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Demonstration and Promotion of Biofertilizer Application for Maximum Grain Yield of Faba Bean(Vicia faba L.) Variety: The Case of Alicho Wuriro District

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Abstract
This experiment was conducted at Alicho wuriro district of SNNPRS during the 2015 cropping season with the objectives to demonstrate and popularize rhizobia strains used as bio fertilizer to enhance the productivity of faba bean. A total of thirty farmerswere randomly selected and organized to participate in the treatments evaluation. Single plot with 10 m x 10 m size was used. Nodule number per plant had positive and significant ($p<0.05$) correlation with grain yield and pod per plant.Treatment FB-1035 rhizobium inoculation+ Dosha + 121 kg NPS /ha gave the highest grain yield (2.68 t ha^{-1}) and had yield advantage of 78.67% over control and got higher score in all parameters and selected as 1st by farmers at study area. Therefore, itwas recommended for production at Alicho wuriro district and similar agro ecological conditions to improve faba bean production and productivity under smallholder farmers.
Keywords: Biofertilizer, demonstration,faba bean variety

1. Background and Justifications

Faba bean (*Vicia faba*L.) is used as human food in developing countries. It can be used as a green vegetable or dried, fresh or canned in the Middle East,Mediterranean region, China and Ethiopia. In Ethiopia, legumes rank second as food after cereals and occupy about 15.2% of the total cultivated areas and contribute about 11.9% of the total production.Yield increase of faba bean by using bio-fertilizer has been reported by the study from Ethiopia. The same study reported several benefits of biofertilizer including increased size and plumpness of faba bean seeds resulting in higher sale prices; increased soil fertility more organic matter as plants are harvested at ground-level leaving roots and nodules in the soil supporting a transition away from fallowing and supporting an increase in productive farm holding size; reduced use of fertilizer (Zelekeet *al.*, 2017).

One of the principle production constraints is poor fertility, especially nitrogen deficiency. Rhizobia species in the process of biological nitrogen fixation for food and commercial legume production is very important (Bottomley, 1991). Of the total SNNPRS area under pulse crops 30.03 % is covered by faba bean and 4.5 % total grain production was obtained from it. Fromthis region faba bean takes up about 5.07%of the area under grain crops of Siltie zone. In the region faba bean occupies an area 66,590.48 ha with production of 109,141.21 ton annually (CSA, 2015) with the average yield of 1.64 tones/ha. Varieties released in specific centres in national agricultural research centres require demonstration with biofertilizer to enhance faba bean production and productivity in south region. Therefore, the present study attempts to popularizerhizobia strains used as bio fertilizerto the areas where the productivity of faba bean is low.

2. Materials and Methods

2.1. Description of study Area

The study was conducted in Alicho wuriro from Siltie zone of SouthernNations Nationalities and People's Region (SNNPR) ofEthiopia. One kebele (Bune-sakemo) was selected based on the highest area coverage of faba bean production. List of the testing locationwith characteristics is indicated in Table 1.

Table 1. Agro-ecological characteristics of test site

Location	Altitude (masl)	Mean annual rainfall (mm)*	Average temp (^oC)*	Soil texture	Global position	
					Latitude	Longitude
Alicho	2984	825	14.26	Clay loam	7^0 58′ 23″	37^0 29′ 49″

*Source: National Meteorology Agency, Hawassa branch

2.2. Experimental Materials and Procedures

The experiment was carried out with one released faba bean variety namely Dosha. Planting date was done on June, 2015. The experiment in single plot was planted at kebeleFTC. The seed was planted at the rate of 150 kg ha^{-1}within row spacing 40 cm and 10 cmbetween plants in plots of 100 m^2. Biofertilizer strain rhizobia were obtained from Menagesh biofertilizer private sector, used during this study. Seeds were coated with inoculum single strains before planting: Dosha as a test varietyandthe experiment includes four treatments

T1=FB1035 rhizobium inoculation+ Dosha + 121 kg NPS /ha
T2= FB1018 rhizobium inoculation+ Dosha + 121 kg NPS /ha

T3= FBEL-110rhizobium inoculation+ Dosha + 121 kg NPS /ha
T4= Control (Dosha + non inoculated + 121 kg NPS /ha)

The same fertilizer rates of 121 kg NPS $ha^{-1}$for all plots applied once during planting time uniformly and only plots with biofertilizer were fertilized with urea as enhancement (50kg ha^{-1}) applied after three weeks for bio fertilized plots. Weeding, plowing and other management practices were done as required.

