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Full Length Research Paper

The effects of nitrogen and phosphorus on yield and yield components of garlic (*Allium sativum L*) varities at Beressa watershed, Mesqan Woreda, South Central-Ethiopia

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Abstract

Garlic *(Allium sativum L.)* is one of the most important bulb vegetables used as spice and flavoring agent of food and medicinal plants throughout the globe. It is a cold weather crop with high water and nutrient requirement. Numerous problems accounted for the low productivity of garlic in Ethiopia, among which appropriate fertilizer management is the major issue. Therefore, a field experiment was conducted with the objectives to investigate the effect of nitrogen and phosphorus levels on yield and yield attributes of two garlic varieties at Beressa watershed, Mesqan woreda, south –central Ethiopia under supplemental irrigation from November to April 2010/11. The treatments consisted of 2 garlic varieties Local and improved, 4 levels of N (0, 50, 100 and 150 kg N/ha) and 3 levels of P (0, 50 and 100 kg P_2O_5/ha) triplicated in a factorial randomized block design. Data on yield and yield components were collected. Varieties differed significantly on bulb diameter, mean clove fresh weight, bulb fresh and dry weight and bulb yield. Nitrogen application significantly influenced bulb yield and yield component. Phosphorus had significantly influenced bulb diameter, bulb fresh and dry weight, mean clove fresh weight and bulb yield and also yield all the yield attributes were significantly affected by the interaction of N and P. However; the three way interaction effect between N, P and variety were found to be significant for the bulb dry matter at 120 DAE and total bulb yield. The highest bulb yield of 3.34 t/ha was achieved at 100 kg N + 100 kg P_2O_5/ha combination, and was 244 % higher than the control and statistically similar to the yield of 3.27 t/ha obtained from 100 kg N and 50 kg/ha P_2O_5 application for Tsedey92. Hence, based on the economics of fertilizers to the mean bulb yield for the experiment, application of 100 kg N and 50 kg P_2O_5 /ha to variety Tsedey92 had tentatively recommended for the study area.

Keywords: Garlic, variety, nitrogen, phosphorus, bulb yield

INTRODUCTION

Garlic (*Allium sativum*L.) is one of the most important *Allium* plants widely cultivatedthroughout the world including Ethiopia. It is an aromatic herbaceous plant belonging to the family *Alliacae*. It is one of the most important bulb vegetables which is used as spice and flavoring agent for foods and as medicinal plant (Velisek *et al.,* 1997).

The multiple uses of garlic today translate into its increasing demand for domestic consumption as well as production input for pharmaceutical and cosmetic industries. Despite its importance and increased production, garlic productivity in many parts of the world is low due to genetic and environmental factors affecting its yield and yield related traits (Nonnecke, 1989).

Numerous problems accounted for the low mean yield of garlic in Ethiopia: lack of proper planting material, inappropriate agronomic practices, absence of proper pest and disease management practices and marketing facilities are the prominent ones (Getachew and Asfaw,2000).

Area under garlic cultivation in the world increased from 846,300 ha in 2007 to 1,199,929 ha in 2010 with total production from 65000 tons to 17674893 tones (FAO, 2012). In Ethiopia, the total area under garlic production in 2009/2010 reached 15,361.25ha and the production is estimated to be over 179,657.8tones (CSA, 2010).

In Ethiopia, past efforts have been engaged in identifying production problem, improving garlic cultivars and its production practices. Garlic is a cold weather annual crop having high nutrient and water requirement (Anon, 2006). Several production and management related limiting factors have not yet been addressed among which fertilizer management is the major area that should get consideration to improve the production of garlic (Getachew and Asfaw, 2000). So experiments that determine the optimum nutrient requirements in general and nitrogen and phosphorus requirement in particular are of paramount importance. Reports on fertilizer management of garlic are very scarce in the country and the released high yielding varieties are suffering with low productivity due to decline soil fertility over time (DZARC, 2000). In Ethiopia, a blanket recommendation (200kg DAP and 150kgha^{-1}Urea) had settled for garlic production from DebreZeit Agricultural Research Center (EARO, 2004). In Mesquan woreda where this experiment was conducted, farmers who produce garlic rely on traditional practices and local cultivars and they also do not use fertilizer. Therefore, the experiment was initiated to observe the effects of nitrogen and phosphorus fertilizers on the bulb yield and yield components of garlic.

