

INFLUENCE OF MICROBIAL FERTILIZERS ON MORPHOLOGICAL, PHYSIOLOGICAL AND VALUABLE ECONOMIC CHARACTER OF CHICKPEA (*CICER ARIETINUM* L.)

¹Farrukh Matkarimov, ²Oybek Kholliyev, ³Abdulla Faizullaev, ⁴Oygul Raulova, ⁵Dilafroz Kulmamatova and ⁶Saidmurat Baboev

¹PhD student, Institute of Genetics and Plant Experimental Biology, Academy of Sciences of Uzbekistan

² PhD student, Institute of Genetics and Plant Experimental Biology, Academy of Sciences of Uzbekistan

³ Senior Researcher, Institute of Genetics and Plant Experimental Biology, Academy of Sciences of Uzbekistan

⁴Teacher, Chirchik State Pedagogical University, Uzbekistan

⁵Head of laboratory, Institute of Genetics and Plant Experimental Biology, Academy of Sciences of Uzbekistan

⁶Professor, Institute of Genetics and Plant Experimental Biology, Academy of Sciences of Uzbekistan

To Cite this Article

Farrukh Matkarimov, Oybek Kholliyev, Abdulla Faizullaev, Oygul Raulova, Dilafroz Kulmamatova and ⁶Saidmurat Baboev” INFLUENCE OF MICROBIAL FERTILIZERS ON MORPHOLOGICAL, PHYSIOLOGICAL AND VALUABLE ECONOMIC CHARACTER OF CHICKPEA (*CICER ARIETINUM* L.)” *Musik In Bayern*, Vol. 89, Issue 10, Oct 2024, pp1-17

Article Info

Received: 30-09-2024 Revised: 08-10-2024 Accepted: 20-10-2024 Published: 30-10-2024

Abstract: A field experiment was conducted to study the effects of *Rhizobium* 3 , *Rhizobium* 9 and PlantaStim microbial fertilizers on the morphological, physiological and valuable economic characters of chickpea (*Cicer arietinum* L.). All samples treated with microbial fertilizers showed positive results compared to the control variation. Efficiency of *Rhizobium* 3, among the microbial fertilizers, was

higher. In the chickpea samples, treatment with *Rhizobium 3* increased the total chlorophyll content by 14.91%, carotenoid content by 20%, plant biomass by 31.39%, grain number by 19.37%, productivity by 27.25%, total protein content by 25.29%, and amount of nodule by 2.07 times, compared to the control variation.

Keywords: chickpeas, microbial fertilizer, chlorophyll, carotenoid, transpiration rate, productivity elements

INTRODUCTION

Global climate change is causing water scarcity in many territories of the world. Ensuring the food security of the population requires the wide implementation of high caloric crop types which are resistant to drought. Chickpea plant is considered as one of such crops (Field CB, 2014). The annual production of chickpeas worldwide reaches up to 15.0 million tons. Herein India's makes up 73% (FAOSTAT). There are mainly two types of chickpeas in the market. They are Kabuli and Desi.

Desi is cultivated in 75% of the whole chickpea cultivation area in the world, and 25% of the area belongs to Kabuli ecotype [Kassie M., 2009]. Chickpea plant has types with large, small and medium sized seeds, with different colors. According to the size of seeds, they are divided into 2 groups: large-grained (12 x 9 mm) and small-grained types. The kabuli type of chickpeas has large white grains, while the grains of desi type plant are small, dark in colour (Adams Frimpong, 2009).

Chickpea plant grain occupies an important place in the human diet. It contains protein, carbohydrate, folate, β -carotene, minerals, vitamins and fatty acids necessary for human health (Jukanti 2012).

A number of microbial fertilizers are used in the cultivation of legumes. One of these are microbial fertilizers based on *Rhizobium strains*.

Rhizobium bacteria is effective in increasing the yield of leguminous plants and soil fertility . It is advisable to use bacterial fertilizers with the most active strains of the nodule bacteria on leguminous (mung bean, soybean, bean, lentil, pea) crops [Zahran, HH, 1991].

When microbial fertilizers are used in the cultivation of leguminous crops, the microflora that mobilizes nitrogen, phosphorus and potassium in the soil is activated. As a result, the plant will be able to get the nutritional minerals it needs, not only during the application period, but also during the entire vegetation period (Sytnikov D. M. 2012).

