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Quality enhancement in chickpea mediated through integrated nutrient management

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Abstract
The present investigation was carried out at lovely professional University, Jalandhar, India, to enhance nutritional States, quality and productivity in chickpea through Rhizobium. 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 doze and absolute control. To study the various growth parameters, yield, plant water status, quality parameters, of the experiment. The study revealed that treatments involving Rhizobium inoculation along with inorganic NPK lead to significantly heights plant growth and productivity as compare with recommended dose fertilizer. Similarly maximum increase in quality parameter was recorded under Rhizobium containing treatments. Moreover Rhizobium inoculated treatments indicated an increase in yield. Thus the use of Rhizobium in production can play an important role in enhancing crop quality and productivity.

Keywords: agriculture, biotic, crop, density, energy, forage

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) [1]. The major reason for poor soil health in India seems to be the unbalanced nutrient application (Bai 2014) [2]. 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) [3]. 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) [5]. 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) [6].

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% proteins, 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) [7]. 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 soils 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 quality and productivity through inoculation with *Rhizobium* in chickpea with following specific objective: Impact of integrated application of inorganic and organic sources of nutrients on yield attributes crop productivity and crop quality.

Material 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 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 31° 15‟ N latitude and 75⁰ 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. The relevant information is given in Table 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.

Growth observations

In each plot, four chickpea plants were selected randomly, tagged and used for recording growth parameters periodically.

Plant height (cm)

Above parameter was recorded three times during crop growth (30 days interval) using a meter scale from ground level to tip of the upper most leaf in extended position.

Dry weight accumulation (g)

The dry matter accumulation was recorded three times during crop growth at 30 day intervals. The randomly selected plants were removed from each plot. Above plant samples were dried in an oven at 60°C for 72 hours and their weights were recorded.

Plant water status (Relative Water Content)

Six leaves were sampled from each plot. These were brought to the laboratory in tightly closed polythene begs and then their fresh weight was recorded. Now, they were chopped into small pieces and saturated overnight in Petri plates. The saturated leaves were taken out the next day, dried between the folds of the filter paper followed by recording of their turgid weight. The same were now transferred to an oven (60 ⁰C) and dried for 72 hours after which their weights were taken. The RLWC was computed from the data involving fresh weight, turgid weight and oven dry weight, using to the method given by Weatherly (1950) as

$$\text{RLWC} \; \frac{\text{Fresh weight} - \text{Oven dry weight}}{\text{Fully turgid weight} - \text{Oven dry weight}} \times 100$$

Laboratory Analysis
Plant analysis

Plant samples (leaves and pods) collected at final picking from all the field plots, were air dried and then, dried in an oven at 60 °C for 72 hours. The dried samples were now ground in a Willey Mill fitted with stainless steel parts, and passed through 1 mm sieve and stored in paper bags for analysis. The analytical procedures employed for the estimation of N, P and K is given in Table 2.

Quality Parameters
Protein content in chickpea seeds

Above parameter was estimated in chickpea seeds through the estimation of total nitrogen (Jackson, 1973) [9], in various samples. The value thus, obtained is multiplied by factor 6.25 to obtain crude protein content.

Results and Discussion

The experimental results pertaining to the current study based on effects of Integrated Nutrient Management have been presented in this section.

Plant height (cm)

