Original Research Article

Response of Nitrogen and Phosphorus ~~f~~Fertilizer on ~~yield,~~ ~~y~~Yield ~~c~~Component and ~~q~~Quality of ~~f~~Faba ~~b~~Bean (*Vicia faba* L.) ~~v~~Varieties at Arsi Zone, Oromia

Abstract

A field experiment was conducted at Arsi Zone, Oromia regional stat during the main cropping season (June-~~-~~De~~c~~ember) 2017/18, with the objective of evaluating the response of different fertilizer level on faba bean (Vicia faba L.*) ~~V~~varieties by identifying the most cost-~~-~~effective variety and fertilizer level. Three fertilizer levels (RNP, 150% RNP, and RNPS) and three faba bean varieties (Degaga, Gora, and Moti) were tested in a ~~R~~randomized complete block design, with ~~replicated~~ three replications~~times~~. The mean value of fertilizer levels showed that significant ~~t (P<0.05)~~ difference (p<0.05) was observed on plant height, number pods per plant and biomass yield, while number of seeds per pod, ~~B~~biomass yield and harvest index was not significantly affected (p>0.05) by fertilizer level. The use of 150% RNP fertilizer level resulted relatively higher ~~(154.1 cm)~~ plant height (154.1 cm), ~~N~~number of pods per plant (23.2) and ~~B~~biomass yield (14718 kg ha^{-1}). Higher ~~and significant (P<0.05)~~ number of seeds per plant (3.07), harvest index (52.55) and ~~(151.7 cm)~~ plant height (151.7 cm) was recorded for~~om~~ Degaga variety. There was interaction significant (p<0.01) between fertilizer levels and faba bean varieties on grain yield, with a production of 4230 kg ha^{-1} ~~effect of~~ under 150% RNP fertilizer level~~s~~ and Degaga variety~~ies had highly significant (P<0.01) effect on grain yield and produced (4230) kg ha^{-1} grain yield~~. The most benefits and cost effective outcome for farmers also obtained from this combination. There for a combination of 150% RNP fertilizer level with Degaga variety~~ies can be recommended at first option, while RNP and RNPS fertilizer level at a second and third option respectively for the production of faba bean in the study area and similar agro ecologies.*

Keywords: Fertilizer level; faba bean; varieties; grain yield.

1. INTRODUCTION

Faba bean (*Vicia faba* L.) is among the major grain legumes cultivated in Ethiopia and is used extensively as a break crop, human food and animal feed with high nutritive value and is an excellent nitrogen fixer in the highlands [1,2]. ~~(Sahile *et al*., 2008; Rubiales, 2010).~~ It is one of the major pulse crops occupying about 35% both in terms of area coverage and volume of annual production of all pulses produced in the country and grown predominantly with an altitude range of 1800 to 3000 meter above sea level (Gemechu et al., 2003).

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The citations must be placed in the item "**REFERENCES**" in the order that this numbering appears throughout the text.

Faba bean is the fourth most important pulse crops in the world (Talal, 2006). In Ethiopia among the pulse crops grown; the greatest area of land was allocated to faba bean (CSA, 2012). ~~It is also 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 primarily from June to September. ~~In Ethiopia among the pulse crops grown; the greatst area of land was allocated to faba bean (CSA, 2012).~~

Faba bean occupies about 28% of the total land area under pulse crops in the country (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, above ~~>~~2 t ha^{-1} (MoA, 2011; CSA, 2015). At the highlands of Arsi Woreda, faba bean productivity is much lower than the national average yield.

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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).

Faba bean is also a very important crop in the Arsi zone grown to break the monoculture wheat_based farming system that always suffers from attacks by new races of rust with significant yield reductions. In Ethiopia research work regarding use of P and its role in legume growth, nodulation, N2 fixation and grain yield and yield components is very limited. Inclusion of this crop in the crop rotation system with the application of optimum phosphorus fertilizer which is a limiting factor for the production of faba bean is crucial in the highlands like study area. Indeed, testing of the alternative technology for different varieties is very essential to assess its feasibility and ascertain the response of improved varieties to inputs of

production in the region. Therefore, the objective was to determine the response of faba bean varieties to different rates of phosphorus and nitrogen fertilizer rates on yield and yield components of faba bean varieties in Arsi Zone, Oromia Regional state.

