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Response of Faba Bean (Vicia faba L.) to Rhizobium Inoculation and Potassium Fertilizer Rates at Alicho Wuriro Highland, Southern Ethiopia

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ABSTRACT

Soil fertility decline is the second prime factor after diseases that limit faba bean productivity in Ethiopia. Due to this effect, a pot experiment was conducted to evaluate the response of faba bean to rhizobium inoculation and K fertilizers application at Worabe Agricultural Research Center, Siltie Zone of Southern Nations Nationalities and Peoples' Regional State, from June to October, 2016. A factorial combination of two levels of rhizobium (inoculated and uninoculated) and three K levels (0, 30, and 60 kg K ha-1) was laid in randomized complete block design with six replications. The results showed that inoculation of rhizobium strain significantly affected all parameters studied in this experiment except number of seeds pod-1. Combined application of rhizobium inoculation with potassium fertilizer significantly (p< 0.05) influenced plant height, leaves plant-1, root dry weight, pods plant-1 and above ground dries matter. The results indicated that the combined use of potassium fertilizer with rhizobium inoculation could be good nutrient management strategy that increases faba bean production.

Keywords: *growth, rhizobium, yield, yield component;*

INTRODUCTION

Faba bean is one of the major pulse crops widely produced in the highlands of Ethiopia. It is an annual crop grown by subsistence farmers, during the cool main rainy season (June to September). Faba bean occupies about 28% of the total land area under pulse crops in the country (CSA, 2015). Southern Nations Nationalities and Peoples' Regional State shares 14.08% pulse crop area and holds 12.29% of the national pulse production (CSA, 2015). Of the entire regional area under pulse crop production (219,502.58 hectares), 3.34% is covered by faba bean and accounts for 3.32% of total pulse production (CSA, 2015). Despite its multifaceted benefits the productivity of faba bean, both national and regional productivity, 18.93 and 16.39 t ha^{-1}, respectively, remained low compared to its attainable yield >2 t /ha^{-1} (MoA, 2011; CSA, 2015). At the highlands of Alicho wuriro, faba bean productivity is much lower than the national average yield. This could be mainly due to poor soil fertility, as it is cultivated in inherently poor soils, with the perception that it performs better than cereal crops. In low-input agriculture systems of Ethiopia chemical fertilizers are rarely used in the production of faba bean and other pulse crops; instead, these crops are used as a restorer of soil fertility, subsequently after cereal crops (Mulissa and Fassil, 2012).

Most highlands of Ethiopia are deficient in major essential nutrients N and P. Recently soil inventory data from EthioSIS (Ethiopian Soil Information System) also revealed that in addition to N and P, deficiencies of nutrients such as K, S, B, and Zn are widespread in Ethiopian.

Nitrogen is a nutrient required by plants in comparatively larger amounts than other elements. It is a constituent of many biological compounds that play a major role in photosynthetic activity and also a part of enzymes. Due to this fact various researchers have recommended the application of commercial fertilizers as a way of correcting nitrogen deficiency for the enhancement of productivity of crops (Daur *et al.*, 2008).

Also, potassium is important for the symbiotic relationship that enables bacteria to fix nitrogen from the air (Weisany *et al.*, 2013). Despite of the above background information, little is documented about the role of phosphorus, potassium and the interactive effect of phosphorus, potassium and rhizobium in influencing nitrogen fixation, growth and productivity of faba bean. Hence, this study aimed to evaluate the combined effect of rhizobium inoculation, phosphorus and potassium fertilizers application on growth and yield components of faba bean.

MATERIALS AND METHODS

Experimental Site Description

The pot experiment was conducted from June to October, 2016 under transparent plastic shade at Worabe Agricultural Research Center, Southern Nations Nationalities and Peoples' Regional State of Ethiopia. Worabe Agricultural Research Center is situated at $07^{O}50'49''$N and 0 $38^{O}10'52''$E, and at 2088 m.a.s.l. The soil was collected from Alicho wuriro, faba bean grown farmers' fields. Alicho wuriro is one of a district in Siltie zone and located at $07^{o}56'96''$N and $038^{o}09'39''$E, and 2814 m.a.s.l. The area receives a bimodal rainfall with an annual average rainfall of 1008 mm. Rainfall is distributed between the short rainfall season (March to April) and the main rainy season (June to September). The rainfall pattern is, however, extremely variable with high. Mixed crop-livestock farming is the dominant economic activity in the rural areas.

