ACTA SCIENTIFIC AGRICULTURE (ISSN: 2581-365X)

Volume 4 Issue 3 March 2020

Research Article

Effects of Nitrogen and Phosphors Fertilization on Growth Performance of Garlic (*Allium sativum* L.) In Wolaita Zone, Ethiopia

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Received: January 11, 2020

Published: February 19, 2020

Abstract

Garlic (*Allium sativum* L.) is the second most important *Allium* species next to common onion. Garlic is widely recognized as an important cash crop in Ethiopia. It is one of the most important bulb vegetables, which is used as spice and flavoring agent for foods and as medicinal plant. Proper rate of fertilizer rate are very important factors to increase the productivity and marketability of garlic. It is successfully produced under rain fed as well as irrigated conditions in different climatic regions of the country for dry bulb by farmers and commercial growers in Ethiopia. It is widely sold in the local and export markets. The experiment was conducted, Wolaita during April – June in 2017. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data were collected on growth parameters analyzed using SAS 9.1 computer software. The experiment consisted of four treatments. The treatments were four levels of NP 52.5: 46 kg/ha, 105: 92 kg/ha, 157: 92 kg/ha and 0: 0 kg/ha.

Application of different levels of NP fertilizer rates exhibited significant influence on the growth parameters of local garlic variety at 50 days after planting. The maximum plant height (44.14 cm) and leaf length (41.14 cm) were obtained at the application of 157:92 kg ha^{-1} $N:P_2O_5$ from the treatment (T3) whereas the maximum number of leaf per plant (6.36 cm) and the widest leaf width (1.67 cm) were obtained at the application of 105:92 kg ha^{-1} $N:P_2O_5$ from the treatment (T2) at 70 days after planting. From this study it can be concluded that different NP fertilizer rates at 70 days after planting can be used for maximum growth parameters of local garlic variety in the study area Wolaita Zone, Southern Ethiopia. In order to come up concrete recommendation the experiment should be further repeated in similar experiment up to yield.

Keywords: N,P Fertilizer Rate; Garlic; Growth Parameter

Introduction

Garlic (*Allium sativum* L.) is the second most important *Allium* species next to common onion (*Allium cepa* L.) [1,2]. It is grown worldwide in all temperate to sub tropical areas as an important spice and medicinal plant [3]. Etoh and Simon [4] reported that garlic is originated on the northwestern side of the Tien-Shan Mountains of Kirgizia in the arid and semi arid areas of central Asia (Kazakhstan). It is more tolerant to cold than common onion [4,5]. It is one of the most ancient cultivated herbs and is vegetatively propagated from cloves. This mode of clones' propagation allows the production of a uniform crop that preserves quality traits, such as flavour and the nutritive properties of the plant (Iblibner, 1989; Salomon, 2002). The garlic bulb consists of numerous cloves, which is the main economic organ consisting largely of swollen, bladeless storage leaves. Although bolting occurs some times, seeds do not form [4,6,7].

Garlic is primarily grown for its cloves used mostly as a food-flavouring condiment. Green tops are eaten fresh and or cooked.

In tropical areas consumption of immature bulbs for saladuse is also popular [3,5,7,8]. Garlic is one of the best-studied medicinal plants that its antibacterial and antiseptic property is well known. The use of garlic was well documented by the Egyptians, Greeks and Romans. Garlic contains remedies, which were applied against heart problems, headache, bites, worms and tumours (Keusgen, 2002) and as a herbal remedy reduces a multitude of risk factors which play a decisive role in the genesis and progression of arteriosclerosis [2,7]. Brewster [2] reported that many actions associated with garlic supplements may help prevent or potentially alleviate arteriosclerosis (inhibit the aggregation of human blood platelets to form the clots which have the potential for arterial blocking which narrow arteries). Garlic has been demonstrated to kill parasites including amoeba and hookworm in test tubes and animals (WWW. healthnotes.com, 2002).

Garlic's active 2 constituents have also been shown to kill HIV in the test tube, though these results have not been confirmed in human trials (WWW. healthnotes.com, 2002). In one study, administration of an aged garlic extract reduced the number of infections and relieved diarrhoea in a group of patients with aids (WWW. Virtual health. LLC, 1998). The world garlic cultivation was increased from 771,000 ha (hectare) in 1989-91 to 1,126,000 ha of land in 2002 with total production of 6.5 million and 12.1 million tons respectively. The major producing countries are China, India and Korea Republic (FAO, 2003). In Ethiopia the *Alliums* group (onion, garlic, and shallot) are important bulb crops produced by small and commercial growers for both local use and export [9,10]. These crops are produced for home consumption and as a source of income to many peasant farmers in many parts of the country [10,11]. Metasebia and Shimelis [10] reported that the per capita consumption of these crops is estimated to be over 1.74 kg and 5.9 kg in the rural and urban centre, respectively. Statistics on the production of *Allium* crops showed that about 15,290 ha of land was cultivated and 0.21 million tons of bulbs were produced in the year 2001/2002 [12].

