Research Article

Response of Nitrogen and Phosphorus Fertilizer on Yield, Yield component and Quality of Faba Bean (*Vicia faba* L.) Varieties at Arsi Zone, Oromia

Abstract

A field experiment was conducted at Arsi Zone, Oromia regional stat during the main cropping season (June- December) 2017/18, with the objective of evaluating the response of different fertilizer level on faba bean (Vicia faba L.) 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 randomized complete block design with three replicated. The mean value of fertilizer levels showed that significant difference ($P<0.05$) was observed on plant height, number pods per plant and biomass yield, while number of seeds per pod, 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 plant height (154.1 cm), number of pods per plant (23.2) and biomass yield (14718 kg ha^{-1}). Higher number of seeds per plant (3.07), harvest index (52.55) and plant height (151.7cm) was recorded for Degaga variety. There was interaction ($p<0.01$) between fertilizer level and faba bean varieties on grain yield with a production of 4230 kg ha^{-1} under 150% RNP fertilizer levels and Degaga variety. 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 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.

Key words: *Fertilizer level, faba bean, varieties and 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). 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 (3).Faba bean is the fourth most important pulse crops in the world (4). In Ethiopia among the pulse crops grown: the greatest area of land was allocated to faba bean (5). It is an annual crop grown by subsistence farmers, during the cool main rainy season primarily from June to September.

Faba bean occupies about 28% of the total land area under pulse crops in the country (6).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}) (7,6). At the highlands of Arsi Woreda, faba bean productivity is much lower than the national average yield.

This could be attributed to low soil fertility, as it is cultivated in soils that are intrinsically poor, with the belief that it performs better than cereal crops. Chemical fertilisers are rarely employed in the cultivation of faba bean and other pulse crops in Ethiopia's low-input agriculture systems; instead, these crops are used as a restorer of soil fertility after cereal harvests (8). The majority of Ethiopia's highlands are lacking in the vital minerals N and P. In addition to N and P shortages, soil inventory data from EthioSIS (Ethiopian Soil Information System) recently revealed that inadequacies of nutrients like K, S, B, and Zn are common in Ethiopian soils. Nitrogen is a nutrient that plants require in greater quantities than other elements. It's found in a variety of biological substances that play a key role in photosynthetic activity, as well as enzymes. As a result, a number of researchers have advocated for the use of commercial fertilisers to remedy nitrogen shortage and boost crop output (9).

In the Arsi zone, the faba bean is an essential crop produced to break up the monoculture wheat-based farming system, which is constantly attacked by new races of rust, resulting in severe output declines. In Ethiopia, there is very little research on the usage of P and its effect in legume growth, nodulation, N2 fixation, grain yield, and yield components. In the highlands, such as the research area, including this crop in the crop rotation system with the administration of optimal phosphorus fertiliser, which is a limiting factor for faba bean production, is critical. Indeed, evaluating the feasibility of alternative technology for various varieties and determining the reaction of enhanced varieties to regional production inputs is critical. 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.

