OPTIMIZING CHICKPEA GROWTH AND YIELD WITH ASSESSING FERTILIZER LEVELS AND MICROBIAL INOCULANTS IN RESPONSE TO MOISTURE STRESS CONDITION

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(Chickpea (*Cicer arietinum* L.) is the largest produced food legume in South Asia and the third largest produced food legume globally, after common bean (*Phaseolus vulgaris* L.) and field pea (*Pisum sativum* L.). Chickpea is grown in more than 50 countries (89.7% area in Asia, 4.3% in Africa, 2.6% in Oceania, 2.9% in Americas and 0.4% in Europe). Chickpea is a *Rabi* season crop it require cool climate during vegetative growth. Chickpea varieties vary with their rainfall requirement*s,* plants will tolerate frosts during the vegetative stage, but once flowering, frosts, if severe enough can cause flower drop. Chickpeas prefer warmer growing conditions, average temperatures below 15º C will reduce pollen viability and can cause flower drop, and average temperatures over 35º C will lower the potential yield and cause possible flower abortion. Interactions between crop establishment, development and the environment should be considered at the whole plant biology level if plant stress response is to be understood. Various defense mechanisms control plant adaptation in high and low temperature stresses and subsequently determine crop yields. This chapter provides an overview of the status of chickpea temperature stress research and provides a perspective on strategies for breeding temperature stress tolerant chickpea. Chick pea is grown under 500-900 mm annual rainfall. India is the largest chickpea producer with 9.19 Mha and 8.22 Mt (65%) of global production. Other major producing countries: Pakistan, Turkey, Iran, Myanmar, Australia, Ethiopia, Canada, Mexico, and Iraq. In India pulses are cultivated on marginal lands under rain fed conditions. Only around 15% of the area under pulses has assured irrigation, because of the high level of fluctuations in pulse production and prices. India is the major chickpea (Gram/ Chana) producing country, while chickpea is basically grown in the dried region of India. The major chickpea producing states of India are Madhya Pradesh, followed by Maharashtra, Rajasthan, Uttar Pradesh, Andhra Pradesh and Karnataka. Chickpeas are a nutrient-dense food, providing rich content (20% or higher) of protein, dietary fiber, folate, and certain dietary minerals such as iron and phosphorus per 100 gram. Compared to reference levels established by the United Nations Food and Agriculture Organization and World Health Organization, proteins in cooked and germinated chickpeas are rich in essential amino acids such as lysine, tryptophan, and total aromatic amino acids. A 100 g serving of cooked chickpeas provides 164 kilocalories energy. Chickpea is a highly nutritious grain legume crop. Chickpea/ Bengal gram is widely appreciated as health food. It is a protein-rich supplement to cereal-based diets, especially to the poor in developing countries, where people are vegetarians or cannot afford animal protein, chick pea an important source of protein (20-22%) in South Asia who are largely vegetarians. Rich in fiber, minerals, B-carotene, and lipid fraction is high in unsaturated fatty acids. Chick pea also improves soil fertility by fixing atmospheric N_2 up to 140 kg/ha. The success of any inoculation program depends on many factors, including environmental conditions, rhizobia strain, inoculants carrier and inoculation method (Smith. 1992, Hynes *et al*., 1995). Most early research in the area of Rhizobium inoculants formulation focused on the carrier material, which included peat, coal, clay, and compost made from sawdust or rice husks. Ideally, the carrier material should support large numbers of viable Rhizobia for extended periods in a suitable physiological state to maintain the effectiveness of the Rhizobium and to facilitate the ready formation of a symbiotic association with the host seedling (Paau *et al*., 1990, Paau, 1991). The most common invocation method involves treating the seed with a peat based or liquid inoculants prior to planting. Although this practice is widely accepted, its efficiency is questionable under several situations.

In recent years, microbial inoculants have gained attention as potential biotechnological tools to enhance plant resilience to environmental stresses, including moisture deficits. These inoculants, containing beneficial microorganisms such as rhizobia, mycorrhizal fungi, and plant growth-promoting bacteria, can establish symbiotic relationships with plants, improving nutrient uptake, water absorption, and stress tolerance.

MATERIALS AND METHODS

Studies on the influence of fertilizers on the formation of chickpea productivity and seed quality were conducted during 2017-2018 by setting up a two-factor field experiment in the experimental Soil Conservation and Water Management farm, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. This farm is located on North side of G.T. Road, 8.4 km away from the main railway station. The location represents the agro-climate condition of central plain zone of U.P. situated between 260 27’ N- 260 58’ N latitude and 79 031’E to 800 31’E longitude and at an elevation of 125.9 m from sea level. The indicator of the new vegetation period is insanely atmospheric. However, the effectuality of the fall in a significant world is to lie in the middle of winter, which means in the middle of the temperature regime, which is to be stored by the stretch of vegetation.

