Asian Journal of Applied Science and Technology (AJAST)
Volume 8, Issue 3, Pages 149-155, July-September 2024

Application of Rhizobium inoculants and Phosphorus fertilizer for effective nodulation of Chickpea at T/koraro Tigray Ethiopia

Weldegebrel Gebrehiwet[1*], Geberesemaeti Kahsu[1], Tewolde Berhe[1], Kinfe Tekulu[1], Samrawit Mebrahtu[1], Solomon Mebrahtom[1], Tsadik Tadele[1], Goitom Aregawi[1] & Aklil Gebremedhin[2]

[1]Tigray Agricultural Research Institute, Shire Soil Research Center, Ethiopia. [2]Tigray Agricultural Research Institute, Mekelle Soil Research Center, Ethiopia. Corresponding Author Email: weldetem1@gmail.com[*]

DOI: https://doi.org/10.38177/ajast.2024.8314

Article Received: 22 June 2024 Article Accepted: 28 August 2024 Article Published: 30 August 2024

ABSTRACT

This study was conducted over the 2015 and 2016 main cropping seasons under rain-fed conditions at T/koraro in the North Western Zone of Tigray Regional State, Ethiopia. The objective was to evaluate the impact of different fertilizer treatments on chickpea agronomic performance and soil properties. The experiment employed a randomized complete block design (RCBD) with four treatments: T1 (control without inoculant), T2 (50 kg DAP), T3 (50 kg DAP + CP inoculant), and T4 (CP inoculant + compost), each replicated three times. Composite soil samples were collected and analyzed for texture, pH, EC, organic carbon, available phosphorus, and CEC before planting. Agronomic data collected included biomass yield, grain yield, days to 50% emergency and flowering, plant height, number of nodules, and harvest index. Results showed that treatments significantly affected soil properties and chickpea growth parameters. T4 (CP inoculant + compost) produced the highest biomass (4412.3 kg/ha) and grain yield (2015.0 kg/ha), indicating a 40.03% increase over the control. The number of nodules per plant was highest in T4, emphasizing the role of phosphorus and inoculants in enhancing nitrogen fixation and plant growth. Days to 50% emergency and flowering were reduced in treated plots, suggesting an accelerated growth rate due to nutrient availability. Plant height and the number of pods per plant were positively influenced by the application of compost and DAP fertilizer. Statistical analysis using ANOVA and LSD tests confirmed significant differences between treatments at a 5% significance level. The study concludes that the combined application of compost and CP inoculant significantly improves chickpea yield and soil health, offering a sustainable approach to crop production in the region.

Keywords: Chickpea; Fertilizer treatments; Compost; CP inoculant; Soil properties; Randomized complete block design (RCBD); Biomass yield; Grain yield; Nodulation; Pods.

1. Introduction

High nutritive value and source of protein chickpea (*Cicer arietinum* L.) is an important leguminous crop. The crop is adapted to cool semi-arid areas of the tropics, sub-tropics as well as the temperate areas. In Africa, Ethiopia stands first in area and production but third in productivity after Egypt and Sudan [1]. It is the third most important pulse in volume of production after faba bean and haricot bean, in Ethiopia. It occupies 239,755.25 ha of lands with estimated production of 4,586,822.55 quintals. In Tigray region chickpea is produced on 6,845.93ha of land annually with estimated production rate of 16.30 quintals per hectare [1]. Chickpea has an important role in the diet of small-scale farmers. It serves as a source of income; its straw used for animal feed and improves the fertility status of soil through its biological nitrogen fixation [2]. It is usually grown on Vertisols in Ethiopia, which might be considered highly productive soils, if its water logging and workability problems are managed properly. Many soils in the highlands of Ethiopia are inherently poor in available plant nutrients and organic matter (OM) content, and the application of nutrients are considered essential to improve crops chickpea, and faba bean were the potential legume crops which can be grown in rotation to break the mono-culture cropping practice in Tahtay Koraro. However, application of P fertilizer and rhizobium application are limited in the study area. The productivity of chickpea in Ethiopia is far below its potential. Although 100kg ha^{-1} of DAP (Di ammonium phosphate) is recommended for cereals in Ethiopia to increase production, the chickpea is mainly produced under marginal conditions without application of external inputs including fertilizer. Accordingly, the amount of DAP rate and effective type of rhizobium strain were not identified for the study area. Most tropical soils are deficient in available