Growth and development of leguminous plants is improved and productivity increases when they are treated with plant growth-accelerating rhizobacteria compared to the treatment of leguminous plants with *Rhizobium bacteria* separately [Dardanelli MS, 2008, Yadegari M., 2010]. Microbial fertilizers obtained on the basis of azotobacters increase the germination of seeds and absorption of nutrients in plants . Moreover, it accelerates the synthesis of protein and amino acids, benefits the growth of crops and helps restore soil fertility [Arjun Dev Jnawali 2015].

Application of *Rhizobium* and *Azotobacter* strains together on chickpea plants increased the amount of nitrogen in the roots and grain yield as well [Anvar Abdiev, 2019; Anis Siddiq, 2014].

In addition, there are microbial fertilizers obtained on the basid of Trichoderma fungi types. Trichoderma species are symbiotically associated with the apoplastic part of plant roots and directly affect the plant. It has a positive effect on the germination of seeds, absorption of substances and increases productivity [Bansh Narayan Singh 2015].

Microbial fertilizers affect physiological and biochemical processes in plants, improve plant growth and development, and serve to increase crop productivity. Based on this, the aim of the research is to study the effect of microbial fertilizers on the change of the morphophysiological and valuable economic characteristics of the chickpea plant.

MATERIALS AND METHODS

Malkhotra variety of Chickpea (*Cicer arietinum* L.) seed was used in the field experiments. *Rhizobium* 3 and *Rhizobium* 9 preparations were obtained from the collection of the Department of Microbiology and Biotechnology, National University of Uzbekistan. *PlantaStim* (*Trichoderma Lignorum*) was obtained from private company of AnGuzal Agroservice, Uzbekistan.

Field experiments were conducted in 2021 and 2022 to study the effect of *Rhizobium* 3, *Rhizobium* 9 and *PlantaStim* on growth, nodulation and yield of Chickpea (*Cicer arietinum* L.) at the Institute of Genetics and Plant Experimental Biology, Kibray, Tashkent region, Uzbekistan. In the experiments randomized block design was used with three replications, in a plot of 10 m² with a row spacing of 30 cm and a plant spacing of 10 cm was used. Experimental treatments included a non-inoculated control, inoculated with *Rhizobium* 3, *Rhizobium* 9 and *PlantaStim*.

The soil of the area where the field experiments were conducted is considered to be irrigated gray soil, the humus content is 0.8-1.2%, and the level of availability of mobile phosphorus is on average 30-38 mg/kg [Kulmamatova DE, 2022].

In the Malkhotra variety of chickpea, physiological indicators were determined during the period of general flowering of plants.

Extraction and determination of pigment concentration: Amount of pigments in leaves of chickpea plant samples were determined in the experiment, i.e. 3-4 leaves, calculating from the glineth point. Fifty milligrams of each leaf sample, placed in a test tube, obtained homogenization in 5 ml of 95% ethyl alcohol solution (Lichtenthaler and a Wellburn, a 1983). The homogenization underwent centrifugation at a speed of 5000 rpm for 12 min. The amount of chlorophyll *a*, *b* and carotenoids in the resulting extract attained determination by an Agilent Cary 60 UV-Vis spectrophotometer at 664, 649 and 470 nm. Based on these indicators, the

following equations were used in calculating the amounts of chlorophyll *a*, *b* and carotenoids in chickpea leaves [Nayek et al., 2014]:

$$\text{Ch-a} = 13.36A_{664} - 5.19 A_{649}$$

$$\text{Ch-b} = 27.43A_{649} - 8.12 A_{664}$$

$$C_{x+c} = (1000A_{470} - 2.13C_a - 97.63C_b) / 209$$

Transpiration rate was determined according to Ivanov's method [Ivanov A.A. et.al, 1950], water holding capacity was determined with the method by Kushnirenko [Kushnirenko M.D. et al, 1970], and Tretyakov's method [Tretyakov N.N. et.al, 1990] was used in determining the total amount of water in leaves.

