Available online at www.pelagiaresearchlibrary.com

Pelagia Research Library

Asian Journal of Plant Science and Research, 2018, 8(2):8-14

ISSN : 2249-7412
CODEN (USA): AJPSKY

Effects of Different Level of Phosporous Fertilizer on Yield and Yield Component of Field Pea (*Pisum sativum* L.) Varieties in Hadiya Zone Duna Area Southren Ethiopia

Daniel Manore[1*], Tefese Altaye[2]

[1]MSc in agronomy, Wachemo University, Hossana, Ethioia
[2]MSc in Plant breeding, Wachemo University, Hossana, Ethiopia

ABSTRACT

Field pea with other food legumes covers about 11-15% of the total 6-7 million hectares of crop areas in Ethiopia and is the third most important stable food legume among the highland pulses in rural Ethiopia but the lack of nutrient for plant growth in many soils limit crop production in Ethiopia and to study this problem a field experiment was conducted at Latabo farmers training centre to evaluate the effect of different level of to phosphorous (0, 23, 46, and 69 kg ha-1) with four types of field pea varieties: Local Tegegnech, Burikitu and Wolimera combined in RCBD. Data grain yield and yield components were recorded during specific physiological stages. The effect of phosphorous was significant in hastening physiological maturity of crop, and its effect was significant on flowering and growth parameters. The grain yield ranged between 2.43 tone ha-^{1} at 0 kg phosphorous ha-^{1} and 2.67tone ha-^{1} at application of 69kg phosphorous ha-1. Besides, total biomass was also significantly influenced by phosphorous and ranged between4.4 tone ha-^{1} at control to 4.87tone ha-^{1} at rate of 69 kg phosphorous ha-^{1}.The highest phosphorous use efficiency (48.3%) was obtained at 69 kg phosphorous ha-^{1} and increased with increasing rates of phosphorous application, whereas apparent phosphorous recovery was found to be highest at 46 and 69 kg phosphorous ha-^{1}repectively. Both agronomic and physiological phosphorous use efficiencies of the crop were highest at the rate of 69 kg phosphorous ha-^{1}.a. Therefore, Wolimera and Birukit with application of 69 kg phosphorous ha-^{1} are recommended for field pea production at Duna area.

Keywords: Duna, Field pea, Phosphorus, Yield

INTRODUCTION

Field pea (*Pisum sativum* L.) is grown in many countries and currently ranks fourth among the pulses in the world [1]. In Ethiopia, the crop is widely grown in mid to high altitude and ranks fourth with an annual production of 2, 632, 663.87 t [1]. It is the major food legumes with a valuable and cheap source of protein having essential amino acids (23-25%) that have high nutritional values for resource poor households [2]. The crop has important ecological and economic advantages in the highlands of Ethiopia, as it plays a significant role in soil fertility restoration and also serves as a break crop suitable for rotation to minimize the negative impact of cereal based mono-cropping [3]. It is also used as a source of income for the farmers and foreign currency for the country [4]. Having all these multiple benefits in the economic lives of the farming communities, however, the average yield of the crop is only 1.24 t ha^{-1} in Ethiopia [1] which is far below the potential worldwide average yield of 1.7 t ha^{-1} [5]. Lack of improved high yielder varieties absence recommended rate of phosphorous fertilizer can be cited as a major reason for this low productivity. According to Telaye et al. [6], the yield of field pea may be reduced by several factors among which poor cultivars and phosphorous fertilizer are outstandingly important. Therefore, it is of paramount importance to identify the type of varieties and fertilizer rate of a given crop, which the following objects were very important.

General objective:

To increase the production of field pea (*Pisum sativum* L.) through identification and use of optimum spacing and phosphorous fertilizer at Duna area

Specific objectives

To identify optimum rate of phosphorous fertilizer and that result in increased growth and yield of field pea varieties.

To identify field pea varieties that respond to rate level at study area.

To investigate if there are interactions between phosphorous rate level and field pea varieties.

MATERIALS AND METHODS

Description of area

The experiment was conducted at Duna Woreda Hadiya zone Southern Ethiopia during 2017 cropping season. The area receives a mean annual rain fall of 1800 mm with mean maximum temperature of 12-24^{0}C and minimum of 12^{0}C. The soil is clay loam with pH of 5.8.

