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Effects of Rhizobium Inoculation and Blended Fertilizer Rate on Yield and Yield Components of Faba Bean (*Vicia faba* L.) in Dangila District, Northwestern Ethiopia

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Abstract **– Faba bean (*Vicia faba* L.) is economically an important crop in Ethiopia. The productivity of Faba bean in Ethiopia has been declined due to poor management practices of inappropriate fertilizer rate and Bio fertilizer rates usage. Factorial combination of five rates of Blended fertilizer (0, 60, 121, 180 and 240 kgha-1 NPSZnB) and three rates of Bio fertilizer (0,500 and 750 gha-1) treatments were laid out in RCBD with three replications. Days to 50% flowering, days to 90% physiological maturity, plant height, number of productive tillers, total biomass yield, numbers of pods per plant, number of nodule per plant, effective nodule, grain yield and straw yield were recorded and significantly affected by the main effects. On the other hand, days to 50% flowering, plant height, effective nodule, grain yield and number of seed per pod were significantly affected by the interaction effect of Blended and Bio fertilizer rates. The maximum grain yield (3278 kgha-1) was recorded from combined 180 kg ha-1 blended fertilizer and 750gha-1 bio-fertilizer treatment. About 180kgha-1 Blended fertilizer rate and 750 gha-1 Bio fertilizer rates were preferable for the study area. However, further study has to be done under different seasons and locations to come up with workable recommendations related to the present study.**

Keywords **– Blended Fertilizer, Bio Fertilizer, Faba Bean, Inoculation, Nodule, Rhizobium.**

I. INTRODUCTION

Legumes are significant harvests in giving food to people around the world. They are an essential wellspring of amino acids and 33% of prepared vegetable oil for human taking care of (Arafa et al., 2018a) This low efficiency in grain vegetables is because of the declining in soil ripeness and diminished N2 obsession. Low profitability of grain vegetable can be improved through vaccination of versatile compelling rhizobia (Kenasa et al., 2014). Ignoring the way that using rhizobia in vaccinating vegetables can achieve liberal extensions being developed and yield proficiency and improve soil lavishness, there is no vulnerability that un equivocality exists between rhizobia strain and the vegetable combination, and closeness between the two is essential for viable nodulation and nitrogen fixation (Arafa et al., 2018). Among Legumes, Faba bean (Vicia faba L.) is a yearly vegetable harvest plant having a place with the family Fabaceae and can fill in different climatic zones (Singh et al., 2013). The yield is appointed to the Central Asian, Mediterranean, and South American communities of variety and accepts to be a local to North Africa and southwest Asia, and widely developed somewhere else (Kenasa et al., 2014). Faba bean is the most seasoned and the third most significant feed grain crops on the planet, after soya bean (Glycine max L.) and pea (Pisum sativum L.) as far as zone inclusion and yield(Etemadi et al., 2018). China, Ethiopia, Egypt and the Unified Realm are the most creating nations on the planet. Ethiopia is the main maker of Faba bean in Africa it accounts about 56% of the yield (Rogers et al., 2014). It is the main heartbeat crop in the good countries and mid-high countries in Ethiopia and it is cool-season vegetables filled in the nation (CSA, 2015). The world-developed territory was assessed at 2.4 million hectares in 2014 of which C-

-hina develops the most, trailed by Ethiopia, Morocco and Australia(Köhl et al., 2015).

Rhizobia, enormous number of bacterial species, can fix barometrical N because of a harmonious relationship with vegetable plants (Redmon et al., 2004). In a harmonious relationship, both the plant and microbes add to one another and advantage because of their affiliation (Redmon et al., 2004). Diverse leguminous harvests require explicit rhizobium species for the arrangement of powerful knobs and nitrogen obsession(Butts et al., 2005). For new foundations, seed of vegetables are needed to be vaccinated with the appropriate rhizobia specie.

