Effect of Seed priming, Beejamrit, Jeevamrit and Micronutrients on Symbiotic traits,Growthattributes,Dehydrogenaseactivity,Leghaemoglobincontent, Protein content and Grain yield of chickpea

ABSTRACT

A field experiment was conducted at Research Farm area of R.A.K. (Rafi Ahmad Kidwai) College of Agriculture, Sehore, Madhya Pradeshduring *rabi* season 2023-24 to study the effect of Seedpriming,Beejamrit, Jeevamrit and Micronutrients (Zn and Mo) in combination with *Rhizobium* and PSB inoculation on symbiotic traits, growth attributes, soil dehydrogenase activity (DHA) and leghaemoglobin content in root nodules, protein content in seed and grain yield of chickpea crop grown with one irrigation in Vertisol. The experiment was laid out in Randomized Block Design (RBD) with 10 treatments and replicated thrice.The treatments comprised of T_1: RDF + *Rhizobium* (Rh) + Phosphate Solubilizing Bacteria (PSB), T_2: RDF + Rh + PSB + Seed primingwithwater,T_3:RDF+Rh+PSB+Beejamrit treatment (seed primed), T_4: RDF + Rh+PSB+Seedprimingwith0.05%MoasAmmonium Molybdate (AM), T_5: RDF + Rh + PSB + AM 1 gm kg^{-1} seed with inoculation, T_6: RDF + Rh + PSB + Jeevamrit spray at 35 and55 days after sowing (DAS), T_7: T_1 + 0.05% AM spray at 35 and 55 DAS, T_8: T_1+ 0.5% $ZnSO_4$+ 0.25% Lime spray at 35 and 55 DAS, T_9:T_1 +0.05%AM+0.25%$ZnSO_4$+0.25%Lime spray at 35 and 55 DAS and T_{10}: 50% RDF + Rh + PSB + Jeevamrit spray + 0.05% AM + 0.25% $ZnSO_4$+ 0.25% Lime spray at 35 and 55 DAS. The symbiotic traits, growth attributes at 50 DAS and grain yield was significantly increased by the application of RDF + *Rhizobium* + PSB + Ammonium Molybdate @ 1 gm kg^{-1} seed with inoculation (T_5), followed by treatment T_{10}(50% RDF + *Rhizobium* + PSB + Jeevamrit spray + 0.05% AM + 0.25% $ZnSO_4$+ 0.25% Lime sprayat 35 and 55 DAS). The T_5 treatmentproduces about 26% higher grain yield over theRDF + *Rhizobium* + PSB (T_1). The treatment T_5 recorded highest protein content in seed i.e. 19.50%, followed by the treatment T_{10} (19.31%). DHA in rhizosphere soil and leghaemoglobin content in root nodules at 50 DAS was found maximum in treatment T_5 (31.20µgTPF [Triphenyl formazan]g^{-1} soilhr^{-1} and3.10mg g^{-1}respectively),followedby treatment T_{10} with values 30.60 µg TPF g^{-1} soil $hr^{-1}$and 3.08 mg g^{-1} respectively. The study indicated necessity of application of molybdenum wherever deficient in Vertisol under intensive (Soybean-Chickpea)cultivation oflegumes, for enhancing productivity of chickpea and also gave indication that by integration of Jeevamrit spray + 0.05% AM + 0.25% $ZnSO_4$+ 0.25% Lime sprayat 35 and 55 DAS, a saving of 50% RDF can be made under existing practice.Further, this study also give an indication that the use of RDF along with biofertilizers i.e. *Rhizobium* +PSB and seed priming in beejamrit (T_3) for four hours before sowing may also be a beneficial option with slightly lower, but statistically identical chickpea yield with highest yielded treatment T_5.

Key words: Seed priming, Beejamrit, Jeevamrit, Micronutrients, Dehydrogenase activity, Leghaemoglobin, Protein content, Chickpea.

1. INTRODUCTION

Chickpea (*Cicer arietinum* L.) is a cool- season long-day legume crop and has a diverse use with specific consumer preferences in the global market. It is also known as Gram or Bengal gram. During 2021-2022, India produced13.75milliontonnesofchickpeafrom an area of 10.91 million ha and productivity of 1260kgha^{-1}.Witha2.03millionhaareaand3.03 million tonnes of production, Madhya Pradesh (M.P.) is the major chickpea growing state in India.(Source:DA&FW,2021-2022; Directorate of Economics and Statistics).

