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Review

Effect of Phosphorus Fertilizer Levels on Growth and Root Character of Chickpea (*Cicer Arietinum* L.) Varieties in West Showa Zone, Ejersa Lafo, Ethiopia

Chala Chalchissa[1], Midekesa Chala[2]

[1][2]Ethiopian Institute of Agricultural Research, Ambo Agricultural Research Center, P. O. Box 37, Ambo, Ethiopia

*Corresponding Author E-mail Address: mideksachala@gmail.com

Chickpea is one of the most important staple pulse crops in Ethiopia. However, its growth 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 effect of phosphorus fertilizer levels on growth and root character of chickpea varieties at Ejersa Lafo district, central 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. The results revealed that main effect of both phosphorus rates and varieties were highly significant (P<0.001) on plant height, number of primary branches, number of secondary branches, root length and number of pods per plant. Significantly higher number of primary branches plant^{-1} (5.37) was obtained from Teketay variety, higher root (14.33) and number of nodules plan-1(62.48) were obtained from Natoli variety and higher plant height (51.02) and number of secondary branches plant^{-1}(14.58) were obtained from local variety with application of 46 kg P_2O_5 ha^{-1}.Therefor, application of phosphorus at the rate of 46kg P_2O_5 ha-^{1} was recommended for higher growth and root character of chickpea at study area.

Key words: Chickpea, Phosphorus levels, Growth and Root character

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is an important pulse crop cultivated and consumed across the world. It is the third most important pulse crop in the world, after dry bean and field pea (FAOSTAT, 2013). The major producers are India, Pakistan, Turkey, Australia, Iran, Myanmar, Canada, Ethiopia, Mexico and Iraq with over 93% of the global production (Upadhyaya *et al.*, 2008).

Most of the chickpea is produced with rainfall under marginal situation in developing countries (Toker *et al.*, 2007). In Africa, chickpea is widely grown in Ethiopia, Sudan, Eritrea, Kenya, Tanzania and Malawi (Bejiga and van der Maesen, 2006). In Ethiopia chickpea is an important staple pulse crop and leads in production and area under cultivation next to faba bean and haricot bean (CSA, 2017). It is grown in several regions of the country with residual moisture on black vertisol soils (Kassie *et*

al., 2009). Chickpea is produced for different purposes including food and feed, cash and foreign currency earning. In addition to these it 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} (CSA, 2017) which is less than half of the global chickpea production potential (5 ton ha^{-1}). 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 and biotic stresses (Upadhyaya et al., 2011). 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 grows chickpea on marginal lands using local varieties with little fertilizer application.

Phosphorus is a major nutrient element required for proper growth and yield of grain legumes. Ryan et al. (2012) has clearly demonstrated the significance of phosphorus for all animals and plant life on the earth. Sharma et al. (2014) reported that the application of phosphorus was found to increase the production of pulse crops. Islam et al. (2011) also found that there is a positive yield response of chickpea to phosphorus fertilizer. Shivakumar et al. (2004) reported that the growth attributes like plant height, branches per plant and dry matter accumulation were increased with increasing level of P$_2$O$_5$ up to 80 kg ha^{-1} over control in chickpea. Application of mineral P fertilizer at 46.5 kg P$_2$O$_5$ ha^{-1} result in a significant increase in growth characters of chickpea over control (Ahmed and Badr, 2009). It is essential in efficient and early root development, enhanced nodulation, leaf size, tillering, flowering, grain yield, and fastens maturity (Memon et al., 2016). It also plays an important role in photosynthesis process and storage and transfer of energy and sugar and starch utilization by being constituent of energy rich compounds viz. adenosine triphosphate (ATP) and adenosine diphosphate (ADP). Many biochemical reactions cannot be carried out unless the phosphate in high energy compounds (ATP, ADP) is transferred to other energy requiring molecules in the plant (Green and Sharma, 2012). 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 (Uddin et al., 2014). Legumes generally have higher P requirement because the process of symbiotic nitrogen fixation consumes a lot of energy (Schulze et al., 2006).

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 growth and root character of chickpea varieties in Ejersa Lafo district.

MATERIALS AND METHODS

Description of the study area

The study was conducted in Ejersa Lafo district at (09^0 33'412"N latitude and 038^0 14'697"E longitude with altitude of 2154m 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 1339.8mm per annum. The 2016 year mean maximum and mean minimum temperatures were 24.4^{0}C and 8.7^{0}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$_2$O$_5$ ha^{-1}) which were laid down in a randomized complete block design in three replications in a factorial fashion of 4 x 4 x 3 arrangement. Each plot size measured 3m × 2.4m (7.2m^2) consisting of 8 rows of 0.3 m apart and 3m in length, while the net plot size measured 2.8m ×1.8m (5.04 m^2). The spacing between plots and replications were 0.5m and 1m 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 20kg N ha^{-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. Crop management practices such as weeding, thinning and plant protection measure were done as per requirement equally for all treatments.