Most high lands of Ethiopia are lacking in significant fundamental supplements N and P. As of late soil stock information from Ethio Sister (Ethiopian Soil Data Framework) additionally uncovered that notwithstanding N and P, lacks of supplements, for example, K, S, B, and Zn are far reaching in Ethiopia. Nitrogen is a supplement needed by plants in similarly bigger sums than different components. It is a constituent of numerous organic mixes that assume a significant job in photosynthetic movement and furthermore a piece of proteins. Because of this reality different scientists have suggested the use of business composts as a method of rectifying nitrogen inadequacy for the improvement of profitability of harvests (Daur et al., 2008). Potassium additionally, is significant for the cooperative relationship that empowers microorganisms to fix nitrogen from the air (Weisany et al., 2013).

Low degree of compound and Bio-compost utilization and absence of powerful native soil populaces of rhizobia strains has restricted possible yield of Faba bean (Dereje et al., 2012). In low-input editing frameworks of Ethiopia, synthetic composts are seldom utilized in the creation of Faba bean and other heartbeat crops; all things being equal, these yields are utilized as a restorer of soil fruitfulness for the accompanying oat crops (Mulissa and Fassil, 2011) the potential organic manures would assume a vital job in efficiency and maintainability of soil and furthermore secure the climate as eco-accommodating and financially savvy contributions for the ranchers (Tolera et al., 2009). Nonetheless, improvement of Faba bean creation requires determination of viable rhizobia strains (Moawad et al., 2004).

1.1. *Statement of the Problem*

Sustainable crop production can be achieved through integrating high and low cost inputs such as Bio fertilizer and fertilizer. However, the yield in the country in general and in the study area in particular is still low, which is below the world average where Faba bean yield is 1700 kg ha^{-1}. The low productivity is associated with poor agronomic practices mainly inappropriate fertilizer and Bio fertilizer rates together with other factors including soil fertility degradation, soil erosion, inappropriate weeding practices and occurrence of different pests and diseases. Meager information availability on appropriate nutrient management mainly integrating use of Bio fertilizer and chemical fertilizer to improve Faba bean yield has been hindered the extension service. Hence, this study is designed to evaluate the effect of different fertilizer and Bio fertilizer rates on growth and yield of Faba bean in Dangla District's soils.

1.2. *Objectives*

1.2.1. *General Objective*

- ✓ To increase the productivity of Faba bean through optimizing its Rhizobium Inoculation and blended fertilizer rate in the study area.

1.2.2. *Specific Objectives*

- To study the response of growth and yield of Faba bean to blended fertilizer rates and rhizobium inoculation in the study area.
- To evaluate the interaction effects of blended fertilizer rates and rhizobium inoculation on yield and yield components of Faba bean in the study area, and

II. MATERIALS AND METHODS

2.1. *Description of the Study Area*

The study was conducted in 2018 main cropping season on Farmer Training Center (FTC) of Wuftadati Kebele in Dangila district, Awi Zone, Amhara National Regional State. The district is located at 85 km southwest of Bahir Dar, the capital city of the Amhara Region and 485 km northwest of Addis Ababa. While the experimental site is located 10 km northwest of Dangla town at 2156 m.a.s.l. altitude and on geographical location of 11º 14' N of latitude and 33º 45' E of longitude.

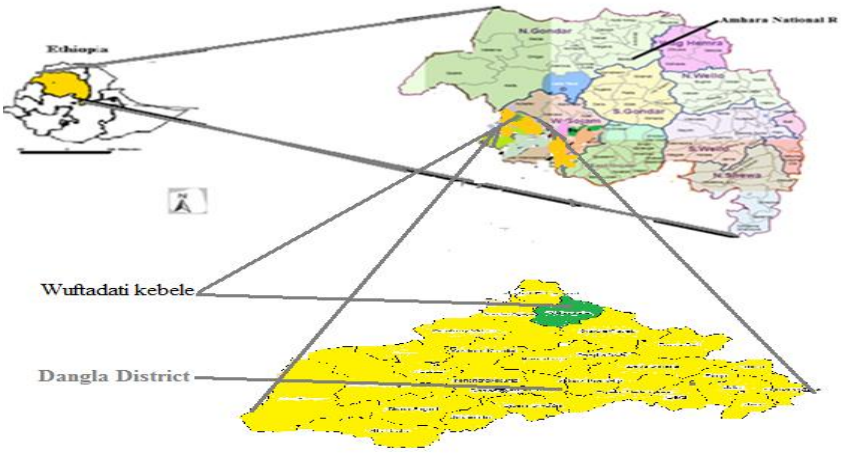

Fig. 1. Map of geographical location of the study area.