2. MATERIAL AND METHODS

2.1. Experimental Sites

The experiment was ~~undertaken~~ carried out at Lemu-Bilbilo district of Oromia Regional State, South-eastern Ethiopia under two on-farm sites during the 2017/18 main cropping seasons (June-December). The experimental site were situated for faba bean production which, characterized by Dega agro ecologies. The experimental site are located from ~~0~~7°-30'~~'~~ 37" N and~~-~~ 39°-11'~~'~~ 31" ~~"~~E, and from 7°-37'~~'~~19" N and -39°-23'~~'~~ 40"~~"~~ E, and ~~from~~ at altitude of 2400~~-~~ and 2780 m.a.s.l., respectively. This wereda receives mean annual rainfall of 951.5 mm. The monthly mean minimum and maximum temperatures were 4.05 and 19.88°C, respectively. The dominant soil type of this wereda was luvisoil and slightly acidic (pH = 6). The dominated soil of the area is Nitosols.

2.2. Treatment and Experimental ~~d~~Design

The field experiments were~~as~~ ~~laid~~ carried out in completely randomized block design in a 3 × 3 factorial scheme~~factorial arrangement of randomized complete block design~~, consisting of three fertilizer levels, RNP (100 kg ~~/~~ha^{-1} urea + 150 kg ~~/~~ha^{-1} DAP) (73 N, 69 P2O5), 150% of RNP, and RNPS (100 kg ~~/~~ha^{-1}) (19 N 38 P2O5 + 7 S) and three faba bean varieties (~~Moti,~~ Degaga~~, and~~ Gora, and Moti), with ~~replicated~~ three replications~~times~~.

2.3.Experimental Procedure and Management

The experimental field was prepared following the conventional tillage practice before planting the faba bean seed seeds. In accordance with the specifications of the design, a field layout was prepared and each treatment was assigned randomly to experimental plots within each block~~s~~. The blocks were separated by a 1.5 m wide, whereas the plots within a block were 0.5 m apart from each other. Each plot consisted of 10 rows of 4 m in length and spaced 40 cm apart. The total and the net plot size were 10.4 m^2 (2.6 m × 4.0 m) and 6 m^2, respectively. Faba bean seeds were planted at the recommended rate of 137.5 kg ha^{-1} (KARC, 2018). The seeds were planted in rows by using a manual row marker on the beginning of July, 2018 G.C. All other recommended cultural practices were properly followed to produce

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a successful crop. The grain was harvested within the range of middle of November to early December 2018, depending on the maturity date of each variety.

2.4. Data Collected

Agronomic parameters collected included, seed yield per hectare, biological yield per hectare thousand seed weight, harvest index which is calculated by the ratio of seed yield to biological yield. To estimate seed yield of faba bean, plot sizes of 2 m ~~×~~x 3 m (6 m^2) were harvested from each plot in December. After threshing, the harvested materials, seeds were cleaned, weighed and adjusted to 10% moisture level. The total seed yields recorded on a plot basis were converted to kg ha^{-1} for statistical analysis.

2.5. Statistical Analysis

The crop data were subjected to analysis of variance using the General Linear Model Procedure of SAS computer software version 9.1 (SAS Institute, 2002). Data were not combined over the year due to heterogeneity. Whenever treatment effects were significant, the mean differences were separated using the least significant difference (LSD) test at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1. Faba ~~b~~Bean ~~a~~Agronomic ~~p~~Parameter and ~~y~~Yield ~~c~~Components

The major agronomic parameters such as plant height, number of pod per plant, number of seeds per pod, spike per 0.5 m, 1000 grain weight, grain yield, ~~B~~biomass yield and harvest index were measured for this study.

3.2. Plant ~~h~~Height ~~(cm)~~

The plant height of faba bean affected by application of ~~three levels of~~ fertilizer levels and varieties ~~wa~~is presented in ~~(~~Table 1~~)~~. The variance analysis result indicated that plant height of faba bean varieties was significant (~~P~~p<0.05) effect due to main factors of fertilizer levels and varieties. The longest (154.1 cm) plant height was recorded from fertilization of 150% RNP, followed by (142.8 cm) and (140.1 cm) plant height from RNPS~~s~~ and RNP fertilizer application respectively. Such increment of plant height along with increasing of nitrogen fertilizer rate might be directly related to the effect of nitrogen which promotes vegetative growth as other growth factors are in conjunction with it. These findings are similar to

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Wakene *et al.,* (2014) and Minale *et al.,* (2011), who reported that plant height of barley increased with increasing nitrogen fertilizer rates. Similarly, Melesse (2007) reported that as the nitrogen fertilizer rate increased from 0 to 69 kg ha^{-1}, the plant height of bread wheat was increased approximately 12%~~from 82.63 cm to 94.18 cm~~. The present research result also similar with the finding of Singha *et al.,* (2014) and Deshbhratar *et al*, (2010), who stated that the role of macro nutrient primarily nitrogen (N) and phosphorus (P) in chlorophyll formation, transformation of sugars and starches, nutrient movement within the plant ,which boost vegetative growth resulting increase in plant height of faba bean. The presence of plant height increment via ~~nitrogen (~~N~~)~~ and ~~phosphors (~~P~~)~~ levels was elaborated by Mam-Rasul, (2017).

