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Demonstration of Blended Fertilizer (NPSZnB) Along with Rhizobium Inoculation on Faba Bean in Tahitay and Laelay Maichew Districts, Tigray, Ethiopia

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Due to low application of inputs and poor agronomic practices with improved varieties, the productivity of faba bean has continued to be low in the central zone of Tigray despite its potential. To address of, low productivity, a demonstration was initiated to showcase the blended NPSZnB (125 kgha^{-1}) along with Rhizobium inoculation (500 g EAL-110 ha^{-1}) at the its appropriate rate in the farmers' field. The experiments was involved 36 farmers selected from Laelay and Tahitay Maychew districts based on their willingness to adopt the practice and used the improved seed "Hachalu" for both, the experimental and the control plots. A semi-structured questionnaire was used to collect the required data at various stages and the data were analyzed using descriptive

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analysis methods. The results showed that the average yield of Hachalu variety was 3.1024 tons ha^{-1} in on the use of NPSZnB and bio-fertilizer compared to yield of the control plot (2.25 ton ha^{-1}). Similarly, The study shows that the perception of the respondents' had good perception (preferred by farmers) for most of the faba bean attributes like vegetative, resistance to disease and pest, pod size, seed yield improvement, and final profitability of the practice with an average mean score of 3.33 which is higher than the mean agreement level mean score (3). Therefore, the application of blended fertilizer with inoculant for faba bean needs to be popularized in the faba bean growing potential areas and it is better to involved stakeholders for facilitating adoption the practice.

Keywords: Demonstration; blended fertilizer; rhizobium inoculation and Hachalu; yield.

1. INTRODUCTION

Faba bean (*Vicia faba* L.) is one of the major pulse crop produced in Ethiopian, following to China in worldwide. Ethiopia is now considered as one of the centers of secondary diversity for Faba bean [1]. It is largely sown by subsistence farmers in Ethiopia which occupying an average of about 485,146 hectares and producing with a total production of 717,818 tons. The productivity of the faba bean is 1.47 tons per hectare [2]. The crop accounts for the largest share in the area and production of the pulses grown in Ethiopia. It grows in the mid- highland areas ranging from 1800 up to 3000 meters above sea level receiving of annual rain fall ranging from 700 mm to 1100 mm on well-drained soil with a pH of 5.5 to 7.5 [3,4,5].

Faba bean plays a significant role in economic lives of the farming communities in the highlands of Ethiopia. It serves as a source of food and feed, providing a valuable and affordable source of protein. Additionally, it contributes to soil fertility restoration as a suitable rotation crop that fixes atmospheric nitrogen. Fababean is a good source of income for the farmers and generates foreign currency for the country, making it strategic for export in Ethiopia. Despite being the country is the largest exporter after France, Australia and the United Kingdom [4]; However, its share in the country's pulse export is remaining small [6-8].

Fababean is recognized as a major source of protein in human and animal nutrition. It also plays crucial role in improving soil fertility by fixing nitrogen from the atmosphere in association with bacteria, reducing the weed, disease, and pests incidence when used in crop rotation with cereal crops. The crop can be grown for green manure, silage, cover crop, and animal forage. Production in Ethiopia is entirely rain fed on nitosols and cambisol soil types [3].

Despite its significance contribution to the economic lives of Ethiopian highland farming communities, the productivity and production of faba bean remains low (currently 1.89 tons/ha) due to biotic and abiotic yield stresses [2]. The inherent low yielding potential of the local varieties, diseases (root rot, chocolate spot) and low soil fertility are among the most important production constraints. Similarly, productivity is lower than the national average in the Tigray region, particularly in Central Zone of Tigray. Low soil fertility levels, diseases and lack of improved varieties are among the major constraints of low faba bean production and productivity in the central zone of Tigray. The study areas are suitable for pulse production especially for faba bean. The faba bean production in Laelay and Tahtay Maichew districts is produced rotated with cereals. Farmers used crop rotation of cereal (Tef) to faba bean to improve their crop productivity. The pulse production is challenged by supply and utilization of improved packages. Access of improved seed of faba bean is limited by amount and variety. Utilization of chemical fertilizers (DAP/NPS) by farmers is less compared to the other cereals dominated crop (Tef).

