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Effect of Micronutrients and NPK Consortia on Nodulation, Yields and Economics of Chickpea (*Cicer arietinum* L.) in Vertisols

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ABSTRACT

The present investigation was carried to understand the effect of micronutrients and NPK consortia on nodulation, yields and economics of chickpea in vertisols. The experiment was laid out in randomized block design with three replications. The treatments involved in the study were eight in number, i.e., T1: Control, T2: Zn @ 5 kg/ha, T3: Zn @ 7.5 kg/ha, T4: Zn @ 7.5 kg/ha + 0.5% foliar spray of ZnSO4 at 30 DAS, T5: Zn @ 7.5 kg/ha + seed treatment with molybdenum @ 2 g/kg seed, T6: Zn @ 7.5 kg/ha + 0.5% foliar spray of ZnSO4 at 30 DAS + seed treatment with molybdenum @ 2 g/kg seed, T7: Zn @ 7.5 kg/ha + seed treatment with NPK consortia @ 10 ml/kg, T8: Zn @ 7.5 kg/ha + 0.5% foliar spray of ZnSO4 at 30 DAS + seed treatment with molybdenum @ 2 g/kg seed + seed treatment with NPK consortia @10 ml/kg seed. Results clearly indicates that application of Zn @ 7.5 kg/ha + 0.5% foliar spray of ZnSO4 at 30 DAS + seed treatment with molybdenum @ 2 g/kg seed + seed treatment with NPK consortia @10 ml/kg (T8) gave significant and positive effect on nodulation (total nodules, effective nodules, fresh and dry weight of nodules/plant) and yield parameters viz., pods/plant (72.88) and 100-seed weigh (23.10 g), seed yield (18.99 q/ha) and biological yield (37.06 q/ha) as compared to other treatments. Similarly, maximum protein content (21.25%), protein yield (40.23 t/ha), gross returns (Rs.100447/ha), net returns (Rs. 68856/ha) and B:C ratio (3.18) was also noted under T8 treatment. The chemical properties of soil (available N, P and K) also improved but not reached at significant level. Hence, application of 7.5 kg/ha + 0.5% foliar spray of ZnSO4 at 30 DAS along with seed treatment with molybdenum @ 2 g/kg seed and NPK consortia @10 ml/kg improved the nodulation, productivity as well as economics of chickpea under rainfed conditions.

Keywords: Chickpea, Micronutrients, Nodulation, Consortia Productivity and Protein content

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INTRODUCTION

Pulses are the second most important group of crops after cereals. Gram is a member of leguminous family and originated in South west-Asia. It is a self-pollinated, diploid, annual grain-legume crop. Pulses are played an important role in sustaining soil productivity by improving its physico-chemical and biological properties; it further enhances soil nitrogen content by increased trapping of atmospheric nitrogen in their root nodules (Chandra et al., 2020). The major gram growing states in India are Madhya Pradesh, Maharashtra and Rajasthan. In the world, chickpea is grown in an area of 14.81 million hectares with a total production of 18.09 million tonnes with a productivity of 1221 kg/ha and in India, chickpea are grown in an area of 10.74 million hectares with a total production of 13.54 million tonnes with productivity of 1261 kg/ha. In India, Madhya Pradesh is the leading producer with a production of 3.19 million tonnes which shares about 27.52% of the total production (Anonymous, 2023).

Micronutrients play an important role in increasing the yield of pulses, oilseeds and legumes through their direct effects on the plant and through symbiotic nitrogen fixation process. The continuous use of micronutrients free high nitrogen and phosphorous fertilizers in the intensive cropping system with diminishing use of organic manures has resulted in the depletion of micronutrients cations from the soil reserves. Owing to this, the productivity of many crops has reduced substantially over the years (Khandkar et al., 2019). In legumes, during symbiotic N fixation, molybdenum (Mo) acts as a co-factor for nitrogenase enzymes to catalyze the redox potential to convert elemental N into ammonium (NH_4^+) ions and nitrate reductase enzymes required for the assimilation of