Soil sampling

Composite soil sample was collected at 0-30cm 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 plant height (PH), Number of primary branches per plant (NPB), Number of secondary branches per plant (NSB), Root length (RL) and Number of nodules per plant.

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 (0-30cm) 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 Cation Exchange Capacity (CEC) of 57.38 Cmol(+)/kg.

Table 1. Soil physical and chemical analysis result before planting

PH	EC	Total	Ava P	K	OC	CEC	Texture (%)			Textural
1:2.5(H2o)	ds/m	N %	ppm	Cmol(+)/kg	%	Cmol(+)/kg	Sand	Silt	Clay	Class
7.57	0.53	0.08	3.3	1.08	0.88	57.38	15	51	34	Silty-Clay

OC = organic Carbon; TN = Total Nitrogen; AVP=Total Available Phosphorus; CEC = Cation Exchange Capacity, EC=Exchangeable Cation; K= Potassium

Analysis of Variance (ANNOVA)

Analysis of variance showed that varieties and different phosphorus levels significantly (P<0.001) affected the plant height, number of primary branches, number of secondary branches, root length and number nodules per plant of chickpea under study. The interaction effect was non- significant (P > 0.05) for all parameter as presented in (table 2).

Table 2: Analysis of variance for the effect of different levels of phosphorus fertilizer on growth and root character of chickpea varieties.

Source of Variation	df	PH	NPB	NSB	RL	NPP
				MS		
Rep	2	72.8531583***	0.22395833**	0.08687500NS	2.34247708*	27.030833NS
Var	3	54.8737021***	0.51722222***	20.46520833***	5.05460833**	1880.404444***
Fer	3	92.1348188***	3.18333333***	16.21243056***	18.05888056***	137.291111***
Var*Fer	9	3.8446225NS	0.02574074NS	0.26891204NS	0.36213241NS	1.734074NS
Error	30	4.5927939	0.02884722	0.1675417	0.56433264	9.093056
CV (%)		4.43	3.35	3.2	5.6	6.2

NS, *,** and ***= non-significant, significant at 5% , 1% and 0.1% respectively, PH= plant height, NPB= No of primary branches, NSB= No of secondary branches, RL= Root length and NPP= Nodules per plant

Plant height (cm)

The analysis of variance indicated that plant height was significantly ($P < 0.001$) affected only by the main effect of varieties and phosphorus rates (Table 3). The result revealed that the highest plant height (51.02) was recorded from local variety, while the lowest plant height (46.59) was recorded from Natoli variety. The difference between Natoli and Dalota was statistically at par. Numerically, Dalota variety gave the highest plant height. The maximum plant height (51.83) was recorded from application of 46 kg P_2O_5 ha^{-1}, while the minimum plant height (45.34) was recorded from control, where phosphorus was not applied. The mean plant height increased with increased phosphorus fertilizer rates. Increased in plant height with increased rate of P_2O_5 for all varieties might be due to phosphorus fertilizer contributes to availability of soil nutrients which increases their uptake by plants. This result was agreed with the findings of Ahmed and Badr (2009), who reported that application of mineral P fertilizer at 46.5 kg P_2O_5 ha^{-1} result in a significant increase in growth characters (plant height) of chickpea over control. It also more supported with the finding of Yadav *et al.* (2014), who reported that increases phosphorus application rates up to optimum level increasing plant height of chickpea.

Number of primary branches per plant

The analysis of variance indicated that number of primary branches plant[-1] was significantly ($P < 0.001$) affected by the main effect of varieties and phosphorus rates, while the interaction effect was not significant (Table 3). The result indicated that Teketay variety produced significantly higher number of primary branches per plant (5.37), while Dalote variety produced significantly lower number of primary branches per plant (4.91). The difference between Dalota, Natoli and Local varieties were statistically at par. Numerically, Local variety gave the highest number of primary branches per plant. The maximum number of primary branches plant[-1] (5.56) was recorded from application of 46 kg P_2O_5 ha^{-1}, while the minimum number of primary branches plant[-1] (4.34) was recorded from control, where phosphorus was not applied. There was non-significant difference between application of 23 kg P_2O_5 ha^{-1} and 69 kg P_2O_5 ha^{-1}. The mean number of primary branches plant[-1] increased with increased phosphorus fertilizer rates. Increasing in number of primary branches per plant might be due to the cumulative effect of phosphorus on the processes of cell division and balanced nutrition. This result was agreed with the findings of Kumar *et al.* (2009), and Yadav *et al.* (2014), who reported that application of Phosphorus up to 50kg P_2O_5 ha^{-1} significantly increased number of primary branches plant[-1] in chickpea over control. Similarly, it also supported with Meseret and Amin (2014), who reported that the number of branches per plant increases with increasing phosphorus application rates up to optimum level.

Table 3: The main effect of varieties and phosphorus fertilizer levels on Plant height, No of primary branches plant-1 and No of secondary branches plant-1 of chickpea.

