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Cultivation of leguminous crops of chickpeas and ways to increase the yield and quality of grain in the arid steppe of the Urals

R Sh Japarov, G K Nurgaliyeva, Zh M Gumarova, Sh B Sakhipova and A M Nurgaliyev

West Kazakhstan Agrarian-Technical University named after Zhangir Khan, 51, Zhangir Khan street, Uralsk, 090009, Kazakhstan

E-mail: dzhaparovr84@mail.ru

Abstract. The article discusses the data of field experiments on the cultivation of chickpea with the use of mineral fertilizers and biological products. Chickpea, for the dry steppe of the Ural region of Kazakhstan, is a good drought-resistant crop to ensure stable grain yields with a high protein content. Experiments in 2012-2014 showed that the yield of the crop was in the range from 0.78 t / ha in the control variant to 1.16 t / ha, where the strain H-27 was applied according to the background of the applied fertilizers $N_{20}P_{20}$. From the use of only one strains of the genus Rhizobium, the increase in yield, on average for the options, amounted to 0.17 t / ha (21.7%), according to the background of mineral fertilizers from 0.22 to 0.38 t / ha. In 2015-2017 the yield from the use of mineral fertilizers and microbial preparations increased by 0.74-1.12 t / ha, or by 22-51%. The increase from nitrogen fertilization is 8-12%, from microbial preparations - 6-12%. With the combined use of nitrogen fertilizer and Rhizoagrin or Flavobacterin preparations, the yield increased by almost 50%, as well as with the combined use of microbial preparations. An increase in the protein content of grain is associated with the use of nitrogen fertilization and the use of biological products for inoculating seeds, since these factors improve the nitrogen nutrition of plants.

1. Introduction

Chickpea is a rich source of proteins, carbohydrates, amino acids of dietary fiber and microelements, is an important source of unsaturated fatty acids, mainly linoleic and oleic, is used for the prevention of many diseases, diabetes, has anti-inflammatory and hypocholesterolemic properties, it is also used in medicine [1-2].

For regions prone to drought, the chickpea legume is a good alternative for cultivation. There are early ripening varieties that can be successfully cultivated in arid conditions [3].

Chickpeas are well adapted to the conditions of arid regions with a harsh continental climate. It tolerates drought well, when there is a shortage of soil moisture, it restrains its growth, and when favorable conditions occur, it resumes it. In Northern Kazakhstan [4] chickpea grows even at low relative air humidity (25-33%), which is little for other crops. plants. Due to its well-developed root system and resistance to water deficit, chickpeas have adapted well in the drier regions of the Canadian Prairies [5].

At the Ural Agricultural Experimental Station in 1993-1995 the highest yield of chickpea reached 17.9-25.6 c / ha in favorable years for precipitation and was not inferior to grain crops. In dry years, being a reliable insurance crop, chickpeas exceeded the yield of early spring crops by 2.2-2.8 times [6].

In the studies of the West Kazakhstan Agrarian Technical University named after Zhangir Khan in 1991-1995 [7], chickpeas, when placed after winter crops, surpassed all spring wheat and barley, millet in yield, and in some years they approached their predecessor.

The use of microbial preparations is of great interest in this region for leguminous crops, which will give a better idea of the fixation of nitrogen in the soil and its assimilation by the plant, depending on the soil and climatic conditions [8].

2. Materials and methods

Research in 2012-2014 were carried out in a two-factor field experiment according to the 4 x 6 scheme.

Factor A - pre-sowing application of mineral fertilizers:

1 Control; 2 N_{20} - 20 kg a.i. / ha nitrogen fertilizer; 3 P_{20} - 20 kg a.i. / ha of phosphate fertilizer; 4 $N_{20}P_{20}$ - 20 kg of ai / ha of nitrogen fertilizer and 20 kg of ai / ha of phosphorus fertilizer.

Factor B - seed treatment with strains of nodule bacteria:

1 Without seed treatment; 2 Strain H-18; 3 Strain 527; 4 Strain 065; 5 Strain 522; 6 Strain H-27.

Plants (chickpea variety Yubileiny) were inoculated with industrial strains Rhizobium leguminosarum bv.cicer H-18, 522, 065, 527, and H-27; for cultivation of chickpea nodule bacteria, a liquid nutrient medium based on mannitol was used [9].

Ammonium nitrate (ammonium nitrate, ammonium nitrate) NH_4NO_3. Contains 34.6% nitrate and ammonia nitrogen.

Simple superphosphate (granular superphosphate). The amount of assimilated P_2O_5 is 19.5-22.0%.

