symbiotic potential 20 300 thousand kg/ha, which was only 59.6 % of the total. However, with the use of Rizohumin, the total symbiotic potential was 226 1000 kg·day/ha, and the active one was 205 300 kg·day/ha, which made up 90.8 % of the total potential. Similar patterns continued in the interstage period of flowering – bean filling. Therefore, the use of seed inoculation with Rizohumin contributed to an increase in the active symbiotic potential to 90.8–91.6 % of the total symbiotic potential.

The best indicators of active symbiotic potential were obtained in the treatments with seed inoculation with Rizohumin, and the use of phosphate-mobilizing formulations Polymixobacterin and Azogran B in combination with foliar dressing with Algae 600.

Leghemoglobin is an indicator of the physiological activity of nodule bacteria; therefore, its study allows more accurate description of the state of lentil symbiotic apparatus (table 3).

Table 3 – Leghemoglobin content in lentil nodules (mg/g of wet weight) as affected by the components of the agricultural technology, the average for 2017/19

Seed inoculation	Introduction in the row	Foliar dressing	Phenological stage		
			Budding	Flowering	Bean filling
Without inoculation	Control (without application)	No foliar dressing	0.20	2.12	1.85
		Alga 600	0.20	2.15	1.93
	Polymixobacterin	No foliar dressing	0.21	2.38	2.11
		Alga 600	0.19	2.18	1.96
	Biophosphorin (Azogran B)	No foliar dressing	0.20	2.07	1.91
		Alga 600	0.20	2.19	2.04
Rizohumin	Control (without application)	No foliar dressing	2.25	4.93	4.76
		Alga 600	2.23	5.34	5.01
	Polymixobacterin	No foliar dressing	2.20	5.18	5.01
		Alga 600	2.23	5.58	5.10
	Biophosphorin (Azogran B)	No foliar dressing	2.27	5.05	4.92
		Alga 600	2.30	5.50	5.06
$LSD_{0.05}$			0.05	0.17	0.11

In the budding stage, plant nitrogen demand was minimal compared to the other growth and developmental stages under study, and therefore, in control treatments, the content of leghemoglobin in lentil nodules was 0.20 mg/g of wet mass and in treatment with Rizohumin 2.25 mg/g of wet mass.

In the flowering stage, the highest content of leghemoglobin in lentil nodules was in the treatments with Rizohumin, phosphate-mobilizing formulation Polymixobacterin and Azogran B in combination with Alga 600, 5.58 and 5.50 mg/g of wet mass.

However, in the stage of beans filling, there was a decrease in the content of leghemoglobin in the lentil nodules, compared with the previous stage. The nodules gradually lost their pink colour, shape, their structure changed, probably due to the destruction of the leghemoglobin nucleus with its conversion to green pigment choleglobin.

Peculiarities of leaf area formation under the effect of components of the agricultural technology through the major phonological stages are shown in table 4.

Table 4 – The leaf area of lentil (m^2/ha) as affected by the components of the agricultural technology, the average for 2017/19

Seed inoculation	Introduction in the row	Foliar dressing	Emergence	Stem formation	Budding	Flowering	Bean filling
Without inoculation	Control (without application)	No foliar dressing	2.4	10.0	19.6	32.0	20.2
		Alga 600	2.4	10.0	19.6	34.4	21.9
	Polymixobacterin	No foliar dressing	2.4	11.1	20.9	35.2	22.9
		Alga 600	2.4	11.1	20.8	36.4	23.4
	Biophosphorin (Azogran B)	No foliar dressing	2.4	11.5	21.5	35.1	23.1
		Alga 600	2.4	11.5	21.3	36.4	23.4
Rizohumin	Control (without application)	No foliar dressing	2.5	12.4	22.1	37.8	22.2
		Alga 600	2.5	12.4	22.1	38.9	24.5
	Polymixobacterin	No foliar dressing	2.5	13.7	23.1	39.1	24.7
		Alga 600	2.5	13.7	23.2	39.9	25.4
	Biophosphorin (Azogran B)	No foliar dressing	2.5	13.9	23.4	39.3	24.6
		Alga 600	2.5	13.9	23.5	40.3	25.0
$LSD_{0.05}$			0.2	0.3	0.4	0.5	0.2

At the time of complete emergence lentil plants formed a rather insignificant leaf area, from 2 400 to 2 500 m^2/ha. However, in the inoculation treatments with Rizohumin, the leaf area was higher by 100 m^2/ha, although the deviations did not exceed experimental error.

During the stage of stem formation, leaf area of 11 100 m^2/ha was formed with Polymixobacterin, and 11 500 m^2/ha with Azogran B. However, seed inoculation with Rizohumin ensured the highest leaf area index, 13 300 m^2/ha and for use in the complex of Polymyxobacterin or Azogran B, respectively, 13 700 and 13 900 m^2/ha.

