Effect of different Fertility Management Practices on Plant Population and Mortality in Chickpea (*Cicer arietinum* L.)

Abstract

Aims: To assess the effect of Humic acid (HA), Plant growth-promoting bacteria (PGPR), and Recommended dose of fertilizer (RDF) alone or in combination on plant population and mortality percentage in Chickpea (*Cicer arietinum* L.).

Study of design: The experiment was laid out in Randomized block design (RBD) with three replications.

Place and Duration: A field experiment was conducted during the *rabi* season in the year 2020-21 and 2021-2022 at D_6 Block, Norman E. Borlaug Crop Research Center at G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand (India).

Treatments details: Total ten treatments were used. The details of the treatments are as follows:T_1- Absolute control, T_2 - Humic acid @ 2.5 kg/ha (soil application), T_3 -Humic acid @ 20 g/kg of seed (seed treatment), T_4 - PGPR @ 20 g/kg of seed (seed treatment), T_5- RDF through 150 kg NPK mixture (12:32:16 Grade), T_6 -RDF + HA (soil application), T_7 -RDF +HA (seed treatment), T_8- RDF +PGPR (Seed treatment), T_9- HA (soil application) +PGPR (seed treatment), T_{10}- RDF + HA (soil application)+PGPR (seed treatment).

Methodology: For plant population, the number of plants that emerged in the second row from both sides of the field were counted at 30 DAS and at harvest stage then averaged and calculate the number of plants for 1 m^2 area. The mortality percentage was calculated by using the following formula:

$$\text{Plant mortality (\%)} = \frac{\text{No. of plants at 30 DAS - No. of of plants at harvest}}{\text{No. of Plants at 30 DAS}} \times 100$$

Results: Findings of the investigation revealed that the effect of different fertility management on plant population was found not significant, but it was found significant in mortality percentage. Among the sole application of treatments T_2 (Humic acid @ 2.5 kg/ha (soil application) and T_4 (PGPR @ 20 g/kg of seed (seed treatment) recorded minimum mortality percentage, while among the combination treatments, T_{10} (RDF+HA (soil application) + PGPR as seed treatment) recorded minimum percentage of mortality.

Keywords- Humic acid, Plant growth-promoting bacteria, chickpea

Introduction

Chickpea (*Cicer arietinum* L.) is one of the first grain legumes domesticated by mankind. It is an important *rabi* pulse in India. Chickpea is the world's most significant legume crop, and its seed contains 16-31 percent protein, 3 percent fiber, 38-73 percent carbohydrate, 0.3 percent Phosphorus, vitamins (B and C), and minerals (Zn, Fe, K, Mg) (Özer et al., 2010). In India, chickpea occupied 9.85 Mha with a production of 11.99 Mt and a 1217 kg/ha productivity. Madhya Pradesh, Rajasthan, and Maharashtra are India's top chickpea-producing (Directorate of Economics and Statistics, 2021). Chickpea belongs to a *Leguminosae* family, which can fix atmospheric nitrogen (N_2) in association with Rhizobium bacteria. For the proper germination of chickpea, the edaphic and climatic conditions should be favorable. Uniform plant population is directly correlated with the yield. A high mortality rate can reduce the economic yield of chickpeas. Some sustainable approach needs to adapt to minimize the mortality percentage and improve the soil fertility status.

Humic acid is a dark black substance resistant to further decomposition made up of plant and animal materials through microbial degradation. Leonhardite (sedimentation layers), an oxidation result of lignite, is a key source of humic acid (RW O'donnell, 1973). Humic acid consists of 51 to 57% Carbon, 4 to 6% Nitrogen, and 0.2 to 1.0% Phosphorus and other terrace nutrients in minute amounts. Humic acid directly enhances plant growth by improving the soil's physical, chemical & biological properties and indirectly by increasing chlorophyll content, membrane permeability, and respiration in plants (Rajpar et al., 2011). Humic acid's structure comprises a wide range of compounds that cannot be defined by a single structural formula; hence its molecular weight ranges from 1000 to 30,000. HA provides more surface area and possesses more negative charge resulting in more water retention and Cation-exchange capacity of the soil (Rong et al., 2020). It is made up of chemically composite non-biochemical organic compounds, which Improve soil health and balanced plant nutrition. Thus, it is important for soil and plant productivity (Adani et al., 2006). It is also tolerant of abiotic stress (Shah et al., 2019).