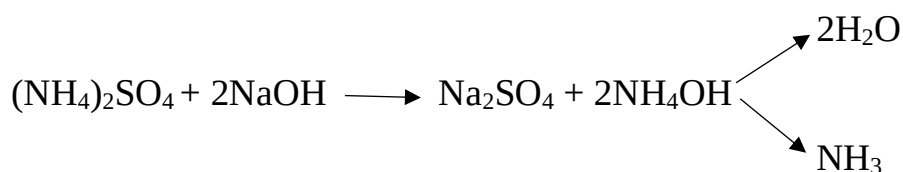
Harvest index was calculated according to the following formula:

$$\text{Harvest index}(\%) = \frac{\text{Seed yield}}{\text{Biological yield}} \times 100$$

Determination of nitrogen and total protein contents. Kjeldahl is one of the methods used to determine the amount of total proteins. According to this method, the total calculated protein has the amount of nitrogen determining it. The essence of the process is to hydrolyze the organic substances in the sample with the help of concentrated sulfuric acid (amine groups in the protein) to form ammonium sulfate salts.



After completing the hydrolysis, the ammonium sulfate formed receives treatment with sodium hydroxide to convert it to ammonia.



Ammonia or ammonium hydroxide formed, after neutralization, assimilates into the sulfuric acid solution. The remaining acid gets titrated with an alkaline solution. Estimating the amount of nitrogen from the amount of ammonia calculated

followed. An accurate sample for analysis came from the average crushed homogeneous specimen of the studied material in a test tube; the error rate should not exceed 0.1%. The sampling progressed to quantitate in a Kjeldahl flask. Later, the experiment advanced according to the protocol and instructions of Metody Kontrolya (Chemical Factors, 2004).

Processing of the obtained results. The mass fraction of nitrogen (X) in the analyzed sample for calculation used the formula as a percentage of the mass of the specimen by the volume after the titration of the amount of ammonia that has passed through the diluted sulfuric acid.

$$X = \frac{(V_1 - V_0) \times K \times 0,0014 \times 100}{M}$$

The volume of 0,1 mol/l sodium hydroxide solution served to titrate the remaining 0.1 mol/l sulfuric acid solution in sample experiment vo, ml

The obtained data were analyzed on the statistical software ANOVA STATGRAPHICS-18 (www.statgraphics.com).

The research was carried out in order to study the effect of microbial fertilizers on changes in photosynthetic pigments, water balance, morphological characters, productivity elements in chickpea plants.

RESULTS AND DISCUSSIONS

When photosynthetic pigments in leaves were analyzed, the chickpea plants, which were inoculated with microbial fertilizers, showed higher results than the control variation (Figure 1). In this case, the amount of chlorophyll *a* increased by 7.29 (10.94%), the amount of chlorophyll *b* by 12.05 (24.10%), the total amount of

chlorophyll by 7.72 (14.91%) and the amount of carotenoids by 15, 55 (20%) as well. No difference was observed between the amounts of photosynthetic pigments in samples treated with *Rhizobium 9* and *PlantaStim* microbial fertilizers. The

samples, which were treated with *Rhizobium 3*, chlorophyll *a*, chlorophyll *b*, total chlorophyll, and carotenoid, showed the highest indicators.

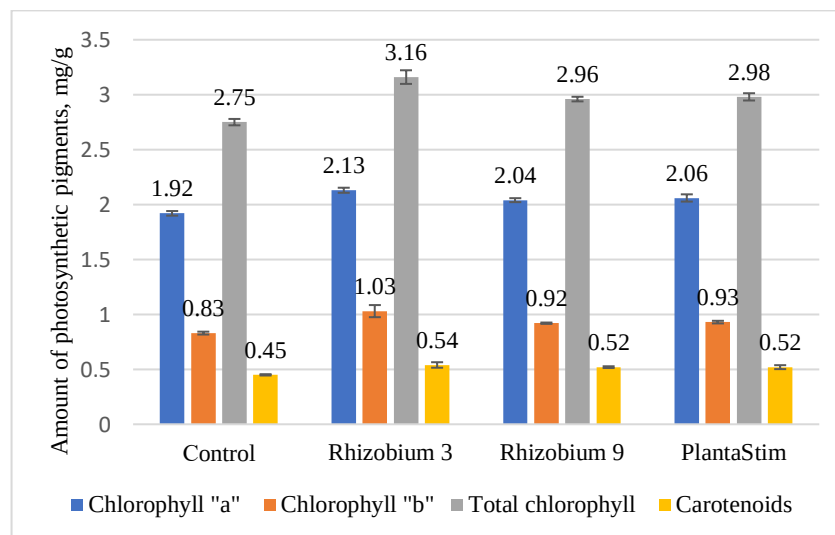


Figure 1. The effect of microbial fertilizers on changes in the amount of photosynthetic pigments in chickpea plants

Changes in the rate of photosynthesis are directly related to the photosynthetic pigments in chloroplasts [Maisura]. These pigments affect the growth and development of the plant [Taiz]. A number of abiotic factors influence the change in the amount of photosynthetic pigments. The decrease in the amount of chlorophyll in the leaves of plants is mainly observed in conditions of salinity stress [Saqib, Z. A 2012], heat stress [Sangwan, S., 2012], water stress (soil waterlogging) [Amri M., 2014] and water shortage [Alaei, Y. 2011].