Research activities conducted in different parts of the country and soil types have shown that the application either of blended fertilizers, inoculation or a combination of both can improve faba bean yields e.g. a study in West Shewa Zone, demonstrate on that an application of 69 kg of Phosphorus (P_2O_5) with a bio- fertilizer (Fb_{18}) shows a significantly increased faba bean yields compared to the control (no input) practice [9]. Similarly, a combination of blended fertilizer (NPSZnB) and inoculant has shown a significance influence on yield and yield components resulting higher yields compared to control [10].

In our experimental sites, the application of blended fertilizer such as NPSB/NPSZnB (125

kg/ha) with Rhizobium inoculation of 500 g ha^{-1}showed promising results in faba bean and chickpea productivity reported by [11]. This study aims; 1) to demonstrate and evaluate the effectiveness of blended fertilizer with Rhizobium inoculation (EAL-110) on faba bean and 2) to analyze farmers' perceptions towards this practice under field conditions.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The study was carried out in the Laelay and Tahtaty Maychew Districts, 2019/20 crop season which located in the Central Zone of the Tigray Region in Northern Ethiopia. These Districts are situated at a distance of 245 and 262 kms away from Mekelle traveling the north-west through the way along Adi-Grat to Shire-Endaslassie route, respectively. Laelay Maychew is located between14°07'00" to 14°09'20"N latitude and 38°38'00" to 38°49'09"E longitude and at an altitude of ranges from 1650-2500 m.a.s.l. Tahtay Maichew district is situated at a latitude of 14°7'N, and longitude of 38°36'E and at an altitude 2148 m above sea level in the semi-arid tropical belt of Ethiopia [12,13]. Laelay and Tahitay Maichew districts received mono modal rainfall pattern which is concentrated July to September of rainfall. The annual rainfall of Laelay maichew received from 700-800 mm while Tahtay Maychew was 354.6-1037 mm per annum for the year 1961-2006 [10]. Similarly, the mean minimum and maximum monthly temperature of Laelay Maychew is 12.6^{0}c and 25.51^{o}c while Tahtay Maychew ranges from 8.7^{0}c and 13.2^{0}c and 24.4^{0}c to 31.4^{0}c, respectively. The study areas highly suitable for faba bean production since the agro ecology of the districts lie between mid-highland and highland climate condition (Map of the study area See Fig. 1).