The experimental design was factorial experimental design by using RCBD which comprised of sixteen treatments made four types of field pea varieties and four levels of phosphorous fertilizer with three replications. A 4.2 m x 3 m plot size was used as an experimental unit, with 0.6 m distance between plots. The blocks were separated by a 1m wide space. Each treatment was randomly assigned to the experimental unit within a block and 70 kg ha^{-1} of seed rate was used for each variety

Table 1: Treatment combinations of phosphorous level and field pea varieties

Phosphorous Kg/ha	Field pea Varieties			
	Local	Tegegnech	Burikit	Wolimera
0	L0	T0	U-0	W0
23	23L	23T	23W	23W
46	46L	46T	46W	46W
69	69L	69T	69W	69W

Data to be collected

Soil sampling and analysis

Soils sample was collected from a depth of a depth of 30 cm at 10 random points in the field before crop plant and after crop harvest depending to the treatments.

Days to emergence and flowering

Days of emergence, from days of sowing to 50% emergence was recorded, similarly 50% days of flowering was recorded after 50 % of flowers appeared in plants.

Plant height, number of branches and days to physiological maturity

Plant heights (cm), were measured at mid flowering, and from the base of the plant to tip of the main stem in average five plants. Also number of branches born on the main stem of plant was counted and averaged to represent number of branches per plant

Dry matter production

Destructive sampling used for nodulation parameters to record dry matter production at 50% flowering stage. The sampled plants were separated in to leaves and stem. These samples were sun dried until constant weight was obtained.

Yield and yield components

Number of pods per plant: Total filled pods present in five tagged plants were counted for all plants and the mean was calculated and expressed as number of pods per plant.

Number of seeds per pod: From a random sampled five pods of each plant, the seeds from pods were separated, counted and mean number of seeds per pod was calculated.

Hundred seed weight (g): A random sample from the yield of net plot was taken out and hundred seeds were counted and weighed.

Grain yield (tone ha^{-1}): After harvest plants from the net plot area were allowed to dry in sun and adjusted at 11% content and converted in tone per ha.

Plant tissue analysis

Nitrogen and phosphorous content of the shoot and grains at harvest was estimated by modified micro Kjeldahl method as outlined by Jackson (1958) [7]. The straw part was oven dried at 70°C for 48 hours, milled with mechanical miller and Passed through a 1 mm sieve. Subsequently, the plant samples were analyzed for total nitrogen and available phosphorous. The straw total phosphorous and nitrogen uptake was first calculated as a product of the straw yield and its phosphorous content obtained from the laboratory analysis. Grain nitrogen content was assumed to be about twice of that of the straw [8].

Statistical Analysis

Data collected on various characters or parameters were subjected to Analysis of Variance (ANOVA) using general liner model SAS®, (2002) Software [9]. Mean separations were done using LSD (5%) as following [10]. Analysis of variance (ANOVA) was considered to test for significant differences among treatment means.

RESULT AND DISCUSSION

Physico-chemical analysis of experimental site

Soil analysis before and after planting

Table 2: Selected physico-chemical properties of the experimental soil before and after planting

Physical properties					**Chemical properties**				
Particle size distribution (%)		Textural class			pH:1.25 H_20	Total soil N (%)	Available p mg/kg		
Sand	silt	clay	Sandy loam		5.15	0.30	36.3		
23	26	28	23						
Physical properties after planting					**Chemical properties after planting**				
Particle size distribution (%)		Textural class			pH:1.25 H_20	Total soil N (%)	Available p mg/kg		
Sand	silt	clay	Sandy loam		5.65	0.480	46.3		
23	26	28.5	23						

TN=total nitrogen in the soil, OC=organic carbon in the soil, Av. P=available phosphorous in soil

With respect to available P, the experimental soil rated in high range (>25 mg kg^{-1}). Havlin (1999) [11] indicated that soils having total N contents with ranges of <0.1, 0.1-0.15, 0.15-0.25, 0.25-0.5 and >0.5% can be grouped as very low, low, medium, high and very high, respectively. Thus, with respect to total available N, the soils of the experimental area can be rated in a low range (Table 2). Most Ethiopian soils, similar to the agricultural soils in other tropical countries, are reported to be generally low in N [12]. According to Herrera (2005) [13], soil carbon content rated as into very low (< 2%), low (2-4), medium (4-10), high (10-20) and very high (>20%), thus the soil at experimental site has very low carbon content.

