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Effect of rhizobium on growth and yield of chickpea (*Cicer arietinum*): A review

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Abstract
The multiplicity of beneficial effects of soil microorganisms, particularly plant growth promotion (PGP), highlights the need to further strengthen the research and its use in modern agriculture. Rhizobia are considered as PGP comes in symbiosis with legumes taking advantage of nutrients from plant root exudates. When interacting with legumes, rhizobia help in increased plant growth through enriching nutrients by nitrogen fixation, solubilizing phosphates and producing phytohormones, and rhizobia can increase plants' protection by influencing the production of metabolites, improve plant defense by triggering systemic resistance induced against pests and pathogens. In addition, rhizobia contain useful variations to tolerate abiotic stresses such as extreme temperatures, pH, salinity and drought. The search for rhizobium tolerant strains is expected to improve plant growth and yield, even under a combination of constraints.

Keywords: Chickpea, rhizobium, yield

Introduction
Increasing of population coupled with climate change is posing a great threat to the crop production, especially in arid regions. Uzbekistan is located in an arid region with harsh climate encountering hot summer and cold snowy winter weather. Almost 60% irrigated crop fields in Uzbekistan have a different level of soil salinity. Depleted soil with low nitrogen (N) content and salinity are the limiting factors of chickpea production in Uzbekistan. Chickpea (*Cicer arietinum* L.) is a one of the essential legume food crops which contains valuable nutrients with the high amount of protein (24%) and oil (7%) in the seed. New chickpea varieties with high yield potential and salt tolerant ability have been released, however many farmers still continue to grow locally available old varieties in conjunction with poor agronomic management practices. Furthermore, natural and anthropogenic factors such as salinity, drought, lack of nutrients availability and rhizobial strains in the soil deteriorating chickpea production in the area. There is an urgent need to implement new management technologies for increasing grain yield and quality of chickpea. Legume-rhizobium symbiotic N fixation is the most important biological function by providing fixed N to the plants, and also plays a critical role in improving soil N fertility. Chickpea fixes atmospheric N biologically if they form nodules with appropriate Rhizobium available in the soil. Previous studies have shown that when legumes are inoculated with appropriate Rhizobia, nodulation efficiency increases which subsequently promotes plant growth, and leads to the increase of grain yield.

Rhizobium effect on chickpea
Ibrahim *et al*. 1978 [9] indicated thata field trial was carried out at Hudeiba Research Station where soil is generally characterized by high salinity. A local chickpea cultivar was inoculated with rhizobium strain CB 1189 or 161a (strain 161a was isolated from a saline soil). Treatments also included addition of nitrogen (N) at 90 kg/ha either alone or in combination with each of the 2 strains. Elsheikh *et al*. 1990 [7] reported that Chickpea cultivar ILC 482 was inoculated with salt-tolerant Rhizobium strain Ch191 in solution culture with different salt concentrations added either immediately with inoculationor 5 d later.

The inhibitory effect of salinity on nodulation of chickpea occurred at 40dS m− 1(34.2 mol m− 3NaCl) and nodulation was completely inhibited at 7dS m− 1 (61.6 mol m− 3NaCl); the plants died at 8dS m− 1 (71.8 mol m− 3NaCl).

Beck (1992) [2] reported that the development of new cultivars for winter sowing, production of Kabuli chickpea (*Cicer arietinum* L.) has expanded into drier areas of the Mediterranean region where low or less effective populations of indigenous rhizobia may limit N2 fixation. This study was conducted to quantify field N2 fixation using 15N for eight chickpea.

Danso *et al*. 1995 [4] reported that Chickpeas inoculated with two local isolates of Bradyrhizobium, either singly or as a mixed culture and with an imported strain were compared with an uninoculated treatment in a greenhouse trial using five cultivars of chickpea growing in soil that had not supported legume growth in the recent past.

Hadi *et al*. (1999) [6] reported that Rhizobium inoculation or N fertilization significantly increased the total nodule number per plant, 100 seed weight, yield and protein content of seeds. The results indicated that the three Rhizobium strains are infective and effective in nitrogen fixation.

