Journal of Agricultural Science and Food Research

OPEN ACCESS Freely available online

Research Article

Evaluation of Phosphorus Rates and Rhizobial Strain on Haricot Bean (*Phaseolus Vulgaris* l.) in Western Amhara

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ABSTRACT

The experiment was conducted on farmer's field in 2015, 2016, and 2017 in the main cropping season under rain fed conditions at Gonji Qolela, Yilmana Densa, and Bahir Dar Zuria districts in northwestern Ethiopia. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Five phosphorus rates (0, 23, 46, 69 and 92 kg ha^{-1} P_2O_5) were applied in the form of TSP (0-46-0) side-banded with the seed. One nationally recommended indigenous strain of *Mesorhizobium spp*. (HB-429) was used. Awash Melka variety was used as a test crop. The application of phosphorus fertilizer significantly increases the grain yield of haricot bean at the Gonji Qolela district. At the Gonji Qolela district, the maximum grain yield of haricot bean (2702.4 kg ha^{-1}) was obtained by applying 40 kg of phosphorus which has a 682.8 kg yield advantage over the farmer practice. The application of phosphorus fertilizer did not significantly increase the grain yield of haricot bean at Yilmana Densa and Bahir Dar Zuria testing sites. Application of rhizobial strain didn't give a significant yield advantage over the non-inoculated at Gonji Qolela and Yilmana Densa districts while at Bahir Dar Zuria district application of rhizobial strain has 531 kg and 576.9 kg yield advantage over non-inoculated and the control respectively increases the other hand, there was no a significant grain yield difference for the applied phosphorus.

Keywords: Phosphorus; Rhizobial strain; Haricot bean

INTRODUCTION

Haricot bean or common bean (*Phaseolus vulgaris L.*) is an herbaceous annual crop grown worldwide for its edible bean. It is a source of dietary protein (22% with high lysine content) and cash income (2nd important grain legume as a cash crop in Eth). Its crop residues serve as feed for livestock and also form a good basis for compost manure and used in intercropping systems with maize and tree seedlings [1]. The 2013/14 national average yield of haricot bean in Ethiopia was about14 q ha−1 (MoA, 2014) but yield ranges from 25–30 q ha−1 at research sites using improved varieties [2,3]. The use of fertilizers is considered to be one of the most important factors to increase crop yield per unit area basis. Nutrient requirements of pulse crops are fulfilled by soil, rhizobia and chemical fertilizers [4]. The low yield of haricot bean is associated with soil acidity which reduces the availability of Phosphorus (P), basic cations and affects the activities of soil microbes. P is among the principal nutrient elements needed for the growth of legumes [5]. A good supply of P is associated with: increased root growth, early maturity of crops, and the formation of root nodules, N_2 fixation and increased yield [6,7]. Responses for P are dependent on residual levels in the soil. Without enough P in the soil, a legume can't fix N_2 [8,9]. "Ethiopian soils harbor gnomically diverse rhizobia not related to reference species" [10]. About 60%-80% N in legumes comes from N_2 fixation [11,12]. Small starter doses of N can be beneficial to plant development, nodulation and N_2 fixation [13]. Starter N provides a benefit with very low soil N levels. It is only recommended when soil test N levels are below 20 kg ha^{-1} in the 0-12 inch soil. N-fixation in root nodules is sensitive to extremes of pH: nodulation and N-fixation are reduced where pH<5.5 and>8.0 or with excessive salinity [14,15]. Rhizobia needed by common bean for N_2 fixation do not always occur in the soil naturally. Seed inoculation fills this gap and ensures N_2 fixation resulting in a good yield (20-40 q ha^{-1}) with very little cost. Inoculation is the practice of applying the inoculant to the seed. It is cheap insurance to maximize nodulation and to

