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# Agronomic Practices for Improving Garlic (*Allium sativum* L.) Production and Productivity in Ethiopia Review

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**Abstract:** Garlic is the most important Allium crop and oldest known horticultural crops, ranks second next to onion in the world. It is mainly used for flavoring and seasoning vegetables in different dishes and also has many medicinal properties. Poor agronomic practices are among the major constraints limiting the production and productivity of this crop. Improving agronomic practices such as seedbed preparation, sowing date, planting methods seed rate, weed control and pest management will enhance the production and productivity of garlic. Concerning on nitrogen application, combined increasing levels of nitrogen from 0 to 120 kg $ha^{-1}$ resulted in significant increase in fresh bulb yield. Further increase to 240 kg N $ha^{-1}$ reduced the yield. The highest fresh bulb yield of 8.4 tons $ha^{-1}$ was recorded with 120 kg N $ha^{-1}$. The recommended seed rate is 400 to 1000 kg per hectare depending on the clove size and planting method. The plant spacing significantly increases bulb size, bulb weight and yield. Planting date is dependent on the availability of soil moisture, altitude, soil type and maturity period of the specific crop cultivar but in general, garlic is often planted, in rain fed agriculture at the beginning of the rainy period (June-July) is the recommended time for planting garlic in Ethiopia. For garlic, two to three hand-weeding and leaving the straw mulch in place will greatly reduce emergence and pressure of weed. Application of herbicides, fungicides and insecticides was also recommended for control of weed, fungus and insect pests of garlic on large scale farming respectively.

**Key words:** Agronomic Practices · Productivity · Garlic · Bulb Size · Cloves

## INTRODUCTION

Garlic (*Allium sativum* L.) belongs to the family of Alliaceae [1]. Other crops in this family are Onion (*A. cepa* L.), Leek (*A. ameloprisum*), Shallot (*A. asacloncum* L) and Chile (*A. schoenoprasum* L). The origin of garlic is thought to be in Central Asia (India, Afghanistan, West China, Russia) and spread to other parts of the world through trade and colonization [2]. Garlic has been used in China and India for more than 5000 years and Egypt since 2000 B.C. [3]. Garlic is the most important Allium crop and ranks second next to onion in the world [4]. It is an erect annual herb that can reach a height of 75 cm- 90 cm and grows during dry and middle winter season [5]. According to FAO [6] production of garlic stood at about 10 million tons per annual which is only about 10% that of bulb onion. The world average yield of garlic is about 10 tons per hector, but it can go up to 19 tons $ha^{-1}$. World garlic cultivation was increased from 771, 000 ha of 1989/90 to 1, 204, 711 ha of land in 2007 with total production from 6.5 million tons and productivity from 8.43 tons per hector to 13.02 tons per hector respectively.

In Ethiopia, a total of 15, 381.01 ha of land was under garlic production during the 2016/17 main cropping season, taking up about 6.71% of land area covered by all root crops at country level and yielding about 138, 664.30 tons of those cultivated by small scale farmers, contributing about 2.99% to the total country level root crop production [7]. According to the CSA report, over 1, 020 ha of land is planted to garlic in the Tigray region. Southern, central and Eastern zones are the main garlic growing areas in Tigray region [7].

Garlic is rich in sugar, protein, fat, calcium, potassium, phosphorus, sulfur, iodine, fiber and silicon, in addition it contains vitamins. Its pungent flavor makes it is used mainly as spices, seasoning and flavoring for food. Its medicinal value is also well recognized in the control and treatment of hypertension, worms, germs, bacterial

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and fungal disease, diabetes, cancer, ulcer, rheumatism etc. dehydrated garlic and extracts are fast replacing fresh bulbs for industrial and home usage in the production of drug, insecticide and explosives [8].

According to Shanmugarelv *et al.* [9] this bulbs crop is another foreign exchange earner for India. Compound bulbs contain the edible products of these crops. A group of small segments or cloves is surrounded by a thin, white or pinkish sheath. The flavor of the cloves is stronger and pungent than other crops of bulbs. Garlic is different from onion in that instead of producing one large bulb, it produces a group of small bulb called cloves. But seeds stalk is similar to that of onion and bears both seeds and bullets in the same head. The foliage of garlic is flattened rather than hallow like that onion. It is also grouped in the family alliaceous, a genus allium, because of its superior ovary. The traditional husbandry practices have resulted in 3-4 t/ha yield against the world average of 10-15 t/ha. At off-season some quantity of garlic is usually sold at twice or three times the value of onions. It is mostly exported to other parts of Africa, Middle East Asia and Europe through various trade routes.