The yield levels of chickpea have been generally low which might be attributed to its major cultivation under rainfed conditions with less/imbalance use of fertilizers, very limited seed inoculation with biofertilizers (Sharma and Gupta, 2005), no use of organic manures which is associated with decline in soil organic carbon and overall soil healthand also due to its susceptibility to wilt, insect, pest and diseases. Further, due to intensive cultivation of Soybean-Chickpea in Vertisol of M.P., some of the micronutrients deficiencies are also observed which might be affecting the productivity. Hence, it is imperative to find ways to integrate natural farming inputs like Beejamrit and Jeevamrit and micronutrients to improve crop yield with reduction in the use of chemical fertilizers.

BeejamritreferstoBeej,whichmeansseed, is dipped into Amrit which means magical liquid. It is a homemade organic inputoriginally made up of cow dung and cow urine. AccordingtoChadha*etal.*(2012),itisbelieved to protect seeds and plants from pest infestation and illnesses, especially those that are transmitted by seeds.Beejamrit, an organic product, was used to treat seeds prior to sowing in order to improve germination and protect young roots from fungi, as well as soilborne and seed-borne diseases. This is also believed to induce seed germination and improve seedling/plant growth.Jeevamrit is traditional fermented liquid organic manure that is frequently employed as a soil microbial enhancer in natural farming. It is abundant in beneficial microflora, macronutrients, essential micronutrients, growth-promoting factors like IAA (Indole-3-acetic acid) and GA (Gibberellic acid), numerous vitamins, and essential amino acids (Nitin and Purohit, 2021). Jeevamrit, an organic product used as spraying on standing crop.Seed priming is a pre-sowing approach thatinfluences seedling development by modifying pre-germination metabolic activity prior to radicle emergence, resulting in rapid, uniform emergence and improved plant performance to attain high vigor and yield. Micronutrients are needful elements for normal growth of plants that are needed at little amount. Zinc (Zn) is an important micronutrient involved in distinct biochemical processes in plants, such as respiration, photosynthesis, chlorophyll biosynthesis, and the synthesis and degradation of proteins, lipids, carbohydrates, and nucleic acids (Nishizawa, 2005). Molybdenum (Mo) is involved in important functions like nitrogen metabolism, nitrogen-fixation, and transportation of sulphur-containing amino acids in legumes (Togay *etal.,* 2008). Zn deficiency in M.P. soils in many places was reported earlier by Shukla *et al.*, 2016.Similarly, Mo deficiency in some tested samples in M.P. reported by Behera *et al.*, 2014.Micronutrient deficiency causes significant yield loss in chickpea, and the application of deficient micronutrients is often recommended to maintain the desired yieldlevel (Montenegro *et al.,* 2010).

Thus, keeping this in view, the experiment was conducted to assess the effect of Seed priming, Beejamrit, Jeevamrit and Micronutrients (Zn and Mo) in combination with*Rhizobium*andPSBinoculationongrowth, yield, protein content in seed, Soil Dehydrogenase activityand leghaemoglobin content in root nodules of chickpea.

2. MATERIALSANDMETHODS

Afieldexperimentwasconductedat Research Farm area at Department of Soil Science, R.A.K. College of Agriculture, Sehore, Madhya Pradesh (23º 20' N latitude and 77º08' E longitude) during *rabi* season 2023-24 to study the effect of Seed priming, Beejamrit, JeevamritandMicronutrients(ZnandMo)incombination with *Rhizobium* and PSB inoculation on symbiotic traits, growth attributes, grain yield, protein content in seed, DHA of rhizosphere soil andleghaemoglobincontentinrootnodules of chickpea crop grown with one irrigation in Vertisol having soil pH 7.4 (Jackson,1973), EC (Electrical conductivity) 0.36 dSm^{-1}(Jackson,1973), available nitrogen (N): 204.50 kg ha^{-1}(Subbiah and Asija, 1956), available phosphorus (P): 17.32 kgha^{-1}(Olsen's *etal*., 1954),available potassium (K):515.20kgha^{-1}(Hanway and Heidel, 1952),available sulphur (S): 10.72 mg kg^{-1}(Chesnin and Yien, 1951), available zinc (Zn): 0.48 mg kg^{-1} (Lindsay and Norvell, 1978) and available molybdenum (Mo): 0.02 mg kg^{-1}. The experiment was laid out in randomized block design with 10 treatments replicated thrice. The treatments details are mentioned in Table 1. Before sowing, the seed were treated with *Rhizobium* and PSB cultures @ 5g eachkg^{-1}seed.Forseedpriming,theseedswere soaked for 4 hours before sowing.