Table 1. The effects of fertilizer rate and varieties on plant height, seed per pod, spike per 0.5 m and thousand kernel weights on faba bean averaged over site

Treatments	Plant height (cm)	Pod per plant	Seeds per pod
Fertilizer			
RNP	140.0b	17.7b	2.93
150% RNP	154.1a	23.2a	2.97
RNPS	142.8b	19.2b	2.96
LSD (5%)	9.87	2.2	ns
Varieties			
Degaga	151.7a	19.01	3.07a
Gora	140.4b	20.7	2.67b
Moti	144.6ab	20.5	2.83ab
LSD (5%)	10.15	ns	1.17
CV (%)	11.4	16.14	8.83

LSD = least significant difference; CV = coefficient of variation; ns = no significant; similar letters in columns indicate significantly different according LSD test at 5% level of significance.

The mean values in function of the faba bean varieties ~~that was~~are presented in ~~t~~Table 1, indicated that significant variation was observed among three varieties. The highest mean of ~~heist (151.7 cm)~~ plant height (151.7 cm) was recorded for~~om~~ Degaga variety, while the other~~remaining~~ two varieties (Gora and Mot~~t~~i) had statically similar mean values (140.4~~ cm~~ and 14~~4~~0.6 cm,~~)~~ respectively~~) (Table 1)~~. However, the plant height of Moti variety was statically similar to Degaga variety. This may be due to combined effect of genotypic and environmental effect, which was suited for the local cultivar to the detriment of~~than the two~~ others.

3.3. Number of ~~p~~Pods per ~~p~~Plant

A pod is a seed container that grows on plants such as peas or beans. The main difference in number of pods per plant recorded from a fertilization of 150% RNP fertilizer was significantly (~~P~~p<0.05) higher than the mean difference of the rest two fertilizer level (RNP and RNPS). The analysis of variance show that the main effect of fertilizer rate had significant (p<0.05) effect on number of pods per plant (Table 1). The highest number of pod per plant (23.2) was recorded at fertilization of 150% RNP, while the~~and~~ lowest values (17.7 and 19.2) were observed ~~pod per plant was recorded from~~ at ~~fertilization of 150%~~ RNP and RNPS fertilization, respectively. ~~The mean value of pod per plant that was gained from RNP and RNPS fertilizer level was statically similar with each other, but lower than the value that produced from 150% RNP.~~ Thus, increasing number of pods per plant was directly related with the role of NP fertilizer that increasing root growth of the crop plants by improving the water holding capacity, aeration of the soil, photosynthetic efficiency, partitioning of carbohydrate and supply of nutrient that is important for increments in number of pod per plant. The present research result is in line with the finding of Nikfarjam SG. *et al*., (2015) and Meseret T. *et al*., (2014), who reported~~elaborated~~ a increased in the~~that~~ number of pods per plant in faba bean ~~was increased~~ with ~~the level of phosphorus (~~P fertilization~~) level~~.

The number of pods per plant was not significantly influenced (p>0.05) as a function of the~~The main effects of~~ faba bean varieties ~~had not shown significant (P>0.05) effect on number of pods per plant~~ (Table 1). The number of pods per plant were between 19. 01 and ~~highest (~~20.7~~) for~~~~number of pod per plant was recorded from~~ Degaga and Gora varieties, respectively. ~~Gora variety, followed (20.5) and (19.01) pods per plant was recorded from Moti and Degaga varieties respectively.~~ The present research result was in contradiction with the finding of Tafere M. *et al*. (2012), who stated that Degaga variety had relatively higher number of pods per plant than Moti and Gebelcho faba bean varieties.

3.4.Number of ~~s~~Seeds per ~~p~~Pod

Analysis of result of this study showed that, the main effect of faba bean varieties had significant effect (~~P~~p<0.05) on number of seeds per pod (Table 1). On the other hand, differences among fertilizer level and the interaction between variety and fertilizers were not significant ~~table~~ (p>0.05~~1~~). The highest (3.07) and the lowest (2.67) number of seeds per pod was recorded for~~om~~ Degaga and Gora faba bean varieties, respectively. Statics showed that

mean value of Degaga and Moti varieties were not significant difference with each other~~, but not significant with Gora variety~~.

