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Effect of Phosphorus Fertilizer Levels on Yield and Yield Component of Chickpea (*Cicer arietinum* L.) Varieties: The Case of West Showa Zone, Ejersa Lafo, Ethiopia

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Abstract

Chickpea is one of the most important staple pulse crops in Ethiopia. However, its productivity is constrained by a number of problems out of which fertilizer rates and varieties are the most important ones. Therefore, a field experiment was conducted in 2016 cropping season to determine the performance of different chickpea varieties under varied phosphorus levels in Ejersa Lafo, Ethiopia. Treatments consisted of four chickpea varieties (Dalota, Teketay, Natoli and Local check) and four phosphorus rates (0, 23, 46 and 69 kg P_2O_5 ha^{-1}) arranged in a randomized complete block design with three replications in a factorial fashion of 4 × 4 × 3 arrangement. The data thus obtained were subjected to the Analysis of Variance (ANOVA) technique by using Statistical Application Software (SAS 9.4) and treatment means were separated by using Duncan test at 5% significance. The results revealed that the main effect of both phosphorus rates and varieties were highly significant ($P<0.001$) on number of pods per plant, thousand seed weight and biological yield. Statistically significant interaction effect of phosphorus rates and varieties was recorded for number of seed per pod and grain yield. Significantly higher grain yield (2945 kg ha^{-1}) was obtained for Teketay variety with application of 46 kg P_2O_5 ha^{-1}, while the local variety with zero application recorded the lowest grain yield. Therefore, Teketay variety with application of 46 kg P_2O_5 ha^{-1} is recommended for obtaining higher yield of chickpea.

Keywords: Chickpea; Phosphorus levels; Grain yield; Yield component

Introduction

Chickpea (*Cicer arietinum* L.) is the third most important pulse crop in the world, after dry bean and field pea [1]. The crop is originated in an area of South-eastern Turkey adjoining Syria [2]. It accounts for 12% of the world pulses production [3]. Africa contributes about 3.87% to the global chickpea in terms of area and about 4.9% in terms of production [4]. Chickpea is an important staple pulse crop in Ethiopia, and leads in production and area under cultivation next to faba bean and haricot bean [5]. Chickpea is mainly cultivated in the central highland and some lowland areas. It provides substantial economic merits for many smallholder farmers as a source of protein for human and livestock. It also fetches good price when sold in local market and hence generates cash for farmers. Moreover, it is being exported to Asia and Europe contributing positively to Ethiopia foreign exchange earnings [4]. In addition to these chickpeas served as a break crop since it improves soil fertility through biological nitrogen fixation. During 2016/17 Ethiopia produced 499,925.55 ton of chickpea from an area of 242,703.3 ha with average productivity of 2.06 ton ha^{-1} which is less than half of the global chickpea production potential (5 ton ha^{-1}) [5]. In most chickpea growing areas of the world the main constraints reported to affect chickpea production are lack of high yielding varieties, limited use of fertilizers, abiotic (poor soil fertility, drought and extreme temperatures) and biotic (Ascochyta blight, Fusarium wilt and Pod borer) stresses [6]. From these constraints lack of high yielding varieties and limited use of fertilizers (especially phosphorus fertilizer) are the major limiting factors of chickpea in the study area. Even though there is no research recommendation on fertilizer application for chickpea production in the study area, farmers grow chickpea on marginal lands using local varieties and little fertilizer application with general perception that being a legume crop it does not require any nutrients.

Phosphorus (P) has been recognized as one of the most important elements in plant nutrition [7]. It stimulated root development, increased stalk and stem strength, improved flower formation and seed production, more uniform and earlier crop maturity, increased nitrogen N-fixing capacity of legumes, improvements in crop quality, and increased resistance to plant diseases [8]. Sharma et al. reported that the application of phosphorus was found to increase the production of pulse crops [9]. Islam et al. also found that there is a positive yield response of chickpea to phosphorus fertilizer [10]. Legumes generally have higher P requirement because the process of symbiotic nitrogen fixation consumes a lot of energy [11]. In leguminous crops, the requirement of P as ATP or ADP compounds is not only vital but much higher due to symbiotic fixation of N [12].

