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Role of Rhizobial inoculation in the production of chickpea crop

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Abstract

Twenty rainfed crops of chickpea on farmer's fields were surveyed to determine the nodulation status of this important legume crop in Lakki Marwat and Karak districts of North West Frontier Province (NWFP). Ten fields (50%) were found with poor nodulation and 4 fields with fair nodulation, which means that about 70 % crop area needs artificial seed inoculation of this crop. Field experiment to evaluate the effect of rhizobial inoculation and nitrogen application on the performance of chickpea was conducted at two different sites in Bannu division of NWFP. It was found that rhizobial inoculation improved nodulation on the root system of the crop at both sites, however, nitrogen application @ 30 kg ha $^{-1}$ at sowing could not affect the nodulation status of the crop. Inoculation and fertilizer nitrogen @ 30 kg ha^{-1} individually and in combination significantly increased the grain yield of the crop at both locations. Significantly higher yield was obtained at Marmondi Azim as compared to Titar khel. The inoculated treatment receiving 30 kg N ha^{-1} produced the highest grain yield at both locations. There was no significant difference in between the nitrogen treated and inoculated plots.

Key words: Chickpea, nodulation, nitrogen fixation, inoculation, rhizobia.

Introduction

Chickpea (*Cicer arietinum* L.) is an important pulse crop in Pakistan, mainly grown in the rainfed areas. It was grown in Pakistan on about 1.1 million hectares producing 868.2 thousand tons at 794 kg ha^{-1} while in NWFP it was cultivated on an area of about 0.52 million hectares, yielding about 34.3 thousand tons with an average yield of 655 kg ha^{-1} (Agric. Statistics of Pakistan, 2004-05).

Chickpea is an important cool season legume of the semi arid tropics, and is considered to sustain cropping system productivity due to its ability to fix atmospheric nitrogen. This crop possess nodules on its roots where bacteria of the genus *rhizobium* live with a specific function of converting the atmospheric nitrogen into plant available form called biological nitrogen fixation (BNF). In this way an appreciable amount of free of cost nitrogen is deposited in the soil which can be used by the same crop and the subsequent one. The efficiency of such crop in fixing maximum nitrogen depends upon the cultivar, nodules number and the efficient strain of the bacteria existing in their root nodules. Chickpea has the capacity to fix sufficient atmospheric nitrogen to replace the nitrogen removed in harvested grains (FAO, 1984; Schwenke *et al*.,. 1998). In addition, it is an important proteinacious crop that meets protein requirements of the bulk of the population of our country. The average yield (360 kg ha^{-1}) of chickpea is very low than its potential yield. The unavailability of good quality seed, absence of effective rhizobial inoculation and serious damage by blight and pod borer attack were reported responsible for low yields.

Artificial seed inoculation of chickpea in those soils lacking native effective rhizobia is a very useful practice for improving root nodulation and yield of the crop (Rupela and Dart, 1979; Patil and Sbinde, 1980; Hernandez and Hill, 1984; Shamim and Ali, 1987; Shah *et al*., 1994). Chickpea also responded positively to artificial rhizobial inoculation when grown in soils that contain its native rhizobia (Sharma *et al*., 1983).

Our soils are generally deficient in nitrogen; the most important element in the metabolism of plants and protein synthesis. Its deficiency in soil usually results in low crop yield. A starter dose of fertilizer nitrogen is often used to stimulate early growth of leguminous crops and to induce the activity of nitrogen fixing bacteria in most legumes (Ali *et al*., 1998; Jefing *et al*., 1992).

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Chickpea is traditionally grown in Bannu Division of NWFP and native soil rhizobia may be present to produce root nodules, i.e. the sites of nitrogen fixation. However, with the introduction of improved varieties or sowing of this crop on new areas, inoculation with effective rhizobial strain is essential for getting higher yields. The present study is, therefore, aimed to study the effect of rhizobial inoculation and nitrogen application on nodulation and grain yield of chickpea.

Materials and methods

Collection of nodulation data

A detailed survey of chickpea crop on farmers' fields was conducted to find out their nodulation status in the southern districts of Lakki Marwat and Karak. Twenty fields at different sites were studied, 10 in each district.

The nodule score was determined by the number of effective nodules (healthy and pinkish/red coloured nodules) in the crown-root zone, the region 5 cm below the first lateral root of the crop (Corbin *et al*., 1977). This was about 10 cm below soil level, depending on the sowing depth and root system of the crop. Ten plants were carefully dug out at random across the field and scored each plant. The score from all plants were added to obtain a mean nodule score.
A mean of nodule score:
4 : excellent nodulation; excellent potential for N_2 fixation.
0-2 : poor nodulation; no N_2 fixation.