The topographic feature of the district is characterized by plain with altitudinal ranges between 1353 and 2454 m.a.s.l. Meanwhile, most of Dangla district is categorized under *Woina Dega* agro-ecological zone which has been received 700-1000 mm mean annual rainfall. The same source disclosed that its rainfall pattern is mono-modal which start from May to October, about 88 percent of the annual rainfall occurs in May to August months.

Its mean minimum and maximum temperatures are 15 ºC and 21 ºC, respectively. As per DDAO (2018) report indicated that most of the District (80%) is covered by Nitisols (red soil) while the remaining 20% by Vertisols. Soils of Dangla District is one of the most degraded soils in the region, and its soil is very low in soil organic matter content, macro and micro nutrients such as N, P, K, S, B and Zn.

2.2. *Experimental Materials Used for the Study*

Faba bean of *Welki* (EH96049-2) variety was used as a test crop. The variety was released in the year 2008 by Holleta Agricultural Research Centre (HARC). It can grow in 1900 to 2800 m.a.s.l. altitude area with ecological requirement of 700 to 1000 mm annual rainfall. Blended fertilizer with 17.8% N, 35.7% P_2O_5, 7.7% S, 2.2% Zn

and 0.1% B content was used as a source fertilizer while uniform rate of urea fertilizer was applied as a source of N. Rhizobium inoculants *leguminosarum bio varviceae* were collected from *Menagesha* Biotech Addis Ababa.

2.3. *Experimental Treatments, Design and Procedures*

Factorial combinations of five Blended fertilizer rates (0, 60, 121,180 and 240 kg ha^{-1}) and three Bio-fertilizer rates (0, 500 and 750 g ha^{-1}) 15 treatment combinations were laid out in a randomized complete block design (RCBD) and replicated three times (Table 1). The predetermined rate of Blended fertilizer and Bio fertilizer were applied during crop sowing. Uniform rate of urea (25 kg/ha) was applied as starter. The gross plot size was 2.4 m x 2.4 m (5.76 m^2) while net plot size was determined by excluding one outer row and 0.20 m length from both sides of each plot as border effects, thus the net plot size was 2 m x 2 m (4 m^2) area. The spaces between blocks and plots were 1 m and 0.5 m, respectively. The crop was planted in 6 rows on each plot with inter and intra row spacing of 40cm and 10cm, respectively and at 8 cm depth on July 28, 2018.

2.4. *Data to Collection*

Number of nodule per plant (NNP), Effectiveness of the nodules (EN), Nodulation rating (NR)*;* Plant height (P^H), Number of leaves per plant (NLP), Number of productive tillers (NPT), Number of pods per plant (NPP), Number of seeds per pod (NSP), Total biomass yield (TBY kg ha-1), Seed yield (SY), Hundred seed weight (HSW)*,* Straw yield (SY), Harvest index (HI %) has been collected.

2.5. *Data Analysis*

The data collected from the experiment at different growth stages were subjected to statistical analysis (ANOVA) as per the experimental design using SAS (Statistical Analysis Software) version 9.4. Whenever the ANOVA results showed significant differences between treatments, mean separation was carried out using the least significant difference (LSD) test. Interpretations were made following the procedure described by Gomez and Gomez (1984).

III. RESULTS AND DISCUSSION

3.1. *Number of Productive Tillers (NPT)*

The analysis of variance indicated that numbers of productive tillers was highly significantly ($P<0.01$) influenced by the main effects of fertilizer rates while Bio fertilizer rates and the interaction effect were non-significant.

The highest numbers of productive tillers (3) were observed at NPSZnB fertilizer applied plots T_9 with the combination of 180kg ha^{-1} NPSZnB and 500g ha^{-1} Rhizobium, T_{10} with the combination of 240kg ha^{-1} NPSZnB and 500g ha^{-1} Rhizobium and T_{14} with the combination of 180kg ha^{-1} NPSZnB and 750g ha^{-1} Rhizobium; while the lowest numbers of productive tillers (1) was recorded at plots that T_1 with 0g ha^{-1} NPSZnB and 0g ha^{-1} Rhizobium. Similarly, Meseret and Amin (2014) reported the highest number of productive tillers per plant (5.67) at 20 kg P2O5 ha-1. Likewise, Habtamu *et al.* (2017) reported the maximum number of productive tillers per plant (6.6) due to application of recommended rate of NP fertilizer (46 kg ha-1 of P_2O_5 and 41 kg ha^{-1} of N).