In the flowering stage, plants formed the maximum leaf area, which on the average in the experiment was 37 100 m^2/ha; however, in the control treatment, it was only 32 000 m^2/ha. Moreover, in the treatment with Rizohumin, Azogran B and Alga 600, lentil plants formed a leaf area of 40 300 m^2/ha.

In the bean filling stage, the leaf area decreased significantly with an average of 23 400 m^2/ha. The better indices, similar to the previous stages, demonstrated the treatments with inoculation and phosphate-mobilizing microorganisms, while the use of Algae 600 in this stage of growth and development did not have a significant effect on the leaf area formation.

Considering the importance of finding the features of nutrients uptake, it is necessary to determine how much nutrients are removed with the harvest. Since the vegetative part of the plants remains in the field and is not processed, we did not take into account the residues of the nutrients in the lentil straw and root residues (table 5).

Table 5 – Removal of the major nutrients with harvest (kg/ha) as affected by the components of the agricultural technology, the average for 2017/19

Seed inoculation	Introduction in the row	Foliar dressing	N	P_2O_5	K_2O
Without inoculation	Control (without application)	No foliar dressing	84.4	28.6	40.0
		Alga 600	92.1	31.2	43.7
	Polymixobacterin	No foliar dressing	100.3	33.9	47.6
		Alga 600	113.3	38.4	53.8
	Biophosphorin (Azogran B)	No foliar dressing	103.3	35.0	49.0
		Alga 600	110.3	37.4	52.3
Rizohumin	Control (without application)	No foliar dressing	99.1	33.6	47.1
		Alga 600	103.2	35.0	49.0
	Polymixobacterin	No foliar dressing	112.7	38.2	53.5
		Alga 600	128.0	43.4	60.8
	Biophosphorin (Azogran B)	No foliar dressing	109.7	37.2	52.1
		Alga 600	118.0	40.0	56.0
$LSD_{0.05}$			2.3	0.7	1.2

In the control treatments, lentil used 84.4 kg/ha of nitrogen, 28.6kg/ha of phosphorus and 40.0 kg/ha of potassium to form the harvest. However, the formation of much higher productivity due to the use of additional agricultural practices also led to an increase in nutrient removal. Therefore, removal of the nutrients in the experiment was the maximum in the treatments with seed inoculation combined with the introduction of phosphate-mobilizing formulation and foliar dressing using Alga 600. Under the combination of Rizohumin, Polymixobacterin and Alga 600, pants needed 128.0 kg/ha of nitrogen, 43.4 kg/ha of phosphorus and 60.8 kg/ha of potassium to form the harvest, however, under the combination of Rizohumin, Azorgan B and Alga 600 they needed 118.0 kg/ha of nitrogen, 40.0 kg/ha of phosphorus and 56.0 kg/ha of potassium. Shown in table 6 are the data on lentil yield as affected by seed inoculation, nitrogen-fixing and phosphate-mobilizing microorganisms and foliar dressing.

Table 6 – Lentil yield (t/ha) as affected by seed inoculation and foliar dressing with plant growth stimulant

Seed inoculation	Introduction in the row	Foliar dressing	Yield (t/ha)
Without inoculation	Control (without application)	No foliar dressing	1.23
		Alga 600	1.33
	Polymixobacterin	No foliar dressing	1.48
		Alga 600	1.70
	Biophosphorin (Azogran B)	No foliar dressing	1.52
		Alga 600	1.65
Rizohumin	Control (without application)	No foliar dressing	1.46
		Alga 600	1.52
	Polymixobacterin	No foliar dressing	1.69
		Alga 600	1.95
	Biophosphorin (Azogran B)	No foliar dressing	1.64
		Alga 600	1.79
$LSD_{0.05}$			0.14

The use of Alga 600 in the budding stage ensured intensive branching of lentil plants, development of more flowers, improved pollination of plants, and uniformity of bean formation. As a consequence, the lentil yield was higher in all treatments of the experiment.

Thus, with the use of nitrogen-fixing (Rizogumin) and phosphate-mobilizing microorganisms (Polymixobacterin and Biophosphorin), lentil yield increased significantly. Combination of Rizohumin + +Azogran B + plant growth stimulator Alga 600 ensured seed yield of 1.79 t/ha, while combined application of Rizohumin + Polymixobacterin + growth promoter Alga 600 resulted in lentil yield of 1.95 t/ha.

Conclusions. Seed inoculation with Rizohumin contributed to 5.3 times larger the number of active nodules in the budding stage, 4.5 times the flowering stage and 3.8 times in the bean-filling stage compared to control and increased active symbiotic potential to 90.8–91.6 % of total symbiotic potential. However, the best indicators of active symbiotic potential were in the treatments with seed inoculation with Rizogumin, and the use of phosphate-mobilizing formulation Polymixobacterin and Azogran B in combination with foliar dressing using Alga 600.

In the flowering stage, the maximum content of leghemoglobin in lentil nodules was in the treatments with Rizohumin, phosphate-mobilizing formulation Polymixobacterin and Azogran B in combination with Alga 600, 5.58 and 5.50 mg/g of wet mass.