Effect of phosphorous fertilizer level and varieties on phenological characteristics of field pea

The Field pea varieties tested have shown significant variation with respect to days of 50% emergence and days of 50% flowering and physiological maturity in both factors. (Table 3). Aikins and Afuakwa (2008) [14] indicated that uniform and complete emergence of vigorous seedlings positively affect the overall output of an annual crop by allowing the establishment of better canopy structure and providing time and spatial advantages to compete with weeds. Rengel, (2001) [15] hypothesized that such a variety can be nutrient efficient genotype.

Effects of different level of phosphorous fertilizer on biological yield

Studies by Getachew A, Abraham F, Temesgen D. (2006) [16] reported that phosphorus rate can enhance plant growth by increasing the efficiency of biological N fixation and also by enhancing the availability of trace elements and the production of plant growth promoting substances in the rhizosphere.

As shown in Fig 1, the interaction effect of p level and varieties on total biomass (t ha-[1]) was significantly differed (at P< 0.05)

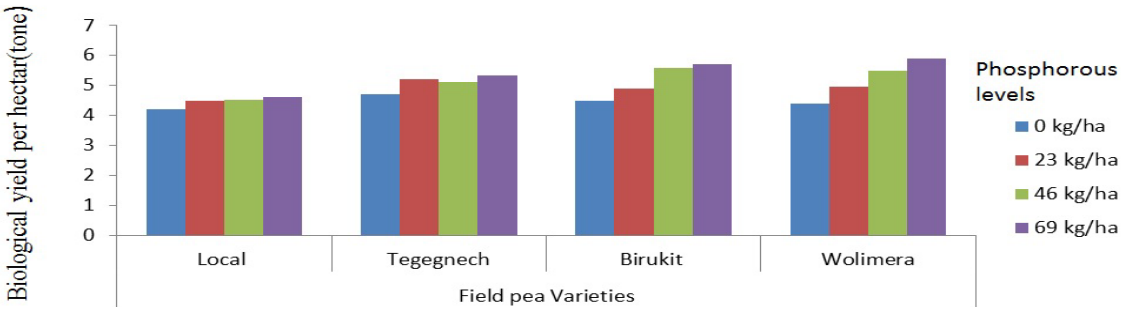

Figure 1: Interaction effects of phosphorous fertilizer rate and field pea varieties on biological yield per hectare

Table 3: Effects of phosphorous fertilizer level and field pea varieties on phenology and yield parameters

Treatments	Level	Days 50% emergence	Days 50% flowering	Number of branches per plant	Days to physiological maturity	Pod per plant	Seeds per pod	Biological yield per ha (tone)
TSP/ha	0	7.9 B^{A}	107.4^{B}	2.4B	122.66^{B}	25^{C}	3.06^{B}	4.4^{B}
	23	8.1^{A}	110.8^{BA}	2.55B	$124.5B^{A}$	28.6^{B}	3.4^{A}	4.77^{A}
	46	$8.0B^{A}$	109.33^{BA}	2.65B	126^{A}	30.1^{B}	3.15^{B}	4.83^{A}
	69	7.6^{B}	113^{A}	3.06A	126.5^{A}	33.4^{A}	3.4^{A}	4.87^{A}
LSD (5%)	**Varieties**	**0.47**	**4.0**	**0.31**	**2.51**	**2.28**	**0.18**	**0.278**
Varieties	Local	8.5^{A}	108^{B}	2.38B	121.5^{C}	26^{C}	2.9^{C}	4.44^{B}
	Tegegnech	7.8^{B}	109^{B}	2.6A	120.5^{C}	31^{A}	3.1^{B}	4.69^{A}
	Burikitu	7.3^{C}	110^{BA}	2.8A	126.3^{B}	28.58^{B}	3.43^{A}	4.6^{B}
	Wolimera	8.08^{BA}	113.5^{A}	2.85A	131.3^{A}	31.83^{A}	3.51^{A}	4.9^{A}
LSD (5%)		**0.47**	**4.0**		**2.51**	**2.28**	**0.18**	**0.27**
CV%		**7.12**	**4.3**	**13.9**	**2.4**	**9.3**	**6.8**	**6.9**
TSP/ha* Varieties		**ns**	**ns**	**ns**	*	*	*	*