3.2. *Number of Pods Per Plant (NPP):*

Main effects of Rhizobium inoculation rate and NPSZnB rates were very highly significant (P<0.001) on numbers of pods per plant, while the interaction effect was non-significant (Appendix Table 2). Among the treatments, the highest number of pods per plant (15) was recorded from T_9 with the combination of 180kg ha^{-1} NPSZnB and 500g ha^{-1} of Rhizobium, T_{10} with the combination of 240g ha^{-1} NPSZnB and 500g ha^{-1} of Rhizobium and T_{15} with the interaction of 240g ha^{-1} NPSZnB and 750g ha^{-1} of Rhizobium while the lowest number of pods per plant was recorded from control plots. Also application of nitrogen increases panicles or heads in cereals and number of pods in legumes (Fageria *et al*., 2006). In line with this result, Zafal *et al.* (2003) reported that application of phosphorus increases nutrient which stimulated the plants to produce more pods per plant as phosphorus strongly encourages flowering and podding.

Similarly, Meseret and Amin (2014) obtained higher number of pods per plant (48) of common bean with application of phosphorus at rate of 20 kg P ha^{-1}. Amare *et al.* (2014) also reported that, application of phosphorus at 40 kg P_2O_5 ha^{-1} produced the maximum significant number of pods per plant (19). Pod number per plant was significantly higher in seed-inoculated plants (15) compared to uninoculated plants which might indicate the effectiveness of inoculant over native soil Rhizobium. This result was in agreement with the study by Cigdem and Kucuk (2011) who indicated that inoculation had given significantly higher number of pods per plant for Faba bean over the control (no fertilizer and no inoculant). Likewise, Yoseph (2011) explained that the increased supply of nitrogen through BNF and the direct supplementation of phosphorus that in turn play important roles in enhanced growth and assimilate accumulation, thereby improving the reproductive performance of the plants.

Table 1. Main effect of Bio fertilizer and Blended fertilizer rate on grain and yield related parameters of Faba bean in 2018 cropping season in Dangla District.

Treatments FT (kg ha-1)	NPT	NPP	NSP	HSW
0	1.3^{b}	9.0^{c}	2.4^{c}	59^{c}
60	2.0^{b}	10^{c}	3b^{c}	61^{bc}
121	2.0^{b}	12^{b}	3b^{c}	63^{ab}
180	3.0^{a}	13^{ab}	3.5^{b}	67^{a}
240	3.0^{a}	14^{a}	4.3^{a}	64^{ab}
SE ±	0.2	0.5	0.3	1.5
BF (g ha- 1)				
0	1.9^{b}	10.7^{c}	2.5^{b}	62^{a}
500	2.4^{a}	13.1^{a}	3.7^{a}	63^{a}
750	2.1^{ab}	11.9^{b}	3.6^{a}	63^{a}
CV (%)	11.8	11.4	21.9	7.1
SE +	0.1	0.4	0.2	1.2

FT = Fertilizer rate, BF = Bio fertilizer rate, NPT = Number of productive tiller, NPP = Number of pod per plant, DPS = Days to 50% pod setting and HSW = Hundred seed weight.

3.3. *Number of Seeds Per Pod (NSP)*

The analysis of variance indicated that numbers of seeds per pod was very highly significantly different at (P<0.001) influenced by the main effects of both Rhizobium rate and Blended fertilizer rates. Whereas it was significantly (P<0.05) affected by the interaction effect of Rhizobium rate and Blended fertilizer rates on Faba bean. In line with this result, Meseret and Amin (2014) also reported the highest number of seeds per pod (5.85) at applied P rate of 20g ha^{-1}. Similarly, Habtamu *et al*. (2017) reported relatively highest number of seeds per pod with the application of 46 kg ha^{-1} of P2O5 and 41 kg ha^{-1} of N. Lemma *et al*. (2008), Aleemulah *et al*. (2000) and Russo (2003) reported increase in the number of seeds per pod in response to fertilizer supply.