Mineral fertilizers, especially nitrogen fertilizers, play an important role in increasing the amount of chlorophyll in plant leaves. A high chlorophyll content results in a high yield [Skudra]. Moreover, a number of microbial fertilizers also cause changes in the amount of photosynthetic pigments in leaves. In soybean,

Rhizotorphin microbial fertilizer [Tsvetkova, Yu], in green pea (*Pisum sativum*), microbial fertilizer obtained from T42 strain of *Trichoderma asperellum* [Bansh Narayan Singh 2015] and in mung bean *Rhizobium* 3 and *Rhizobium* 9 [Matkarimov

2024] increased chlorophyll and carotenoids content up to 10.91%-14.08% respectively.

Influence of microbial fertilizers on the physiological processes as transpiration rate, total amount of water in leaves, water retention property, which are related to water exchange in chickpea plant, was comparatively analyzed (Table 1). According to the results of the analysis, the transpiration rate in the leaves of chickpea plants, treated with *Rhizobium* 3 and *Rhizobium* 9, did not differ significantly from the control variations. It helped to partially increase the total amount of water in leaves and water retention property.

In the samples, treated with *PlantaStim*, the transpiration rate increased by 9.95%, and the total amount of water in leaves and water retention property decreased partially. In the process of transpiration, the increase of absorption of water and mineral substances, with the help of root hairs, and evaporation from the leaves, lead to decrease in temperature and prevent overheating of the leaves [Sagdiev M.T., 2007].

Table 1

The effect of microbial fertilizers on physiological processes related to water exchange in chickpea plants

	Transpiration rate (mg H ₂ O /1 g. wet leaf x 1 hour)	Total amount of water in leaves, %	Water retention property, %
Monitor	277.33 ± 5.48	80.87 ± 0.33	31.09 ± 0.28
<i>Rhizobium</i> 3	279.75 ± 7.16	81.37 ± 0.28	30.16 ± 0.18
<i>Rhizobium</i> 9	280.26 ± 5.25	80.99 ± 0.31	30.23 ± 0.22

PlantaStim	304.93 ± 8.16	79.21 ± 0.20	32.37 ± 0.52
------------	---------------	--------------	--------------

Height of one plant 83.47 ± 0.91 cm in control variations, and under variations treated with *Rhizobium 3*, *Rhizobium 9* and *PlantaStim* was 86.47 ± 0.57 cm, 85.33 ± 0.88 and 84.07 cm respectively (Fig. 2). There wasn't noted significant

difference in plant height among the variations. However, the highest value was detected under the variation treated with *Rhizobium 3*, and it was 3.59% higher than control variation.

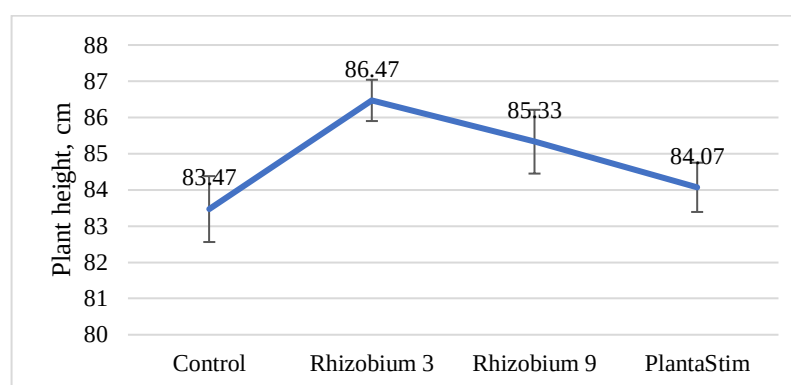


Figure 2. Effect of microbial fertilizers on plant height of pea plants

Plant height and branching are important morphological characteristics of chickpea plant [Taspaev N.S. 2018]. Primary and secondary branching is considered to be one of the main morphological characters in chickpea plant. It was observed that the number of main branches of one plant was from 3.20 ± 0.14 to 3.33 ± 0.13 , and the number of side branches was from 14.87 ± 0.40 to 15.47 ± 0.31 . The highest rate was found under the variation treated with *Rhizobium 3* (Fig. 3).