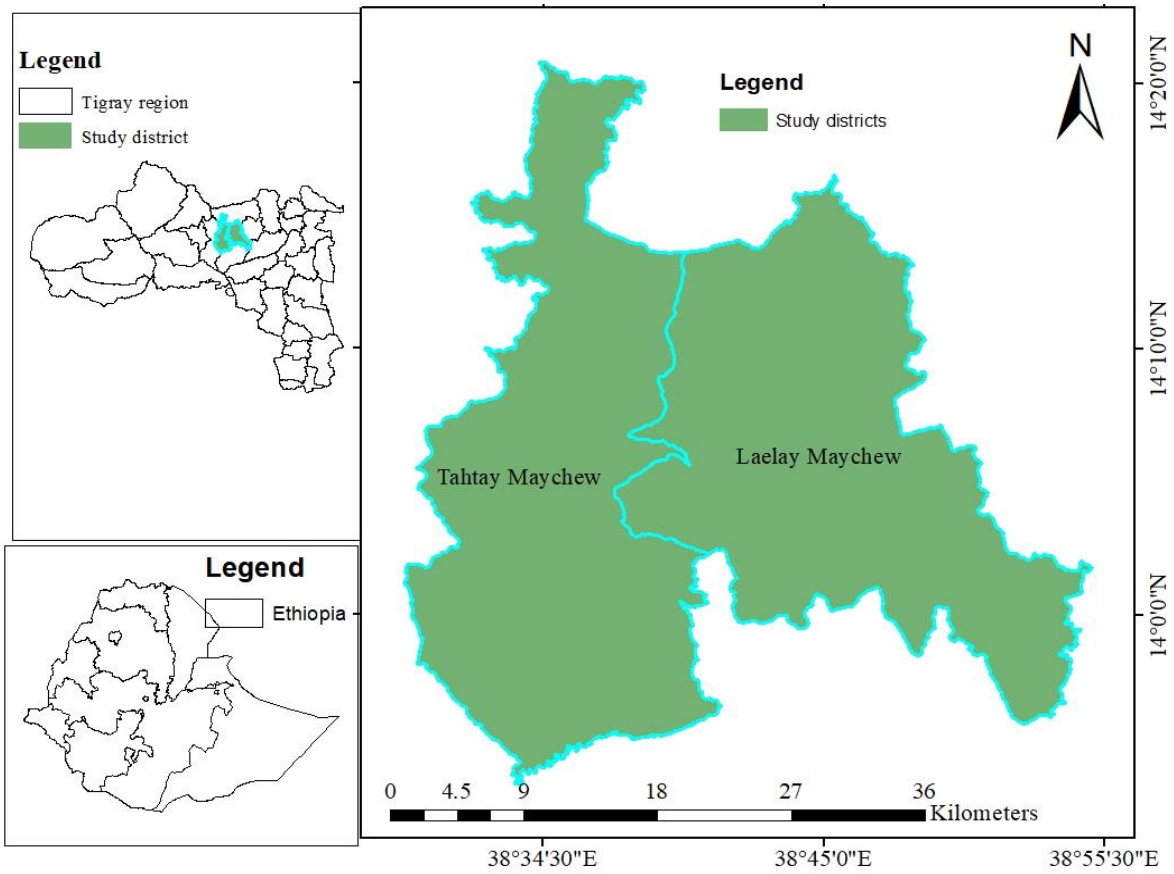

Fig. 1. Map of the study area

2.2 Selection of Peasant Association and Client farmers

The study was done in two adjacent Districts of Laelay and Tahitay Maychew Districts namely Debire-birhan and Kewanit peasant Associations, Respectively. Purposively the two Districts selected by their potential growing of fababean agro climatic suitability. Farmers were also selected on their willingness to participate and adopt the practice easily. The study was conducted on 36 farmers, and they were allocated a trial plot of land 400 m^2 (20 m x 20m) for each of the improved and control practices. The improved seed variety for faba bean trial "Hachalu" to plant at a seed rate of 200 kg/ha and the blended fertilizer rate of 125 kg/ha (NPSZnB) plus Rhizobium inoculant (EAL-110) 500 gram Ha^{-1} inoculant was used while the control not. The design of the experiment was laid out by him the farmer side by side of 20*20 m for each practice and left 1m between the experiments plots. According to the [14] guideline, given farmers an improved seed weight of 8 kg, 5 kg blended fertilizer and 20 g of inoculant and each farmer was prepared 2 teaspoon sugar and sufficient pure water in a jar. The sugar was added to the water stirred until it dissolves. The solution is used as sticker for the inoculant and the seed. Continued, the sticker was added to the seed which was place in container and mixed until the seeds evenly coated and well drained the excessive sticker before adding the inoculant. Then inoculant and seeds were mixed, coated uniformly. Finally, placed the seed under shade, then sowing continued and blended fertilizer was not mixed with the seed and bio fertilizer but sown separately before sown the seed (see Photo 2). The second trail (control) was sown parallel and they used improved seed but sown solely.

Photo 1. Training and awareness creation given for farmers, DAs and agricultural experts

Photo 2. Applied the inoculant (EAL-110) and sowing on farmers field

Photo 3. Status of the faba bean at growing stage of control (right) and inoculated (left)

2.3 Capacity Building

Training was organized in two sites i.e. in Laelay maichew; Debire-birhan and T/maichew; Kewanit Districts and peasant associations, respectively. The farmers, Development Agents (DAs) and Woreda experts were trained and informed about the improved faba bean "*Hachalu*", the inoculant, fertilizer and agronomic practices to be on the recommended way. All agronomic practices (ploughing, weeding, harvesting, threshing, etc.) were carried out by the farmer by him or herself but all necessary technical backstopping follow up done closely by researchers.

