Journal homepage www.jzs.univsul.edu.iq
Journal of Zankoy Sulaimani
Part-A- (Pure and Applied Sciences)

Effect of level combinations of nitrogen and phosphorus fertilizers on growth and yield of faba bean (*Vicia faba* L.) in a calcareous soil from Sulaimani province

Ghafoor Ahmed Mam Rasul[1]

1 Department of Soil and Water Sciences, College of Agricultural Sciences-Sulaimani University, Kurdistan Region-Iraq
Email: : ghafwr.mamrasul@univsul.edu.iq

Article info

Original: 16 November 2017
Revised: 10 january 2018
Accepted: 22 February 2018
Published online: 20 March 2018

Key Words:
Faba bean, Nitrogen, and Phosphorus fertilizers

Abstract

A field experiment was carried out in the Research Farm of the College of Agricultural Sciences, University of Sulaimani, Kurdistan Region of Iraq, during the winter season of 2014 to evaluate the effect of levels combinations of nitrogen and phosphorus fertilization on growth and yield of faba bean(*Vicia faba* L.). The experiment was arranged in arandomized completeblock design (RCBD) with three replicates. The results indicate that the nitrogen and phosphorus fertilizers had no significant effect on most studied growth characteristics of faba bean except for the plant height. The greatest plant height was observed from the application of 78 kg N $ha^{-1}$and 200 kg P_2O_5 ha^{-1}(T_3) fertilizers. Chlorophyll content index (CCI) was not affected by the nitrogen and phosphorus fertilizer application. The highest chlorophyll content index was found under the application of 98 kg N ha^{-1} and 250 kg P_2O_5 ha^{-1} (T_4) to the soil. Statistical analysis revealed that nitrogen and phosphorus fertilizers had no significant effect on the value of harvest index, the highest value of harvest index 43.93% was shown from the application of 98 kg N ha^{-1} and 250 kg P_2O_5 ha^{-1} (T_4). Phosphorus application had no significant effect on phosphorus use efficiency (PUE). The lower phosphorus use efficiency (PUE) was observed at highest P rates application, the maximum PUE (86.40) was observed from the combination of 58 kg N ha^{-1} with 150 P_2O_2 kg ha^{-1} (T_2), and it decreased at higher P rate application to (61.22).

Introduction

Faba bean (*Vicia faba* L.) is one of the major winter-sown legume crops grown in the world and has considerable importance as low-cost food rich in proteins and carbohydrates [1]. Faba bean has four main functions in agro-ecosystems: (1) providing food and feed that is rich in protein; (2) supplying N to agro-ecosystems by symbiotic N_2 fixation with *Rhizobium*bacteria to increase soil fertility; (3) diversifying the crop system to reduce constraints on growth and yield by the other crops in the rotation; and (4) reducing fossil energy consumption for crop production [2]. Nitrogen is a plant nutrient required in comparatively larger amounts than other elements for plant growth. Nitrogen is an essential component of many compounds of the plant, such as chlorophyll, nucleotides, proteins, alkaloids, enzymes, hormones and vitamins [3]. Nitrogen supply must be in sufficient amount to plant for an optimal yield. Nitrogen deficiency results in stunted growth, chlorotic leaves because the lack of N limits the synthesis of proteins and chlorophyll [4]. Phosphorus is one of the most important elements that are significantly affecting plant growth and metabolism. It is, along with N, a major yield-limiting nutrient in many regions of the world, legumes require high amounts of P due to the involvement of P in energy transfer rate that must take place in the nodule [5]. Richards *et al.*[6] pointed out that the increase in solubility of phosphorus in soil solution

causes an increase in iron uptake by the plant which contributes to increasing nitrogen fixation by legumes then increases in protein content and seed quality.

In spite of the considerable addition of phosphorus to the soil, the available amount of phosphorus for plants is usually low because its availability to plants is limited by different chemical reactions especially in arid and semi-arid soils [7]. Phosphorus plays a significant role in several physiological and biochemical plant activities like photosynthesis, the transformation of sugar to starch and transporting of the genetic traits [8].Phosphorus has positive effects on nodule formation and nitrogen fixation in legume crops and plays a vital role in the structure of the nucleus and cell membrane [1; 9].

