EFFECT OF CLOVE SIZE AND MULCHING ON THE GROWTH AND YIELD OF GARLIC

BY

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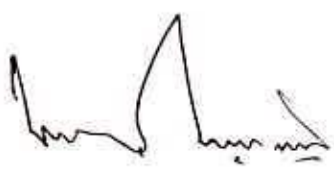
A Thesis
Submitted to the Department of Horticulture and Postharvest Technology
Sher-e-Bangla Agricultural University, Dhaka
In partial fulfillment of the requirements
for the degree
of

MASTER OF SCIENCE (MS)
IN
HORTICULTURE

SEMESTER: JULY-DECEMBER, 2008

APPROVED BY:



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This is to certify that the thesis entitled **"Effect of Clove Size and Mulching on the Growth and Yield of Garlic"** submitted to the Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE**, embodies the result of a piece of bona fide research work carried out by **Mahfuza Sultana**, Registration No. **03-01174** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

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DEDICATED
TO
MY BELOVED PARENTS

ACKNOWLEDGEMENTS

The author first wants to express her enormous sense of gratefulness to the Almighty Allah for countless blessing, love, support, protection, guidance, wisdom and assent to successfully finish the research work in time.

The author feels proud to express her heartiest sence of gratitude, sincere appreciation and immense indebtedness to her supervisor Professor A. K. M. Mahtabuddin, Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University (SAU), Dhaka, for his continuous intellectual and scholastic guidance, assistance, constructive criticism and suggestions in carrying out the research work and preparation of thesis, without his intense co-operation this work would not have been possible.

The author feels proud to express her deepest respect, sincere appreciation and immense indebtedness to her co-supervisor Md. Hasanuzzaman Akand, Associate Profesor, Department of Horticulture and Postharvest Technology, SAU, Dhaka, for his scholastic guidance, constructive criticism and valuable suggestions during the entire period of course and research work and preparation of this thesis.

The author expresses her sincere respect to Chairman, Departement of Horticulture and Postharvest Technology, SAU, Dhaka for valuable suggestions and cooperation during the study period. The author also expresses her heartfelt thanks to all the teachers of the Department of Horticulture and Postharvest Technology, SAU, for their valuable teaching, suggestions and encouragement during the period of the study.

The author expresses her sincere appreciation to her brother, sisters, relatives, well wishers and friends for their inspiration, help and encouragement throughout the study.

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ABSTRACT

The experiment was conducted in the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from November, 2007 to March, 2008 to find out the effect of clove size and mulching on the growth and yield of garlic. The experiment consisted of two factors. Factor A: Three levels of clove size; C_1: 44 g/100 cloves, C_2: 63 g/100 cloves and C_3: 90 g/100 cloves and Factor B: Four types of mulch; M_0: no mulch (control), M_1: rice straw, M_2: black polythene and M_3: water hyacinth. In case of clove size maximum number of cloves per bulb (23.50), highest fresh weight of bulb (15.09 g) and the highest yield (3.91 t/ha) was recorded from C_3 treatment while C_1 treatment gave the minimum. In case of mulches maximum number of cloves per bulb (24.33), highest fresh weight of bulb (15.42 g) and the highest yield (4.29 t/ha) was recorded from M_2, while all the above parameters was the lowest at M_0. For combined effect maximum number of cloves per bulb (27.00), highest fresh weight of bulb (15.85 g) and the highest yield of bulb (4.51 t/ha) was recorded from C_3M_2 and the lowest (2.81 t/ha)was recorded from C_1M_0. The highest benefit cost ratio (2.00) was noted from C_2M_2 and the lowest (1.38) was obtained from C_1M_0. From the above results C_2M_2 treatment combination were best for growth and yield of garlic.

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LIST OF ABBREVIATED TERMS

ABBREVIATION	FULL NAME
AEZ	Agro-Ecological Zone
et al.	and others
BBS	Bangladesh Bureau of Statistics
cm	Centimeter
°C	Degree Celsius
DAP	Days After Planting
etc	Etcetera
FAO	Food and Agriculture Organization
g	Gram
ha	Hectare
Kg	Kilogram
LAI	Leaf Area Index
LSD	Least Significant Difference
m	Meter
mm	Millimeter
MP	Muriate of Potash
%	Percent
RCBD	Randomized Complete Block Design
SAU	Sher-e-Bangla Agricultural University
m^2	Square meter
TSP	Triple Superphosphate
UNDP	United Nations Development Program

CHAPTER I

INTRODUCTION

Garlic (*Allium sativum* L) is an aromatic herbaceous annual spice and one of the most important bulb crop belongs to the family Alliaceae (Kurian, 1995). It is the second most widely used *Allium* after onion (Bose and Som, 1990). It is well known as a spice crop in Bangladesh as well as in the world. According to Vvdensky (1946) this crop is originated in Central Asia, especially in Mediterranean region (Thompson and Kelly, 1957) from where it was extended to North-East wards to the Pamir-Ali and Tien Shen regions of China. The major garlic producing countries of the World are China, South Korea, Spain, India, USA, Egypt, Thailand, Turkey, Sudan and Mexico (FAO, 2007).

Garlic is popular all over the world as a valuable spice for different dishes. It has been considered as a rich source of carbohydrate, protein and phosphorus. According to Unani and Ayurvedic medicines in the treatments of diseases like chronic infection of stomach and intestine, dysentery, typhoid, cholera and disease of lungs garlic is successfully used (Chopra *et al.,* 1958). In Bangladesh and other Asian and Middle-East countries, it is used in several food preparations, notably in chutneys, pickles, curry powder, curried vegetables, meat preparation, tomato ketchup and the like (Bose and Som, 1990). In recent year's oil, powder, kind of salt are prepared from it for adding flavor to the curries (Pruthi, 1976). Aqueous extracts of garlic cloves (allicin and related essential oil viz. disulphides) significantly reduced cholesterol level on human body (Augusti, 1977).

The demand of garlic consumption is increasing day by day with ever increasing population of Bangladesh. The average yield of garlic in Bangladesh is only 3.16 t/ha (BBS, 2007), which is very low compared with many countries of the world. According to FAO, 2005 the highest national yield has been recorded in America (40 t/ha) and the other countries and their mean production are China (13.62 t/ha), South Korea (11.56 t/ha), USA (19.11 t/ha), Egypt (32.05 t/ha) and Sudan (18.30 t/ha). In Bangladesh about 4, 43,000 metric tonnes of garlic was produced from 123 thousands hectares of land in 2006-07 (BBS, 2007). The requirements of garlic in Bangladesh are about 85,000 metric tons (Rahim, 1992).

Garlic is usually propagated through clove planting (about 90%). The size of clove can greatly influence the growth and yield of garlic (Rahim *et al.*, 1984 and Sultana *et al.*, 1997). The expression of life cycle, the ontogeny of the phenotype and the strategy of bulbing depend on the size of the cloves and effect the final yield of garlic (Baten *et al.*, 1989). Large sized cloves had the highest root length, plant height, number of leaves per plant, stem length and total dry matter and yield. Though, large size of clove influence higher yield with optimum growth but the return may be lowest due to seed cost.

Garlic is known to be thermo photo sensitive crop and grown in Bangladesh in short day condition in winter (Jones and Mann, 1963; Rahim and Fordhan, 1988). The role of mulching is well known on the growth and production of plants. Its vegetative growth and bulb development are greatly influenced by growing environment. Garlic is produced in dry period of the year and soil moisture is

dependent on the irrigation and it's frequent. Mulching helps in retaining moisture in the soil and sometimes even substitutes soil (Amal *et al.*, 1990). It protects the plants from loss of soil moisture by wind and soil evaporation and reduces the irrigation requirements (Amal *et al.*, 1990; Vanderwerken *et al.*, 1988). Mulches help to check weed growth and improve the soil structure and fertility (Clarkson, 1957). Mulches also help in proper utilization of all nutrients in the soil meeting up the requirements of irrigation and thus increase crop yield.

Considering the above facts, the present investigation was undertaken with the following objectives-

1. to find out the appropriate clove size for growth and yield of garlic.
2. to find out the appropriate mulch materials for growth and yield of garlic.
3. to find out the combined effect of clove size and mulch material on growth and yield of garlic.

CHAPTER II

REVIEW OF LITERATURE

2.1 Effect of clove size on growth and yield of garlic

Field trials were carried out by Ahmed *et al.* (2007) during 2002/03 and 2003/04 dry seasons (Nov. to March) at Sokoto to investigate the performance of garlic (*Allium sativum* L.) to varying levels of irrigation interval and clove size. Treatments consisted of factorial combinations of four irrigation intervals in days (3, 5, 7 and 9 days) and two clove sizes (small, <2 cm and large, 2-3 cm). The results revealed that clove size had significant effect on the number of leaves per plant, plant height, bulb yield, bulb weight, number of cloves per bulb and clove weight and they increased as the clove size increased. Large sized cloves had significantly and consistently yielded small sized cloves in both seasons.

Castellanos *et al.* (2004) conducted an experiment depending on clove size and plant stand, planting represents a considerable proportion of the total production costs in garlic cultivation. The objectives of this study were to analyse the influence of seed clove size, planting density and planting method on yield, bulb size and on the profitability of garlic for the fresh market, planted under fertilization. Two additional experiments were established to evaluate the effect of seed size in the range of 1.9-10 g/clove in 1998-99, and 1.9-17 g/clove in 1999-2000. Seeds of Taiwan-type 'Tacatzcuaro' garlic were used in all the experiments. For the seed clove size study, yields varied from 18.7 to 27.3 t/ha for the first year and from 16.3

to 32.2 t ha^{-1} for the second season. In regard to seed size, the highest yield was achieved with 7.5 g/clove for the first season and 13 g/clove for the second season, which also resulted in the biggest bulb diameters and therefore in more valuable commercial classes.

The effect of planting density, seed clove size and planting methods on the yield of Hamedan garlic was investigated by Nosraty (2004). The effects of plant density and seed size on yield were significant, while cultivation method did not significantly affect crop yield. The density of 740 000 plants/ha, seed cloves with weights in the range 5-7 g and planting in 2 rows were the best treatments for obtaining the highest yield.

Gupta *et al.* (2003) evaluate the effects of planting date (20 September, 5 October, 20 October and 5 November) and clove size (less than 10 mm, 10-15 mm, and more than 15 mm) on the performance of garlic cv. 'Yamuna Safed-3' were studied in Karnal, Haryana, India, during the rabi seasons of 1999/2000 and 2000/2001. Clove size greater than 15 mm gave the greatest bulb diameter (3.15 cm), bulb size index (8.78 cm^2), clove diameter (0.96 cm), clove size index (1.79 cm^2), weight of 50 cloves (73.21 g), gross yield (162.50 quintal/ha), and marketable yield (151.39 quintal/ha).

The field experiments were conducted by Hossain *et al.* (2003) to determine the effect of different seed sizes (large (95.1 g/100 cloves), medium (66.5 g/100 cloves) and small (46.3 g/100 cloves) and 4 spacings (25×20 cm, 20×20 cm, 20×15 cm and 20×10 cm) on growth parameters of garlic cv. 'Pabna' in Bangladesh,

during November 2000-April 2001. Large sized cloves had the highest root length, plant height, number of leaves per plant, stem length and total dry matter.

The investigation was conducted by Alam *et al.* (2000) to find the effect of planting date (10 October, 10 November and 10 December) and clove size (large-1.94 g, medium-1.4 g and small-0.7 g) on the growth and yield of garlic in Bangladesh during October 1999 to April 2000. Planting date had significant influence on the growth and yield of garlic. Yield and yield contributing characters were maximum in 10 October planting compared to that of 10 November and 10 December plantings. Yield was decreased as the planting date was delayed. Higher yield was also obtained from large sized clove (6.79 t/ha) than that of the medium (6.11 t/ha) and small (4.94 t/ha) ones. The combined effect of planting date and clove size revealed significant variation in bulb yield and various yield components.

A field experiment was conducted in Punjab, India, in 1998-99 by Brar and Gill (2000) to determine the effect of clove size on garlic cv. 'LCC-1' yield. Cloves of different sizes (0.71, 1.66 and 3.30 g) were sown on 18 October 1998. Bulb diameter and bulb weight per 10 bulbs increased with increasing clove size. The maximum bulb weight per 10 bulbs (287.50 g) was obtained with the sowing of the largest clove size (3.30 g). The highest bulb yield (20.92 t/ha) was also obtained with the sowing of the largest clove.

Hafidh (2000) conducted an experiment to find out the effect of planting material quality (clove weights of >4 g, 1-4 g, and <1 g) on the growth and yield of 2 garlic cultivars (Mexican and Local) was investigated in the field during 1994-95, and in

plastic tunnels in 1995-96. Mexican exhibited higher fresh and dry weights, length of leaves, bulb diameter and yield than Local. Regarding planting material quality, better growth and higher yield were associated with heavier cloves at planting.

