AGRONOMIC PERFORMANCE OF CHICKPEA (*CICER ARIETINUM* L.) VARIETIES UNDER VARIED PHOSPHORUS LEVELS AT EJERSA LAFO DISTRICT, WEST SHOWA ZONE, CENTRAL ETHIOPIA

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ABSTRACT

Chickpea is one of the most important staple pulse crop cultivated in Ethiopia. However, its productivity is constrained by a number of factors, 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 district, West Showa Zone, Central Ethiopia. Treatments consisted of a factorial combination 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 ($P<0.01$) on days to 50% flowering, days to 90% maturity, number of primary branches, number of secondary branches, nodule per plant, root length, number of pods per plant and hundred seed weight. Statistically significant interaction effect of phosphorus rates and varieties was recorded for plant height, number of seeds per pod, biological yield, seed yield and harvest index. Significantly high seed yield (2945 kg ha^{-1}) and biological yield (7991 kg ha^{-1}) were obtained for Teketay variety with the application of 46 kg P_2O_5 ha^{-1}, while the local variety with zero application recorded the lowest seed and biological yield. Optimum net benefits of EB 53703ha^{-1} was recorded on Teketay variety with application of 46 kg P_2O_5 ha^{-1}. Therefore, Teketay variety with 46 kg P_2O_5 ha^{-1} fertilizer application was found to be economically beneficial compared to the other treatments and hence suggested for farmers in the study district.

KEYWORDS: Fertilizer rates, Chickpea varieties, Grain yield, Net benefit

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the third most important pulse crop in the world, after dry bean and field pea. Africa contributes about 3.87% to the global chickpea in terms of area and about 4.9% in terms of production (FAOSTAT, 2014). Ethiopia is also considered as the secondary centre of diversity for chickpea (Yadeta and Geletu, 2002). Chickpea is an important staple pulse crop in Ethiopia, and leads in production and area under cultivation next to faba bean and haricot bean. It is mainly cultivated in the central highlands and some lowlands areas. Oromia National Regional State share 43% from the total national's chickpea in area coverage, and 48% production (CSA, 2015). The crop contributes 17% of the total pulse production in the country. It provides substantial economic merits for many smallholder farmers as a source of protein for human and livestock. Chickpea 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. Chickpea served as a break crop since it improves soil fertility through biological nitrogen fixation. The *desi* type of chickpea is the most commonly grown. Chickpea is consumed in different forms such as *kollo* (roasted seed), *nifiro* (boiled seeds), *shiro* and *bukulti* (sprouts) and the seeds consumed during the green pod stage as a vegetable (MOA, 2011). According to Ejersa Lafo district production annual report (EJDA, 2015) chickpea is the fourth most important crop gown in the district after Teff, wheat and barley, and ranks first from pulses main cropping seasons.

In Ethiopia, the average potential seed yield is estimated to be 1.9 ton ha^{-1} (CSA, 2015) which is less than half of the global chickpea production potential (5 ton ha^{-1}). In most chickpea growing areas of Ethiopia, the main constraints reported to affect chickpea production includes: lack of high yielding varieties, abiotic (poor soil fertility, drought and extreme temperatures) and biotic (*Ascochyta blight, Fusarium wilt* and Pod borer) stresses (Upadhyaya *et al.*, 2011). Lack of improved varieties and poor soil fertility are among the major limiting factors in West Showa Zone and in particular, Ejersa Lafo District (EJDA, 2015). Therefore, the objective of the study was to evaluate the performance of different chickpea varieties under varied phosphorus levels in Ejersa Lafo district.

METHODOLOGY

Description of the study area

The study was conducted in Cheleka Bobe kebele, Ejersa Lafo district, West Showa Zone, Oromia National Regional State of Ethiopia in 2016/2017 cropping season. Ejersa Lafo is one of the 22 districts of West Showa Zone, located at about 65 km from Addis Ababa to the Western part of the country, 47 km from Ambo town to the East. The study area is situated at $09^0$33'412"N, and $038^0$14'697"E at an altitude of 2154 meters above sea level (m.a.s.l). The soil is predominantly Vertisols (EARO, unpublished) with pH values of 7.15 - 7.6. The study area has a bimodal rainfall pattern, with the main rain from June to September and short rain from February to April. The 2016 year average annual rainfall, maximum and minimum temperatures were 1339.8 mm and, 24.4 and 8.7^{0}C respectively, with 56.4% average RH.

