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EFFECT OF INTERGATED APPLICATION OF INORGANIC AND ORGANIC FERTILIZERS ON THE ROOTS OF CHICKPEA

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Abstract

The present investigation was carried out to know about the effect of integrated application of inorganic and organic fertilizers on the roots of chickpea. The field experiment was done in a Randomized Block Design with three replications, comparing seven treatments involving different doses of Rhizobium culture, inorganic NPK + FYM, recommended fertilizer dose and absolute control for study the agronomic efficiency of nitrogen, various root parameters of the experiment. Rhizobium inoculation enhancing overall plant root and shoot parameter. Thus the use of Rhizobium in production can play an important role in enhancing crop quality and productivity.

Key words : Agriculture, biotic, chickpea, density, energy, forage, gap.

Introduction

The facts reveal that on one hand, the world population is increasing continuously, whereas on the other hand, food grain production is not increasing proportionately due to various factors such as decline in soil fertility and repercussions arising from climate change phenomenon as manifested by unpredictable patterns of rainfall and temperature (Boivin *et al*., 1997). The major reason for poor soil health in India seems to be the unbalanced nutrient application (Bai, 2014). Amongst, various strategies to cope with above situation, soil test based integrated nutrient management holds the key to reverse above trend leading to restoration of soil fertility and in turn, boosting crop production and productivity (Bagyaraj 1979). Fertilizer nitrogen has contributed tremendously towards increasing food production, yet even with best agronomic practices, the recovery of fertilizer nitrogen hardly exceeds 30-60 per cent, because most of the applied nitrogen gets leached and becomes unavailable for plant use (Brockwell *et al*., 1995). A number of approaches aimed at increasing N use efficiency have been developed in India and abroad, but none of the strategies are equally effective under different situations (Darzi *et al*., 2012).

Therefore, there is an urgent need to attempt some alternative approach to tackle the problem of low N use efficiency. Chickpea (*Cicer arietinum* L.) is an important grain legume crop grown throughout the world. It is a highly nutritious pulse and places third in the importance list of the food legumes that are cultivated throughout the world. It contains 25% protein, which is the maximum provided by any pulse and 60% carbohydrates so can help people improve the nutritional quality of their diets (Dileep *et al*., 2001). Chickpea is also a good source of vitamins (especially B vitamins) and minerals like potassium and phosphorus. Through symbiotic nitrogen fixation, crop meets up to 80% of the soil nitrogen needs, so farmers have to apply less nitrogen fertilizer than they do for other non-legume crops.

The aim of the experimentation is assessing the quality and productivity through inoculation with *Rhizobium* in chickpea with following specific objective: effect of integrated application of inorganic and organic fertilizers on the roots of chickpea.

Materials and Methods

The experimental site is characterized as "Central Plain Zone (PB-3)" of Punjab. The rainfall in the region varies from 500-800 mm and about 80 per cent of which

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is received in a short period 3 months (mid June to mid September). Major constraints of the region are declining water table and soil sodicity and salinity. It comprises parts of eight districts of Punjab *viz*. Amritsar, Tarn taran, Kapurthala, Jalandhar, Ludhiana, Fatehgarh Sahib, Sangrur and Patiala. The soils predominantly belong to Central Alluvial Plain or sandy loam. The major crops grown in the region are mainly wheat, rice, maize, groundnut, cotton, gram, barley, pear and guava. The experimental site is located at 31º 15" N latitude and 75^0 41" E longitudes at an elevation of 245 m above mean sea level. The climate of the experimental area is characterized as hot and dry summer and wet and humid monsoons, distinctly experiences all the four seasons. The soil of experimental field was Sandy loam.

Experimental details

A total of 7 treatments was evaluated in a Randomized Block Design (RBD) with three replications, *viz*., T1: No Rhizobium inoculation + No NPK, T2: Recommended dose of fertilizer i.e. 20 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1}, T3: Rhizobium inoculation + 20 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1}, T4: Rhizobium inoculation + 15 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1}, T5: Rhizobium inoculation + 10 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1}, T6: Rhizobium inoculation + 15 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 15 kg K_2O ha^{-1}, T7: Rhizobium inoculation + 0 kg N ha^{-1} + 40 kg P_2O_5 ha^{-} 1 + 2s0 kg K_2O ha^{-1}.