A number of studies in various parts of the world have shown that garlic production can be improved though appropriate cultural practice [10]. Garlic is sensitive to moisture stress and high temperature and about 60% reduction in yield has been associated with water stress for this, it was envisaged that mulching, which offers a practical and reliable means of conserving soil water and regulation soil temperature, is likely to have advantageous effect on the growth and yield of this crop. Such affects might also be reflected in reducing cost of irrigation and ensuring sufficient management of the little water resource [11]. There are numerous problem of garlic production accounted to low yield or reduction of yield. Some of these are level of fertilizer application, ways of weed management practice, irrigation and mulching. The objective of this paper is to review major agronomic practices for improving production and productivity of garlic.

Garlic is among the oldest known horticultural crops. Globally, Egyptian and Indian cultures referred to garlic 5000 years ago and historical evidence for its use by the Babylonians 4500 years ago and by the Chinese 2000 years ago. Some literatures suggest that garlic was grown in China as far back as 4000 years ago. Garlic grows wild only in Central Asia (centered in Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan) today. Wild garlic may have occurred in an area from China to India to Egypt to the Ukraine (center of origin). In Ethiopia, More than 50% of the country's garlic production is produced in the western highlands where the Amhara National Regional State (ANRS) and 10% garlic produced from ANRS's from Yilmana Densa district 11.13 $tha^{-1}$ and 10.5 $tha^{-1}$, respectively [12]. It was diversified to wide range of climatic conditions. The center of origin for a plant species is also referred to as its "center of diversity" since it is here that the broadest range of genetic variation can be expected.

**Plant Characteristics**

**Botanical Description:** Garlic is a perennial that can grow two feet high or more. The most important part of this plant for medicinal purposes is the compound bulb and is made up of 4 to 20 cloves and each clove weighs about one gram. The parts of the plant used medicinally include fresh bulbs, dried bulbs and oil extracted from the garlic [13]. The Bulb, 12 inches to 18 inches tall (30-45 cm), 9 inches to 12 inches in spread (22.5-30 cm). The roots are trimmed and the stems snipped or braided. Depending on where they are grown, the size, shape, color and flavor will differ. Colors can range from white to red to purple or pink [14]. Garlic leaves are 1-2 feet long, surrounding a central flower stalk, which develops a globular cluster of tiny white blossoms [15]. A head of garlic is composed of more discrete cloves, an underground structure comprised of thickened leaf bases. The foliage comprises a central stem 25-100 cm tall, with flat or keeled leaves 30-60 cm long and 2-3 cm broad. The growing point may then either form a clove and go dormant, or form an incomplete leaf that degenerates [16].

**Production and Productivity in Ethiopia:** In Ethiopia, Garlic is one of the important bulb crops grown and used as a spice or a condiment throughout the country. It is mainly used for flavoring and seasoning vegetables in different dishes and also has many medicinal properties [17]. Small growers in the highlands are growing garlic traditionally but due to lack of full package of cultural practices, yields are generally low. The yield in large-scale production with irrigation is expected to be about 10 tons per hectar [18]. According to the CSA [19] the number of holders practicing garlic farming is considered to be 1, 411, 151 farmers which are much less than that of grains or cereals crops. In the same year the area under garlic production was estimated 10, 690.41 hectars and the production obtained from these hectares were about 1, 284, 409.36 quintals as well as the average production obtained was 120.15 quintal yield per hectare [19]. Under the comparison of countries in garlic production,

next to ten top garlic producers, China, India, South Korea, Egypt, Russia, Bangladesh, Burma, Uzbekistan, Ukraine, United states. Ethiopia has placed number 12 in the world ranking and world share of Ethiopia in garlic exporting was very small amount only 0.7 % [20].

**Ecological and Edaphic Conditions:** Garlic is adapted to cool climates and should not generally be planted at altitude below 2000 m. a.s.l. Amount of rainfall during the growing period 4 to 6 months should be 600 mm to 700 mm. The optimum temperature for growing garlic lies between 12°C and 24°C. Garlic withstands moderate frost on well-drained soils, rain fed crops may be planted on flat beds; but on heavy soils, which are poorly drained during the rains; it is advisable to plant on ridges beds. It is essential to select land with high fertility or apply considerable quantities of manure or fertilizers to obtain good yields [18]. Garlic grows best on high in organic matter sandy loam or loam soils have the most ideal texture for garlic drought or excessively wet conditions will reduce yields and marketable bulbs.