Plant growth-promoting rhizobacteria (PGPR) are a diverse set of bacteria found in the rhizosphere, on root surfaces, and in close proximity to roots that can, directly and indirectly, promote the growth and development of plants (Bhattacharjya et al., 2013). PGPR has been found to release siderophores, which are extracellular metabolites. Microbial Fe-chelating low molecular weight molecules are referred to as siderophores. The siderophores help to facilitate the accessibility of Fe^{+3} to plants and protect the plant from soil-borne pathogens, which improves plant development and agricultural productivity (Verma et al., 2012). Rhizobium inoculant applied directly to planting furrows aids germination and nitrogen fixation of foreign strains (ES Jensen, 1987).

The rising population of the world has become a severe issue in respect to soil health due to the vast cultivation of crops for fulfilling the requirements of the present and future generation. In this approach, the soil mass has been widely examined without thinking for its health. If we can find some alternative to inorganic fertilizers, we can protect the soil. Two organic sources i.e humic acid and PGPR are being studied here to evaluate the influence on crop performance.

Material and Methods

The present study was conducted during the *rabi* season in 2020-21 and 2021-2022 at Norman E. Borlaug, a Crop research center at G.B. Pant University of agriculture and technology, district Udham Singh Nagar, Uttarakhand, India. The location is situated at 29˚ N latitude, 79.5˚ E longitude and an altitude of 243.83 m above mean sea level in the foothills of the Himalayas. The soil order of this region is Mollison, and the texture is sandy loam. Soil has a poor or moderately drain condition. The climate is humid and subtropical.

The experiment was laid out in a Randomized block design with three replications. The treatments included the application of humic acid, PGPR, and RDF alone or in combination. The details of the treatments are as follows: T_1- Absolute control, T_2 - Humic acid @ 2.5 kg/ha (soil application), T_3 -Humic acid @ 20 g/kg of seed (seed treatment), T_4 - PGPR I @ 20 g/kg of seed (seed treatment), T_5- RDF through 150 kg NPK mixture (12:32:16 Grade), T_6 -RDF + HA (soil application), T_7 -RDF +HA (seed treatment), T_8- RDF +PGPR (Seed treatment), T_9- HA (soil application) + PGPR (seed treatment), T_{10}- RDF + HA (soil application)+PGPR (seed treatment).There were a total 30 plots, and each plot size was 18 m^2. The crop was sown at 30×10 cm spacing. PG-186 variety of chickpea was used in the experiment.

Sampling and Calculation

For plant population, the number of plants that emerged in the second row from both sides of the field were counted at 30 DAS and at harvest stage then averaged and calculate the number of plants for 1 m^2 area. The mortality percentage was calculated by using the following formula:

$$\text{Plant mortality (\%)} = \frac{\text{No. of initial plants - No. of plants at harvest}}{\text{No. of initial plants}} \times 100$$

Result and Discussion

The data presented in Table 1 revealed that the plant population at both stages do not significantly affect by fertility management practices during both years. At harvest, the plant population during both years was reduced in all the treatments. The effect of treatments on mortality percentage was found to be significant during both years. In the first year of the experiment, the combination treatments, i.e., T_6, T_7, T_8, T_9, and T_{10}, were found at par and were significantly superior to the sole application of treatments while in the second year, T_6, T_9, and T_{10} were found at par. The lowest mortality was recorded in T_{10} (RDF+HA+PGPR), and the highest mortality was observed in T_1 (Control) Fig 1. It may be due to the effect of combining humic acid, PGPR, and RDF. Among the sole application of humic acid and PGPR treatments, PGPR using treatment recorded lower mortality in the first year. Humic acid (T_2) soil application recorded lower mortality in the second year. Among the combination treatments, T_6 obtained a lower percentage of mortality in both the years.

Table 1- Effect of different fertility management practices on plant population and mortality percentage in chickpea

Treatment	Plant Population/m^2				Mortality %	
	At 30 DAS		At harvest			
	2020-21	**2021-22**	**2020-21**	**2021-22**	**2020-21**	**2021-22**
T_1	34.0	34.0	27.3	27.3	19.5	19.5
T_2	34.0	35.0	28.3	29.6	16.6	15.2
T_3	33.0	34.3	27.3	28.3	17.6	17.5
T_4	35.0	33.6	29.6	28.3	15.1	15.9
T_5	34.0	34.3	28.0	28.6	17.3	16.6
T_6	33.0	35.3	29.3	31.3	11.0	11.4
T_7	33.0	32.6	28.6	28.0	12.7	14.4
T_8	34.6	33.0	30.3	28.6	12.4	13.1
T_9	35.0	35.0	30.6	30.6	12.4	12.2
T_{10}	33.0	33.0	29.6	30.0	10.1	9.2
S. Em±	0.9	1.0	1.2	1.3	1.1	1.1
C.D. (P=0.05)	NS	NS	NS	NS	3.5	3.5

