CROP PRODUCTION

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INFLUENCE OF BACTERIAL FERTILIZERS ON FERTILITY OF CHERNOZEM AND PRODUCTIVITY OF CHICKPEAS

Research article

Abstract

In a short–term field experiment, studies were carried out on the effectiveness of inoculation of chickpea seeds with symbiotic microbial strains. The soil is ordinary chernozem with an average supply of mineral nutrients and a neutral reaction of the environment. The high efficiency of microbial strains has been established, which improves the supply of plants with available forms of nitrogen, phosphorus and potassium. An increase in the content of nitrate nitrogen is typical for the first half of the growing season, available phosphorus and mobile potassium – throughout the growing season. The symbiotic preparations increased the grain productivity by 0.30–0.34 t/ha, while the control yield was 1.51 t/ha. The collection of protein in this case increased by 0.49–0.74 c/ha.

Keywords: chickpea, effective fertility, productivity.

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ВЛИЯНИЕ БАКТЕРИАЛЬНЫХ УДОБРЕНИЙ НА ПЛОДОРОДИЕ ЧЕРНОЗЕМА И ПРОДУКТИВНОСТЬ НУТА

Научная статья

Аннотация

В краткосрочном полевом опыте проведены исследования эффективности инокуляции семян нута симбиотическими микробными штаммами. Почва чернозем обыкновенный со средней обеспеченностью элементами минерального питания и нейтральной реакцией среды. Установлена высокая эффективность микробных штаммов, способствующая улучшению обеспеченности растений доступными формами азота, фосфора и калия. Повышение содержания нитратным азотом характерно для первой половины вегетации, доступным фосфором и подвижным калием – в течение всего вегетационного периода. Симбиотические препараты увеличивали зерновую продуктивность на 0,30–0,34 т/га при уровне урожайности на контроле 1,51 т/га. Сбор белка при этом повышался на 0,49–0,74 ц/га.

Ключевые слова: нут, эффективное плодородие, урожайность.

1. Introduction

Chickpea is a rather plastic culture, resistant to adverse environmental factors [1]. The scientific community is constantly searching for technological methods aimed at stabilizing soil fertility and increasing the productivity of crops. Presowing inoculation of chickpea seeds with symbiotic strains plays a significant role in activating physiological processes, improving the quality and yield of grain [2]. Mineral fertilizers reduce the productivity of chickpeas [3], [4].

The cultivation of high–protein crops can solve the problem of fodder protein [1], [5]. Microbial preparations optimize soil fertility and plant growth processes. In this regard, the use of the biological characteristics of legumes capable of symbiotic nitrogen fixation is a promising area of scientific research. The use of microbial preparations enhances the adaptive capacity of plants, productivity, and resistance to stressful situations [6], [7].

2. Materials and methods of research

The purpose of the research is to establish the effect of rhizotrophin strains on the change in the fertility of ordinary chernozem and the yield of chickpeas.

The studies were carried out in the conditions of the southeast of the Central Black Earth region on the fields of the Voronezh Federal Agrarian Research Center named after V.V. Dokuchaev. The soil of the experimental plot is ordinary (segregation) chernozem, medium humus, heavy granulometric composition. Agrochemical characteristics of the arable horizon: humus content – 6.8–7.2%, pH of the water extract – 7.0–7.2, content of mobile phosphorus and available potassium (according to Chirikov) 100–120 and 120–140 mg / kg. Chickpea variety – Krasnokutsky 36, Sowing was carried out in the third decade of April with a sowing rate of 700 thousand pieces/ha. Harvesting in the ripeness phase with a Sampo combine – 130. The area of the sowing plot is 5m2, repetition – 6 times. Predecessor – winter cereals. Rizotorfin obtained from the All–Russian Research Institute of Agricultural Microbiology.