The production is spread throughout the country both under irrigation and rainfed conditions in different agro climatic regions [12]. Next to onion, garlic is the most widely used crop among cultivated *Allium* species in Ethiopia and it has a wide range of climatic and soil adaptation [13]. Of the total production of *Alliums* in the country the area coverage of garlic in 2001/2002 was 4,802 ha, and total production was about 70,471 tons of bulbs [12] and produced by 713,062 landholders [12].

Garlic accounts for 0.06% of area and 0.62% of yield from the total private peasant holdings of 'Meher' season temporary crops in the country. In 2003/2004, CSA (2004) reported that national garlic cultivated land was 9,465 ha owned by 1.07 million landholders. Among vegetable crops it ranks fourth in the number of landholders next to Ethiopian cabbage (2.23 million landholders), red peppers (1.30 million landholders), and potatoes (1.15 million landholders). Garlic is produced mainly in the mid and high lands of the country [11,12] and the bulk of garlic for domestic market is produced in homestead 3 gardens of subsistence farmers. The crop is produced mainly as a cash crop to earn foreign currency by exporting to it Europe, the Middle East and USA. It had also been under commercial production by Horticultural Development Corporation at Debre Zeit, Guder and Tseday State Farmers [11]. Planting larger cloves of garlic will produce larger bulbs than planting smaller cloves; and the size of bulbs harvested is directly related to the size of cloves planted and the spacing of plants (WWW.sfc.ucdavis.edu, 2005). Bulb yield increases with plant density and this has been shown to correlate with the percentage light interception by the crop leaf canopy [12]. In Wolaita sodo, garlic is produced in the highlands and mid altitudes both for home consumption and for local market as a source of cash (Alemu, 1998). The production activities are carried using local cultivars and planting is done in closer spacing with or without addition of organic fertilizer. The size of cloves used varies because planting is done on the available clove size at hand. Farmers are not well aware of the different agronomic practices influencing yield. The use of inappropriate clove size and planting density, NP fertilizer rate could reduce yield considerably. There is shortage of information on specified planting density for different clove weight (size) of the crop in Ethiopia that can greatly help to increase garlic production. Considering the importance of garlic as one of the potential vegetable crops for both domestic consumption and export, it is imperative to increase its productivity along with appropriate planting size, NP fertilizer application and plant density. Therefore, there is need to identify the optimum NP fertilizer, planting and spacing (both between row and plant spacing) for optimum bulb yield and quality.

Statement of the problem

Garlic has a great economic value crop through the world. As a result its demand is increasing from time to time. To balance this demand the world Garlic production should increased. As it was listed in the introduction parts, In Ethiopia the *Alliums* group (onion, garlic, and shallot) are important bulb crops produced by small and commercial growers for both local use and export [9,10]. These crops are produced for home consumption and as a source of income to many peasant farmers in many parts of the country [10,11]. Metasebia and Shimelis [10] reported that the per capita consumption of these crops is estimated to be over 1.74 kg and 5.9 kg in the rural and urban centre, respectively. Statistics on the production of *Allium* crops showed that about 15,290 ha of land was cultivated and 0.21 million tons of bulbs were produced in the year 2001/2002 [12]. The production is spread throughout the country both under irrigation and rain fed conditions in different agro climatic regions [12]. In Awable woreda, garlic is produced both for home consumption and for local market as a source of cash (Alemu, 1998).

The production of Garlic in wolaitasodo 60 quntal/ha and 100 kg DAP fertilizer use as get the information from Wolaita agricutural institution. The production activities are carried using local cultivars and planting is done in closer spacing with or without addition of organic fertilizer. The size of cloves used varies because planting is done on the available clove size hand. Farmers are not well aware of the different agronomic practices influencing yield. The use of inappropriate clove size and planting density, NP fertilizer rate could reduce yield considerably. There is a flow of ideas on specified planting density for different clove weight (size) of the crop in Ethiopia that can greatly help to increase garlic production. Considering the importance of garlic as one of the potential vegetable crops for both domestic consumption and export, it is imperative to increase its productivity along with appropriate planting size, NP fertilizer application and plant density. Therefore, there is need to identify the optimum NP fertilizers:

Objective

- To evaluate the effects of nitrogen and Phosphors fertilizer rates on growth performance of garlic.
- To determine the optimum amount of nitrogen and phosphors rates best growth performance of garlic.

Literature Review

Garlic crop

Garlic (*Allium sativum* L.) is the second most important *Allium* species next to common onion [2]. It is grown world-wide in all temperate to sub-tropical areas as an important spice and medicinal plant [3]. Dehydrated garlic and extracts are fast replacing fresh bulbs for industrial and home usage in the production of drugs, insecticides and explosives [5]. Garlic resembles the common onion in its size and growth but differs in producing cloves and having flat leaves rather than one large bulb and round hallow leaves of onion. Garlic mutates relatively easily; over time it may adapt to new environments becoming somewhat different from the garlic originally introduced to an area [14].