Kole and Hajra [10] reported that no significant differences between Ca superphosphate and rock phosphate were detected on growth and yield of a broad bean plant. Rakha and El-Said [11] found that the application of phosphorus fertilizers in two forms had a non-significant effect on the most plant growth characters of broad bean, this maybe due to the low water solubility of Ca superphosphate and rock phosphate [12].

Some chemical properties of calcareous soil effects on the availability of phosphorus for plants, a number of researchers in the field of soil chemistry and fertility indicated that the chemical factors (soil $CaCO_3$ content, soil pH, soil organic matter content, type of clay minerals) play an important role in the availability of phosphorus for plants [6;13;14;15].The soils of Kurdistan region-Iraq were classified as calcareous soil, depending on the high $CaCO_3$ content, which has the slightly alkaline soil reaction(pH), this may cause decreases in the availability of phosphorus for plants due to chemical and physical fixation of (70-90%) of applied phosphorus fertilizers [16]. Amsalu *et al*.[17] found that variations in grain and biomass yield of faba beans were largely due to the difference in PUE. Hence, the aims of this investigation were to evaluate the effect of different levels of nitrogen and phosphorus fertilizers on some growth characteristics of faba bean (*Vicia faba* L.) and phosphorus use efficiency in calcareous soil.

Materials and Methods

Experimental Design

This study was conducted at the College of Agricultural Sciences Research Farm, University of Sulaimani, Bakrajo, Kurdistan Region of Iraq. (45°32' 5" E and 35°32" 05" N 737m. a.s.l.) During the winter season of 2014, the soil was uniform and calcareous ($CaCO_3$> 5) in nature. Nitrogen and phosphorus application to the soil was from Diammonium Phosphate (DAP) fertilizer which has the fertilizer formula (18:46), or DAP fertilizer contain 18% N and 46% P_2O_5. The treatments including T_1 = 0 N:0 P_2O_5, T_2 =58 N:150 P_2O_2, T_3 = 78 N:200 P_2O_5 and T_4= 98 N:250 P_2O_5 kg ha^{-1}were applied to the soil at the time of sowing. The field experiment was arranged in a randomized complete block design(RCBD) with three replicates;the plot dimensions were 2 m by 3 m covering an area of 6 m^2, and the distance between the experiment units was one meter while the distance between blocks was two meters. Each plot was contained eight row and spacing 25 cm between the plants. The seed of regional faba bean was planted at a depth of 5 cm during the winter season on 23rd December 2014. The potassium fertilizer was applied at the rate of 150kg K_2O ha^{-1} as potassium sulfate to each experimental unit. The potassium fertilizer was applied at the time of sowing for all treatments. Weeds were controlled manually. The crop was harvested at maturity on 29th April 2015.

Sample Collection and Physicochemical analysis

Soil samples were taken from (0 -30 cm) of the soil used in the field experiment and were prepared for some physical and chemical analysis. Soil particle size distribution was determined by the pipette method according to Gee and Bauder [18]. The soil reaction (pH) and Electrical conductivity (EC_e) were measured for the soil saturation extract with a pH meter (HANA), model (HI 83141), and EC meter, model (HI 2314) respectively. Some cations and anions in the soil saturation extract were determined according to the soil analysis methods described by Page *et al.* [19]. Organic matter (O.M.) content was determined by the method described by Nelson and Sommer [20]. Cation exchange capacity (CEC) of the soil particles was obtained by saturating the soil sample with 1*M* ammonium acetate (NH_4OAc) at pH 8.1 as an extraction

solution according to the method described by Suarez [21]. Total calcium carbonate ($CaCO_3$) in the soil, was determined by a rapid titration method according to Rayment and Higginson [22].The active lime or active equivalent $CaCO_3$ (AECC), which is a fine particle size calcite, was estimated by the 0.5 *M* NH_4-oxalate method as described by Drouimeau[23]. The available phosphorus concentration as determined by extracting the samples with 0.5 *M* $NaHCO_3$[24].Total N in soil sample was determined by the Kjeldahl method.Some physicochemical properties of the soil of the experimental field and meteorological data of the experimental field location during the study period are shown in Table 1 and 2 respectively.