Treatment	PH	NPB	NSB
Varieties			
Dalota	46.64c	4.91b	12.41b
Taketay	49.10b	5.37a	12.68b
Natoli	46.59c	4.95b	11.46c
Local	51.02a	5.04b	14.58a
DMRT (0.05)	***	***	***
Phosphorus levels			
0	45.34d	4.34c	11.63c
23	47.18c	5.16b	12.4b
46	51.83a	5.56a	14.38a
69	49.01b	5.21b	12.72b
DMRT (0.05)	***	***	***
CV (%)	4.43	3.35	3.2

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

Number of secondary branches per plant

The analysis of variance indicated that number of secondary branches plant[-1] was significantly (P < 0.001) affected only by the main effect of varieties and phosphorus rates (Table 3). The highest number of secondary branches plant[-1] (14.58) was recorded from Local variety, while the lowest number of secondary branches plant[-1] (11.46) was recorded for the Natoli variety. There was non-significant difference between Dalota and Teketay varieties. The maximum number of secondary branches plant[-1] (14.38) was recorded from application of 46kg P_2O_5 ha^{-1}, while the minimum number of secondary branches plant[-1] (11.63) was recorded from control. The effects of 23kg P_2O_5 ha^{-1} and 69kg P_2O_5 ha^{-1} were statistically at par. The mean number of secondary branches plant[-1] increased with increased phosphorus fertilizer rates. Increasing in number of secondary branches per plant might be due to the cumulative effect of phosphorus on the processes of cell division and balanced nutrition. This result was supported with the findings of Yadav *et. al. (*2014), who reported that increasing phosphorus rates increases secondary branches per plant of chickpea.

Root length (cm)

The analysis of variance indicated that root length was significantly (P < 0.01) affected only by the main effect of varieties and phosphorus rates (Table 4). The highest root length (14.33) was recorded from Natoli variety, while the lowest root length (12.92) was recorded for the Dalota variety. The difference between Dalota, Teketay and Local varieties were statistically at par. Numerically, Teketay variety gave the highest root length. The highest root length (14.86) was recorded from application of 46 kg P_2O_5 ha^{-1}, while the lowest root length (11.88) was recorded from control, where phosphorus was not applied. There was non-significant difference between application of 23 kg P_2O_5 ha^{-1} and 69 kg P_2O_5 ha^{-1}. The mean root length increased with increased phosphorus fertilizer rates. Increasing in root length might be due to that phosphorus encourages the formation of new cells and thus promotes the root and shoot growth. This result was in line with the findings of Dhage *et al*. (2014), who reported that application of phosphorus levels significantly increased the root length of soybean over control.

Number of nodules per plant

The analysis of variance showed that number of nodules plant[-1] was significantly (P < 0.001) affected by the main effect of varieties and phosphorus rates, while there is non-significant interaction effect (Table 4). The highest number of nodules plant[-1] (62.48) was recorded from Natoli variety, while the minimum number of nodules plant[-1] (32.08) was recorded from local variety. There was no significant difference observed between Teketay and Dalota varieties in case of number of nodules plant[-1]. The maximum number of nodules plant[-1] (52.38) was recorded from application 46 kg P_2O_5 ha^{-1}, while the minimum number of nodules plant[-1] (44.15) was recorded from control. The effects of 23kg P_2O_5 ha^{-1} and 69kg P_2O_5 ha^{-1} were statistically at par. The mean number of nodules plant[-1] increased with increased phosphorus fertilizer rates. Increasing in number of nodules plant[-1] might be due to the fact that application of phosphorus results profuse growth of roots which ultimately resulted formation of more number of nodules of large size. This result was agreed with the findings of Yadav *et al*. (2014), who reported that growth characters and number of root nodules/plant increased with increasing level of phosphorus fertilizer significantly up to 50kg P_2O_5 ha^{-1} on chickpea.

Table 4: The main effect of varieties and phosphorus fertilizer levels on Root length and Nodules per plant of chickpea

Treatment	RL	NPP
Varieties		
Dalota	12.92b	48.55b
Taketay	13.35b	50.75b
Natoli	14.33a	62.48a
Local	12.98b	32.08c

Table 4. Continues

DMRT (0.05)	**	***
Phosphorus levels		
0	11.88c	44.15c
23	13.23b	48.3b
46	14.86a	52.38a
69	13.62b	49.03b
DMRT (0.05)	***	***
CV (%)	5.6	6.2

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

CONCLUSION AND RECOMMENDATION

From the results of the study it can be concluded that out of four varieties, Teketay variety showed better performance by number of primary branches plant[-1], Natoli variety showed higher root length and number of nodules plan[-1] while, local variety showed higher plant height and number of secondary branches plant[-1] with the application of 46kg P_2O_5 ha^{-1}. Therefore, application of phosphorus at the rate of 46kg P_2O_5 ha^{-1} was recommended for higher plant height, number primary and secondary branches plant[-1], root length and nodules plant[-1] of chickpea at study area. However, this research was conducted at one location and one year it should be better to repeat the experiment in multi locations and years so as to assure the results of this experiment.

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