Mean values within column followed by the same letter are not significantly different (p≤0.05), NS=non-significant at 5% probability level, n=48(Number of observation for each parameter)*, ***, **=Significant at 5%, 1% and 0.1% probability level

Effects of different level of phosphorous fertilizer on grain yield of field pea varieties

Grain yield differed significantly between varieties, and the highest seed yield was obtained in variety Wolimera (2.687 t ha-1). Our result is in accordance with the findings of Bilatu and Biniyam (2011) [17] who had compared seven Cowpea varieties in western Ethiopia, reported 2.9 t ha^{-1} from Black eye bean and also Takim and Uddin, (2010) [18] reported the grain yield of Cowpea 2.0 t ha^{-1} with application of N and P fertilizer. Ashraf et al. (2009) [19] showed that seed sowing with phosphorous level significantly increased Mung bean seed yield. In earlier investigation done by Germew H (2007) [20] at Melkassa research center, the yields field pea per hectare without urea application were 2.06 t ha^{-1} .The interaction effect of p level and varieties were significantly differed with respect to grain yield (P<0.05) as shown Table 4 and Figure 2

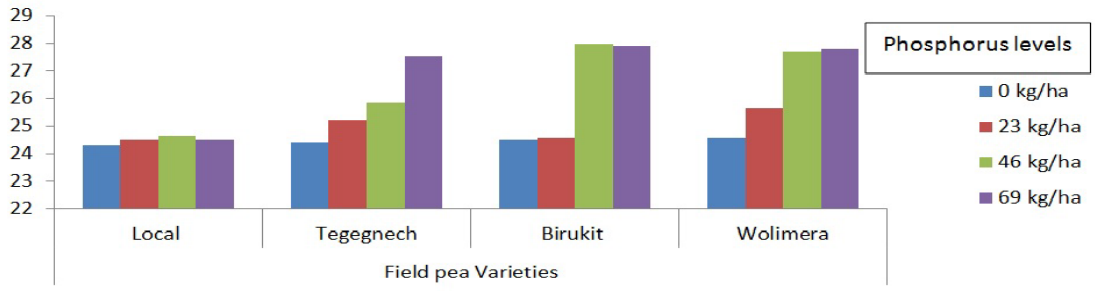

Figure 2: Interaction effects of phosphorous fertilizer rate and field pea varieties on yield per hectare

Effects of different level of phosphorous fertilizer on Harvest index of field pea varieties

Harvest indices varied significantly at P<0.05 among p fertilizer level. Varieties with lower total yields tended to have

higher HI and varieties with higher total yields tended to have lower harvest index. Wolimera , Burikitu and Tegegnech had higher harvest index (53%, 53% & 50%) respectively. Among all level 69 kg/ha and 46 kg/ha recorded higher hundred seed weight and the others levels including control without p fertilizer were statistically at par. Also, there was statistically significant difference between varieties in hundred seed weight at ($p<0.05$ (Table 4). Highest hundred seed weight was recorded from variety wolimera and lowest was from local cultivar.

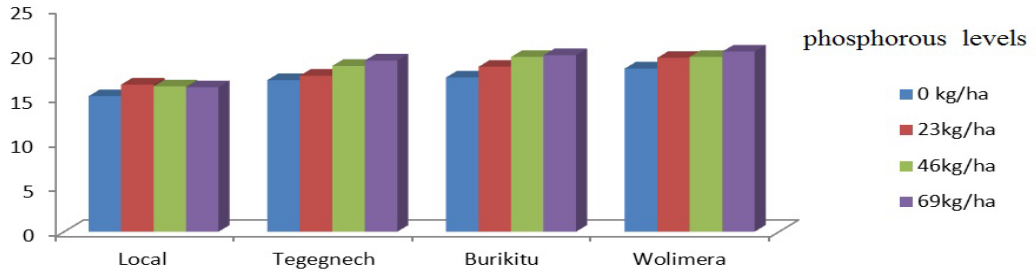

Figure 3: Interaction effects of phosphorous fertilizer rate and field pea varieties on hundred seed weight (gram)

Effect of phosphorous fertilizer level on plant total N content

There was a significant difference among p rates on total N contribution. Level 69/ha were superior to the others. Also the four field pea varieties were significantly different on total N ($P<0.05$). Similar works done by Getachew A, Abraham F, Temesgen D. (2006) [16]. reported that optimum applications of phosphorous significantly increased the protein content of soybean seeds. Sultana et al. (2005) [21] also reported that the increased crude protein content in cowpea forage is due to phosphorous fertilizer.