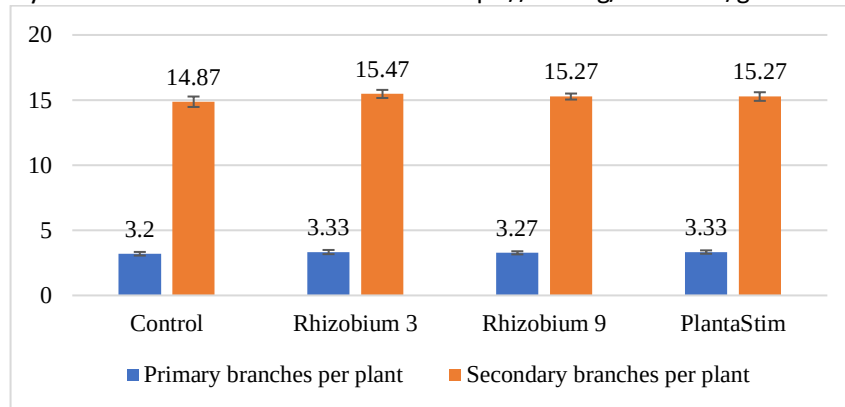


Figure 3. Effect of microbial fertilizers on branching of chickpea plants

Chickpea is a plant with a deep and strong root system, which forms nodules in the roots together with *Rhizobium bacteria*. These nodules have the property of fixing atmospheric nitrogen in a useful form for the plant. In chickpea, nodulation

begins approximately one month after germination [Gaur PM 2010]. The number of nodules was higher in chickpea plant samples treated with microbial fertilizers as *Rhizobium 3* and *Rhizobium 9* compared to control variation and *PlantaStim* microbial fertilizer (Fig. 4). In this case, the nodule mass per plant during the general flowering phase was 2.22 ± 0.05 g. and 2.21 ± 0.05 g. in the control variation and plants treated with *PlantaStim*, respectively, and in the samples treated with *Rhizobium 3* and *Rhizobium 9* the nodule mass was 4.60 ± 0.17 g and 3.84 ± 0.09 g, respectively. The root nodule mass in the treated samples with *Rhizobium 3* and *Rhizobium 9* was 2.07 and 1.73 times higher than in the control variety, respectively (Fig. 5). An increase in nodule mass in the root of a chickpea plant leads to an increase in nitrogen fixation [Wadisirisuk, 1985]. It has been found that treating mung bean plants with *Rhizobium 3* and *Rhizobium 9* microbial fertilizers has a positive effect on the formation of root nodules, growth and development [Matkarimov 2019].



Figure 4. Formation of nodules in chickpea plants as a result of the effect of microbial fertilizers.

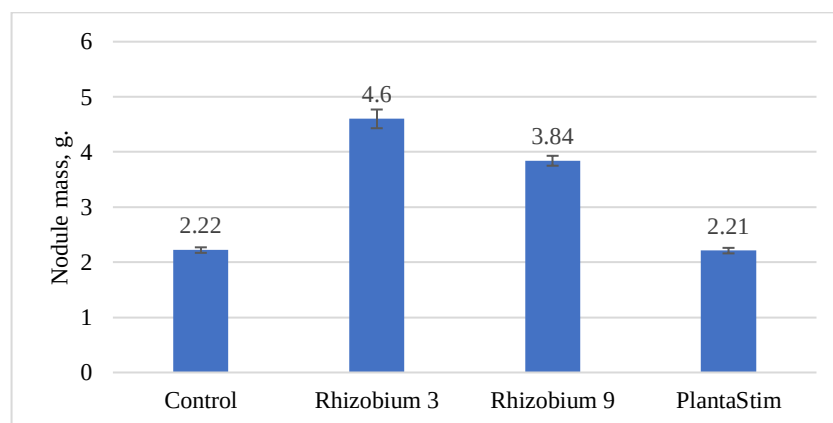


Figure 5. Effect of microbial fertilizers on changes in nodule mass in chickpea plants

Increasing crop productivity in agriculture is of great importance. In the framework of the research, valuable economic characteristics such as biomass per plant, number of pods per plant, number of grains per plant, pods weight per plant,

grain weight per plant, 100-seed weight, grain yield ($1 \text{ m}^2/\text{g}$), harvest index and total protein quantity were analyzed (Table 2).

