Agric. Sci. Digest., 39(1) 2019: 55-58
Print ISSN:0253-150X / Online ISSN:0976-0547

AGRICULTURAL RESEARCH COMMUNICATION CENTRE
www.arccjournals.com

Effect of phosphorus fertilizer levels on growth and yield of haricot bean (*Phaseolus vulgaris* .L.) in South Ommo Zone, Ethiopia

Degife Asefa Zebire[1] and Samuel Gelgelo[2]

Arba Minch University, College of Agricultural Sciences,
Department of Plant Science, P.O.Box 21, Arba Minch, Ethiopia.
Received: 15-08-2018 Accepted: 26-03-2019 DOI: 10.18805/ag.A-294

ABSTRACT

Haricot bean (*Phaseolus vulgaris* L.) is an important cash crop and protein source for farmers in many parts of Ethiopia. However, its production is limited by phosphorus fertilizer. Therefore, field experiment was conducted at the Malle woreda in Koybe kebele farmers training center during the main rain season of 2016 to investigate the responses of haricot bean to different levels of phosphorus fertilizer and its effect on growth, and bean yield. Four phosphorus rates (0, 23, 46, and 69kg ha^{-1}) were used as treatments were laid out in a randomized complete block design with three replications. Red Wolaita haricot bean variety was used as planting material. Recommended rate of N (46 kg/ha) was applied to all treatments. The effect of phosphorus was significantly ($P< 0.05$) increased bean yield and growth parameters such as leaf area and number of branches per plant, whereas its effect was not significant on plant height. Based on result obtained, application of 46kg P ha^{-1} is recommended for better production of haricot bean at Malle woreda and similar areas which have the same soil property.

Key words: Growth, Haricot bean, Malle woreda, Phosphorus fertilizer, RCBD, Yield component.

INTRODUCTION

Background: Haricot bean (*Phaseolus vulgaris* L.) is an annual pulse crop with substantial variation in growth habit, vegetative characters, flower color and the size shape and color of the pods and seeds (Onwueme and Sinha, 1991). It is well adapted to the range an altitude between 1200 and 2000m above sea level (Wortmann, 1998), and in areas with annual average rainfall of 500-1500mm. It can be grown successfully on most soils types, from light sands to heavy clays, but friable, deep and well drained soils are best preferred (Onwueme and Sinha, 1991). Haricot bean is also one of the most commonly cultivated pulse crops in the study area, Hammere. Its average productivity in the area is 5.5 qt ha^{-1} which is lower than its regional and national yield.

Haricot bean is mainly used as sources of food and cash. It is exported to earn foreign exchange and is also one of the cash crops locally used by farmers (Mitiku, 1990; Tenaw, 1990). As source of food, it is extensively consumed in traditional dishes, and being part of the diet of the farming households, it serves as a source of protein to supplement the protein deficient main dishes like maize and enset in the southern parts of our country especially in Wolaita and Sidamo areas (Tenaw and Yeshi, 1990). Besides this, the farmers also grow the bean to use the straw as forage for livestock, source of fuel, mulching, bedding, and covering material for houses of poor farmers. Despite all these advantages, little effort was made to improve its productivity and the yield. It is an important pulse crop distributed and grown in different parts of Ethiopia depending on climatic and socio-economic factors. In southern parts of the country, it is also widely distributed and grown by farmers for various uses (Tenaw, 1990). This low productivity might be partly attributed to the inadequate supply of available P.

Phosphorus is the most important element for adequate grain production (Brady and Weil, 2002). For instance, high seed production of legumes primarily depends on the amount of P absorbed (khan *et al*., 2003). The yield of haricot bean increases with p application (Gemechu, 1990). Getachew (1990) reported that lack of optimum fertilizer rate is one of the several factors contributing to the low grain yield of the bean in the region.