3. The research results

Provision with mineral nutrition elements is one of the main conditions for normal growth, development and formation of productivity elements. Our study of the effect of microbial preparations on indicators of effective fertility indicates their positive effect, starting from the initial stages of chickpea organogenesis. In the seedling phase on the control variant (without seed inoculation), the amount of nitrate nitrogen was 12.0 mg/kg of soil. The use of active strains of symbiotic preparations for most strains contributed to an increase in the content of N–NO3 by 0.7–1.7 mg/kg (Table 1). In absolute terms, the excess ranged from 5.9 to 14.2%. The maximum value is typical for inoculation with strains 065 and 522. The use of strain 527 did not improve the supply of soil nitrogen.

As the vegetative mass grows and forms, the soil reserves of mineral elements are consumed. By the phase of flowering-bean formation, a regular decrease in the amount of available nitrogen was noted. Its value according to the variants of the experiment varied within 10.0 – 11.5 mg/kg. The excess in relation to the control was 8.0–15.0%. In absolute terms, the indicators were close to the germination phase.

In the second half of the growing season, during the formation of elements of grain productivity, the consumption of mineral elements increases. The content of nitrate nitrogen by the ripeness phase decreased to a greater extent in the variants with the use of symbiotic strains, which is due to the formation in this case of increased grain productivity.

Along with nitrogen, the amount of phosphorus available to plants is also an essential element in promoting plant growth. It directly affects the energy metabolism of cells. According to our observations, in the phase of seedlings under the influence of microbial strains, a significant increase in the supply of chickpea plants with phosphorus was noted. The minimum amount is typical for the control variant (without inoculation) – 96.0 mg/kg. Symbiotic nitrogen fixers contributed to an increase in the amount of available phosphorus to 104.0 – 133.0 mg/kg. The maximum indicators were noted when using strains 522 and 527, the excess in relation to the control was 25.0 and 38.5%, respectively.

In the flowering phase, the noted regularity was preserved. But the total background content was higher than the beginning of the growing season. With an average value of available phosphorus in the seedling phase at the level of 114 mg/kg, in the flowering phase it increased to 125.4 kg/kg. The inoculants contributed to an increase in the amount of available phosphorus by 20.7 – 39.6%. The maximum values, as in the seedling phase, are characteristic of strains 522 and 527. At a control level of 101.0 mg/kg, the phosphorus content in these strains was 134.0 and 141.0 mg/kg.

By the end of the growing season, the total background content of phosphorus, on average, according to the variants of the experiment, rises to 138.2 mg/kg. At the same time, a higher level is noted when using symbiotic inoculants. The excess in relation to the control was 6.8–9.2%.

The conducted studies also revealed an increased availability of mobile potassium under the influence of symbionts in all phases of determination. The maximum value was noted in the initial period of development of chickpea plants. According to the variants of the experiment, the content of potassium varied within 120–198 mg/kg. By the middle of the growing season (flowering phase) gradually decreased to 99.0–170.0 mg/kg. By the end of the growing season, a decrease to the level of 93.0–157.0 mg/kg was noted. During the entire growing season, the minimum values are typical for the control variant (non-inoculated seeds). Consistently high values are noted when seeds are treated with strains 522 and 527.

Table 1 – The content of nutrients in the soil

Strains	$N–NO_3$			P_2O_5			K_2O		
	Seedlings, mg/kg	Bloom, mg/kg	Ripeness, mg/kg	Seedlings, mg/kg	Bloom, mg/kg	Ripeness, mg/kg	Seedlings, mg/kg	Bloom, mg/kg	Ripeness , mg/kg
Control	12,0	10,0	7,5	96,0	101,0	131,0	135,0	99,0	93,0
Strain H–27	12,7	10,8	6,6	104,0	129,0	139,0	147,0	170,0	112,0
Strain 065	13,3	11,4	10	117,0	122,0	139,0	120,0	107,0	138,0
Strain 522	13,7	11,5	6,5	120,0	134,0	142,0	154,0	136,0	157,0
Strain 527	10,2	10,0	6,0	133,0	141,0	140,0	198,0	131,0	132,0
NDS_{05}	0,42	0,36	0,28	7,56	10,5	7,3	6,2	8,6	10,3

The use of symbiotic strains for presowing inoculation of chickpea seeds had a positive effect on increasing the productivity of chickpea plants. On average, over the years of research, the yield under the influence of inoculants increased by 0.23 – 0.34 t/ha. The maximum productivity was ensured by pre–sowing inoculation with strain 522 – 1.85 t/ha, with a control yield of 1.51 t/ha. For other strains of preparations, the grain harvest per unit area was close and amounted to 1.74–1.77 t/ha. At the same time, the excess of the control variant was 0.23–0.26 t/ha.