3.5. Grain ~~y~~Yield ~~kg ha^{-1}~~

The analysis of variance showed that the interaction effect of varieties and fertilizer levels had significant effect (~~P~~p<0.01) on grain yield (Fig. 1). The highest grain yield (4230 kg ha^{-1}) was obtained fo~~rom variety~~ Degage variety and fertilized with 150% RNP, followed by ~~(4002 kg ha^{-1}) grain yield was obtained from~~ Gora ~~faba bean~~ variety ~~interact with~~ and RNP fertilization, with grain yield of 4002 kg ha^{-1}. The lowest ~~(2158 kg ha^{-1})~~ grain yield (2158 kg ha^{-1}) was obtained from Gora variety interacts with RNPS (figure 1).Statics showed that the interactive effect of Gora variety with RNP fertilizer level was significantly (P< 0.05) different with grain yield that obtained from fertilization of 150% RNP with Degaga variety, but had not statically different with the value that obtained fertilization of Degaga variety with RNP. Grain yield increment through fertilizer level might be due to the fact that the experimental site had no sufficient amount of NP fertilizer that boosts plant growth at a maximum productive stage. The current research result was in agreement with the finding of Kubure. T. (2016) who stated that fertilization of faba bean consequently increase grain yield and biomass yield compared to that unfertilized treatments. Increasing in grain yield of faba bean as a function of increasing phosphorus application rates also sported by Fisseha and Yayis, (2015).

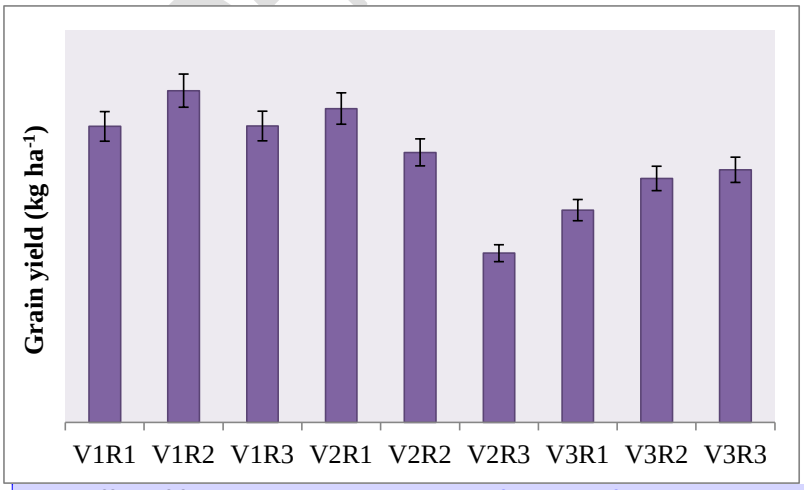

Fig. 1. Effect of fertilizer levels on grain yield of the three faba bean varieties~~averaged over site~~

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On the Y axis of the graph, place the numerical scale.

Describe in the legend the meaning of these X-axis abbreviations.

Delete the background and edges of the graphic.

These bars in the columns of the means is the standard deviation. Inform.

Put the average values in each column.

3.6. Biomass ~~y~~Yield ~~kg ha $^{-1}$~~

The analysis of variance shows that there was significant difference due to the main effect of fertilizer level, while the main effects of varieties and interaction of main effects was not significant. Highest (14718 kg ha^{-1}) biomass yield was obtained from 150%RNP, followed (12240 kg ha^{-1}) from fertilization of RNPS (Table 2).The statically result showed that the main effects of fertilizer level had significant effect (P<0.05) on biomass yield. Biomass yield was directly related with plant height (Personal observation). This is might be linked with increasing fertilizer levels leads rapid explanation of dark green leaf which could intercept and utilise more light energy in the production of food via the process of photosynthesis. The present research result is in line with the finding of Shroff. C., (2003) who stated that increased production of photosynthat had direct effect on increasing of plant height, number of tillers which might be responsible for higher seed and straw yield. Likewise Muhammad *et al.*, (2013) how elaborated that application of phosphorus (P) and Sulphur (S) resulted in increased biomass yield of chickpea. More over the effects of NPK fertilizer on yield and yield components of faba bean was discussed by Hana *et al*., (2016).