Site selection was done in participatory way with district agricultural office and experts working on faba bean production. Accordingly, kebele was selected based on potential production of faba bean among others. Similarly, farmer's selection criteria were done with collaboration of agricultural office experts, kebele official and developmental agent by considering different selection criteria.

2.3. Data collection and analysis

All data were measured on five randomly selected plants and plot based. Grain and hundred seed weight were measured using squadra from the three places diagonal of the 1 m^2 plot at maturity. Similarly, seed per pod and pod per plant were determined on five randomly sampled plants and collected and subjected to statistical analysis using SPSS version 20 software. A group of farmers having thirty members (ten female and twenty male) and randomly selected were organized to participate in the treatments evaluating process. Farmers have evaluated and ranked the treatments at different growth stages of the crop. They used parameters like plant height, pod per plant, seed weight,nodules per plant andgrain yield, to evaluate the treatments. These evaluation criteria were identified through brainstorming.

Farmer's preference were collected and analyzed by using simple ranking method in accordance with the given value (Boef and Thijssen, 2007). The formula of ranking method used was specified as: Rank =$\sum\frac{N}{n}$Where N, is value given by group of farmers for each variety based on the selection criteria and n is number of selection criteria used by farmers.

3. Results and Discussion

Among treatments, FB-1035 rhizobium inoculation+ Dosha + 121 kg NPS/hahad gave high yield compared to control (Dosha + non inoculated + 121 kg NPS/ha). The mean grain yield value indicated that FB-1035 rhizobium inoculation+ Dosha + 121 kg NPS/hafollowed by FB-1018 rhizobium inoculation+ Dosha + 121 kg NPS /ha)gave the highest grain yield (2.68 t ha^{-1}) and (2.53 t ha^{-1}), respectively while the lowest grain yield (1.50 t ha^{-1}) was recorded bycontrol (Dosha + non inoculated + 121 kg NPS /ha) (Table 2). TreatmentFB-1035 rhizobium inoculationgave the highest grain yield and had yield advantage of 78.67% over control. Treatment FB-1018 (100.20 cm) and the control (60.20 cm) were the tallest and shortest plant height, respectively (Table 3).

Table 2. Grain yield performance of four biofertilizer treatments at Alicho wuriro in 2015

Treatments	Grain yield t ha^{-1}	Yield difference t ha^{-1}	Yield increase over control (%)
FB-1035 rhizobium inoculation + Dosha + 121 kg NPS /ha)	2.68	1.18	78.67
FB-1018 rhizobium inoculation + Dosha + 121 kg NPS /ha)	2.53	1.03	68.67
FBEL-110 rhizobium inoculation+ Dosha + 121 kg NPS /ha)	1.79	0.29	19.33
Control (Dosha + non inoculated + 121 kg NPS /ha)	1.5	-	-

Picture 1. Evaluation of biofertilizer treatments by farmers and other stakeholders

Table 3.Effect of biofertilizer strains on yield and other traits of Dosha faba bean variety in 2015 at Alicho wuriro

Treatments	GY t ha^{-1}	SNP	PPP	PH	NNP	HSW
FB-1035 rhizobium inoculation + Dosha + 121 kg NPS /ha)	2.68a	18.61a	10.67a	96.47ab	29.5ab	65.66
FB-1018 rhizobium inoculation + Dosha + 121 kg NPS /ha)	2.53a	17.89a	11.33a	100.20a	33.33a	65.03
FBEL-110 rhizobium inoculation+ Dosha + 121 kg NPS /ha)	1.93b	16.22ab	8.67ab	84.07b	18.18b	68.07
Control	1.49b	11b	6.33b	60.20c	15.87b	65.22
Mean	2.16	15.93	9.25	85.24	24.22	65.99

Where: GY = Grain yield, SNP = Seed number per plant, PPP = Pod per plant, Plant height, NNP = Nodule number per plant, HSW = Hundred seed weight