Table 2

Effect of microbial fertilizers on valuable economic characteristics of chickpea plant

	Control	<i>Rhizobium 3</i>	<i>Rhizobium 9</i>	PlantaStim
Biomass per plant, g.	53.74±1.79	70.61±1.65	63.68±1.19	58.57±1.57
Number of pods per plant	68.20±2.05	76.80±1.46	73.40±0.86	70.67±1.46
Number of grains per plant	75.73±1.80	90.4±2.09	88.20±1.47	84.87±1.3
Pod weight per plant, g.	35.93±1.06	40.12±1.02	38.04±0.80	37.36±0.70
Grains weight per plant, g.	24.04±0.56	30.31±0.68	28.30±0.66	28.33±0.43
100-seed weight	33.07±0,54	33.68±0,41	33.15±0,48	33,41±0,61
Grain yield, g. (1 m^2)	315.16±9,1	401.04±8,6	376.48±9,4	377.88±10,7
Total protein content, %	21.43	26.8 5	24.13	23.37
Harvest index	45.08	43.06	44,42	44.60

The above-ground dry biomass indicator of the chickpea in one plant was 53.74±1.79 g in control variation, and in the samples treated with *Rhizobium 3*, *Rhizobium 9* and *PlantaStim*, this indicator showed 70.61±1.65 g, 63.68±1.19 g and 58.57±1.57 g, respectively. The main yield elements as the number of pods per plant, the number of grains, the weight of pods and the weight of grains per plant were 68.20±2.05 pcs, 75.73±1.80 pcs, and 35.93±1.06 g, and 24.04±0.56 g, respectively. These indicators were higher in all variations treated with microbial fertilizers than the control variation. The grain weight of the plant is of great importance in obtaining high yield [S.V. Bulyntsev]. The main components that improve grain yield in chickpea plants are plant biomass, grain number and grain weight [Kulmamatova, D.E. 2023]. According to the results of the experiment the weight of 100 grains made up 33.07 - 33.68 g. Grain weight of the samples treated with microbial fertilizers increased slightly. The grain yield per 1 m^2 under the control

variety was 315.16 g, whereas, in the samples treated with *Rhizobium 3*, *Rhizobium 9* and *PlantaStim* was 401.04 g, 376.48 g, and 377.88 g, respectively. The highest rate was observed in the samples treated with *Rhizobium 3* and the yield was 27.25% higher than in the control variation. The total amount of protein in the grain was between 21.43 and 26.85%. Also, the highest rate was observed in the samples treated with *Rhizobium 3*, and the yield was 25.29% higher than in the control variety. The harvest index was 43.06 - 45.08. Higher biomass in the samples treated with microbial fertilizers led to a partial decrease in the yield index.

In the chickpea samples grown under field conditions, higher total water amount, number of photosynthetic pigments, root nodules and yield elements in the leaves treated with *Rhizobium 3* and *Rhizobium 9* microbial fertilizers, as well as increased transpiration rate, photosynthetic pigment content and yield elements in the samples treated with *PlantaStim* had a significant positive effect on the productivity of the plant, compared to the control variation.

During the selection process, in cultivation of chickpea, *Rhizobium 3* , *Rhizobium 9* and *PlantaStim* microbial fertilizers have a positive effect on the morphological, physiological characteristics of the plant, as well as the valuable economic characteristics, and serve to increase crop productivity.

REFERENCES:

1. Abdiev, A., Khaitov, B., Toderich, K., & Park, K. W. (2019). Growth, nutrient uptake and yield parameters of chickpea (*Cicer arietinum* L.) enhance by *Rhizobium* and *Azotobacter* inoculations in saline soil. *Journal of Plant Nutrition*, 42(20), 2703-2714.
2. Alaei, Y. (2011). The effect of amino acids on leaf chlorophyll content in bread wheat genotypes under drought stress conditions. *Middle-East J. Sci. Res*, 10(1), 99-101.