2.4 Data Collection Methods

The effect of the blended fertilizer on yield of the faba bean (Hachalu) data had collected. Here farmers threshed the crop separately carefully and weighed by the researchers when they were threshed as soon as on scheduled. In addition, perception data of prepared pre-harvest attributes of faba bean also collected and analyzed using descriptive statistics. Much empirical evidences related to perception studies of agricultural improved technologies conducted on different commodities using simple descriptive statistics methods for different perspectives. Rensis Likert was developed a Likert scale measurement used to collect respondents' attitudes and opinions towards a product or parameters/items in the form of different agreement and disagreement levels of measurements. For instance, the authors used five Likert scale measurement levels for prepared perception parameters. It is used to analyze the perception of respondents towards the faba bean attributes and practice.

2.5 Statistical Analysis

The data was collected from both districts analysed in one way since they are adjacent in location and there was no difference in any agro ecology, farming system and another factors. Yield data as well as perception towards the faba bean attributes wereanalysed using methods descriptive statistical (mean, minimum, maximum and standard deviation) and five scales Likert scale by analysis using tools of SPSS. The Likert scales assigned from 1-5, namely strongly Disagree up to Strongly Agree. Additionally, partial budget analysis also has done using CIMMYT [15] guideline.

$$\text{Marginal rate of return (\%)} = \frac{\text{Change in net benefit}(\Delta I)}{\text{Change in variable cost}(\Delta C)} \text{x}100$$

3. RESULTS AND DISCUSSION

3.1 Grain Yield Performance of the NPSZnB + Inoculated Compared to the Farmers' Practice

The analysis of mean yield has recorded a mean yield of 3.024ton ha^{-1}which had a yield advantage of 7.74 ton ha^{-1} that is a 34.4% yield increment over the farmer's practice (control). The yield between the two practices had showed a significance yield difference. Applications of a blended fertilizer with Rhizobium inoculation gave maximum 4.246 ton ha^{-1} yield in farmers' management (See Appendix Table 1). Farmers' management is differed from farmer to farmer which showed a promised and could stretch up to 4.2462 ton ha^{-1}. This could be due to the