Grain yield is the most complex trait and it is influenced by genetic and environmental factors that determine productivity of the cultivars. Therefore, understanding of the relationships of grain yield and other traits is highly important. Correlation coefficients among agronomic traits of the tested treatments are indicated in (Table 4). Plant height had positive and significant correlation with grain yield and highly significant with seed number per pod and pod per plant.Seed number per pod had positive and significant correlation with grain yield. Pod per plant also had positive and significant correlation with grain yield and seed number per pod. Nodule number per plant had positive and significant ($p<0.05$) correlation with grain yield and pod per plant. These results gave a clear indication that theyield components were mutually very closely associated. This is in agreement with obtained by Yasin and Esrael (2017) where plant height was reported to have been strongly associated with the major yield components.

Table 4.Pearson Correlation for six traits of Dosha variety with biofertilizer at Alicho wuriro

	GY	SNP	PPP	PH	NNP	HSW
GY	1.00	0.942*	0.967*	0.952*	0.934*	-0.216
SNP		1.00	0.953*	0.981**	0.815	0.113
PPP			1.00	0.991**	0.946*	-0.150
PH				1.00	0.893	-0.016
NNP					1.00	-0.463
HSW						1.00

*, ** the significant difference at the 0.05 and 0.01 probability level, where GY = Grain yield, SNP = Seed number per pod, PPP = Pod per plant, Plant height, NNP = Nodule number per plant, HSW = Hundred seed weight

Farmers set out main selection criteria in order to rank the treatments. These criteria include seed number per pod, pod per plant, plant height,nodules per plant and yield. Based on the selection criteria, farmers indicated that treatment FB-1035 rhizobium inoculation+ Dosha + 121 kg NPS /ha) was preferred by farmers and other neighbour farmers during field day organized on FTCs. The mean scores of farmers' selection criteria ranged from nodules per plant (1.00)for Control (Dosha + non inoculated + 121 kg NPS /ha)to Pod per plant (9.5)for FB-1035 rhizobium inoculation+ Dosha + 121 kg NPS /ha). The highest totalscore (30) recorded to FB-1035 rhizobium inoculation+ Dosha + 121 kg NPS /ha)and 12 to Control (Dosha + non inoculated + 121 kg NPS /ha) at Alicho wuriro. However, the score in terms of nodules per plant for FB-1035 and FB-1018 rhizobium inoculation+ Dosha + 121 kg NPS /ha)(3.5) and for FB-1018 rhizobium inoculation+ Dosha + 121 kg NPS /ha) and FBEL-110(5.0)were the same. In general FB-1035 rhizobium inoculation+ Dosha + 121 kg NPS /ha got higher score in all parameters than others and selected as 1st by farmers at study area (Table 5).

Table 5.Farmer's preference criteria on the treatments(score out of 5)

Treatments	Alicho wuriro							
	PH	PPP	NNP	SNP	GY	Total	Mean	Rank
Control (Dosha + non inoculated + 121 kg NPS /ha)	2.5	2	1	3.5	3	12	2.4	4th
FB-1018 rhizobium inoculation + Dosha + 121 kg NPS /ha)	3.4	8.6	3.5	5	3	23.5	4.7	2nd
FBEL-110 rhizobium inoculation+ Dosha + 121 kg NPS /ha)	3	9	3	5	2	22	4.4	3rd
FB-1035 rhizobium inoculation + Dosha + 121 kg NPS /ha)	4	9.5	3.5	6	7	30	6	1st

Where, PH = plant height,PPP = pod per plant, NNP = nodules per plant, SNP = seed number per pod, and GY = Grain yield

4. Conclusion and Recommendation

This experiment was conducted at Alicho wuriro district during 2015 to demonstrate and promote biofertilizer. Nodule number per plant had positive and significant ($p<0.05$) correlation with grain yield and pod per plant.FB-1035 rhizobium inoculation+ Dosha + 121 kg NPS /ha treatment was out performed and preferred under farmer's condition by its plant height, pod per plant, nodules per plant, seed number per pod and grain yieldandgave the highest grain yield (2.68 t ha^{-1}) and had yield advantage of 78.67% over control. It hadgot higher score in all parameters and selected as 1st by farmers at study area. Therefore, it was recommended for

production at Alicho wuriro and similar agro ecological conditions to improve faba bean production and productivity.

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