One of the solutions to alleviate the problem could be applying P fertilizers from external sources based on recommended rate for the crop. In order to make site-specific recommendation of P for haricot bean production, nutrient rate experiment is needed. An adequate supply of P early in the life of a plant is important in the development of its reproductive parts. In addition to this, a good supply of P is associated with increased root growth and it also associated with early maturity of crops, particularly grain crops. The formation and quality of fruits and seeds are depressed in the plant suffering from P deficiency (Mengel and Kirkby, 1987). Poor nodulation and poor plant vigor are observed in beans grown in P deficient soils (Amijee and Giller, 1998).

*Corresponding author's e-mail: degife.asefa@amu.edu.et

P sufficiency for crop growth does not always exist in most soils because of losses due to erosion and high fixation (Miller and Donahue, 1995; Brady and Weil, 2002). This problem is most severe in highly weathered acid soils that dominate the highlands of the tropics (Linguist *et al.,* 1997). Available P content of most soils in Sothern Ethiopia is less than 5mg /kg which is in the range of low P conetent (Kelsa *et al.,* 1996). Under black soil (Vertisols) low productivity of haricot bean the main problem as a result of both nitrogen and phosphorus deficiency (Kumar *et al*., 2009).

So far, limited work has been conducted on determination of optimum phosphorus fertilizer rate for production of common bean at Hammer. Therefore, there is a need to acquire of information on influences of phosphorus in growth, and yield of haricot bean and to know optimum rate of fertilizers in the study area.

MATERIALS AND METHODS

Description of study area: The study was conducted in Malle woreda at koybe kebele FTC, which is one of the wereda located in southern nation's nationalities and people's regional state, South Omo Zone. Malle woreda is an area in our country where per capital food production has constantly decline over the past many years. It is found in SNNPRS, South Omo zone and it is 792 km far from the Addis Ababa which capital city of Ethiopia. There are about 24 kebeles in this woreda. The total number of population in this woreda is about 46,470 from this 22, 961 are male and 24, 509 are female (CSA 2015. The Woreda is categorized into three agro climatic zones: Dega (high altitude) covers about 14% of the area with an altitude of more than 2300 m.a.s.l, Weinadega (mid-altitude) ranging from 1900–2300m.a.s.l and encompasses about 53% and kola(low altitude) covers 33% with altitude of 1100-1800 m.a.s.l of the woreda. The mean annual temperature of the woreda in degree Celsius is about 15-35°C. The study area has bimodal rain fall distribution. It gets rain for long period extending from March to May during spring and from July to November during Autmn season.

The soil type is sandy to sandy loam. Small holder farm house holder mainly relay on crop production. The major annual crops grown in the area are maize, sorghum, teff and other types of crops are grown in small coverage. The role of livestock is more significant the type live stock existing in the study area are cattle's, sheep, goats and poultries.

According to the Office of Woreda Agriculture and Rural Development office of Male woreda, the total area of the Woreda is estimated to be 142,655.77 hectare. From the total area 46.19% (68,886) is cultivated land, 12.9% (18,397.77) occupied forest and shrubs, 28.79% (41,071 ha) is lied for grazing, 7.23% (10,312ha) is used for settlement and 4.9% (6989 ha) are occupied by others such as unproductive and wetland.

Experimental design and treatments: The experiment was laid out in randomized complete block design (RCBD) with four treatments of phosphorus fertilizer rates (0, 23, 46 and 69 kg ha^{-1}) and three replications to evaluate the effect of phosphorus on bean yield of haricot bean (*Phaseolus vulgaris* L.) variety Red Wolaita. The size of each experimental unit was 1.6m X 2m (3.2 m^2) having four rows, each contains 20 plants. A distance of 1m and 1.5 m were left between plots and blocks, respectively. Two seeds per hole were sown at the recommended planting depth of 6 cm with spacing of 40 cm between rows and 10 cm between plants. Thinning of one seedling per hole was carried out after 15 days from sowing. Diamonium phosphate (DAP) was used as a source of phosphorus and full doses which varied depending on treatments were applied as side banding at sowing time. Urea was used as starter and to make a uniform 46 kg Nha^{-1}application on each treatment unit. Similarly, other agronomic practices were kept uniform for all treatments as recommended and adopted for the location with soil pH of 6.7-7.3.