The data presented in Fig 1, revealed that at 30 DAS, highest magnitude of increase in plant height was registered under “recommended dose of fertilizer (RDF)” i.e. 100% NPK followed “Rhz + 100% NPK” and “Rhz + 75%N + 100% PK”, all of which were observed statistically at par with one another. However, a significant respective increases of 16.5 and 26.5% were recorded under RDF over, Rhz + 50%N + 100% PK‟ and Rhz + 75%NPK‟ significant higher the lowest plant height was observed under the absolute control (No Rhz $N_0P_0K_0$). At 60 DAS, highest plant height was recorded under “Rhz + 50%N + 100% PK” followed by “Rhz + 100% NPK” and “Rhz + 75%N + 100% PK”. Above treatments gave statistically similar plant height (Fig 1). However, treatment “Rhz + 50%N + 100% PK” gave significantly higher (14.5%) plant height in comparison with Rhz + N_0 + 100% PK. The lowest plant height was observed under absolute control (No Rhz $N_0P_0K_0$). At 90 DAS, highest plant height was noted under “Rhz + 75%N + 100% PK” followed by “Rhz + 50%N + 100% PK”, “Rhz + 50%N + 100% PK”, Rhz + N_0 + 100% PK” and “Rhz + 100% NPK” (Fig 1). Above treatment gave statistically similar plant height. However, treatment “Rhz + 75%N + 100% PK” gave significantly higher 1.44%, 2.48% and 2.45% in respectably RDF the minimum plant height was noted under absolute control. The present results are in conformity with the findings of Panjebashi *et al*. (2012) [14], who reported significantly higher plant height of chickpea under *Rhizobium* inoculated treatments. *Rhizobium* has a positive effect on biomass production and subsequently enhanced plant height. According to present analysis, *Rhizobium* has increased plant height by enhancing the N content and the rate of photosynthesis (Migahed *et al*. 2004) [10].

Day matter accumulation per pant (g)

It is apparent from Fig. 2 that at 30 DAS, highest and similar magnitude of increase in dry matter accumulation was recorded under “recommended dose of fertilizer (RDF)” i.e. RDF (100% NPK) and Rhz + 75%N + 100% PK. Both of above treatments were observed statistically at par with one another. However, a significant increase of 2.56% above parameter was found under Rhz + 100% NPK in comparison with RDF. The lowest dry matter accumulation was found under absolute control (No Rhz $N_0P_0K_0$). At 60 DAS, highest and similar magnitude of increase in dry matter accumulation was recorded under “Rhz + 75%N + 100% PK” and “Rhz +

100% NPK", both of which were observed statistically alike (Fig 2). However, above treatments gave significantly higher i.e. 7.8% and 4.76% DMA in comparison with RDF. The lowest DMA was observed under absolute control "No Rhz $N_0P_0K_0$". The absolute control showed lower dry matter accumulation per plant. At 90 DAS, highest plant (DMA) was found under "Rhz + 100% NPK", followed by "Rhz +100% NPK", both of which were found statically alike (Fig 2). However, above treatments gave significant respective increases of 11.06% and 8.10% in comparison with RDF. Likewise, 30 and 60 DAS, at 90 DAS lowest DMA was recorded under control i.e. "No Rhz $N_0P_0K_0$". The above trends are attributed to the same reasoning as given under plant height. A higher amount of dry matter accumulation in *Rhizobium* inoculated plants is attributable to more N availability to plants. *Rhizobium*s have a positive effect on biomass production. In a study aimed at investigating the effect of biofertilizer inoculation on field pea in conjunction with different doses of chemical fertilizers, Mishra and his associates (2010) [11] observed that the plant dry weight at 90 DAS increased with each increment in recommended dose of fertilizers (RDF) i.e. 50, 75 and 100 per cent of recommended N, P and K. The dry weights recorded in case of above RDF levels were 21.0, 21.7 and 25.8 respectively. Bai (2014) [2] while working with *Rhizobium* in field grown garden pea under temperate climate involving acid Alfisol, observed that *Rhizobium* inoculated plants gave significantly larger biomass as compared to uninoculated control plants and RDF.

No. of branch plant^{-1}

The data presented in Fig. 3, revealed that none of treatment influenced number of branches per plant significantly.

Hundred seed weight (g)

The data with respect to seed weight (g per 100 seeds) is presented in Figure 3. None of the treatment influenced 100 seed weight significantly barring absolute control, which gave lowest value in above parameter.