After harvesting, the plant samples were dried at 70°C; the dried samples were ground and after grinding the samples were mixed thoroughly and stored for analysis.

Wet digestion was used for destruction of organic matter, acids that have been used in these procedures include sulfuric (H_2SO_4), and Hydrogen peroxide (H_2O_2) was used to enhance reaction speed and to complete the digestion.

Table-1: Some physical and chemical properties of the soil of the experimental field at Bakrajo site

Physical properties of the studied soil							
Particle Size Distribution (PSD) g kg^{-1}							
Sand		*Silt*		*Clay*		*Texture Class*	
75.40		*518.40*		*406.20*		*Silty Clay*	
Chemical properties of the studied soil							
pH	*EC$_e$*	*O.M.*	*CEC*	*Available P*	*Total nitrogen*	*CaCO$_3$ equivalent g kg^{-1}*	
	dS m^{-1}	*g kg^{-1}*	*cmol$_c$ kg^{-1}*	*mg L^{-1}*	*g kg^{-1}*	*Total*	*active*
7.52	*0.40*	*19.00*	*47.00*	*6.55*	*1.18*	*327.00*	*117.00*
Soluble ions mmol L^{-1}							
T68Ca^{2+}	*Mg^{2+}*	*Na$^+$*	*K$^+$*	*HCO$_3^-$*	*Cl$^-$*	*SO$_4^{2-}$*	
2.20	*0.58*	*0.49*	*0.09*	*2.34*	*0.40*	*0.88*	

Table-2: Meteorological data of the experimental field location during the study period.

Months (2014-2015)		Dec. (2014)	Jan. (2015)	Feb. (2015)	Mar. (2015)	Apr. (2015)
Precipitation (mm)		128.60	100.00	65.00	98.4	25.80
Temperature °C	Mini.	2.20	-3.20	0.20	3.20	5.00
	Max.	17.90	16.60	19.80	22.00	32.20

Measured Parameters

The measured parameters comprise most of the yield components of faba bean such as plant height (cm), seed yield (ton ha^{-1}), biological yield (ton ha^{-1}), the number pods per plant, the number of seeds per pod, and 1000 seed weight(g).

Harvest Index (HI%)

Harvest index (HI)(%) was calculated by using following formula:

$$\text{Harvest index (\%)} = \frac{\text{Grain Yield}}{\text{Biological Yield}} \text{ x } 100 \quad (1)$$

Phosphorus Use Efficiency (PUE)

The efficiency of phosphorus was calculated according to the equation described by Doberman [25].

$$Phosphorus\ Use\ Efficiency\ (PUE) = \frac{faba\ bean\ grain\ yield(kg\ ha^{-1})}{Fertilizer\ applied\ (kgP_2O_5ha^{-1})} (2)$$

Chlorophyll content index(CCI)

At flowering stage, three plants in three different rows were randomly selected, and chlorophyll content index (CCI) of upper, middle and lower leaves was measured by a chlorophyll meter (CCM-200, Opti-Science, USA). Also, to determine the biological yield, three plants were randomly selected in the three different rows, then the mean of plant weight was multiplied by the number of plants at each plot.

Statistical Analysis of data

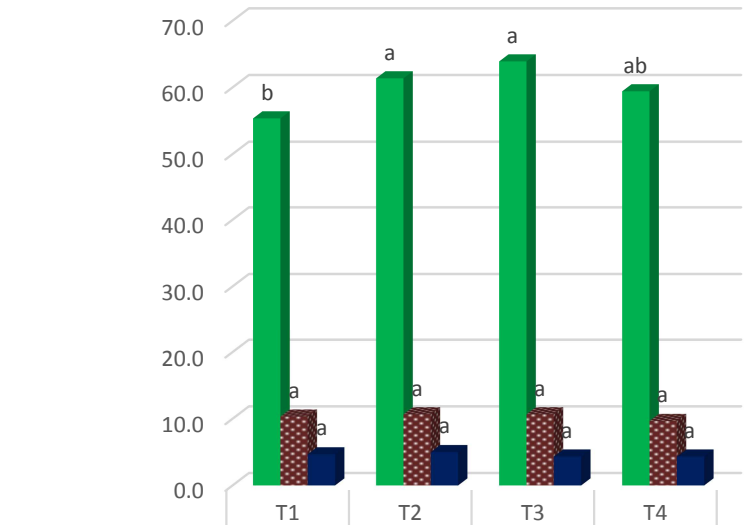
All obtained data were analyzed by using XLSTAT version 7.5. The Duncan's multiple range tests were used to compare the means at 5% of significant [26].