Climatic and Weather condition

Kanpur city is situated under sub-tropical zone falling between 25026’ and 26098’North latitude and 71031’ 80034’ East longitudes. It lies in the alluvial belt of indo-genetic plain in the central part of U. P and its elevation from the sea level about 125.5 meter. The mean annual rainfall of the area is 800 mm which is mostly received during rainy season, winter showers is also not common feature of this zone. The winter month cold and summer are very hot and dry. May-June is the hottest month with maximum day temperature.

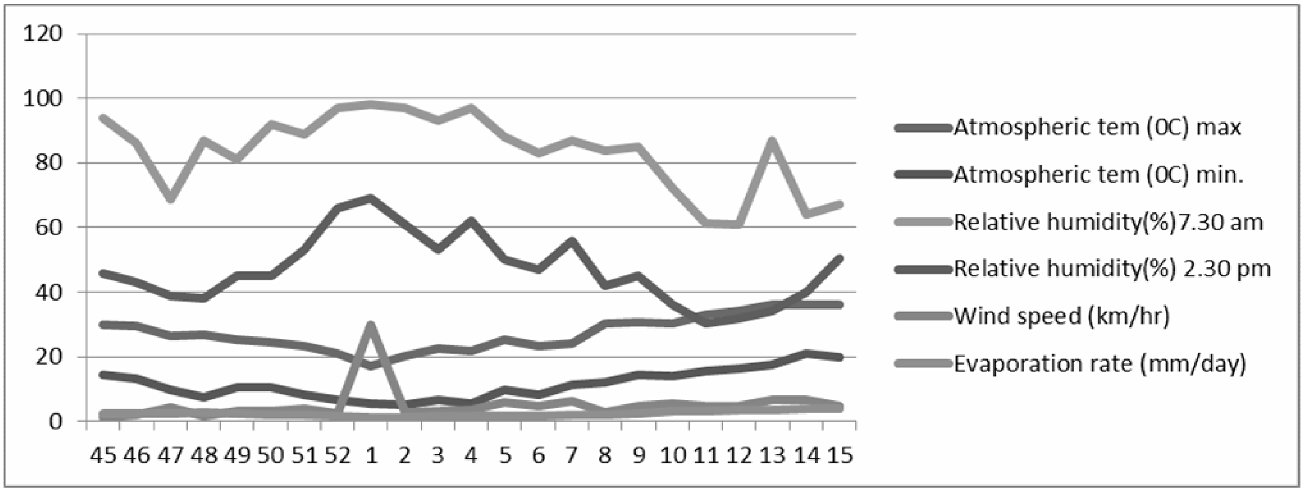

Fig 1. Variations in weather parameters during experimental period (2017-2018).

The experiment field was meticulously organized into a structured layout to facilitate systematic testing. Initially, the field was divided into three blocks, maintaining a one-meter border around each block. Within each block, further division was carried out to create nine plots. Ridges were manually prepared with the aid of spades to provide suitable conditions for plant growth. The layout adhered to a Factorial Randomized Block Design, ensuring random allocation of treatments within each block to minimize bias. The treatments under investigation included seed treatment by various bio-inoculants and different levels of fertilizer application based on Recommended Dose of Fertilizer (RDF-NPK-20:60:20). The seed treatments comprised four variations: Rhizobium, Rhizobium combined with RII-4, Rhizobium combined with NC-9, and Rhizobium combined with RII-4 and NC-1. Additionally, fertilizer levels were categorized into three groups: 100% RDF, 75% RDF, and 50% RDF, reflecting varying degrees of nutrient application. This comprehensive layout allowed for the examination of the combined effects of seed treatments and fertilizer levels on chickpea growth and yield, ensuring robust experimental design and reliable results. Growth attributes were meticulously observed throughout the chickpea cultivation period. Five to six plants were randomly selected from each plot, and their growth attributes were recorded at successive stages of crop development. Initial and final plant populations per square meter were determined by counting the number of plants within a 1 square meter quadrate at 60-day intervals during the growth period. The first plant population count was recorded post-germination, while the final count was taken just before harvesting from each chickpea plot (Bahadur *et al.*, 2002). Plant height was measured in centimeters from ground level to the tip of the main stem and averaged over five plants from each plot at 60 days, 90 days, and at the harvesting stage. This method provided a straightforward means of monitoring plant height throughout the growth period. Primary and secondary branching were assessed by selecting five plants from each experimental plot and counting the total number of branches. The average number of branches per plant was then determined, with recordings taken at 60 days, 90 days, and at harvesting time after sowing. Days to first flower were noted by recording the appearance of the first flower in each plot, representing the genotype-specific days to initial flower appearance. Additionally, the days to 50% flowering were calculated based on the time required for 50% of the plants in the two selected rows of each plot to flower. This was achieved by maintaining observations on the flowering of 50% of the plants in the chosen rows over consecutive days. The process involves several key measurements to assess agricultural yield. Firstly, the weight of cleaned grain obtained from five selected plants within each plot is determined. These individual values are then converted into yield per plant by multiplication with an appropriate factor. Subsequently, the focus shifts to quantifying the weight of cleaned grain obtained from each net plot. Recorded values undergo conversion into yield per hectare through the application of a suitable factor. Gan *et al.* (2009). Additionally, the assessment includes the determination of straw yield, which is derived by subtracting the grain yield of each net plot from the total biological yield of the same net plot. The methodology for calculating straw yield per hectare mirrors that used for grain yield. Finally, the harvest index serves as a crucial metric, representing the ratio of economic yield (seed yield) to biological yield. Expressed as a percentage, it is calculated using the formula suggested by Donald in 1969. This comprehensive approach allows for a thorough evaluation of agricultural productivity and efficiency. Harvest Index (%) = (Seed yield) / (Biological yield), where biological yield equals the sum of economic yield (grain yield) and straw yield. The data collected in this study was subjected to analysis of variance (ANOVA) and means comparison has done using Duncan's Multiple Range Test.