MATERIALS AND METHODS

Description of the Study Area

A field experiment was conducted at farmers' field in Beresa watershed, Mesqanworeda, Guraghie Administrative Zone of the South Nations Nationalities and Peoples Region (SNNPR) using supplementary irrigation during November to April of 2010/2011. The site is located south west of Addis Ababa in the coordinates 08^{o} 06′ 422" latitude and 038^{o} 24′ 909" longitude and at an altitude of 1960m.a.s.l. The average annual rainfall of the area over a decade was 1206.83 mm with a range of 504.7 mm to 1783.3 mm with average annual temperature of 18.6^{0}C (NMAHB, 2010).

Treatments and Experimental Design

The treatments consisted of four nitrogen levels (0, 50,100,150 kgNha^{-1}) and three phosphorus levels (0.50, 100 kgP_2O_5ha^{-1}) with two garlic varieties, Local (farmers' variety) and Tsedey92 (G-493). The 24 treatment combinations were triplicated factorially in a randomized complete block design (RCBD). The individual plot sizes were 2.448m^2 with intra and inter spacing of 17x30cm containing a total of 48plants per plot.

Conduct of Field Experiment and Crop Management

Two varieties of garlic used were Local (farmers' variety) and Tsedey-92(G-493) from DebreZiet Agricultural Research center. Tsedey92 (G-493) is a released variety from Debrezeit Agricultural Research Center and characterized by white purple bulb color. Prior to planting, garlic bulbs were split into the individual cloves and planted upright. One third of the nitrogen through urea was applied at the planting time, one third top dressed at 30 days after planting and the remaining one third top dressed 20 days after emergence whereas all the phosphorus was applied at the time of planting through triple super phosphate (TSP). At the time of planting, urea and TSP were applied beneath and to the side of the cloves. Weeding and other cultural practices were done uniformly for all treatments as per need. The fungicide RidomilGoldMZ68WG was sprayed to control garlic fungus starting 40 days after emergence (DZARC, 2000).

Data Collection

Data on the bulb yield and yield related attributes of garlic were recorded from each plot by taking four randomly selected plants destructively for the yield attributes *.i.e.*, bulb diameter (cm), bulb fresh weight (g plant^{-1}), bulb dry weight (g plant^{-1}), fresh weight of cloves (g bulb^{-1}) and the total bulb yield per hectare (t ha^{-1}) was pooled from the middle two rows of each plot at final harvest.

Statistical Analysis

All bulb yield and yield related data were analyzed using analysis of variance (ANOVA) and the general linear model using SAS (SAS, 2002). Wherever treatment effects were significant at 5% probability level, the means were separated using the Duncan's Multiple range Test (DMRT) procedures. Correlation analysis was carried out using Pearson's simple correlation coefficients for yield and yield components of garlic as affected by nitrogen and phosphorus applications.

RESULTS AND DISCUSSION

Analysis of Variance

There was a highly significant (P≤0.001) effect of N and P fertilizer application on bulb diameter (cm), bulb fresh

Table 1: Analysis of variance for the studied traits

Traits	Variety(V)	Nitrogen(N)	Phosphorus(P)	V*N	V*P	N*P	V*N*P
BD	0.55*	9.39***	5.92***	0.12^{ns}	0.04^{ns}	1.22***	0.133^{ns}
BFW	52.38*	404.79***	223.79***	6.25ns	6.319ns	29.82**	10.07ns
CFW	15.59*	125.34***	95.83***	1.81ns	1.55ns	9.15**	2.15ns
BDW	10.19***	75.70***	32.61***	0.79ns	0.43ns	6.36***	1.05*
BY	0.81**	7.72***	3.77***	0.55***	0.43**	0.42***	0.30**

*NB: *, **, *** indicate significance at p≤0.05, p≤0.01, p≤0.001, respectively, 'ns' non significant. DB= Bulb diameter, BFW=Bulb fresh weight , CFW= Clove fresh weight, BDW= Bulb dry weight, BY= Bulb yield*