The observation on symbiotic traits at 50 DAS (number of root nodules plant^{-1} and dry weight of root nodules plant^{-1}),growth attributes i.e.,dryweight plant^{-1} at 50 DAS and plant height and number of branches plant^{-1} at 50 DAS and maturity, protein content in seed and grain yield at harvest. Dehydrogenase activity (DHA) in rhizosphericsoil andleghaemoglobin content inrootnodulesat50DASwererecordedusing standard procedure described by Klein *et al.* (1971) and Wilson and Reisenauer (1963) respectively. For analysis of Soil DHA, the soil adhere to roots of uprooted plants was collected from individual treatment plot and used for analysis after drying soil in shed. Composite soil sample collected and analyzed for knowing initial nutrient status. The data obtained in various observations were statistically analyzed under RBD and are presented and described under results. The data was tabulated in systematic manner and analyzedstatisticallybyFisher'sMethod.Thecalculated"F"valuecomparedwithtabulated "F" value at 5 percent level of significance. Critical difference (C.D.)or least significant difference at 5 percent level of probability was calculated to judgethedifference betweenthetreatmentmeans. The data was analyzed through ANOVA (Analysis of Variance).

Preparation of indigenous inputs of Natural Farming:

a) **Beejamrit:-** For preparation of Beejamrit, 5 kg cow dung taken in cloth which was bind and hang in a drum containing 20 litre of water for 12 hours. Simultaneously, 1 litre of water and 50 gm lime was taken to prepare lime water and kept it stable for overnight. Then, cow dung bundle squeezed in water thrice. To this solution, 1 kg soil, 5 litre cow urine and lime water added and stirred well for final preparation of Beejamrit. Seeds were treated with Beejamrit by dipping seed for 4 hour prior to sowing. Remove seeds and dry and then use them for sowing.

b) **Jeevamrit:-**For preparation of Jeevamrit, 10 kg cow dung, 10 litre cow urine, 50 gm lime, 2 kg jaggery, 2 kg pulse flour, 1 kg soil was taken and all these ingredients mixed in a drum containing 200 litre water. This mixture was allowed to ferment for a week in shade. The solution intermittently stirred twice/ thrice a day. Now, the solution is ready to spray on crop as Jeevamrit.

Table 1: Treatments details

S. No.	Treatment	Treatment Details
1.	T_1	RDF+ *Rhizobium* + PSB
2.	T_2	RDF + *Rhizobium* +PSB +Seedpriming with water
3.	T_3	RDF + *Rhizobium* +PSB +Beejamrit treatment (seedprimed)
4.	T_4	RDF + *Rhizobium* +PSB +Seedpriming with 0.05% Mo asAM
5.	T_5	RDF + *Rhizobium* +PSB +AM1gmkg^{-1} seed with inoculation
6.	T_6	RDF + *Rhizobium* +PSB +Jeevamrit sprayat35and55 DAS
7.	T_7	T_1+ 0.05%AMsprayat35and55 DAS
8.	T_8	T_1+ 0.5%$ZnSO_4$+0.25%Limesprayat 35 and 55 DAS
9.	T_9	T_1+ 0.05%AM +0.25%$ZnSO_4$+0.25%Limesprayat 35 and 55 DAS
10.	T_{10}	50% RDF+*Rhizobium* + PSB +Jeevamrit spray + 0.05%AM +0.25%$ZnSO_4$+0.25%Limesprayat 35 and 55 DAS

Note: RDF:Recommendeddoseoffertilizer,PSB:Phosphatesolubilizingbacteria,DAS: Days after sowing, AM: Ammonium Molybdate,$ZnSO_4$: Zinc sulphate

