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Evaluation of Different Mulching Practices on Garlic (Allium sativum L.) Growth Parameters under Irrigated Condition in Fiche, North Shoa Ethiopia

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Abstract
An experiment to assess the effect of mulch on growth (days to maturity, plant height, leaf length and leaf number) of Garlic (Allium Sativum L.) were conducted in 2015/16 at Addis Ababa University Selale campus, on demonstration field, with the objective of; to identify optimum plant growth using different mulches for Garlic tested independently. The experiment was conducted using randomized complete block design with three replicates. The area occupied by a single plot was 1.5*2 m^2 and with a spacing of 1 m and 0.5 m between blocks and plots, respectively. There were nine treatments. The spacing between plants was 10 cm and between rows was 30 cm. The analyzed result using ANOVA shows significance difference among the treatments. Plots treated with black polyethylene mulch and grass mulch enhanced maturity by about 114.6 and 116.73 days, respectively, while garlic treated with no mulch showed slightly delayed maturity of 125.36 days. Maximum plant height (66.52 cm) was recorded in the plants mulched by black polyethylene mulch followed by grass mulch which records 62.37 cm and 52.36 cm, respectively. A highly significant variation ($p<0.05$) in the leaf length was observed at the different mulch treatments. Significantly maximum leaf number (15.36) was recorded in plants mulched with black polyethylene followed by grass mulch with 14.06 leaf number. Thus, black polyethylene and grass mulch performs better than the bare land in growth parameters evaluation of garlic crop under fiche condition.
Keywords: Black polyethylene, Mulches, Allium Sativum, Growth, Grass

1. INTRODUCTION

Garlic (*Allium sativum* L.) belongs to the family *Alliaceae* and genus *Allium,* and is a shallow rooted vegetable crop (CSA, 2014).The genus *Allium*, which belongs to the family *Alliaceae*, is diverse and comprises about 750 species; but only seven of them are widely cultivated in different parts of the world. Of these, the species important in Ethiopia are onion (*Allium cepa* L.), shallot (*Allium cepa var. ascalonicum*L.), garlic (*Allium sativum* L.) and leek (*Allium ampeloprasum* L.). The first three are diploid with the basic chromosome number of 2n=16 whereas leek is tetraploid with 2n=32 (Jones, 1990; Currah and Rabinowitch, 2002).

Garlic is an ancient crop originated in Central Asia (Bodnar *et al.,* 1997 cited in Zakari et al., 2014).The alliums are distributed widely throughout the temperate, warm temperate and boreal zones of the northern hemisphere (Brewster, 1994).It is one of the oldest cultivated vegetables and the second most widely produced Allium next to onion (Shiferaw, 2014).The species has been already grown and consumed in ancient Egypt and Rome (Rekowska and Skupien, 2007). According to Goldy (2000), evidence of garlic cultivation can be found as far back as 3200 BC in Egypt and it continues to be an important part of Mediterranean, European and Asian diets as a food item, as well as a medicinal plant used to treat a variety of ailments.

Garlic is grown globally buy is China is by far the largest producer of garlic, with around 20 million tons grown annually accounting for over 81% of world output. India (4.6%) and South Korea (1.4%) follow, with Egypt (1.2%) on fourth place. Ethiopia is the seventh producer in the World by producing 222,548 tons annually (FAO, 2015).

Garlic is grown for its edible bulbs, which are composed of a number of cloves. The bulbs can be eaten fresh, cooked in various ways, processed into a dehydrated product, or saved for the seed to be planted later (Hannan and Sorensen, 2001).The crop has been grown for culinary, medicinal, and religious purposes for several millennia (Brewster, 1994Hannan and Sorensen, 2001).Garlic takes one of the top places among vegetables contributing to the maintenance of good health of humans. It is a natural antiseptic and had used in the First World War (Gene, 2009).Not surprisingly, in view of its strength of flavor, it is used primarily as a condiment rather than a bulk foodstuff (Purseglove, 1992).