Yield

The highest magnitude of increase in chickpea seed yield was registered "Rhz + 75%N + 100% PK" followed by "Rhz + 100% NPK" and "Rhz + 50%N + 100% PK", all of which were observed statistically at par with one another (Fig. 3). Moreover, all above treatments were found statistically at par to RDF, signifies economy in fertilizer N by 25-50%. Likewise, other parameter, lowest seed yield was registered under absolute control. It is inferred from current experimentation that inoculation with *Rhizobium* can economize soil test based fertilizer N sharply by about 50%. Increased yield of chickpea under *Rhizobium* is owing to improvement of yield components such as plant height, seed weight and dry matter yield. Moreover, *Rhizobium* has ability to fix atmospheric N and make it available to plants, further, adding it to the soil, which in turn enhance soil fertility. The present results are in conformity with the findings of Moradi *et al*. (2010) [12] and Darzi *et al*. (2012) [6].

Relative water content of leaf (%)

The effect of various treatments on relative leaf water content was registered non- significant across all the growth stages i.e. 30, 60 and 90 DAS (Fig. 4). Above trend is obvious, as crop did not suffer due to moisture stress at important physiological stages viz. flowering and pod formation. The total rainfall was throughout more than adequate and the same was well-distributed. As such, plants indicate higher relative leaf water content or plant water status.

Nitrogen concentration (%)

In general, treatments involving *Rhizobium* inoculation gave significant higher N concentration in chickpea seed comparison with recommended dose of fertilizer i.e. RDF (100% NPK) and absolute control (fig 5). A significant respective increases of 19.81% and 16.71% in above parameter were observed under "Rhz + 100% NPK" and "Rhz + 75%N + 100% PK" in comparison with RDF. Similarly, treatments Rhz + 50%N + 100% PK, Rhz + 75%NPK and Rhz + N_0 + 100% PK gave significant increases of 10.52%, 8.35% and 10.52%, respectively in N concentration over RDF. The higher N concentration in inoculated treatments might be due to higher nitrogen‟s enzyme activity and enhanced N_2 fixation (Islam, 1990) [8]. Our findings are in agreement with the observation of Tarafdar and Rao (2001) [15] found that the nitrogen's activity in *Rhizobium* inoculation involving treatment was 71 per cent.

Phosphorus concentration (%)

None of the treatment influenced P concentration in chickpea seed except absolute control, which was found significant inferior to all other treatments (fig 5). However, treatments involving *Rhizobium* inoculation gave nominally higher (but non-significant) magnitude of p concentration in comparison with RDF, indicating improvement in quality of chickpea in long term or following its continuous use.

Potassium concentration (%)

The different treatments did not influenced K concentration significantly barring absolute control, which gave lowest value of K in chickpea seed due to obvious reason (fig 5). However, treatments involving *Rhizobium* inoculation gave nominally higher (but non- significant) magnitude of p concentration in comparison with RDF, indicating improvement in quality of chickpea in long term or following its continuous use.

Crude protein content (%)

In general, treatments involving *Rhizobium* inoculation gave significant higher crude protein content in chickpea seed comparison with recommended dose of fertilizer i.e. RDF (100% NPK) and absolute control (fig 5). A significant respective increases of 20% and 20% in above parameter were observed under "Rhz + 100% NPK" and "Rhz + 75%N + 100% PK" in comparison with RDF. Similarly, treatments Rhz + 50%N + 100% PK, Rhz + 75%NPK and Rhz + N_0 + 100% PK gave significant increases of 10%, 10% and 10%, respectively in crude protein content over RDF. The crude protein content depends upon the plant nitrogen concentration. *Rhizobium* inoculation improved nitrogen concentration, thereby enhancing the protein content of chickpea pods. The above results are in conformity with the findings of Bagyaraj *et al*. (1979) [3]. Rao *et al*. (1986) also suggested that seed inoculation with *Rhizobium* enhanced protein content of black gram and green gram.