Well-composted manure applied and incorporated at a rate of 20 tons to 30 tons per acre has also been shown to be ideal as a soil amendment, especially on low organic matter soils. Sandy, silt and clay loam are recommended for commercial production. The soil should be fertile and rich in organic matter, well drained, capable of holding moisture during the growth period and having the pH Soil ranging 6.8 to 7.2. Lower pH levels, inhibits plant growth and soil pH below 5.0 can actually lead to plant death. In heavy soils the bulbs produced are deformed and they do not keep well storage they get discolored in badly drained soil [21].

**Crop Managements**

**Seedbed Preparation:** The crop requires thoroughly prepared soil seedbed by repeated ploughing and light irrigation before planting the crop with a well decomposed FYM application at the rate of 10 to 20 t $ha^{-1}$ [22]. Soils with high organic matter content are preferred due to their increased moisture and nutrient-holding capacity and less proneness to crusting and compaction [23]. The application of organic fertilizers assist structuring of clay soil to open and admit air penetration to roots and drainage, both conditions necessary for satisfactory plant growth [24].

**Varieties:** The variety must be selected from a list of recommended or local varieties. Apart from its adaptation, the variety should have high yield potential, tolerance to biotic and abiotic stresses, good marketability and high consumer preferences. Unless the variety meets the requirements of farmers and consumers, it is less likely to be widely adopted and therefore, the demand for seed cannot be addressed [25].

**Fertilizers**

**Nitrogen:** Nitrogen has been identified as being the most limiting nutrient in plant growth. Plants absorb nitrogen in the cation form ($NH_4$ +) or the anionic form (NO3-). As increased the level of N, increased the growth trend of the number of leaves, leaf length and plant body that garlic has a high nitrogen requirement, particularly in the early stages of growth. Application of 200 kg N $ha^{-1}$ significantly increased the growth attributes like plant height in cm and neck thickness, bulb diameter, number of cloves per bulb, fresh weight of cloves, dry weight of cloves, fresh weight of bulb, dry weight of bulb and bulb yield $tha^{-1}$ (16.518) in 16 comparison to 50 kg N $ha^{-1}$ and 100 kg N $ha^{-1}$. However, no significant difference was recorded between 200 kg N $ha^{-1}$ and 150 kg N $ha^{-1}$ [26]. The highest yield was obtained in high N application of 300 kg N $ha^{-1}$ [27]. It is necessary and important element for increasing the yield and quality of vegetables such as garlic [28]. N, P and K are referred to as the primary macronutrients. Because of the general probability of plant being deficient in these nutrients and the larger quantities taken up from the soil relative to other essential nutrients. The alliums species have low nutrients extraction capacity than most crop plants because of their shallow and un-branched roots system. The required and often respond well to additional fertilizer [5]. Garlic (*Allium setivum* L.) has a moderate to high demand for nitrogen. Recommendations for nitrogen are based on previous crop and organic matter content. Nitrogen deficiency include a yellowing of older leaves and leaf tips, general yellowing of the plant poor vigor, thin stems and low yields but sufficient N of garlic are dark green and high yields [29].

The application of increasing rates of nitrogen had significant effect on fresh bulb yields. It was observed that combined increasing levels of nitrogen from 0 to 120 kg $ha^{-1}$ resulted in significant increase in fresh bulb yield. Further increase to 240 kg N $ha^{-1}$ reduced the yield. The highest fresh bulb yield of 8.4 tons $ha^{-1}$ was recorded with 120 kg N $ha^{-1}$. Application of varying of rate of phosphorus had no significant impact on fresh bulb yield of garlic and its statistical analysis [30].