The crop is a good source of income income for many farmers in many parts of the country and earns foreign currency by exported to Europe, Middle East and North America (DARC, 2006), (Getachew and Asfaw,

2000; CACC, 2002) and proved to be income generating activity for farmers, especially for those who have limited cultivated land or small holder farmers (FAO, 2006).

In terms of production, garlic is ranked second after the onion and it is grown for its pungent flavored bulbs and used world-wide to season foods (Brewster, 1990; Valadez, 1992). Garlic produces unique flavors savored by almost all of the global culture (Havey, 1999). Garlic's volatile oil has many sulphur containing compounds that are responsible for the strong odor, its distinctive flavor and pungency as well as for its healthful benefits (Salomon, 2002). In Africa, Ethiopia was third in the area (10,690 ha) after Egypt and Algeria, second in production but fourth in productivity with 9.63 t ha^{-1} which was far below Egypt (24.36 t ha^{-1}), Kenya (23.87 t ha^{-1}) and Niger (10.64 t ha^{-1}) in 2011 (FAOSTAT, 2013). In Ethiopia garlic produced mainly as a spice crop for seasoning of foods and for its medicinal values. It is widely cultivated around home gardens, but nowadays, its production is practiced in some large farms.

A lion share of95% of the vegetables and fruits produced in Ethiopia comes from the small holder sector. In Ethiopia, garlic crop is one of the most important vegetables produced by small hold farmers mainly as a source of cash income and for flavoring the local stew 'wet. The crop is believed to be more intensively consumed than any other vegetable crop. In Africa, Ethiopia was third in area (10,690 ha) after Egypt and Algeria, second in production but fourthin productivity with 9.63 t ha-1 which was far below Egypt (24.36 t ha^{-1}), Kenya (23.87 t ha^{-1}) and Niger (10.64 t ha^{-1}) in 2011 (FAOSTAT, 2013). A range of factors maycontribute to the low productivity of garlic. In many areas characterized by low and erratic rainfall and crop water stress, lack of available nutrients is frequently the limiting factor next to the soil water. Besides, lack of soil water diminishes nutrient availability by reducing microbial activity, which is responsible for the liberation of N, P and S from soil organic matter (FAO, 2003).

Garlic production in Ethiopia was increased from 6,042 ha in 2001/02 to 21,258 ha of land in 2012/13 with a total production increment from 79,421 to 222,548 tons of bulbs. The crop is produced mainly in the mid and high lands of the country (Getachew and Asfaw, 2000; CACC, 2002) but its productivity was decreased from 13.20 to 10.47 t ha^{-1} (CACC, 2002; CSA, 2012/13).

In many parts of the country, garlic crop yields are low due to a number of constraints, among which lack of balanced nutrient supply, poor soil fertility, weed infestation, diseases, and moisture stress are the major ones (Shiferaw, 2014).

Mulching is a cropping practice that entails placing organic or inorganic or synthetic materials on soil close to plants to provide a more favorable environment for growth and development. Organic or inorganic mulches can be used for weed control. Mulch controls weeds by smothering seedlings, prevent day light which helps foster germination from reaching weed seeds and prevents airborne seeds from taking hold on the soil surface (Altland and Lanthier, 2007; Amoroso et al*.,* 2009).

Mulches serve as protective covering, reduce moisture loss from the soil by preventing evaporation from the sunshine and desiccating winds, regulate soil temperature cooler in summer and warmer in winter. The temperature regulating effect encourages the root growth. It was observed that different mulching materials highly influenced the plant height and bulb diameter (Iroc et al., 1991) as well as yield of garlic (Menezes et al., 1974).

