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Evaluating the Role of Nitrogen and Phosphorous on the Growth Performance of Garlic (*Allium sativum* L.)

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ABSTRACT

Garlic is a potential vegetable crop in Ethiopia in general and in Jimma area in particular. However, there is no much information on the agronomic practice especially on the role of nutrient application in improving the growth and development of Garlic. This study was conducted to elucidate the role of nitrogen and phosphorous nutrients on the growth performance of local garlic variety called Minjar Nech Shinkurt. Four nitrogen doses (0, 50, 100 and 120 kg N ha^{-1}) and four phosphorus doses in the form of P_2O_5 (0, 60, 120 and 180 kg P_2O_5 ha^{-1}) used to create different level of growth parameters. The plots were arranged in Randomized Complete Block Design (RCBD) with three replications. Growth parameters such as plant height, leaf number per plant and leaf length were recorded and analyzed by using JMP statistical software. The results of the study showed that application of 100 kg N ha^{-1} + 120 kg P_2O_5 $ha^{-1}$and 100 kg N ha^{-1} + 130 kg P_2O_5 ha^{-1} significantly increased the growth of garlic than other treatments. The application rate of 100 kg N ha^{-1} + 120 kg P_2O_5 ha^{-1} significantly enhanced plant height. This study further confirms the role of nitrogen and phosphorus fertilizers in increasing growth in garlic production. From the result of the study, application rate of 100 kg N ha^{-1} + 120 kg P_2O_5 ha^{-1} may be recommended for increasing growth of garlic. Further study is being conducted to compare the role of chicken manure, animal and green manure with the commercial chemical fertilizers on the growth performance and yield of garlic.

Key words: Garlic, nitrogen, phosphorous, growth performance

INTRODUCTION

Garlic (*Allium sativum* L.) is among the most important bulb vegetable which is used as spice and flavoring agent for foods (Velisek *et al*., 1997). It is widely used around the world for its pungent flavor as a seasoning or condiment. It is a fundamental component in many or most dishes of various countries in the world including Ethiopia. Garlic adds a taste to foods as well as it helps to make them more palatable and digestible. It is an important ingredient in the leading cuisine around the world. In Ethiopia, garlic is used while preparing foods, particularly some kinds of stew and in making dried foods for storage (Rubatzky and Yamaguchi, 1997).

All part of the plant has a use. The cloves are used as seed, for consumption (raw or cooked) and for medicinal purposes. The leaves, stems (scape) and flowers (bulbils) on the head (spathe) are also edible and are most often consumed while immature and still tender. The papery, protective layers of "Skin" over various parts of the plant and the roots attached to the bulb are the only parts not considered palatable (Kero, 2010).

Garlic contains different useful minerals, vitamins and many other substances used for health of human beings. It also contains more than 200 chemical compounds such as allicin, alliin and ajoene, allinase, peroxidase and myrosinase. Allicin is what gives garlic its antibiotic properties and is responsible for its strong odor. Ajoene contributes to the anticoagulant action of garlic. Thus, garlic can rightfully be called one of nature's wonders because it inhibits and kills bacteria, fungi, parasites, lower blood pressure, blood cholesterol and blood sugar, prevents blood clotting, protects the liver and exhibits anti-tumor properties (Sovova and Sova, 2004).

Garlic is the second most widely cultivated *Allium* species in Ethiopia next to onion. Adet, Ambo, Debre-Work, Sinana, Jimma and many other areas of the Ethiopian highlands produce the bulk of garlic under the small-scale farmers sector. In Jimma, south eastern Ethiopia, farmers produce garlic under rain fed condition during both winter (August-December) and summer (March-July) cropping seasons for consumption and commercial purpose (Getachew and Asfaw, 2000).

According to the central statistical authority of Ethiopia (CSA, 2003), the average yield of garlic production in Oromia region is 120.82 qt ha^{-1}. But the average yield of garlic production in Jimma area is 84.10 qt ha^{-1}. This indicates that average yield of garlic production in Jimma area is still low compared to the average garlic production in the Oromia region.

There are many biotic and abiotic factors that contribute for the low productivity of garlic in Ethiopia. Some of the major causes of low garlic yield are declining soil fertility, insufficient and inefficient use of fertilizers resulting in severe nutrient depletion in the soils, inappropriate agronomic practices, absence of proper pest and disease management practices etc (Teweldebrhan, 2009; Worku and Dejene, 2012). Among these factors, in appropriate agronomic practice especially fertilizing and garlic rust which is caused by *Puccinia allies*, are the major problems in almost all garlic producing regions of Ethiopia (Tesfaye and Habtu, 1986).