Environmental requirements and cultural practices

Garlic grows best within the warmer geographic areas receiving 600-700 mm annual rainfall with a mean monthly growing temperature ranging from 12 to 24°C [15]. Excessive humidity and rainfall are detrimental to both vegetative growth and bulb formation. The crop is, therefore, normally grown in low rainfall areas with irrigation during the early vegetative growth. In most areas, elevations ranging from 500-2000m above sea level (masl) provide suitable growing conditions particularly during dry periods [16]. Any soil that produces onion will do well for garlic production [15]. Fertile, well-drained sandy or silt loams with organic matter added to improve water holding capacity are preferred [7,8,15,16]. Soil pH ranging from 6 to 7.2 is ideal [15]. The garlic bulb consists of numerous cloves, which are the main economic organs for consumption and propagation. Although bolting occurs sometimes, seeds do not form [4,6,7]. While it is possible to propagate garlic sexually, all of the garlic commonly grown is propagated vegetatively from cloves of the bulb. The cloves should be planted right side up with base down [7]. Bulbs stored for planting should be maintained between 5 and 10°C [15]. Medium to large cloves should be selected as planting materials being detached individually during planting from fully matured and well-developed bulbs [17]**.** Garlic is often planted in raised beds for ease of digging, good soil drainage, and reduction of soil compaction [18].

In temperate regions, the crop is generally planted in the fall or early winter and bulbs are harvested during the summer. Garlic cloves require a period of 6-8 weeks of cool weather after planting to vernalize the plant so that it will form bulbs [6,7,19]. New cloves develop from the lateral buds in the leaf axils of foliage leaves of the clove used for propagation. Garlic is known to be thermo-photosensitive crop and its vegetative growth and bulb development are greatly influenced by growing environment [20]. Manipulation of growing environment by cultural practices has the potential to improve yield [21].

Bulbing occurs as in onion, with lengthening of the photoperiod and increasing temperature up to 25°C. However, in the case of garlic, during the clove formation period, bulbing influenced by the temperature of the stored dormant cloves as well as during plant growth before clove formation begins [15]. As soon as bulbing starts, leaf initiation ceases. For highest yields, therefore, the cloves must be planted early enough to permit the development of large vegetative plants during the short cool days of late winter [14]. Proper bulbing is therefore a function of adequate growth, vernalization and subsequent growth under longer days. Bulb and clove size is related to the amount of vegetative growth that takes place before bulb and clove initiation occurs. Yield and quality of garlic bulbs vary with climate, region, altitude, soil type and pH, cultural practices and variety of garlic (Engeland, 1991). Bulbs begin to mature in 4-6 months in temperate areas [15] and 4 months in the tropics [8] after planting. The garlic plants are ready for harvest when the tops begin to dry out and collapse. Indices for maturity are softening of the main stem above the bulb and the yellowing of 75% of the leaves [19] before they are completely dry. After harvest, the bulbs should be cured or dried for 8 - 10 days before either marketing or storage to prevent deterioration [16]. When the outer skins are dry and crispy, the garlic is ready for storage or sale. Largest mature and best-formed bulbs may also be braided into garlic ropes. This coiled braided garlic, which are hanged at a place away from heat and light, may be used for the next planting [22]. The yield potential of the plant depends upon the amount of vegetative growth before bulbing commences. This determines optimum clove storage temperatures and associated growing temperatures and changing day length. After curing, garlic can stay 6 to 7 months without damage if it is stored at 0°C and 65 to 70% relative humidity. Good air circulation is essential.

Moisture requirement

Water needs are critical since rooting depth in garlic is shallow; therefore, soil water should be maintained near field capacity during most of the growing period with an even and consistent supply of water [22]. The most critical stage for watering is during bulbing. Lack of irrigation or rainfall during this stage will result in smaller bulbs and earlier maturity. Some studies indicated that 60% reduction in yield has been associated with water stress (Miko., *et al*. 2000). It is also sensitive to water logging [7] and prefers a slightly moist but not wet soil. If it stays too wet, diseases such as fungus and blight can set in. Garlic needs to be protected from those diseases by giving it the growing conditions it likes and avoiding those conditions that lead to problems. The soil moisture requirement of garlic is influenced by several factors such as crop variety, soil type and environmental factors. If the moisture content of the soil at the root level is below 50%, it is time to water the garlic (www.gourmet garlic gardens.com.2005).