In 2015-2017 a microfield experiment was carried out in vessels without a bottom.

The objects of research are the chickpea variety Krasnokutskiy 36. The seeding rate is 700 thousand seeds / ha.

Experience scheme:

1 Control; 2 Background (P_{30} K_{30}) - phosphorus fertilizer 30 kg a.i. / ha and potash fertilizer 30 kg a.i. / ha; 3 P_{30} K_{30} + N_{30} - nitrogen fertilizer 30 kg a.i. / ha; 4 P_{30} K_{30} + Rizotorfin; 5 P_{30} K_{30} + Rizotorfin + N_{30}; 6 P_{30} K_{30} + Flavobacterin; 7 P_{30} K_{30} + Flavobacterin + N_{30}; 8 P_{30} K_{30} + Rizotorfin + Flavobacterin + N_{30}.

The experiment studied the effectiveness of the use of two microbial drugs: Rizotorfin and Flavobacterin and mineral fertilizers: ammonium nitrate, double superphosphate and 60% potassium salt.

Rizotorfin is a preparation of nitrogen-fixing bacteria with fungicidal-stimulating action for pre-sowing treatment of legume seeds, based on effective strains of nodule bacteria Mesorhizobium ciceri.

Flavobacterin is a microbiological preparation created on the basis of a highly effective strain of associative nitrogen fixers, which includes a new bacterial strain from the genus Pseudomonas.

Nitrogen fertilizers were applied at a dose of 1.15 g N / vessel (at the rate of 3 g / m^2), which corresponds to 30 kg / ha. Double superphosphate and potassium salt were used as background in doses equivalent to $P_{30}K_{30}$. The experiment was repeated six times.

In both experiments, the studies were carried out on dark chestnut heavy loamy soil, which is typical for the West Kazakhstan region.

3. Results and Discussion

In the first experiment, the highest yield of chickpea was in 2013, averaging 1.51 t / ha for the options, which is 0.39 t / ha higher in 2014 and 1.04 t / ha in 2012. Differences in yield over the years was associated with the difference in precipitation over the growing season of the crop, which was a high direct correlation dependence.

On average for 2012-2014 (table 1) the yield in the control variant was 0.78 t / ha. For the studied microbial preparations (without fertilizers), the yield, in all variants without exception, ranged from 0.13 t / ha to 0.22 t / ha, with the highest indicator with the 522 strain.

Table 1. Chickpea yield on average for 2012-2014, t / ha.

Fertilizer, A	Strain, B						Average A HCP_{05} = 0.03 t / ha
	Control	H-18	527	065	522	H-27	
-	0.78	0.91	0.95	0.91	1.00	0.97	0.92
N_{20}	1.01	1.05	1.14	1.13	1.11	1.05	1.08
P_{20}	0.96	1.01	1.13	1.06	1.05	1.00	1.03
$N_{20}P_{20}$	1.01	1.07	1.13	1.12	1.13	1.16	1.10
Average B HCP_{05} = 0.07 t / ha	0.94	1.01	1.09	1.05	1.07	1.04	1.04
	To assess partial differences: HCP_{05} A = 0.07 t / ha HCP_{05} B = 0.13 t / ha						

Chickpea responds well to the use of mineral fertilizers, in particular nitrogen fertilizers. In the conditions of the arid climate of Canada, the productivity of the crop has a good relationship with the content of soil nitrogen, the intensity of the accumulation of dry matter from the concentration of nitrates in the soil was noted [10].

According to the background of mineral fertilizers, without microbial preparations, the yield was the same 0.96-1.01 t / ha (to assess the partial differences HCP_{05} B = 0.13 t / ha) and significantly higher than the control option (without fertilizers). Microbial preparations against the background of mineral fertilizers had, without exception, an increase in yield in comparison with the control, and variants N_{20} + 527, P_{20} + 527 and $N_{20}P_{20}$ + H-27 had an increase relative to their backgrounds (with one mineral fertilizer), respectively by 0.13, 0.17 and 0.15 t / ha, showing the maximum yield.

According to the main factor A (fertilization), the yield for backgrounds with N_{20}, P_{20}, and $N_{20}P_{20}$ significantly increased relative to options without fertilizers by 0.16, 0.11 and 0.18 t / ha, respectively.

According to the main factor B (strain), the average yield for options with H-18, 527, 065, 522 and H-27 significantly exceeded the control option (mean B HCP_{05} = 0.07 t / ha) by 0.07, 0, respectively, 15, 0.11 0.13 and 0.10 t / ha, with the highest indicator with strain 527 - 1.09 t / ha.