3.4. *Hundred Seed Weight (HSW)*

The main effect of NPSZnB rate was highly significant (P<0.01) while Rhizobium inoculation rate and the interaction effect was non-significant.

With respect to the effect of NPSZnB fertilizer rate, the highest 100 seed weight (70g) was at NPSZnB rate of 180 kg ha^{-1}. The possible reason for this might be that nitrogen improves grain or seed weights in crop plants and reduces grain sterility (Fageria *et al.*, 2006). In line with this result, Shamim and Naimat (1987) reported that the increment in 100 seed weight due to the influence of cell division, phosphorus content in the seeds as well as the formation of fat. Similarly, Amare *et al*. (2014) Faba bean reported that the increasing doses of phosphorus from the control to 40 kg P_2O_5 ha^{-1} resulted in significant increment in 100 seed weight.

In addition, Abdulkadir *et al.* (2014) reported that phosphorous fertilized crop when compared with the control produced more pods per plant which were better filled with heavier seeds and this translated to higher grain yield. Nebret (2012) reported that increasing Sulphur rate from 0 kg ha^{-1} to 20 kg ha^{-1} increased 100 seed weight from 35.7 g to 36.8 g. Ogutu *et al.* (2012) reported that increasing N rate from 0 kg ha^{-1} to 50 kg ha^{-1} increased 1000 seed weight from 301.19 g to 311.63 g. The increased yield under Sulphur application might be ascribed to increase pods/plant and grains pod along with heavier grains. Therefore, significant improvement in yield obtained under Sulphur fertilization seems to result from increased concentration of Sulphur in various parts of cluster bean that helped to maintain the critical balance of other essential nutrients in the plant, and resulted in increased metabolic processes in plants (Sharma and Singh, 2005).

3.5. *Total Biomass Yield (TBY kg ha^{-1})*

Analysis of variance showed that the main effect of Blended fertilizer rate was very highly significantly (P<0.001) affect above ground biomass yield. Whereas the main effect of Rhizobium rate and interaction effects were not significant.

Sulphur, being major nutrient, might have played an important physiological role by enhancing cell multiplication, elongation, expansion and chlorophyll biosynthesis which, in turn, increased the assimilate production (Dubey and Khan, 1993). Also nitrogen increases shoot dry matter, which is positively associated with grain yield in cereals and legumes (Fageria, 2008). In agreement with this result, Veeresh (2003) reported that the dry matter production of Faba bean increased significantly with the application of different levels of nitrogen and phosphorus fertilizers.

This is in agreed with Abayu (2012) found that high biomass yield is obtained from treatments that receive B-

-lended fertilizers compared with plots that receive DAP and urea and control plots in teff production. Similarly, Dagne (2016) reported that the highest (16867.7 kg ha^{-1}) average biomass of yield of maize was obtained with the application of blended fertilizer and also Agegnehu *et al.* (2014) reported that application of Blended fertilizer increases biomass yield than DAP and Urea because it contains many mineral elements together.

3.6. *Grain Yield (GY)*

The present research result showed that the main effects of Rhizobium inoculation rate, NPSZnB rate and the interaction effect of Rhizobium inoculation rate with NPSZnB rate were very highly significant ($P<0.001$) on grain yield of Faba bean. The highest grain yield (3325 kg ha^{-1}) was obtained from T_9 interaction effect of 500g ha^{-1}Rhizobium inoculation rate with NPSZnB rate of 180 kg ha^{-1} while the lowest grain (1304 kg ha^{-1}) was obtained from the combination of 0 kg-ha blended fertilizer and 750g ha^{-1} Rhizobium inoculation rates.