3. Amri, M., El Ouni, M. H., & Salem, M. B. (2014). Waterlogging affect the development, yield and components, chlorophyll content and chlorophyll fluorescence of six bread wheat genotypes (*Triticum aestivum* L.). *Bulg. J. Agric. Sci*, 20(3), 647-657.
4. Dardanelli, M. S., de Cordoba, F. J. F., Espuny, M. R., Carvajal, M. A. R., Díaz, M. E. S., Serrano, A. M. G., & Megías, M. (2008). Effect of *Azospirillum brasilense* coinoculated with *Rhizobium* on *Phaseolus vulgaris* flavonoids and Nod factor production under salt stress. *Soil Biology and Biochemistry*, 40(11), 2713-2721.
5. FAOSTAT. Food and Agriculture Organization of the United Nations. Rome: FAO. 2022. Available online at: <https://www.fao.org/faostat/en/#data>
6. Field, C. B., & Barros, V. R. (Eds.). (2014). *Climate change 2014–Impacts, adaptation and vulnerability: Regional aspects*. Cambridge University Press.
7. Frimpong, A., Sinha, A., Tar'an, B., Warkentin, T. D., Gossen, B. D., & Chibbar, R. N. (2009). Genotype and growing environment influence chickpea (*Cicer arietinum* L.) seed composition. *Journal of the Science of Food and Agriculture*, 89(12), 2052-2063.
8. Gaur PM, Tripathi S, Gowda CLL, Ranga Rao GV, Sharma HC, Pande S and Sharma M. 2010. Chickpea Seed Production Manual. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 28 pp.
9. Ivanov, L. A., Silina, A. A., & Tsel'niker Yu, L. (1950). O metode bystrogo vzveshivaniya dlya opredeleniya transpiratsii v estestvennykh usloviyakh [On the Method of Rapid Weighing to Determine the Transpiration under the Natural Conditions]. *Botanicheskiy zhurnal*, 35(2), 171-185.
10. Jnawali, A. D., Ojha, R. B., & Marahatta, S. (2015). Role of *Azotobacter* in soil fertility and sustainability—a review. *Adv. Plants Agric. Res*, 2(6), 1-5.

11. Jukanti, A. K., Gaur, P. M., Gowda, C. L. L., & Chibbar, R. N. (2012). Nutritional quality and health benefits of chickpea (*Cicer arietinum* L.): a review. *British Journal of Nutrition*, 108(S1), S11-S26.
12. Kassie M., Shiferaw B., Asfaw S. et al. Current situation and future outlooks of the chickpea subsector in Ethiopia. – Nairobi: ICRISAT, 2009. – 43 p.
13. Kushnirenko, M. D., Goncharova, E. A., & Bondar, E. M. (1970). Metody izucheniya vodnogo obmena i zasukhoustoychivosti plodovykh rasteniy [Methods for studying water metabolism and drought tolerance of fruit plants]. *Kishinev: AS MSSR. [in Russian]*.
14. Lichtenthaler, H. K., & Wellburn, A. R. (1983). Determinations of total carotenoids and chlorophylls a and b of leaf extracts in different solvents. *J. Biochem. Soc. Trans.* 11:591-592.
15. Maisura, Maisura, et al. "Some physiological character responses of rice under drought conditions in a paddy system." *J. ISSAAS* Vol. 20, No. 1:104-114 (2014)
16. Matkarimov F., Xakimov A., Rasulova O., Tuxtayev D., Qulmamatova D., Baboyev S. (2024). Mikrobiologik o'g'itlarning mosh (*Vigna radiate* L.) o'simligidagi fotosintetik pigmentlar miqdoriga ta'siri. Oziq ovqat xavfsizligi: Milliy va global muommolar ,(2), 60-64.
17. Matkarimov, F., Jabborova, D., & Baboev, S. (2019). Enhancement of plant growth, nodulation and yield of mungbean (*Vigna radiate* L.) by Microbial Preparations. *International Journal of Current Microbiology and Applied Sciences*, 8(08), 2382-2388.
18. Nayek, S., Choudhury, I.H., Jaishee, N., Roy S. 2014. Spectrophotometric analysis of chlorophylls and carotenoids from commonly grown fern species by using various extracting solvents. *Res. J. Chem. Sci.* 4:63-69.
19. Qulmamatova D.E., Baboev S.K. and Buronov A.K. Genetic variability and inheritance pattern of yield components through diallel analysis in spring wheat. *SABRAO Journal of Breeding and Genetics* 54 (1) 21-29, 2022