Treatments and experimental design

The treatments consisted of a factorial combinations of four Desi type chickpea varieties (Dalota, Teketay, Natoli which are improved varieties and one local cultivar (*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. Nitrogen fertilizer in the form of urea was applied as starter dose at the rate of 20 kg N ha^{-1} and Triple super phosphate (46 kg P_2O_5) as source of phosphate to all the treatments. Seeds were sown in rows with spacing of 10 cm between plants and 30 cm between rows in a 2.4m x 3 m (7.2m^2) plot. The spacing between plots and blocks were 0.5 m and 1 m respectively. Each plot has 8 rows and the central 4 rows were considered as net plot. The 2nd and 7th rows of each plot were used for nodule measurement, while the outer most rows on both sides of each plot was considered as border. All improved varieties were obtained from Debre Zeit Agricultural Research Center (DZARC)

Soil sampling and analysis

A composited initial soil sample before planting was taken at 0-30 cm soil depth from the experimental site. The soil was processed following standard procedures and analyzed in Ambo University Chemistry department laboratory for organic matter content following the procedure Walkley and Black (1934), total nitrogen by the Kjeldahl method (Bremner and Mulvaney, 1982). Soil reaction (pH-H_2O) using a pH meter with 1:2.5 soil to solution ratio via a glass electrode attached, and Cation Exchange Capacity (CEC) leaching the soil with neutral 1 N ammonium acetate (FAO, 2008). Available phosphorous by Olsen *et al.*, (1954); exchange able potassium by the use of flame photometer. The particle size analysis was done using the hydrometer method as outlined by Anderson and Ingram (1993).

Agronomic management of the experiment

All agronomic practices were implemented in accordance with the given recommendation of the crop. The experimental field was ploughed by oxen, and land leveling done manually prior to planting. The seed was treated with Apron star before planting on the 15th of September 2016. Basal application of Phosphorus was carried out at planting for all plots and treatments. Hand weeding was carried out twice; first weeding at 32 days after sowing (DAS) and the second weeding at 60 DAS. Dimethoate (40 % EC) and Endosulfan (35% EC) at 2 liters per hectare was sprayed for the control of cutworms and pod borer

(*Helicoverpa armigera*) respectively during the early growth and pod development stage of the crop. Harvesting and threshing were manually done. The chickpea was cut close to the ground when the foliage, stem and pods color had all changed to golden brown and fully dried.

Data collection

Phenological, growth, yield and yield components data were collected. The parameters were days to 50 % flowering, days to 90 % physiological maturity , Plant height (cm), Number of primary branches per plant, Number of secondary branches per plant, Stand count, Nodule and Root length, Number of pods per plant (NPPP) , Number of seeds per pod (NSPP), Thousand seed weight (TSW), Biomass yield (BY), Seed yield (SY) and Harvest index (HI).

Statistical analysis

All collected data were subjected to analysis of variance (ANOVA) using statistical application software (SAS) version 10 (SAS, 2004) and interpretations were made following the procedure of Gomez and Gomez (1984). Where significant differences exist among treatments, the least significance difference (LSD) test was used for the separation of means. The partial budget analysis technique was applied to determine the cost and benefit of the treatments.

RESULTS AND DISCUSSION

The soil physico-chemical properties of the experimental site

The result of laboratory analysis of the soil sample showed that the soil textural class is silty clay according to the soil textural triangle classification with 15% sand, 51% silt and 34% clay particle size distribution (Table 1). High clay content in the soil might indicate better water and nutrient holding capacity of the soil. The soil pH of the experimental site was 7.57, which is slightly alkaline (Landon, 1991). Chickpea specifically grows well under the pH range of 6.0 to 8.0 (ICRISAT, 2010). Hence, the soil pH of the experimental site is ideal for chickpea production. The CEC of the experimental soil was 57.38 cmol (+)/kg (Table 1) which lies in the very high range according to Landon (1991) classification.

The soil of the study site had a low organic carbon content based on Netherlands commissioned study by Ministry of Agriculture and Fisheries of Ethiopia (1995) that classify soils with OC contents with (%) >3.50, 2.51-3.5, 1.26-2.50, 0.60-1.25 and <0.60 as very high, high, medium, low and very low, respectively, indicating low potential of the soil to supply N as corroborated by the record total per cent N (0.08%) and available phosphorus which are all in the low category according to Landon (1991) classification. Generally, the soil of the study site can be described as low in fertility which indicates the need for fertilization.