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soil nitrates. Therefore, plant N metabolism is closely related to the Mo concentration in soil, especially for leguminous plants (Kumar et al., 2014). Zn is an essential micronutrient, not only enhance the crop productivity but also improves the quality of produce. It enhances water use and water use efficiency, nodulation and nitrogen fixation. Furthermore, it is important for plant growth and development. It is involved in much metabolic process like carbohydrate, lipid, protein and nucleic acid synthesis and degradation. As well it can substantially improve seed germination and seedling vigour (Nandan et al., 2018). The prices of chemical fertilizers are increasing day-by-day and ultimately availability of fertilizers and therefore, it is necessary to minimize the cost of fertilizers by using biofertilizers for enhances the productivity of crops. Biofertilizers are carrier-based preparations containing beneficial microorganisms in the rhizosphere, and it is the source of increasing the productivity and sustainability of the soil. The application of biofertilizers reduces the risk of the soil acidification and contamination of the groundwater. Rhizobium inoculation, as biofertilizer, was shown to induce an increase in nodulation of roots, plant growth, seed yield (upto 35%) and nitrogen fixation in chickpea (Kumawat et al., 2019). Therefore, the present investigation was undertaken to study the Effect of Micronutrients and NPK Consortia on Nodulation, Yields and Economics of Chickpea (Cicer arietinum L.) in Vertisols.

MATERIALS AND METHODS

The investigation was conducted at College of Agriculture, Indore during rabi, 2020-21. It is situated at 75°48' East longitude and 22°43' North latitude with an altitude of 567 meters above mean sea level. In Madhya Pradesh, this region falls under agroclimatic Zone IX (Malwa plateau). The climatic condition of this region is sub-tropical. On the basis of the experimental field soil testing, the soil was found to be slightly alkaline in pH reaction (7.8), low in organic carbon (0.42%), nitrogen (245 kg/ha), medium in phosphorus (12.3 kg/ha), and high potassium levels (480.2 kg/ha). The experimental field was laid out in a randomized block design with three replications, comprising of eight treatments in which zinc, molybdenum, and NPK consortia were applied as sole and in combinations. The treatments applied for the research purpose were T1: Control, T2: Zn @ 5 kg/ha, T3: Zn @ 7.5 kg/ha, T4: Zn @ 7.5 kg/ha + 0.5% foliar spray of ZnSO4 at 30 DAS, T5: Zn @ 7.5 kg/ha + seed treatment with molybdenum @ 2 g/kg seed, T6: Zn @ 7.5 kg/ha + 0.5% foliar spray of ZnSO4 at 30 DAS + seed treatment with molybdenum @ 2 g/kg seed, T7: Zn @ 7.5 kg/ha + seed treatment with NPK consortia @ 10 ml/kg, T8: Zn @ 7.5 kg/ha + 0.5% foliar spray of ZnSO4 at 30 DAS + seed treatment with molybdenum @ 2 g/kg seed + NPK consortia @10 ml/kg seed. Chickpea variety RVG- 202 was selected in the experiment. To cultivate a good crop, all other recommended cultural practices were followed. The observations were recorded in randomly taken five plants per plot and tagged plants from each replication on yield attributes traits viz., pods/plant, seeds/pod, 100-seed weight, seed and straw yield (q/ha). Seed yield was computed by threshing pods from net plot, cleaned and the seeds weight was recorded. From this seed yield per hectare was computed. Protein content in grain was worked out by multiplying the nitrogen content in grain with the factor by (AOAC, 1970). Protein harvest (kg/ha) was determined by multiplying the protein content in grain with their respective yields. Net returns (Rs./ha) was calculated by deducting cost of cultivation (Rs./ha) from gross returns, while B: C ratio were worked out as ratio of gross returns (Rs./ha) to cost of cultivation (Rs./ha). All the data obtained from trial was statistically analyzed using the F-test (Gomez and Gomez, 1984). Critical difference (CD) values at 5% probability were used for determine the significance of differences between mean values of treatments.

RESULTS AND DISCUSSION

Nodulation

The data recorded on nodules parameters of chickpea (Table 1) clearly indicate that the total nodules, effective nodules, fresh weight and dry weight of nodules/plant were significantly influenced by the micronutrients and NPK consortia. The maximum total number of nodules/plant (36.33), effective nodules/plant (30.82), fresh weight of nodules/plant (736.67 mg) and dry weight of nodules/plant (115.0 mg) were observed under the treatment T8 (Zn @ 7.5 kg/ha + 0.5% foliar spray of ZnSO4 at 30 DAS + seed treatment with molybdenum @ 2 g/kg seed + NPK consortia @10 ml/kg), which was found statistically superior over all other treatments except control. While the minimum number of all nodule's parameters (27.73, 22.13, 515.67 and 81.33, respectively) was noted under control plots. The enhancement in number of nodules and nodule dry weight of chickpea with the application of Zn could be ascribed to its major role in regulating the nodulation in pulses. Zn acts as antioxidant and its application helps in reducing the lipid peroxidation and hydrogen peroxide concentration in plant and also involved in the functioning of transcriptional regulators responsible for nitrogen fixation in plants (Weisany et al., 2012). The improvement in these characters might be due to the fact that molybdenum is a constituent of enzyme nitrogenase, which is essential nutrient for the process of symbiotic nitrogen fixation. It is also present in the enzyme nitrate reductase, which is responsible for reduction of nitrates to ammonia in plant resulting into increased amino acids and protein synthesis in cell of plant, causing better growth and development. The increase in nodulation might also be due to synergistic effect of microbial consortium, the fact that PSB by virtue of their property of producing organic acids solubilize insoluble or fixed form of phosphorus in the rhizosphere and make it available to the growing plants, which promotes root development in plants and enhanced biological N2 fixation at root zones. NPK consortia release of growth promoting substances which provide favourable environment for Rhizobium, which promote to root development resulting improve the nodulation (Kumar et al., 2014).