Watering has to be Interrupted when the plants start to mature (tops fall over) during the last week or two before harvesting as it is easier to pull or dig garlic out of fairly dry soil than mud, and the garlic will store better. Excess water as the crop matures causes bulb splitting, delays curing and may cause storage problems [22]. Soil water deficits inhibit leaf expansion, which reduces the amount of solar radiation intercepted as well as uptake of nutrients, because of reduced transpiration rates [23]. In onions, rates of transpiration, photosynthesis and growth are lowered by mild water stresses (EL-Habbasha and Shaheen, 1976, Begum., *et al*. 1990). Stressed onion plants may bulb too early, produce small sized bulbs and bulb splits giving rise to reduced marketable yield (Brewster and Butler, 1989; Begum., *et al*. 1990; Hegde, 1998). Moisture is the most important soil factor in semi-arid and subtropical regions, where in adequate rainfall may frequently limit production. The major constraint to successful crop production in the dry land areas is water stress, which is caused due to low and erratic rains, high evapo-transpiration due to high temperature, shallow soil depth and low organic matter with poor water retention capacity. Therefore, soil moisture management should be a primary practice in areas where natural rainfall is too marginal to support full season crop growth (Kidane and Rezene, 1989). Therefore, it can be a vital factor in improving water use efficiency (Erenstein, 2003), moderating soil temperatures and minimizing excessively fluctuating temperatures in the winter and early spring (Rosen., *et al*. 2006. www.extension.umn.edu).

Nutrient requirements

Fertilizer requirements of a crop vary with fertility status of the soil, availability of soil moisture, variety of the crop, purpose for which the crop is grown, etc. The major factors determining the level of soil fertility are organic matter content, availability of major and micro nutrients, soil reaction and physical soil characteristics such as texture, structure, depth and nature of the soil profile (Tisdale., *et al*. 1995). The effects of these factors are expressed in terms of nutrient availability to plants and fertility requirements as well as the level of crop production. Both manure and chemical fertilizers have a potential role on the growth and development of crops. Mineral fertilizers of balanced dozes increased the leaf area, photosynthetic productivity and yield of garlic (Borabash and Kochina, 1989). Manure supplies all the essential nutrients as well as improves physical, chemical and biological properties of the soil and helps in boosting up production of garlic. Bulb crops are high value crops and their improved yield and quality are important economic considerations. Sullivan., *et al.* (2001) reported that nutrients supply interacted with other management practices, pest and climatic factors to affect quality and yield of onion. The *Allium* species have low nutrient extraction capacity than most crop plants because of their shallow and un-branched root system. Hence they require and often respond well to additional fertilizers [2].

Nitrogen, P and K are referred to as the primary macronutrients because of the general probability of plants being deficient in these nutrients and because of the large quantities taken up from the soil relative to the other essential nutrients (Marschner, 1995). Garlic has a moderate to high fertilizer requirement with banding being a preferable application method.

Among the primary macronutrients, N and P are the most commonly reported deficient plant nutrients in most Ethiopian soils [9,24].

Nitrogen

Nitrogen has been identified as being the most often limiting nutrient in plant growth. It is an important component of proteins, enzymes and vitamins in plants, and is a central part of the essential photosynthetic molecule, chlorophyll (Marschner, 1995). Plant demand for N can be satisfied from a combination of soil and fertilizer N to ensure optimum growth. Most crop plants take up both NH_4^+ and NO_3^- ions through the root system. Most uptake at normal soil pH levels for crop production occurs as nitrate due to the rapid conversion of ammonium to nitrate in the soil following application of any ammonium fertilizers (Archer,1988). Plants obtain readily available N forms from different sources which include: biological N-fixation by micro-organisms, mineralization of organic matter, industrial fixation of N gas and fixations of oxides of N by atmospheric electrical discharge (Tisdale., *et al*. 1995). The availability of N through biological fixation and mineralization is influenced by soil pH and its nutrient status, soil temperature, level of soil moisture and oxygen supply (Miller and Donanue, 1995; Tisdale., *et al*. 1995). The available form of N can be made unavailable or lost via plant uptake, immobilization, denitrification, volatilization, leaching and ammonium fixation (Tisdale., *et al*. 1995). The loss of available N through natural processes is believed to suppress the gain (Miller and Donanue,1995; Tisdale., *et al*. 1995). This fact has made fertilizer management an important aspect of crop production practices (Kleinkopf., *et al*. 1987). Consequently, N is applied relatively in large quantities all over the world (Miller and Donanue, 1995). Vegetative growth and yield (6.21 t/ha) of garlic were maximum for plants receiving N at the rate of 100 kg ha^{-1} (Singh., *et al*. 1994). Kilgori., *et al*. (2007) reported a significantly increased cured bulb yield of garlic with increased N from 0 to 60 and 120 kg ha^{-1}. Moreover, they found that higher dosage of 180 and 240 kg N ha^{-1} reduced the bulb yield. On contrast, IAR (1981) compared four levels of N (0, 50,100,150 kg N ha^{-1}) and reported insignificant effect of increased N on total yield, marketable yield and mean bulb weight of onion under Melkassa condition. Escaff and Aljaro (1982) reported that the application of N up to 150 kg ha^{-1} increased the yield and quality of garlic bulbs. Maksoud., *et al*. (1984) also reported significantly increased yield of cured marketable bulbs of garlic from 12.4 to 20.5 t/ha in one trial and from 13.6 to 17.3 t/ha in another trial with the addition of N at 360 kg ha^{-1}. Similarly, Ruiz [25] reported that increasing rates of applied N from 0 to 150 kg ha^{-1} increased bulb yield of garlic from 4.6 to 10.6 t/ha. At Samaru (Nigeria), Babaji (1994) observed that N application increased almost all growth and yield parameters of garlic significantly with a maximum yield of 15 t/ha at 90 kg N ha^{-1}. In another study, Arboleya and Garcia (1993) found increased growth and yield parameters of garlic with increasing N rates up to 150 kg ha^{-1} though further increase of N to225 kg ha^{-1} decreased them. It is best not to apply N when the bulbs are beginning to enlarge since it will encourage excessive leaf growth and reduce bulb size [18]. The fertilization and manuring of garlic are about the same as for onions (Mahmood, 2000).