Table 2 – Chickpea yield

option	t/ha
control	1,51
H–27	1,76
strain 065	1,77
strain 522	1,85
strain 527	1,74
strain KZ–2013	1,56
NDS_{05}, t/ha	0,15

Chickpea is a protein crop. In this regard, the assessment of the protein productivity of chickpea crops is of current importance. All strains of symbiotic nitrogen fixers had a positive effect on the protein content in chickpea grain, and ultimately on its yield per unit area. As a result of improved provision with mineral nutrition elements and growing conditions, the protein content in chickpea grain increased from 17.0 to 17.4 – 18.8% (Table 3). At the same time, protein harvest increased from 2.57 to 3.06–3.31 c/ha. According to the percentage content and protein yield, the variant with pre–sowing inoculation with strain H–27 was distinguished – 18.8% and 3.31 c/ha, respectively. The use of strains 065 and 522 was slightly inferior in this respect.

Table 3 – The content and collection of protein in chickpea crops

option	%	c/ha
control	17,0	2,57
H–27	18,8	3,31
strain 065	18,2	3,22
strain 522	17,4	3,22
strain 527	17,6	3,06

4. Conclusions

Presowing inoculation of chickpea seeds with symbiotic strains of bacteria increases the content of available mineral nutrients in the soil. The amount of available nitrate nitrogen in relation to the control increases in maximum terms to 8.0–15.0%. This pattern is especially pronounced in the first half of the growing season. The supply of available phosphorus and mobile potassium is also significantly increased.

Improving root nutrition has a positive role in the formation of higher grain productivity of chickpeas. Under the influence of symbiotic preparations, the yield increases by 0.23–0.34 t/ha.

The inoculants contributed to an increase in protein content in chickpea grain by 0.4–1.8% and protein productivity by 0.49–0.74 kg/ha.

Conflict of Interest **Конфликт интересов**

None declared. Не указан.

References

1. Петрова Г.В. Урожайность и качество зерна нута в зависимости от технологий выращивания на южных черноземавх Оренбурского Предъуралья / Г.В. Петрова, В.В. Безуглов, Г.Н. Ярцев и др. // Известия Оренбурского государственного аграрного университета. – 2018. – №1 (69). – С.48–50.

2. Щукин В.Б. Продуктивность посевов нута при использовании в технологии его возделывания регуляторов роста, микроэлементов и Ризоторфина / В.Б. Щукин, Н.В. Ледовский, Р.И. Джафарова и др. // Известия Оренбурского государственного аграрного университета. – 2016. – №6 (62). – С.28–30.

3. Агафонов, Е.В. Применение минеральных и бактериальных удобрений под нут на черноземе обыкновенном в Ростовской области / Е.В. Агафонов, Е.И. Пугач, К.И. Пимонов // Агрохимия. – 2008. – № 7. – С. 22–30.

4. Балашов В.В. Влияние минеральных удобрений, предшественника и ризоторфина на развитие симбиотического аппарата и урожайность нута / В.В. Балашов, А.В. Балашов, В.В. Кудинов // Плодородие. – 2016. – № 6 (93). – С. 14–15.

5. Воскобулова Н.И. Зернобобовые культуры в кормопроизводстве степной зоны Оренбурской области / Н.И. Воскобулова, А.П. Будилов, В.Н. Соловьева // Вестник кормового скотоводства. – 2017. – №3 (99). – С.202–207.

6. Турусов В.И. Влияние биопрепаратов ассоциативных диазотрофов на урожайность зерновых культур в условиях юго–востока Центрального Черноземья / В.И. Турусов, М.Ю. Сауткина, А.Ю. Чевердин и др. // Достижения науки и техники АПК. – 2016. – Т.30. – №5. – С. 38–42.