Asian Journal of Applied Science and Technology (AJAST)
Volume 8, Issue 3, Pages 149-155, July-September 2024

phosphorus and in terms of appropriate and effective strains that are capable of fixing [3]. Here is a need to identify appropriate rhizobium strain which will enhances nitrogen fixation attributes and yield of chickpea under the application of phosphorus fertilizer. Therefore; this research was initiated to study the effect of rhizobium inoculants and phosphorus fertilizer on yield and yield component of chickpea.

2. Materials and Methods

2.1. Area description

The field experiment was conducted for 2015 and 2016 main cropping season under rain fed conditions at farmer's field in T/koraro, North western Zone of Tigray Regional State Ethiopia. T/koraro district is located on 38°18'45.099" E 14°3'17.535"N. The district altitude varies is the dominant soil types in the area. The area has crop-dominated mixed crop-livestock farming system.

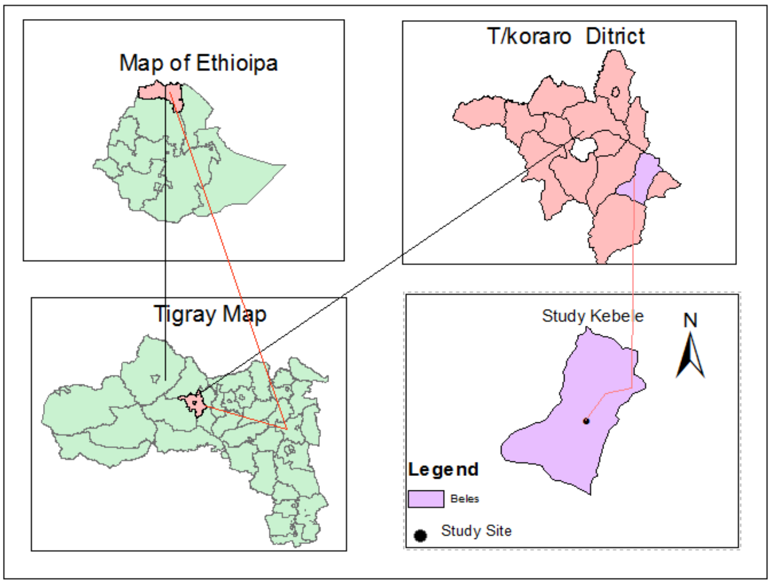

Figure 1. Map of the study area

2.2. Soil Sampling and analysis

Composite soil samples were collected from the experimental site at 0-20 cm depth using auger following zigzag technique. The collected soil sample before planting was analyzed for soil texture, pH, EC, organic carbon (OC), available P, and CEC.

2.3. Experimental design and Treatments

The experimental design was a randomized complete block design (RCBD) with four treatments and three replicates for two years. The inoculants were collected from national biofertilizer production center. The treatments consist of T1 (control without inoculant), T2 (50kg DAP), T3 (50kg DAP + CP inoculant), and T4 (CP Inoculant + compost).

2.4. Agronomic Data Collection

Agronomic data such as biomass yield, grain yield, days to 50% emergency, days to 50% flowering, plant height, and number of nodules, and harvest index were recorded at the appropriate growth stage of chickpea.

2.5. Statistical analysis

The data was subjected to the analysis of variance (ANNOVA) by following the standard procedure and by using SAS software analysis. After performing ANOVA, the differences between the treatment means were compared by LSD test at 5% level of significance.