Mahmud (1998) carried out an experiment to see the effect of seed clove size and spacing on the growth and yield of garlic. Two-factor experiment consisted of 4 levels of clove size, viz. Large (1.208 g), medium (0.705 g), small (0.417 g) and too small (0.316) and 4 levels of spacing viz. 25 cm × 20 cm, 20 cm × 20, 20 cm × 15 cm and 20 cm × 10 cm accommodating 20, 25, 33 and 50 plants/m^2 respectively. Results revealed that the large clove size was superior to medium and small seed cloves in bulb yield, number of leaves, fresh weight of leaves, bulb weight, root weight, bulb diameter, plant height and earlier emergence. The highest yield (5.77 t/ha) was obtained from large cloves.

Ara (1993) stated that the plant characters, viz. plant height, number of leaves per plant, fresh weight of leaves, bulb and pseudostem per plant, dry weight of leaves, pseudostem and bulb per plant, diameter of bulb per plant, leaf length, leaf dry weight (mg/cm^2) and yield of garlic were significantly affected by clove size. The highest yield (4.37 t/ha) was found form large size clove but similar (3.98 t/ha) with medium size, while the small clove gave the lowest yield (1.73 t/ha).

Grad *et al.* (1993) reported that garlic (cv. Peshawar local) cloves were separated into 2 sizes, <1.0 g and > 2.3 g, and planted 8 cm apart rows 15 cm apart. Control received no fertilizer, the others were supplied with N (120 kg/ha) and P (90 kg/ha) alone or in combination. Data were tabulated on days to 80% sprout emergence,

plant height, number of leaves, days of maturity, number of cloves/bulb, bulb size and yield per hectare. Large cloves sprouted earlier than small ones regardless of manorial treatment and produced taller plants (108 cm compared with 101.05 cm for small cloves). The original cloves size did not significantly influence the size of harvested bulb; bulbs were larger with a combination of N and P than with either element alone.

Baten *et al.* (1991) conducted an experiment with three different sizes of cloves of garlic to evaluate the pattern of dry matter production and partitioning at various stages of growth. The large size cloves produced higher dry matter of root stem, leaf and bulb followed by medium and small cloves. The large size cloves produced higher bulb diameter, bulbing ratio and harvest indices at various stages of growth than those of medium and small cloves. The bulbs originated from large cloves were to be a stranger sink. The small size cloves were highly inferior as propagating materials for garlic production.

In another experiment, Baten *et al.* (1990) stated that growth parameters such as leaf area index (LAI), specific leaf area (SLA), net assimilation rate (NAR), relative growth rate (RGR) and total dry matter (TDM) accumulation at various growth stages in garlic raised from 3 different clove sizes showed highly significant variation. Large clove size always gave the highest leaf area index (LAI) and total dry matter (TDM) accumulation throughout the whole ontogeny. The specific leaf area (SLA) of plants grown from the large cloves had a decreasing tendency, which

was more pronounced from 42 to 112 days after planting than that of the plants grown from medium and small size.

Baten *et al.* (1989) stated the effect of the size of seed cloves on growth and yield of garlic. Large, medium and small seed cloves weighing 140, 86 and 40 g per 100 cloves, respectively were planted and harvested at 8 different dates at fortnight interval from 28 to 126 days after planting. Large seed cloves were superior to medium and small seed cloves in respect of bulb yield, biological yield, number of green leaves, total leaf area, fresh leaf weight and plant height. Large cloves also produced significantly higher individual bulb weight, bulb diameter, clove length clovediameter.

Rahim *et al.* (1988) conducted another experiment at the Bangladesh Agricultural University, Mymensingh with a local cultivar. The cloves taken from large, medium or small mother bulb were planted on three dates between 31 October and 10 December at six densities (17-100 plants/m^2). Cloves taken from large mother bulbs and planted on 31 October at 100/m^2 gave the highest yield (15 t/ha).

Shin *et al.* (1988) from Korea reported that yields were higher (by 20-25%) from large bulbs which in turn gave a higher yield (by 12-13%) than small bulbs. Wardjito *et al.* (1988) conducted an experiment in Bangdung (Indonesia) to study the effect of bulb size and spacing on the production of garlic. Bulbs weighing 0.6-1.0, 1.1-1.5 or 1.6-2.0 g were planted at spacing 10 × 10, 15 × 10, 20 × 10, 15 × 15, 20 × 15, or 20 × 20 cm. Garlic yields tended to be lower when smaller planting

stock was used and were significantly higher (5.7 t/ha) at the closest spacing than at other spacings (0.90-2.95 t/ha) used.

Chernykh (1986) carried out an experiment to determine the optimal size of planting material of the cultivars 'Otradenskii' and 'Donetskii Foiletovyi' and observed that with decreasing clove weight the bulb yield was reduced to a greater extent than the yield of aerial bulbils, suggesting the possibility of producing satisfactory yield of aerial bulbils from small cloves.

El-Habbash *et al.* (1985) carried out two experiments at the Agricultural Research Centre at Fudhiliya, Baghdad. Each experiment included treatment combinations of three clove sizes and three levels of cold storage period (2, 4 weeks and control) at 12-14^{0}C. The best results were obtained from those stored for 4 weeks with the large clove of garlic.

Rahman and Das (1985) conducted an experiment at Gazipur with a local variety. Garlic cloves of 0.54, 0.76 and 1.08 g in weight were planted in rows 10, 15, 20, or 25 cm apart. The highest yield (9.03 t/ha) was obtained by planting 1.08 g cloves in rows 10 cm apart.

Gherman (1984) conducted two-year trials at Romania with the cv. 'Timpurin' de Ciolpani. Seed cloves ranging in weight from 1 g to 3.5 g and derived from the periphery or centre of mother bulbs were planted and assessed for yields and bulb size. Large cloves derived from the periphery of mother bulbs gave the highest yield (8.54 t/ha) of large bulbs.

Rahim *et al.* (1984) stated that the yield of bulb was significantly influenced by the size of mother cloves and the plant height declined as the size of mother bulb was reduced. Large mother bulb naturally contained large cloves and small mother cloves contained small cloves. Production of large bulb by the use of large cloves has been reported by a number of authors (Medina and Casseres, 1960; Duimovic and Bravo, 1979; Minard, 1978).

Omar and Arafa (1979) conducted a trial in Egypt during two seasons with small (0.95 g), medium (3.15 g) and large (5.10 g) cloves of the garlic cv. 'Balady' by planting in mid September. The plants received N at 15.5, 29.5 or 46.5 kg/feddan as a side dressing in a split plantation, half at 45 days after planting and the other half later. Data were tabulated on bulb size, plant fresh and dry weight, yield and bulb chemical composition. Large cloves receiving the high dose of N gave the highest yield.

Karlovic and Komissrew (1977) reported from their experiment that the plants produced from large seed cloves were higher yielding than those from medium to small seed cloves. Duimovic and Bravo (1979) reported that yield increased with increasing clove weight from 4.6 to 5.5 t/ha. Yield of exportable bulbs (>5.1 cm in diameter) also increased from 21 to 46% with an increase in seed clove weight in garlic.

Morvace *et al.* (1974) reported a significant positive correlation between clove size and number of cloves per bulb. Bogatirenko (1975) conducted a trial in the UK with the garlic cv. Boguslavskii-10. The highest yield (10.2 t/ha) was obtained by

planting cloves of 1.6-2.1 cm in diameter with spacing of 45 × 4 cm.

2.2 Effect of mulches on growth and yield of garlic

Islam *et al.* (2007) conducted an experiment to find out the effects of mulching and fertilizer management practices on the growth and yield of garlic were studied in Bangladesh. Three kinds of mulches (black polyethylene, straw and water hyacinth [*Eichhornia* sp.] with a control) and 3 types of fertilizers were compared with no fertilizer/manure. Mulching with black polyethylene, water hyacinth and straw resulted in yields of 5.80, 5.70 and 5.48 t/ha, which were 39, 36.6 and 31.41% higher than the yields of the control (4.17 t/ha). The effects of black polyethylene and water hyacinth mulch on the growth and yield of garlic were almost similar.

The effects of plastic, straw and sawdust mulches on the yield and yield components of garlic (cv. Bannu Local) were studied by Jamil *et al.* (2005) in Dera Ismail Khan, Pakistan, during the spring of 2003. Plants without mulch (control) were smaller by 6 and 13 cm than the plants mulched with plastic and straw, respectively. Bulb survival was the greatest (71.83%) with plastic mulch used throughout the cropping season and the lowest (50%) in the control. Bulb diameter was the greatest with plastic mulch (4.71 cm), and the lowest with sawdust mulch (4.33 cm) and in the control (4.18 cm). Straw mulch resulted in the greatest bulb weight (385.9 g) and yield (6.35 t/ha). Straw mulch, which is cheaper and effective in enhancing garlic yield, is recommended under the agro-climatic conditions.

Akand (2003) conducted an experiment with mulching and organic manure trial on carrot in BAU Mymensingh, and observed that black polythene mulch significantly resulted the highest yield of carrot of his experiment,

Hossain (2003) carried out an experiment on the effect of mulches on the growth and yield some garlic germplasm, they reported that the highest (4.32 t/ha) obtained from water hyacinth mulch. It also increased plant height, number of leaves, fresh and dry weight of leaves, roots and bulb, neck diameter, bulb diameter and number of cloves/plant.

Halim (2000) conducted an experiment on the effect of different mulches on the growth and yield of some garlic germplasm. In this experiment, it was found that 'G1 9' variety with water hyacinth mulch produced the highest yield (10.90 t/ha) and G4 variety with white polythene gave the lowest (1.90 t/ha) yield of garlic.

Bhuiyan (1999) carried out an experiment in Bangladesh Agricultural University, Mymensingh, on effect of planting time, mulch and irrigation on the growth and yield of garlic, who stated that mulches had marked effect on growth and yield of garlic. The author found water hyacinth mulch yielded (4.27 t/ha) best followed by straw mulch.

While working with mulching on garlic in Bangladesh Agricultural University, Mymensingh, Hasan (1999) reported that, water hyacinth mulch gave the tallest plant and the highest number of leaves per plant at 75 DAP. The author added that

fresh weight of bulbs and roots, dry weight of bulbs and root and bulb diameter were increased.

Rekowaska (1997) conducted experiment to compare mulches performance like transparent plastic film 0.05 mm thick, black plastic film 0.05 mm thick, pressed cereal straw, saw dust and peat as mulch material for garlic cv. 'Dolnoslaski'. Mulches generally had positive effect on yield and crop quality. The black plastic film mulch gave the highest average marketable yield of 13.3 ton/ha compared with 10.15 ton/ha in the unmulched control. The black plastic film mulch gave the highest average marketable yield of 13.3 ton/ha compared with 10.15 ton/ha in the unmulched control. The black plastic mulch also produced the largest and heaviest bulbs. None of the treatments had a significant effect on the number of cloves/bulb.

In Indonesia, straw has been proved to be the best mulch for garlic compared to transparent plastic, black polythene and cabbage residues as it yielded the largest bulbs and the highest number of cloves/bulb (Uddin, 1997).

Hossain (1996) carried out an experiment in Bangladesh Agricultural University, Mymensingh, and commented that plant height, leaf number, pseudostem and bulb diameter, dry matter content of foliage, bulb weight and bulb yield were found significantly higher for mulched plants.

Mia (1996) found that plant grown with mulch gave higher bulb yield than non mulch showing better performance in most of yield contributing characters such as

plant height, number of leaves/plant, pseudostem diameter and dry matter of roots etc. of onion.

Baten *et al.* (1995) evaluated the use of water hyacinth [*Eichhormia crassipes*] root rice straw or dried grass as mulch for their effects on the growth and yield of late planted garlic at Bangladesh Agricultural University during the 1990-91 growing season. Plants treated with any of the mulches showed significantly increased plant height, number of leaves per plant, length of leaf length of pseudostem, number of roots/plant, bulb and neck diameter compared with the control. Bulb length, bulb diameter, clove length, clove diameter, number of clove per bulb, 100 clove weight and yield were also significantly higher in mulched plants. All mulches provide weed control. Among the treatments, water hyacinth root gave the best results in terms of garlic yield. All types of mulch in this study comprehended for reduction in garlic yield due to late planting.

Adetunji (1994) found that mulch significantly enhanced vegetative growth to optimize water use and soil condition during dry season in semi arid Nigeric where onions were mulched with polyethylene film. They found that, total bulb yield of onion was 80% higher than no mulched treatment.

Arboleya *et al.* (1994) tested five planting densities, viz. 240,000; 320,000; 560,000; 720,000 and 960,000 plants/ha and two mulch treatments, viz. Black polythylene or organic matter, and no mulch and tabulated data on plant height, marketable yield and bulb sizes (ranging from 15-20 to 60 mm in diameter). The highest yield (14.24 ton/ha) of good size bulb was obtained with 560,000 plants/ha.

it declined with higher densities. Mulching had no marked effect on the variations parameters.

Iroc *et al.* (1991) stated that, different mulch materials highly influenced the average height and the average bulb diameter of garlic seedlings. Garlic mulched with saw dust plus cogon significantly gave the greatest average height of 11.97 cm. This was followed by those mulched with cogon only (control) rice hull plus cogon, carab grass plus cogon and rice straw plus cogon which exhibited average heights of 10.94, 10.04, 5.97 and 5.30 cm respectively. The difference among the average heights of these treatments was found to be significant. Garlic mulched with rice hull and cogon produced the highest bulb diameter with an average of 0.97 cm. The other treatments resulted in reduced bulb diameters. The plants mulched with carab grass plus cogon significantly developed the smallest bulb diameter with an average of 0.64 cm only.