Table 1: Average yield and some other characters of garlic varieties

| Sr | Cultivar | Year of release (EC) | Maturity Time (days) | Rainfall (mm) | Altitude | Yield (qt/ha) | | | Breeder/ Maintainer |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Research | Demons-tration | Farmers | |
| 1 | Bishoftu | 1999/00 | 132 | >870 | 1900-2400 | 100-130 | 75-85 | 55-85 | DZARC/EIAR |
| 2 | Tsedey | 1999/00 | 138 | >870 | 1900-2400 | 100-120 | 80-90 | 60-70 | DZARC/EIAR |
| 3 | Qoricho | 2006 | 138 | 500-1000 | 1900-3350 | 61 | - | 15-20 | SARC/OARI |
| 4 | Kuriftu | 2010 | 140 | Early to mid-June | 2100-2400 | 41 | - | - | DZARC/EIAR |
| 5 | Bora | By farmers | 120-150 | 600-700 | 1800-2700 | - | 80-126* | 50-90* | Bora-Alaje farmers |

*CASCAPE trial

Table 2: NPK treatments on growth characteristics of garlic plant height (cm) number of leaves stem circumference (cm) shoot length (cm) shoot diameter (cm)

| Treatments | Plant height (cm) | Number of leaves | Stem circumference (cm) | Shoot length (cm) | Shoot diameter (cm) | Shoot weight | Height of top growth | Clove weight |
|---|---|---|---|---|---|---|---|---|
| $N_{300}K_0$ | 77.6 | 4.30 | 3.66 | 39.0 | 0.47 | 8.0 | 46.6 | 13.0 |
| $N_{300}K_{150}$ | 88.0 | 5.16 | 4.43 | 59.1 | 0.64 | 14.7 | 68.7 | 16.0 |
| $N_{300}K_{300}$ | 91.4 | 5.23 | 4.66 | 64.0 | 0.69 | 16.6 | 80.0 | 17.5 |
| $N_{375}K_0$ | 83.3 | 4.56 | 3.80 | 40.8 | 0.51 | 9.3 | 53.6 | 13.8 |
| $N_{375}K_{150}$ | 86.6 | 5.20 | 4.43 | 59.0 | 0.65 | 14.6 | 73.5 | 16.5 |
| $N_{375}K_{300}$ | 93.3 | 5.30 | 4.60 | 63.8 | 0.70 | 15.60 | 82.0 | 16.30 |

Source: Lujin *et al*. 2004

**Phosphorus:** Phosphorus deficiency is one of the largest constraints to crop production in many tropical soils, owing to low native contents and high P fixation capacity of the soil [31- 33]. Phosphorus is essential for root development and when the availability is limited, the growth of plant can be reduced. It is involved in several physiological and biochemical processes in plant maturity, fruit setting and seed production [34, 35]. It is part of plant nucleoprotein and hence important in plant heredity and also plays a role in cell division, stimulates root growth and hastens plant maturity and physiologically notable in the storage and transfer bonds of ATP. The need for P is critical during the early stage of growth when normal meristem development and rapid height growth are necessary for a high yield [34]. The movement of P in soils is very low and its uptake generally depends on the concentration gradient and diffusion in the soil near roots [36].

**Potassium:** Potassium (K) greatly promoted garlic growth and yield. Potassium with other fertilizer elements proven to improve crop values by large margin, with farm income being enhanced considerably. Potassium used in combination with the higher N rate produced 103 to 137% higher shoot yields and 11 to 36% higher clove yields. High yield garlic crop demands large amounts of nutrients especially N and K. Garlic is particularly sensitive to low soil K supply. Potassium up take imbalance relative to N can predispose the crop to serious disease and insect damage. All P and K were applied basally with 60% of the N. Potassium had an obvious growth promoting effect on garlic. Plant height, number of leaves, stem circumference, to P growth weight per plant substantially increased with N and K. The majority of highest value resulted with N, $P_2O_5$, $K_2O$ rates of 375; 90; 30 kg/ha. Similarly, Selections of the best variety with their proper rate of fertilizer rate are very important factors to increase productivity and marketability of garlic [17, 37]. Moreover, the interaction of variety, nitrogen and potassium were increased the total bulb yield of garlic [17].

**Planting Method:** Planting garlic is relatively simple by separating cloves. Space the cloves 4-6 cm apart. Rows should be spaced one foot apart. The cloves should be planted with the pointed end up and the blunt end down. Push each clove 1-2 cm into the ground, firm the soil around it and water the bed if it is dry. According to purse glove [8] garlic is often planted in the late outman, so as to give vigorous growth in the warmer spring weather and it is frost hardy and it can grow on a variety of soil and much of it is grown with irrigation.