Data collections: Data on plant height (cm), leaf area (cm^2), number of branches per plant, number of pods per plant, number seed per pod and bean yield were taken from ten pre tagged plants of each two middle rows. The plant height was measured from the base of the plant to the apical bud of plant and expressed in centimeters. Total leaf area was recorded by using a leaf area meter. The number of branches per plant was recorded by counting number of branches from each ten pre tagged plants and the mean was taken as number of branches per plant. Pods from pre tagged plants were counted and average was recorded as number of pods per plant. Seeds per pod counted from ten randomly selected pre tagged plants was converted to mean value and recorded as number of seeds per pod. Yield was obtained by ten randomly selected pre tagged plants were cut above the ground and partitioned into different parts *viz.* leaf, stem and reproductive parts. The samples were weighed and weights were recorded. The means recorded as yield of the plant (gm). Finally haricot bean biomass was harvested from 73 days after planting. Fresh weight and the oven-dry weight were recorded and calculated for yield.

Statistical analysis: Data on plant height, leaf area, number of branches per plant, number of pods per plant, number seed per pod and bean yield were statistically analyzed using analysis of variance (ANOVA) and means were compared using LSD test at a probability level of 5%.

RESULTS AND DISCUSSION

Effect of different rates of phosphorus fertilizer on plant height: As indicated in (Table 1), application of P fertilizer has no significant effect on plant height. The highest plant was (80.2 cm) was recorded at a rate of 46 kg P ha^{-1}. Moreover, application of 23 kg P ha^{-1} has revealed plant height (79.9cm) next to P 46 kg $ha^{-1.}$ On the other hand, there was no

Table 1: Effect of different rates of phosphorus fertilizer on growth, dry matter yield and yield component of common bean.

Treatments (kg/ha)	Plant height (cm)	Leaf area (cm^2)	Branches/ plant	Pods/ plant	seeds / pod	yield (qt/ha)
0	78.8a	58.6d	3c	5bc	9b	2.64d
23	79.9a	89.07c	5b	6b	14a	3.96c
46	80.2a	109.8a	7a	8a	14a	7.42a
69	78.6a	98.8b	6ab	6b	13a	6.38b
CV(%)	3.24	2.47	21.3	8	4	5.2
LSD	NS	4.4	1.6	0.99	4.2	0.97

Means with the same letter at the same column are not significantly differentat (*LSD-value = 0.05*).

significant difference between means of applied P fertilizer rates. This result is similar to the result reported by (Birhan., 2006), a non- significant response of plant height to P application on haricot bean. The lowest plant height (78.6cm) was recorded at high application of P rate, this confirms with the lowest plant height was recorded at application rate of P 69 kg ha^{-1} reported by (Eden., 2003). The highest rate of P application at the study site had no effect on plant height. This might be due to high dose of phosphorus fertilizer tends to form nutrient interaction and may affects the availability of other nutrients which are essential for growth of the bean.

Effect of different rates of phosphorus fertilizer on leaf area (cm^2): The P application at all rates resulted in significant higher leaf area than the control (Table 1). The highest leaf area (109.8cm^2) was recorded at rate application of P 46 kg ha^{-1}. In contrast, the lowest leaf area of (58.6 cm^2) was recorded from the treatment with application of 0 kg P ha^{-1}(control).This result was in agreement with that significant decrease in leaf area was observed with decline in P application from 75 to 25 kg ha^{-1}(Veeresh., 2003). In contrast, the low leaf area of (98.8 cm^2) was recorded from the treatment with application of 69 kg P ha^{-1} than that recorded at rate application of P 46 kg ha^{-1}. This might be due to P response dependence on available P in study site and when it is above the optimum level it may interrupt other nutrients, which in turn can bring decrease in growth of bean.