The maximum protein content in grain can be obtained when the soils are well supplied with nitrogen.

So, on average for research (table 2), it was possible to obtain when using only one strains from 22.8% with H18 to 28.7% from 522, with 21.1% in the control variant. According to the background N_{20} (without preparations), the protein content of grain was 0.8% lower than the control variant, but in general, the collection of crude protein exceeded the standard due to a higher yield.

Table 2. Crude protein content in chickpea grain, on average for 2012-2014.

Fertilizer	Strain					
	Control	H-18	527	65	522	H-27
No fertilizers	21.1	22.8	26.2	26.5	28.7	28.2
N_{20}	20.3	21.5	22.2	20.7	24.3	21.1
P_{20}	22.4	22.6	23.7	22.5	23.1	25.6
$N_{20}P_{20}$	26.0	27.2	25.9	25.2	25.2	23.3

Of the three backgrounds with mineral fertilizers, the best was with the combined use of nitrogen and phosphorus fertilizers, showing 26% of the protein content without a microbial preparation and on average 25.4% for variants with strains, with the highest indicator for the variant with H-18 - 27.2 %.

With the separate application of nitrogen and phosphorus fertilizers with microbial preparations, the protein content was 20.7-24.3% and 22.5-25.6%, respectively.

In the second experiment, conducted in 2015-2017 crop yield (table 3) ranged from 0.74 t / ha with a standard of up to 1.12 t / ha with a full range of mineral fertilizers and biological products.

Table 3. Chickpea yield, 2015-2017.

Option	Productivity, t / ha			
	2015	2016	2017	The average
1.Control	0.68	0.80	0.76	0.74
2. $P_{30}K_{30}$ - background	0.80	0.96	0.95	0.90
3. $P_{30}K_{30} + N_{30}$	0.86	1.02	1.12	1.00
4. $P_{30}K_{30}$ + Rizotorfin	0.88	1.01	1.10	1.00
5. $P_{30}K_{30}$ + Rizotorfin + N_{30}	0.93	1.12	1.16	1.08
6. $P_{30}K_{30}$ + Flavobacterin	0.83	1.00	1.01	0.95
7. $P_{30}K_{30}$ + Flavobacterin + N_{30}	0.86	1.19	1.15	1.07
8. $P_{30}K_{30}$ + Rizotorfin + Flavobacterin + N_{30}	0.95	1.20	1.21	1.12
HCP_{05}=	0.02	0.02	0.02	0.02

The increase in the productivity of chickpea was in close relationship with the mineral nutrition of plants, namely through the use of mineral fertilizers and microbial preparations. Improving the phosphorus-potassium nutrition of plants, due to the introduction of fertilizers, significantly increased the grain yield by 21.6%. The introduction of three macronutrients nitrogen, phosphorus and potassium contributed to a further increase in productivity, which amounted to 35.1%.

The use of the biological product Rizotorfin increased symbiotic nitrogen fixation, which significantly increased the productivity of the culture relative to the background $P_{30}K_{30}$ by 0.10 t / ha or 11.1%. Rizotorfin, against the background of complete application of mineral fertilizer, increased the grain yield relative to the control variant by 0.34 t / ha (45.9%), the increase from nitrogen fertilization was 0.08 t / ha (8.0%). The efficiency of inoculation of chickpea seeds with Flavobacterin was 5.6% against the background of phosphorus-potassium fertilizers and 7.0% - the full application scheme.

The greatest efficiency was shown by the biological product Rizotorfin, showing a significant increase - 35.1%. With the combined use of biological products Rizotorfin and Flavobacterin, the productivity of the culture increased by 0.38 t / ha or by 51.4%.

From the binary use of microbial preparations, the increase in the productivity of chickpea increased by 0.12 t / ha (12.0%) in comparison with the option providing for the introduction of the mineral complex.

The study of nitrogen transformation processes in the soil-fertilizer-plant system is an issue of interest to scientists throughout the world community. Scientists from the People's Republic of China are conducting research on nitrogen uptake in rice paddies and increasing the gross nitrogen transformation ratio [11-12]. In the United States, the teachings use the isotope indication method to study its uptake and assess the retention of N15 in biota tissues [13]. In France, scientists studied the dynamics of the soil nitrogen and carbon cycle after the transformation of agricultural crops. lands from meadow to arable and vice versa, as well as accounting for nitrogen losses from the transformation of such systems [14-15].

Chickpea plants use 32-35% of nitrogen from the applied fertilizer dose for crop formation. The maximum utilization factor of nitrogen was obtained with binary inoculation of seeds with Rizooagrin and Flavobacterin, separate inoculation of seeds with these biological products provides a tendency to decrease the utilization factor of nitrogen by plants for crop formation.