**Spacing and Seed Rate:** The planting material is prepared first by separating the clove from one another. The cloves from the outer parts of the bulb are the best planting material. When there is a shortage of planting materials, the inner cloves can be used also but these should be separated from the outer cloves. The recommended seed rate is 400 to 1000 kg per hectare depending on the clove size and planting method. There are two major planting methods use for Garlic. The plant spacing significantly increase bulb size, bulb weight and yield [38-41]. Maximum yield in early planting could be attributed to better growth of plants and large sized bulb and also the enhanced crop growth rate which might have resulted in efficient metabolism, there by increased the sink capacity.

**Mulching:** Mulching three to five weeks after planting, rows should be covered to moderates in the winter and minimize excessively fluctuating temperatures in the winter and early spring. This mulch also will help control weeds during the growing season. Mulch can be removed in the spring after the threat of hard freezes is over. Garlic shoots can tolerate air temperatures as low as 20°F without damage. Plant death, multiple shoots and poor bulb development may occur if bulbs and shoots are exposed to temperatures below 10°F growers remove mulch completely in the spring to allow the soil to warm faster and then return the mulch after the shoots are about six inches tall; others will leave the mulch in place to minimize weed pressure and conserve moisture [29].

**Irrigation:** Garlic has relatively shallow root system and is sensitive to dry soil conditions. Most of the time garlic really likes moist soil. Watering regularly in the fall during germination is essential. The amount of Water to apply will depend on soil type. Irrigation is essential on sandy soils and may be beneficial. In drier climates some people like to heavily irrigate at the pre-planting phase to help build a deep soil moisture reserve [42]. Enough irrigation should be provided so that the available water holding capacity does not drop below about 50 % .The most critical stage for irrigation is during bulbing. Lack of irrigation or rainfall during this stage will result in smaller bulbs and earlier maturity. Irrigation should be stopped about two weeks before harvest to avoid stained bulb wrappers and diseases [43].

According to Rai and Yadev [44] first irrigation is given soon after sowing and later field is irrigated after 10 to 15 days until bulb begin to develop. Irrigation after Temporary setback during bulb development causes the partially developed cloves to form tops. The last irrigation should be given three days before harvesting for making it easy without damaging the bulbs.

The average weight per bulb was notably reduced with the lowest N rate, but not affected by irrigation regimes. So, average across N fertilization treatments, bulb weight per 5ft sub plots was less with higher rate of irrigation treatments and no significant difference were found in weight per bulb.

**Weed Management:** Garlic is a poor competition with weeds, if not controlled; they can easily overtake young garlic resulted in several yield losses. Leaving the straw mulch in place will greatly reduce weed pressure. If mulch is removed in the spring to allow the soil to warm up, a thorough, shallow cultivation before reapplying straw much will keep down annual weed populations. If desired, a few soil applied and post emergence herbicides are registered for use on garlic production [44]. Weed control studies in garlic crop were conducted during two seasons at the National Agricultural Research Center. During the first year, pendimenthalin was sprayed at 0.80a.i.ha$^{-1}$ Pre emergence two days after first irrigation in moist condition followed by different mechanical weeding regimes. During second year, pendimenthalin, oxadiazon, glyphosate and metribuzin were sprayed at 0.801, 0.251, 0.61 and 0.45 kg.a.i.ha$^{-1}$, respectively. Pre-emergence two days after first irrigation in moist condition followed by one hoeing at 80 days after herbicide application. Herbicide treatments were compared with weed free and weedy check. The most dominant weed species *Phalaris minor*, *Cronopus didymus*, *Medicago denticulata* and *Rumex dentatus*. All herbicide followed by hoeing except metribuzin gave bulb yield at par with weed free treatment. Metribuzin resulted in minimum bulb yield (0.59 tha$^{-1}$) because of its extreme phytotoxicity to garlic crop, which resulted in survival of a few plants. Pendimenthalin in combination with manual hoeing gave high yield and monetary returns [45]. Germination percentages in all treatments indicate that or were recorded after 15 days of sowing. The germination varied from 81% to 89% during 2000-2001 and 81% to 94% during 2002-2003. However, there was no significant difference in germination percentage in all treatments during both years. These results indicate that pre emergence application of all herbicides did not affect the germination of the garlic crop, but not in case of metribuzin as shown in the following table.

In all weed control treatments, higher bulb weight was recorded as compared to weedy control during both years (Tables 5). During 2000-2001, significantly less bulb weight (29.86 g) was recorded in the treatment where pendimenthalin alone was used followed by no hoeing. The minimum bulb yield (0.59 tha$^{-1}$) was recorded when metribuzin at 0.45 kga.i.ha$^{-1}$ was used. This lowest yield due to extremely phytotoxicity of metribuzin to garlic crop and bulb yield (7.29 tha$^{-1}$) was recorded in the treatment where pendimenthalin alone was used followed by no hoeing. However, pendimenthalin suppressed weeds growth for approximately a period of two months but later on, the weed began to flourish and competed with crop resulted in lower yield [46].