A yield of 30 tones of onions is reported to remove 15 kg N, 42 kg P, and 130 kg of K (Choudhry, 1979). The efficacy and utilization of N by onion crops were shown to be correlated with the availability of soil moisture (Rahn., *et al*. 1996; Hegde, 1998; Kebede, 2003). Narang and Dastane (1972) reported that onion bulbs under low nitrogen and moisture regime were small in size, had low dry matter content and dried out earlier than those grown under adequate moisture and nutrition conditions. Baloch., *et al*. (1991) conducted fertilization experiments on onions and found that application of 125 kg N ha^{-1} with 75 kg K_2O ha^{-1} gave the highest yield. Other studies by Shaikh., *et al*. (1987b) showed that application of 90 kg N ha^{-1} increased yield of onion. Mahmood (2000) reported that application of 125 - 150 kg N ha^{-1} is an appropriate dose for getting good yields of garlic applied in two doses for best results. Korejo (1984) found that application of 60 kg N ha^{-1} resulted in good yields of garlic. Garlic requires 84 to 168 kg N ha^{-1}, the exact amount depending up on the past cropping and fertilization, soil type and water management (Sims., *et al*. 2003. http:// vric. ucdavis.edu). Findings of other researchers (Pandey and Ekpo, 1991; Vachhani and Patel, 1993; Sharma, 1998; Neeraja., *et al*. 2000) showed further increase in the yield of onions with increase in N rates beyond 50 kg N ha^{-1}, in the range of 50 to 200 kg N ha^{-1}. Verma., *et al*. (1996) reported that application of 100 kg N ha^{-1} increased the total soluble solids (TSS) and dry matter of garlic. Lipiniski., *et al.* (1995) reported that application of 240 kg N ha^{-1} increased garlic yield only by 10-15% compared to the control in the soil with initial total nitrogen of 800-900 ppm. In an experiment conducted in Nigeria under tropical low land conditions with sandy loam soil,it has been reported that application of 80 kg N ha^{-1} significantly increased tomato yield compared with no N, while doubling the rate did not produce any yield advantage (Asiegbu,1991). During the short rainy season of 1999 at the research farm of Haramaya University, a yield reduction of shallot was observed as the nitrogen levels increased from 0 to 150 kg N ha^{-1} due to the cessation of rain before the crop reached maturity (Kebede, 2003). On the contrary, he found that an increase in yield of shallot with the increase in N fertilization from 0 to 150 kg ha^{-1} in both dry season and main rainy season of irrigated and rain fed with supplemental irrigation shallot crop during 2000 and 2001 respectively with non significance difference of yields at 75 and 150 kg of N ha^{-1}. However, application of 225 kg N ha^{-1} drastically reduced yield in the 2001 experiment. He further reported that N fertilization at the rates of 150 and 225 kg ha^{-1} not only increased dry matter contents of bulbs, but also resulted in storage weight losses. Furthermore, Kebede (2003) suggested that rain fed shallots should not be fertilized with N unless the crop growth period can be extended by supplemental irrigation or moisture conservation. Arboleya and Garcia (1993) in a trial of garlic with N at 0, 75, 150, and 225 kg ha^{-1} observed an increased marketable bulb yield from 4.66 t/ha at 0 kg N ha^{-1} to 8.04 t/ha at 225 kg N ha^{-1}. On contrary, Yeshi (2003) reported that increased nitrogen fertilization levels of 0 to 150 kg N ha^{-1} showed no significant effects in all the plant characteristics except on unmarketable bulb number and leaf length of shallot crop grown on vertisol of Haramaya university research farm during the cropping season of 2002/2003.