Togay *et al*. (2008) [15] reported that the effects of rhizobium inoculation for a chickpea variety, Aziziye-94, under Eastern Turkey conditions in 2004 and 2005. The trial was laid out in split-split block design with three replications. Chickpea variety was applied on three different inoculations (inoculated and uninoculated).

Bhuyian *et al*. (2008) [3] reported that the effect of *Rhizobium inoculation* on four varieties of chickpea *viz*., BARI Chola-3, BARI Chola-4, BARI Chola-5 and BART Chola-6. Each variety was tested with and without *Rhizobium inoculation*. Each plot received basal application of 22 kg P/ha as TSP, 42 kg K/ha as MOP, 20 kg S/ha as gypsum and 5 kg Zn/ha as zinc oxide. Peat based *rhizohial inoculurn* (*Rhizohium strain* RCa-220) @ 1.5 kg/ha was used for seed inoculation.

Akhtar *et al*.(2009) reported that rhizobium sp. caused a greater increase in growth and yield than P. putida, P. aeruginosa or G. intraradices. The number of nodules per root system was significantly higher in plants inoculated with *Rhizobium* sp. compared to plants without Rhizobium sp. Inoculation.

Nishita *et al*. (2010) [8] reported that Rhizobium effect was studied using *Cicer arietinum* and controlled condition. Soil analysis was done for all physico-chemical and microbiological parameters. The bacterized seeds showed, 14.06% in total length over control, Increase of 10.83% in total weight over control and an increase of 9.0% on germination over control in pot experiment. The results indicate that rhizobium inoculation is a promising fertilizer because it is cheap, easy to handle and improves plant growth and seed quality.

Yagmur *et al*. (2011) reported that the effects of different combination of rhizobium inoculation, nitrogen application and irrigation on nodule dry weight, protein ratio and seed yield of spring sown chickpea (*Cicer arietinum* L. cv ILC 482). The combination of inoculation, nitrogen (20 kg N ha^{-1}) and irrigation. Inoculation has superior performance in seed yield and protein ratio under irrigation.

Shrila *et al*. (2012) reported that Rhizobium inoculation in combination with different micronutrients recorded higher nodulation, plant dry weight, grain and straw yield and uptake of N and P than the treatments of only micronutrients or Rhizobium alone. The highest nodule dry weight of 235, 616 and 1476 mg/plant was recorded with treatment of 5 kg Borax/ha + Rhizobium at 45, 75 and 120 DAS, respectively.

Tagore *et al*. (2013) [14] reported that the *Rhizobium* + PSB was found most effective in terms of nodule number (27.66 nodules $plant^{-1}$), nodule fresh weight (144.90 mg $plant^{-1}$), nodule dry weight (74.30 mg $plant^{-1}$), shoot dry weight (11.76 g $plant^{-1}$), and leghemoglobin content (2.29 mg g^{-1} of fresh nodule) and also showed its positive effect in enhancing all the yield attributing parameters, grain and straw yields.

Zorwar *et al*. (2018) reported that Rhizobium can reduce the need for chemical fertilizers and decrease adverse environmental effects. The studies have shown positive effect of rhizobium (Meso rhizobium) inoculation on growth attributes, symbiotic parameters, yield and yield components, nutrient uptake and quality in chickpea.

Tamiru Meleta *et al*. (2019) [12] reported that the effectiveness of Rhizobium strains and phosphorus fertilizer application on two varieties of chickpea (Arerti and Habru). The thirty treatments included: two Rhizobial inoculants (EAL018 and EAL029), five P2O5 rate (0, 15, 30, 45and 60 kg P2O5 ha-1); and two varieties of chickpea (Arerti and Habru).

Khaitov *et al*. (2020) [10] reported that Rhizobium strains, R9 and R6 strains produced the best results, particularly grain yield, seed protein, and oil content in Halima and Flip 06-66 genotypes were increased by 27.8% and 36.5%, 5.8% and 5.9%, 2.4% and 4.6% over the control, respectively.

Conclusion

Rhizobia produce multiple beneficial effects on plant growth stimulation, host defense against disease and survival under stress with many other unknown benefits. This chapter describes the potential of rhizobia for the promotion of plant growth and highlights the different mechanisms of growth stimulation and the spectrum of resistance available against various abiotic stresses in several crops.

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