Table 3. Available water holding capacity for different soils texture

| | AWHC | |
|---|---|---|
| Soil texture | Inches/inch of soil | Inches/foot of soil |
| Loamy fine sand | 0.08-0.12 | 0.96-1.44 |
| Sandy loam | 0.10-0.18 | 1.20-2.16 |
| Loam | 0.14-0.22 | 1.68-2.64 |
| Silt loam | 0.18-0.23 | 2.16-2.76 |
| Clay loam | 0.16-0.18 | 1.92-2.16 |

Source: Jerry Wright, 2011

Table 4: Yield data for treatments with irrigation application

| Treat Ments | Applied water % evaporate | Irrigation cut of date | Bulb count* | Bulb weight (kg)* | Piece weight (g/bulb) |
|---|---|---|---|---|---|
| T1 | 110 | 10 may | 117.3 | 6.75 | 58.0 |
| T2 | 110 | 24 may | 113.0 | 6.36 | 61.1 |
| T3 | 130 | 10 may | 104.8 | 5.92 | 57.0 |
| T4 | 130 | 24 may | 111.4 | 6.15 | 55.3 |
| LSD | - | - | Ns | 0.53 | Ns |

Source: Anonmous, 1995

Table 5: Yield and other parameters of garlic crop as affected by different weed control method in garlic crop (2000-2001)

| Treatments | Germination (%) | Fresh biomass of weed kg $m^{-2}$ | No. of bulbs ($m^2$) | Average bulb weight (g) | Yield ($tha^{-1}$) | Yield increased over weedy check 9 $tha^{-1}$ | Percent increase |
|---|---|---|---|---|---|---|---|
| Pendimenthalin alone | 86.67$^{ns}$ | 1.000$^{b}$ | 30.18$^{a}$ | 29.86$^{b}$ | 7.29$^{b}$ | 4.12 | 130 |
| Pendimenthalin +1 hoeing | 86.7 | 0.054$^{c}$ | 31.93$^{a}$ | 42.30$^{a}$ | 13.38$^{a}$ | 10.21 | 322 |
| Pendimenthalin +2 hoeing | 86.67 | 0.020$^{c}$ | 32.58$^{a}$ | 42.66$^{a}$ | 13.83$^{a}$ | 10.66 | 336 |
| Pendimenthalin +3 hoeing | 85.00 | 0.010$^{c}$ | 32.58$^{a}$ | 43.49$^{a}$ | 14.17$^{a}$ | 11.00 | 347 |
| Weed free | 84.67 | 0.010$^{c}$ | 31.08$^{a}$ | 42.39$^{a}$ | 12.21$^{a}$ | 9.04 | 285 |
| Weedy check | 81.00 | 3.290$^{a}$ | 15.83$^{b}$ | 21.36$^{c}$ | 3.170$^{c}$ | - | - |

Source: Mehmood *et al*., 2004

**Disease and Insect Management**

**Disease Management:**

**Damping-Off:** Damping off is an important disease of garlic during nursery stage which causes about 60 to 75% damage to the crop. The disease is more prevalent during kharif (rainy) season and causes delayed seedling emergence in addition to root and basal rots. High soil moisture and moderate temperature along with high humidity especially in the rainy season leads to the development of the disease. Management strategies are, the seed should be treated with Thiram or captan at 2 g/kg of seed before sowing and the top soil of nursery should be treated with Thiram or captan at 5 g/m area of the soil and nursery should be drenched with the same chemical at 2 g/litre of water at fortnight interval and trichoderma viride in soil at 4 to 5 kg/ha is also found effective to control damping-off to considerable extent.

**Purple Blotch:** It is an important disease of onion and garlic prevalent in all the onion and garlic growing areas in the world. Hot and humid climate with temperature ranging from 21 to 30°C and relative humidity (80 to 90%) favors the development of the disease. It is more common in rainy season. The intensity of disease varies from season to season, variety to variety and region to region. Its management strategies are, Cultural methods include long rotations with non-related crop and good drainage brings down the incidence of the disease, lowering the density of plant population crops causes reduced infection, avoid excess doses of nitrogenous fertilizers, use of resistant/tolerant varieties, frequent and judicious application of fungicides reduces the incidence of purple blotch.