3. Results and Discussion

Table 1. Selected Soil properties of the study area

Site	Available P	PH	EC	% OC	% OM	CEC	Texture			
							% Sand	% Silt	% Clay	Textural class
1	59.368	7.670	0.424	0.944	1.628	48.400	22	35	43	Clay
2	5.296	7.360	0.264	0.924	1.593	44.800	20	35	45	Clay loam
3	3.399	7.450	0.283	0.763	1.316	39.000	23	33	44	Clay

Note: EC= Electrical Conductivity; OC= Organic Carbon; Total N= Total Nitrogen; Total P=Total Phosphorus; and Total K=Total potassium.

3.1. Days to 50% Emergency and Days to 50% flowering

The maximum number of days to reach 50% emergency was observed on the control plots than the plots treated with 50kg/ha of DAP as indicated in Table 2. This may indicate the application of DAP fertilizer may that increase the matrix potential of the soil and short period of moisture content in the study area speed up the heading of the crop at that period of time. This finding agrees with that of [4] who reported that seeds inoculated with rhizobia increased the days to flowering of chickpea. This might be due to the fact that the importance of P for flowering and seed formation and fastening crop maturity. The result is in conformity with that of [5] who reported that P plays important role in flowering and seed formation in turn fastening crop flowering. This might be due to the relatively higher moisture content in his study area in which can affect nutrient availability that can persist throughout the growth stage of the crop.

Table 2. Means of Days to 50% heading, days to physiological maturity, and plant height of teff under the effect of different lantana manure

Treatment	Days to 50% Emergency (days)	Days to 90 % flowering (days)	Plant Height (cm)	No. pods per plant
T1	6.083	69.83	35.18	43.10
T2	6.25	66.91	37.76	50.18
T3	5.75	67.33	35.48	50.50
T4	5.66	67.58	36.05	50.53
Mean	5.93	67.91	34.87	48.57
LSD ($P \leq 0.05$)	1.54	4.60	5.85	14.46
CV (%)	23.82	6.21	15.39	27.31

Where LVC = Lantana vermicomposts; DLM= Dry lantana manure; MixCOM= mixed compost; FYM= Farmyard manure; FLM= fresh lantana manure; and LCOM= lantana compost.

3.2. Plant Height and Number of Pods

The application of composts and DAP fertilizer positively influenced plant height and number of pods (Table 2). Thus, the tallest plant height was found from treatments that received DAP at 50kg/ha plus Inoculants resulted in (37.48 cm) followed by Compost plus inoculants (37.05m) while the shortest plant (35.18 cm) was obtained from control plots, respectively. Correspondingly, a large number of pods per plant was obtained from conventional compost plus inoculants whereas the shortest panicle was from the unfertilized plots. Though non-significant the result of the data presented in Table 2 revealed that an application of fertilizers positively increases in number of pods per plant. This finding agrees with [6] who reported that the combined application of P and S increased the plant height of chickpea.

3.3. Number of nodules per plant

The application of phosphorous and compost significantly influenced the number of nodules per plant as compared to the control plots (Table 3). The highest (26.66) nodule number was obtained from the combined application of inoculant with compost followed by inoculants plus 51 kg P/ ha; while the lowest (17.33) was obtained from a plot without inoculation. This might be due to the vital role of P is required for plant growth, nodule formation and development, and is vital for N_2 fixation as well as for the rhizobia bacteria to infect the roots to form nodules. This result is in line with [7] who observed that the combined application of P with rhizobia inoculant increased the number and dry weight of nodule on chickpea.