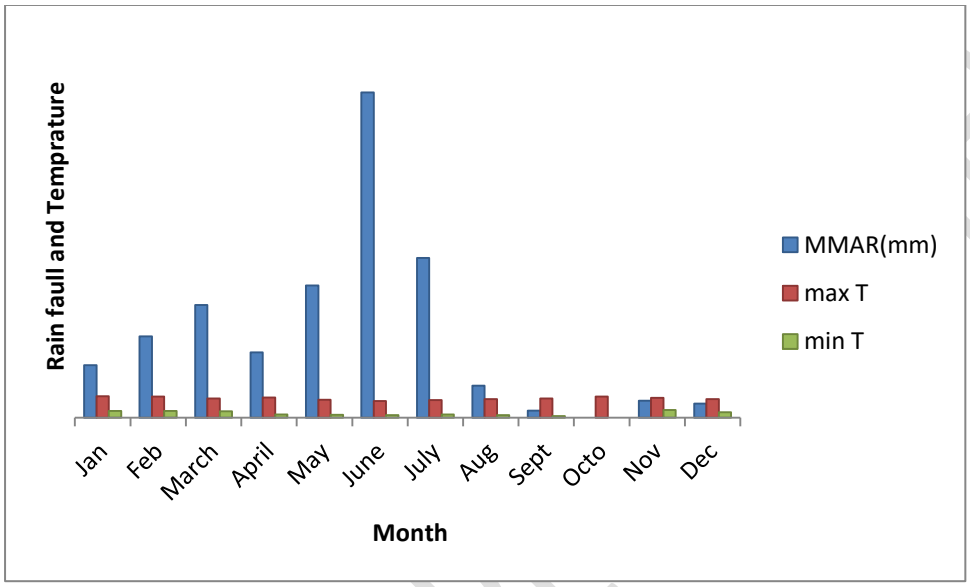
2. Material and Methods

2.1. Experimental Sites

The experiment was undertaken 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 07° 30‟ 37” N -

39° 11‟ 31‟‟‟E and from 7° 37‟ 19” N -39° 23‟ 40‟‟‟E and from 2400- 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.

Figure 1. Monthly Total, Mean rain full, maximum and minimum T^0 and Rainfall for Growing Period of faba bean in the study area.



Source: Row Data of the KARC's Climate and Geospatial Research Process (2018).

2.2. Treatment and Experimental Design

The field experiments were carried out in completely randemized block design in a 3*3 factorial scheme, consisting of three fertilizer levels, [R1=RNP (100 kg- ha^{-1} urea + 150 kg- ha^{-1} DAP) (73N, 69 P2O5), R2= 150% of RNP and R3= RNPS (100 kg- ha^{-1}) (19 N 38 P2O5 + 7.S) and three faba bean varieties (V1=Degaga, V2= Gora, andV3= Moti), with three replications.

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. 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 $m2$ (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} (10). The seeds were planted in rows by using a manual row marker on the beginning of July, 2018 cropping season. To produce a successful harvest, all other recommended cultural activities were adhered to. Depending on the maturity date of each variety, the grain was harvested from the middle of November until the beginning of December 2018.

2.4. Data Collected

Seed yield per hectare, biological yield per hectare thousand seed weight, and harvest index, which is derived by the ratio of seed yield to biological yield, were among the agronomic characteristics gathered. In December, plot sizes of 2m × 3m (6 m2) were taken from each plot to determine faba bean seed yield. The harvested materials were cleaned, weighed, and adjusted to a moisture level of 10% after threshing. For statistical purposes, total seed yields on a plot basis were converted to kg ha-1. **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 (10). Due to the variability of the data, it was not combined over the course of the year. The mean differences were separated using the least significant difference (LSD) test at a 5% level of significance if treatment effects were significant.

3. Result and Discussion

3.1. Faba bean agronomic parameter and yield 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, Biomass yield and harvest index were measured for this study.

3.2. Plant Height

The plant height of faba bean affected by application of fertilizer levels and varieties is presented in (Table 1).The variance analysis result indicated that plant height of fababean varieties was significant ($p<0.05$) 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 and RNP fertilizer application respectively. The action of nitrogen, which increases vegetative development when other growth elements are in conjunction with it, may be directly tied to such an increase in plant height along with an increase in nitrogen fertiliser rate. These findings are comparable to those of (11) and (12), who found that increasing nitrogen fertiliser rates improved barley plant height. Similarly, (13) found that increasing the nitrogen fertiliser rate from 0 to 69 kg ha-1 enhanced the plant height of bread wheat by almost 12%. The present research result also similar with the finding of (14) and (15) 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 (N) and (P) levels was elaborated by (16).

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

The mean values in function of the faba bean varieties presented in Table 1, indicated that significant variation was observed among three varieties. The highest mean of plant height (151.7 cm) was recorded for Degaga variety, while the other two varieties (Gora and Moti) had statically similar mean values (140.4 cm and 144.6 cm) respectively. However, the plant height of Moti variety was statically similar with to Degaga variety. This may be due to combined effect of genotypic and environmental effect, which was suited for the local to the detriment of others.

3.3. Number of Pods per 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 ($p<0.05$) 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 pods per plant (23.2) was recorded at fertilization of 150%RNP, while the lowest values (17.7) and (19.2) were observed RNP and RNPS fertilization respectively. 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 (17) and (18) who reported an increased in the number of pods per plant in faba bean with (P) fertilization.