Effect of different rates of phosphorus fertilizer onnumber of branches per plant: The application of P fertilizer significantly affected the number of branches per plant (Table 1). The number branch per plant increased with increasing phosphorus application rates up to optimum level. The highest number of branches per plant (7) was recorded at rate of 46 kg P $ha^{-1.}$ This is also similar to result reported by (Shubhashree., 2007) significantly higher number of branches per plant is recorded with high application rate of phosphorous. The Mean of P fertilizer applied revealed significantly higher number of branches per plant over control. The lowest number of branches per plant (3) was recorded at control. The increment in number of branches per plant might be importance of P for cell division activity, leading to the increase of plant height and number of branches and consequently increased the plant dry weight (Tesfaye., Liu., 2007)

Effect of different rates of phosphorus fertilizer on number of pods per plant: Application of P fertilizer had significantly increased the number of pod per plant (Table 1). Significantly higher number of pods per plant (8) was recorded from P rates of 46 kg ha^{-1} over rest of the levels. All applied P fertilizer rates significantly increased pods per plant over the control. The lowest pods per plant (5) were recorded at control (no application of P fertilizer).The result is similar to (Shubhashree., 2007) reported that applications of different rates of phosphorus fertilizer influence number of pod per plant. Similarly, (Veeresh., 2003) observed significantly more number of pods per plant of common bean at application rate phosphorous. Also (Singh and Singh 2000) reported significant increase in number of pods per plant, due to increased P fertilization. Thus the increment of number of pods per plant due to application of P fertilizer confirms with P fertilizer promotes the formation of nodes and pods in legumes.

Effect of different rates of phosphorus fertilizer on number of seeds per pod: The analysis of variance for seeds per pod (Table 1) showed significant response to P levels. The highest number of seeds per pod (14) was obtained at applied P rate of 46 kg ha^{-1}, whereas the lowest seed per pod (9) was recorded in the control treatment. The result of the present study were in agreement with the findings of (Shubhashree., 2007) who reported that number of seeds per pod increased significantly to levels of phosphorus added. The increment of seeds per pod with increasing P fertilizer application up to optimum level might be P fertilizer for nodule formation, protein synthesis, fruiting and seed formation.

Effect of different rates of phosphorus fertilizer on haricot bean yield: The applied rates of P fertilizer have significantly ($P < 0.05$) increased the bean yield of haricot bean. There was a significant difference among four levels P fertilizer rates (0, 23, 46 and 69 kg). The maximum (74.2gm $plant^{-1}$) bean yield was recorded at application of P 46 kg ha^{-1}, whereas the minimum (26.4 gm $plant^{-1}$) was recorded under control. This result was similar to (Shubhashree., 2007) who reported bean yield accumulation increase with application of phosphorus rates. Similarly, significant and linear increase in total bean yield production of haricot bean plant was observed due to increased phosphorus (Veeresh., 2003). This increment in bean yield with application of P fertilizer might be due to the adequate supply of P could be attributed to an

increase in number of branches per plant, and leaf area. This in turn increased photosynthetic area and number of pods per plant, which demonstrates a strong correlation with dry matter accumulation and yield.

CONCLUSION

Application of the correct level of fertilizer is necessary to achieve maximum yield of haricot bean crop. The applied P fertilizer levels revealed a significant difference on leaf area, number of branch per plant, number of pods per plant, seeds per pod and bean yield. The application P 46 kg ha^{-1} has significantly increased bean yield and all growth parameters, except plant height over the rest levels. While, application of 69 kg P ha^{-1} declined plant height and leaf area as compared to control. Thus, based on the result obtained, it was possible to conclude that phosphorus fertilizer rate of 46kg ha^{-1} was promising to enhance yield of haricot bean in Malle woreda and similar areas which have the same soil property.

In general it is recommended that investigating the same study in different localities to have a real recommendation for the optimum level of P fertilizer to produce haricot bean.

REFERENCES

Amijje, F and Giller K., (1998). Environmental constraints to nodulation and nitrogen fixation of phaseolusvulgari L. in Tanzania, 1 A survey of soil fertility, root nodulation and multi-locational responses to Rhizobium inculation, *African Crop Science Journal* **6:**159-169.

Birhan Abdulkadir .(2006). Response of haricot bean (*Phaseolus vulgaris* L.) to nitrogen, phosphorous and inoculation of Rhizobium leguminosarum on yield and yield components at Melkassa. M.Sc. thesis, university of Hawassa college of agriculture, Ethiopia, 97 p.