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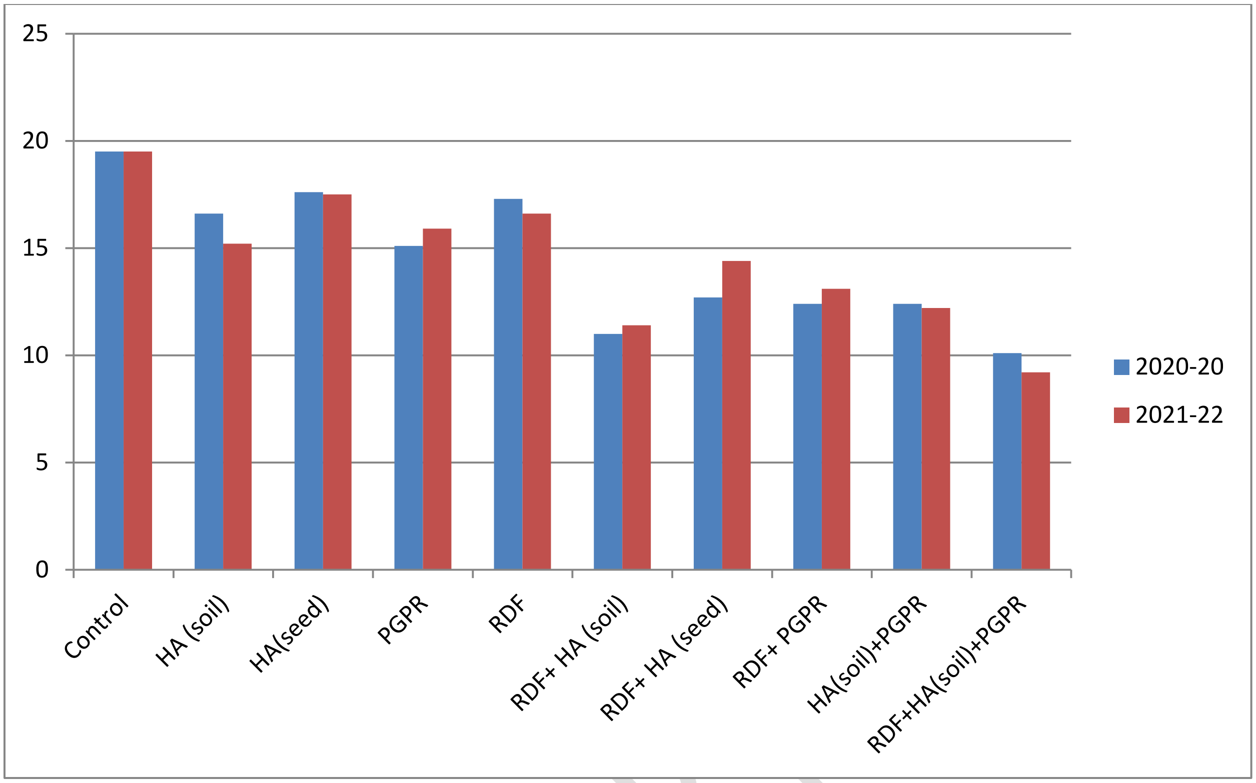

Figure 1- Effect of different fertility management practices on mortality percentage in chickpea.

Among the sole application of treatments, T_2, T_3, T_4, and T_5 recorded 14.51%, 9.38%, 22.41%, and 11.12% less mortality in the first year and 22.15%, 10.56%, 18.42%, and 15.26% in the second year, respectively as compared to T_1(control). Among the combination treatments, humic acid (soil application) and PGPR using treatments recorded the lowest mortality. This might be due to the application of HA which improves the soil structure by increasing the aggregation between the soil particles, which facilitates better aeration and provides strength to the soil to hold the plant against abnormal weather conditions (Chaney & Swift, 1986). On the other hand, PGPR releases some antioxidant which prevents the soil-borne diseases and also provides the favorable environment to the crop by regulating the rhizobacteria (Verma et al., 2012) similar results were obtained by (Sahni & Prasad, 2020)

Conclusion

This investigation concluded that the application of humic acid or PGPR along with RDF could reduce the mortality percentage and contribute to more grain yield in chickpeas. As humic acid and PGPR are organic substances that help improve the soil properties and enhance the microbial population in soil on a long-term basis. Application of humic acid and PGPR can reduce the amount of fertilizer that may sustainably protect the soil. This approach can reduce the fertilizer and lead to a step forward in sustainable agriculture.

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