Oh *et al.* (1991) planted in field traits in 1986-87, garlic cv. 'Namdo' in autumn was given combinations of 0-3330 kg N, 0-300 kg K_2O/ha and was mulched with either straw or polyethylene film. Plant height in November was greatest with the 0 or 110 kg N ha^{-1} and no P or K, but in March plant heights were greatest with the highest rates of fertilizer. The highest yields with straw mulch were given by 210 kg each of N and K_2O and 250 kg P_2O_2/ha, but under polyethylene film yields were lower and the optimum rates of fertilizer were 220 kg N, 170 kg P_2O_5 and 250 kg K_2O/ha. Response to fertilizer efficiency was highest with K. Soil organic matter

and K was higher with straw mulch than with polyethylene film. There was significant correlation between yield and soil organic matter or soil P_2O_5 content.

Soil moisture conservation is an important aspect for crop growth and yield. In an experiment conducted by Suh *et al.* (1991) transparent polyethylene film and black polyethylene film mulches were applied to onion crops. The mean soil water content was 2.1-2.8% higher in the mulched plots than the control.

Roy *et al.* (1990) by using water hyacinth, straw and saw dust as mulch on potato opined that mulches increased leaf area index (LAI) and crop growth rate (CGR). Calendacion *et al.* (1990), Imam *et al.* (1990) and Prihar (1986) noted the same result.

Asandhi *et al.* (1989) conducted an experiment with garlic cv. 'Lumbu Hijak' which was mulched with rice straw, transparent plastic and black plastic. They found that, mulching with rice straw gave the largest bulb (2.8 cm diameter) and the highest number of cloves/bulb (12.75).

Chung (1987) observed that mulching with polyethylene film gave the highest yield, they also found that effect of the mulch resulted faster maturing of plants and growth rate, bulb, weigh, number of cloves per bulb and rate of secondary growth were all increased.

Sutater (1987) in a find trial found that the yields were higher in potato with mulch than without mulch, who also reported that, mulch reduced day soil temperature.

Number of leaves increased slightly with mulching. Rice straw mulch gave higher yield in potato (Teja *et al.*, 1992).

Aliudin (1986) observed that, application of straw, husk and broad leaf mulches increased yield of garlic by 21.11 percent, but application of grass mulch reduced garlic yield by 2.11 percent compared to no mulches.

Duranti and Barbicri (1986) reported the results of a two year study conducted on the Seteriver plain of Itali with cv. 'Messidrome' grown at 33.3 and 16.7 plants m-2 without irrigation or with irrigation at three frequencies ie, 25, 50, and 75 mm of reference. Marmetable garlic bulb yield, plant survival and keeping duration feel, and non-marketable yield increased with increasing irrigation frequency. Mean weight also increased with irrigation frequency. Bulb yield and plant survival fell with increasing volume of irrigation. Damage by *Pseudomonas cepcia* was linked to frequent irrigation.

Jha *et al.* (1986) stated that, the highest yield of ginger cv. 'Jorth' was obtained from mulchd treatment in comparison with unmulched one. Some report was made on ginger through another trial by Maity *et al.* (1988).

Sumi *et al.* (1986) stated that mulching has significant effect on the yield of garlic. They applied super phosphate to cv. 'Chinese' at the dose of 0, 100, 200, 300, or 400 kg/ha with or without mulch of *Paspalum notatum* with a high P content, they found that super phosphate had no effect on yield but mulching gave the maximum

yield of 10.30 ton/ha with an average bulb size of 31.22 g compared with 6.06 ton ha/ha and 19.01 for the unmulched control.

The rapid growth made under plastic film mulches or tunnels tended to accelerate secondary growth of garlic and his caused undesirable rough bulb to develop as discussed by Moon and Lee (1985).

Leaf area, number and total shoot dry weight of sweet potato cultivar Jewel were significantly higher for unmulched plants as reported by Hockmuth and Howell (1983). They reported that the highest marketable yield (18.6 ton /ha) was obtained from mulched raised beds where flat unmulched beds gave the lowest yield (7.0 t/ha).

Increasing in growth and yield has been reported from Korea by mulching the crop with polyethylene films. Late mulch removal increased the secondary bulb growth and bolting in garlic Cho *et al.* (1982). El-Beheidi *et al.* (1983) reported that, the highest and relative yield of garlic was obtained as a result of irrigation after the depletion of 20% available soil moisture under the condition of Egypt.

Donnari *et al.* (1978) reported that, in garlic high yield and yield and quality bulbs were obtained from two irrigations (20 mm) in August and September, and 3 irrigations (30 mm) in October and November.

Benoit and Ceustermans (1975) reported that mulching in carrots immediately after sowing with perforated polyethylene film 0.02 mm thick greatly increased the yields and size of root of carrot. Awal *et al.* (1978) obtained a significant increased

in yield of Mukhi Kachu with the use or rice straw. Shya (1979) found that *Dioscorea alata* mulched with rice straw, black plastic film on citronella yielded 350, 622 and 299 g fresh weight of tuber per plant, respectively, compared with 131 g obtained from unmulched plants. Dry weight were all highest will black plastic mulch.

Menezes *et al.* (1974) conducted an experiment with local cultivar of garlic, spaced at 4.75 or 10 cm with in the row (25-30 cm) between rows) with 500, 1000 kg/ha or no sulphate of ammonia with or without mulch and found that mulching increased yield and average bulb weight at all spacing and N levels.

San *et al.* (1974) carried out an experiment in Brazil on garlic with and without rice straw mulch and found that mulching reduced soil temperature variations and the temperature on soil surface and at a depth of 10 cm soil temperature disappeared. Regardless of mulching, levels of Ca, Mg, K and organic matter in the soil fell during traits. Mulching reduced the loose of soil K.

CHAPTER III

MATERIALS AND METHODS

3.1 Experimental site

The experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the rabi season (November, 2007 to May, 2008).The location of the experimental site is situated in 24.09^0 N latitude and 90.26^0 E longitude (Anon., 1989). The altitude of the location was 8.2 m from the sea level.

3.2 Soil

The experimental site located in the Modhupur Tract under AEZ No. 28 (UNDP, 1988). The selected experimental plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Resource Development Institute (SRDI), Farmgate, Dhaka and presented in Appendix I.

3.3 Climate

The experimental area is situated in the sub-tropical climatic zone, which is characterized by heavy rainfall during the months of April to September and scanty rainfall during the rest period of the year. Details of weather data in respect of temperature (^{0}C), rainfall (cm) and relative humidity (%) for the study period will be collected from the Meteorological Department of Bangladesh, Agargoan, Dhaka-1207 and presented in Appendix II.

3.4 Planting materials

A local cultivar of garlic (local developed) was used in this experiment. Bulbs were collected from Kushtia district of Bangladesh. The cloves of uniform size and thick shell were selected for planting.

3.5 Treatment of the experiment

The experiment was carried out to find out the effects of clove size and mulching on the growth and yield of garlic. The experiment considered as two factors.

Factor A: Clove size (weight of 100 cloves)

i. C_1: 44 g ii. C_2: 63 g iii. C_3: 90 g

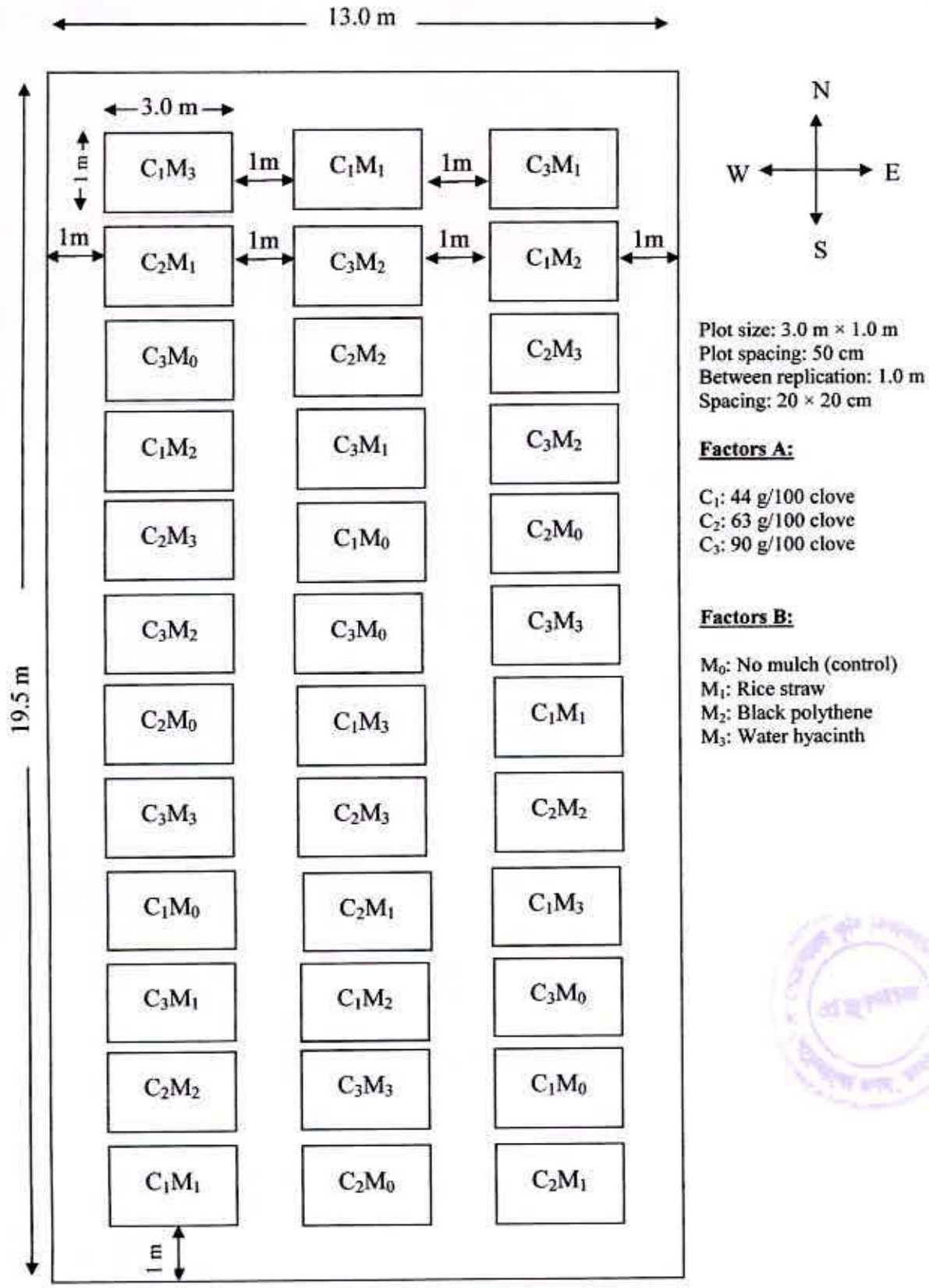
Factor B: Mulch material (4 levels)

i. M_0: No mulch (Control) ii. M_1: Rice straw
iii. M_2: Black polythene iv. M_3: Water hyacinth

There were on the whole 12 (3 × 4) treatment combinations such as C_1M_0, C_1M_1, C_1M_2, C_1M_3, C_2M_0, C_2M_1, C_2M_2, C_2M_3, C_3M_0, C_3M_1, C_3M_2 and C_3M_3.

3.6 Experimental design and layout

The experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. The experimental area was first divide into three blocks. Each block was divided into 12 plots to assign 12 treatment combinations. Therefore the total number of plots was 36. Thereafter, 12 treatment combinations was randomly assigned to each block as per design of the experiment. The size of the unit plot was 3 m × 1 m. A distance of 50 cm between the plots and 1 m between the blocks was kept. Thus the total area of the experiment was 253.5 m^2. The layout of the experiment is shown in Figure 1.



Plot size: 3.0 m × 1.0 m
Plot spacing: 50 cm
Between replication: 1.0 m
Spacing: 20 × 20 cm

Factors A:

C_1: 44 g/100 clove
C_2: 63 g/100 clove
C_3: 90 g/100 clove

Factors B:

M_0: No mulch (control)
M_1: Rice straw
M_2: Black polythene
M_3: Water hyacinth

Figure 1. Layout of the experimental plot

3.7 Land preparation

The land selected for conducting the experiment was opened in the first week of November 2007 with a power tiller and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain until good tilth. Weeds and stubbles were removed, and finally a desirable tilth of soil was obtained for planting cloves of garlic. Cowdung and chemical fertilizers as indicated below were mixed with the soil of each unit plot.

3.8 Application of manure and fertilizers

The sources of N, P_2O_5, K_2O, S and Zn as urea, TSP and MP, Zypsum and Zinc were applied, respectively. The entire amounts of MP, Zypsum and Zinc were applied during the final land preparation. Urea and TSP was applied in two equal installments at planting time and the time of mulching applicaion. Well-rotten cowdung also applied during final land preparation. The following amount of manures and fertilizers were used which shown as tabular form recommended by Fertilizer Recommended Guide, 2005 (published by BARC).