The number of pods per plant The number of pods per plant were between (19.01) and (20.7) Degaga and Gora varieties respectively. was not significantly influenced ($p>0.05$) as a function of the faba bean varieties (Table 1). The present research result was in contradiction with the finding of (19), who stated that Degaga variety had relatively higher number of pods per plant than Moti and Gebelcho faba bean varieties.

3.4. Number of Seeds per Pod

Analysis of result of this study showed that, the main effect of faba bean varieties had significant effect ($p<0.05$) 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 ($p>0.05$).The highest (3.07) and the lowest (2.67) number of seeds per pod was recorded for Degaga and Gora faba bean varieties respectively. Statics showed that mean value of Degaga and Moti varieties were not significant difference with each other.

3.5. Grain Yield

The analysis of variance showed that the interaction effect of varieties and fertilizer levels had significant effect ($p<0.01$) on grain yield (Fig. 1). The highest grain yield (4230 kg ha^{-1}) was obtained for Degage variety and fertilized with 150% RNP followed by, Gora variety and RNP fertilization, with grain yield of (4002 kg ha^{-1}). The lowest grain yield (2158 kg ha^{-}

[1]) was obtained from Gora variety interacts with RNPS (Fig.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 (20) 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 (21).

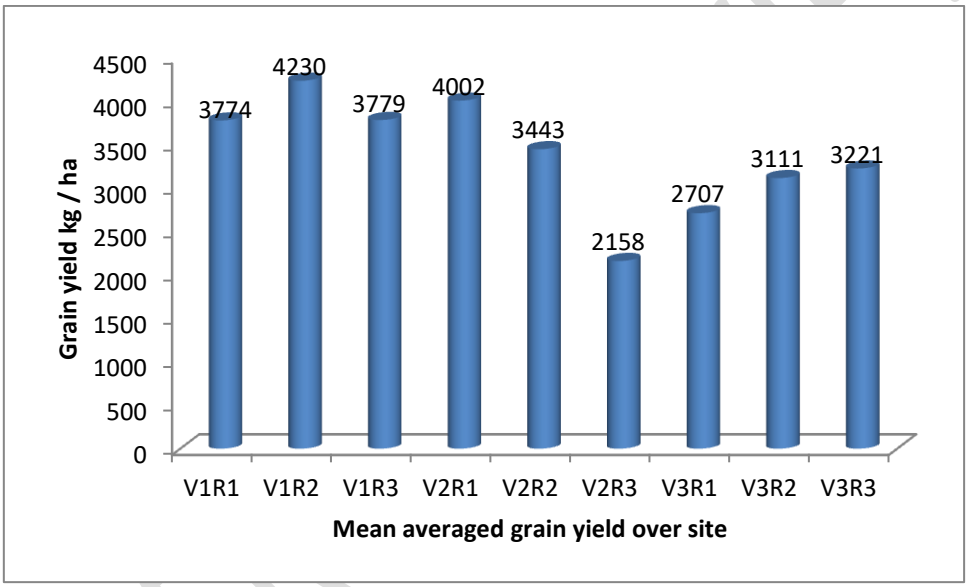


Figure 2.Effect of fertilizer levels on grain yield of the three faba bean varieties

3.6. Biomass Yield

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 (22) who stated that increased production

of photosynthetic had direct effect on increasing of plant height, number of tillers which might be responsible for higher seed and straw yield. Likewise (23) 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 (24).

3.7. Harvest 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 (25) who elaborated that faba bean varieties show significant difference on harvest index. In contradict with the present research finding (20) and (26) 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 (27).

3.8. Thousand Kernel Weight

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 (28) 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 (29).

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

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. 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.

5. Reference

27. Abdalla AA, El Naim AM, Ahmed MF, Taha MB. Biological yield and harvest index of faba bean (Vicia faba L.) as affected by different agro-ecological environments. World Journal of Agricultural Research. 2015;3(2):78-82.

29. Abebe Megers, et. al. (2020). Effect of Plant Population on Growth, Yields and Quality of Bread Wheat (Triticum Aestivum L.) Varieties at Kulumsa in Arsi Zone, South-Eastern Ethiopia. International Journal of Research Studies in Agricultural Sciences (IJRSAS), 6 (2), pp. 32-53.

25. Ashenafi Mitiku, and Mekuria Wolde. Effect of Faba Bean (Vicia faba L.) Varieties on yield attributes at Sinana and Agarfa Districts of Bale Zone, Southeastern Ethiopia. Jordan Journal of Biological Sciences. 2015;8(4):281-286.