Table 1: Effect of micronutrients and bioinoculants on nodulation and yield attributes of chickpea

Treatments	Total nodule/ plant (No.)	Effective nodules/ plant (No.)	Fresh weight of nodules (mg)	Dry weight of nodules (mg)	Pods/ plant (No.)	Seeds/ pod (No.)	100-seed weight (g)
Control (T1)	27.73	22.13	515.67	81.33	59.13	2.00	18.83
Zn @ 5 kg/ha (T2)	31.00	25.67	583.33	95.33	64.00	2.03	20.33
Zn @ 7.5 kg/ha (T3)	31.10	27.67	633.33	99.43	66.67	2.07	20.47
Zn @ 7.5 kg/ha + 0.5% foliar spray of ZnSO4 (T4)	31.33	28.13	635.00	101.67	67.06	2.03	20.57
Zn @ 7.5 kg/ha + seed treatment with molybdenum @ 2 g/kg seed (T5)	34.33	30.13	683.33	106.33	70.20	2.07	22.33
Zn @ 7.5 kg/ha + 0.5% foliar spray of ZnSO4 + molybdenum @ 2 g/kg seed (T6)	35.67	30.33	730.00	110.00	71.00	2.11	22.70
Zn @ 7.5 kg/ha + seed treatment with NPK consortia @10 ml/kg (T7)	32.73	29.17	660.00	102.67	68.83	2.03	21.85
Zn @ 7.5 kg/ha + 0.5% foliar spray of ZnSO4 + molybdenum @ 2 g/kg seed + NPK consortia @10 ml/kg seed (T8)	36.33	30.82	736.67	115.00	72.88	2.13	23.10
CD (P=0.05)	5.34	3.31	64.23	12.97	4.58	NS	1.96
SEm +	1.83	1.13	21.95	4.43	1.56	0.07	0.67

Yield attributes and yield

The yield attributes weight of pods/plant, 100-seed weight, seed yield and biological (q/ha) were significantly higher with the application of Zn @ 7.5 kg/ha + 0.5% foliar spray of ZnSO4 at 30 DAS + seed treatment with molybdenum @ 2 g/kg seed + NPK consortia @10 ml/kg (T8). The difference in seed yield and biological was 376 and 617 q/ha which was higher by 24.57 and 19.97 per cent due to application of T8 treatment. The straw yield was remained unaffected by different treatments (Table 1 & 2). The Zn application also improves protein and carbohydrates synthesis and their transportation to the site of seed formation. While, Mo plays an important role in synthesis of chlorophyll and plant growth regulator and also improves photosynthesis and assimilates transportation to sink and finally increases seed yields (Banjara and Majgahe, 2019). The application of Mo allowed synthesis of more nodule tissue due to better supply of Mo from soil to plants and also by maintaining supply of essential metabolites to the nodules might be due to more availability of nitrogen throughout crop season due to basal N application, N-fixation and urea spray. The NPK consortia might have helps in better availability of N, P and K nutrients caused well developed root system having higher nitrogen fixing capacity resulting better growth and development of plants and better diversion of photosynthates towards sink (Kumawat et al., 2020).