Phenological, growth and yield parameters of chickpea

Days to 50 % flowering and 90 % physiological maturity

The result showed that both days to 50% flowering and days to 90 % physiological maturity were significantly ($P< 0.01$) and ($P<0.05$) affected by the main effect of varieties and phosphorus rates. The main effect of variety showed that local variety flowered earlier than the three improved varieties as it attain 50 % flowering at 50 days after planting (DAP) (Table 2). Natoli, one of the improved varieties flowered late (56.4 DAP) when compared to Taketay and Dalota. This could be due to varietal differences in their genetic makeup (Addisu, 2013). The main effect of phosphorus also showed that the longest (53.8) number of days to 50 % flowering was recorded with zero P application (control) and the shortest (51.6) with a non-significant difference between 46 and 69 kg P_2O_5 ha^{-1} (Table 2). Days to flowering decreased with increment of phosphorus up to 46 kg P_2O_5 beyond which no further increase or change was observed in number of days to flowering. This might be attributed to the association of phosphorus with early maturity of crops. This finding corroborates Brady and Weil (2002) who reported that phosphorus application could decreases days to flowering since it promotes rapid cell division and growth. Tessema and Alamayehu (2015) had also reported that phosphorus is important for flowering and seed formation as well as advances crop maturity.

The analysis of variance for days to 90 % physiological maturity was also significantly ($P<0.05$) affected by the main effect of chickpea varieties and phosphorus rates. The variety Natoli matured significantly late with 120.4 days compared to other varieties (Table 2). The shortest (115.3) days to maturity was recorded with the local variety (Table 2). This might be attributed to the inherent genetic difference among the varieties of chickpea and the high variability in adapting to the environment. The main effect of Phosphorus rates indicated that the shortest day to physiological maturity was obtained with application of phosphorus at all levels showing no significant differences and the longest days (120.4) was recorded on the control (Table 2). The probable reason might be that phosphorus hastens maturity of plant. This is in agreement with Dotaniya (2014b) who reported that phosphorus stimulates flowering and hastens maturity.

Number of primary and secondary branches per plant

The numbers of primary and secondary branches per plant were significantly ($P < 0.05$) affected by the main effect of phosphorus rates and varieties. The main effect of variety indicated that Teketay produced significantly higher number of primary branches per plant (5.33) than all the other varieties, while the local variety produced significantly higher (14.57) secondary branches (Table 3). Moreover, Natoli variety produced significantly lower number of secondary branches per plant (11.46). Dalota, Natoli and local varieties did not varied significantly among themselves on the number of primary branches per plant (Table 3). All varieties varied significantly among themselves for number of secondary branches per plant. Sarker (2005) had reported a high variability in the number of branches in legumes which is in line with the findings in this study.

The main effect of phosphorus showed that significantly lower (4.34) and higher (5.56) number of primary branches per plant was recorded in control and 46 kg P_2O_5 ha^{-1} respectively (Table 3). The mean number of primary branches per plant increased by 18, 28 and 20% for 23, 46 and 69 kg P_2O_5 ha^{-1} respectively in comparison with control (Table 3). This might probably be due to the cumulative effect of phosphorus on the processes of cell division and balanced nutrition. Meseret and Amin (2014) reported that application of P significantly increased the branches $plant^{-1}$ over control. The number of secondary branches also showed same trend (Table 3). The mean secondary branch was increased by 7, 24 and 10 % with the application of 23, 46 and 69 kg P_2O_5 ha^{-1}, respectively when compared to control. Similarly Guriqbal *et al.* (2011) reported that secondary branches per plants of chickpea increases with increasing level of nutrient supply.

Root length and Number of nodule per plant

The analysis of variance for root length, showed a highly significant ($P < 0.01$) effect due to the main effect of varieties and phosphorus rate. The highest mean number of root length was recorded for Natoli (14.45) and Teketay (13.94), whereas the lowest was obtained for variety Dalota (13.18) and local variety (13.13) (Table 3). This might be due to the presence of genetic variability. Root length increased significantly with the increase in applied phosphorus rates from zero (control) to 46 kg P_2O_5 ha^{-1}, beyond which there was no significant change noticed. Moreover, the longest root length was obtained with 46 kg P_2O_5 ha^{-1} (Table 3). It was observed that with incremental supply of phosphorus, there was likely an improvement in available phosphorus in the soil which might have helped improved the root length. This result was in line with the finding of Dotaniya (2014a) who reported phosphorus stimulates early crop root development.