Significantly higher and lower numbers of medium sized bulbs of shallot were obtained at higher rates of N during the main rainy season of 1999 and main rainy season with supplementary irrigation of 2000 respectively at Haramaya University research farm (Kebede, 2003).

Phosphorus

Phosphorus deficiency is one of the largest constraints to crop production in many tropical soils, owing to low native content and high P fixation capacity of the soil (Warren, 1992). Accordingly, P fertilization is usually recommended in these regions. Plants supplied with adequate amount of P were reported to form good root system as a result crop of which, water uptake is promoted resulting in strong stem, early maturity and higher yield. Consequently, the beneficial effects of P fertilizers are relatively greater in seasons of lower rainfall than those of higher rain fall (Warren, 1992). According to Miller and Donanue (1995), the original natural source of soil P is the mineral appetite. Besides, the soil organic matter including plant residues, animal excretion and remains are also known to contribute to the P pool upon mineralization. The form of P available in the soil to be taken up by the plant root system depends primarily on soil P^H. Archer (1988) indicated that P is taken up in the form of HPO_4^- and H_2PO_4– under high and low soil pH conditions respectively. The maximum availability of P for plant utilization occurs at soil pH between 6.5 and 7.5 (Mengell and Kirkby, 1987).

Phosphorus fertilization at the rate of 50 kg P ha^{-1} in irrigated shallot and 25 kg P ha^{-1} in rain fed with supplemental irrigation of shallot showed increased bulb yield and mean bulb weight (Kebede, 2003). The report also indicated that the 50 kg P ha^{-1} applied to the irrigated shallot significantly reduced storage weight loss of bulbs, whereas 25 kg P ha^{-1} had no significant effect on storage weight loss of rain fed shallot with supplemental irrigation. Kilgori., *et al*. (2007) reported that increase in P levels from 0 to 44 kg P ha^{-1} had no significant effect on yield of garlic. This is in agreement with the findings of Escaff and Aljaro (1982) who found no significant effect on the growth and yield of garlic with the application of 41.11 kg P ha^{-1}. On the other hand, Minard (1978) reported 114.75 kg P ha^{-1} as optimum for increased bulb yield of garlic among other parameters. He attributed this effect to the influence of P on root development, which led to effective nutrients uptake and water absorption. In western Kenya, maize yields increased from about 4.0 t/ha to over 9.0 t/ha with P additions in the form of TSP (Jamma, 1998). In other trials in the area, the same author reported that soil; water and nutrient losses can be reduced tremendously by P additions as a result of the rapid formation of soil cover following P additions. Increased levels of P from 0 to 150 kg P ha^{-1} resulted in non significant effect of total yield, marketable yield and mean bulb weight of onion bulbs grown under Melkassa condition (IAR, 1981).

Application of P from 29 to 48 kg P ha^{-1} will usually adequate for better garlic production while in the desert areas, however, rates of P up to 96 kg P ha^{-1} may be needed (Sims., *et al*. 2003. http://vricucdavis.edu/) Increased P levels are also known to improve bulb size and the number of marketable bulbs in shallots (Zaharah., *et al*. 1994; Nagaraju., *et al*. 2000; Kebede, 2003). Regardless of the P status of the soil, placement of P fertilizers in the soil near the plant would be the most effective method of P supply to onion plants (Mulkey., *et al*. 1979; Brewster, 1994; Henriksen and Hansen, 2001).

Material and Methods

Experimental site

The experiment was conducted at Wolaita Sodo University Collage of Agriculture Department of Horticulture, it is 337 km away from Addis Ababa. The capital city of Ethiopia and 167 km South of Hawasa at 649,37E Latitude and 36,57S Longitude and also Altitude 1800 above sea level [M,a,s,l] the maximum and minimum temperature 20c and 11.4c respectively. The maximum and minimum rainfall is1.4% and 31.2% respectively and the annual rainfall of the area is estimated to be 1212 mm.

Experimental treatments and design

Garlic variety obtained from the local market Center was used for this experiment. It is one of the common methods of seed source for Wolaita sodo in Ethiopia. The experimental field was divided into three blocks each containing four plots and a plot size of 2.5 m^2 (1.5 m length x 1 m width) has been used. The total experimental area (7.5 X 6.5) = 30 m^2 and the total net plot area was 28.8 m^2. Each plot contains about 50 seedlings with spacing of 30 cm between rows and 10 cm between plants and the total seedling 600 was applied on the experimental fields. A distance of 0.5 m was used between the plots within a block and 0.5 meter distance was be used between blocks and 30 cm between rows and 10 cm within plants spacing has been uniformly used and medium clove size and disease free clove was planted [26].

The entire rate of DAP and one third urea was applied at the time of planting and the rest two third Urea was side dressed in two applications, Urea (46% N), Diammonium phosphate (DAP) (46% P_2O_5, and 18 % N) fertilizers was used as sources of nitrogen and phosphorus. Land preparation, planting and other management practices were applied as per the recommendations (Getachew and Asfaw, 2000; ARARI, 2005).