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Received: 12-Jun-2021, Manuscript No. JBFBP-21-002-PreQc-22; **Editor assigned:** 15-Jul-2021, Pre QC No. JBFBP-21-002-PreQc-22 (PQ); **Reviewed:** 5-Aug-2021, QC No. JBFBP-21-002-PreQc-22; **Revised:** 19-May-2022, Manuscript No. JBFBP-21-001-PreQc-22(R); **Published:** 01-Aug-2022, DOI: 10.35248/2593-9173.22.13.501

Citation: Alemayehu B, Amare T, Gashu K (2022) Evaluation of Phosphorus Rates and Rhizobial Strain on Haricot Bean (*Phaseolus Vulgaris l.*) in Western Amhara. Agri Sci Food Res. 13:501.

increase N_2 fixation leading to significant improvement of legume yield [16,17]. Nitrogen fixation requires more P than does plant growth. Even though common bean production is expanding across years in western Amhara (personal observation), there is no recommended fertilizer rate for its production. The national blanket recommendation used so far is 100 kg ha^{-1} DAP (46% P_2O_5 or 20% P). Therefore, this research was carried out to determine the optimum rate of phosphorus fertilizer for haricot bean production in western Amhara.

MATERIALS AND METHODS

Description of the study sites

The study was conducted in Gonji Qolela, Yilmana Densa, and Bahir Dar Zuria districts of northwestern Ethiopia on farmer's field in 2015, 2016, and 2017 in the main cropping season under rainfed conditions.

The experiment was comprises five levels of phosphorus with and without HB 429 rhahizobial strain (11 treatments) namely, control, 0 P_2O_5, 23 P_2O_5, 46 P_2O_5, 69 P_2O_5, 92 P_2O_5, 0 P_2O_5+ HB 429, 23 P_2O_5 + HB 429, 46 P_2O_5 + HB 429, 69 P_2O_5 + HB 429, and 92 P_2O_5 + HB 429. Phosphorus was applied in the form of TSP (0-46-0) side-banded with the seed. One nationally recommended indigenous strain of *Mesorhizobium spp*. (HB-429), which is under commercial use, was used. The source of the inoculant was Menagesha Biotech PLC. 18 Kg ha^{-1} N was used as a starter for all plots. Only one improved variety Awash Melka which is white and an exportable (cunning type) commodity was used as a test crop. Seeds were soaked in lukewarm water for about 30 minutes until the seed coat gets wrinkled, basking and draining under the shade, palm-testing when many seeds are sticky, dressing the seeds with the inoculant, sown and covered with soil as soon as possible [18,19]. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The spacing was 1.5 m between replications and 0.5 m between plots with 4 m wide 3 m long plot size. The inter-row spacing was 40 cm and inter-plant 10 cm. There were ten rows and eight net harvestable rows within a plot. The100 kg ha^{-1} seed rate was used. Other agronomic practices were applied as per recommendations.

Soil sampling, preparation and analysis

Before planting, representative soil samples were collected from a depth of 0-20 cm at representative points of the experimental field. The samples were thoroughly mixed and composited to one representative sample for physio-chemical analysis. The sample was air-dried and ground to pass through a 2 mm sieve for analyses of soil texture, pH, total nitrogen, and available P, CEC (meq/100 g), Organic carbon. Soil pH was determined in a 1:2.5 soil to water suspension following the procedure outlined [20]. Soil organic carbon content will be determined by the wet digestion method using the Walkley and Black procedure at a soil: water ratio of 1:2.5. Total nitrogen by the micro Kjeldhal method and available P was analyzed by the Olsen method. Soil particle size distribution was determined by the hydrometer method [21].

Data collection and analysis: Grain yield was harvested from central rows by avoiding border effects and converted to kg ha^{-1} after adjusting the moisture content at 10%. Nodulation was assessed when 50% of plants of each plot exhibit flowering stage by carefully uprooting five plants randomly from each plot. The adhering soil was removed by washing gently over a metal sieve. The nodules from each plant were removed and separately spread on the sieve to drain water from their surface. Nodules were counted and their average was taken as the number of nodules/plant.