Table 1. Dose and method of application of fertilizers in garlic field

Fertilizers	Dose/ha	Application (%)	
		Basal	During mulch application
Cowdung	3 tons	100	--
Nitrogen (as urea)	200 kg	--	33.33
P_2O_5 (as TSP)	90 kg	100	--
K_2O (as MP)	240 kg	100	--
S (as $CuSo_4$)	30 kg	100	
Zn (as $ZnSO_4$)	3.0 kg	100	

3.9 Sowing of cloves

On 15 November 2007 maintaining a spacing of 20 cm × 20 cm the cloves were sown. The depths of sowing was around 2.5 cm from the surface of the soil.

3.10 Intercultural operation

When the seedlings started to emerge in the beds it was always kept under careful observation. After emergence of seedlings, various intercultural operations were accomplished for better growth and development of garlic seedlings.

3.10.1 Gap filling

The experimental area kept under careful observation. The unsprouted cloves shell was replaced by healthy seedling taken from border plant at 15 December, 2007. The damaged plants also replaced by healthy border plants, which were planted at the same time.

3.10.2 Weeding

Weeding was done to keep the plots free from weeds, easy aeration of soil, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully for two times at 29 November and 14 December. Breaking of the soil crust was done when needed.

3.10.3 Irrigation

Light irrigation was given just after sowing the cloves. A week after sowing requirement of irrigation was envisaged through visual estimation. Whenever the plants of a plot had shown the symptoms of wilting the plots were irrigated on the same day with a hosepipe until the entire plot was properly wet.

3.10.4 Top Dressing

After basal dose, the remaining doses of urea and TSP were top-dressed at 30 November during mulch application. The fertilizers were applied on both sides of plant rows and mixed well with the soil by hand. Earthing up was done with the help of nirani immediately after top-dressing of fertilizer.

3.10.5 Plant Protection

Leaf blotch disease was noticed in the experimental plot. Curative measure was taken by spraying Bavistin 50WP at an interval of 10 days @ 50 g in 10 liters of water.

3.11 Harvesting

Garlic cloves were harvested at 22 March at complete mature stages. Maturity stage was identifying by observation of plant. When about 80% plants of the unit plot became reddish in color and showing lodging status and it was selected for harvest.

3.12 Data collection

Data were recorded on the following parameters from the sample plants during the course of experiment. Ten plants were randomly selected from each unit plot for the collection of data. The plants in the outer rows and the extreme end of the middle rows were excluded from the random selection to avoid the border effect.

3.12.1 Plant height

Plant height was measured in centimeter (cm) by a meter scale at 30, 45, 60 and 75 days after planting (DAP) from the point of attachment of the leaves to the ground level up to the tip of the longest leaf and the mean value was calculated.

3.12.2 Number of leaves per plant

Number of leaves of ten randomly selected plants was counted at 30, 45, 60 and 75 DAP. All the leaves of each plant were counted separately except the smallest young leaf at the growing point of the plant. The average number of leaves of ten plants gave number of leaves/plant.

3.12.3 Diameter of garlic neck

Diameter of garlic neck was measured in centimeter (cm) by a slide calipers at 30, 45, 60 and 75 days after planting (DAP) from the point of neck and after collection the reading of the mean value was calculated.

3.12.4 Leaf length

Leaves of ten randomly selected plants at maximum growth stage were detached by a sharp knife from pseudostem attachment and average length of leaves was taken by a meter scale and mean weight was recorded in centimeter.

3.12.5 Fresh weight of leaves per plant

Leaves of ten randomly selected plants at maximum growth stage were detached by a sharp knife from pseudostem attachment and average fresh weight of leaves was taken by an electric balance and mean weight was recorded in gram.

3.12.6 Dry weight of leaves per plant

After harvest, leaves of ten selected plants were weighed and kept in an oven at 80^0C for drying. It took 72 hours to reach the constant weight and then the average dry weight per plant was calculated in gram.

3.12.7 Diameter of bulb

The diameter of bulb was measured with a slide calipers at the middle part of the bulb after harvest and their average was calculated in centimeter.

3.12.8 Number of cloves per bulb

After harvesting the number of cloves of 10 selected bulb was counted thoroughly. The mean of cloves/bulb was calculated by dividing the total number of cloves counted from ten bulbs by ten.

3.12.9 Fresh weight of bulb per plant

After removing the top portion and roots, the bulb weight of ten randomly selected plants was taken in gram and their average was calculated as weight of individual bulb.

3.12.10 Dry Weight of bulb per plant

After lifting and sun drying for two days the bulb samples were dried 72 hours at 80°C in an oven. After drying, the weights of the bulb were recorded in gram.

3.12.11 Fresh weight of roots per plant

The root weight of ten randomly selected plants was taken in gram and their average was calculated as weight of individual root weight per plant.

3.12.12 Dry weight of roots per plant

Fresh roots of ten lifted plants were kept in an oven at 80^0C for drying. It took 72 hours to reach the constant weight and then average dry weight was recorded and expressed in gram.

3.12.13 Yield of bulb per hectare

Bulb yield per plot was recorded by harvesting all the bulbs in each plot and taking their weight after removing roots by a weighing scale. Yield of bulb per plot was converted into hectare and was expressed in metric ton.

3.13 Statistical Analysis

The experimental data obtained for different parameters were statistically analyzed to find out the effect of clove size and mulching on the growth and yield of garlic. The mean values of all the recorded characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the individual and treatment combinations means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

3.14 Economic analysis

The cost of production was analyzed in order to find out the most economic treatment of clove size and mulching. All input cost were considered in computing the cost of production. The market price of garlic was considered for estimating the return. The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ratio} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Plant height at different growth stages

Statistically significant variation was recorded from plant height of garlic due to different clove size at 30, 45, 60 and 75 DAP (Appendix III). At the different days after planting (DAP) the tallest plant (25.61 cm, 32.16 cm, 35.83 cm and 45.61 cm) was found in C_3 (90 g/100 cloves) which was statistically identical (25.12 cm, 31.37 cm, 35,28 cm and 44.31 cm) with C_2 (63 g/100 cloves) at 30, 45, 60 and 75 DAP, respectively. On the other hand, at the same DAP the shortest (22.64 cm, 28.44 cm, 32.36 cm and 40.08 cm) was obtained from C_1 (44 g/100 cloves), respectively (Figure 2). It was revealed that with the increases of clove size plant height showed increasing trend. Large sized clove stored comparatively large amount of nutrients that helps to the development of plant immediate after emergence of seedlings. Rahim *et al.* (1984) stated that the plant height declined as the size of mother bulb was reduced. Baten *et al.* (1989) stated that large seed cloves were superior to medium and small in respect plant height.

Different mulching showed significant variation at 30, 45, 60 and 75 DAP for plant height of garlic (Appendix III). At 30, 45, 60 and 75 DAP the tallest plant (28.06 cm, 33.73 cm, 39.11 cm and 46.80 cm) was obtained from M_2 (black polythene mulch) which was closely followed (25.09 cm, 31.41 cm, 34.65 cm and 44.21 cm) and (24.20 cm, 31.03 cm, 33.93 cm and 43.74 cm) by M_3 (water hyacinth mulch)

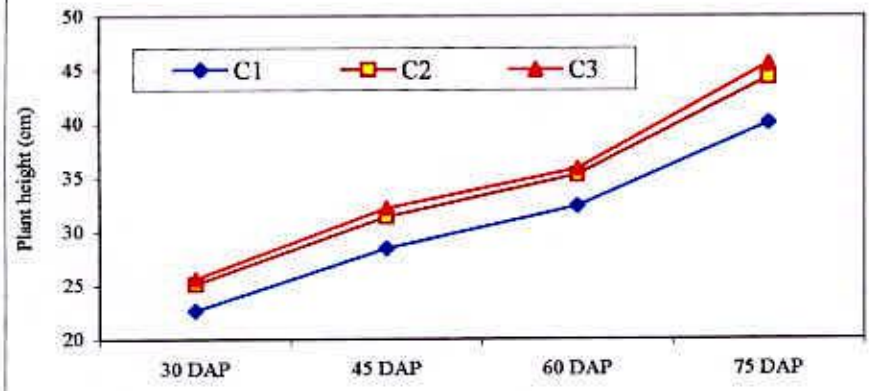


Figure 1: Effect of clove size on plant height of garlic

C_1 : 44 g/100 cloves C_2 : 63 g/100 cloves C_3 : 90 g/100 cloves

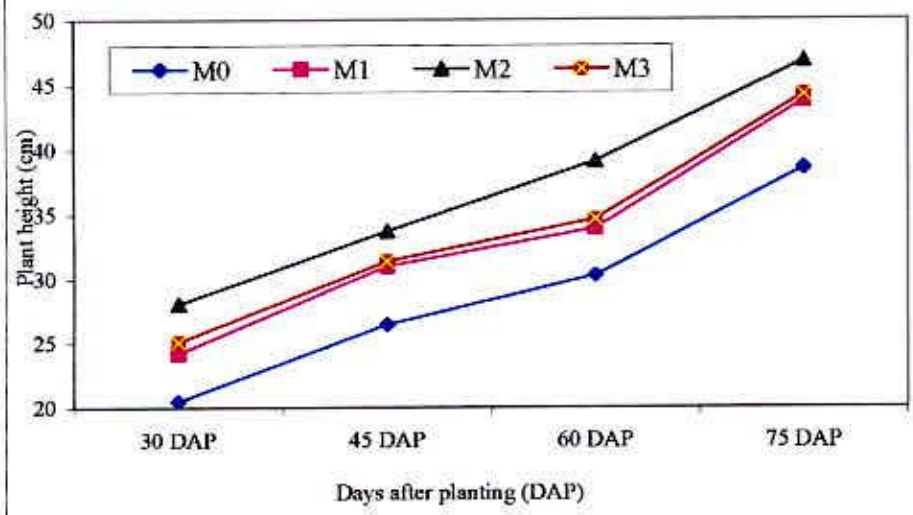


Figure 2. Effect of mulching on plant height of garlic

M_0 : No mulch (control) M_1 : Rice straw

M_2 : Black polythene M_3 : Water hyacinth

and M_1 (rice straw mulch) respectively. Again, the shortest plant (20.48 cm, 26.44 cm, 30.28 cm and 38.57 cm) was found from M_0 as no mulch i.e. control condition at same DAP (Figure 3). Mulch significantly enhanced vegetative growth to optimize water use and soil condition that leads to the longest plant. Iroc *et al.* (1991) stated earlier that different mulch materials highly influenced the average plant height. Hossain (1996) commented that plant height was significantly higher for mulched plants than the control.

Statistically significant variation was recorded due to interaction effect of clove size and mulching in terms of plant height of garlic at 30, 45, 60 and 75 DAP (Appendix III). The tallest plant (29.58 cm, 35.47 cm, 41.36 cm and 49.57 cm) was observed from C_2M_2 (63 g/100 cloves + black polythene mulch) at 30, 45, 60 and 75 DAP respectively. On the other hand, the shortest plant (18.01 cm, 24.00 cm, 28.57 cm and 35.70 cm) was found from C_1M_0 (44 g/100 cloves and no mulch) at 30, 45, 60 and 75 DAP respectively (Table 2). It was revealed that optimum clove size and mulch materials ensure maximum vegetative growth by ensuring nutrients immediate after germination that lead to the development of plants and the ultimate results was the highest plant height of garlic.

Table 2. Interaction effect of clove size and mulching on plant height of garlic

Treatment combination	Plant height (cm) at			
	30 DAP	45 DAP	60 DAP	75 DAP
C_1M_0	18.01 e	24.00 g	28.57 g	35.70 h
C_1M_1	22.80 c	29.60 de	32.87 de	41.10 f
C_1M_2	25.40 b	30.50 cd	35.53 bc	42.73 ef
C_1M_3	24.36 b	29.67 de	32.47 def	40.77 f
C_2M_0	20.71 d	26.70 f	30.87 f	38.83 g
C_2M_1	24.86 b	31.43 bc	33.70 cd	44.43 de
C_2M_2	29.58 a	35.47 a	41.36 a	49.57 a
C_2M_3	25.32 b	31.87 b	35.20 bc	44.40 de
C_3M_0	22.73 c	28.63 e	31.40 ef	41.17 f
C_3M_1	24.93 b	32.07 b	35.23 bc	45.70 cd
C_3M_2	29.20 a	35.23 a	40.43 a	48.10 ab
C_3M_3	25.59 b	32.70 b	36.27 b	47.47 bc
$LSD_{(0.05)}$	1.461	1.264	1.818	1.868
Significance level	0.01	0.01	0.05	0.05
CV(%)	8.53	5.43	10.11	6.55

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

C_1: 44 g/100 cloves
C_2: 63 g/100 cloves
C_3: 90 g/100 cloves

M_0: No mulch (control)
M_1: Rice straw
M_2: Black polythene
M_3: Water hyacinth

4.2 Number of leaves per plant at different growth stages

Number of leaves per plant of garlic showed statistically significant variation due to different clove size at 30, 45, 60 and 75 DAP (Appendix IV). At the different days after planting (DAP) the highest number of leaves per plant (4.32, 5.27, 6.27 and 7.75) was found in C_3 (90 g/100 cloves) which was closely followed (4.23, 5.07, 6.08 and 7.45) by C_2 (63 g/100 cloves) at 30, 45, 60 and 75 DAP respectively. On the other hand, at the same DAP the lowest number of leaves per plant (3.87, 4.65, 5.81 and 6.75) was found in C_1 (44 g/100 cloves) respectively (Figure 4). It was revealed that number of leaves per plant showed increasing trend with the increases of clove size. Baten *et al.* (1989) stated that large seed cloves were superior to medium and small seed cloves in respect of number of green leaves. Mahmud (1998) reported that the large clove size was superior to medium and small seed cloves in number of leaves.