Besides limited use of fertilizers luck of high yielding varieties is another limiting factor of chickpea production in the study area. Selection of suitable variety plays a vital role in crop production. The choice of right variety of chickpea helps in increasing crop productivity. Therefore, the study was planned with the objective of to evaluate the effect of different levels of phosphorus fertilizers on yield and yield components of chickpea varieties in Ejersa Lafo district.

Materials and Methods

Description of the study area

The study was conducted in EjersaLafo district at (09°33'412''N latitude and 038°14'697''E longitude with altitude of 2154 m above sea level) in West Showa Zone, Oromia National Regional State of Ethiopia during 2016/2017 cropping season. The study area has a bimodal type of rainfall pattern with a total precipitation of 1339.8 mm per annum. The 2016 year mean maximum and mean minimum temperatures were 24.4 °C and 8.7 °C respectively with 56.4% average RH.

Experimental design, land preparation and treatments

The experiment consisted of a factorial combinations of four Desi type chickpea varieties (Dalota, Teketay, Natoli which are improved varieties and one local variety (Mucha lame)) with four Phosphorus fertilizer rates (0, 23, 46 and 69 kg P_2O_5 ha^{-1}) which were laid down in a randomized complete block design in three replications in a factorial fashion of 4 × 4 × 3 arrangement. Each plot size measured 3 m × 2.4 m (7.2 m^2) consisting of 8 rows of 0.3 m apart and 3 m in length, while the net plot size measured 2.8 m × 1.8 m (5.04 m^2). The spacing between plots and replications were 0.5 m and 1 m respectively. The experimental field was ploughed by oxen, and land leveling done manually prior to planting. The seed was treated with Apron star before planting and two seeds were planted per holes on the 15th of September 2016 and thinned to 2 plants per stand. Nitrogen fertilizer in the form of urea was applied as starter dose at the rate of 20 kg/Nha^{-1} to all plots at planting and Phosphorus fertilizer in the form of TSP (Triple super phosphate) was applied as per the treatments at planting. Hand weeding was carried out twice. Dimethoate (40% EC) and Endosulfan (35% EC) at 2 liters per hectare was sprayed for the control of cutworms and pod borer respectively. Harvesting was carried out when the foliage, stem and pods color had all changed to golden brown and fully dried from the net plot area (four inner most middle rows).

Soil sampling

Composite soil sample was collected at 0-30 cm depths before fertilizer application/planting and this was analyzed for physical and chemical properties, texture, available P, total N, pH, organic carbon and exchangeable bases at National soil testing laboratory.

Data collection

Data was collected from the four middle rows for Number of pods per plant (NPPP), Number of seeds per pod (NSPP), thousand seed weight (TSW), Biological yield (BY) and Grain yield (GY).

Data analysis

Data were subjected to the analysis of variance (ANOVA) appropriate to the design of the experiment (Gomez and Gomez, 1984) using SAS 9.4 and treatment means were separated by Duncan test at 5% significance.

Results and Discussion

Soil analysis data

The physical and chemical properties of top soil (0-30 cm) before sowing were presented in (Table 1). The soil texture of experimental site was silty-clay with the pH value of 7.57 which was slightly basic and with the electrical conductivity (EC) of 0.53 ds/m.

PH 1:2.5 (H_2O)	EC ds/m	Total N %	Ava P ppm	K Cmol(+)/kg	OC %	CEC Cmol(+)/kg	Texture (%)			Textural
							Sand	Silt	Clay	Class
7.57	0.53	0.08	3.3	1.08	0.88	57.38	15	51	34	Silty-Clay

Note: OC: Organic Carbon; TN: Total Nitrogen; AVP: Total Available Phosphorus; CEC: Cation Exchange Capacity; EC: Exchangeable Cation; K: Potassium

Table 1: Soil physical and chemical analysis result before planting.