Results and Discussion

The results of variance analysis and mean comparison indicated that the number of pods per plant and number of seeds per pod (Figure:1), biological yield (kg ha^{-1}), seed yield (kg ha^{-1}) 1000 seed weight (g) (Figure:2) were not influenced by the application rates combination of nitrogen and phosphorus to the soil and the results were not significant at 0.05 level of probability, these may be due to the high $CaCO_3$ content of the studied soil, which leads to precipitate phosphorus as calcium phosphate $Ca_3(PO_4)_2$(Table 1).These results are in disagreement with those obtained by Yirga *et al*. and Esmail and Miran [27] and [28]. Who found that the application of phosphorus fertilization had a significant influence on yield and yield components of faba bean. While the results are matching with the results of Salem and Ei-Nakakhlawy [29], who found that the application of 80 kg ha^{-1} P_2O_5 to the soil did not affect yield component of faba bean. Similar results were reported by Rakha and El-Said [11], who found the two forms of phosphorus fertilizers application had a non-significant effect on the most plant growth characters of faba bean.

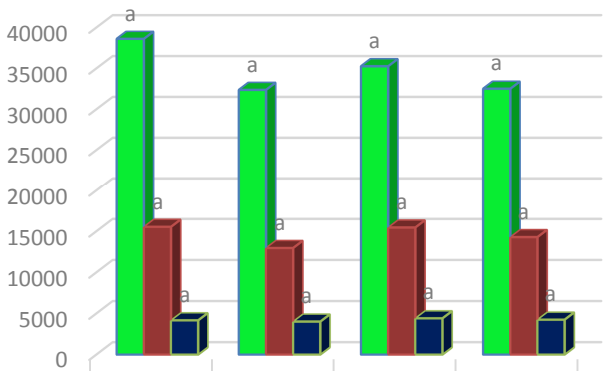
Plant height (cm)

Plant height was affected by various nitrogen and phosphorus rates, statistical analysis of data indicated that there was a significant difference between T_1 and both of T_2 and T_3 at 0.05 level of probability (Figure:1). These results are in harmony with the results obtained by Yirga *et al*. and Rouhollah [27] and [30], who found that the chemical fertilizer at a rate of 50 kg urea ha^{-1} and 150kg ha^{-1} of triplesuperphosphate had a significant effect on plant height of faba bean. The high availability of nutrients, especially nitrogen, affects the growth and increase the length of internodes through the increased plant height [30]. While the results are not matching with the results of Somayah and Hashem [31], who found that the P application had no significant effect on plant height



	T1	T2	T3	T4
Plant height (cm)	55.353	61.363	63.900	59.420
No. of pods plant-1	10.330	10.667	10.667	9.667
No. of seeds pod-1	4.667	5.000	4.333	4.333

Figure -1: Effect of different levels combination of N and P fertilizers on some growth indicators of faba bean.



	T1	T2	T3	T4
Biological yield (kg ha-1)	38613	32371	35264	32514
Seed yield(kg ha-1)	15538	12960	15452	14286
1000 seed weight (g)	4160	4007	4403	4240

Figure -2: Effect of different leveles combination of N and P fertilizers on yield and some yield components of faba bean.

Chlorophyll Content Index (CCI) in The Leaf

According to the results, there was no significant differenceat 0.05 level of probabilityin the interaction of nitrogen and phosphorus fertilizers on the chlorophyll content in the leaf of faba bean (Figure: 3). The results were not inline with the finding of Rouhollah *et al*. [30], who found that faba bean leaf chlorophyll content is significantly affected by nitrogen and phosphorus fertilizer application to the soil.