Statistically significant variation was recorded due to different mulching for number of leaves per plant of garlic at 30, 45, 60 and 75 DAP (Appendix III). At 30, 45, 60 and 75 DAP the highest number of leaves per plant (4.66, 5.72, 7.10 and 8.52) was recorded from M_2 (black polythene mulch) which was closely followed (4.25, 5.06, 6.14 and 7.91) and (4.15, 4.91, 5.89 and 7.45) by M_3 (water hyacinth mulch) and M_1 (rice straw mulch) respectively and the lowest number of leaves per plant (3.49, 4.30, 5.09 and 5.39) was found in M_0 as no mulch i.e. control condition at same DAP (Figure 5). Number of leaves increased slightly with mulching (Taja *et al.*, 1992). The highest number of leaves produced in mulching treatments were possibly due to greater plant height and favorable temperature, pH and moisture

condition of the soil. Hossain (1996) commented that leaf number significantly higher for mulched plants.

Interaction effect of clove size and mulching showed statistically significant differences in terms of number of leaves per plant of garlic at 30, 45, 60 and 75 DAP (Appendix III). The highest number of leaves per plant (5.06, 6.10, 7.67 and 9.07) was found in C_3M_2 (90 g/100 cloves + black polythene mulch) at 30, 45, 60 and 75 DAP respectively. On the other hand, the lowest number of leaves per plant (3.30, 3.93, 5.00 and 5.00) was recorded from C_1M_0 (44 g/100 cloves and no mulch) at 30, 45, 60 and 75 DAP respectively (Table 3). Number of leaves per plant increased with black polythene mulch and larger size of cloves. It was revealed that optimum clove size and mulch materials produced the highest number of leaves per plant with ensuring maximum vegetative growth.

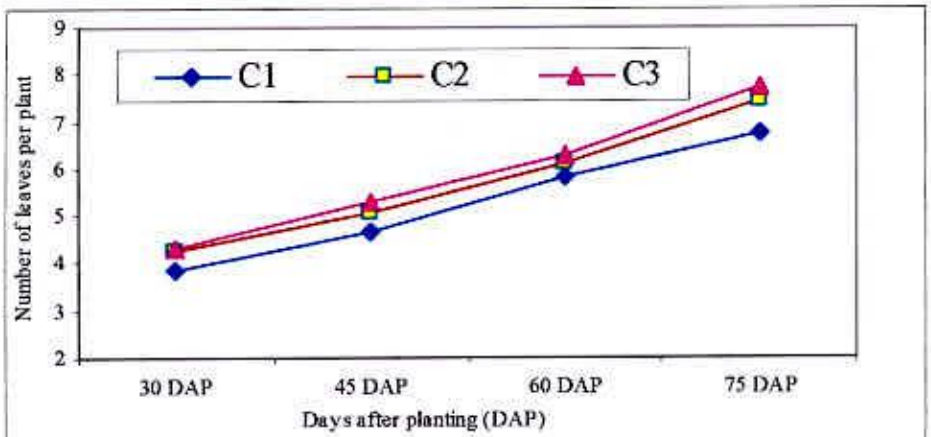


Figure 4. Effect of clove size on number of leaves per plant of garlic

C_1 : 44 g/100 cloves C_2 : 63 g/100 cloves C_3 : 90 g/100 cloves

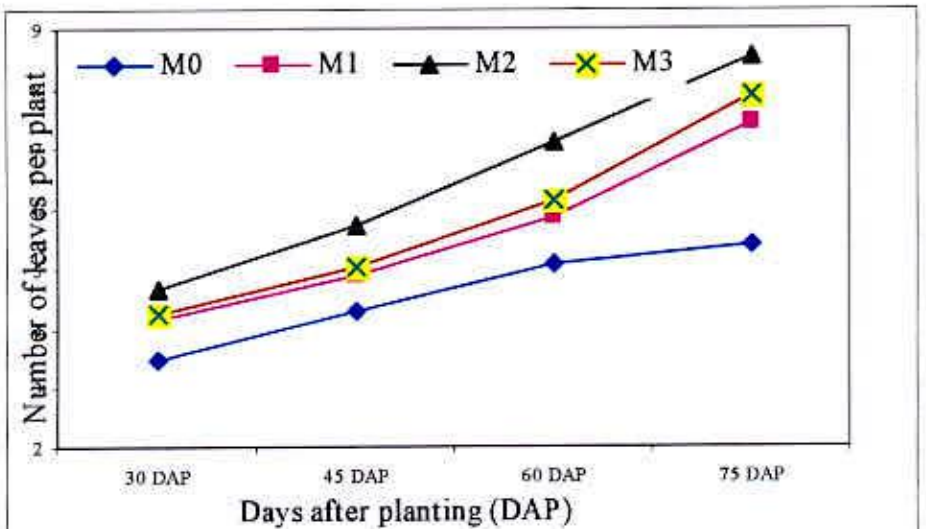


Figure 5. Effect of mulching on number of leaves per plant

M_0 : No mulch (control) M_1 : Rice straw

M_2 : Black polythene M_3 : Water hyacinth

Table 3. Interaction effect of clove size and mulching on number of leaves per plant of garlic

Treatment combination	Number of leaves per plant at			
	30 DAP	45 DAP	60 DAP	75 DAP
C_1M_0	3.30 e	3.93 g	5.00 f	5.00 h
C_1M_1	4.03 cd	4.67 e	5.72 e	6.82 f
C_1M_2	4.03 cd	5.23 c	6.53 c	7.83 d
C_1M_3	4.11 bc	4.77 e	6.00 e	7.37 e
C_2M_0	3.43 e	4.30 f	5.17 f	5.50 g
C_2M_1	4.20 bc	5.00 d	5.99 e	7.55 e
C_2M_2	4.90 a	5.83 b	7.10 b	8.67 b
C_2M_3	4.38 b	5.17 cd	6.07 de	8.10 cd
C_3M_0	3.73 d	4.66 e	5.10 f	5.67 g
C_3M_1	4.23 bc	5.07 cd	5.95 e	7.98 d
C_3M_2	5.06 a	6.10 a	7.67 a	9.07 a
C_3M_3	4.27 bc	5.24 c	6.36 cd	8.27 c
$LSD_{(0.05)}$	0.298	0.186	0.326	0.268
Significance level	0.01	0.01	0.01	0.05
CV(%)	5.27	7.19	5.24	9.16

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

C_1: 44 g/100 cloves
C_2: 63 g/100 cloves
C_3: 90 g/100 cloves

M_0: No mulch (control)
M_1: Rice straw
M_2: Black polythene
M_3: Water hyacinth

4.3 Diameter of garlic neck at different growth stages

Significant differences was recorded from diameter of garlic neck due to the planting of different clove size at 30, 45, 60 and 75 DAP (Appendix III). At the different days after planting (DAP) the highest diameter of garlic neck (3.28 cm, 3.88 cm, 4.91 cm and 6.53 cm) was recorded from C_3 (90 g/100 cloves) which was closely followed (2.93 cm, 3.49 cm, 4.57 cm and 6.03 cm) by C_2 (63 g/100 cloves) at 30, 45, 60 and 75 DAP respectively. On the other hand, at the same DAP the lowest diameter of garlic neck (2.65 cm, 3.22 cm, 4.11 cm and 5.42 cm) was recorded from C_1 (44 g/100 cloves) respectively (Figure 6). In case of large clove, maximum number of leaves was found that produced maximum food materials which were stored in bulb and pseudostem. So maximum diameter of garlic neck was found in plant, grown from large clove. This result is similar with the report of Ara (1993).

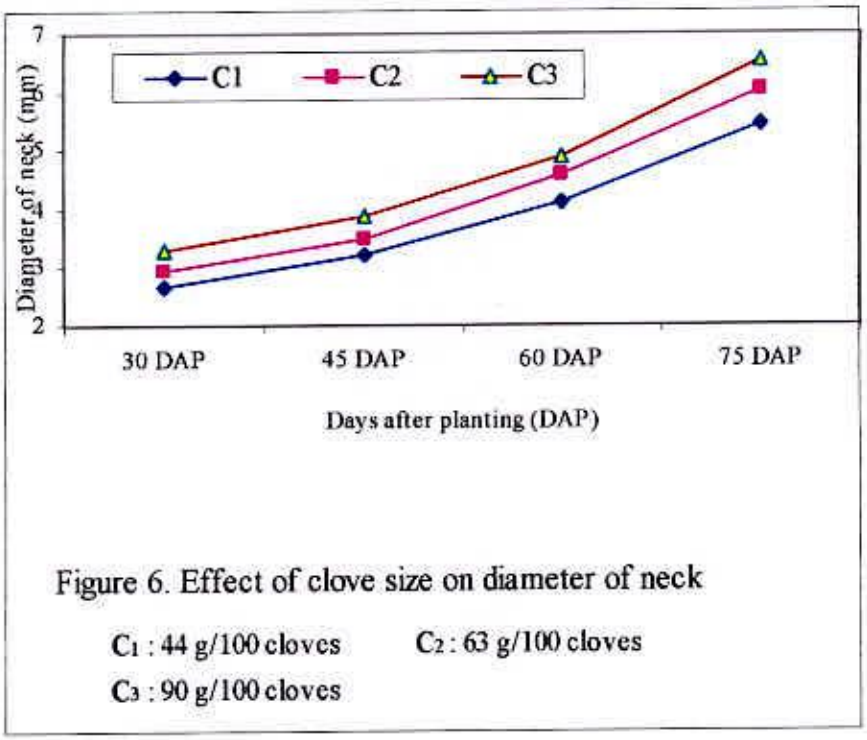


Figure 6. Effect of clove size on diameter of neck

C_1 : 44 g/100 cloves C_2 : 63 g/100 cloves

C_3 : 90 g/100 cloves

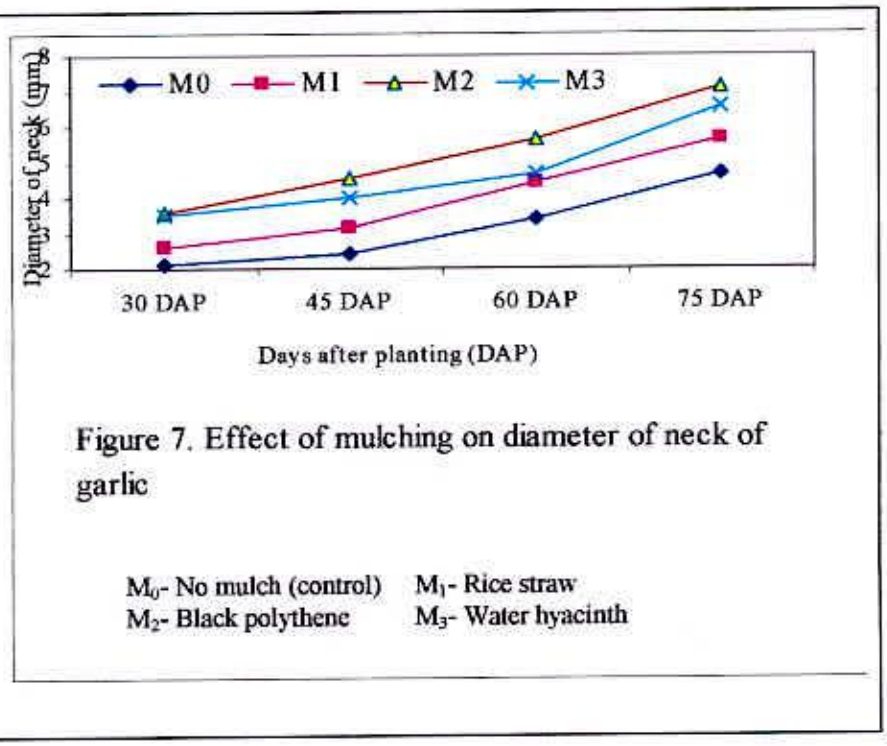


Figure 7. Effect of mulching on diameter of neck of garlic

M_0- No mulch (control) M_1- Rice straw

M_2- Black polythene M_3- Water hyacinth

Different mulching showed statistically significant differences for diameter of garlic neck at 30, 45, 60 and 75 DAP (Appendix III). At 30, 45, 60 and 75 DAP the highest diameter of garlic neck (3.59 cm, 4.53 cm, 5.62 cm and 7.12 cm) was found in M_2 (black polythene mulch) which was closely followed (3.49 cm, 3.99 cm, 4.67 cm and 6.57 cm) and (2.62 cm, 3.16 cm, 4.42 cm and 5.61 cm) by M_3 (water hyacinth mulch) and M_1 (rice straw mulch) respectively. Again, the lowest diameter of garlic neck (2.11 cm, 2.44 cm, 3.41 cm and 4.68 cm) was obtained from M_0 as no mulch i.e. control condition at same DAP (Figure 7). Mulching preserve soil moisture that leads to maximum vegetative growth for the plants and the results was the highest diameter for garlic neck. Hossain (2003) reported that neck diameter significantly higher for mulched plants.