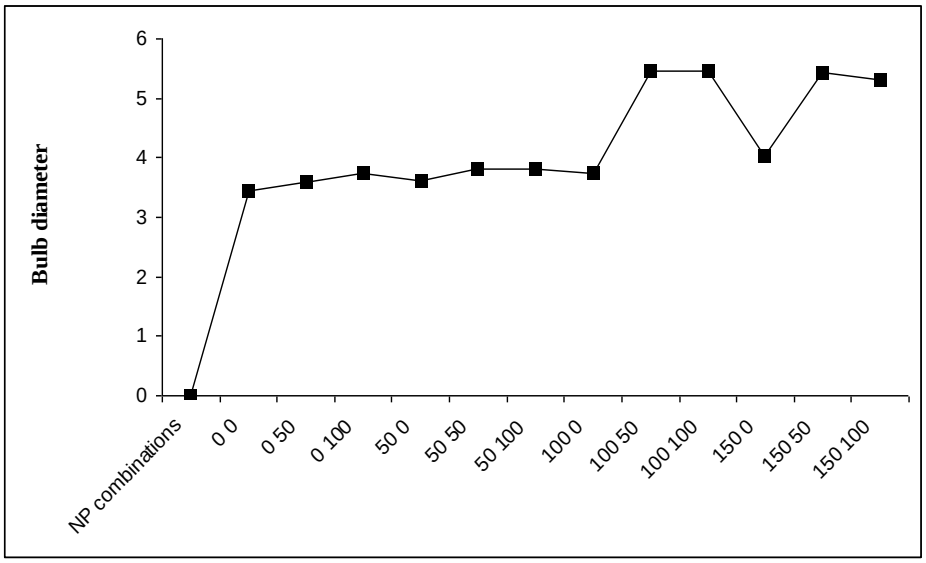

Figure 1: Interaction effect of nitrogen and phosphorus on bulb diameter (cm) of garlic varieties at Beressa during 2010-11

weight (g plant^{-1}), clove fresh weight (g plant^{-1}), bulb dry weight (g plant^{-1}) and bulb yield (t ha^{-1}) of garlic. The varietal difference was also observed significant for all the traits considered for the experiment. The results of the interaction effects of N and P were highly significant (P≤0.001) and bulb dry weight and bulb yield were also significantly (P≤0.05) and (P≤0.01) affected by interaction between variety, nitrogen and phosphorus (Table.1)

BULB Diameter

The interaction between N and P had a highly significant (P≤0.001) effect on the mean bulb diameter of garlic (Table.1). The bulb diameter at all N and P combinations (100:50), (150:50), (100:100) and (150:100) was significantly higher than that of control. The highest bulb diameter of 5.47cm was observed at N and P combination of 100:100 and it was at par with 100:50 (Figure 1). This result is in agreement with the findings of Aregawi (2006) and Gebrehawaria (2007) who reported asignificant effect of NP fertilizer combination on bulb diameter of garlic.The increment in bulb size of garlic in response to nitrogen and phosphorus application may be due to the fact that these two nutrients have synergistic physiological effect in plants.

Bulb Fresh Weight

The interaction between N and P showed a significantly (P≤0.001) increased mean bulb fresh weight (Table 1). Although most of the combinations had a similar trend of increment in average bulb weight, the lowest value (26.13g) was recorded from the unfertilized treatments, whereas, NP combinations increased the mean bulb fresh weight of garlic by 25 to 72% over the control (Figure 2). The highest bulb fresh weight per plant (44.85g) was recorded from treatment combinations of 100 kg N+100 kg P_2O_5 ha^{-1}. In line to this result, Aregawi (2006) and Hilman and Noordiyati (1988) reported a significantly increased bulb fresh weight of garlic in response to NP combination.

Clove Fresh Weight

Nitrogen and phosphorus interaction significantly (P≤0.01) affected the mean clove fresh weight (g bulb^{-1}) of garlic (Table 1). All the combinations had significantly

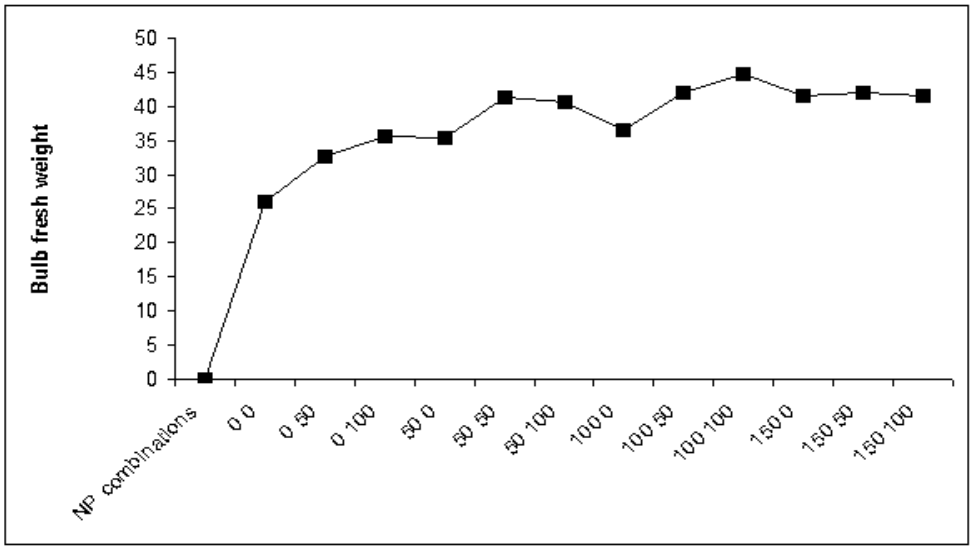

Figure 2: Interaction effect of nitrogen and phosphorus on bulb fresh weight (g) of garlic varieties Beressa during 2010-11