Collected data were subjected to analysis of variance using the general linear model SAS version 9.0. Treatments means were compared using the Least Significant Difference (LSD) at a 5% level of significance.

Physico-chemical properties of the soil: Before planting laboratory soil analysis result indicated that the soil reaction ranges from slightly acidic to moderately alkaline (5.85-7.93) according to Landon, 1991. In all experimental sites, the available phosphorus ranges from 0.86-0.91 ppm, total nitrogen ranges from 0.12-0.21%, and Organic carbon ranges from 0.74-1.35%, as very low according to Landon, 1991 [22]. The Cation Exchange Capacity (CEC) was in medium-range according to Landon, 1991 (55.7-76.1 meq /100 g of soil). According to the textural class analysis, the before was Clay in texture.

RESULTS AND DISCUSSION

Vegetative performance

At the 50% flowering stage, the responses of the crop under investigation to the applied fertilizer and rhizobial strain was evaluated by the researcher. The evaluation at this stage revealed that there was no significant difference between and among treatments (Figure 1).

The response of effective nodule number per plant

As the combined analysis result shown in Table 1, the number of effective nodules per plant did not have a statistically significant difference among treatments and the rhizobial strain didn't significantly affect the effective nodule number in all testing sites. The result is contrasting the finding of Abera and Tadele's (2016) inoculation of rhizobium bacteria increased significantly the number of nodules per plant (Table 1).

The response of grain yield

The result from this study showed that the application of phosphorus fertilizer significantly increases the grain yield of haricot bean at the Gonji Qolela district. At the Gonji Qolela district, the maximum grain yield of haricot bean (2702.4) was obtained by applying 40 kg of phosphorus which has a 682.8 kg yield advantage over the farmer practice (Table 2). As shown in Table 2, the interaction effect of rhizobia strain and phosphorus fertilizer is insignificant. The result is agreed with the finding of Shimelis (2019) addition of P without and with inoculation had a significant effect on the yield of haricot bean. As shown in Table 2 the result from this study showed that the application of rhizobial strain didn't give a significant yield advantage over the non-inoculated at Gonji Qolela district. The result is agreed with Pereira and Bliss (1987) finding without enough P in the soil, a legume can't fix nitrogen (Table 3).

Figure 1: Evaluation of phosphorus rates and rhizobial strain on haricot bean.

Table 1: Response of effective nodule number for the applied strain on haricot bean.

	Districts		
Treatments	Gonji Qolela	Yilmana Densa	Bahir Dar Zuria
Control	4	11	15
0 P_2O_5	4	5	10
23 P_2O_5	4	8	12
46 P_2O_5	4	8	16
69 P_2O_5	6	16	20
92 P_2O_5	5	12	17
0 P+HB429	4	4	12
23 P_2O_5+HB429	5	13	18
46 P_2O_5+HB 429	5	11	16
69 P_2O_5+HB429	8	15	19
92 P_2O_5+HB429	8	14	19
LSD	NS	NS	NS

Table 2: Response of haricot bean grain yield to applied phosphorus fertilizer and rhizobial strain in Gonji Qolela (Zema).

		Grain yield (kg ha^{-1})		
	Year I	Year II	Year III	Combined over the years
Without strain	2658.3	2036.75	3402.1	2558.4
With strain	2184.9	2102.99	3537.8	2422.7
LSD	244.97	NS	NS	NS
N (kg ha^{-1}) P_2O_5 (kg ha^{-1})				
18 0	2314.3	1639.6	2957.9	2173.1
18 23	2408.3	1900.8	3596.6	2442.9
18 46	2522.3	2091.7	3235.3	2492.7
18 69	2475.1	2301.2	3656.1	2641.8
18 92	2388.1	2416	3903.8	2702.4
LSD	NS	292.8	690.9	404.2
Treatments	NS	***	*	NS
P	NS	***	NS	NS
R.S	*	NS	NS	NS
P*R.S	NS	NS	*	NS
CV (%)	19.4	17.2	15.7	31.8
Without inputs(N,P andR.S)	2517.5	1271	2521	2019.6

Table 3: Response of haricot bean grain yield to applied phosphorus fertilizer and rhizobial strain in Yilmana Densa.