Diameter of garlic neck varied significantly due to the interaction effect of clove size and mulching at 30, 45, 60 and 75 DAP (Appendix III). The highest diameter of garlic neck (4.07 cm, 4.90 cm, 5.97 cm and 7.70 cm) was found in C_3M_2 (90 g/100 cloves + black polythene mulch) at 30, 45, 60 and 75 DAP respectively. On the other hand, the lowest diameter of garlic neck (1.93 cm, 2.07 cm, 3.03 cm and 3.90 cm) was observed from C_1M_0 (44 g/100 cloves and no mulch) at 30, 45, 60 and 75 DAP respectively (Table 4). It was revealed that the largest sized clove and mulch materials ensure favorable condition for the growth and development of plants and the ultimate results was the highest diameter of garlic neck.

Table 4. Interaction effect of clove size and mulching on diameter of neck of garlic

Treatment combination	Diameter of garlic neck (cm) at			
	30 DAP	45 DAP	60 DAP	75 DAP
C_1M_0	1.93 i	2.07 i	3.03 i	3.90 i
C_1M_1	2.33 g	2.90 g	4.03 fg	5.20 g
C_1M_2	3.07 e	4.13 cd	5.17 b	6.60 d
C_1M_3	3.27 d	3.77 ef	4.20 ef	5.97 e
C_2M_0	2.10 h	2.43 h	3.43 h	4.83 h
C_2M_1	2.60 f	3.00 g	4.43 de	5.50 f
C_2M_2	3.63 c	4.57 b	5.73 a	7.07 b
C_2M_3	3.40 d	3.97 de	4.70 cd	6.73 cd
C_3M_0	2.30 g	2.83 g	3.77 g	5.30 fg
C_3M_1	2.93 e	3.57 f	4.80 c	6.13 e
C_3M_2	4.07 a	4.90 a	5.97 a	7.70 a
C_3M_3	3.80 b	4.23 c	5.10 b	7.00 bc
$LSD_{(0.05)}$	0.169	0.214	0.273	0.278
Significance level	0.01	0.05	0.05	0.05
CV(%)	10.44	8.59	10.56	6.75

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

C_1: 44 g/100 cloves
C_2: 63 g/100 cloves
C_3: 90 g/100 cloves

M_0: No mulch (control)
M_1: Rice straw
M_2: Black polythene
M_3: Water hyacinth

4.4 Leaf length

Leaf length of garlic showed statistically significant differences for planting at different clove size (Appendix VI). The longest leaf (52.52 cm) was recorded from C_3 (90 g/100 cloves) which was closely followed (49.69 cm) by C_2 (63 g/100 cloves). On the other hand, the shortest leaf (41.59 cm) was observed from C_1 as 44 g/100 cloves (Table 5). It was revealed that with the increases of clove size, leaf length showed increasing trend. That might be happened due to the ensuring available nutrients by the large size cloves immediate after germination. Hossain *et al.* (2003) reported that large sized cloves had the highest leaf length.

Significant variation for leaf length of garlic was found due to the application of different mulching (Appendix VI). The longest leaf (55.89 cm) was recorded from M_2 (black polythene mulch) which was closely followed (50.77 cm) by M_3 (water hyacinth mulch). Again, the shortest leaf (37.09 cm) was found in M_0 as no mulch i.e. control condition which was closely followed (48.56 cm) by M_1 as rice straw mulch (Table 5).

Interaction effect of clove size and mulching in terms of leaf length of garlic showed statistically significant variation (Appendix VI). The longest leaf (60.33 cm) was obtained from C_3M_2 (90 g/100 cloves + black polythene mulch). On the other hand, the shortest leaf (34.20 cm) was recorded from C_1M_0 as 44 g/100 cloves and no mulch (Table 6).

Table 5. Effect of clove size and mulching on yield contributing characters of garlic

Treatment	Leaf length (cm)	Fresh weight of leaves per plant (g)	Diameter of bulb (cm)	Number of cloves per bulb
Clove size				
C_1	41.59 c	21.31 c	2.67 c	18.00 c
C_2	49.69 b	27.14 b	3.01 b	21.83 b
C_3	52.95 a	28.97 a	3.14 a	23.50 a
$LSD_{(0.05)}$	1.496	0.882	0.071	0.827
Significance level	0.01	0.01	0.01	0.01
Mulching				
M_0	37.09 d	19.83 d	2.57 d	17.45 d
M_1	48.56 c	25.37 c	2.88 c	20.78 c
M_2	55.89 a	31.51 a	3.30 a	24.33 a
M_3	50.77 b	26.51 b	3.02 b	21.89 b
$LSD_{(0.05)}$	1.727	1.018	0.082	0.955
Significance level	0.01	0.01	0.01	0.01
CV(%)	5.68	9.03	11.90	6.63

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

C_1: 44 g/100 cloves
C_2: 63 g/100 cloves
C_3: 90 g/100 cloves

M_0: No mulch (control)
M_1: Rice straw
M_2: Black polythene
M_3: Water hyacinth

Table 6. Interaction effect of clove size and mulching on yield contributing characters of garlic

Treatment combination	Leaf length (cm)	Fresh weight of leaves per plant (g)	Diameter of bulb (cm)	Number of cloves per bulb
C_1M_0	34.20 g	16.37 f	2.21 g	14.67 h
C_1M_1	40.00 f	20.70 e	2.53 f	19.00 fg
C_1M_2	47.67 d	28.03 c	3.16 bc	20.67 def
C_1M_3	44.50 e	20.13 e	2.80 e	17.67 g
C_2M_0	38.20 f	20.40 e	2.69 e	17.67 g
C_2M_1	49.67 cd	27.30 c	2.98 d	21.33 cde
C_2M_2	59.67 a	32.60 ab	3.29 b	25.33 b
C_2M_3	51.20 c	28.27 c	3.07 cd	23.00 c
C_3M_0	38.87 f	22.73 d	2.82 e	20.00 ef
C_3M_1	56.00 b	28.10 c	3.12 cd	22.00 cd
C_3M_2	60.33 a	33.90 a	3.45 a	27.00 a
C_3M_3	56.60 b	31.13 b	3.19 bc	25.00 b
$LSD_{(0.05)}$	2.992	1.763	0.142	1.654
Significance level	0.01	0.01	0.01	0.05
CV(%)	5.68	9.03	11.90	6.63

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

C_1: 44 g/100 cloves
C_2: 63 g/100 cloves
C_3: 90 g/100 cloves

M_0: No mulch (control)
M_1: Rice straw
M_2: Black polythene
M_3: Water hyacinth

4.5 Fresh weight of leaves per plant

Significant variation was recorded due to the planting of different clove size for fresh weight of leaves per plant of garlic (Appendix VI). The maximum fresh weight of leaves per plant (28.97 g) was found in C_3 (90 g/100 cloves) which were closely followed (27.14 g) by C_2 (63 g/100 cloves). On the other hand, the minimum fresh weight of leaves per plant (21.31 g) was recorded from C_1 as 44 g/100 cloves (Table 5). It was revealed that with the increases of clove size fresh weight of leaves per plant showed increasing trend. Baten *et al.* (1989) stated that large seed cloves were superior to medium and small seed cloves in respect of fresh weight of leaves. Mahmud (1998) reported that the large clove size was superior to medium and small seed cloves in fresh weight of leaves.

Application of different mulching showed significant variation for fresh weight of leaves per plant of garlic (Appendix VI). The maximum fresh weight of leaves per plant (31.51 g) was recorded from M_2 (black polythene mulch) which was closely followed (26.51 g) by M_3 (water hyacinth mulch). Again, the minimum fresh weight of leaves per plant (19.83 g) was observed from M_0 (control condition) which was closely followed (25.37 g) by M_1 as rice straw mulch (Table 5). Hossain (2003) reported earlier that water hyacinth mulch increased the fresh weight of leaves.

Clove size and mulching showed statistically significant variation in terms of fresh weight of leaves per plant of garlic for interaction effect (Appendix VI). The maximum fresh weight of leaves per plant (33.90 g) was recorded from C_3M_2 (90

g/100 cloves + black polythene mulch). On the other hand, the minimum fresh weight of leaves per plant (16.37 g) was found in C_1M_0 as 44 g/100 cloves and no mulch (Table 6). Maximum weight of leaves as produced by black polythene mulch might be due to high moisture content at different depth of soil. Availability of moisture at root zone of the plants and stored food materials in the clove might be increased vegetative growth as well as weight of leaves.

4.6 Diameter of bulb

Diameter of bulb of garlic differs significantly due to different clove size (Appendix VI). The highest diameter of bulb (3.14 cm) was observed from C_3 (90 g/100 cloves) which was closely followed (3.01 cm) by C_2 (63 g/100 cloves). On the other hand, the lowest diameter of bulb (2.67 cm) was observed from C_1 as 44 g/100 cloves (Table 5). It was revealed that with the increases of clove size diameter of bulb showed increasing trend. Baten *et al.* (1989) stated that large seed cloves were superior to medium and small seed cloves in respect of bulb diameter. Mahmud (1998) reported that the large clove size was superior to medium and small seed cloves in bulb diameter.

Statistically significant variation for diameter of bulb of garlic was recorded for different mulching (Appendix VI). The highest diameter of bulb (3.30 cm) was found in M_2 (black polythene mulch) which was closely followed (3.02 cm) by M_3 (water hyacinth mulch). Again, the lowest diameter of bulb (2.57 cm) was recorded from M_0 as no mulch i.e. control condition which was closely followed (2.88 cm) by M_1 as rice straw mulch (Table 5). Mulch materials ensured available moisture

for the plants that leads to largest sized bulb. Asandhi *et al.* (1989) found that mulching with rice straw gave the largest bulb (2.8 cm) diameter.