RESULTS

The influence of bio-inoculants and fertilizer levels on chickpea growth attributes, particularly plant height and number of branches per plant, was systematically assessed throughout the crop's developmental stages. At 60 days after sowing (DAS), the tallest plants were observed in plots treated with Rhizobium+RII-4+NC-1, followed by Rhizobium+NC-9, while the lowest heights were recorded in plots treated with Rhizobium (seed coating). Fertilizer levels showed non-significant effects on plant height at this stage. Similarly, at 90 DAS and at harvest, the trend persisted, with Rhizobium+RII-4+NC-1 consistently producing the tallest plants. However, at harvest, a significant difference in plant height was observed among the treatments, with Rhizobium (seed coating) displaying the lowest height Walley *et al*. (2005). Fertilizer levels demonstrated a significant effect on plant height at this stage, with plots receiving 100% RDF displaying the tallest plants. Regarding the number of branches per plant, an increase was observed with plant age, with the maximum number of branches recorded at maturity across all treatment groups. At 60 DAS, the number of branches did not significantly differ among treatments or fertilizer levels. However, at 90 DAS and at harvest, plots treated with Rhizobium+RII-4+NC-1 consistently exhibited the highest number of branches per plant. Fertilizer levels showed non-significant effects on the number of branches at all stages.

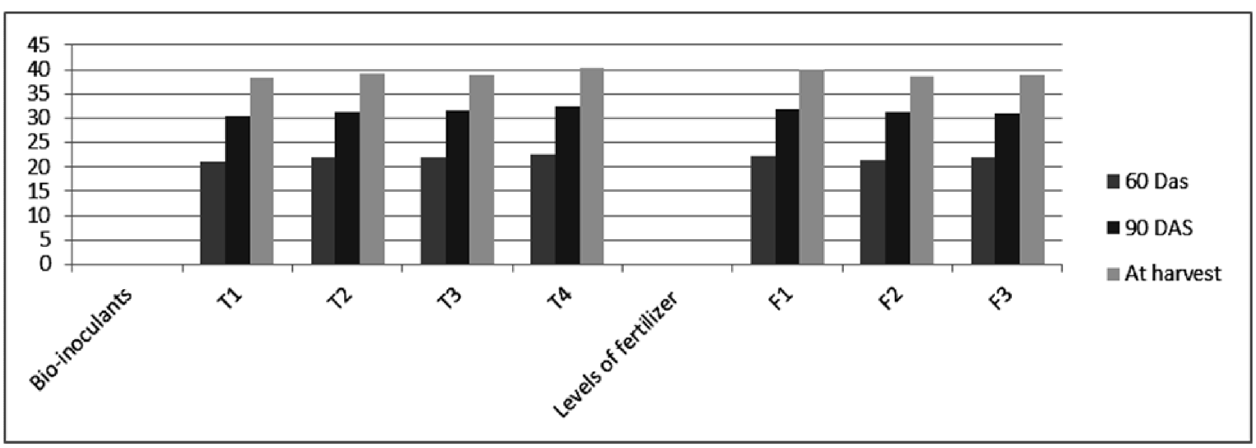

Fig. 2 Height of chickpea plants at full ripeness by year and fertilizer variants.