Results of different kinds of mulching indicated increased plant growth, yields, and improved bulb size of the garlic. Many of these effects were attributed to the capacity of the mulch to conserve soil moisture (Adetunji, 1994; Abu-Awwad, 1999; Shock *et al.,* 1999), regulate soil temperature (Rahman and Khan, 2001), control weeds and diseases (Durante and Cuocolo, 1989; Shock *et al*., 1997), and reduce loss of nutrients (Shock et al., 1997). Mulching has been reported to conserve moisture (Adetunji, 1990; Gajri et al., 1994) by protecting the plant from excess transpiration and direct evaporation from soil thus reducing the irrigation requirements (Amal *et al.*, 1990). Mulching helps in significant increase in N, P and K uptake over unmulched (Acharya and Sharma, 1994).

Therefore, a better understanding of the uses of mulching in garlic production is very importantin order to develop management strategies, which optimize moisture and increasing returns to the producers by increasing Garlic yield and quality. Thus, it is in view of this background the research was undertaken with the objective of the following:

- To evaluate the effect of different mulches on garlic growth parameters in fiche condition.

2. MATERIAL AND METHOD

2.1. Description of the Study Area

The study was conducted at Fiche, Addis Ababa University, Selale campus demonstration farm. The experimental site lies on an altitude of about 2750 *m.a.s.l* and is located at latitude of 9◦ 48′′0′′ N and longitude of 38°42′′0′′ E which is found 112 km far from Addis Ababa city. Fich district is characterized by a highland agro-ecological zone which has a cold condition with annual average temperature of 16.5°c and average rainfall of 1150 mm $year^{-1}$. The soil type of the study area is clay with pH of 6.4 (Sara *et.al*. 2015).

2.2. Experimental Material

Local garlic cultivar was used for planting as a test crop for the experiment which is widely cultivated in the study area. Black polyethylene mulch and grass mulch were used as experimented materials. DAP and Urea fertilizers were used as per the recommended rate of the crop uniformly in all treatments.

2.3. Treatments and Experimental Design

The experiment was conducted by using randomized complete block design (RCBD), which consists of three treatments (black polyethylene mulch, grass mulch, no mulch/control) with three replications. The plot size was 2m length and 1.5m width consisting 5 rows with 20 plants per row which comprised a total of 100 plants per plot; the clove was planted at a space of 30 cm x 10cm between rows and plants respectively. The spacing between plots and blocks was 0.5m and 1m respectively.

2.4. Experimental Procedure

The experimental field was digging out. Large clods were broken down in order to make the land fine tilth, and then 9 plots with size of 1.6m x 2m were measured and laid out. Irrigation and drainage channels were designed for conveyance and drainage of excess water. The plots was leveled; furrows and ridges were made at a spacing of 40cm. Local garlic cultivar was used for planting. At planting time, cloves were separated from the bulb and sorted (i.e. diseased, damaged and very small size clove were separated). Cloves with the same size were used for planting.

After land prepared, fertilizers were applied according to the national recommendation at the rate of 92 kg ha^{-1} P_2O_5 and 92 kg ha^{-1}N from Di-ammonium phosphate (DAP) and urea fertilizers, respectively. The DAP will be applied all at planting and the urea was splinted and applied one third during planting, and the rest two third were side dressing in two applications. One half was applied after three weeks and the rest one half five weeks after plant emergence. The experimental plots were kept free from any disease, weed, insect and other pests as much as possible and regularly watered. Harvesting was done when70% of the leaves fell over by digging up or pulling the individual plants by hand and sun dried for days.

2.5. Data Collection

The growth parameter data was collected during the field experiment by sampling plants randomly from the two central rows of each plot except days to maturity which was determined on a plot basis. The following parameter was recorded on ten randomly taken plants from each plot of no mulch, grass mulch and black polyethylene mulch. All data pertaining to growth, yield components. Accordingly, the following data was collected.

Days to maturity: Days to maturity was the actual number of days from the day of transplanting to the time when 70% of plants' foliage fall down and when plants show neck fall in the field experiment (EARO, 2004).

Plant height (cm): plant height was measured in centimeter from the soil surface to the tip of matured leaf in the plant at maturity by a ruler.

Leaf number per plant: is the mean number of leaves produced by sampled plants and was calculated by dividing the total number of leaves counted from the sampled plants to the number of sampled plants to get mean leaf number per plant.