Number of nodule per plant

The analysis of variance result of number of nodule per plant indicated a significant ($P < 0.05$) main effect of both varieties and phosphorus rates and a non significant interaction effect. Higher number of nodule per plant (62.48) was obtained for the variety Natoli and least number of nodules per plant (32.08) was recorded for local variety (*Mucha lame)* (Table 3). There was no significant difference observed between Dalota and Teketay varieties. The application of phosphorus also significantly ($P<0.05$) affected number of nodules $plant^{-1}$ (Table 3). Highest (52.38) number of nodules $plant^{-1}$ was produced with the application of 46 kg P_2O_5 ha^{-1}, while lowest (44.15) number of nodules $plant^{-1}$ was recorded from the control. Generally, the number of nodules per plant increased with increment of Phosphorus fertilizer. This might be attributed to the role of phosphorus as an essential element for the development and function of nodules in pulses. This result was in line with the finding of Ripudaman *et al.* (2014) who reported that number of nodules per plant increased with increasing level of phosphorus significantly up to 50 kg P_2O_5 ha^{-1}. The result also agrees with that of Adissu (2013) who reported that application of phosphorus produced significantly high number of nodules per plant and nodule weight.

Nodule dry weight per plant

The dry weight of nodules was significantly ($P<0.001$) affected by interaction effect of chickpea varieties and phosphorus rate (Table 4). Higher nodule dry weight (7.26 g) was observed at 46 kg P_2O_5 ha^{-1} with Natoli variety, while lower nodules dry weight (2.13g) was observed at control with local variety. The interaction effect shows that Natoli was more responsive to phosphorus application in terms of nodule dry weight at 46 kg P_2O_5 ha^{-1} beyond which a decrease was also observed. This could be due to the genetic makeup of the variety in the use of available phosphate. Phosphorus had been reported to have a stimulating effect on nodule growth and nitrogenase activity in nodules of legumes (Tang *et al.* 2001).

Plant height

The analysis of variance showed a significant ($P < 0.01$) interaction effect of varieties and phosphorus rates on the plant height of chickpea. Significantly taller plants 52.1 and 51.53 cm were obtained for varieties Teketay and local varieties respectively with application of 46 kg P_2O_5 ha^{-1}(Table 5). All P_2O_5 rates gave significantly taller plants than the control for all varieties. Plant height increased as P_2O_5 applied rate increased from zero (control) to the highest level for all varieties. The differences in height can only be attributed to varietal differences. Moreover, Erdemci *et al.* (2016) reported that difference in plant height could be due to variation in genetic make-up or the hormonal balance and cell division rate that result in changes in the plant height of the different varieties.

Number of seeds per pod

Number of seed per pod was significantly ($P < 0.05$) affected by the interaction effects of different rate of Phosphorus applications and chickpea varieties. Significantly lower (1.12) seed number was recorded for Natoli variety (Table 6). Teketay with the application of 46 kg P_2O_5 ha^{-1} gave the highest average seed number (1.62). Overall all varieties perform better with phosphorus application on this parameter. This finding is in line with that of Erdemci *et al.* (2016) who reported that number of seeds $plant^{-1}$ of chickpea was significantly affected by the interaction effects of varieties and phosphorus fertilizer levels.

Number of pods per plant and thousand seed weight

The number of pods per plant and thousand seed weight were significantly ($P < 0.05$) affected by the main effect of varieties of chickpea and phosphorus rates. No significant interaction effect was observed on these parameters. Moreover, significant differences were observed among the four chickpea genotypes in number of pods per plant. The local variety produced highest (122) number of pods $plant^{-1}$, while the lowest (67) number of pods $plant^{-1}$was recorded for Natoli variety (Table 7). Genotypic variation might have played significant role in producing the varied number of pods per plant. The main effect of phosphorus showed that Phosphorus level at 46 kg P_2O_5 ha^{-1} resulted in maximum (92) pods $plant^{-1}$ while minimum (70) pods $plant^{-1}$ was recorded in control treatment (Table 7). The result shows that increasing phosphorus levels simultaneously increased the number of pods $plant^{-1}$. There was an increase of 30.9 % in the mean number of pods per plant when 46 kg P_2O_5 ha^{-1} was applied compared to zero application (control). This might be due to improved availability of plant nutrients which stimulated the plants to produce more pods per plant as phosphorus encourages flowering and fruiting. This finding is in line with Kumar *et al.* (2009) that reported application of phosphorus at 50 kg P_2O_5 ha^{-1}significantly increased number of pods per plants in chickpea over control. Similarly it agrees with Meseret and Amid (2014) who reported that application of phosphorus fertilizer had significantly increased number of pods per plant in common bean. Thousand seeds weight also showed same trend as with number of pods per plant. Significantly ($P < 0.05$) higher (302g) hundred seed weight was recorded for Dalota variety and lowest (118 g) for the local variety, though there was non-significant difference between Teketay and Natoli varieties (Table 7). The main effect of phosphorus application shows that 1000-seed weight increases with increase in levels up to 46 kg P_2O_5 ha^{-1} which recorded the maximum weight (248g) that was at par with the application of 69 kg P_2O_5 ha^{-1}(Table 7). Increase in 1000-seed weight might be due to favorable climatic condition during grain filling stage as well as the formation of starch and albumin. This agrees with the findings of Amare *et al.* (2014) and Ripudaman *et al.*

(2014) who reported that increasing phosphorus rates increases 1000 seed weight.