3. RESULTSANDDISCUSSION

3.1 EffectonSymbioticTraits:

The data of symbiotic traits i.e., number of root nodules plant^{-1} and dry weight of root nodules plant^{-1} at 50 DAS (Table 2) indicates significant effect by different treatments over control. The treatment T_5recorded maximum number of root nodules plant^{-1}(25.81), followed by thetreatment T_{10} (24.51) and T_9 (24.00). The treatment $T_5$was statistically at par with $T_9$and T_{10}treatments. Similarly, the dry weight of root nodules plant^{-1} was also recorded highest in treatment T_5 with a value of 40.00 mg, followedbythetreatmentT_{10}i.e., 38.64 mg at 50 DAS. The minimumnumber of root nodules plant^{-1} and dry weightof root nodules plant^{-1} was recorded in treatment T_1 (15.41 and 28.01mg respectively). The increased microbial activity through effective inoculated rhizobia and P solubilizing bacteria along with micronutrients molybdenum and Zn application may be the cause of rise in number of root nodules and dry weight of nodules. Molybdenum plays an important role in nitrogen metabolism as it is involved in process of nitrogen fixation, nitrate reduction and in the transport of nitrogen in plants. Zinc is required for synthesis of tryptophan, which is essential for the formation of nodules and for promoting plant cell differentiation. Jeevamrit application might favor microbial activities in the rhizosphere, which resulted in increased nodulation. These findings are in accordance with the results of Gupta and Sahu (2012), Gangwar and Dubey (2012) and Khandkar *et al.* (2019).

3.2 EffectonGrowthAttributes:

The data of growth attributes i.e., plant height, number of branches plant^{-1} and total dry weightplant^{-1}(Table2)indicatessignificant effect by different treatments over control. The highest plant height and number of branches plant^{-1} at 50 DAS and maturity was recorded under treatment T_5 with a value of 29.42 cm (At 50 DAS), 35.04 cm (At Maturity) and 3.31 (At 50 DAS) and 4.30 (At Maturity) respectively, followed by thetreatment T_{10}.TheT_5 treatmentrecordedhighesttotal dryweightplant^{-1}at50DAS(2.28g),whichwas statistically at par with $T_9$and T_{10}treatments. This could be explained byincreased nitrogenase and nitrate reductase activitiesasaresultofusingmolybdenumalong with

Rhizobium + PSB, which could boost nitrogen fixation. Increased phosphorus solubilization, improved nitrogen fixation and increased Mo nutrition, all these contributed to legume crop's quicker development, which raised the plant height and number of branches. Zinc plays an important role to synthesize the plant growth regulator such as auxin, which takes active role in enlargement and elongation of plant height and also helps in increasing the number of branches of crop. Jeevamrit contains beneficial microorganisms and plant growth promoting substances like IAA and GA, which promotes growth such as plant height and number of branches of crop. These findings are in accordance with the results of Nagaraju and Mohankumar (2010), Sutar *et al.* (2019) and Bharadwaj *et al.* (2021).

3.3 EffectonGrain Yield(kg ha^{-1}):

The grain yield is the most important character of any treatment which represents the superiorityofanytreatment.Highestgrainyield was observed under treatment T_5 (1333.3 kg ha^{-1}), followed by the treatment T_{10}(1250.0 kgha^{-1}), T_9(1229.3 kg ha^{-1}), T_7 (1228.3 kg ha^{-1}) and T_3 (1225.0 kgha^{-1}) which were statistically identical with each other (Table 2). The results indicates that use of Mo as Ammonium molybdate produced maximum yield, however treatment T_{10} involving integration of 50% RDF with biofertilizers along with Jeevamrit, Mo & Zn sprayat 35 and 55 DAS and also treatment T_3 which involves use of RDF along with biofertilizers and beejamrit priming of seed, though yielded numerically lower, but were statistically identical with highest yielded treatment T_5.Lowest grainyieldwasfoundinT_1i.e. 1058.3 kg ha^{-1}. The grain yield of treatment $T_5$was about 26% more than the treatment T_1. These responses may be attributed to use ofMo-treated seed which enhances nitrogen fixation with increased nitrogenase activity and also enhances N use efficiency through nitrate reductase because Mo is a key component of both of these enzymes. Enhanced N contentalso improves chlorophyll production, which boosts photosynthesis and increases plant attributes, which in turn raised seed yields.Zn influences the synthesis of IAA in plants which indirectly improves the growth, development and symbiotic parameters and ultimately the seed yield of the crop. Jeevamrit contains beneficial microbe's viz. bacteria, fungi, yeast, actinomycetesandsomephotosyntheticbacteria which are beneficial for plant nutrient availability which increases seed yield. Together, all these factors contribute in better crop growth and yield attributes, which leads to higher seed yield under these treatments. These findings are supported by Poonia and Pithia (2014), Poojar *et al.* (2022) and Singh *et al.* (2023).Comparatively low yield of crop under natural farming as against chemical fertilization, also reported by Korat *et al.* (2023).