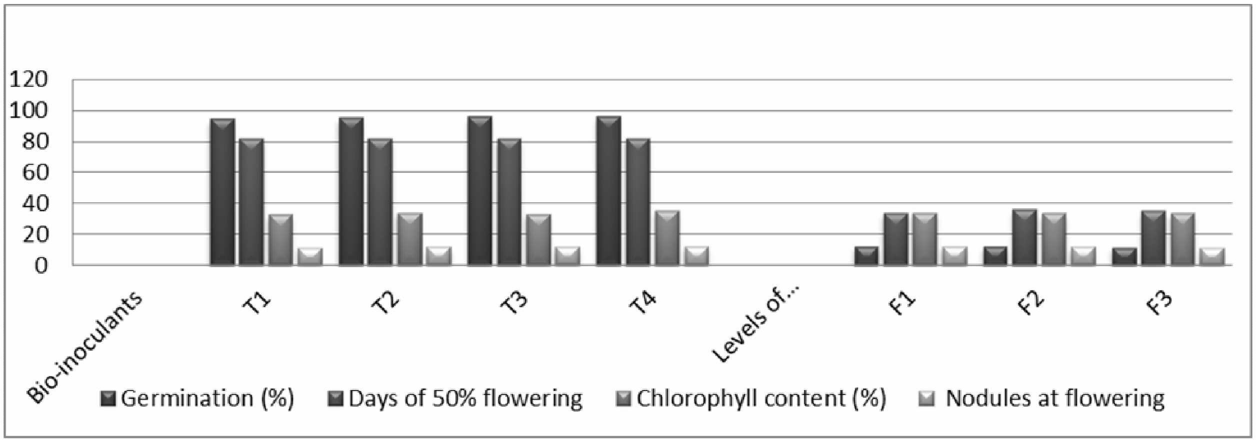

Fig. 3 Effect of Bio-Inoculants and Different Levels of Fertilizer on Growth Character at Different Stages of Crop Growth

Additionally, seed germination rates were highest in plots treated with Rhizobium+RII-4+NC-1, followed by Rhizobium+NC-9, while the lowest rates were observed in plots treated with Rhizobium (seed coating). Fertilizer levels did not significantly affect seed germination. The combined application of bio-inoculants, particularly Rhizobium+RII-4+NC-1, and recommended fertilizer doses positively influenced chickpea growth attributes, including plant height, number of branches per plant, and seed germination rates. Verma *et al*. (2008). These findings underscore the importance of careful management of bio-inoculants and fertilizer levels in optimizing chickpea productivity. The impact of bio-inoculants and different levels of fertilizer on chickpea yield characteristics, including seed yield per hectare, seed weight per plant, straw yield per hectare, and harvest index, was comprehensively evaluated. The mean data presented in highlighted the significant effects of these treatments on various yield attributing characters.

Firstly, the number of pods per plant was significantly influenced by the treatments, with Rhizobium+RII-4+NC-1 resulting in the highest pod count, followed by Rhizobium+RII-4. Fertilizer levels also played a significant role, with the highest pod count observed in plots receiving 100% RDF Shalu *et al.* (2011). The interaction effect between treatment and fertilizer was significant in terms of pod count. The seed weight per plant exhibited significant variations among treatments, with Rhizobium+RII-4+NC-1 producing the heaviest seeds. Fertilizer levels did not show significant effects on seed weight per plant. However, there was a significant interaction effect between treatment and fertilizer.

Thirdly, seed yield per hectare was significantly influenced by both treatments and fertilizer levels, with Rhizobium+RII-4+NC-1 resulting in the highest seed yield Neenu *et al.* (2014). Similarly, the highest seed yield was obtained in plots receiving 100% RDF. There was no significant interaction effect between treatment and fertilizer on seed yield per hectare. Additionally, straw yield per hectare showed significant variations among treatments and fertilizer levels, with Rhizobium+RII-4+NC-1 and plots receiving 100% RDF exhibiting the highest straw yields (Meena *et al*., 2013). Lastly, the harvest index, representing the ratio of seed yield to total biomass, was significantly influenced by treatments and fertilizer levels. Rhizobium+RII-4+NC-1 and plots receiving 100% RDF displayed the highest harvest indices. Khan *et al.* (2003). The study underscored the significant impact of bio-inoculants and fertilizer levels on chickpea yield attributes, emphasizing the importance of these factors in optimizing crop productivity. These findings contribute to our understanding of sustainable agricultural practices for enhancing chickpea yields and ensuring food security.