Four treatment rates of NP fertilizer T1 (N: P_2O_5, 52.5: 46), T2 (N: P_2O_5, 157:92) and T3 (N: P_2O_5; 105:92) kg ha^{-1} and T4 control (without fertilizer) was applied in randomized complete block design with three replications. All management practices, such as weeding, insect pest and diseases control was applied as the general recommendations for garlic [26].

All other non-experimental cultural practices were applied uniformly to the entire plots. Plants of middle three rows plot were used for data collection. Data was recorded at 50 days after planting.

S. No.	Treatments	
	N	P_2O_5
1	52.5	46
2	105	92
3	157	92
4	0	0

Table 1: Experimental Treatment.

Data collection

Data was collected from ten randomly selected plants from three central rows for determination of plant height, leaf length, number of leaves per plant and leaf width data was recorded using the following parameters:

- **Plant Height (PH):** Plant height was recorded from five randomly selected plants from net plot area by measuring the height of the largest leaf from ground level to the tip using ruler at 50 days after planting (DAP) and the mean values were computed and used for further analysis.

- **Leaf Length (LL):** Leaf length was recorded from five randomly selected plants from net plot area by measuring the leaf length of the largest leaf from the distal end of the neck to the tip using ruler at 50 days after planting (DAP) and the mean values were computed and used for further analysis.
- **Leaf Width (LW):** Leaf width was recorded from five randomly selected plants from net plot area by measuring the average width (cm) of leaves at the widest part at 50 days after planting (DAP) and the mean values were computed and used for further analysis.
- **Number of Leavesper Plant (NLP):** The numbers of healthy leaves of five randomly selected plants were counted from net plot area by counting the average numbers of leaves per plant at 50 DAP and the mean values were computed and used for further analysis.
- The data collected from the experimental plots were subjected to analysis of variance (ANOVA) using the procedures as described by Gomez and Gomez (1984) with the help of Statistical Analysis Software (SAS) version 9.2. Least significant difference (LSD) test at 5% probability was used for mean separation when the analysis of variance indicated the presence of significant differences.

Results and Discussion

Plant height

Plant height is one of the important growth parameters garlic plants. It depends on several factors like genetic makeup, nutrient availability, climate, soil and etc. Kakara., *et al*. [27]. The variance analysis revealed that plant height was significantly ($p < 0.05$) affected by different levels of NP fertilizer rate (Appendix Table 1).

The tallest plant height (46 cm) was obtained from the treatment T3 received 157:92 kg ha^{-1} of N:P_2O_5 followed by T2 (42.2 cm) and T1 (39.4 cm) which were statistically similar when compared each other. The shortest plant height was recorded in T4 (36.4 cm) which was not supplied with NP fertilizer (Table 1). The result is in agreement with the findings of Kakara., *et al*. [27] and Gebrehawaria (2007) had also reported significant effect of N on plant height. However, the effect of N on plant height was more pronounced at early growth phase, which was 21.76, 20.16 and 16.21% at 50, 70 and 90 DAE, respectively.

Number of leaves per plant

The effects of different levels NP fertilizer rates had no significant ($P < 0.05$) influence on number of leaves per plant (Table 2, Appendix 2) at 50 days after planting. In garlic, leaves play an important role for photosynthesis and the number of leaves per plant is major in garlic.

The maximum of number (6.36) of leaves per plant was observed from the treatment of (105:92 of kg ha^{-1} N: P_2O_5) while the lowest number (6.1) of leaves per plant was obtained from the control treatment which has no NP fertilizer (T4). Increasing labels of NP fertilizer rates has no significance effect for increasing leaf number per plant (Table 1). This may due to the fertilizer has no effect at 50 Days. This result is consistent with that of Gebrehawaria (2007) who reported a significant effect of nitrogen and phosphorus interactions on leaf number of garlic and observed highest leaf number (8.71) from N P combination of 120 kg N and 60 kg P/ha at 50, 70 and 90 DAE, respectively [28-31].

Leaf length (LL)

Leaf Length per plant is an important parameter considering the highest performance of garlic growth. The effects of different NP fertilizer rate applications did significantly ($P < 0.05$) affect leaf length (Appendix 3, Table 2) which is in contrast to the results of Tindall (1991) who observed significant effect of N fertilization on leaf length of shallot. Leaf Length was significantly influenced by the different NP fertilizer rates ($P < 0.05$). The tallest leaf length (43 cm) was obtained from the treatment T3 received 157: 92kg ha^{-1} of N:P_2O_5 followed by T2 (39.2 cm) and T1 (38.2 cm) which were statistically similar when compared each other. The shortest Leaf Length was recorded in T4 (36.4 cm) which was not supplied with NP fertilizer (Table 1).