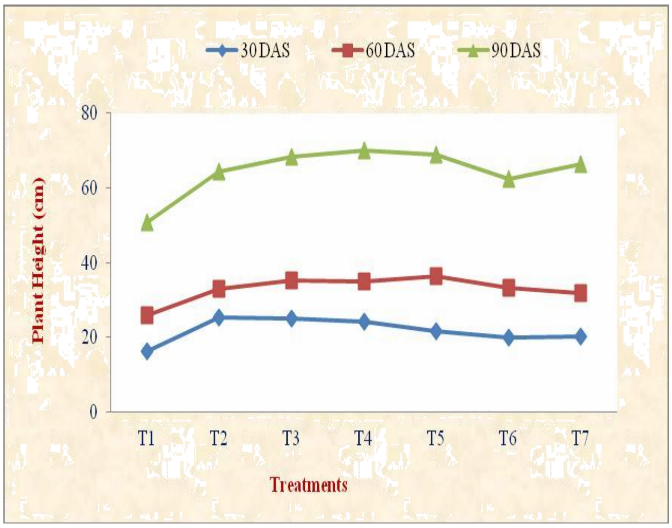
Table 1: Detail of the treatments evaluated in chickpea during *Rabi**

Treatments	Treatments detail	Treatment code
T_1	No Rhizobium inoculation + No NPK (Absolute control)	No Rhz, $N_0P_0K_0$
T_2	Recommended dose of fertilizer i.e. 20 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1}	RDF (100% NPK)
T_3	Rhizobium inoculation + 20 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1}	Rhz + 100% NPK
T_4	Rhizobium inoculation + 15 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1}	Rhz + 75%N + 100% PK
T_5	Rhizobium inoculation + 10 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1}	Rhz + 50%N + 100% PK
T_6	Rhizobium inoculation + 15 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 15 kg K_2O ha^{-1}	Rhz + 75%NPK
T_7	Rhizobium inoculation + 0 kg N ha^{-1} + 40 kg P_2O_5 ha^{-} 1 + 2s0 kg K_2O ha^{-1}	Rhz + N_0 + 100% PK

***Rabi* season:** The season that started from October/ November and ended in March/ April. FYM application @ 5 t ha^{-1} was applied in 7^{th} treatments viz. No application of FYM was made to treatment T_1.Recommended dose of NPK @ 20:40:20 kg ha^{-1}.

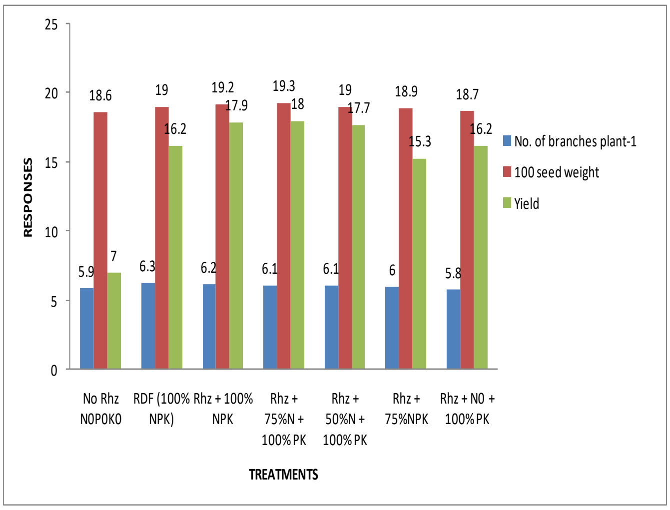
Table 2: Analytical methods employed for plant analysis

Sr. No.	Parameters	Method Employed	References
1.	Nitrogen	Micro-kjeldahl method	Jackson (1973)
2.	Phosphorus	Vanado-molybdo-phosphoric acid yellow colour method	Jackson (1973)
3.	Potassium	Wet digestion method	Black (1965)



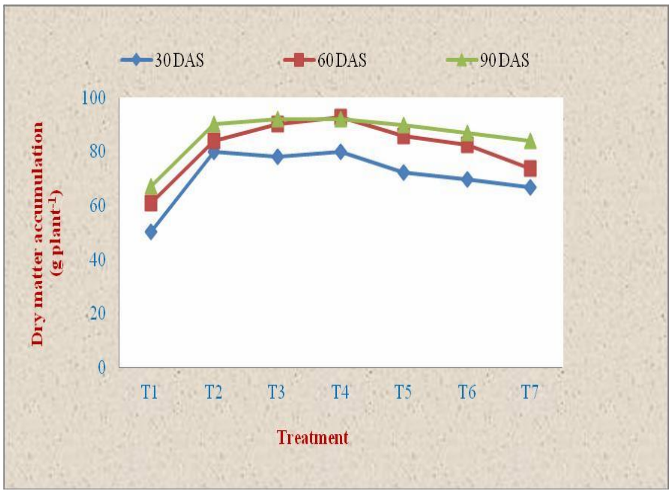
(*Source*: Drawn by authors, 2018)