	Grain yield (kg ha^{-1})	
	Year I	**Year III**
Without strain	3004.2	2062.5
With strain	2726.2	2268.6
LSD	NS	NS
N (kg ha^{-1})) P_2O_5 (kg ha^{-1})	-	-
18 0	2807.2	2156.9
18 23	2841.6	2075.1
18 46	2810	2207.7
18 69	2996.7	2421.2
18 92	2870.3	1967
LSD	NS	NS
Treatments	NS	NS
P	NS	NS
R.S	NS	NS
P*R.S	NS	NS
CV (%)	35.9	29.6
Without inputs(N,P andR.S)	2703.8	1575

As showed in Table 3 the two years result showed that the application of rhizobial strain and phosphorus fertilizer did not significantly affect the grain yield of haricot bean at Yilmana Densa district. The interaction effect between rhizobia strain and phosphorus fertilizer is also insignificant. The result is contrasting the finding of Shimelis (2019) inoculation with P or without the addition of inoculant had a significant effect on the yield of haricot bean. As shown in Table 3 the result from this study showed that the application of rhizobial strain didn't give a significant yield advantage over the non-inoculated at Yilmana Densa district the result is agreed with Pereira and Bliss (1987) finding without enough P in the soil, a legume can't fix nitrogen.

As showed in Table 4 at Bahir Dar Zuria district application of rhizobial strain has 531 kg and 576.9 kg yield advantage over non- inoculated and the control respectively, however, there was no significant grain yield difference for the applied phosphorus fertilizer. The interaction effect between rhizobia strain and phosphorus fertilizer was not significant. As showed in Table 4 the combined year's result showed that the application of rhizobial strain and phosphorus fertilizer did not significantly affect the grain yield of haricot bean at Bahir Dar Zuria district. The result is in contrast with the finding of Shimelis (2019) inoculation with P or without the addition of inoculant had a significant effect on the yield of haricot bean (Table 4).

Table 4: Response of haricot bean grain yield to applied phosphorus fertilizer and rhizobial strain at Bahir Dar Zuria.

	Grain yield (kg ha^{-1})		
	Year II	**Year III**	**Combined over the years**
Without strain	1378.2	2571.3	1775.9
With strain	1903.7	3113.5	2306.9
LSD	255.2	NS	464.5
N (kg ha^{-1})) P_2O_5 (kg h^{1})	-	-	-
18 0	2113.9	2048.2	2092
18 23	1788.6	2503.5	2026.9
18 46	1695.3	3197.1	2195.9
18 69	1304.4	3048	1885.6
18 92	1302.4	3415.2	2006.7
LSD	403.5	NS	NS
Treatments	**	NS	NS
P	*	NS	NS
R.S	*	NS	*
P*R.S	NS	NS	NS
CV (%)	29.8	46.8	54.1
Without inputs(N,P andR.S)	1324	1811	1730

CONCLUSION

The application of phosphorus fertilizer significantly increases the grain yield of haricot bean at the Gonji Qolela district. Application of rhizobial strain (HB-429) inoculant did not significantly increase haricot bean grain yield at both Gonji Qolela and Yilmana Densa districts, while at Bahir Dar Zuria district a significant grain yield difference was observed by application of rhizobial strain. The application of phosphorus fertilizer did not significantly increase the grain yield of haricot bean at Yilmana Densa and Bahir Dar Zuria testing sites. Live ness of strain/inoculant should be verified before inoculation. The study needs further investigation.

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