**Stemphylium Blight:** It infects herbaceous plants such as onion, garlic, asparagus, lucerne, tomato and soybean and trees also, that is, pear, mango etc. The fungus produced significant damage alone and in a complex with *Alternaria porri*. In some fields, foliage losses of 80 to 90% have been recorded. Its management strategies are; reduced plant density and good field drainage significantly reduced the disease incidence, avoid excess doses of nitrogenous fertilizers, use of resistant/tolerant varieties and judicious application of fungicides reduces the incidence of disease.

**Neck Rot:** Neck rot of garlic, onion and shallot is one of the major bulbs destroying diseases are caused by *Botrytis allii*, *B. squamosa* and *B. cinerea*. The fungus usually infects mature plants through the neck tissues or through wounds in the bulbs. Management practices are; the most common point of infection is through the exposed succulent tissue when plants are topped before they have dried sufficiently, a combination of several of the following cultural procedures should reduce losses, Plant varieties that mature properly so neck tissues are dry before storage and generally colored varieties are more resistant than white varieties.

**Insect Management**

**Thrips:** These are important pests of garlic, onions and several other crops in most parts of the world. Management strategies are; it is very important that onion seedlings are clean of thrips before transplantation, spraying of Deltamethrin at 1 ml/L gives best performance, Fipronil at 1 ml/L of water and spionsad at1 ml/L of water offer best control of this pest, at high temperature, profenophos at 2 ml/L gives good control, alternately use chemical groups, spinosad is a recently discovered insecticide, derived from the fermentation of actinomycetes bacteria, commonly found in soil and the National Organic Board has recommended that Spinosad be allowed in organic Production.

**Onion Maggot:** Maggot is an onion pest rather than garlic and does not generally causes economical damages to garlic, but cause losses on onion from 20% to 90% in temperate regions. Its management strategies are; avoid planting in soils that are high in undecomposed matter, avoid planting where crop rotations are not followed, employ biological control, no promising natural enemies exist, which can be successfully employed for control of this pest at field level, only braconid, Aphaereta pallipes, Staphylinid and Aleochara bilineata have significantly increased the mortality of onion maggot, but the performance in field is poor and ground beetle is an onion maggot predator and establishing grassy refuse stripes in an onion crop enhances beetle population and reduces maggot population.

**Harvesting:** Garlic is a crop of 4½ to 5 months duration, when the leaves start turning yellowish or brownish and show signs of drying up the crops is ready for harvest. The plant are then pulled out with a oxen and are field in to small bundles which are then kept in the field or in the shade for two to three days for curing and drying so that the bulbs become hard and their keeping quality. The bulbs may be stored by hanging them on bamboo sticks or by keeping them dry sand on the floor in well ventilated room [9]. Earlier harvesting result in small bulbs that do not stored well and harvesting too late will force the clove to crack out of the skins, making them susceptible to disease and resulting in unmarketable size bulbs. To harvest, the bulbs should be dug with the roots and shoots still attached. If the soil is not wet at harvester if the garlic is grown on sandy soils, it is generally not necessary to wash the bulbs [44].

According to Attra [47] begin to mature four to six month in temperate and four months in tropics at planting. The garlic plants ready for harvest when the tops begin to dry out and collapse at this time irrigation is stopped one two weeks before harvesting, it is easier to pull garlic out of dry soil. Indicators of maturity are store bitter and softening of the main stem above the bulb and yellowing of 75% of level.

## CONCLUSIONS

Generally garlic grows best on well-drained soil and high in organic matter content Sand, silt and clay loam soils are recommended for commercial production. This bulb crops can adapt wide range of climatic condition best prefer cool season grows at high elevation. The rational use of potassium greatly promoted garlic growth and yield and it had an obvious growth. The majority of highest value resulted with N, P2O5, K2O rate of 375, 90, 30 kg $ha^{-1}$ respectively. All herbicides followed by hoeing except metribuzun gave bulb yield at par with weed free treatment. Garlic has four to six months duration to harvest, early harvesting resulted in small bulbs that do not store well, while too late harvesting will face the clove to split out the skin and the results are unmarketable size bulbs. For this reason, using full packages of agronomic practices including disease and insect pests are advisable for small and large scale producer farmers to get high production, productivity and quality of garlic.

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