3.4 Effecton Protein content in seed (%):

Protein content in chickpea seed is directly related to nitrogen content in seed. The data of protein content in chickpea seed (Table 2) indicates significant effect of different treatments over control. The treatment T_5 recorded highest protein content in seed (19.50%), followed by the treatment T_{10} with 19.31%protein content in seed and $T_9$with 19.18%protein content in seed. This may be the result of application of molybdenum along with the efficient use of *Rhizobium* + PSB, which boosted BNF. Mo is necessary for the nitrogenase and nitrate reductase enzymes, as well as for the quicker nitrate transformation that occurs inside the plant systems. Since nitrogen is a component of amino acids, which are known to be the building blocks of protein, the notable increase in protein content under these treatments may be the result of a continuous supply of nitrogen from various organic and inorganic sources. The results are in agreement with the findings of Gupta and Sahu (2012) and Gangwar and Dubey (2012).

3.5 EffectonDehydrogenaseActivity(DHA):

Dehydrogenase activity (DHA) reflects the total range of oxidative activity of soilmicroflora.ThetreatmentT$_5$ recorded highest dehydrogenaseactivityinrhizospheresoili.e., 31.20 µg TPF g^{-1} soil hr^{-1}, followed by the treatment $T_{10}$with the value of 30.60 µg TPF g^{-1} soil hr^{-1} as shown in Figure1.ThisaccelerationinDHAcouldbe attributed due to increased microbial activity in the rhizosphere might be due to application of effective *Rhizobium*, PSB,along with ammonium molybdate and jeevamrit which increases the microbial activity in the rhizosphere soil. These findings are in accordance with the results of Bidyarani *et al.* (2016), Gupta *et al.* (2020) and Swami *et al.* (2021).

3.6 Effect on Leghaemoglobin content in root nodules:

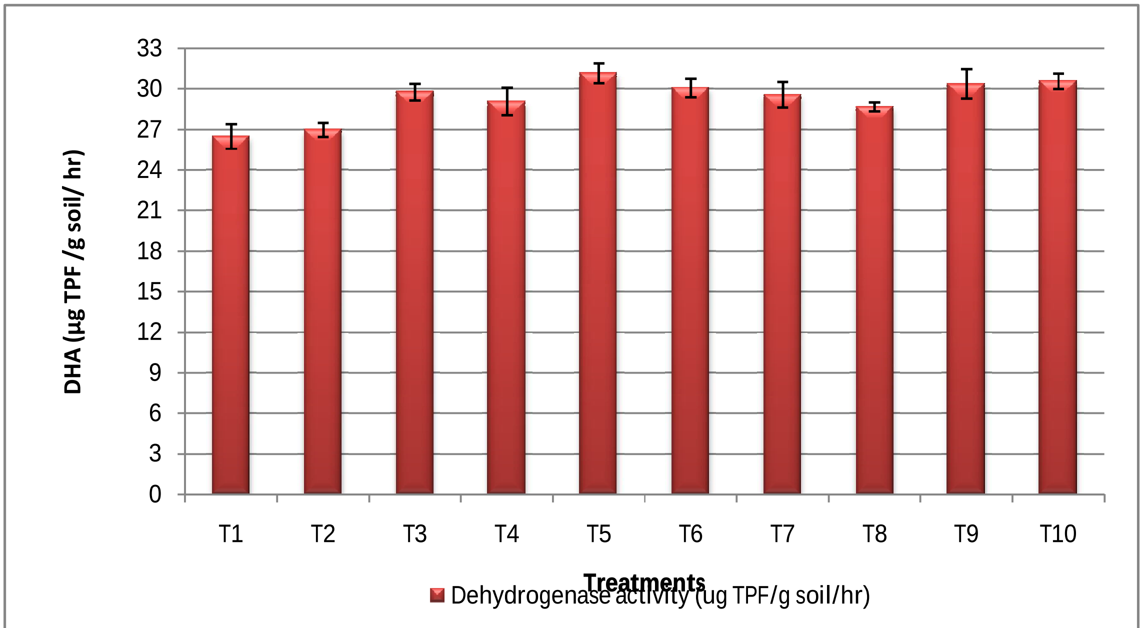
Highest leghaemoglobin content in root noduleswasobservedundertreatment T_5 (3.10 mg g^{-1}),followed by the treatment T_{10} (3.08 mg g^{-1}) as shown in Table 2. This might be ascribed to the use of efficient strainof *Rhizobium,* which produces more nodulation and aids in biological nitrogen fixation. Further the use of Mo, which is an essential component of nitrogenase enzyme, led to increase leghaemoglobin content in root nodules. Mo is an important component of nitrate reductaseand nitrogenase, which stimulate BNF and nodule formation. Zinc is an important micronutrient for nodulation and nitrogen fixation and also involved in leghaemoglobin synthesis. Jeevamrit application might favor microbial activities in the rhizosphere which resulted in increased nodulation and ultimately enhance leghaemoglobin content in nodules. The findings are in accordance with the results of Tagore *et al.* (2013) and Edulamudi *et al.* (2017).