Garlic is heavy feeder and most of the *Allium* species have low nutrient extraction capacity than most crop plants because of their shallow and un-branched root system. It has a high fertilizer requirement with banding being a preferable application method (Brewster, 1997).

Availability of nitrogen is of prime importance for growing plants as it is a major and indispensable source of protein and nucleic acid molecules (Naruka *et al.*, 2005).

Phosphorus is also a key element for vegetables as it stimulates the root formation and centre for the components of nucleic acid. Inappropriate application rate of phosphorus affects the growth and development of plant and the bulb formation (Cantwell *et al.*, 2006).

A number of studies in various part of the world have shown that garlic production can be increased through appropriate cultural practice. Unfortunately there is a dearth of information on garlic production and productivity in Ethiopia.

It is in view of this basis that this study was undertaken aiming at exploring the opportunities to improve the productivity of the crop through the choice of appropriate levels of nitrogen and phosphorus fertilizers that contribute to maximize the growth performance, development and yield of garlic.

MATERIALS AND METHODS

Description of the study area: The experiment was conducted at Jimma University, College of Agriculture and Veterinary Medicine, Horticultural farm, located in Jimma zone, Oromia Regional State, South Western Ethiopia, 346 km from Addis Ababa at about 7° 46'N and 36° 57' E geographical location. The elevation of the area is 1750 m.a.s.l. Mean annual rain fall is1750 mm

Table 1: Fertilizer treatment used in this study

Treatment code	Treatment
T1	Control
T2	50 kg N ha^{-1} + 25 kg P(60 kg P_2O_5 ha^{-1}
T3	50 kg N ha^{-1} + 50 kg P(120 kg P_2O_5 ha^{-1}
T4	50 kg N ha^{-1} + 60 kg P(130 kg P_2O_5 ha^{-1}
T5	100 kg N ha^{-1} + 25 kg P(60 kg P_2O_5 ha^{-1}
T6	100 kg N ha^{-1} + 50 kg P(120 kg P_2O_5 ha^{-1}
T7	100 kg N ha^{-1} + 60 kg P(130 kg P_2O_5 ha^{-1}
T8	120 kg N ha^{-1} + 25 kg P(60 kg P_2O_5 ha^{-1}
T9	120 kg N ha^{-1} + 50 kg P(120 kg P_2O_5 ha^{-1}

N: Nitrogen, P: Phosphorous, kg: Kilogram, Nitrogen and phosphorus sources used for the experiment were urea and diammonium phosphate (DAP), respectively

from April to October. The maximum and minimum temperature of the area is 14 and 26.8°C where as, the minimum and maximum relative humidity is 39.92 and 91.4%, respectively. The dominant soil type in the area is notisol (reddish brown clay soil) (BPED, 2000).

Experimental design: The experiment was laid out in a Randomized Complete Block Design (RCBD). There were nine treatments (Table 1) replicated three times.

Planting and cultural practices: Garlic variety locally called "Minjar Nech Shinkurt" was collected from the local farmers around Jimma town. The cloves were soaked with water before sowing. Two cloves were planted per hole at a spacing of 12×25 cm. Garlic seedlings were later thinned to one plant per stand. The treatments (nitrogen and phosphorus nutrients at different doses) were applied two weeks after planting through side placement.

Weeds were controlled through hand weeding to reduce competition for space, water, light and nutrients between the crops and weeds. The field borders were kept clean to minimize encroachment by insects and rodents.

Data collection: Growth related parameters such as plant height, leaf number per plant and leaf length were recorded at different stages of crop growth and development. Garlic crop is characterized by three growth stages; sprouting stage (20-30 days from sowing, Shoot growth stage; from the end of sprouting until 40 Days After Sowing (DAS) and Bulb growth stage, during the inductive stage (from sprouting up to 90 days and during morphogenetic stage (80-170 DAS) and Harvest (Maturity stage) (Arguello *et al.*, 2000).

Data collection started three weeks after the treatments were applied. The data was recorded at three growth stages of the plant at sprouting stage, shoot growth stage and bulb growth stages.