Harvest Index (HI%)

Statistical analysis of data shows that the P and N fertilizer applications had no significant effect on the value of harvest index. The highest value of harvest index was 43.93% from T_4, and the lowest value was 40.48% from the control(T_1). All the treatments showed more or less similar behavior for HI%. These results are in harmonic with the results found by Amsalu *et al*. [17], who found that P application rates had non-

significant effects for harvest index (HI%) of faba beans. While the results are not matching with the results obtained by some researchers [32 ; 33], who reported that there was a significant difference in 5% level of the interaction between treatments of biological phosphorus, mineral phosphorus and nitrogen on harvest index.

Phosphorus Use Efficiency (PUE)

Data of Phosphorus use efficiency (PUE) of faba bean are given in Fig3. PUE was calculated regarding faba bean seeds to yield per unit of P fertilizer application. The results indicated that P application had no significant effect on PUE, the lower PUE was seen at higher P rates application. The maximum PUE of 86.40was observed at T_2, and it decreased significantly at higher P rates application the minimum value of PUE 61.22 obtained from T_4. These results were in agreement with finding by [17]; they found that P application had no significant effect on PUE of faba bean and decreased at higher Phosphorus rate.

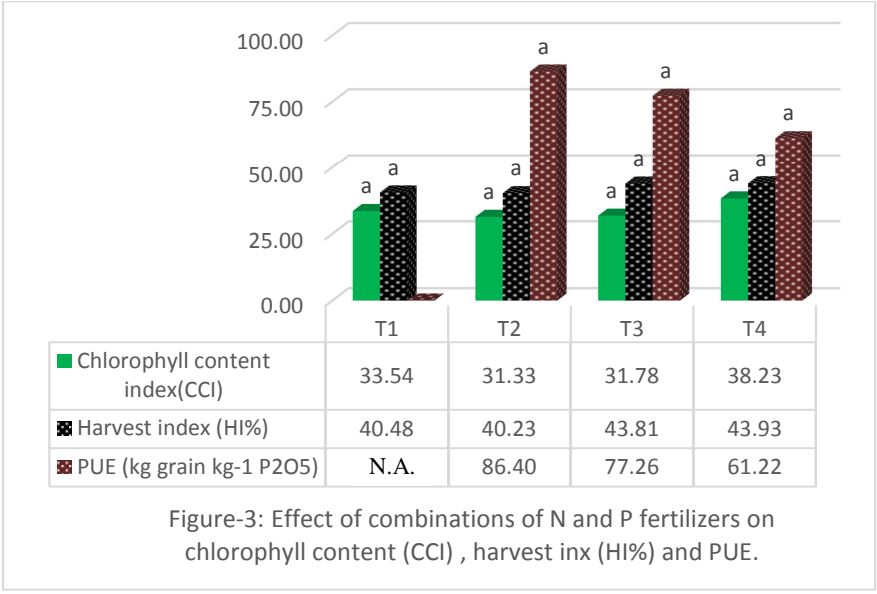


Figure-3: Effect of combinations of N and P fertilizers on chlorophyll content (CCI) , harvest inx (HI%) and PUE.

Conclusion

We can conclude from the present study that nitrogen and phosphorus fertilization has brought a significant effect on yield attributes. The plant height as a yield attribute was increased with increasing nitrogen and phosphorus fertilizer. Finally, application of proper amount of nitrogen and phosphorus will increase chlorophyll content index (CCI) in the leaf and harvest index (HI%) of faba beans plant.While the biological yield (kg ha^{-1}) and seed yield (kg ha^{-1}) were not influenced significantly by the application levels of nitrogen and phosphorus fertilizers.These may be due to the high $CaCO_3$ content of the studied soil, which leads to precipitate added phosphorus as calcium phosphate $Ca_3(PO_4)_2$. Phosphate solubilizing bacteria is recommended to solve this problem in the future studies.

References

[1]Sepetoğlu, H. "*Grain legumes*".Ege University Faculty. of Agriculture. Publication: 24/4. P.262 (2002).

[2] El-Wakeil, N. E. and El-Sebai, T.N. *" Role of Biofertilizer on Faba Bean Growth, Yield and its Effect on Bean Aphid and the Associated Predators"*. Research Journal of Agriculture and Biological Sciences. Vol.3, No. 6, pp.800-807.(2007).

[3] Marschner, H. *"Mineral nutrition of higher plants"*. Academic Press, (London). (1995).