Number of seeds per pod

Number of seed per pod was significantly (P<0.001) affected by the main effects of varieties and phosphorus fertilizer application rates. It also significantly (P<0.01) affected by interaction effect of chickpea varieties and phosphorus fertilizer rates (Table 2).The result indicated that the highest number of seeds per pod (1.62) was recorded from Teketay variety with the application of 46 kg P_2O_5 ha^{-1}, while the lower number of seeds per pod (1.12) was recorded from Natoli variety with control, where phosphorus was not applied.

Teketay variety with application of 46 kg P_2O_5 gave the highest number of seed per pod than another variety. This might be due to genetic characters and this finding was in line with Erdemci et al. who reported that number of seeds pod^{-1} of chickpea was significantly affected by the interaction effects of varieties and phosphorus fertilizer levels [13].

Fer rates (P_2O_5) kg ha^{-1}	Varieties(V)			
	Dalota	Teketay	Natoli	Local
0	1.16^{jk}	1.28^{gh}	1.12^{k}	1.24^{hi}
23	1.28^{gh}	1.46^{c}	1.21^{ij}	1.36^{ef}
46	1.38^{de}	1.62^{a}	1.28^{gh}	1.47^{c}
69	1.32^{fg}	1.54^{b}	1.26^{i}	1.41^{d}
DMRT (5%)	**			
CV (%)	4.43			

Note: Means within the same column and row followed by the same letter are not significantly different at 5% probability level.

Table 2: Interaction effect of Phosphorus rates and varieties on number of seeds per pod of chickpea.

Number of pods per plant

The analysis of variance indicated that the number of pods per plant was significantly (P<0.001) affected only by the main effect of varieties and phosphorus rates (Table 3). The Local variety produced significantly highest number of pods plant^{-1} (122.1), while the lowest number of pods plant^{-1} (67.12) was observed in case of variety Natoli. Significant differences were observed among the four chickpea varieties in number of pods per plant. This might be due to genotypic variation which played significant role in producing varied number of pods per plant. The highest phosphorus level of 46 kg P_2O_5 ha^{-1} resulted in maximum pods (92.07) plant^{-1}, while the minimum pods (70.37) plant^{-1} was noted in control, where phosphorus was not applied. The mean number of pods per plant increased with increased phosphorus levels. This might be due to the liberal availability of plant nutrients which stimulated the plants to produce more pods per plant as compared to other treatments as phosphorus powerfully encourages flowering and fruiting. The result was agreed with Badini et al., who reported that increasing phosphorus levels simultaneously increased the number of pods plant^{-1} of chickpea [14].

Treatment	NPPP	TSW	BY
Varieties	-		
Dalota	69.45^{c}	295.7^{a}	6202.8^{b}
Taketay	75.17^{b}	282.4^{b}	6880.8^{a}
Natoli	67.12^{d}	277.8^{b}	6212.2^{b}
Local	122.1^{a}	118.2^{c}	3392.8^{c}
LSD (0.05)	***	***	***
Phosphorus levels	-		
0	70.37^{d}	226.8^{c}	4490.9^{c}
23	84.25^{c}	242.5^{b}	5757.8^{b}
46	92.07^{a}	262^{a}	6555.6^{a}
69	87.15^{b}	242.7^{b}	5888.3^{b}
LSD (0.05)	***	***	***
CV (%)	1.96	3.88	10.02

Note: Means followed by different letters in columns are statistically significant at 5% probability levels using Duncan test.

Table 3: The main effect of varieties and phosphorus fertilizer levels on number of pods per plant (NPPP), TSW and BY of chickpea.