Table 2:EffectofSeedpriming,Beejamrit,JeevamritandMicronutrientsonsymbiotictraits, growth attributes, grain yield, protein content in seed and leghaemoglobin content in root nodules of chickpea crop.

Treatments	Number of root nodules plant^{-1}at 50 DAS	Dry weightof root nodules plant^{-1}(mg) at 50 DAS	Plantheight (cm)		Number of branchesplant^{-1}		Total dry weight plant^{-1}(g) at 50DAS	Grain yield(kgha^{-1})	Protein content in seed (%)	Leghaemoglobin content in root nodules (mg g^{-1}) at 50 DAS
			50 DAS	Maturity	50 DAS	Maturity				
T_1:RDF+ Rh + PSB	15.41	28.01	23.15	28.86	2.27	2.68	1.43	1058.3	18.56	2.94
T_2: RDF + Rh +PSB +Seedpriming with water	17.60	32.11	23.22	30.02	2.31	3.15	1.55	1138.0	18.68	2.99
T_3: RDF + Rh +PSB +Beejamrit treatment (seedprimed)	21.03	36.15	27.28	31.71	2.48	3.64	1.81	1225.0	18.75	3.06
T_4: RDF + Rh +PSB +Seedpriming with 0.05% Mo as AM	19.90	36.00	26.01	33.07	2.43	3.52	1.60	1212.7	19.12	3.04
T_5: RDF + Rh +PSB +AM1gmkg^{-1} seed with inoculation	25.81	40.00	29.42	35.04	3.31	4.30	2.28	1333.3	19.50	3.10
T_6: RDF + Rh +PSB +Jeevamrit sprayat35and55 DAS	18.01	33.04	24.81	33.29	2.40	3.22	1.68	1172.7	18.75	3.04
T_7: T_1+ 0.05%AMsprayat35and55 DAS	21.31	35.51	26.35	33.68	2.51	3.46	1.81	1228.3	19.0	3.06
T_8: T_1+ 0.5%$ZnSO_4$+0.25%Limesprayat 35 and 55 DAS	19.40	33.28	25.00	31.42	2.35	3.41	1.74	1208.0	18.87	3.02
T_9:T_1+ 0.05%AM +0.25%$ZnSO_4$+0.25%Limesprayat 35 and 55 DAS	24.00	37.51	27.75	34.00	2.78	3.78	2.01	1229.3	19.18	3.07
T_{10}: 50% RDF+Rh+ PSB +Jeevamrit spray + 0.05%AM +0.25%$ZnSO_4$+0.25%Limesprayat 35 and 55 DAS	24.51	38.64	28.0	34.78	3.00	4.02	2.16	1250.0	19.31	3.08
S.E.m$_{\pm}$	0.90	1.40	0.99	1.16	0.14	0.22	0.09	47.05	0.18	0.02
CD @5%	2.69	4.17	2.96	3.47	0.42	0.67	0.29	139.73	0.55	0.06
CV (%)	7.58	6.93	6.59	6.2	9.30	10.8	7.77	6.76	1.63	1.31

RDF:Recommendeddoseoffertilizer,Rh:*Rhizobium*,PSB:Phosphatesolubilizingbacteria,AM: Ammonium Molybdate, DAS: Days after sowing

Figure 1:- Effect of different treatments on Soil Dehydrogenase activity (DHA) (µg TPF g^{-1} soil hr^{-1}) at 50 DAS in chickpea.