Again in the flowering stage, plants formed the maximum leaf area, which on the average in the experiment was 37 100 m^2/ha; in the control treatment, it was only 32 000 m^2/ha. Moreover, in the treatment with Rizohumin, Azogran B and Alga 600, lentil plants formed a leaf area of 40 300 m^2/ha.

Under the combination of Rizohumin, Polymixobacterin and Alga 600, pants needed 128.0 kg/ha of nitrogen, 43.4 kg/ha of phosphorus and 60.8 kg/ha of potassium to form the harvest; however, under the combination of Rizohumin, Azorgan B and Alga 600 they needed 118.0 kg/ha of nitrogen, 40.0 kg/ha of phosphorus and 56.0 kg/ha of potassium.

Combination of Rizohumin + Azogran B + plant growth stimulant Alga 600 ensured seed yield of 1.79 t/ha, while combined application of Rizohumin + Polymixobacterin + Alga 600 resulted in lentil yield of 1.95 t/ha.

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АЗОТ ТҮЗУШІ ЖӘНЕ ФОСФАТ МОБИЛИЗАЦИЯЛАЙТЫН МИКРООРГАНИЗМДЕРДІ ҚОЛДАНУ АРҚЫЛЫ ЖАСЫМЫҚ ДАҚЫЛЫН ҚАЛЫПТАСТЫРУ ЕРЕКШЕЛІКТЕРІ

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ОСОБЕННОСТИ ФОРМИРОВАНИЯ УРОЖАЙНОСТИ ЧЕЧЕВИЦЫ ПОД ВЛИЯНИЕМ АЗОТФИКСИРУЮЩИХ И ФОСФАТМОБИЛИЗИРУЮЩИХ МИКРООРГАНИЗМОВ

Актуальность темы исследования. Получение стабильного и экологически чистого урожая семян чечевицы требует минимального применения минеральных удобрений и других синтетических агрохимикатов. Поэтому изучение особенностей применения азотфиксирующих и фосфатмобилизирующих микроорганизмов и внекорневой подкормки растений и определения вклада этих элементов технологии в формирования продуктивности культуры остается актуальным вопросом.

Цель – изучить особенности формирования продуктивности чечевицы под влиянием применения азотфиксирующих и фосфатмобилизирующих микроорганизмов в условиях Лесостепи Украины.

Методы. Полевой, лабораторный, статистический.

Результаты. Доказано, что создание оптимальных условий для роста и развития растений чечевицы сказывается и на формировании колоний клубеньковых бактерий на корневой системе. Так, максимальное количество и масса активных клубеньков на корневой системе чечевицы формировалась в фазу налива бобов – когда и потребность в азоте у растений была максимальна. Инокуляция семян Ризогумином способствовала увеличению количества активных клубеньков в фазу бутонизации в 5,3 раз, в фазу цветения – в 4,5 раз а в фазу налива бобов – в 3,8 раза по сравнению с контролем. Кроме того, при применении фосфатмобилизирующих препаратов и внекорневой подкормки Альга 600 был отмечен рост количества активных клубеньков и их массы в фазу цветения и налива бобов.

Данные определения симбиотического потенциала свидетельствуют о том, что на вариантах без инокуляции Ризогумином в межфазный период бутонизации-цветения общий симбиотическая потенциал был 34,0 тыс. кг суток/га, а активный симбиотический потенциал – 20,3 тыс. кг суток/га, что составляло только 59,6 % от общего. А вот лучшие показатели активного симбиотического потенциала были на вариантах инокуляции семян Ризогумином, и применения фосфатмобилизирующих препаратов Полимиксобактерин и Азогран Б в сочетании с внекорневой подкормкой Альга 600. Кроме того, в фазу цветения, максимальное содержание леггемоглобина в клубеньках чечевицы – 5,58 и 5, 50 мг/г сырой массы клубеньков было на аналогичных вариантах опыта.

В фазу цветения максимальные показатели площади листьев растения чечевицы сформировали на варианте инокуляции Ризогумином, внесении Азограна Б и обработки Альга 600 – 40,3 тыс. м^2/га.

Определено, что при применении Ризогумина, Полимиксобактерина и Альга 600 на формирование урожая нужно было 128,0 кг/га азота, 43,4 кг/га фосфора и 60,8 кг/га калия, а вот за внесения Ризогумина, Азоргана Б и Альга 600 соответственно 118,0 кг/га азота, 40,0 кг/га фосфора и 56,0 кг/га калия, что соответствовало максимальным показателям усвоения элементов питания по опыту.

Применение Ризогумина + Азограна Б + стимулятор роста Альга 600 способствовало формированию урожайности семян чечевицы на уровне 1,79 т/га, а в варианте внесения Ризогумин + Полимиксобактерин + стимулятор роста Альга 600 получено максимальные значения - 1,95 т/га.

Ключевые слова: чечевица; инокуляция семян; клубеньковые бактерии; леггемоглобин; симбиотическая потенциал.

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