Field operations

The field used for raising chickpea crops was cultivated twice with a tractor and then, it was planked. Now, the field was divided into small plots each of size 8 m^2. Full doses of N, P and K were placed basally in the above crop at the time of sowing. The fertilizers and manures were applied as per the treatments scheduled in various plots. The seeds were treated with Bavistin @ 3g per kg of seeds to avoid any fungal disease. The Rhizobium treated seeds of chickpea were now sown. The row to row planting distance maintained was 60 cm, whereas plant to plant distance maintained within the rows was 15 cm. In order to manage weeds, pendimethalin was sprayed @ 4 liter ha^{-1} one day after sowing. Further, all relevant plant protection measures were followed.

Root studies

Above studies were carried out at the maximum flowering stage (120 DAS). The root samples were taken by "core break method" (Bohm, 1979) to a depth of 0-0.30 m. In the present study, metallic core of size 1532 cm^3 was used. The soil samples with root biomass were kept in water overnight and then, roots were made free from soil by gentle washing under a fine jet of water. The roots were collected on sieves and observations on following parameters were made.

Root volume (ml)

The root volume was determined by the displacement method given by Mishra and Ahmed (1987). About 500 ml of water was poured into a 1000 ml measuring cylinder; thereafter the roots were transferred into it and the change in water volume reading resulting from the addition of the roots was recorded.

Root nodule count

Freshly collected roots for the given treatment were washed and then the roots bearing nodules were separated out and the total nodule number was recorded in the respective treatment.

Root weight (g)

Root samples collected earlier were dried in an oven at 60ºC for 72 hours, after which their weights were recorded.

Root weight density

Above parameter is the ratio between root dry weight and volume from which the roots were sampled in the field (Mishra and Ahmed, 1987). As such, it was worked out using relevant data recorded earlier.

Quality parameters

Nitrogen use efficiency (kg yield kg^{-1} N)

The efficiency of applied N nutrient in different treatments was estimated in the form of N response ratio (agronomic efficiency) by applying the following formula:

N use efficiency (kg yield kg^{-1}N)

$$= \frac{Yield\ in\ treated\ plot\left(kg\ ha^{-1}\right) - Yield\ in\ Absolute\ control\ plot\left(kg\ ha^{-1}\right)}{N\ applied\left(kg\ ha^{-1}\right)}$$

Statistical analysis

All the field and laboratory data were analyzed statistically by the methods described by Gomez and Gomez (1984).

Results and Discussion

The data on rooting depth, root volume, root dry weight and root weight density at maximum flowering stage in depicted in table 1.

Rooting depth (cm)

In general, treatment involving *Rhizobium* inoculation gave higher value of rooting depth in comparison with recommended dose of fertilizer (table 1). The highest magnitude of increase in rooting depth was registered under Rhz + 75%NPK, which gave a significant increase of 38.88% over RDF. Similarly, magnitude of increase in rooting depth following Rhz + 100% NPK treatment was to the tune of 11.11% over RDF. The lowest value of rooting depth was found under absolute control. The higher rooting depth following *Rhizobium* inoculation is probably due to more N availability in soil through the activity of *Rhizobium*. Moreover, there is more root proliferation and production of high order lateral and in turn more rooting depth. The present results are in conformity with the finding of Bai (2014), who reported altered root morphology with *Rhizobium* inoculation.

Root volume ($x10^{-6}m^3$)

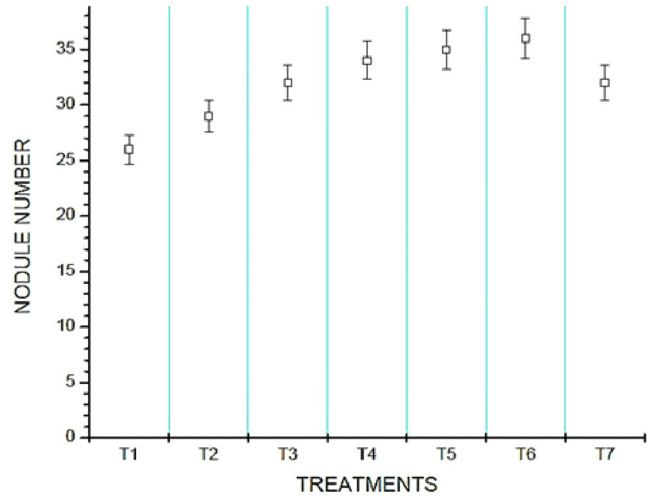
The treatment wise trend with respect to root volume was found similar as that observed under rooting depth and the treatments involving *Rhizobium* inoculation gave higher value of root volume in comparison with recommended dose of fertilizer (table 1). The highest magnitude of increase in root volume was registered under Rhz + 75%NPK, which gave a significant increase of 26.66% over RDF. Similarly, magnitude of increase in rooting depth following Rhz + 100% NPK treatment was to the tune of 23.33% over RDF. The lowest value of root volume was found under absolute control. Above trend is ascribed to the same reasoning as given under rooting depth parameter earlier.