Thousand seed weight (gm)

The analysis of variance indicated that thousand seed weight was significantly (P<0.001) affected only by the main effect of varieties and phosphorus rates (Table 3). The highest thousand seed weight (295.7 gm) was recorded from Dalota variety, while the lowest thousand seed weight (118.2 gm) was recorded for the local variety. There was non-significant difference between Teketay and Natoli varieties. The maximum thousand seed weight (262 gm) was recorded from 46 kg P_2O_5 ha^{-1}, while the minimum thousand seed weight (226.8 gm) was noted in control. The mean thousand seed weight increased with increased phosphorus fertilizer rates. Increasing in thousand seed weight might be due to favorable climatic condition during grain filling stage as well as the formation of starch and albumin. This result was agreed with the findings of Amare et al. and Yadav et al., who reported that increasing phosphorus rates increases thousand seed weight [15,16].

Biological yield (kg)

The results in relation to biological yield of chickpea varieties as influenced by different phosphorus levels are indicated in Table 3. The analysis of variance demonstrated that the biological yield was significantly (P<0.001) affected by the main effect of different phosphorus levels and varieties, while the effect of their interaction was non-significant (P>0.05). The results showed that Teketay variety produced significantly highest biological yield (6880.8 kg), while the lowest biological yield (3392.8 kg) was observed in case of local variety. There was non-significant difference between Dalota and Natoli varieties in case of biological yield (Table 3). Variety Teketay showed its superiority for this trait over Natoli, Dalota and Local Varieties. The highest biological yield (6555.6 kg) was recorded from application of 46 kg P_2O_5 ha^{-1}, while the lowest biological yield (4490.9 kg) was observed in control, where no phosphorus was applied. The results showed that increasing phosphorus levels up-to 46 kg ha^{-1} increase biological yield. The possible reason may be the adequate supply of phosphorus that played a vital role in physiological and developmental process in plant life and the favorable effect of these important nutrients might have accelerated the growth processes that increased the biomass yield of the crop. This result was agreed with the finding of Gulpadiya et al., who reported that biological yield was significantly increased with increasing rates of phosphorus application up to optimum levels [17].

Grain yield (kg)

The results in relation to grain yield of chickpea varieties as influenced by different phosphorus levels are indicated in Table 4. The analysis of variance indicated that the grain yield was significantly (P<0.001) affected both by main effect and interaction effect of Varieties and phosphorus levels. Significantly higher grain yield (2945 kg ha^{-1}) was obtained from Teketay variety with the application of 46 kg P_2O_5 ha^{-1}, while lower seed yield (1265 kg ha^{-1}) was recorded for local variety, where phosphorus was not applied. Grain yield increased as rate of P_2O_5 applied increased from zero (control) up-to 46 kg P_2O_5 ha-1 for all varieties and decline after 46 kg P_2O_5 ha^{-1} for all varieties that showing increase in phosphorus beyond 46kg P_2O_5 ha^{-1} would not be uneconomical. All P_2O_5 rates gave highest grain yield than the control for all varieties. The result was supported by the finding of Rashid et al., who reported that grain yield of chickpea was significantly affected by the interaction effects of varieties and phosphorus fertilizer levels [18].

Varieties (V)	Fertilizer rates (P_2O_5) kg ha^{-1}			
	0	23	46	69
Dalota	1684^{fgh}	1880^{ef}	2512^{b}	2014de

Teketay	1595[fgh]	2408[bc]	2945[a]	2430[bc]
Natoli	1483[ghi]	1984[de]	2571[b]	2189[cd]
Local	1265[i]	1460[hi]	1751[efg]	1453[hi]
LSD (5%)	*			
CV(%)	8.8			

Note: Means within the same column and row followed by the same letter are not significantly different at 5% probability level using Duncan test.

Table 4: Interaction effect of Varieties and Phosphorus rates on grain yield of chickpea.

Conclusion and Recommendation

From the results of the study it was concluded that application of 46 kg P_2O_5 ha^{-1} had result better performance in all of the phosphorus levels applied and Teketay variety responded better with regard to grain yield. Therefore, Teketay variety with application of 46 kg P_2O_5 ha^{-1} was recommended for higher seed yield of chickpea at study area. However, this research was conducted at one location and year it should be done in multi locations and years so as to assure the results of the present experiment.

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