Seed yield

The analysis of variance indicated a highly significant (P<0.01) interaction effects of phosphorus rates and varieties on seed yield of chickpea (Table 8). Significantly higher seed yield (2945 kg ha^{-1}) was obtained for Teketay with application of 46 kg P_2O_5 ha^{-1}, while lower seed yield (1418 kg ha^{-1}) was recorded for local variety without P application. Seed yield increased as rate of P_2O_5 applied increased from zero (control) to 46 kg P_2O_5 ha^{-1}. Mean seed yield ranged from 1728 kg ha^{-1} for the control treatment to 2509 kg ha^{-1} for 46 kg P_2O_5 ha^{-1}. Abdur *et al.* (2013) reported a significant interaction effect of chickpea varieties and phosphorus fertilizer levels on number of seed $plant^{-1}$, grain yield, biological yield, seed protein content as well as net income in chickpea. This result is further supported by Erdemci *et al.* (2016) who reported that grain yield of chickpea was significantly affected by the interaction effects of varieties and phosphorus fertilizer levels.

Biological yield

The analysis of variance result showed a highly significant (P<0.01) interaction effect of variety and phosphorus rate on dry biomass yield of chickpea (Table 9). Significantly higher biological yield was obtained from Teketay (7991 kg/ha) and Natoli (7767 kg/ha) with application of 46 kg P_2O_5 ha^{-1}, while the lowest (3787 kg ha^{-1}) was recorded with the local variety at zero application (Table 9). The findings of Abdur *et al.* (2013) and Erdemci *et al.* (2016) had also reported significant interaction effects of chickpea varieties with phosphorus fertilizer application rates on biological yield of chickpea.

Harvest index

Harvest index is the measure of physiological efficiency of a crop plant to convert photosynthates into economically important parts of the plant, that is ratio of grain to above ground dry biomass are important indicators in seed yield (Rahman *et al.,*2013). The result showed that harvest index of chickpea was significantly (P<0.05) affected by the interaction of chickpea varieties and phosphorus fertilizer rates. The application 46 kg P_2O_5 ha^{-1} in combination with local variety gave significantly higher (43.4%) harvesting index than the rest treatments (Table 10), while Dalota with no P application recorded the lowest harvest index. The performance of the local variety over the improved varieties in terms of harvest index might partly be attributed to its adaptation to the environment. Hussain *et al.* (2002) reported that chickpea cultivars differed significantly from one another regarding to harvest index. Likewise, Chiezey *et al.* (1992) reported that lower harvest index at low level of phosphorus application might be due to poor development of plants at different growth stages.

Economic feasibility of chickpea production with phosphorus application

The highest net benefit of 55,703 EB ha^{-1}(Ethiopian Birr) and a 1547 % marginal rate of return was obtained with the application of 46 kg P_2O_5 ha^{-1} followed by 48,126 EB ha-1 and 773 % marginal rate of return with application of 23 kg P_2O_5 ha^{-1} (Table 11). The value to cost ratio ranged from 4 EB to 13EB per unit of investment for application of recommended 46 kg P_2O_5 ha^{-1} fertilizer rate and non-fertilized. Therefore, the use of Teketay variety combined with 46 kg P_2O_5 ha^{-1} fertilizer application was economically feasible for chickpea production compared to the other treatments.

CONCLUSION AND RECOMMENDATION

Based on the study results, it is concluded that the application of phosphorus significantly influenced the performance of the chickpea varieties. Days to 50% flowering, days to 90 % maturity, number of pod per plant, and thousand seed weight were affected by the main effects of varieties and phosphorus. Moreover, plant height, number of seeds per pod, nodule dry weight, grain yield, biomass yield and harvest index were all affected by the interaction effect of both varieties and phosphorus rate. Teketay variety was found to have performed better among the varieties with application of 46 kg P_2O_5 ha^{-1} and a net benefit of 55,703 EB ha^{-1}. Hence, Teketay variety with 46 kg P_2O_5 ha^{-1} was suggested for economic chickpea production and productivity in the study district.

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