Root dry weight (g)

It is apparent from table 1 that none of the treatment influenced root dry weight except absolute control, which was found significantly inferior to all other treatments. However, treatments involving *Rhizobium* inoculation gave marginally higher (but non-significant) value of above parameter in comparison with RDF, indicating better plant condition. The increase in root dry weight in inoculated treatments is attributable to the increase in root nodulation. Yadav *et al*. (2007) reported that an increase in number and weight of nodules in *Rhizobium* inoculated plants led to a significant increase in root dry and fresh weights of chick pea in comparison to non-inoculated plants. Similar results were obtained by Moradi *et al*. (2013).

Root weight density

Above parameter is a function of root dry weight and actual root volume, *i.e.* the soil volume from which the roots were collected (1.53 m^3) and measured. It is obvious that the trend observed herein is the same as in case of root dry weight (table 1). The different treatments did not influenced above parameter significantly barring absolute control. The same reasoning as given under root dry weight holds true here also.



(Source: Drawn by authors, 2018)

Fig. 1 : Effect of different treatments on root nodule number at maximum flowering stage.

Table 1 : Effect of treatments on root parameters.

Treatments	Rooting Depth (cm)	Root Volume ($x10^{-6}m^3$)	Root dry weight (g)	Root weight density
T1	14	20	3.14	2.05
T2	18	30	3.94	2.58
T3	20	37	4.24	2.77
T4	23	33	4.03	2.63
T5	24	33	4.05	2.65
T6	25	38	4.26	2.78
T7	22	33	4.02	2.63
CD	2.21	4.11	0.92	0.72

Table 2 : Effect of treatments on N response ratio or N response ratio (%).

Treatments	Yield (kg ha^{-1})	N applied (kg ha^{-1})	N response ratio (%)
No Rhz $N_0P_0K_0$	700	0	-
RDF (100% NPK)	1620	20	46
Rhz + 100% NPK	1790	20	54
Rhz + 75%N + 100% PK	1800	15	74
Rhz + 50%N + 100% PK	1770	10	107
Rhz + 75%NPK	1530	15	55
Rhz + N_0 + 100% PK	1620	0	-

Root nodule count

The data presented in fig. 1, revealed that the highest numbers of nodules were registered under “Rhz + 75%NPK” followed by “Rhz + 50%N + 100% PK” and “Rhz + 75%N +100 PK”, all of which were found statistically alike to one another. However, above treatments gave significant increases of 24.0, 20.6 and 17.2%, respectively over RDF. The lowest nodules were registered under absolute control (No Rhz $N_0P_0K_0$). The inoculation with *Rhizobium* ensures the presence of a high density of these organisms in close proximity to the root systems of the seedlings causing the development of the high number of nodules especially at the early stage of plant development. The above information is in agreement with the findings of Antoun *et al.* (1998) and Dileep-Kumar *et al.* (2001), who reported that rhizobia are capable of colonizing the roots of legumes and produce plant growth-promoting substances of phytohormonal nature and also exhibit antagonistic effects against many plant pathogenic fungi.

Effect of different treatments on agronomic efficiency of N or N response ratio

Above parameter was computed to evaluate biological efficiency of nitrogen applied under various treatments. The relevant information is presented in Table 2. It is obvious that, there was an impressive increase in the N response ratio due to use *Rhizobium* biofertilizer in concerned treatments. The treatment "RDF (100% NPK)" gave relatively a lower response ratio due to higher N dose. However, in pursuance of the law of diminishing returns, it decreased as the N levels increased, with every additional increment of N. The highest N response ratio was registered under "Rhz + 50%N + 100% PK" followed by "Rhz + 75%N +100% PK" and "Rhz + 100% NPK" due to increasing N levels from 50 to 100% of recommended dose. The general trend of response ratio data can be explained through the law of diminishing returns (Voisisn, 1962). However, the higher the response ratio in case of *Rhizobium* involving treatments under varying levels of N is obviously the outcome of higher chickpea productivity.

Conclusion

The results of the current study suggest that the practice of Rhizobium inoculation can go a long way in reducing the cost of production directly as well as otherwise. Moreover, its continuous use is going to enhance its nutritional status and crop quality, which is the need of the hour. Above practice led to a reduction in soil test based N requirement in chickpea by about 50 %. Moreover, use of above biofertilizer enhanced N-use-efficiency significantly over the recommended dose of fertilizer.

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