Leaf length (cm): The length of three leaves per plant (from upper, medium and lower) was measured at maturity by using a ruler and the average leaf length was taken.

3. RESULTS AND DISCUSSION

3.1. Phenology and Growth Parameters

Plant height, days to maturity, Leaf length and leaf number were significantly (P<0.05) influenced by the effect of different Mulches (Table 1).

Table 1: The effect of different Mulch on plant height (cm), leaf length (cm), leaf number (No) and days to maturity (days) of local garlic

Treatment	DM	PH	LL	LN
BPM	114.06**	66.526**	39.1533**	15.366**
GM	116.73*	62.37*	37.96**	14.066**
NM	125.36^{ns}	52.363^{ns}	32.756^{ns}	9.9^{ns}
$LSD_{0.05}$	2.49	6.62	2.30	2.57
CV (%)	0.93	4.84	7.74	3.10

* = Statistically significant at P<0.05, ** = statistically highly significant at P<0.01, DF= degree of freedom, NS = non-significance, PH= Plant Height, LL= Leaf Length, LN= Leaf number, DM= Days to maturity, BPM= black polyethylene mulch, GM= grass mulch, NM= no mulch.

3.1.1. Days to maturity

Days to maturity was highly significantly (p<0.05) influenced by black polyethylene mulch (Table 1). Black

polyethylene mulch and grasses mulch enhanced maturity by about 114.6 and116.73 days, respectively, while the control treatment showed slightly delayed maturity by 125.36 days. This might be attributed due to increasing soil organic matter (grass mulch) and water efficiency by minimizing excess evaporation, regulation of temperature in causing early bulb maturity while not using mulch allowed plant to have access for adverse conditions like scarcity on water and temperature. Similarly Haque et al. (2003), Karaye and Yakubu (2006) and Hossain et al. (2007) also reported significant effect of mulching on day to maturity.

3.1.2. Plant height (cm)

Plant height was highly significantly ($p<0.05$) affected by black polyethylene mulch (Table 1). Various mulches significantly affected the plant height in garlic production. Maximum height (66.52cm) was recorded in black polyethylene mulch followed by grass mulch (62.37cm) and without mulch (52.36cm) respectively. With respect to plant height, another researches also reported that, the highest values of these parameters were recorded in black polyethylene mulch. Iroc et al. (1991), Haque et al. (2003) and Hossain et al. (2007) reported the effect black polyethylene mulch on plant height for garlic. Similarly, Kebede (2003) observed also an increased plant height for shallot. These Might be attributed to the possible competition for soil moisture, appropriate temperature and nutrients without competitor through suppressing nature of mulches.

3.1.3. Leaf number

The result of the field experiment showed that there is significance difference among treatments with reference to leaf number per plant. Black polyethylene and grass mulch increases leaf number by 5.466 and 4.166 respectively as compared to the control treatment (Table 1).The highest leaf number (15.36) was recorded on black polyethylene mulch treatment, followed by grass mulch (14.06) which was statistically at par while the lowest leaf number (9.9) was recorded on treatment with no mulch. This might be due to addition of nutrient from straw mulch and reduction of competition and water stress by black polyethylene plastic. Research finding conducted at Agarfa on garlic reported that, the highest number of leaves plant^{-1} was obtained with straw mulch which was statistically at same level with black polyethylene mulch (Wolde, 2014). This result is in line with the results of John (2000) and Umar *et al*. (2000) who reported significant effect of mulching on leaf number of onions. Similarly, result of Haque et al. (2003), Karaye and Yakubu (2006) and Hossain et al. (2007) showed that, significant effect of mulching on leaf number plant^{-1} of garlic.

3.1.4. Leaf Length (cm)

Highly significant variation ($p<0.01$) in the leaf length was observed at the different mulches. Black polyethylene mulch produced the longest (39.15cm) leaf length 37.96cm by black polyethylene mulches and the shortest 32.75 was recorded in the absence of mulch.This might be due to less competition for light with large canopy leaf of weed which suppressed by the application of mulches. According to Gebrehaweria (2007) reported that, Black polyethylene mulch significantly increased leaf length. This result is comparable with the findings of Asiegbu (1991) who found significant increase in leaf sizes of tomato by using mulches.