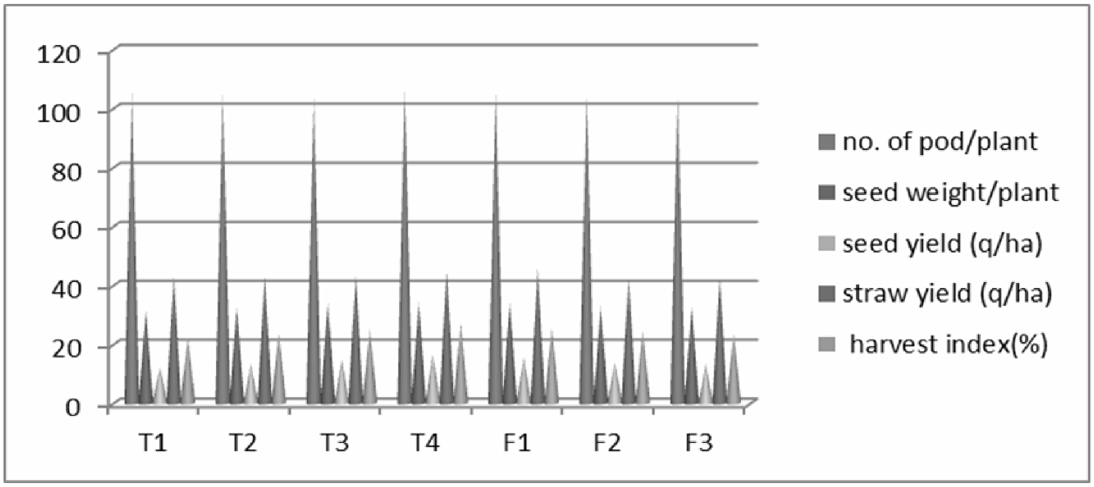

Fig 4. Effect of Microbial Inoculants and Different Levels of Fertilizer on Yield Character of Crop.

DISCUSSION

The examination of various treatments revealed significant effects on chickpea growth and yield attributes. Plant germination rates were highest in the Rhizobium+RII-4+NC-1 treatment, followed closely by Rhizobium+NC-9, while the lowest rates were observed in the Rhizobium (seed coating) treatment. Regarding fertilizer levels, maximum germination was recorded in the 100% RDF treatment, with lower rates observed in both the 75% RDF and 50% RDF treatments. Notably, the Rhizobium+RII-4+NC-1 bio-inoculant combined with 100% RDF fertilizer levels resulted in the tallest plants and the highest number of branches at maturity Venkatesh *et al*. (2012). These findings align with previous studies, highlighting the significant influence of inoculation treatments on chickpea plant height and nodulation, consequently affecting seed yield. Additionally, the application of recommended fertilizer doses combined with Rhizobium inoculation led to superior growth characteristics and higher seed yields (Kedar Prasad *et al* (2009). Yield attributing characters, including the number of pods per plant, seed weight per plant, and overall seed yield, were significantly higher in the Rhizobium+RII-4+NC-1 treatment with 100% RDF levels (Tolanur *et al.,* 2003). This indicates that the combination of bio-inoculants and appropriate fertility levels positively influenced chickpea growth and development. The higher seed and straw yields associated with Rhizobium+RII-4+NC-1 treatment further confirm the positive impact of this inoculation strategy on crop productivity (Sharma *et al.*, 1995). Moreover, the findings underscore the importance of fertilizer management and bio-inoculant application in enhancing chickpea yield and quality attributes.

CONCLUSION

In this study, we examined the effects of different levels of fertilizers and microbial inoculants of chickpea. Rhizobium (seed coating), Rhizobium+RII-4, Rhizobium+NC-9, Rhizobium+RII-4+NC-1 in combination with 3 levels of fertilizer i.e. 100% RDF, 75% RDF, 50% RDF tested in factorial Randomized Block Design with three replication. The results show that maximum seed yield was (16.80 q/ha) in bio-inoculants treatment Rhizobium+RII-4+NC-1 and (15.71 q/ha) in 100% RDF (20 kg N, 60 kg P, 20 kg K) kg/ha and straw yield was maximum (42.78 q/ha) in bio-inoculants Rhizobium+RII-4+NC-1 and (45.83 q/ha) fertility level i.e. 100% RDF (20 kg N, 60 kg P, 20 kg K

)kg/ha. All the treatments with improving all the tested growth and yield attributes of chickpea could be effective in improving growth and yield of chickpea and serve as an alternate eco-friendly option to the excessive usage of single source fertilizers inputs for sustainable agriculture and environmental stewardship.

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