Effects on seed phosphorous contents

There is a significant difference among varieties in terms of available seed phosphorous ($P<0.05$).The total biomass of field pea has a great importance in farm level nutrient cycling due its role as either animal feed or organic matter to be returned to the soil.

Effects on soil available phosphorous and Nitrogen

The effect of levels 23, 46 and 69 kg/ha on soil available phosphorous were the highest and N fertilizer that of the least. These results are in accordance with the findings of several other studies increased supply of and nitrogen phosphorous through BNF and direct supplementation of phosphorus was reported which in turn play important role in soil fertility [8].

Table 4: Effects of phosphorous fertilizer level and field pea varieties on yield and yield parameters

Treatments		Grain yield per ha	Harvest index	100 seed weight(g)	Total nitrogen mg/g	Phosphorous mg/g
Phosphorous Kg /ha	0	2.43^{C}	0.48^{B}	17.6^{B}	2.29^{D}	0.248^{B}
	23	2.52^{C}	0.49^{B}	18.25^{BA}	2.5^{C}	0.257^{B}
	46	2.605^{B}	0.51^{BA}	18.0^{A}	2.8^{C}	0.3^{A}
	69	2.67^{A}	0.53^{A}	19.11^{A}	3.1^{A}	0.31^{A}
LSD (5%)		**0.41**	**0.042**	**0.9**	**0.16**	**0.22**
Varieties	Local	2.47^{C}	0.43^{B}	16.82^{C}	2.33^{D}	0.264^{B}
	Tegegnech	2.52^{B}	0.5^{A}	17.65^{C}	2.63^{C}	0.265^{B}
	Burikitu	2.54^{B}	0.53^{A}	18.98^{B}	2.81^{B}	0.27^{B}
	Wolimera	2.687^{A}	0.53^{A}	20.11^{A}	2.99^{A}	0.32^{A}
LSD (5%)		**0.41**	**0.042**	**0.9**	**0.17**	**0.22**
CV%		**1.96**	**10.08**	**5.9**	**7.4**	**9.67**
Phosphorous * Varieties		*	*	*	**	*

Mean values within column followed by the same letter are not significantly different ($p\leq0.05$), NS=non-significant at 5% probability level, n=48(Number of observation for each parameter)*, ***, **=Significant at 5%, 1% and 0.1% probability level

SUMMARY AND CONCLUSION

The experiment was comprised of sixteen treatments made up of a factorial combination of two input factors and four

field pea varieties. The design was RCBD with three replications. Results obtained from the experiment indicated that most of the parameters tested significantly responded ($p<0.05$) to the treatments. In the case of yield and yield components, rates 46 kg/ha and 69 kg/ha showed significant effects on all parameters of yield and yield components and in almost all cases rate 69 kg/ha appeared to be more effective than other treatments. However, so far, researches on the contribution of field pea varieties to the farming system are given lower emphasis, as compared to haricot bean varieties and their adoption and benefit to the small-scale farmers is very minimal but varieties Wolimers and Burikit were better in increasing soil fertility for the next season crop than local and Tegegnech.

ACKNOWLEDGEMENT

First and foremost I would like to give many praises and thanks to the almighty God, who offered me everything. His help and guidance is really great in every aspect of my life. Thank you Jesus! I have many thanks for Wachemo university research and community service office for financial support towards this research is acknowledged. I wish to express my gratitude to my wife Mrs.Hiwot Kelbo for here encouragement and tireless optimism that have kept me going.

LIST OF ABBREVIATION

Acronym	**Descriptions**
ANOVA	Analysis of variance
ATP	Adenosine triphosphate
BNF	Biological nitrogen fixation
CV	Coefficient of variation
ha	hectare
HI	Harvest Index
LAI	Leaf area index
LSD	Least Significant Difference
RCBD	Randomized Complete block design
SAS	Statistically Analysis Software
TSP	Triple Supper Phosphate

REFERENCES

[1] FAO., FAOSTAT. Food and Agriculture Organization of the United Nations, Rome, Italy, **2012**.