4. CONCLUSION AND RECOMMENDATION

Garlic is one of the main alliums vegetables known worldwide with respect to its production, and economic, medicinal and food seasoning values next to common onion with a characteristic pungent smell, and It is rich in sugar, protein, fat, calcium, potassium, phosphorous, sulfur, iodine fiber and silicon in addition to vitamins and many other substances that contributes significant nutritional value to the human diet and it has miracle pharmaceutical effects which used to cure an enormous disease.

In Ethiopia Production of cash crops like garlic is the most widely cultivated species and proved to be income generating activity for farmers, especially for those who have limited cultivated land or small holder farmers. However, its productivity is low due to diverse crop management problems including the nature of propagation, Limited precipitation and erratic rainfall as well as low soil fertility in the arid and semi-arid regions, limit crop production, poor laterally spread and scarce root system, lack of improved agronomic practices, lack of improved and adaptable varieties, low soil fertility, diseases, insect pests and lack of improved post-harvest technologies. On the other hand, all alliums including garlic have lower nutrient extraction capacity than most crop plants because of its shallow depth root. As a resultmulching has been reported to conserve moisture by protecting the plant from excess transpiration and direct evaporation from soil thus reducing the irrigation.

Therefore, a field experiment was conducted at Addis Ababa University, Selale campus demonstration farm in 2014/15 under irrigation to assess the effect of different mulches on growth parameters of garlic. The treatments were composed of two types of mulches the so called black polyethylene mulch and grass mulch, with comparing to bare land and were arranged in randomized complete block design (RBCD) with three replications.

Results of the field experiment revealed that the effects of different mulches showed a significant effect on, plant height, leaf length, leaf number and days to maturity. Maximum height (66.52cm) was recorded in black polyethylene mulch, followed by the grass mulch (62.37cm). More leaf number (39.15) and late maturity

day (114.6 days) were also recorded in treatments treated with black polyethylene mulch followed by grass mulch measured leaf number of 37.96 and 116.73 days to maturity, respectively.

It could be conclude that, under Fiche condition, good quality and quantity of garlic is possible to produce by using different types of mulch. According to this research finding black polyethylene mulch is very favorable for garlic production and result obtained from grass mulch is also comparative. There is a need to study the effect of further types of mulches across sites. There is also a need to undertake soil analysis after harvest in order to check effect of the different mulches on the improvement of soil. It is important even to undertake similar studies at different seasons with different varieties in consideration of their cost benefit analysis.

References

A. Ayalew, D. Tadesse, Z.G. Medhin and S. Fantaw (2015). Evaluation of Garlic (*Allium sativum* L.) Varieties for Bulb Yield and Growth at Dabat, Northwestern Ethiopia; Open Access Library Journal, 2: e1216. http://dx.doi.org/10.4236/oalib.1101216, accessed date February 23, 2016.

Amir J, and Sinclair TR (1996). A straw mulch systems to allow continuous wheat production in an arid climate. Field Crops Res., 47: 21–31.

Anderson DF, Garisto MA, Bourrut JC, Schonbeck MW, Jaye R, Wurzberger A, and De Gregorio R (1995). Evaluation of a paper mulch made from recycled materials as an alternative to plastic film mulch for vegetables. J. Sustainable Agric., 7: 39–61

Amberber Wasihun (2013). Effect of Mulching on Moisture Conservation and Yield of Snap Bean (*Phaseolus vulgaris* L.), Under Drip Irrigation System.

ATTRA (2001). Organic garlic production; National Center for Appropriate Technology under a grant from the Rural Business-Cooperative Service, U.S. Department of Agriculture AR.USA.

Adetunji IA (1990). Effect of mulches and irrigation on growth and yield of lettuce in semi-arid region. Biotronics, 19: 93-98.