Fig 1: Effect of different treatments on plant height at different stages of crop growth



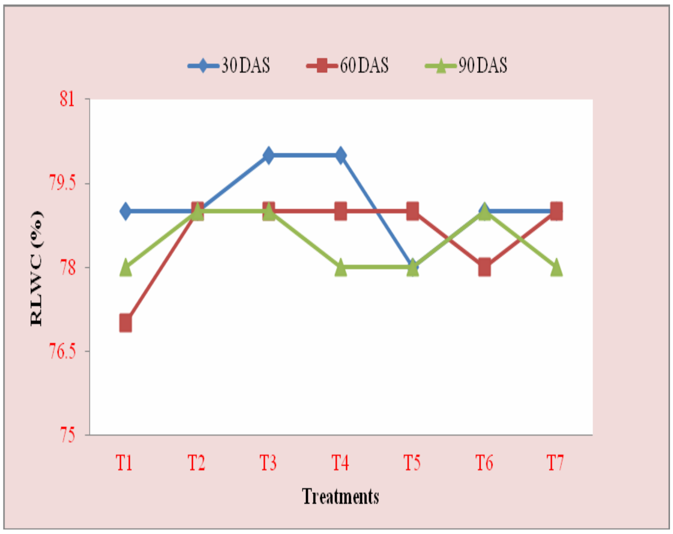
(*Source*: Drawn by authors, 2018)

Fig 3: Variation in yield parameters according to treatments



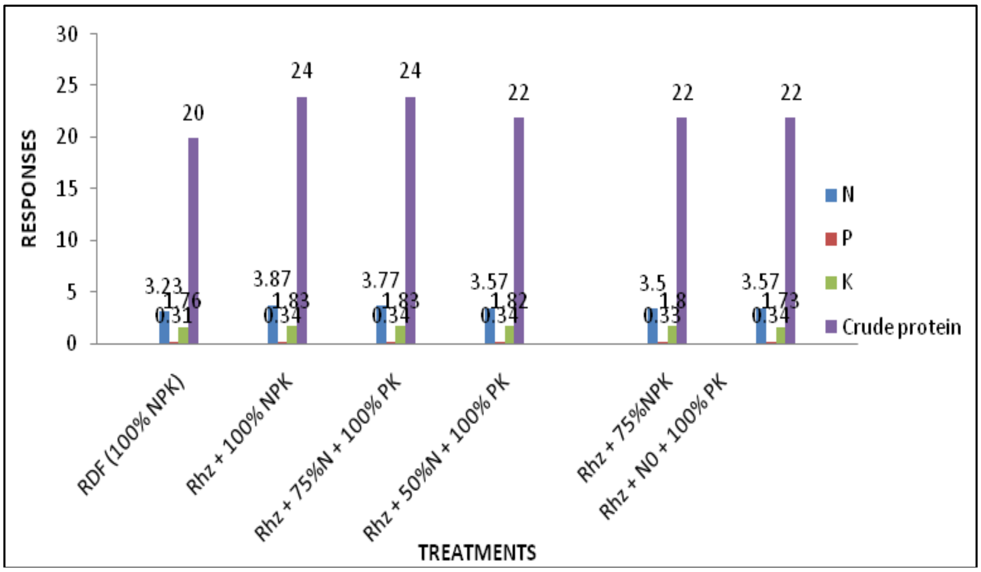
(*Source*: Drawn by authors, 2018)

Fig 2: Effect of different treatments on dry matter accumulation at different stages of crop growth



(*Source*: Drawn by authors, 2018)

Fig 4: Effect of different treatments on Relative Water Content (RLWC) at different stages of crop growth



(***Source***: Drawn by Authors, 2018)

Fig 5: Effect of treatments on quality parameters

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 recommended dose of fertilizer.

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