28. Bakry, B. A., Elewa, T. A., El Karamany, M. F., Zeidan, M. S., & Tawfik, M. M. (2011). Effect of row spacing on yield and its components of some faba bean varieties under newly reclaimed sandy soil condition.

15. Deshbhratar P.B., Singh P.K., Jambhulkar A.P. and Ramteke D.S. 2010. Effect of sulfur and phosphorus on yield, quality and nutrient status of pigeonpea. (Cajanus cajan). Jr. of Env. Biol., 31(6): 933-937.

21. Fisseha Negash and Yayis Rezene. 2015. Nitrogen and Phosphorus Fertilizers Rate as Affecting Common Bean Production at Areka, Ethiopia. Journal of Agriculture and Crops, 1(3):33-37

24. Hanan S.S., Samia H.A., Mona G.A., and Awatef A.M. 2016. Partial Replacement of Integrated Mineral Fertilizer through Biofertilization to Maximize Economic Yield of Faba Bean under Saline Soil Conditions. Intentional Journal of Chem.Tech. Research. 9(6):153-164.

26. Khamooshi, H., Mohammadian, N., Saamdaliri, M., & Foroughi, Z. (2012). Study on effect of plant density and nitrogen on yield and yield components of Faba bean (Vicia faba L.). Journal of Ornamental and Horticultural Plants, 2, 161–167.

20. Kubure, T. E., Raghavaiah, C. V., & Hamza, I. (2016). Production potential of faba bean (Vicia faba L.) genotypes in relation to plant densities and phosphorus nutrition on vertisols of central highlands of West Showa Zone, Ethiopia, east Africa. Advances in Crop Science and Technology, 1-9.3.

16. Mam-Rasul G.A. 2017. Effect of Different Levels of Nitrogen and Phosphorus on Yield and Yield Components of Faba Bean (Vicia faba L.) in Calcareous Soil from Kurdistan Region of Iraq Journal of Agricultural Research, 2(1): 120.

13. Melesse Harfe. 2007. Response of bread wheat (Triticum aestivum L.) varieties to N and P fertilizer rates in Ofla district, Southern Tigray, Ethiopia. African Journal of Agricultural Research, 12(19): 1646-1660

18. Meseret Turuko, Amin Mohammed. Effect of different phosphorus fertilizer rates on growth, dry matter yield and yield components of common bean (Phaseolus vulgaris L.). World Journal of Agricultural Research. 2014;2(3):88-92.

12. Minale Liben, Alemayehu Assefa. & Tilahun Tadesse. 2011. Grain yield and malting quality of barley in relation to nitrogen application at mid and high altitude in Northwest Ethiopia. Journal of Science and Development, 1(1): 75-88.

23. Muhammad I., Muhammad A. and Aslam K. 2013. Effect of phosphorus and sulfur application on soil nutrient balance under chickpea (cicer arietinum) mono-cropping. Romanian Agricultural research, no. 30: 225-232.

17. Nikfarjam SG, Aminpanah H. Effects of phosphorus fertilization and Pseudomonas fluorescents strain on the growth and yield of faba bean (Vicia faba L.). 2015;33(4): 15-21.

10. SAS. 2002. Software Syntax, Version 9.1, SAS Institute, Cary, NC, USA.

22. Shroff C.J. 2003. Influence of nitrogen and weed management practices on growth and seed yield of coriander under Middle Gujarat condition. M.Sc. (Agri.culture) Thesis.

14. Singh D.P., Das A.K. and Pradhan A.P. 2014. Yield and yield attributing parameters of organically cultivated mungbean as influenced by PGPR and organic manures. Journal of Crop and Weed, 10(1):172-174.

19. Tafere Mulalem, Tadesse Desalegn, Yigzaw Desalegn. Participatory varietal selection of faba bean (Vicia faba L.) for yield and yield components in Dabat district, Ethiopia. Wudpecker Journal of Agricultural Research. 2012; 1:270-274.

11. Wakene Tigre, Walelign Worku & Wassie Haile. 2014. Effects of nitrogen and phosphorus fertilizer levels on growth and development of barley (Hordeum vulgare L.) at Bore district, Southern Oromia, Ethiopia. 2(5): 260-266.