Ahmed H (1991). Effect of weed on growth of garlic (*Allium sativum* L.). Weed Sc. Abstract, 39(6): 230.

Asiegbu JE (1991). Response of tomato and eggplant to mulching and nitrogen fertilization under tropical conditions, Scientia Hortic., 46: 33-41.

Brewster JL (1994). Onions and Other Vegetable Alliums. CAB International, Wallingford.

Boja M (2006). Evaluation of straw and plastic mulch on water use efficiency of drip irrigated pepper. MSc Thesis presented to the school of graduate studies, Haramaya University, 44-47 (In press).

Bachmann J (2001). Organic Garlic Production, http://attra.ncat.org/; accessed date February 19, 2016.

Brewster JL and Butler HA (1989). Effects of N supply on bulb development in onion (*Allium cepa* L.). Journal of Experimental botany, 40: 1155-1162.

Brewster JL (1994). Onions and other vegetable Alliums. CAB International, Walling ford, UK. 236p.

Central Statistical Agency (CSA) (2006). Agricultural Sample Survey 2005/2006. Report on Area and Production of Crops (Private Peasant Holdings, Meher season). Addis Ababa, July, 2006.

Chien SH and Menon G (1995). Agronomic evaluation of modified phosphate rock products Fertilizer Research, 41: 197-205.

Carter J and Johnson C (1988). Influence of different types of mulches on eggplant production. Hort science, 23: 143-145.

Central Statistical Agency (CSA) (2006). Agricultural Sample Survey 2005/2006. Report on Area and Production of Crops (Private Peasant Holdings, Meher season), Addis Ababa, July, 2006, Statistical bulletin 361, volume I.

Central Agricultural Census Commission (CACC) (2002). Report on the preliminary result of area, production and yield of temporary crops (Meher season private peasant holdings). Part II. Ethiopian Agricultural sample Enumeration, 2001/2002: Federal Democratic Republic of Ethiopia, Central Statistical Authority; Addis Ababa.

Central Agricultural Census Commission (CACC) (2003). Statistical report on socio-economic characteristics of the production in Agricultural households, land use, and area and production of crops; Part I. Results at Country Level; Ethiopian Agricultural Sample Enumeration, 2001/2003 (CACC) Federal Democratic republic of Ethiopia Central Statistical Authority Addis Ababa.

Carter J and Johnson C (1988). Influence of different types of mulches on eggplant production. Hort science, 23: 143-145.

Delahaut KA and Newhouse AC (2003). Growing onions, Garlic, Leeks, and Other Alliums in Wisconsin: A guide for fresh-market growers; University of Wisconsin system Board of regents and University of Wisconsin Extension, cecomerce.wisc.edu.

DARC (Debrezeit Agricultural Research Center) (2006). Garlic Production Management. Debrezeit Agricultural Research Center, Leaflet (Amharic Version), Debrezeit, Ethiopia.

Diriba SG (2014). Response of Garlic (*Allium sativum* L.) to Fertilizers Management in Ada'a District, Central Highland of Ethiopia.

Daisley LEA, Chong SK, Olsen FJ, Singh L and George C (1988). Effects of surface applied grass mulch on soil water content and yields of cow pea and egg plant in Antigua.

Duranti A, and Cuocolo L (1989). Chemical weed control and mulching in onion (*Allium cepa* L.). And garlic (*Allium sativum* L.) Advances in Horticultural Science, 5: 7-1.

Ernestine O (2003). Small holders' conservation farming in the tropics and sub tropics: a guide to the development and dissemination of mulching with crop residues and cover crops. Agriculture, Ecosystem and environment, 100 (1): 17-37.

Food and Agriculture Organization (FAO), 2003: Optimizing soil moisture for plant production. FAO soils Bull. 79: 22-23; Food and Agriculture Organization of the United Nations, Rome, 2003.

FAO (2004). The market for non-traditional agricultural exports. FAO commodities and trade technical paper 3.