Experimental Design and Treatments

The experiment comprised of factorial combinations of three potassium levels (0, 30 and 60 ha^{-1}) and rhizobium inoculation with two levels (inoculated and uninoculated). The inoculant used was *Rhizobium leguminasanium biovar vacia* strain FB. 1035 obtained from Holeta Agricultural Research Center. *Degaga* faba bean variety was used as test crop. Since *Degaga* variety is adapted to altitude of 1800-3000 meters above sea level, the agro-ecology of the study area is suitable for faba bean production (EARO, 2004).

Rhizobium strain FB. 1035 was applied at the rate of 500 g ha^{-1}. In order to ensure that all the applied inoculum stick to the seed, the required quantity of inoculant was suspended in 10% sugar solution. The sugar slurry was gently mixed with dry seed and then with Carrier-based inoculant so that all the seeds received a thin coating of the inoculants. The inoculated seed was allowed to air dry before sowing. As a precaution of cross contamination, uninoculated treatments were sown first. Four faba bean seeds were planted for every pot and thinned to two plants per pot after 10 days of emergence. Potassium chloride was used as source of potassium. For all treatments, 60kg/ha P was applied using TSP (triple super phosphate). The actual rates of fertilizers were calculated based on soil weight basis assuming the weight of soil in a hectare at 15 cm depth is 2 $x10^{6}$ kg. The pots were arranged in completely randomized design with six replications. Of these, three randomly selected replications were used for destructive sampling.

Statistical Analysis

The data collected on different parameters were statistically analyzed using PROC ANOVA function of SAS program. After performing ANOVA the differences between the treatment means were compared by LSD test at 5% level of significance (SAS, 2004).

RESULTS AND DISCUSSION

Pre sowing Soil Chemical and Physical Properties

Pre-sowing soil sample analysis demonstrated that the textural class of experimental soil belongs to clay loam soil texture, with the proportions of 38% sand, 26% silt and 36% clay (Table 1). The soil held 0.145% total N, 13.2 mg kg^{-1} available K and 12.4 mg kg^{-1} available P. The soil exhibited low ratings for N and K, while that of P was medium. Similarly, organic carbon content (1.58%) was in the low range with soil pH being slightly acidic (Hart *et al.*, 2011).

Effect of Rhizobium Inoculation and Potassium Rates on Yield Components of Faba Bean Plant Height

Rhizobium inoculation resulted significantly ($p < 0.001$) taller plants (55 cm) compared to uninoculated plants (43 cm) (Table 2). The present work is in agreement with the findings of Endalkachew *et al*. (2016) who reported that an increase in plant height of lentil in response to inoculation with rhizobium strain. The combined effect of inoculation and potassium fertilization resulted in taller plants. For instance, the tallest plant (55.16 cm) was recorded due to application of 60 kg K ha^{-1} with rhizobium inoculation while shortest (37.16 cm) was due to the same rate of potassium application without inoculation (Table 3). The current result is in concurrence with the result that potassium supply had positive effect on nitrogen fixation and on shoot growth (Abebe and Tolera, 2014).

Table1. *Some physical and chemical properties of the 0 to 15 cm soil layer experimental soil before sowing*

pH (1: 2.5 soil water suspension)	%OC	Available P (ppm)	Available K (mg/kg)	%Total nitrogen	CEC (meq/100g)	% Texture			Textural class
						Sand	Clay	Silt	
6.6	1.58	12.4	13.2	0.145	24.6	38	36	26	Clay loam

Table2. *Effect of rhizobium inoculation and potassium rates on growth attributes of faba bean*

Treatment	PH (cm)	LPP	NPP	NDW (mg plant^{-1})	PPP	SPP	HSW (g)
Rhizobium							
Un	42.67b	17.56b	33.14b	0.31b	7.00b	2.95	44.86b
In	54.68a	20.96a	55.01a	0.47a	13.08a	3.17	50.66a
LSD (5%)	2.51	1.02	3.96	0.04	0.68	NS	3.22
K (kg ha^{-1})							
0	51.00a	19.91a	42.18b	0.36b	10.05	2.97	46.92
30	49.72ab	19.77ab	43.80b	0.41a	10.58	3.19	49.75
60	47.25b	18.66b	49.91a	0.43a	10.50	3.05	47.58
LSD (5%)	3.06	1.24	4.82	0.05	NS	NS	NS
CV (%)	9.17	9.46	15.74	19.33	11.80	19.17	19.13