Leaf width (LW)

Main effects of different NP fertilizer rate applications did significantly ($P < 0.05$) affect leaf width of garlic (Appendix Table 4). Leaf width was significantly influenced by the different NP fertilizer rates ($P < 0.05$). The widest leaf width (2.1 cm) was obtained from the treatment T3 received 157:92 kg ha^{-1} of N:P_2O_5 followed by T2 (1.92 cm) which was statistically similar when compared each other. The narrowest leaf width was recorded from the treatment T4 (0.95 cm) received 0:0 kg ha^{-1} of N:P_2O_5 (Table 1).

Treatments ($N:P_2O_5$)	LL (cm)	NLP (cm)	PH (cm)	LW (cm)
(52.5:46)	38.26	6.3a	40.9	1.66
(105:92)	38.66	6.36a	41.6	1.67
(157:92)	41.14	6.33a	44.14	1.671
(0:0)	33.46	6.1a	36.46	0.93
Cv(%)	4.5		4.66	
LSD(0.05)	6.29		4.96	

Table 2: Effects of N and P Fertilizer rates on plant height, leaf length, leaf number per plant and leaf width at 50 days after transplanting.

LL: Leaf Length; NLP: Number of Leaf Per Plant; Lw: Leaf Width; ph: Plant Height; Cv: Coefficient of Variation, Lsd: Least Significant Difference.

Summary and Conclusions

Garlic is widely recognized as an important cash crop in Ethiopia. It is one of the most important bulb vegetables, which is used as spice and flavoring agent for foods and as medicinal plant. Selections of the best variety with their proper rate of fertilizer rate are very important factors to increase the productivity and marketability of garlic. It is successfully produced under rainfed as well as irrigated conditions in different climatic regions of the country for dry bulb by farmers and commercial growers in Ethiopia. It is widely sold in the local and export markets.

The effect of different NP fertilizer rates on growth parameter of local garlic (*Allium sativum* L.) variety was studied in Wolaita Sodo. The experiment was laid out in RCBD with three replications and four treatments. Growth parameters were evaluated from the three central rows and from five randomly taken plants of each plot respectively and analysed accordingly.

The present experiment was conducted to assess the effects of different NP fertilizer rates on growth parameters of local garlic variety. The results showed that fertilizer rates was significantly almost for three the parameters considered in this experiment and application of different NP fertilizer rates were significantly influenced at 50 days after planting to plant height, leaf length and leaf width while these parameters did to give a response for the applied different NP fertilizer levels.

The maximum plant height (44.14 cm) and leaf length (41.14 cm) were obtained at the application of 157:92 kg ha^{-1} $N:P_2O_5$ from the treatment (T3) whereas the maximum number of leaf per plant (6.36 cm) and the widest leaf width (1.67 cm) were obtained at the application of 105:92 kg ha^{-1} $N:P_2O_5$ from the treatment (T2) and 157;92 respectively. Therefore, the result of this study has shown that application of different levels NP fertilizers had a significant positive influence on the growth parameters at 50 days after planting.

Due to time constraint, we are not able to include yield components. However, the yield related parameters are good indicators of yield. In order to check the positive relation of morphological parameters with yield a similar experiment should be conducted which further assure the results of the present experiment. Therefore, the result of this study has shown that application of different levels nitrogen and phosphorus fertilizers along with varieties had a significant positive influence on the yield and growth of garlic. From this study it can be conclude that locale garlic variety at the rate of 105:92 kg ha^{-1} NP fertilizer had a potential to increase the growth of garlic at 70 days after planting under Wolaita Sodo conditio. This study was emphasis only on vegetative performance of the garlic and it was also conducted only in one location, single season and with only one locale varieties. Therefore, such types of investigations need to be repeated under at different varieties, seasons and until yield to come up a concrete recommendation.

Appendix

Source of variation	DF	SS	MS	F value	Pr > value
Treatment	3	92.1	30.7	8.38*	4.76
Replication	2	5.4	2.7	0.73	
Error	6	22	3.66		
Total	11				

Table 1: ANOVA Table of Plant Height.

Source of variation	DF	SS	MS	F value	Pr > value
Treatment	3	0.3	0.1	0.015ns	4.76
Replication	2	0.4	0.2	0.03	
Error	6	0.04	6.66		
Total	11				

Table 2: ANOVA Table of Number of Leaves Per Plant.

Source of variation	DF	SS	MS	F value	Pr > value
Treatments	3	92.62	30.87	5.14 *	4.76
Replication	2	7.47	3.735	1.25	
Error	6	17.83	2.97		
Total	11				

Table 3: ANOVA Table of Leaf Length.

Source of variation	DF	SS	MS	F value	Pr > value
Treatments	3	1.22	0.4	10*	4.76
Replication	2	0.35	0.175	4.375	
Error	6	0.24	0.04		
Total	11				

Table 4: ANOVA Table of Leaf Width.

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