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The effect of dual seed inoculation of rhizobium and Fe-Zn solubilizer yield of chickpea

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Abstract
A pot culture experiment was conducted during the year 2017-18 at the Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, The experiment was laid out in completely randomized design with two replications and fourteen treatments, which comprised of recommended dose of fertilizer NPK (RDF) and FYM and seed inoculation of rhizobium and iron and zinc solubilizers, and recommended dose of Ferrous sulphate and Zinc sulphate. The result of the experiment revealed that application of GRDF + $FeSO_4$ + $ZnSO_4$ (Rhizobium and Fe-Zn solubilizers inoculated) gave significantly highest grain and straw yield of chickpea i.e. 3.47 (g plant^{-1}) and 10.54 (g plant^{-1}) respectively. The same combination also recorded highest number of branches, pods, height of plant, soil microbial population and residual N, P, K. The total uptake of N, P, K and Fe, Zn, Mn and Cu was also significantly highest in the same treatment.

Keywords: Iron and zinc solubilizers, seed inoculation of rhizobium, soil microbial population

1. Introduction
Chickpea (*Cicer arietinum* L.) is the most important pulse crop of India which occupies an area of about 9.93 million ha with an annual production of 9.53 million tonnes and productivity of 960 kg ha^{-1}. Chickpea is the third most important food legume crop and India is the largest producer contributing to 65% of world's chickpea production.

Chickpea is a cool season legume crop and is grown in several countries world wide as a food source. Seed is the main edible part of the plant and is a rich source of protein, carbohydrates and minerals especially for the vegetarian population. Chickpea is also an important pulse crop from nutrition point of view, as it is free from various anti nutritional factors and has high protein (23%), total carbohydrates (64%) and dietary fiber content (19%). Chickpea is also rich in minerals and vitamins. As in case of other legume crops, even chickpea can fix atmospheric nitrogen through its symbiotic association with *Rhizobium* sp.; thus helping in enhancing the soil quality for subsequent crop cultivation. The yield levels of chickpea have been generally low, which might be attributed to its major cultivation under rainfed conditions with less/imbalance use of fertilizers, limited seed inoculation (10% approximately) with Rhizobium and phosphorus solubilizing bacterial cultures and also due to its susceptibility to wilt, insect, pest and diseases. Keeping in view, the ever-increasing demand for this legume crop, it is essential to improve the production and area under cultivation, at the same time minimizing the stress on this crop plant. Two types of chickpeas are recognized, the white-seeded "Kabuli" and the brown colored "Desi" types. Kabuli chickpeas are relatively bigger in size having a thinner seed coat while the Desi type seeds are relatively smaller in size having a thicker seed coat. The Desi type chickpea contributes to around 80% and the Kabuli type around 20% of the total production.

Being legume, chickpea has got capacity of fixing nitrogen through Rhizobium bacteria. Nodule rhizobia can fix nitrogen actively only if the plant is adequately supplied with all the mineral elements essential for active growth. In this context elements like P, Mo, Fe, Zn and Co can play an important role. Micronutrients are required elements for normal growth of plant, that are required in little amount. If these elements are not available sufficiently plant will suffer from physiological stresses caused by in efficiency of several enzymatic systems and other related metabolic functions. Various responses were observed in growth and yield in crops species and in cultivars to trace elements deficiency (Fageria, 2009) [4]. Hence supplementation of micronutrients along with Rhizobium + PSB inoculation in chickpea may increase BNF and P availability to this crop and thereby its productivity.

FYM is also a good source of addition of organic carbon and plant nutrients required for crop growth. FYM also brings improvement in physical and biological properties of soil's hence its addition may also boost up chickpea productivity (Muddukumar, 2007) [7]. The application of 5 t FYM ha^{-1} improved chickpea grain yield by 14.89% and 25 kg $ZnSO_4$ ha^{-1} by 5.18%. (Singh *et al*., 2012) [8].

2. Material and Methods

2.1 Filling of Pots with Soil

The earthen pots were washed with water and were lined with polythene and used for experiment. Twenty eight pots were filled with 10 kg (2 mm sieved) soil. Before filling the pots FYM @ 5 Mg ha^{-1} was thoroughly mixed with soil.

2.2 Seed Inoculation

The Fe and Zn solubilizing culture required for seed coating for this experiment was procured from the Vasantdada Sugar Institute. Manjari, Dist. Pune. The culture consisted of a consortium of zinc and iron solubilizing bacteria and fungi. The zinc solubilizers included a consortium of bacterial strains *viz*., *Bacillus polymyxa, Bacillus megaterium, Pseudomonas striata, Pseudomonas fluroscense, Ghuconacetabactor diazotrophicus* and *Aspergillus awamorie* a fungal strain. The iron solubilizing microorganisms included bacterial strains *viz*., *Thiobacillus thiooxidans, Thiobacillus ferrooxidans, Aspergillus niger* and *Trichoderma viridae*, which are the fungal strains. This consortium of iron and zinc solubilizing organisms were used for chickpea seed inoculation.

The iron and zinc culture was inoculated @ 250 ml per 10 kg seed in a bowl. This seed was partially dried in shade and was again treated with Rhizobium @ 250 g per 10 kg seed.

2.3 Grain and Straw Yield

Chickpea grain and straw yield from each pot was recorded at harvest from two replication which Where grown till harvest.

2.4 Grain and Straw Sample

The grain and straw sample were collected separately and air dried in shed under ambient condition. These sample were the dried in oven at 70ºC till constant weight and the dry matter was recorded.

3. Result and Discussion

3.1 Grain and Straw Yield

The significantly highest grain yield (3.47 g $plant^{-1}$) was observed in the treatment T_{14} [(GRDF + $FeSO_4$ + $ZnSO_4$ (Rhizobium and Fe-Zn solubilizers inoculated)] followed by T_{12} [(GRDF + $ZnSO_4$ (Rhizobium and Fe-Zn solubilizers inoculated)] (3.45 g $plant^{-1}$). The grain yield increase in treatment T_{14} was at par with treatment T_8, T_{10} T_{11} and T_{12} with grain yield of 3.43, 3.41, 3.41, 3.45 g respectively.

Significantly highest straw yield (10.54 g $plant^{-1}$) was observed in the treatment T_{14} [(GRDF + $FeSO_4$ + $ZnSO_4$ (Rhizobium and Fe-Zn solubilizers inoculated)] which was at par with T_{12} [(GRDF + $ZnSO_4$ (Rhizobium and Fe-Zn solubilizers inoculated)] (10.50 g $plant^{-1}$). The highest grain and straw yield in treatment T14 and T_{12} may be attiributed to an increased supply of major and micronutrient due to solubilization of fixed phosphates and Fe-Zn compound in the soil and added supply of nitrogen, which resulted in good crop growth and higher yield.

The results are in conformity with Kushwaha (1997) [6] who studied contribution of micronutrients in increasing the productivity of pulse crops.

4. Conclusion

Seed inoculation with Fe and Zn solubilizing Microorganisms rhizobium along with recommended dose of fertilizers were found beneficial for obtaining highest yield of chickpea. The highest N, P, K and micronutrient (Fe, Zn, Mn and Cu) uptake by chickpea was also observed to be significantly highest in the seed inoculation treatment with Fe and Zn solubilizing microorganisms along with rhizobium and recommended dose of fertilizers.

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