Means with the same letter are not significantly different; LSD= least significant difference at p< 0.05; NS=no significant difference; In= inoculated; Un^{-}= uninoculated; K= potassium; PH= plant height; LPP= leaves per plant; NPP= nodule number per plant; NDW= nodule dry weight; PPP=pods per plant; SPP= seeds per pod; HSW=hundred seed weight

Number of Leaves Per Plant

Inoculated plants produced 17% more leaves as compared to uninoculated plants (Table 2). Similarly, the study by Mmbaga *et al.* (2015) with climbing bean varieties inoculated with rhizobium and fertilized with phosphorus and potassium showed increased number of leaves per plant after six weeks of planting. Application of potassium along rhizobium inoculation resulted in relatively higher number of leaves per plant as compared to applying without rhizobium inoculation (Table 3). Similarly, study by Mmbaga *et al.* (2015), revealed that number of leaves per plant increased by 20% four weeks after planting relative to control.

Table3. *Interaction effect of rhizobium inoculation and potassium rate on plant height, number of leaves per plant and pods per plant*

Treatments		PH(cm)	LPP	PPP
R	K(kg ha^{-1})			
Un	0	39.83b	17.00c	5.00c
	30	40.75b	17.33bc	6.50c
	60	37.16b	16.00c	6.66c
In	0	58.00a	20.50ab	10.66b
	30	51.66a	21.83a	11.16ab
	60	55.16a	21.16a	13.16a
LSD (5%)		8.95	3.36	2.27

Number of Nodules Per Plant

Rhizobium inoculation showed 82% increase of nodules per plant (Table 2). Correspondingly, Bejandi *et al.* (2012) reported that seed inoculation with *Rhizobium cicerea* produced significantly highest nodule number of active nodule per plant than control. Similarly, application of potassium significantly affected number of nodules per plant. For instance, the highest level (60 kg K ha^{-1}), increased the number of nodules per plant from 42.18 to 49.91 compared to the control (Table 2). Comparably, study by Mmbaga *et al.* (2015) disclosed that nodule number per plant increased with increasing potassium supply on of faba bean and other legume crops.

Nodule Dry Weight Per Plant

Rhizobium inoculation significantly increased nodule dry weight by 34.04% compared with un-inoculated plants (Table 2). Similarly, Bejandi *et al.* (2012) reported that seed inoculation with *Rhizobium cicerea* produced significantly highest nodule dry weight and active nodule per plant than control. Nodule dry weight increased due to potassium application. For instance, from application of potassium at rate of 60 kg ha^{-1} K, 0.43 mg plant^{-1} nodule dry weight was recorded while the control produced 0.36 mg plant^{-1} (Table 2).

Number of Pods Per Plant

Number of pods per plant showed significant ($p < 0.001$) response to phosphorus fertilization and rhizobium inoculation but not for potassium fertilization. Rhizobium inoculation increased number of pods per plant from 7.00 to 13.08 (Table 2). Similarly, the recent research on groundnut by Mohammed and Ismail (2016) showed that plants that were inoculated with rhizobium strain yielded higher number of pods per plant while uninoculated plants yielded lower. This result is supported by the previous findings stated that rhizobium inoculation enhances macro and micro nutrient uptake and provide nitrogen to the host plant through biological nitrogen fixation (Makoi *et al.*, 2013).

Number of Seeds Per Pod

The number of seeds per pod did not vary significantly ($p > 0.05$) among the treatments. Even though, it was not significant, inoculation and supplementation with potassium tend to improve number of seeds per plant (Table 2). Similarly, Abebe and Tolera (2014) showed that number of seed per pod of faba bean was not significantly affect due to fertilizer rate, rhizobium inoculation and lime rate. This is due to the fact that the number of seeds per plant is mainly under genetic control can be little affected by the environmental factors (Gemechu *et al.*, 2006).

Hundred Seed Weight

Inoculation increased hundred seed weight by 11.44%, compared to uninoculated plants (Table 2). The study on lentil also indicated that 100-grain weight was significantly higher in inoculated treatments in the pot experiment (Endalkachew *et al.*, 2016).

Conclusion and Recommendation

Rhizobium inoculation significantly improved grain yield of faba bean. Also, application of potassium improved some yield components of faba bean. Thus, rhizobium inoculation and application of 60 kg/ha K is recommended for better production of faba bean at Alicho wuriro highlands.

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