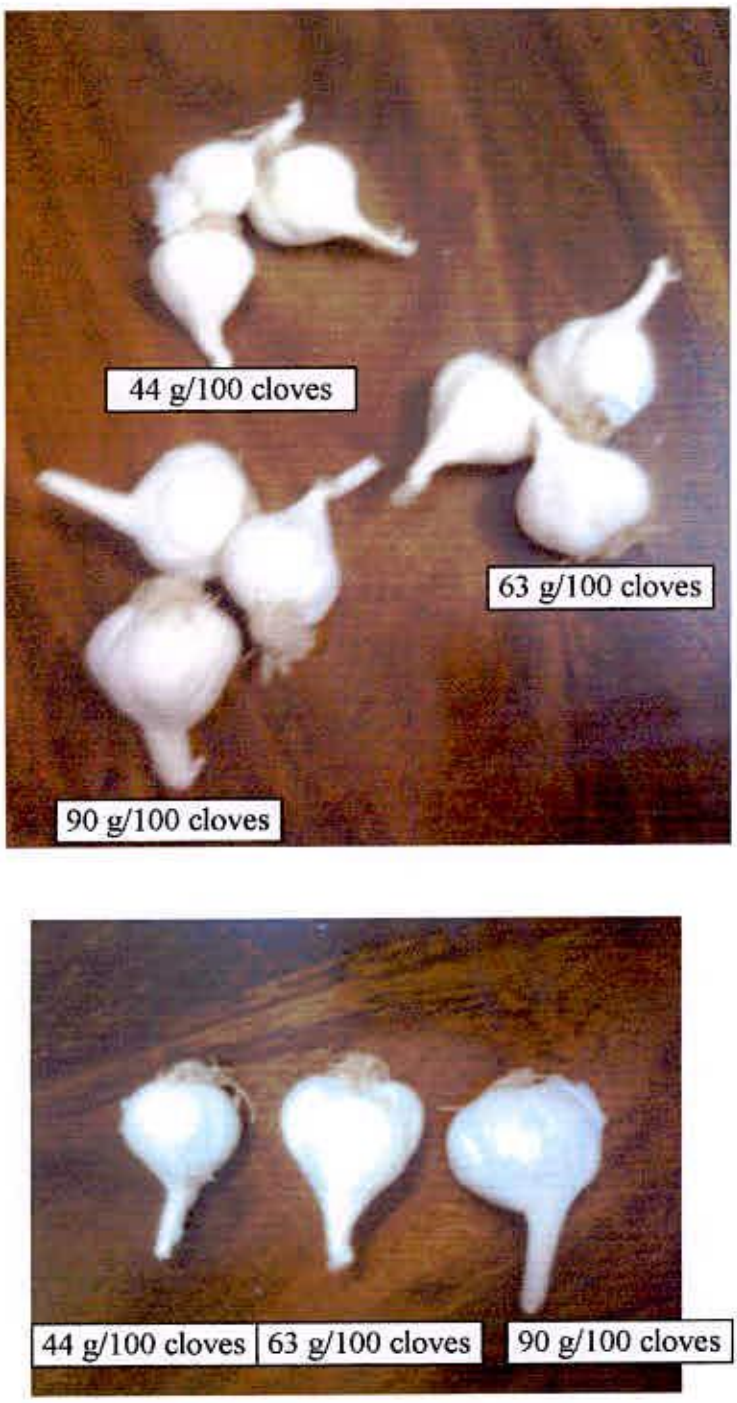


Plate 1. Diameter of bulb for different size clove treated plot

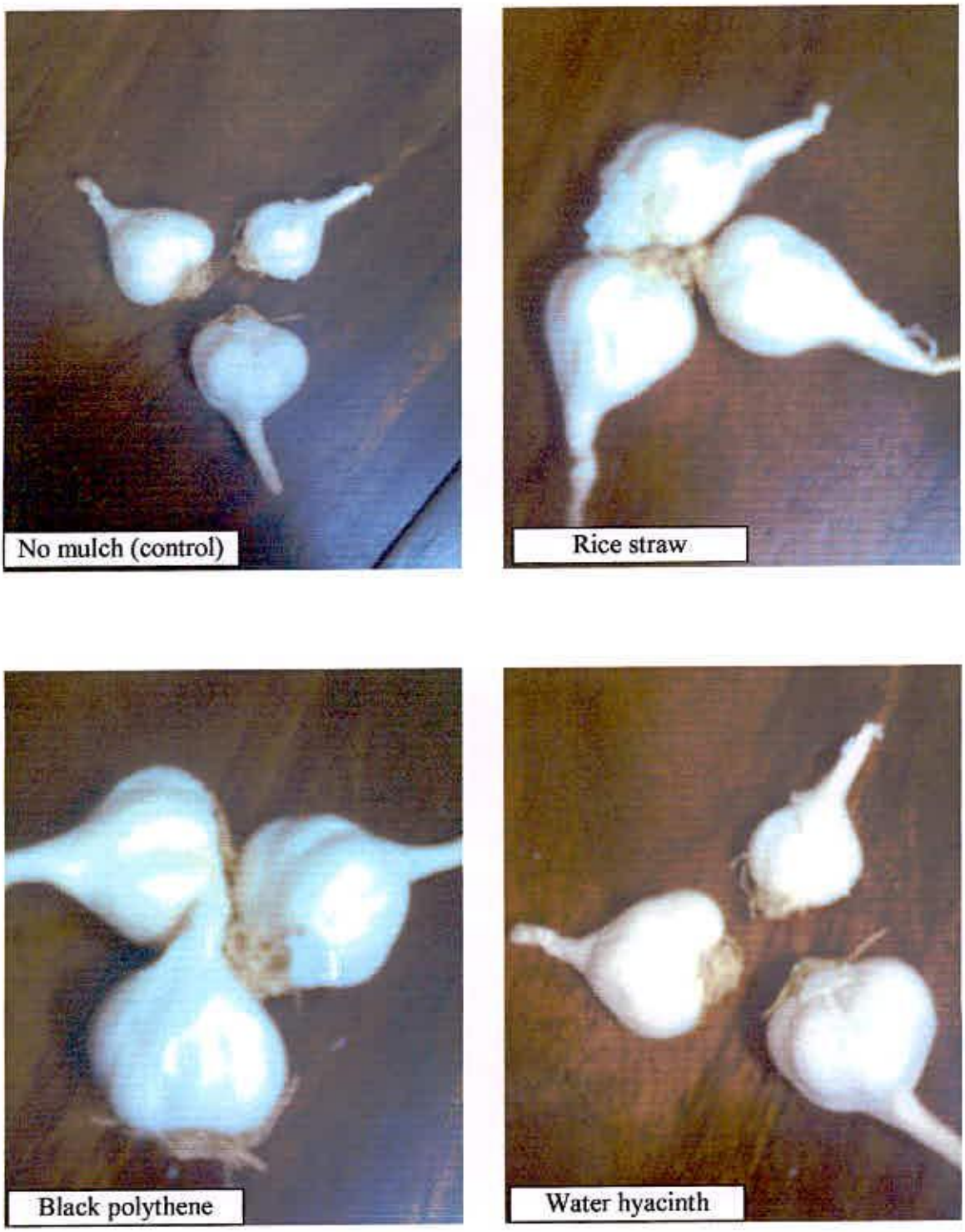


Plate 2. Diameter of bulb for different mulch treated plot

A statistically significant variation was recorded due to interaction effect of clove size and mulching in terms of diameter of bulb of garlic (Appendix VI). The highest diameter of bulb (3.45 cm) was found in C_3M_2 (90 g/100 cloves + black polythene mulch). On the other hand, the lowest diameter of bulb (2.21 cm) was recorded from C_1M_0 as 44 g/100 cloves and no mulch (Table 6). Such effect of black polythene mulch and large sized clove may be attributed to the provision of favorable soil condition and supply of required nutrient for better growth and development which gave larger size bulb as well as the highest diameter.

4.7 Number of cloves per bulb

Statistically significant variation was recorded for number of cloves per bulb of garlic due to planting different clove size (Appendix VI). The maximum number of cloves per bulb (23.50) was obtained from C_3 (90 g/100 cloves) which was closely followed (21.83) by C_2 (63 g/100 cloves). On the other hand, the minimum number of cloves per bulb (18.00) was observed from C_1 as 44 g/100 cloves (Table 5). It was revealed that with the increases of clove size number of cloves per bulb showed increasing trend. Ahmed *et al.* (2007) obtained that clove size had significant effect on the cloves per bulb and it increased as the clove size increased.

Different mulching showed significant variation for number of cloves per bulb of garlic (Appendix VI). The maximum number of cloves per bulb (24.33) was observed from M_2 (black polythene mulch) which was closely followed (21.89) by M_3 (water hyacinth mulch). Again, the minimum number of cloves per bulb (17.45) was found in M_0 as no mulch i.e. control condition which was closely followed

(20.45) by M_1 as rice straw mulch (Table 5). Mulch significantly enhanced vegetative growth to optimize water use and soil condition. For that plant produced healthy maximum number of cloves. Asandhi *et al.* (1989) found that mulching with rice straw gave the highest number of cloves/bulb (12.75).

Interaction effect of clove size and mulching in terms of number of cloves per bulb of garlic showed significant variation (Appendix VI). The maximum number of cloves per bulb (27.00) was recorded from C_3M_2 (90 g/100 cloves + black polythene mulch). On the other hand, the minimum number of cloves per bulb (14.67) was obtained from C_1M_0 as 44 g/100 cloves and no mulch (Table 6).

4.8 Fresh weight of bulb per plant

Fresh weight of bulb of garlic showed statistically significant variation for planting at different clove size (Appendix VII). The maximum fresh weight of bulb (15.09 g) was recorded from C_3 (90 g/100 cloves) which was closely followed (14.58 g) by C_2 (63 g/100 cloves). On the other hand, the minimum fresh weight of bulb (13.87 g) was found from C_1 as 44 g/100 cloves (Table 7). It was revealed that with the increases of clove size fresh weight of bulb showed increasing trend. Rahim *et al.* (1984) stated that large mother bulb naturally contained large cloves and small mother cloves contained small cloves. Baten *et al.* (1989) stated that large seed cloves were superior to medium and small seed cloves in respect of bulb yield.

Significant variation for fresh weight of bulb of garlic was recorded for the application of different mulching (Appendix VII). The maximum fresh weight of bulb (15.42 g) was observed from M_2 (black polythene mulch) which was

statistically similar (15.12 g, 14.89 g) with M_3 (water hyacinth mulch) and M_1 (rice straw mulch). Again, the minimum fresh weight of bulb (12.63 g) was recorded from M_0 as no mulch i. e. control condition (Table 7). Hossain (2003) reported that bulb weight was found significantly higher for mulched plants.

The increased fresh weight of bulb in the mulched plot was possibly due to efficient use of available soil moisture against reduced moisture loss from the soil, effective control of soil temperature, inhibition of weed growth, protection of surface erosion, reduction in nutrients loss from soil etc. which were conducted to yield contributing characteristics and yield of large sized bulb.

Statistically significant variation was found due to interaction effect of clove size and mulching in terms of fresh weight of bulb of garlic (Appendix VII). The maximum fresh weight of bulb (15.85 g) was observed from C_3M_2 (90 g/100 cloves + black polythene mulch). On the other hand, the minimum (11.73 g) was recorded from C_1M_0 as 44 g/100 cloves and no mulch (Table 8).

4.9 Fresh weight of roots per plant

Statistically significant variation was observed for fresh weight of roots per plant of garlic due to different clove size (Appendix VII). The maximum fresh weight of roots per plant (0.75 g) was found in C_3 (90 g/100 cloves) which was statistically identical (0.72 g) by C_2 (63 g/100 cloves). On the other hand, the minimum fresh weight of roots per plant (0.52 g) was observed from C_1 as 44 g/100 cloves (Table 7). It was evident that more soil moisture conserved by mulching enhanced vegetative growth as well as root system which provided the plants with more

nutrient uptake from the soil. Mahmud (1998) reported that the large clove size was superior to medium and small seed cloves in root weight.

Significant variation for fresh weight of roots per plant of garlic was recorded for the application of different mulching (Appendix VII). The maximum fresh weight of roots per plant (0.82 g) was obtained from M_2 (black polythene mulch) which was closely followed (0.71 g) with M_3 (water hyacinth mulch). Again, the minimum fresh weight of roots per plant (0.48 g) was observed from M_0 (control condition) which was closely followed (0.62 g) by M_1 as application of rice straw mulch (Table 7).

Statistically significant difference was recorded due to interaction effect of clove size and mulching in terms of fresh weight of roots per plant of garlic (Appendix VII). The maximum fresh weight of roots per plant (0.95 g) was recorded from C_3M_2 (90 g/100 cloves + black polythene mulch). On the other hand, the minimum fresh weight of roots per plant (0.44 g) was found in C_1M_0 as 44 g/100 cloves and no mulch (Table 8). It was revealed that largest clove size and black polythene mulch ensure maximum fresh weight of roots per plant.

Table 7. Effect of clove size and mulching on yield contributing characters and yield of garlic

Treatment	Fresh weight of bulb (g)	Fresh weight of roots per plant. (g)	Dry weight of leaves per plant (g)	Dry weight of bulb (g)	Dry weight of roots per plant (g)
Clove size					
C_1	13.87 b	0.52 b	2.85 c	5.70 c	0.17 c
C_2	14.58 a	0.72 a	3.44 b	6.37 b	0.22 b
C_3	15.09 a	0.75 a	3.71 a	6.69 a	0.24 a
$LSD_{(0.05)}$	0.572	0.046	0.120	0.154	0.009
Significance level	0.01	0.01	0.01	0.01	0.01
Mulching					
M_0	12.63 b	5.48 d	2.76 c	0.48 d	0.16 d
M_1	14.89 a	5.94 c	3.27 b	0.62 c	0.21 c
M_2	15.42 a	7.44 a	3.90 a	0.82 a	0.26 a
M_3	15.12 a	6.16 b	3.40 b	0.71 b	0.22 b
$LSD_{(0.05)}$	0.661	0.178	0.138	0.054	0.010
Significance level	0.01	0.01	0.01	0.01	0.01
CV(%)	5.66	8.91	5.23	7.58	10.43

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

C_1: 44 g/100 cloves
C_2: 63 g/100 cloves
C_3: 90 g/100 cloves

M_0: No mulch (control)
M_1: Rice straw
M_2: Black polythene
M_3: Water hyacinth

Table 8. Effect of clove size and mulching on yield contributing characters and yield of garlic

Treatment combination	Fresh weight of bulb (g)	Fresh weight of roots per plant (g)	Dry weight of leaves per plant (g)	Dry weight of bulb (g)	Dry weight of roots per plant (g)
C_1M_0	11.73 d	0.44 g	2.50 i	4.74 g	0.14 g
C_1M_1	14.56 abc	0.50 fg	2.91 h	5.64 f	0.17 ef
C_1M_2	14.93 abc	0.60 ef	3.20 fg	6.80 c	0.21 d
C_1M_3	14.27 bc	0.53 fg	2.80 h	5.63 f	0.18 e
C_2M_0	12.23 d	0.50 fg	2.77 h	5.48 f	0.16 f
C_2M_1	15.03 abc	0.67 de	3.31 ef	6.10 e	0.26 c
C_2M_2	15.47 ab	0.92 a	4.13 b	7.58 b	0.27 bc
C_2M_3	15.60 a	0.78 bc	3.53 de	6.31 de	0.21 d
C_3M_0	13.93 c	0.51 fg	3.00 gh	6.22 de	0.18 e
C_3M_1	15.07 abc	0.70 cd	3.58 d	6.07 e	0.20 d
C_3M_2	15.85 a	0.95 a	4.37 a	7.95 a	0.30 a
C_3M_3	15.50 ab	0.82 b	3.87 c	6.53 cd	0.28 b
$LSD_{(0.05)}$	1.145	0.093	0.240	0.308	0.017
Significance level	0.05	0.01	0.01	0.01	0.01
CV(%)	5.66	7.58	5.23	8.91	10.43

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

C_1: 44 g/100 cloves
C_2: 63 g/100 cloves
C_3: 90 g/100 cloves

M_0: No mulch (control)
M_1: Rice straw
M_2: Black polythene
M_3: Water hyacinth

4.10 Yield of bulb per hectare

Yield of bulb per hectare of garlic showed statistically significant variation due to different clove size (Appendix VII). The maximum yield of bulb per hectare (3.91 t) was recorded from C_3 (90 g/100 cloves) which was closely followed (3.83 t) by C_2 (63 g/100 cloves). On the other hand, the minimum yield of bulb per hectare (3.49 t) was observed from C_1 as 44 g/100 cloves (Figure 8). It was revealed that with the increases of clove size yield of bulb per hectare showed increasing trend. Rahman and Das (1985) reported that the highest yield of 9.03 t/ha were obtained by planting 1.08g cloves. Due to higher amount of reserved foods in the large clove, it showed early emergence and vigorous plant growth, and produced maximum number of leaves resulting in maximum bulb yield. Shin *et al.* (1988) reported that garlic yields tended to be lower when smaller planting stock was used and were significantly higher (5.7 t/ha). Ara (1993) stated that the highest yield (4.37 t/ha) was found form large size clove but similar (3.98 t/ha) with medium size, while the small clove gave the lowest yield (1.73 t/ha).