4. CONCLUSION

The present investigation revealed that the treatment T_5:RDF + *Rhizobium* + PSB + Ammonium molybdate 1 gm kg^{-1} seed with inoculation found significantly beneficial for all the observations including grain yield of chickpea, followed by the treatment T_{10}: 50% RDF + *Rhizobium* + PSB + Jeevamrit spray+0.05%AM+0.25%$ZnSO_4$+0.25% Lime spray at 35 and 55 DAS. The use of treatment T_{10} can save 50% RDF without significant yield difference with highest yielded treatment. Further this study also give an indication that the use of RDF along with bio fertilizers i.e. *Rhizobium + PSB* and seed priming in beejamrit (T_3) for four hours before sowing may also be a beneficial option with slightly lower, but statistically identical chickpea yield with T_5. Adoption of natural farming components in integration with chemical fertilizers and biofertilizers will also be beneficial for sustainable agriculture.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

REFERENCES

Behera, S.K., Shukla, A.K. and Lakaria, B.L. (2014). Deficiency of boron and molybdenum in soils and crops of India and their amelioration. *Indian Farming,*63 (12): 27-29.

Bharadwaj, M., Lakhawat, S.S., Upadhaya, B., Pilania, S., Jain, D. and Bunker, R.N. (2021). Effect of organic liquid manures on vegetative growth and yield of pea (*Pisum sativum* L.). *The Pharma Innovation Journal*, 10(9): 1360-1364.

Bidyarani, N., Prasanna, R., Babu, S., Hossain, F., and Saxena, A. K. (2016). Enhancement of plant growth and yields inChickpea(*Cicerarietinum*L.)through novel cyanobacterial and biofilmed inoculants. *Microbiological Research*, 188: 97-105.

Chadha, S., Kumar, R., Ashlesha, Saini, J.P.and Paul, Y.S. (2012). Vedic Krishi: Sustainablelivelihoodoptionforsmall and marginal farmers. *Indian J. Traditional Knowledge*, 11(3): 480-486.

Chesnin, L. and Yien, C.H. (1951). Turbidimetric determination of Available Sulphur. *Proceedings of Soil*