In line with this result, Fatima *et al.* (2007) reported that mixture of Rhizobium strains with phosphorus recorded higher seed yield of soybean over inoculant without phosphorus, and other researchers also reported that inoculation along with phosphorus fertilizer had a significant effect on nodulation, shoot dry matter and grain yield on Faba bean (Rifat, 2008). Abera and Buraka (2016) also reported the maximum seed yield (2160 kg ha^{-1}) of Faba bean from the application of the N rate (23 kg ha^{-1}). Amare *et al*. (2014) also reported the maximum seed yield (2326 kg ha^{-1}) of Faba bean with the application of P_2O_5 at rate of 20 kg ha^{-1}. Similarly, Gifole *et al*. (2011) reported that, the highest grain yield (2547 kg ha^{-1}) of Faba bean from the application of 40 kg P ha^{-1}. Zerihun Abebe (2014) also reported that application of 125kg ha^{-1} chemical fertilizer gave the highest economic yield (4157 kg ha^{-1}).

3.7. *Straw Yield (SY)*

Result of analysis of variance showed that straw yield was very highly significantly ($P<0.001$) influenced by the main effects of Blended fertilizer rates and not significant by the main effects of Rhizobium inoculation rate and the interaction effect of fertilizer and Bio fertilizer rates. The current result was in agreed with, Dagne (2016) the highest average straw yield was obtained with the application of Blended fertilizers. Similar to this result, Addai and Alimiyawo (2015) reported that the application of Blended fertilizers to the Sorghum variety called Dorado significantly increased stalk yield.

3.8. *Harvest Index (HI %)*

Analysis of variance showed that the main effect of Rhizobium inoculation rate was very highly significantly ($P<0.001$) affect harvest index of Faba bean. Whereas the interaction effects were significantly ($P<0.05$) influence harvest index of Faba bean. The increased harvest index of Faba bean with inoculation and application of NPSZnB fertilizer rate might be due to the fact that Rhizobium inoculation increased the number of effective nodules per plant and application of NPSZnB increased hundred seed weight of Faba bean. Similarly, Roy *et al.* (1995) reported that grain inoculation increased the nodules number per plant and gave the highest harvest index and hundred grains weight of chickpea.

IV. CONCLUSIONS AND RECOMMENDATIONS

Low soil fertility status and reduced biological nitrogen fixation are some of the major constraints limiting Faba bean yield in the study area. Ensuring a well-balanced supply of blended NPSZnB fertilizer and

Rhizobium inoculation rates to the crop may result in higher seed yield. Limited research has been done on the effect of blended NPSZnB fertilizer and Rhizobium inoculation rates on yield and yield components of Faba bean. Therefore, field experiment was conducted to evaluate the effect of blended NPSZnB fertilizer and Rhizobium inoculation rates on the yield and yield components of Faba bean and to identify economically appropriate combination of blended NPSZnB fertilizer and Rhizobium inoculation rates that provided maximum yield for the Faba bean production. Five levels of NPSZnB fertilizer rates (0, 60, 121, 180, and 240 kg ha^{-1}) and three levels of Rhizobium inoculation rates (0,500 and 750g ha^{-1}), were tested in factorial combination in three replications in Randomized Complete Block Design.

Based on the result of this study, application of different Blended fertilizer and Bio fertilizer rates had significant effects on yield and yield components of Faba bean. The results of the study showed that high-yield was obtained when Faba bean was sown from the fertilizer rate of 180kg ha^{-1} in combination with 750g ha^{-1} Bio fertilizer. As the fertilizer rates increased from 0 to 180kg ha^{-1} and as Bio fertilizer rates increased from 0 to 750g ha^{-1} number of productive tillers, plant height, number of nodule per plant, grain yield, total biomass yield and straw yield were increased. From the present study, it is possible to conclude that interaction effects of fertilizer rate 180kg ha^{-1} and 750g ha^{-1} Bio fertilizer performed better and gave higher grain yield (3278kgha^{-1}) and had highest grain yield advantage over the remaining Blended fertilizer (NPSZnB) and Bio fertilizer rates.

4.1. *Recommendations*

The present research finding showed that using of 180kg ha^{-1} Blended fertilizer rate and 750g ha^{-1} Bio fertilizer rate gave better grain yield (3278kg ha^{-1}) of Faba bean in the study area. In addition to this, based on partial budget analysis 180kg ha^{-1} Blended fertilizer (NPSZnB) rate combinations with 750g ha^{-1} Bio fertilizer can be recommended as first option and 180kg ha^{-1} Blended fertilizer (NPSZnB) rate combination with 500g ha^{-1} Bio fertilizer can be also recommended as 2nd option.

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