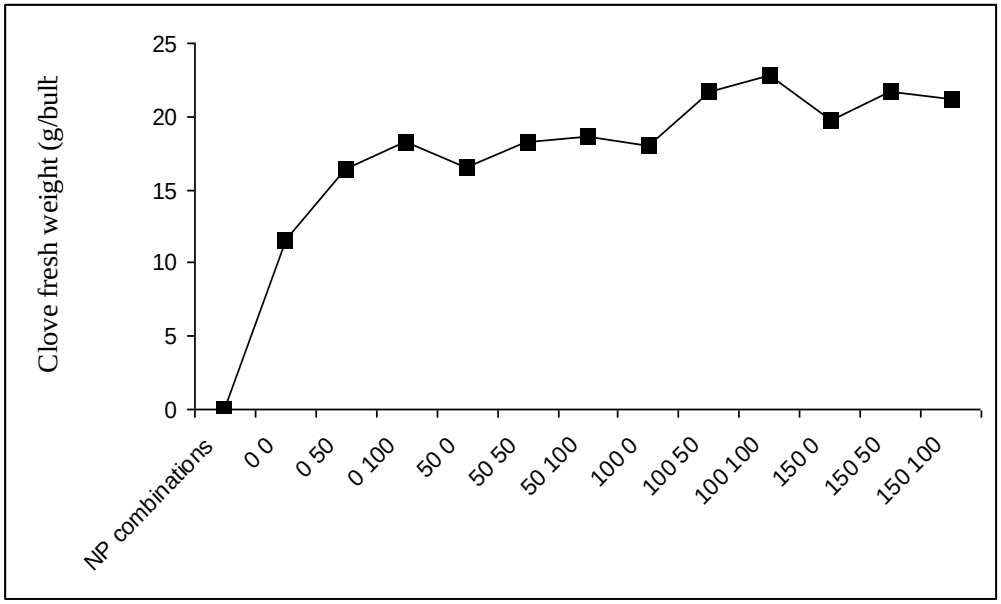

Figure 3: Interaction effect of nitrogen and phosphorus on clove fresh weight (g/bulb) of garlic varieties at Beressa during 2010-11

higher (42 to 96%) mean clove weight than unfertilized treatment (Figure 3). The highest value (22.77g bulb^{-1}) recorded at 100 kg N+100kg P_2 O_5 ha^{-1}whereas the lowest value (11.55g bulb^{-1}) was 0 kg N and 0 kg P_2 O_5 ha^{-1}combination. According to the international plant genetic resource institute, the average clove weight from NP combination is grouped under an intermediate to high (>15g) categories. Gebrehawaria (2007) also reported a significant effect of NxP interaction in clove number and weight of garlic and observed the highest clove weight at 120kg N +60 kg P ha^{-1}.

Bulb Dry Weight

The main effects of N and P was highly and significantly (P≤0.001) affected the bulb dry weight (g plant^{-1})of garlic (Table 1). Interaction effect of variety, nitrogen and phosphorus was significant (P≤0.05) on bulb dry weight of garlic at 110DAE. Variety Tsedey92 resulted in significantly higher bulb dry weight of 14.67g/bulb from combined application of 100 kg N and 50 kg P_2O_5 ha^{-1}, which was 171.7% higher than the dry weight of non fertilized

Table 2: Interaction effect of variety, nitrogen and phosphorus on bulb dry weight (g bulb^{-1}) of garlic at Beressa during 2010-11.

Bulb dry weight (gbulb^{-1}) at 110DAE					
Variety	P_2O_5 (kg ha^{-1})	N rate (kg ha^{-1})			
		0	50	100	150
Local	0	5.47^{i}	8.85^{gh}	12.02^{cd}	11.86^{cd}
	50	8.63^{h}	11.77^{c-e}	12.69^{bc}	12.27^{c}
	100	10^{fg}	11.5^{c-e}	12.20^{c}	11.71^{c-e}
Tsedey92	0	5.4^{i}	10.83^{d-f}	11.61^{c-e}	12.13^{cd}
	50	9.1^{gh}	12.27^{c}	14.67^{a}	12.52^{bc}
	100	10.52^{ef}	12.56^{bc}	13.75^{ab}	12.55^{bc}
CV%			**5.69**		