3.4. Biomass Yield and Grain yield

Analysis of variance revealed that there were significant differences among the combined P application with Rhizobial inoculant treatments for biomass and grain yield of chickpea (Table 3). Thus, the highest biomass (4412.3kg/ha) and grain yield (2015.0kg/ha) followed was obtained from inoculants with compost. However this is in par with the application of P at 50kg/ha plus inoculants that gives 1783.9 kg/ha grain yield and 4400.8kg/ha of biomass yield. Whereas the lowest biomass and grain was obtained from control plots. At the chickpea plants grown in plot received conventional compost 7t/ha ha^{-1} and inoculant increased the grain yield by 40.03% over the control. This could be due to the high-water holding capacity of compost that enhances the moisture content of the soil. This could account for the increased total dry biomass yield caused by the interaction of the CP-M41 strain with NPSB fertilizer application [7]. This outcome is also consistent with [8] who found that using P and Mesorhizobium inoculant together greatly enhanced chickpea grain production. Similarly applying Rhizobium inoculants and NPSB fertilizer together had a synergistic effect on chickpea production, increasing it by 34% over the untreated control [9].

Table 3. Means of Biomass yield, Grain yield, Straw yield, and Harvest index of teff under the effect of different lantana manure

Treatment	No of nodules per plant	Biomass yield (kg/ha)	Grain yield (kg/ha)	Harvest Index	1000 seed wt
T1	17.33b	3150.8b	1334.6b	0.426	222.08^{b}
T2	26.08a	4400.8a	1783.9a	0.406	240.667^{ab}

Asian Journal of Applied Science and Technology (AJAST)
Volume 8, Issue 3, Pages 149-155, July-September 2024

T3	25.58a	4000.0ab	1654.4ab	0.430	245.83[ab]
T4	26.66a	4412.3a	2223.3[a]	0.465	249.00[a]
Mean	23.91	3990.96	2015.0a	0.43	239.39
LSD (P≤0.05)	6.69	870.3	443.27	0.1096	20.056
CV (%)	25.67	20.00	23.96	23.24	7.685

Where LVC = Lantana vermicompost; DLM= Dry lantana manure; MixCOM= mixed compost; FYM= Farmyard manure; FLM= fresh lantana manure; and LCOM= lantana compost.

3.5. Harvest Index and 1000 seed weight

As shown in Table 3 there is a significant effect at (P<0.01) in the application of P fertilizer as well as compost in in thousand seed weight of chickpea in the study area. A possible explanation for the increase in harvest index caused by the NPSB fertilizer and Rhizobial inoculant is that more photosynthetic energy is produced, which eventually partitions to the grains as opposed to the straw [10]. Additionally, the application of balanced NPSB nutrients raised the hundred grains weight of the chickpea crop, and inoculation increased the number of effective nodules per plant and N availability, which in turn enhanced dry matter partitioning in favor of grain showing a larger harvest index [11]. The results of earlier studies also suggested that Mesorhizobium inoculation and the administration of N, P, S, and B nutrients were beneficial in raising the harvest index of chickpea crops [12].

4. Conclusion

The field experiment conducted over two cropping seasons in T/koraro, North Western Zone of Tigray Regional State, Ethiopia, demonstrated that the application of CP inoculant and compost significantly improved chickpea growth and yield under rain-fed conditions. The combined treatment (CP inoculant + compost) resulted in the highest biomass and grain yield, as well as an increased number of nodules per plant, indicating enhanced nitrogen fixation and nutrient availability. The findings highlight the importance of integrating biofertilizers and organic amendments to achieve sustainable agricultural practices, particularly in resource-constrained, rain-fed farming systems.

5. Future Suggestions

a) Conduct long-term studies to evaluate the residual effects of CP inoculants and compost on soil health and crop productivity.

b) Implement large-scale trials and demonstrations to validate and promote the adoption of the most effective treatment combinations among smallholder farmers in the region.

c) Investigate the optimal rates and combinations of DAP, compost, and inoculants to maximize chickpea yield and nutrient use efficiency.

d) Continuously monitor soil health parameters to understand the long-term impact of different treatments on soil fertility and structure.

e) Perform an economic analysis to assess the cost-effectiveness and profitability of using CP inoculants and compost compared to conventional fertilizers.

f) Strengthen extension services to educate farmers on the benefits and application methods of biofertilizers and compost, ensuring proper implementation and maximizing benefits.

g) Explore the potential of using similar biofertilizer and compost treatments on other leguminous and non-leguminous crops to diversify cropping systems and improve overall farm resilience.

h) Investigate the role of these sustainable practices in enhancing the resilience of chickpea production to climate variability and extreme weather events.

