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Evaluating Rhizobium Strains and inorganic fertilizers for Fababean (*Vicia faba L.*) production at Arbegona and Hulla wereda in Sidama zone

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Abstract

Biological nitrogen fixation (BNF) has a great importance as a non-polluting and a cost-effective way to improve soil fertility through supplying N to different agricultural systems. Faba bean (Vicia faba L.) is one of the most efficient nitrogen-fixing legumes that can meet all of their N needs through BNF. This study is aimed to investigate the symbiotic effectiveness of three Rhizobium strains, FB1017, FB1035 and EAL110 in 2016 and 2017 at Arbegona and Hulla woredas. A total of eight experiments were arramged in randomized complete block design with three replications. The current study revealed that there was no significant difference on grain yield between all strain treatments and the control at Arbegona. At Hulla woreda singnificantly higher (2132 kg/ha) yield was obtained from plots treated by FB1035 + 9 kg N + 10 kg P compared to NP alone and the control. The dominance analysis showed that except treatments 4 and 5 all strain treatments and the recommended NP fertilizer were dominated by the treatment with low TVC. The highest net benefit (33817.8 ETB/ha) was obtained from plots treated by FB1035 + 9 kg N + 10 kg P/ha followed by FB1035 + 10 kg P/ha. Therefore, these treatments are recommended for fababean producers around Hulla. Key word: Fababean, yield, Rhizobium strains, nitrogen fixation

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Introduction

Faba bean (Vicia faba L.) is among the oldest crops in the world (Singh et al; 2013) with a long tradition of cultivation in the temperate zone of the northen hemisphere (Due; et al., 2015]. Because of comperatively good adaptivity to groving conditions [(Singh et al ;2013)] they are widely in different agroclimatical regions [Salem and Alghamdi, 2009]. Due to their great resistance to low temperatures, they are, among leguminous plants, the best adapted to colder climates such as the Northern parts of Europe, and represent to the inhabitants of that region a source of energy, protein, folic acid, niacin, vitamin C, magnesium, potassium, iron and dietary fiber. Faba beans are high- yield crop whose both– economic and ecologic role is very significant; they contain up to 35% of crude protein, approximately 50% of carbohydrate and no more than 15% of crude lipid [Hawthorne, 2006]. Faba bean responds to and changes its environment by altering on-site soil fertility, microclimate, and co-habitats of wild flora and fauna (Kopke, and Nemecek 2010). and is an excellent crops for cropping systems because of its unique ability to fix atmospheric nitrogen symbiotically which is heavy depends on sufficient populations of effective rhizobia .

The benefits by the use of *Rhizobium* inoculants show that a quite good deal of money can be saved by marginal farmers by using quality tested inoculants on the farm. Rhizobium is a common soil bacterium. Rhizobium is not toxic to humans, plants or animals. It is one of the most beneficial bacteria in agricultural practices. Biological nitrogen fixation, especially rhizobia-legumes symbiosis, is one of the alternative solutions and the promising technologies which play an important role in reducing the consumption of chemical N-fertilizers, increasing soil fertility, decreasing the production cost, and eliminating the undesirable pollution impact of chemical fertilizers in the environment [peoples et al., 1995). Worldwide, N2 fixed by nodulated legumes (pulses and oilseeds legumes) is estimated to contribute 21.45 Tg N annually to global agricultural systems (Herridge et al., 2008). Further, it has been reported that the legumes crop enrich the fertility of the soil (Bruno, *et al*., 2003). Therefore this study will aimed to test the possibility of enhancing of fababean production among the small holder farmers in Southern Ethiopia through the use of *Rhizobium strain* inoculation.

Materials and Methods

This study was carried out at Arbegona and Hulla woredas in Sidama zone. Fababean seeds were surface sterilized by Mercuric chloride (0.1%) for 2 minuts, and thoroughly rinsed with distilled water. Thereafter, seeds were soaked in distilled water for a minute. For inoculation with peat based inoculums, seeds were moistened in sugar solution (48%) before application of inoculums to get a thin uniform coating of inoculums on seeds immediate before sowing. The field experiment was laid out in a randomized complete block design (RCBD) having eight treatments; (1) control (No-fertilization and strain) (2) Recommended NP 18 N and 20P , (3) FB 1017 + 10 kg P/ha, (4) FB1035 + 10 kg P/ha, (5) FB1035 + 9 kg N + 10 kg P/ha, (6) FB1017 + 9 kg N + 10 kg P/ha, (7) EAL110 + 10 kg P/ha and (8) EAL110 + 9 kg N + 10 kg P/ha. . Each treatment was replicated three times and the experiment was conducted for two consecutive growing seasons in 2016 and 2017. Fababean seeds were planted 10 cm by 40 cm spacing between seeds and row, respectively. The plot size had 4 m width and 3 m length with 1 m space between plots and blocks. Side application of fertilizer was used and covered with soil to avoid direct contact. Urea, DAP and TSP fertilizers were used as sources of nutrients and all dose of Urea, DAP and TSP were applied at planting. First earthing-up and weeding was carried out based on the recommendation for the crop.