Fikreyohanis G (2005). Effects of Clove Weight and Plant Density on the Bulb Yield and Yield Components of Garlic (*Allium sativum* L.) in Awabel Woreda, Eastern Gojam Zone. An MSc Thesis Presented to the School of Graduate Studies of Alemaya University. 57p.

FAOSTAT (2013). Food and Agriculture Organization of the United Nations; http: //faostat.fao.org/ site/567/ Accessed on January 20, 2016.

Gebrehaweria T (2007). Effects Of Mulching, Nitrogen And Phosphorus On Yield And Yield Components Of Garlic (*Allium Sativum* L.) At Alshaday, Eastern Zone Of Tigray, Northern Ethiopia

Goldy R (2000). Producing Garlic in Michigan, Michigan State University Extension. Gene, B., 2009: Garlic Huntington College of Health Sciences, Literature Education Series on Dietary Supplements.

Getachew T and Asfaw Z (2000). Achievements in Shallot and Garlic Research. Report No. 36. Ethiopian Agricultural Research Organization, Addis Ababa Ethiopia.

Gajri PR, Arora VK and Chaudhary MR (1994). Maize growth responses to deep tillage, straw mulching and farmyard manure in coarse textured soils of North West India. Soil Use Manage.10: 15-20.

Geiger SC, Manu A and Mationon A (1992). Changes in a sandy Sahelian soil following crop residue and fertilizer additions. Soil Sci. Soc. Am. J., 56: 172-177.

Hossain MI (1996). Effect of mulches and different manuria practices involving equal cost on the growth, yield and storability of garlic. MSc Thesis, Dept. Horticulture, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Huber GL (2003). Medicinal Uses of garlic in history. Texan nutrition Institute Vol. 5: pp 28-30.

Hossain MI, Ahmed SU, Alam KS and Rahman SL (1998). The impact of mulches and manures on growth and yield of garlic. Bangladesh J. Agri. Res., 23: 115-126.

Hossain AKMM, Islam MJ, Khanam F, Majumber UK, Rahman MM and saifurRahman M (2007). Effect of mulching and Fertilization on Growth and Yield of Garlic at Dinajpur in Bangladesh. Asian J. of Sciences, 6(1): 98-101.

Hannan RM and Sorensen EJ (2001). Crop Profile for Garlic in Washington; Washington State University, Pullman.

Ibrahim AI (1994). Effect of grass mulch and plant spacing on growth and yield of garlic.

Iroc A, Sisson LC and Solidum PP (1991). Effects of different mulching materials on garlic (*Allium sativum* L.); Bulletin Penelitian. Horticultura, 7: 104-108

Jamma B (1998). Soil Fertility Replenishment Initiatives in Western Kenya: Soil Fertility Management Workshop 21-23 April, 1998.

John T (2000). The physical properties of mulches contributing to weed suppression. ARS Publication, USDA Agricultural research. USA. pp. 1-2.

Jones TL, Jones US and Ezell DO (1977). Effect of nitrogen and plastic mulch on properties of Troup loamy sand on yield of "water tomato". J. Am. Soc. Hort. Sci., 101: 265-273.

Karaye AK and Yakubu AI (2006). Influence of intra-row spacing and mulching on weed growth and bulb yield of garlic (*Allium sativum* L.) in Sokota, Nigeria, *African Journal of Biotechnology*. 5(3): 260-264.

Kebede W (2003). Shallot (*Allium cepa* var. *ascalonicum*) Responses to Plant Nutrients and Soil Moisture in a sub-humid Tropical Climate, Doctoral, Thesis Swedish university of Agricultural Sciences, Alnarp, 2003.

Lamont WJ (1993). Plastic mulches for the production of vegetable crops. Hort. Technology.

Lippert LF, Takatori FH and Whiting FL (1964). Soil moisture under hands of petroleum and polyethylene mulches, Proc.Am.Soc.Hortic.Sci. 84: 541-546.