Field experiment

The experiment was conducted in collaboration with the Soil Science Section at Agricultural Research Station Serai-Naurang, Bannu at two sites viz. Titar Khel and Marmondi Azim in district Lakki Marwat, Bannu division. A simple RCB design with three replications and four treatments was used. Composite soil samples of the fields at both sites were collected before sowing for physico-chemical analyses (Table-1). Chickpea cultivar, CM-72 was sown at both sites. A basal dose of phosphorus and potash @ 50 kg P_2O_5 ha^{-1} (TSP) and 30 kg K_2O (sulphate of potash) was applied before sowing along with nitrogen @ 0 and 30 kg ha $^{-1}$ (urea) to their respective plots.

An effective strains of chickpea *Rhizobium* CC-1192, acquired from Australian Inoculants Research and Control Service (AIRCS), at Gosford NSW, Australia *was* cultured in yeast extract mannitol broth in the laboratory, incubated at 28^0C for 3 days to a viable cell count of 10^9 cells mL^{-1}. The broth culture was then mixed with the sterilized carrier (finely ground soil of Kalam forests) and incubated at 28-30^0C for a suitable time until the number of viable cell reached from 10^8 to 10^9 cells g^{-1} of the carrier.

Table 1. Physico-chemical characteristics of the test soils

Characteristic	Titar khel	Marmondi Azim
Textural class	Sandy loam	Sandy loam
pH (1:5)	8.2	8.0
ECe (dS m^{-1})	0.45	0.18
Organic matter (%)	0.17	0.07
Nitrogen (%)	0.009	0.003
$CaCO_3$ (%)	5.8	6.8
AB-DTPA Extractable P (mg kg^{-1})	5.6	6.8

RESULTS AND DISCUSSION

Survey of farmers' fields for nodulation status

Twenty fields (sites) of chickpea crop in Bannu and Karak areas of NWFP were studied for this purpose. The data showed showed that nodulation status of chickpea crop on 50% farmers' fields was poor. 20% fields with fair nodulation also need inoculation. It means that most of these fields are lacking effective rhizobia in chickpea crop.

Response of chickpea to rhizobial inoculation and N application

The results presented in Table 2 indicate that *rhizobial* inoculation improved nodulation on the root system of the crop at both sites, however, nitrogen application @ 30 kg ha $^{-1}$ at sowing could not affect the nodulation status of the crop. The nodulation status of the crop at Marmondi Azim was better in all treatments including the control plot. Our results are almost similar to those reported by Ali *et al*. (1998) and Hernandez and Hill (1984).

Table 2. Effect of rhizobial inoculation and N application on nodulation of chickpea

Treatment	Nodulation Status	
	Titar Khel	Marmondi Azim
Control	Poor	Fair
30 kg N ha^{-1}	Poor	Fair
0 N + Inoculum	Good	Excellent
30 kg N ha^{-1} + Inoculum	Good	Excellent

The grain yield data of chickpea presented in Table 3 show that rhizobial inoculation as well as nitrogen application @ 30 kg ha^{-1} significantly increased the grain yield of the crop at both locations. Significantly higher yield was obtained at Marmondi Azim as compared to Titar khel. Treatment 4 (30 N+ Inoculum) produced the maximum yield at both locations followed by T_3 (inoculated) and T_2 (N treated) plots but there was no significant difference between T_3 and T_2. The general condition of the crop at Marmondi Azim was much better than at Titar Khel. Moreover, heavy rains during grain fill stage coupled with pod borer attack and blight disease affected the grain yield to some extent at Titar Khel site.

Table 3. Effect of *Rhizobial* inoculation and N application on the grain yield of chickpea

Treatment	Grain yield (kg ha^{-1}		
	Titar khel	Marmondi Azim	Mean
1. Control	1070	1699	1385 c
2. 30 kg N ha^{-1}	1337	1850	1594 b
3. 0 N + Inoculum	1432	2041	1737 b
4. 30 kg N ha^{-1} + Inoculum	1517	2342	1930 a
Mean	1339 b	1983 a	

LSD (P=0.05) for Treatments = 183 kg ha^{-1}
LSD (P=0.05) for Treatment* Site = 513 kg ha^{-1}

Conclusion

Native *Rhizobium* population of chickpea in most of the farmers' fields is less than what is required for optimum symbiotic association. Inoculation with effective rhizobia significantly increased the grain yield of chickpea at both locations in Lakki district of Bannu division. A starter dose of N @ 20-30 kg ha^{-1}, P_2O_5 @ 90 kg ha^{-1} and K_2O @ 60 kg ha^{-1} must be applied at sowing time in order to get higher yield of this important pulse crop.

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