Agronomic and economic analysis

During the experimental periods important data for Fababean including nodule numbers, above ground biomass and grain yield were measured at harvesting time. All measured data were subjected to Proc GLM procedures in the SAS 9.3 program (SAS Institute Inc., Cary, NC USA). Mean separation between the treatments was established by using least significant difference (LSD) at 5% probability level. Economic analysis was also performed to see the profitability of the strains combined with inorganic fertilizers. For partial budget analysis adjusted yield by 10% was used, because farmers would get 10% less yield than an experimental site. The average open market price for fababean and the official prices for strains, TSP and DAP fertilizers were used for the analysis. For a treatment to be considered a worthwhile option for farmers 100% acceptable marginal rate of return was used (CIMMYT, 1988).

Results and Discussion

Rhizobium strain FB 1035+50kg/ha TSP and EAL 110+50kg/ha TSP were gave significantly higher nodule number followed by EAL 110+50kg/ha TSP as compared with the other strains and control, which resulted the least nodule number (Table 1). Similar result obtained Bezabih *et al*., (2018) Rhizobium inoculation showed increase of nodules per plant. Correspondingly, Bejandi et al. (2012) reported that seed inoculation with Rhizobium cicerea produced significantly highest nodule number of active nodule per plant than control.

The response of biomass to all strain and recommended NP were in similar fashioned, and by which the highest ($P < 0.01$) biomass yield were obtained as compared with the control. There was any significant ($P > 0.05$) deviation on grain yield (Table 1). This result were similar with Sameh , *et al*., (2017). the capacity of Rlv NGB-FR 126 to produce the uppermost seed yield (4.68 ton·ha−1) and seed N-yield (155 kg N·ha−1) was confirmed and was significantly greater than the full-N fertilizers treatment (TN), which recorded 3.17 ton·ha−1 and 104 kg N·ha−1, respectively.

At Hulla woreda treatment 5 (FB1035 + 9 kg N + 10 kg P/ha) significantly increased grain yield compared to the recommended NP and the control. Similarly, except treatment 3 all strains treatments gave significantly higher grain yield compared to the untreated plots. This result probably contributed from the applied strains which were combined with inorganic fertilizers. was recorded from there was no obtained any significant ($P > 0.05$) improvement on nodule number among all strain, and that of the control (Table 2).The strain, recommended N and the control were not consistent in their effect on biomass yield over year (Table 2), and was no different significantly ($P > 0.05$) in year one. The highest biomass yield ($P < 0.01$) obtained due to the use of FB 1035+50kg/ha TSP, FB 1035+50kg/ha TSP and EAL110+50kg/ha TSP (strain in combination with NP-source) followed by other strain and supplementary recommend N variation as compared with the control. The maximum grain yield obtained ($P < 0.01$) from seed treated by soil FB 1035 and all strain plus 50kg/ha TSP (Table 1), however, other treatments were not significantly different that of the control.

Table 1. Effect of *Rhizobium* strains on Fababean yield and yield components at Arbegona woreda

Treatments	Nodule number Plant^{-1}	Biomass kg ha^{-1}	Grain kg ha^{-1}
1. Control (No inoculation and no fertilizer)	208.3d	3777.8b	1431a
2. Recommended NP (18 kg N + 20 kg P/ha)	237.0cd	5250.0a	2028a
3. FB 1017+10 kg P/ha	282.7bc	5555.5a	2181a
4. FB 1035+10 kg P/ha	342.5a	5611.1a	2215a
5. FB 1035+10 kg p + 9 kg N/ha	240.7cd	5006.9a	2000a
6. FB 1017+10 kg P + 9 kg N/ha	281.3bc	5319.4a	2146a
7. EAL110 +10 kg P/ha	302.0ab	5819.5a	2111a
8. EAL 110+10 kg P + 9 kg N/ha	232.7cd	4750.0ab	1944a
Mean	265.9	5136.0	2007
CV (%)	18.7	20	20.2
LSD at 0.05	58.5	1209.0	NS

Table 2 : Effect of *Rhizobium* strains on fababean production at Hulla woreda

Treatments	Nodule number Plant^{-1}	Biomass kg ha^{-1}	Grain kg ha^{-1}
1. Control (No inoculation and no fertilizer)	155.0	4013.9bc	1458.3cd
2. Recommended NP (18 kg N + 20 kg P/ha)	158.2	4750.0ab	1701.4bcd
3. FB 1017+10 kg P/ha	144.8	3680.6c	1444.4d
4. FB 1035+10 kg P/ha	253.2	4486.1abc	1986.1ab
5. FB 1035+9 kg N + 10 kg P/ha	239.2	5152.8a	2132.0a
6. FB 1017+ 9 kg N + 10 kg P/ha	220.2	5090.3a	2027.7ab
7. EAL110+10 kg P/ha	183.0	5444.4a	1868.1abc
8. EAL 110+ 9 kg N + 10 kg P/ha	182.7	5180.6a	2013.9ab
Mean	192.0	4725.0	1829.0
CV (%)	44.1	18.1	19.6
LSD at 0.05	NS	1010	422.6