7. Sautkina M.Yu. Influence of biological preparations based on associative on the yield of winter triticale in the conditions of the south–east Central Chernozemic Area / M.Yu. Sautkina, Yu.I. Cheverdin // 6th International Conference on Agriproducts processing and Farming IOP Conf. Series: Earth and Environmental Science. – Volume 422 (2020) 012028 – IOP Publishing – DOI:10.1088/1755–1315/422/1/012028 (6th International Conference on Agriproducts Processing and Farming 17–18 October 2019, Voronezh, Russian Federation)

References in English

1. Petrova G.V. Urozhainost i kachestvo zerna nuta v zavisimosti ot tehnologii virash'ivaniya na yuzhnih chernozemavh Orenburskogo Preduralya [Productivity and quality of chickpea grain depending on growing technologies on the southern chernozems of the Orenbur Cis–Urals] / G.V. Petrova, V.V. Bezuglov, G.N. Yarcev et al. // Izvestiya Orenburskogo gosudarstvennogo agrarnogo universiteta [Proceedings of the Orenbursk State Agrarian University] – 2018. – №1 (69). – p.48–50. [in Russian]

2. Sh'ukin V.B. Produktivnost posevov nuta pri ispolzovanii v tehnologii ego vozdelivaniya regulyatorov rosta, mikroelementov i Rizotorfina [The productivity of chickpea crops when using growth regulators, microelements and Rizotorfin in the technology of its cultivation] / V.B. Sh'ukin, N.V. Ledovskii, R.I. Dzhafarova et al. // Izvestiya Orenburskogo gosudarstvennogo agrarnogo universiteta [Proceedings of the Orenbursk State Agrarian University]. – 2016. – №6 (62). – p.28–30. [in Russian]

3. Agafonov E.V. Primenenie mineralnih i bakterialnih udobrenii pod nut na chernozeme obiknovennom v Rostovskoi oblasti [The use of mineral and bacterial fertilizers for chickpeas on ordinary chernozem in the Rostov region] / E.V. Agafonov, E.I. Pugach, K.I. Pimonov // Agrohimiya [Agrochemistry] – 2008. – № 7. – p. 22–30. [in Russian]

4. Balashov V.V. Vliyanie mineralnih udobrenii, predshestvennika i rizotorfina na razvitie simbioticheskogo apparata i urozhainost nuta [Influence of mineral fertilizers, precursor and rhizotorphin on the development of the symbiotic apparatus and chickpea yield] / V.V. Balashov, A.V. Balashov, V.V. Kudinov // Plodorodie [Fertility] – 2016. – № 6 (93). – p. 14–15. [in Russian]

5. Voskobulova N.I. Zernobobovie kulturi v kormoproizvodstve stepnoi zoni Orenburskoi oblasti [Leguminous crops in fodder production in the steppe zone of the Orenbursk region] / N.I. Voskobulova, A.P. Budilov, V.N. Soloveva // Vestnik kormovogo skotovodstva [Bulletin of fodder cattle breeding] – 2017. – №3 (99). – p.202–207. [in Russian]

6. Turusov V.I. Vliyanie biopreparatov associativnih diazotrofov na urozhainost zernovih kultur v usloviyah yugo–vostoka Centralnogo chernozemya [The influence of biological preparations of associative diazotrophs on the yield of grain crops in the conditions of the southeast of the Central Chernozem region] / V.I. Turusov, M.Yu. Sautkina, A.Yu. Cheverdin et al.// Dostizheniya nauki i tehniki APK [Achievements of science and technology of the agro–industrial complex] – 2016. – V.30. – №5. – p. 38–42. [in Russian]

7. Sautkina M.Yu. Influence of biological preparations based on associative on the yield of winter triticale in the conditions of the south–east Central Chernozemic Area / M.Yu. Sautkina, Yu.I. Cheverdin // 6th International Conference on Agriproducts processing and Farming IOP Conf. Series: Earth and Environmental Science. – Volume 422 (2020) 012028 – IOP Publishing – DOI:10.1088/1755–1315/422/1/012028 (6th International Conference on Agriproducts Processing and Farming 17–18 October 2019, Voronezh, Russian Federation)