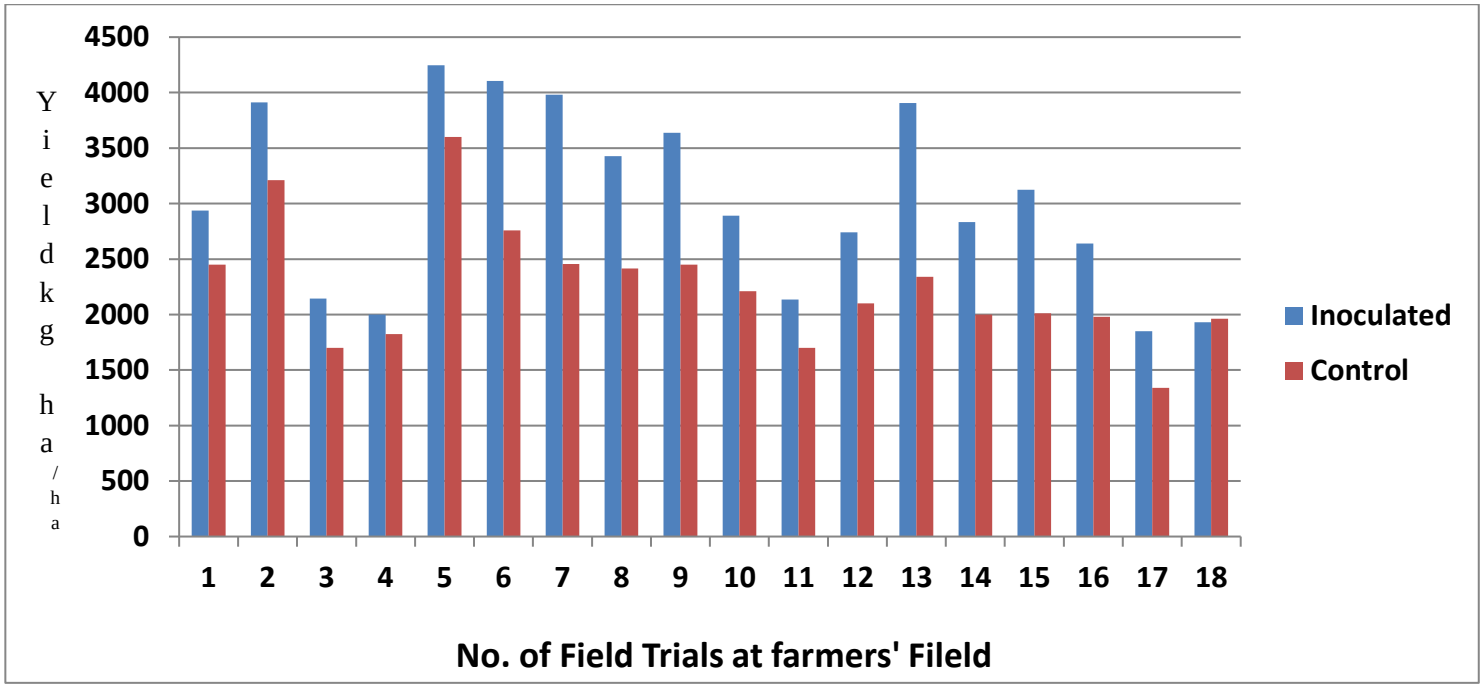

Fig. 2. Mean grain yield (kg/ha) of Faba bean NPSZnB + Rhizobium with inoculation vs. Control

Table 1. Partial budget analysis

Variables	Farmers' practice (Control)	With NPSZnB + R. inoculation
Average yield (kg/ha)	2250	3024
Gross Benefit (Eth birr/ha)	34*2250 = 76500.00	34*3024 = 102,816.00
Cost of NPSZnB (Eth birr /ha)	0	125*17.7098= 2213.725
Cost of Rhizobium inoculant (*Eth birr* /ha)	0	160.00
Labor cost of application of inputs (mixing) and sowing fertilizer (Eth birr /ha)	0	1200.00
Total Variable cost (*Eth birr* /ha)	0	3573.725
Net benefit (*Eth birr /ha*)	76500.00	102,816.00
MRR = $\frac{\text{change in total return}}{\text{Change in total costs}}$	$\frac{102816-76500}{3573.725-0}$=7.36	

Table 2. Participant farmers' perception on the NPSZnB and inoculation application practice attributes Vs Farmers practice

Positive attribute sentences	Perception level (n=18)					Mean	SD
	SA	A	NC	DA	SD		
Applying blended fertilizer and Rhizobium inoculant for faba bean contributed better vegetative growth compare to the Farmers' practice (control)		14 (78)	4 (22)			3.8	0.42
Applying blended fertilizer and Rhizobium inoculant facilitated Early maturity of faba bean		7(38.9)	7(38.9)	3 (16.7)	1 (5.6)	3.11	0.21
Applying blended fertilizer Rhizobium inoculant for faba bean contributed to disease and pest resistant	2(11.1)	6 (33.3)	9(50)	1(5.6)		3.50	0.78
Applying blended fertilizer and Rhizobium inoculant on faba bean increased pod size and number	3(16.7)	10 (55.6)	5(27.8)			3.89	0.67
Applying blended fertilizer and Rhizobium inoculant for faba bean enhances on product quality		2 (11.1)	11 (61.1)	5(27.8)		3.17	0.61
Applying blended fertilizer and Rhizobium inoculant improve yield of faba bean		11 (83.3)	2 (16.7)			3.83	0.38
Applying blended fertilizer and Inoculant for faba bean produced high market demand		1(5.6)	17(94.4)			3.06	0.23
Applying blended fertilizer and inoculant for faba bean is easy to apply in farmers skill			3 (16.7)	15(83.3)		2.17	0.38
Applying blended fertilizer and inoculant for faba bean production package (cost) is less		2 (16.7)	4(22.2)	11(61.1)		2.56	0.78
Applying blended fertilizer and inoculant inputs on faba bean profitable and acceptable	4(22.2)	14 (77.8)				4.22	0.43
Average Weight						3.33	0.64