Brady, N.C and Weil R.R. (2002). The nature and properties of Soils. Thirteenth edition, Prentice Hall, New Jersey, 960 p.

Eden T. (2003). Study on uptake and response of common bean (Phaseolus vulgaris L.) varieties to different levels of phosphorus application on entisol of Alemaya. MSC. Thesis. Harmaya University, Haramaya, Ethiopia.

Gemechu Gedeno. (1990). Haricot bean (*Phaseolus vulgaris* L.) Agronomic Research at Bako. Research on Haricot Bean in Ethiopia: an Assessment of Status, progress, priorities and strategies. Proceedings of a national workshop held in Addis Ababa, 1-3 October, 1990, 114 p.

Getachew Kassaye. (1990). Research Recommendations and the adoption of improved Technology for Haricot Bean in the southern Zone of Ethiopia. Research on Haricot Bean in Ethiopia: an Assessment of Status, progress, priorities and strategies, Proceedings of a National Workshop held in Addis Ababa, 1-3 October 1990. 114p.

Kelsa Kena, Ejigu Jonfa and Tesfaye Birhanu. (1996). Participatory soil mapping and characterization in Koysha, southern Ethiopia. Proceeding of workshop on nutrient.

Khan, B.M..Asif, M., Hussain, N. and Aziz, M. (2003). Impact of different levels of phosphorus on growth and yield of mung bean genotypes. *Asian Journal of Plant Sciences* **2**(9): 677-679.

Kumar, R.P., O.N. Singh, Yogeshwar Singh, J.P. Singh. (2009). Effect of integrated nutrient management on growth, yield, nutrient uptake and economics of french bean. *Indian. J. of Agric. Sci.* **79:** 211. 122-128.

Linguist, B.A., P.W. Singleton and K.G. Cassmann. (1997). Inorganic and organic phosphorus Dynamics during a build up and decline of available phosphrous in an Ultisols. *Soil set*, **164:** 254-264

Mengel, K. and Kirkby E.A. (1987). Principles of Plant Nutrition, fourth edition. International Potash İnstitute, Worblaufen-Bern/ Switzerland, 687 p.

Mesfin Tesfaye, Junqi Liu, Deborah L. Allan and Carroll P. Vance. (2007). Genomic and genetic control of phosphate stress in legumes. *Plant Physiology* **144:**594-603.

Miller, R.W and R.L. Donahue. (1995). Soils in Our Environment. Seventh (ed.), Prentice Hall, Englewood Chliff, New Jersy, USA. Mitiku, H. (1990). Preliminary studies of biological nitrogen fixation by haricot bean on two soil types in Hararghe, Ethiopia. In *CIAT African Workshop Series (CIAT)*. CIAT Regional Programme on Beans in Eastern Africa.

Onwueme, I.C. and Sinha T.D. (1991). Field crop production in tropical Africa. Technical Center of Agriculture and Rural co-operation. Shubhashree, K. S. (2007). Response of rajmash (*phaseolus vulgaris* L.) to the levels of nitrogen, phosphorus and potassium during rabi in the northern transition zone. (Doctoral dissertation, UAS, Dharwad).

Veeresh, N. K. (2003). Response of French bean (*Phaseolus vulgaris* L.) to fertilizer levels in Northern Transitional Zone of Karnataka. M. Sc. (Agri) Thesis, Univ. Agric. Sci., Dharwad, pp. 37-39.

Workayehu, T. (1990). Review of Agronomic Studies on Haricot Bean in the Southern Zone of Ethiopia. In research on Haricot Bean in Ethiopia: an Assessment of Status, Progress, Priorities and Strategies, Proceedings of a National Workshop held in Addis Ababa.

Workayehu, T., and Chiche, Y. (1990). Importance, production system and problems of haricot bean in the southern zone. In *National* Workshop on Research on Haricot Bean in Ethiopia: An Assessment of Status, Progress, *Priorities and Strategies* (*1990, Addis Ababa, Ethiopia*). Proceedings..

Wortmann, C. S. (1998). Atlas of Common bean (*Phaseolus vulgaris* L.) *Production in Africa* (No. 297). CIAT.