[2] Nawab N, Subhani GM, Mahmood K, Shakil Q, Saeed A. Genetic variability, correlation and path analysis studies in garden pea (Pisum sativum L.). *J Agric Res*, **2008**. 46: 333-340.

[3] Angaw T, Asnakew W. Fertilizer response trials on highland food legumes. Proceedings of the 1st National Cool-Season Food Legumes Review Conference, December 16-20, 1993, Addis Ababa, Ethiopia, **1994**. 279-292.

[4] Girma B. The state of grain marketing in Ethiopia. Proceedings of the EDRI/IFPRI 2020 Network Policy Forum on Toward Sustainable Food Security in Ethiopia: Integrating the Agri-Food Chain, AddisAbaba, Ethiopia, **2003**.

[5] Smykal P, Aubert G, Burstin J, Coyne CJ, Ellis NTHN et al. Pea (Pisum sativumL.) in the genomicera. *Agronomy*, **2012**. 2: 74-115.

[6] Telaye A, Getachew T, Demtsu B. Genetics and breeding of field pea. Proceedings of the 1st National Cool-Season Food Legumes Review Conference, Addis Ababa, Ethiopia, **1994**. 285-214.

[7] Jackson ML. Soil Chemical Analyses. Prentice Hall, Inc., Englewood Cliffs, New Jersy. **1958**. 183-204.

[8] Kassa, Ashraf Ali I, Niaz M, Abbass Q. Evaluation of field pea varieties for salt tolerance using physiological indices as screening tool. *Pak J Bot*, **2009**. 44(1): 47-52.

[9] SAS®. User's guide: Statistics, Version 9.1. SAS Institute, Inc. Cary, NC, USA, **2002**.

[10] Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd edition. **1984**.

[11] Havlin JL, Beaton JD, Tisdale SL, Nelson WL. Function and forms of nitrogen in plants. Soil Fertility and Fertilizers, 6th Ed. Prentice Hall, New Jersey. **1999**.

[12] Asgelil D. Effect of fertilizer on the yield and nodulation pattern of Faba bean on a Nitosols of Adet north Western Ethiopia. *Ethiop J Nat res*, **2000**. 2: 237-44.

[13] Herrera E. "Soil Test Interpretations Guide A-122", College of Agriculture and Home Economics New Mexico State University, **2005**.

[14] Aikins SHM, Afuakwa JJ. Growth and dry matter yield responses of cowpea to different sowing depths. ARPN. *J Agric Bio Sci*, **2008**. 3(5&6): 145-148

[15] Rengel Z. Genotypic differences in micronutrient use efficiency in crops. *Communications Soil Sci Plan*, **2001**, 32: 1163-1186.

[16] Getachew A, Abraham F, Temesgen D. Response of Field Pea (Pisum sativum L.) to Phosphate Fertilizer and Weed Control on Nitisols of the Central Highlands of Ethiopia. 66-74 in: crop science society of Ethiopia (ESSE). 12. Proceedings of Twelfth Conference, Addis Ababa, Ethiopia, **2006**.

[17] Bilatu AG, Zelealem TG, Anil KA (2012). Effect of metabolic modifiers on meat quantity and Quality: Review. *Afr J Food Sci*, **2012**. 6(11): 294-301.

[18] Takim FO, Uddin RO. Effect of weed removal on insect populations and yield of Cowpea [Vignaunguiculata(L) Walp]. Aust J Agric Eng, **2010**. 1(5): 194-199.

[19] Kassa, Ashraf Ali I, Niaz M, Abbass Q. Evaluation of field pea varieties for salt tolerance using physiological indices as screening tool. *Pak J Bot*, **2009**. 44(1): 47-52.

[20] Germew. At Melkassa research center School of Plant and Horticultural Sciences, Hawassa University, Hawassa, Ethiopia, **2007**.

[21] Sultana MN, Khan MJ, Khandaker ZH, Uddin MM. Effects of Bradyrhizobia inoculum and nitrogen fertilizer on biomass production of Cowpea (Vigna unguiculata) forage at different stages of maturity. *Bangl J Agri Univ*, **2005**. 3(2): 249-255.