[4] Ihsanullah, D., Hasan, S., Khan, B. M., Gul, H. andIjaz, A. Kh. *"Effect of Different Levels of Nitrogen on Dry Matter and Grain Yield of Faba Bean (Vicia Faba* L.*)"*. Pakistan Journal Botany, Vol.40, No.6, pp.2453-2459. (2008).

[5] Kandil, H., Nadia, G. and Magdi, T, A, *"Effects of Different Rates of Phosphorus and Molybdenum Application on Two Varieties Common Bean of(Phaseolus vulgaris* L.*)"*. Journal of Agriculture and Food Technology, Vol.3, No.3, pp.8-16. (2013).

[6] Richards, J. R., Zhang, H., Schroder, J. L., Hattey, J. A. and Raun, W. R. *"Micronutrient availability as affected by the long-term application of phosphorus and organic amendments"*. Soil Science Society of American Journal, Vol.75, No. 3, pp. 927-939. (2011).

[7]. El-Gizawy, N. K. B., and Mehasen, S. A. S. *"Response of faba bean to bio, mineral phosphorus fertilizers and foliar application with zinc"*. World Applied Sciences Journal, Vol. (6), No.10, pp. 1359-1365. (2009).

[8] Zaki, M. F., Fawzy, Z. F., Ahmed, A. A. andTantawy, A. S. *"Application of phosphate dissolving bacteria for improving growth and productivity of two sweet pepper (capsicumannuum*L.*)"*. Cultivars undernewly reclaimed soil.Australian Journal of Basic and Applied Sciences, Vol. (6), No.3, pp.826-839. (2012).

[9] Raghothama, K. G. and Karthikeyan, A. S. "*Phosphate acquisition. Plant and Soil*". Vol. 274, pp.37-49. (2005).

[10] Kole, S. C. and Hajra, J. N. *"Effect of P solubilizers on the availability of rock phosphate by legumes"*. Indian Agriculture, Vol. 43, No. 3/4, pp. 97 – 105. (1999).

[11] Rakha, M. K. A. and El-Said, M. *"Growth and yield of broad bean Viciafaba*L.*) asaffected by chemical and / or natural phosphorus with differentbiofertilizer"*. Journal. Plant Production, Mansoura University, Vol. 4, No.12, pp.1857 – 1869. (2013).

[12] Mohammed, S.S. *"Integrated approach for rock phosphate sulfur combined with bio-fertilization in sandy loam soil"*.Egyptian Journal of Applied Science, Vol. (19), No.2, pp.316-333.(2004).

[13] Havlin, J. L., Tisdal, S. L., Nelson, W. L. and Beaton, J. D. "*Soil Fertility and Fertilizers, an introduction to nutrient management"*.8th Edition,Pearson. (2013).

[14] Galaly, T.F.S.*"Interaction effect of phosphorus and sulfur on phosphorus availability and some growth parameters of a corn plant grown in calcareous soil"*. MSc. Thesis, University of Salahaddin, College of Agriculture, Department of Soil and Water. (2010).

[15] Saeed, K. S. "*The effects of orthophosphates, pyrophosphates and magnesium on the availability of phosphorus using DRIS methodology"*.Ph.D. thesis Department of Soil and Water Sciences,University of Sulaimani. (2008).

[16] Al- Sulaivani, S. I. A. *"Physico-chemical behavior of ortho and pyrophosphate in some calcareous soils from northern of Iraq"*. Ph. D. thesis College of the Agriculture University of Baghdad. (1993).

[17] Amsalu, N., Jan, D. and Pascal, B. *"Phosphorus use efficiency of improved faba bean (Vicia faba*L.*) varieties in low-input agro-ecosystems"*. Journal of Plant Nutrition and Soil Science. Vol.000, pp. 1-8. (2016).

[18]Gee, G. W. and Bauder, J. W."*Particle-size analysis. P 383-412.In A. Klute (ed.) Methods of soil analysis"*. Physical and mineralogy method, Part I. 2nd Ed. *ASA and SSSA*, Madison, WI. (1986).

[19]Page, A. L., Miller, R. H., and Keeny, D. R. "*Methods of soil analysis".* No. 9, Part2. American Society Agronomy, Inc. Pub. Madison, Wisconsin, U.S.A. (1982).