The parameters were determined in the following ways:

- **Plant height:** This was taken from a sample of nine randomly selected garlic plants marked within each plot. A ruler was used for measuring the height from the ground level to the top-most leaf. The mean from the nine plants was then determined
- **Number of leaves per plant:** Visual counting of leaves on the nine randomly selected plants was made and the number was recorded for each plant. The mean values were then calculated for each plot

- **Leaf length:** This was again taken from nine randomly selected garlic plants marked within each plot. A ruler was used for measuring the length from the point leaf attached to its leaf sheath up to the end tip of the leaf. The mean from the nine plants was then determined

Statistical analysis: The raw data of each parameter from each plot and replication was recorded and analyzed using analysis of their variance (ANOVA). The data was analyzed using SAS software. Fisher's distribution (F-calculated) was calculated from the data. Probability of 5% was used to calculate the tabulated value of F (F-tab) and committing of type one error. The treatment means were separated using the Least Significant Difference (LSD) at 5% level of probability.

RESULTS

Applications of nitrogen and phosphorus nutrients didn`t significantly affect the growth of garlic at sprouting and shoot growth stage (Table 2). But, as the nutrients became used by the plants from the soil, the effect of the nutrients became plain.

Plant height: The data recorded in Table 2 showed that plant height increased across the treatments at all stages of growth. At 3 and 5 Weeks After Planting (WAP), there were no significant differences in the plant heights among the treatments. However, at 7 Weeks After Planting (WAP), plant heights were significantly affected by the different rates of nutrient combinations. The minimum plant height was recorded in the control (zero) plot (T1). Plant height at 7 weeks after planting ranged from 6.70 cm in the control (T1) to 17.20 cm in T6 (100 kg N ha^{-1} + 120 kg P_2O_5 ha^{-1}).

No. of leaves: The results presented in Table 3 showed the trend observed in the number of leaves produced by the plants at different stages of growth. The number of leaves increased across the treatments at all stages of growth. But, at all weeks (3, 5 and 7 weeks after planting), there were no significant differences in the number of leaves per plant among the treatments.

Table 2: Effect of different rates of nitrogen and phosphorus on plant height (cm)

		Weeks after planting		
Treatment code	Treatment	3	5	7
T1	Control	3.4	4.53	6.70^{c}
T2	50 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1}	3.5	5.10	10.86^{b}
T3	50 kg N ha^{-1} + 120 kg P_2O_5 ha^{-1}	3.1	6.10	12.39^{b}
T4	50 kg N ha^{-1} + 130 kg P_2O_5 ha^{-1}	3.3	5.77	13.15^{ab}
T5	100 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1}	3.2	5.50	13.06^{b}
T6	100 kg N ha^{-1} + 120 kg P_2O_5 ha^{-1}	3.8	5.87	17.20^{a}
T7	100 kg N ha^{-1} + 130 kg P_2O_5 ha^{-1}	3.3	5.67	13.26^{ab}
T8	120 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1}	3.2	5.20	13.28^{ab}
T9	120 kg N ha^{-1} + 120 kg P_2O_5 ha^{-1}	3.2	5.43	10.65^{bc}
Significance		NS	NS	**
LSD		-	-	4.05
CV (%)		20	13	18.97
SE (±)		0.13	0.136	0.45

**Highly significant, CV: Coefficient of variance, SE: Standard error, NS: Non significant, Means with different letters are significantly different at 5% level of probability

Table 3: Effect of different rates of nitrogen and phosphorus on number of leaves

		Weeks after planting		
Treatment code	Treatment	3	5	7
T1	Control	5.0	6.33	7.33
T2	50 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1}	5.2	7.00	9.30
T3	50 kg N ha^{-1} + 120 kg P_2O_5 ha^{-1}	5.3	7.23	9.67
T4	50 kg N ha^{-1} + 130 kg P_2O_5 ha^{-1}	4.9	7.10	9.67
T5	100 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1}	5.4	7.33	9.71
T6	100 kg N ha^{-1} + 120 kg P_2O_5 ha^{-1}	5.6	7.23	10.15
T7	100 kg N ha^{-1} + 130 kg P_2O_5 ha^{-1}	5.1	7.23	10.19
T8	120 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1}	5.1	6.33	9.85
T9	120 kg N ha^{-1} + 120 kg P_2O_5 ha^{-1}	5.1	7.57	8.59
Significance		NS	NS	NS
LSD		-	-	-
CV (%)		11.4	8.5	12
SE (±)		0.11	0.115	0.21

CV: Coefficient of variance, SE: Standard error, NS: Non significant, Means sharing common letters are statistically similar at 5% level of probability

Table 4: Effect of different rates of nitrogen and phosphorus fertilizers on leaf length (cm)