Lal R (1980). Crop residue management in relation to tillage techniques for soil and water conservation. In: Organic recycling in Africa. FAO Soils Bulletin No. 43. FAO, Rome. 72p.

Libner N (1989). Vegetable production; van Nostrand Rein hold, New York, USA. 657p.

Mike R. (2008). Garlic production, Ward County Extension Agent.

Mandefro Ch and Shoeb Q (2015). Effect of Deficit Irrigation on Yield and Water Productivity of Garlic (*Allium*

Sativum L.) under Drip Irrigation and Mulching at Wolaita Soddo, Ethiopia. MSc thesis submitted to Haramaya University, Ethiopia.

Patra DD, Ram M and Singh DV (1993). Influence of straw mulching on fertilizer nitrogen use efficiency, moisture conservation and herb and essential oil yield in Japanese mint (*Mentha arvensis* L.), Fert. Res., 34: 135-139.

Purseglove SW (1992). Tropical Crops, Monocotyledons. Vol. 2, Longman Group Ltd., London, 20-140.

Rekowska E and Skupien K (2007). Influence of Flat Covers and Sowing Density on Yield and Chemical Composition of Garlic Cultivated for Bundle-Harvest: Vegetable Crops Research Bulletin, 66, 17-24, http://dx.doi.org/10.2478/v10032-007-0003-y; accessed date February 13, 2016.

Rice RP, Rice LW, Tindall HD (1990). Fruits and vegetables production in warm climates, Macmillan Education Ltd, Hong Kong. 486p.

Rubatzky VE, and Yamaguchi M (1997). World Vegetables, Principles, Production and nutritive values 2nd edition Chapman and hall; International Thomson Publishing New York. USA. 843p.

Sisson and Solidum PP (1991). Effects of different mulching materials on garlic (*Allium sativum* L.).

Shah SSH, Ahmad SB, Shah SHH 92015). Mulching Effects on Water Productivity, Maize Yield and Soil Properties in Bed and Flat Sowing Methods, Intj.plant& soil science. 8(1): 3-4.

Sarolia DK and Bhardwaj R (2012). Effect of Mulching On Crop Production under Rainfed Condition.

[Suh JK and Kim YB (1991). Study of improvement of mulching culture method in onion. I. Influence of mulch materials and times on growth and yield. Res.Rpt.Rural Devel, Admin. Hort., 33: 31-36 (CAB Abstr.No.940304264).

Sullivan DM. Brown BD, Shock CC, Horneck DA, Stevens RG, Pelter GO and Feibert EBG (2001). Nutrient management of onion in the Pacific North West; A Pacific North West Extension Publication, PNW 546p.

The Federal Republic of Ethiopia Central Statistics Authority Agricultural Sample Survey (20013/14). Report on Area and Production of Major Crops.

Umar MS, Muoneke CO, Magaji M.D (2000). Effect of intra-row spacing and mulching materials on growth and yield of onion (*Allium cepa* L.), Nig. J. Agri. and envi., 1(2): 29-39.

Vavrina CS and Roka FM (2000). Comparison of plastic mulch and bare ground production and economics for short day onions in a semi-arid environment. Hort Technology., 10: 326-330.

Wien HC and Minotti PL (1987). Growth, Yield, and Nutrient Uptake of Transplanted Fresh market Tomatoes as affected by Plastic Mulch and Initial Nitrogen rate. J. Amer. Soc. Hort. Sci., 112(5): 759-763.

Yohannes U (994). The effect of nitrogen, phosphorous, potassium, and sulphur on the yield and yield components of Enset (*Ensete ventricosum* W.) in south east Ethiopia, Phd. Dissertation; Institute of Plant nutrition, faculty of Agriculture, Justus Liebig University, Giessen, Germany.

Wolde T (2014). Effect of Mulching and Nitrogen on Weeds, Yield Components and Yield of Garlic (*Allium Sativum* L.) At Agarfa, South-Eastern Highlands of Ethiopia. MSc thesis submitted to Haramaya university, Ethiopia.