[20]Nelson, D. W. and Sommer, L. E. "*Total carbon, organic carbon, and organic matter*". In: Page, A.L., R.H. Miller, and D.R. Keeney,(eds) Methods of Soil Analysis" pp. 539-579 Part.2 Agronomy. 9 SSSA. Madison, W.I. USA. (1986).

[21] Suarez, D. L. *"Beryllium, Magnesium, Calcium, Strontium, and Barium"*. pp. 575-601.In: Sparks, D. L. (ed.) Methods of Soil Analysis: Chemical Methods" Part 3. Soil Science Society of America. Madison, WI, (1996).

[22]Rayment, G. E. and Higginson, F. R.*"Australian Laboratory Handbook of Soil and Water Chemical Methods"*. Inkata Press. Melbourne. (1992).

[23]Drouineau, G. *"Dosage Rapide du Calcaire Actif du sol: Nouvelles Donnees sur la Separation et al. Nature des Fractions Calcaires"*. Ann Agron. Vol. (12), pp. 441-450. (1942).

[24] Olsen, S. R., Cole, C. V., Watanabe, F. S. and Dean, L. A. *"Estimation of Available Phosphorus in Soils by Extraction with Sodium Bicarbonate"*. *Circ*ular No.939, USDA. U. S. Government Printing Office, Washington, D. C, S. R. (1954).

[25] Doberman, A. *"Nitrogen use efficiency-state of the art. IFA International Workshop on Enhanced Efficiency Fertilizers"*. Frankfurt, Germany, June 28-30. (2005). http://soilfertility.unl.edu/Materials%20to%20include/Nitrogen%20use%20efficiency%20state%20of%20the%20art_Dobermann.pdf

[26] Addinsoft. *"XLSTAT version 7.5, Statistical data analysis with MS Excel"*. Addinsoft, NY, USA. (2007).

[27]Yirga, W., Mitiku, H. , and Kiros, H. *"Effect of zinc and phosphorus fertilizers application on yield and yield components of faba bean (Vicia faba L.) grown in calcariccambisol of semi-arid northern Ethiopia"*. Journal of Soil Science and Environmental Management, Vol. (3) No.12, pp.320-326. (2012).

[28] Esmail, O. and Miran, K. Kh.*"Effect of Levels of Phosphorus, Methods of Application and Their Combinations on Growth, Yield, and Quality of Broad Bean in Calcareous Soil"*. Zanco, Journal of Pure and Applied Sciences. Published by Salahaddin University, Vol. 24, No.3, pp.30-36. (2012).

[29] Salem, S.A. and EL-Nakhlawy, F.S. *"Effect of application of nitrogen and phosphorus fertilizer levels on seed yield, its components and other characters in faba bean (Viciafaba*L.*)"*. Alexandria Journal of Agricultural Research, Vol. 32, pp. 139–148. (1987).

[30] Rouholla,h A., Sakhavi, Sh,,Shakiba, M. R. andMohammadi-Nassad, A. D. *"Effect of different intercropping patterns and fertilizers on some growth characteristics of faba bean (Vicia faba* L.*)"*. International Journal of Agronomy and Agricultural Research (IJAAR), Vol. 9, No.1, pp. 6-15. (2016).

[31]Somayeh, G. N. and Hashem, A. *"Effects of phosphorus fertilization and Pseudomonas fluorescens strain on the growth and yield of faba bean (Vicia faba* L.*)"*. IDESIA (Chile), Vol. 33, No. 4, pp. 15-21. (2015).

[32] Bozorgi, H. R., Azarpour, E. andMoradi, M. *"The effect of Bio, Mineral Nitrogen Fertilization and Foliar Zinc Spraying on Yield and Components of Faba Bean"*. World Applied Sciences Journal, Vol. 13, No. 6, pp. 1409-1414. (2011).

[33] Ashoori, J.N.M. "*Effect of Biologic Fertilization, Mineral Phosphorous And Nitrogen on Faba Bean Yield And Yield Components In Northern Iran"*. Indian Journal of Fundamental and Applied Life Sciences, Vol. 4, No.3, pp.84-92. (2014).