		Weeks after planting		
Treatment code	Treatment	3	5	7
T1	Control	26.3	31.67	30.57^{d}
T2	50 kg Nha^{-1} + 60kg P_2O_5 ha^{-1}	30.8	39.33	42.65^{b}
T3	50 kg Nha^{-1} + 120 kg P_2O_5 ha^{-1}	32.1	39.83	48.37^{a}
T4	50 kg Nha^{-1} + 130 kg P_2O_5 ha^{-1}	27.1	37.37	47.68^{a}
T5	100 kg Nha^{-1} + 60 kg P_2O_5 ha^{-1}	28.5	35.47	47.69^{a}
T6	100 kg Nha^{-1} + 120 kg P_2O_5 ha^{-1}	30.5	35.10	47.43^{ab}
T7	100 kg Nha^{-1} + 130 kg P_2O_5 ha^{-1}	28.5	35.90	49.26^{a}
T8	120 kg Nha^{-1} + 60 kg P_2O_5 ha^{-1}	32.3	34.53	45.96^{ab}
T9	120 kg Nha^{-1} + 120 kg P_2O_5 ha^{-1}	31.8	36.57	37.17^{c}
Significance		NS	NS	**
LSD		-	-	4.87
CV (%)		14.44	9	6.35
SE (±)		0.82	0.63	0.54

**Highly significant, CV: Coefficient of variance, SE: Standard error, NS: Non significant, Means sharing common letters are statistically similar at 5% level of probability

Leaf length: The results presented in Table 4 showed that the effect of different rates of nitrogen and phosphorus fertilizers on leaf length of garlic. Accordingly, at 3 and 5 weeks after planting, there were no significant differences in the leaf length among the treatments. However, at 7 weeks after planting, leaf length was significantly affected by the different rates of nitrogen and phosphorous application. The highest leaf length was recorded in T7 (100 kg N ha^{-1} + 130 kg P_2O_5 ha^{-1}), whereas, the minimum leaf length was recorded in the control plot (T1). Leaf length at 7 weeks after planting ranged from 30.57 cm in the control (T1) to 49.26 cm in T 7 (100 kg N ha^{-1} + 130 kg P_2O_5 ha^{-1}).

DISCUSSION

The results obtained from this study showed that different application rates of nitrogen and phosphorous nutrients significantly improved growth of garlic. The growth was mostly supported with application rates of 100 kg N ha^{-1} + 120 kg P_2O_5 ha^{-1} and 100 kg N ha^{-1} + 130 kg P_2O_5 ha^{-1}. This was evident in the plant height and number of leaves produced. It can be observed that number of leaves per plant tended to increase as nitrogen dose increased. The maximum number of leaves was produced with the application rate of 100 kg N ha^{-1} + 130 kg P_2O_5 ha^{-1}. This can be attributed to the fact that nitrogen promotes vegetative growth in garlic (Naruka *et al*., 2005).

Availability of nitrogen is of prime importance for growing plants as it is major and indispensable constituent of protein and nucleic acid molecules. It is an integral part of chlorophyll molecules which are responsible for photosynthesis. An adequate supply of nitrogen is associated with vigorous vegetative growth and more efficient use of it finally leading to higher productivity. The findings of this investigation are in close conformity with those findings demonstrated by Naruka and Dhaka (2001), Yadav (2003) and Naruka *et al*. (2005).

Similarly, application of 130 kg P_2O_5 ha^{-1} significantly increased yield attributes like plant height and leaf length compared to the lower doses of phosphorus. Phosphorus is a key element for vegetables which stimulate the root formation and centre for the components of nucleic acid. Inappropriate application rate of phosphorus affects the growth and development of plant and the bulb formation. Too low application of phosphorus dwarfs the garlic plants. The findings of this investigation are in close agreement with Cantwell *et al*. (2006).

CONCLUSION AND RECOMMENDATION

This study further confirms the role of nitrogen and phosphorus elements in increasing growth in garlic performance of garlic plants. From the result of the experiment, the application rate of nitrogen and phosphorus significantly influenced the growth of garlic.

This was evident particularly in plant height and leaf length of the plant. However, application rate of nitrogen and phosphorous elements has no prominent effect on the number of leaves as it is the nature of the plant to produce leaves even though the size of the leaf is different.

From the result of the experiment, application rate of 100 kg N ha^{-1} + 120 kg P_2O_5 ha^{-1} can be recommended for increasing growth of garlic particularly in notisols. However, application of 50 kg N ha^{-1} + 120 kg P_2O_5 ha^{-1} can also bring about an increase in the growth of garlic. This will greatly benefit farmers in area where supply of nitrogen fertilizer is low or in cases where farmers cannot afford the cost of high fertilizer input.

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