Note: SA= Strongly Agree (5), A= Agree(4), NC= No change(3), DA= Dis agree (2) and SD= strongly disagree (1)

synergistic effect of phosphorus (34% in the form of P_2O_5 compared to 17% N in the NPSZnB) and rhizobium inoculation, contributed to high number of pods per plant. Phosphorus improves root development, which in turn supports more effective *Rhizobium* colonization and nitrogen fixation. In addition to this Nitrogen could be used as a starter until the crop starts to fix atmospheric nitrogen. This result agrees with the finding Genetu et al. [10] who reported that combined application of Phosphorus fertilizer along with effective rhizobium inoculation significantly increased yield of chickpea across smallholder farms in Ethiopia. Similarly, Abere [14] also reported that Rhizobial bio-fertilizer application showed grain yield response to be obtained varies with types of grain legume crop and the location which is yield advantage ranges from 2-26.3%.

3.2 Economic Analysis

In the study area, the net benefit of 102,816.00 Ethiopian birr (Ethbirr) maintained from improved practiced of Blended fertilizer combined with (Eal-110) inoculate. The local market (Axum) at the time differs from time to time shows promising price compared to the other cereal crop. The time price of the local market was approximately 34.00 Eth birr kg^{-1} and the Blended fertilizer also fare price since subsidized by government which is 1770.98 Eth Birr per 100 kg. The Marginal Return Rate (MRR) is laid in the accepted range of [15] (See Table 1). An investing 1 Ethiopian birr (Eth birr) for the blended fertilizer and Rhizobium inoculants gained an additional 7.36 Eth birr.

3.3 Farmers' Perception towards the Practices of NPSZnB with Inoculate

The data analysis shown that majority of the respondents appeared feel that an application of Blended fertilizer in combination of EAL-110 inoculate contributed on the faba bean to have good vegetative growth, pod size, and yield improvement, pest and disease resistance ability compared to the farmers practice without any application inputs (control). In contrary, they perceived that this practice is labor-intensive and have high production cost with economic capacity of poor farmers and production habit as well as low exposure to the improved practices. Finally, the respondents they highly believed that the improved application of packages of the faba bean is more profitable in monetary and for home consumption (See Table 2).

4. CONCLUSIONS AND RECOMMENDATIONS

The finding of the research activities conducted in the study area found that an application of blended fertilizer (NPSZnB) with Rhizobium inoculants of EAL-110 (Ethiopian Agricultural legume -110) applied in the farmers' condition showed yield advancement over the farmers' practice (control). By the combined application of NPSZnB along with Rhizobium inoculation the gave 3.024 ton ha^{-1} with a maximum possibility of 4.3t ha^{-1} while the farmers' practice (control) for the same improved variety was obtained an average yield of 2.3 ton per hectare. Similarly, perception of respondents preferred on most of the pre-harvest attributes of the faba bean like vegetative growth, pod size, yield improvement, pest and diseases resistance as well as profitability of the technology. According to the economic analysis, an application of combined blended fertilizer (125 kg ha^{-1} with 500 gram ha^{-1}) of inoculates, shown the highest profit (102816 Eth birr) with an acceptable marginal return rate (MMR) of 7.36.

The application of NPSZnB + *Rhizobium* inoculation (Eal-110) on faba bean needs popularized to the farmers in the potential faba bean growing areas. Additionally, needs an involvement of concerned stakeholders to be practiced and popularized to the potential areas of faba bean growing areas for the betterment of promoting rural farm community economic improvement.

DISCLAIMER (ARTIFITIAL INTELEGENCE)

Authors hereby declared No generative AI technologies that like large language models and text- to- image generators have been used neither writing nor editing this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX TABLE 1

Table 1. Average grain yield (kg/ha) of Faba bean with NPSZnB + Rhizobium inoculation vs. farmers practice

Yield component	N	Minimum	Maximum	Mean	SD	T-value	P-value
With NPSZnB + inoculant	18	1815	4346.2	3024	546.2	-3.3	0.02
Farmers practice (control)	18	1340	3599.9	2250	810.3		

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