Declarations

Source of Funding

The study has been supported by Tigray Agricultural Research Institute, Ethiopia.

Competing Interests Statement

The authors declare having no competing interest with any party concerned during this publication.

Consent for Publication

The authors declare that they consented to the publication of this study.

Authors' contributions

All the authors took part in literature review, analysis and manuscript writing equally.

Availability of data and material

All data pertaining to the research is kept in good custody by the authors.

References

[1] CSA (2017). Area and Production for Major Crops (Private Peasant Holdings, Meher Season) 2016-17 (2009 E.C.). Stat. Bull. No. 584, Pages 1–122.

[2] Wondwosen, T., et al. (2016). Response of chickpea (*Cicer arietinum* L.) to inoculation with native and exotic Mesorhizobium strains in Southern Ethiopia. African J. Biotechnol., 15(35): 1920–1929.

[3] Meleta, T., & Girma, A. (2019). Effects of Inoculation and Phosphorus Fertilizer Rates on Growth, Yield and Yield Components of Chickpea (*Cicer arietinum* L.) at Goro, Bale Zone, Oromia Regional State. Int. J. Appl. Agric. Sci., 5(3): 62.

[4] Verma, J.P., et al. (2013). Effect of indigenous Mesorhizobium spp. and plant growth promoting rhizobacteria on yields and nutrients uptake of chickpea (*Cicer arietinum* L.) under sustainable agriculture. Ecol. Eng., 51: 82–286. doi: 10.1016/j.ecoleng.2012.12.022.

[5] Melese, A., et al. (2015). Phosphorus status, inorganic phosphorus forms, and other physicochemical properties of acid soils of Farta District, northwestern highlands of Ethiopia. Appl. Environ. Soil Sci. doi: 10.1155/2015/748390.

[6] Sree, C.N., et al. (2020). Effect of phosphorus and iron levels on growth and economics of Chickpea (*Cicer* arietinum L.). Int. J. Chem. Stud., 8(6): 2295–2297. doi: 10.22271/chemi.2020.v8.i6ag.11117.

[7] Wolde-meskel, E. (2018). Additive yield response of chickpea (*Cicer arietinum* L.) to rhizobium inoculation and phosphorus fertilizer across smallholder farms in Ethiopia. Agric. Ecosyst. Environ., 261: 144–152. doi: 10.1016/j.agee.2018.01.035.

[8] Eshetu, M., et al. (2018). Evaluation of best performing indigenous Rhizobium inoculants for Chickpea Evaluation of best performing indigenous Rhizobium inoculants for Chickpea (*Cicer aritenium* L.) production at Ginnir District, Bale Zone, Southeastern Ethiopia. doi: 10.14662/arjasr2018.028.

[9] Das, S.K., et al. (2016). Effect of farm yard manure, phosphorus and sulphur on yield parameters, yield, nodulation, nutrient uptake and quality of chickpea (*Cicer arietinum* L.). J. Appl. Nat. Sci., 8(2): 545–549. doi: 10.31018/jans.v8i2.833.

[10] Ahlawat, I.P.S., et al. (2007). Nutrient management in chickpea. In Yadav, S., et al. (Eds.), Chickpea Breeding and Management, CAB International, Wallingford, Oxon, UK, Pages 213–232.

[11] Nuru, S.T. (2020). Effect of blended NPS fertilizer and Rhizobium inoculation on yield components and yield of common bean (*Phaseolus vulgaris* L.) varieties at mekdela district, south Wollo, Ethiopia. Acad. J. Res. Sci. Publishing, 2: 115–140.

[12] Beza, S. (2017). Response of chickpea (*Cicer aritienum* L.) to sulfur and zinc nutrients application and rhizobia inoculation in north western Ethiopia. MSc Thesis, Haramaya University, Haramaya, Ethiopia.