Table 3: The economical (dominance and marginal rate of return) analysis of fababean strain and fertilizer at Hulla woreda

Treatments	Av. Yield	Adj. yield	TVC (ETB/ha)	Revenue (EB/ha)	NB (ETB/ha)	MRR (%)
1. No inoculation and fertilizer	1458.3	1312.5	0	24280.7	24280.7	
3. FB 1017+ 10 kg P/ha	1444.4	1300	905	24049.3	23144.3	D
4. FB 1035+ 10 kg P/ha	1986.1	1787.5	905	33068.6	32163.6	
7. EAL110 + 10 kg P/ha	1868.1	1681.3	905	31103.9	30198.9	D
5. 9 kg N + 10 kg P/ha + FB1035	2132	1918.8	1680	35497.8	33817.8	

6. 9 kg N + 10 kg P/ha + FB1017	2027.7	1824.9	1680	33761.2	32081.2	D
8. 9 kg N + 10 kg P/ha + EAL110	2013.9	1812.5	1680	33531.4	31851.4	D
2. Recommended 18 kg N + 20 kg P/ha	1701.4	1531.3	1990.5	28328.3	26337.8	D

Av. Yield=average yield, yield adjustment =10%, TVC= total variable cost, NB= net benefit, MRR= marginal rate of return

Table 4: Economic (partial budget and marginal rate of return) analysis of Fababean for strain combined with inorganic fertilizer at Hulla

Treatments	Av. Yield	Adj. yield	TVC (ETB/ha)	Revenue (EB/ha)	NB (ETB/ha)	MRR (%)
1. No inoculation and fertilizer	1458.3	1312.5	0	24280.7	24280.7	
4. FB 1035 + 10 kg P/ha	1986.1	1787.5	905	33068.6	32163.6	871.0387
5. 9 kg N + 10 kg P/ ha + FB1035	2132	1918.8	1680	35497.8	33817.8	213.4452

Table 5: The economical (dominance and margina rate of return) analysis of fababean strain and fertilizer at Arbegona

Treatments	Av. Yield	Adj. yield	TVC (ETB/ha)	Revenue (EB/ha)	NB (ETB/ha)	MRR (%)
1. No inoculation and fertilizer	1431	1287.9	0	23611.5	23611.5	
3. FB 1017+ 10 kg P/ha	2181	1962.9	905	35986.5	35081.5	
4. FB 1035+ 10 kg P/ha	2215	1993.5	905	36547.5	35642.5	
7. EAL110 + 10 kg P/ha	2111	1900	905	34831.5	33926.5	D
5. 9 kg N + 10 kg P/ha + FB1035	2000	1800	1680	33000	31320	D
6. 9kg N + 10 kg P/ha+ FB1017	2146	1932	1680	35409	33729	D
8. 9 kg N + 10 kg P/ha + EAL110	1944	1750	1680	32076	30396	D
2. Recommended 69 N + ---kg P/ha	2028	1825.2	1990.5	33462	31471.5	D

Table 6: Economic (partial budget and marginal rate of return) analysis of Fababean for strain and fertilizer at Arbegona

Treatments	Av. Yield	Adj. yield	TCTV (ETB/ha)	Revenue (EB/ha)	NB (ETB/ha)	MRR (%)
1. No inoculation and fertilizer	1431	1287.9	0	23611.5	23611.5	
3. FB 1017+ 10 kg P/ha	2181	1962.9	905	35986.5	35081.5	1267.4
4. FB 1035+ 10 kg P/ha	2215	1993.5	905	36547.5	35642.5	

Economic Analysis

The marginal rate of return above 100% is high and acceptable to farmers (CIMMYT, 1988).With the acceptable marginal rate of return (MRR), the applied NP rates were resulted in higher net benefits (Table 3). However, the recommended nitrogen was dominated by strains with its benefit. The non-dominated strains were produced 34.5 to 93.0 % of net benefit advantageous as compared with the control (Table 5). The suggested strain in Arbegona woreda slightly higher in its marginal rate of return when compared to sole NP (Table 6). Therefore strains FB1035 and FB1017) were produced 100% net benefit and more important as compared to control (Table 4).

Conclusion

The investigation was indicated that treating the seed of Fababean necessary in improving the yield. So, farmers can produce with strain of FB 1035+ 10 kg P/ ha and FB 1017+ 10 kg P/ha for yield advantage in Arbegona and *FB1035 +10kg/ha p and* 9 kg N + 10 kg P/ ha + FB1035 Hagereselam woreda respectively. Also, farmers could be benefited 32163.6birr/ha and 30198.9 birr/ha if switched their local practice and move to treating the seed of Fababean by strain.

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