Table 3: Interaction effect of variety, nitrogen and phosphorus on bulb yield of garlic at Beressa during 2010-11

Bulb yield of garlic (t/ha)					
Variety	P_2O_5 (Kg ha^{-1})	N rate (kg ha^{-1})			
		0	50	100	150
Local	0	0.67^{j}	1.42^{g-i}	1.88^{fg}	2.31^{d-f}
	50	1.17^{hi}	1.62^{gh}	2.15^{ef}	2.44^{de}
	100	1.85^{fg}	2.37^{de}	2.76^{cd}	2.55^{c-e}
Tsedey92	0	0.97^{ij}	1.39^{g-i}	1.47^{gh}	2.80^{b-d}
	50	1.60^{gh}	1.56^{gh}	3.27^{ab}	3.03^{a-c}
	100	1.60^{gh}	1.66^{gh}	3.34^{a}	3.04^{a-c}
CV%			**13.18**		

treatment. But it was statistically similar to some other treatment combinations. The mean bulb dry weight of the local (farmers') variety was higher by 115.2% from the combined application of 50 kg N and P_2O_5 each than the non fertilized treatments and it was statistically similar to some other combination of the two nutrients (Table 2). In the early growth period, the dry matter of bulb was very low but progressively enhanced at harvest. The reason for this could be attributed to the process of translocation, which is the most important stage in which photosynthates are translocated to the sink (bulb) (Bertoni*et al*. 1992).

Total Bulb Yield per Hectare

Interaction effect of variety, nitrogen and phosphorus significantly (P≤0.01) increased the bulb yield of garlic (Table 1). The variety Tsedey92 resulted in significantly higher mean bulb yield of 3.27 t ha^{-1} from the application of 100 kg N and 50 kg P_2O_5 ha^{-1}, which was 237% higher than that of unfertilized plots. Moreover, the highest garlic production of 3.34 tha^{-1} was obtained with this variety by application of 100 kg N + 100 kg P_2O_5ha^{-1} but it was statistically at par yield produced with 100 kg N + 50 kg P_2Oha^{-1} (Table 3). On the other hand, the local (farmers') variety resulted in highest bulb yield of 2.76 t ha^{-1} from combined application of 100 kg N and 100 kg P_2O_5 resulting in 311 % more over the unfertilized plots. This yield was statistically at par to yield obtained with some other combinations of N and P inputs. Without P_2O_5 application, bulb yield of Tsedey92 increased 0.97 to 2.8 t ha^{-1} when the level of applied N increased from 0 to 150 kg ha^{-1} while it was increased 0.97 to 1.6 t ha^{-1}without N at 50 kgP_2O_5 application and further increase in P had no

effect. Similarly, without P_2O_5 application, the bulb yield of the local (farmers') variety increased from 0.67 to 2.31 t ha^{-1} as the level of N application increased zero to 150 kg ha^{-1} while it was increased 0.67 to 1.85 t ha^{-1} under no N applied. In general, higher mean bulb yield of garlic was obtained from the application of 100 kg N and 50 kg P_2O_5 ha^{-1} for Tsedey92 and 100 kg N and 100 kgP_2O_5 for local variety (Table 3).The increment in bulb yield due to nitrogen and phosphorus combination might be associated to the synergistic effect of the two nutrients on photosynthetic activity, translocation of assimilates and more absorption of nutrients by the plants (Marschner, 1995) and the difference between the two varieties in response to the applied fertilizer could be attributed to the genotypic variability (Kassahun 2006).Phosphorus uptake is enhanced by N (Mengel and Kirkby, 1996), and its application promotes vegetative growth as the result more leaves were produced and assimilatory surface would increase so as to enhance the physiological activity, which leads to the production of more assimilates and consequently resulting in higher bulb yield.

CONCLUSION

Selection of best variety with appropriate nutrient management are very important factors to improve the quality and productivity of garlic and the present study indicated that varieties significantly differed almost for all the parameters considered for this experiment and application of N and P fertilizers in combination significantly influence bulb fresh weight, mean clove fresh weight, bulb diameter and the interaction between variety, nitrogen and phosphorus were also significant for bulb dry weight and bulb yield of garlic. The maximum bulb yield of 3.34 t ha^{-1} was obtained from Tsedey92 in combination with nitrogen and phosphorus (P_2O_5) at 100 kg ha^{-1} of each and was statistically similar to the value from treatment combination ,Tsedey92 (100 kg N+50 kg P_2O_5). Hence, considering the overall results, the combination of variety Tsedey92 and application of 100 kg N and 50 kg P_2O_5 $ha^{-1}$was recommended for the study area to improve garlic productivity.

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