3.7. Harvest ~~i~~Index ~~%~~

Harvest index is very useful in measuring nutrient partitioning in crop plants, which provides an indication of how efficiently the plant utilized acquired nutrients for grain production. The analysis of variance shows that there was significant difference due to the main effect of faba bean varieties, while the main effect of fertilizer level and interaction of varieties with fertilizer level was not significantly affected harvest index. Highest (51.8 %) harvest index was recorded from RNPS fertilizer level and lowest (48.1%) harvest index was from RNP fertilizer level. The higher the harvest index value, the greater the physiological potential of the crop for converting dry matter to grain yield. Highly significant (P<0.0I) difference was observed among faba bean varieties on harvest index (Table 2). Degaga and Gora varieties produced higher harvest index than moti variety. The heist (52.5 %) harvest index obtained from Degaga variety was statically similar with the value of Gora (48.9 %), but significant different with the harvest index, which obtained from Moti variety (Table 2). Like with there was no observed statically difference mean between Gora and Moti faba bean variety. The present research result was in line with the finding of Ashenafi M. (2015) who elaborated that faba bean varieties show significant difference on harvest index. In contradict with the present research finding Kubure *et al*., (2016) and Khamooshi *et al*., (2012) who stated that

faba bean varieties had not significant difference on harvest index. Moreover different faba bean varieties had different harvest index was reported by (Abdella *et al*., 2015).

3.8.Thousand Kernel ~~w~~Weight ~~(gm)~~

Analysis of result of this study showed that, the main effect of faba bean varieties had significant effect (P<0.01) on number of thousand kernel weight. On the other hand, differences among fertilizer levels and the interaction between variety and fertilizers were not significant (Table 2).The highest (77.6 gm) thousand kernel weights was recorded from Gora variety ,followed (63.8 gm) and (45.2 gm) thousand kernel weight was obtained from Moti and Degaga varieties respectively. The current research result was in line with the result of Bakry *et al.,* (2011) stated that there were significant variations among food barley varieties on thousand kernel weight. In addition to that the direct effect of varieties on thousand kernel weight was seen from bread wheat research finding of Abebe M. *et al*., (2020).

Comment [U13]: See suggestions in the topics above and change here as well.

Table 2. The effects of fertilizers levels and varieties on plant biomass, harvest index and thousand kernel weights averaged over sites.

Comment [U14]: See suggested changes in Table 1 and do here as well.

Treatments	By kg ha^{-1}	HI%	TKW (gm)
Fertilizer			
RNP	10954b	48.15	62.2
150%RNP	14718a	48.56	62.2
RNPS	12240ab	51.8	61.3
LSD (5%)	2902	Ns	Ns
Varieties			
Degaga	11954	52.5a	45.2c
Gora	11931	48.9ab	77.6a
Moti	12027	47.1b	63.8b
LSD (5%)	Ns	4.6	10.9
CV (%)	34	14	2.62

4. ~~Summary and~~ CONCLUSION

Now a day the major challenges of agricultural crop production in highlands of Ethiopia are Leeching of macro and micro nutrients, soil acidity, lack of improved varieties, in appropriate use of inorganic fertilizers are the dominant one. Regarding different fertilizer levels and varieties, there was no research output in consideration with the current environmental change rather than using the previous research recommendation, which is not, goes with time, so to overcome this gap conducting research activity in regarding to faba bean response in different fertilizer levels might be a feasible option for improving faba bean varieties.

Field experiment was conducted during the main cropping season (June-December) of 2017/18 at two different farmer's site of Lemu-bilbilo wereda with the objective of evaluating the optimal fertilizer rate for higher yielding of three faba bean varieties. Data on growth, yield and quality parameters of faba bean varieties were collected and analysed. Significant difference in most of agronomic parameter and grain yield was observed due to effect varieties and fertilizer level. The mean value of plant height, biomass yield and number of seeds per pod was significantly affected by main effects of varieties and fertilizer level, while thousand kernel weight and harvest index was significantly affected by varieties.

The interaction effect of fertilizer level and faba bean varieties had highly significant effect on grain yield. The present research result indicated that application of 150% fertilizer level interact with Degage variety produced remarkable beneficial with most promising yield and agronomic performance. Next to this the mean value of RNP fertilizer level interact with Gora variety produced remarkable and most economic efficient grain yield in the study area and similar agro-ecologies.

Comment [U15]: This is no conclusion. Could take this text to the item " RESULTS AND DISCUSSION". Their conclusions should be based on the treatments applied and on the responses of the variables evaluated.

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Comment [U16]: Consult the item "**REFERENCES**" in articles published in the last issue of this Journal.

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