Table 2: Effect of micronutrients and bioinoculants on yields, protein content of chickpea

Treatments	Seed yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Protein content (%)	Protein yield (kg/ha)
Control (T1)	15.23	15.66	30.89	18.22	27.73
Zn @ 5 kg/ha (T2)	15.97	16.42	32.40	18.37	29.39
Zn @ 7.5 kg/ha (T3)	16.25	16.29	32.54	18.25	29.67

Treatments	Seed yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Protein content (%)	Protein yield (kg/ha)
Zn @ 7.5 kg/ha + 0.5% foliar spray of ZnSO4 (T4)	16.38	17.09	33.47	18.89	30.97
Zn @ 7.5 kg/ha + seed treatment with molybdenum @ 2 g/kg seed (T5)	18.34	18.21	36.56	20.67	37.86
Zn @ 7.5 kg/ha + 0.5% foliar spray of ZnSO4 + molybdenum @ 2 g/kg seed (T6)	18.76	17.75	36.51	20.93	39.26
Zn @ 7.5 kg/ha + seed treatment with NPK consortia @10 ml/kg (T7)	17.74	18.63	36.36	20.25	35.78
Zn @ 7.5 kg/ha + 0.5% foliar spray of ZnSO4 + molybdenum @ 2 g/kg seed + NPK consortia @10 ml/kg seed (T8)	18.99	18.08	37.06	21.25	40.23
CD (P=0.05)	19.07	NS	4.98	2.06	3.74
SEm +	6.52	13.55	1.70	0.71	12.79

Protein content and protein yield

The higher protein contents and protein yield were recorded in treated plot Zn @ 7.5 kg/ha + 0.5% foliar spray of ZnSO4 + seed treatment with molybdenum @ 2 gm/kg seed + seed treatment with NPK consortia @ 10 ml/kg in comparison to other treatments (Table 2). Supplementation of Mo and Zn favored nitrogenase activity and thereby enhance N fixation and uptake by plants under the treatment of molybdenum as seed treatments along with bio-fertilizers which ultimately resulted in higher N and protein content in seed. Similarly, seed inoculation with NPK consortia improved the protein in seed because of better nodule development vis-a-vis nitrogen fixation and its utilization towards protein synthesis due to better availability of nutrients like nitrogen, phosphorus and potassium. Similarly, the protein yield is a function of protein content in seed and seed yield per hectare. The higher seed yield and nitrogen content in seed resulting higher the protein yield (Kumawat et al., 2021). The application of micronutrients and NPK consortia treatments marginally improved the pH, EC, organic carbon and nitrogen, phosphorous and potassium content in soil but failed to affect significantly at harvest stage of gram (Table 3).

Table 3: Effect of micronutrients and bioinoculants on economic and chemical properties of soil

Treatments	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Control (T1)	80804	53561	2.97	178.37	14.21	468.87
Zn @ 5 kg/ha (T2)	84745	55802	2.93	176.36	14.22	470.19
Zn @ 7.5 kg/ha (T3)	86135	56442	2.90	176.87	14.22	471.47
Zn @ 7.5 kg/ha + 0.5% foliar spray of ZnSO4 (T4)	86977	57084	2.91	178.56	14.49	473.33
Zn @ 7.5 kg/ha + seed treatment with molybdenum @ 2 g/kg seed (T5)	97199	65968	3.11	179.21	15.14	481.22
Zn @ 7.5 kg/ha + 0.5% foliar spray of ZnSO4 + molybdenum @ 2 g/kg seed (T6)	99234	67803	3.16	180.65	15.32	484.01
Zn @ 7.5 kg/ha + seed treatment with NPK consortia @10 ml/kg (T7)	94182	64329	3.15	178.87	14.97	475.68

Treatments	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Zn @ 7.5 kg/ha + 0.5% foliar spray of ZnSO4 + molybdenum @ 2 g/kg seed + NPK consortia @10 ml/kg seed (T8)	100447	68856	3.18	182.17	15.45	487.27
CD (P=0.05)	10041	10041	0.19	NS	NS	NS
SEm +	3432	3432	0.06	4.59	0.45	8.54

Economics

The results revealed that application of Zn @ 7.5 kg/ha + 0.5% foliar spray of ZnSO4 (at 30 DAS) + seed treatment with molybdenum @ 2 gm/kg seed + seed treatment with NPK consortia @ 10 ml/kg seed treatment fetched significantly maximum gross returns, net returns and benefit cost ratio (Table 3). The improvement in plant growth parameters, yield attributing characters and higher seed and straw yield might have been responsible for the higher gross returns, net returns as well as benefit: cost ratio over control. These findings are in conformity with Katiyar et al. (2017).

CONCLUSION

From the above research findings, it could be concluded that nodulation yield attributes, seed yield of chickpea as well as economics significantly enhanced by the application of 7.5 kg/ha + 0.5% foliar spray of ZnSO4 at 30 DAS along with seed treatment with molybdenum @ 2 g/kg seed and NPK consortia @10 ml/kg under rainfed conditions.

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