Biological products increase the fixation of fertilizer nitrogen in the soil from 35 to 39-43% of the applied fertilizer dose. The maximum fixation of nitrogen in the soil occurs during binary inoculation of seeds. In the same variant, minimal unaccounted losses of fertilizer nitrogen are observed, which is associated with an increase in its use for the formation of a crop and a greater fixation in the soil, which is undoubtedly a positive fact from an ecological point of view.

When forming the harvest of chickpea, the main share of nitrogen belongs to soil nitrogen - 51-59%. When applying nitrogen fertilizer under chickpeas, its share in the formation of the crop is 11-13%. When seeds are inoculated with biological products, the proportion of symbiotic nitrogen in the removal is 18-25%, while as a result of the use of Rizotorfin, the amount of biological nitrogen increased by 4-7%. The share of "extra" - nitrogen, formed when nitrogen fertilization was introduced into the soil, in the formation of the crop when using Rhizoagrin reached 11-13%, and against the background of seed inoculation With flavobacterin, its share increased to 20%, which is probably due to additional mineralization of soil nitrogen.

The protein content of chickpea grain (table 4) increased from the control in all variants without exception, which was ensured by the introduction of the main macroelements into the soil and the use of biological products. The highest content of crude protein was in 5, 7 and 4 variants, respectively, 28.5%, 28.2% and 28.0%, while the control was 25.9%. This trend was observed, practically, during the three years of the study.

Table 4. Crude protein content in chickpea grain, on average for 2015-2017.

Option	Years of research			
	2015	2016	2017	The average
1.Control	25.4	26.0	26.4	25.9
2. $P_{30}K_{30}$ - background	25.2	26.1	27.3	26.2
3. $P_{30}K_{30}$ + N_{30}	26.3	26.7	28.5	27.2
4. $P_{30}K_{30}$ + Rizotorfin	28.2	27.0	28.8	28.0
5. $P_{30}K_{30}$ + Rizotorfin + N_{30}	27.3	27.7	30.4	28.5
6. $P_{30}K_{30}$ + Flavobacterin	26.2	26.7	28.7	27.2
7. $P_{30}K_{30}$ + Flavobacterin + N_{30}	26.5	27.8	30.2	28.2
8. $P_{30}K_{30}$ + Rizotorfin + Flavobacterin + N_{30}	26.8	27.2	29.8	27.9

4. Conclusion

In the conditions of Western Kazakhstan, chickpeas are capable of producing stable yields, even in severely arid years, as in 2012 (table 1). The use of microbial preparations, mineral fertilizers, and their joint use significantly increased the yield of the crop and improved the quality of grain.

The best and recommended options in the experience for 2012-2014. were strain H-27 both separately and according to the background of the combined application of nitrogen and phosphorus fertilizers, showing a yield of 1.16 t / ha.

The use of microbial preparations alone increased the yield by 0.13-0.19 t / ha relative to the control variant. The use of strains separately according to backgrounds with nitrogen and phosphorus fertilizers increased, respectively, by 2.7-3.6 t / ha and 2.2-3.5 t / ha, the combined use of fertilizers and preparations by 2.9-3.8 t / ha.

The protein content in grain was highest when using only one microbial preparation.

The yield of chickpea in the second experiment, due to the introduction of mineral fertilizers and microbial preparations, increased by 22–51%. The additions from nitrogen fertilization ranged from 8 to 12%, from biological products from 6 to 12%. With the combined use of nitrogen fertilizer and biological products Rizotorfin or Flavobacterin, the productivity of the culture increased by 45–46%, and from the combined use of biological products - by 51%. Against the background with phosphorus-potassium fertilizer, the effect of using Rizotorfin was 35%, Flavobacterin - 28%.

Summing up, we can conclude that the introduction of phosphorus is recommended to obtain 1 t / ha of chickpea grain. Potash and nitrogen fertilizers at a dose of 30 kg ai / ha or the use of microbial preparations Rizotorfin or Flavobacterin, as well as their mixtures.

The culture uses up to 32–35% of nitrogen from the applied fertilizer. The highest coefficient was obtained with the combined use of Rizotorfin and Flavobacterin, the separate use of biological products leads to a decrease in the coefficient of nitrogen utilization by plants for crop formation.

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Study of the transformation of nitrogen in mineral fertilizers on the grain-legume crop Cicer Arietinum L by the method of isotope indication State no. registration 0115PK01771.

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