Science Society of America,15: 149-151.
Directorate of Economics and Statistics, DA & FW,2021-2022-https://desagri.gov.in/wp-content/uploads/2023/05/ Agricultural-Statistics-at-a-Glance-2022.pdf.
Edulamudi,P.,Masilamani,A.J.A.,Zakkula,V. and Konada, V.M. (2017). Effect of molybdenum and zinc on nodulation, leghaemoglobin content and pod formation of horse gram. *Annals of Arid Zone*, 56(3&4): 117-123.
Gangwar,S.andDubey, M.(2012).EffectonN and P uptake by chickpea (*Cicerarietinum* L.) as influenced by micronutrientsand biofertilizers. *Legume Research-AnInternationalJournal*,35(2):164-168.
Gupta, S.C. and Sahu, S. (2012). Response of Chickpea to micronutrients and biofertilizers in vertisol. *Legume Research-AnInternationalJournal*,35(3):248-251.
Gupta, S.C., Trivedia, B.K. and Singh, P. (2020). Effect of diverse nutrient application on symbiotic traits, yield attributes, nutrient uptake, microbial population, dehydrogenase activity and productivity of chickpea (*Cicerarietinum* L.) in black soils. *Legume Research-AnInternationalJournal*,43(6): 844-849.
Hanway, J.J. and Heidel, H. (1952). Soil analysis methods as used in Iowa State College Soil Testing Laboratory. *Iowa State College of Agriculture Bulletin*, 57: 1-31.
Jackson, M.L. (1973). Soil Chemical Analysis. *Prentice Hall of India Pvt. Ltd*., *New Delhi, India*, 498: 151-154.
Khandkar, U.R., Tiwari, S.C., Kumawat, N., Ashok,A.K.,Bangar,K.S.andSingh,S.P. (2019). Effect of micronutrients, organics and biofertilizers on growth and yield of soybean under vertisols. *J. Exp. Zool., India*, 22(1): 1433-1436.
Klein, D.A., Loh, T.C. and Goulding, R.L. (1971). A rapid procedure to evaluate dehydrogenase activity of soils low in organicmatter.*SoilBiologyBiochemistry,* 3: 385-387.
Korat, H., Mathukia, R. and Talaviya, H. (2023). Comparative evaluation of low-cost natural farming, organic farming and conventional farming in major crops of South Saurashtra region at Junagadh, Gujarat, India. *Environment Conservation Journal*, 24 (3): 126-135.
Lindsay, W.L. and Norvell, W.A. (1978). Development of a DTPA soil test for zinc, iron, manganese, and copper. *Soil Science Society of America Journal*, 42: 421-428.
Montenegro, J.B.V., Fidalgo, J.A.B. and Gabella, V.M. (2010). Response of chickpea (*Cicer arietinum* L.) yield to zinc, boron and molybdenum application under pot conditions. *Span. J. Agric. Res.*, 8(3): 797-807.
Nagaraju, A.P. and Mohankumar, H.K. (2010). Effectofmicronutrientsandbioinoculants on growth and yield of Soybean (*Glycine max* L.). *Mysore J. Agric. Sci.*, 44(2): 260-265.
Nishizawa, N.K. (2005). The uptake and translocation of minerals in rice plants. In 'Riceislife:scientificperspectivesforthe 21st century. Proceedings World Rice Research Conference', 4th-7th November 2004, Tsukuba, Japan. pp. 90–93 (International Rice Research Institute: Manila).
Nitin and Purohit, H.S. (2021). Effect of different Jeevamrit based liquid organic formulations on biochemical properties of soil and on plant growth of Black gram [*Vigna mungo* (L.) Hepper] under pot culture conditions. *International Journal of Chemical Studies*, 9(1): 2280-2283.
Olsen, S.R., Cole, C.V., Watanabe, F.S. and Dean, L.A. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *USDA Circular No. 939, US Government Printing Office, Washington DC.*
Poojar, S., Vidyavathi, G.Y. and Babalad, H.B. (2022). Influence of ghanajeevamrutha and liquid organic manures on soilfertility and productivity of chickpea in vertisol. *J. Farm Sci*., 35(1): 94-99.
Poonia,T.C.andPithia,M.S.(2014).Increasing efficiencyofseedinoculationwithbiofertilizers through application of micronutrientsinirrigatedchickpea.*Afr. J.Agric.Res.*, 9(29): 2214-2221.
Sharma, H.O. and Gupta, S.C. (2005). Yield of Chickpea under rainfed condition with less/imbalance use of fertilizer with *Rhizobium* and PSB culture*. Indian J. Pure and Applied Biol.,* 20: 197-204.
Shukla, A.K., Tiwari, P.K., Prakash, C., Patra, A.K., Meena, M.C., Singh, P., Tagore, G.S. and Rai, H.K. (2016). Current status of micronutrient deficiencies in soils and crop-specific recommendations for different agro-climatic zones of Madhya Pradesh. *Indian Journal of Fertilizers*, 12 (3): 26-35.
Singh, A., Lal, M., Shivashankar, K., Tiwari,R., Singh, K.S. and Pandey, S.R. (2023). Effect of different natural farming treatments on growth, yield and quality of pigeon pea in inter-cropping system in Western U.P. *Int. J. Environ. Clim. Change*, 13(5): 334-339.
Subbiah, B.V. and Asija, G.L. (1956). A rapid procedure for the estimation of available nitrogen in soils. *Current Science,* 25: 259-260.
Sutar, R., Sujith, G.M. and Devakumar, N. (2019). Growth and yield of Cowpea [*Vigna unguiculata* (L.) Walp] as influenced by jeevamrutha and panchagavya application. *Legume Research-AnInternationalJournal*,42(6):824-828.
Swami, Y.P., Waikar, S.L., Bhosale, A.R. and Sallawar, S.C. (2021). Influence of ammonium molybdate

on enzymatic activity and nodulation in pigeonpea grown on vertisol. *Int. J. Curr.Microbiol. App. Sci*., 10(2): 2253-2259.

Tagore, G.S., Namdeo, S.L., Sharma, S.K. and Kumar, N. (2013). Effect of *Rhizobium* and Phosphate Solubilizing Bacterial inoculants on symbiotic traits, nodule leghaemoglobin, and yield of chickpea genotypes. *International Journal of Agronomy.*

Togay Y, Togay N and Dogan Y. (2008). Research on the effect of phosphorus and molybdenum applications on the yieldand yield parameters in lentil (*Lens culinaris*Medic.).*Afr.J.Biotechnol.*,7(9):1256-1260.

Wilson, D.O. and Reisenauer, H.M. (1963). Determination of Leghaemoglobin in legume nodules. *Analytical Biochemistry,* 6: 27-30.