20. Qulmamatova, D. E. Chickpea (*Cicer arietinum* L.) genotypes evaluation for high yield through multivariate analysis. *SABRAO Journal of Breeding and Genetics* 55 (1) 107-114, 2023 <http://doi.org/10.54910/sabrao2023.55.1.10>
21. Sangwan, S., Ram, K., Rani, P., & Munjal, R. (2018). Effect of terminal high temperature on chlorophyll content and normalized difference vegetation index in recombinant inbred lines of bread wheat. *Int. J. Curr. Microbiol. App. Sci*, 7(6), 1174-1183.
22. Saqib, Z. A., Akhtar, J., Ul-Haq, M. A., Ahmad, I., & Bakhat, H. F. (2012). Rationality of using various physiological and yield related traits in determining salt tolerance in wheat. *African Journal of Biotechnology*, 11(15), 3558-3568.
23. Siddiqui, A., Shivle, R., Magodiya, N., & Tiwari, K. (2014). Mixed effect of *Rhizobium* and *Azotobacter* as biofertilizer on nodulation and production of chick pea, *Cicer arietinum*. *Biosci. Biotech. Res. Comm*, 7(1), 46-49.
24. Singh, B. N., Singh, A., Singh, G. S., & Dwivedi, P. (2015). Potential role of *Trichoderma asperellum* T42 strain in growth of pea plant for sustainable agriculture. *J. Pure Appl. Microbiol*, 9(2), 1069-1074.
25. Skudra, I., & Ruza, A. (2017). Effect of nitrogen and sulphur fertilization on chlorophyll content in winter wheat. *Rural sustainability research*, 37(332), 29-37.
26. Taiz, L., & Zeiger, E. (2006). *Plant physiology* 4th ed., Sinauer Associates Inc. Publishers, Massachusetts. 2006. pp.126-128.
27. Wadisirisuk, P., & Weaver, R. W. (1985). Importance of bacteroid number in nodules and effective nodule mass to dinitrogen fixation by cowpeas. *Plant and Soil*, 87, 223-231.
28. Yadegari, M., & Rahmani, H. A. (2010). Evaluation of bean (*Phaseolus vulgaris*) seeds' inoculation with *Rhizobium phaseoli* and plant growth promoting

- rhizobacteria(PGPR) on yield and yield components. *African Journal of Agricultural Research*, 5(9), 792-799.
- 29.Zahran, H. H. (1991). Conditions for successful Rhizobium-legume symbiosis in saline environments. *Biology and Fertility of Soils*, 12, 73-80.
- 30.Bulyansev, S.V., Novikova, L. Y.U., Gridnev, G. A., & Sergeyev, Ye. A. (2015). Korrelyatsionnye svyazi selektsionnykh priznakov, opredelyayushix produktivnost obrazsov nuta (Cicer arietinum L.) iz kolleksii VIR v usloviyax Tambovskoy oblasti. *Selskoxozyaystvennaya biologiya*, (1), 63-74.
- 31.Sagdiyev M.T., Alimova R.A.. O'simliklar fiziologiyasi. // O'quv qo'llanma. – Toshkent. Yangiyo'l poligraf servis. 2007. 33 – bet.
- 32.Sytnikov, D. M. (2012). Biotexnologiya mikroorganizmov azotfiksatorov i perspektivy primeneniya preparatov na ix osnove. *Biotechnologia Achta*, 5(4), 034-045.
- 33.Taspayev N.S. Produktivnost nuta v zavisimosti ot srokov poseva, norm vyseva i udobreniy na kashtanovyx pochvax saratovskogo zavoljya // Dissertatsiya.2018.-str 83
- 34.Tretyakov, N. N., Karnauxova, T. V., & Panichkin, L. A. (1990). Praktikum po fiziologii rasteniy.–3-ye izd., dop. i pererab. M.: Agropromizdat,–1990.–271 s.
35. Svetkova, YU. V., Lyashko, M. U., & Strajnikova, I. I. (2020). Vliyaniye primeneniya inokulyanta “Rizotorfin” na sodержaniye xlorofilla v listyax introdutsirovannykh sortov soi i ix uroжайnost. *Vestnik Rossiyskogo universiteta drujby narodov. Seriya: Agronomiya i zhivotnovodstvo*, 15(1), 7-18.
- 36.Руководство, Р. "4.1. 1672-03 «Руководство по методам контроля качества и безопасности биологически активных добавок к пище»." М.: Федеральный центр Госсанэпиднадзора Минздрава России 240 (2004).