Significant variation for yield of bulb per hectare of garlic was recorded for the application of different mulching (Appendix VII). The maximum yield of bulb per hectare (4.29 t) was recorded from M_2 (black polythene mulch) which was closely followed (3.98 t) by M_3 (water hyacinth mulch). Again, the minimum yield of bulb per hectare (2.97 t) was recorded from M_0 (control condition) which was closely followed (3.74 t) by M_1 as rice straw mulch (Figure 9). Mulch significantly enhanced vegetative growth to optimize water use and soil condition that leads to

maximum yield. Adetunji (1994) reported that total bulb yield of onion was 80% higher than no mulched treatment. Islam *et al.* (2007) reported that mulching with black polyethylene, water hyacinth and straw resulted in yields of 5.80, 5.70 and 5.48 t/ha, which were 39, 36.6 and 31.41% higher than the yields of the control (4.17 t/ha).

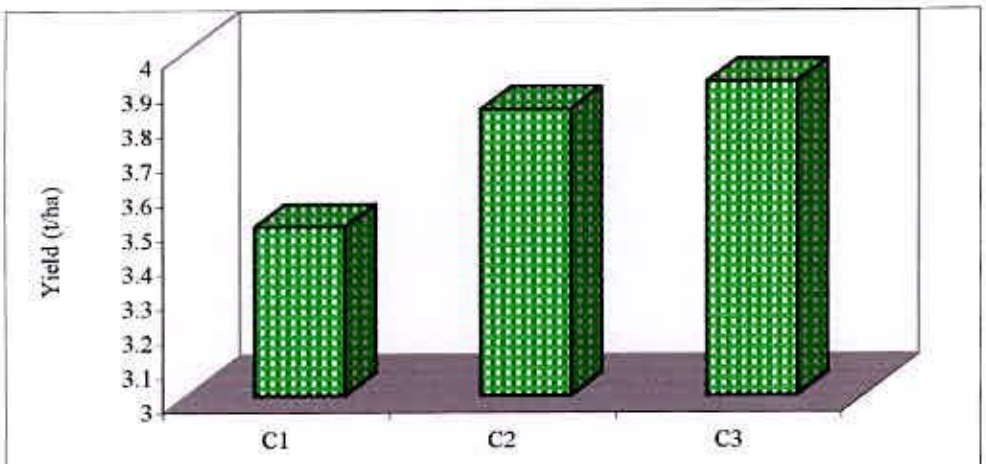


Figure 8. Effect of clove size on yield per hectare of garlic

C_1 : 44 g/100 cloves C_2 : 63 g/100 cloves
C_3 : 90 g/100 cloves

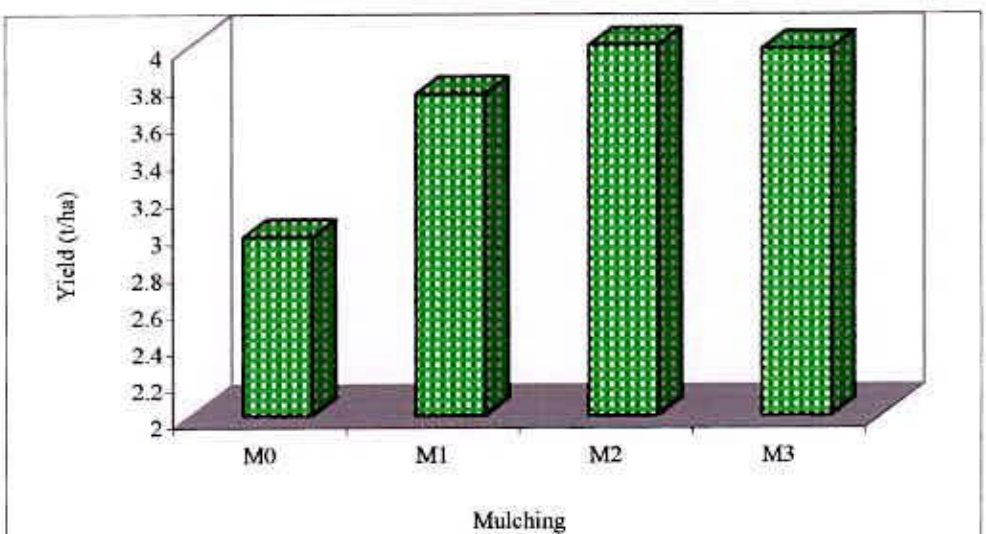


Figure 9. Effect of mulching on yield per hectare of garlic

M_0 : No mulch (control) M_1 : Rice straw
M_2 : Black polythene M_3 : Water hyacinth

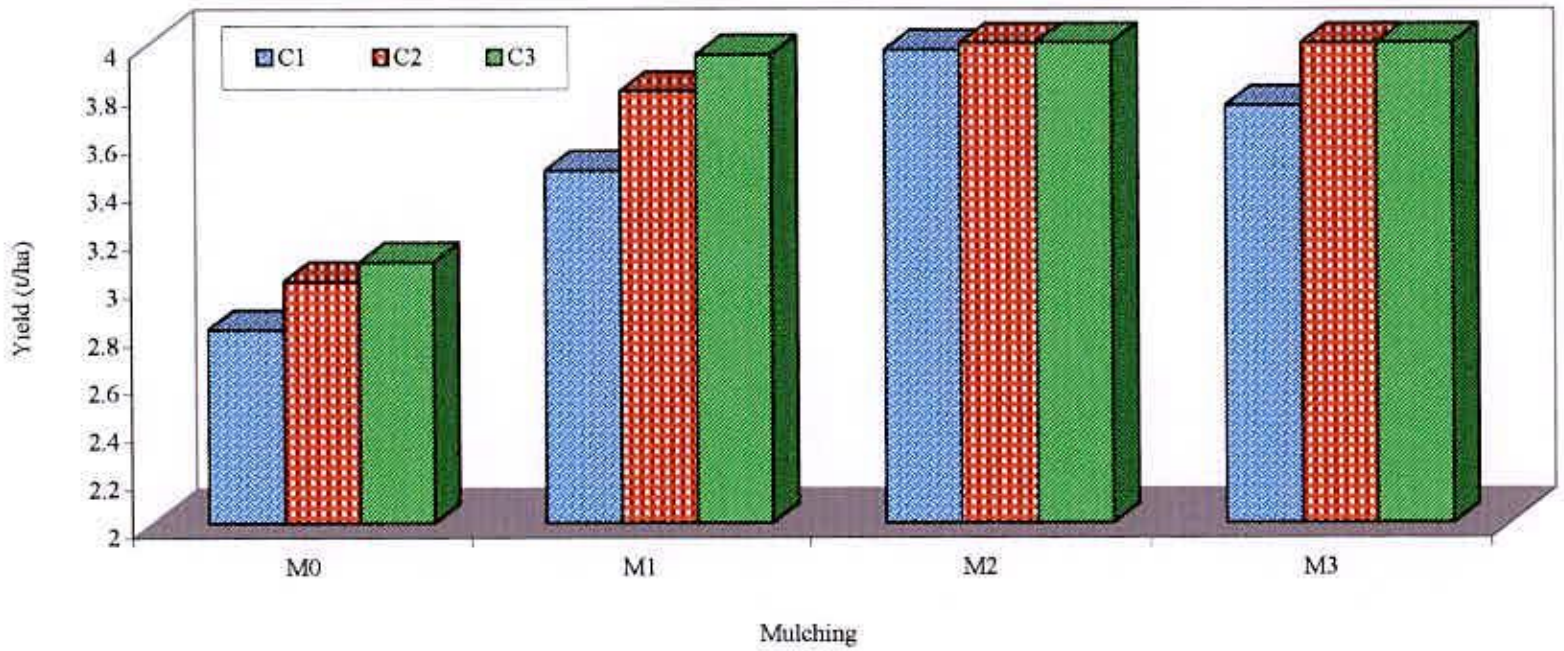


Figure 10. Interaction effect of clove size and mulching on yield per hectare of garlic

C_1 : 44 g/100 cloves C_2 : 63 g/100 clo M_0 : No mulch (control) M_1 : Rice straw

C_3 : 90 g/100 cloves M_2 : Black polythene M_3 : Water hyacinth

Interaction effect of clove size and mulching in terms of yield of bulb per hectare of garlic showed significant differences (Appendix VII). The maximum yield of bulb per hectare (4.51 t) was found in C_3M_2 (90 g/100 cloves + black polythene mulch). On the other hand, the minimum yield of bulb per hectare (2.81 t) was recorded from C_1M_0 as 44 g/100 cloves and no mulch (Figure 10). This result might be due to the presence of sufficient amount of soil moisture in black polythene mulch and large sized clove, which subsequently had contributed in the formation of the highest yield of garlic.

4.11 Dry weight of leaves per plant

Statistically significant variation was recorded for dry weight of leaves per plant of garlic due to different clove size (Appendix VII). The maximum dry weight of leaves per plant (3.71 g) was observed from C_3 (90 g/100 cloves) which was closely followed (3.44 g) by C_2 (63 g/100 cloves). On the other hand, the minimum dry weight of leaves per plant (2.85 g) was observed from C_1 as 44 g/100 cloves (Table 7). It was revealed that with the increases of clove size dry weight of leaves per plant showed increasing trend.

Different mulching showed significant variation for dry weight of leaves per plant of garlic (Appendix VII). The maximum dry weight of leaves per plant (3.90 g) was found in M_2 (black polythene mulch) which was closely followed (3.40 g and 3.27 g) by M_3 (water hyacinth mulch) and M_1 (rice straw mulch). Again, the minimum dry weight of leaves per plant (2.76 g) was observed from M_0 as no mulch i.e.

control condition (Table 7). Hossain (1996) reported that dry matter content of foliage significantly higher for mulched plants.

Interaction effect of clove size and mulching in terms of dry weight of leaves per plant of garlic showed statistically significant variation (Appendix VII). The maximum dry weight of leaves per plant (4.37 g) was obtained from C_3M_2 (90 g/100 cloves + black polythene mulch). On the other hand, the minimum dry weight of leaves per plant (2.50 g) was observed from C_1M_0 as 44 g/100 cloves and no mulch (Table 8).

4.12 Dry weight of bulb

A significant difference was observed for dry weight of bulb of garlic due to different clove size (Appendix VII). The maximum dry weight of bulb (6.69 g) was recorded from C_3 (90 g/100 cloves) which was closely followed (6.37 g) by C_2 (63 g/100 cloves). On the other hand, the minimum dry weight of bulb (5.70 g) was found from C_1 as 44 g/100 cloves (Table 7). It was revealed that with the increases of clove size dry weight of bulb showed increasing trend. Hossain *et al.* (2003) reported that large sized cloves had the highest total dry matter.

Application of different mulching showed significant variation for dry weight of bulb of garlic (Appendix VII). The maximum dry weight of bulb (7.44 g) was obtained from M_2 (black polythene mulch) which was closely followed (6.16 g) by M_3 (water hyacinth mulch). Again, the minimum dry weight of bulb (5.48 g) was observed from M_0 as no mulch i.e. control condition which was closely followed

(5.94 g) by M_1 as rice straw mulch (Table 7). Hossain (2003) reported earlier that water hyacinth mulch increased the dry weight of bulb.

Interaction effect of clove size and mulching in terms of dry weight of bulb of garlic showed statistically significant differences (Appendix VII). The maximum dry weight of bulb (7.95 g) was found in C_3M_2 (90 g/100 cloves + black polythene mulch). On the other hand, the minimum dry weight of bulb (4.74 g) was observed from C_1M_0 as 44 g/100 cloves and no mulch (Table 8). Black polythene mulch and large sized clove combination enhanced the vigorous growth and development of plant and ultimately, higher dry matter was accumulated in the bulbs.

4.13 Dry weight of roots per plant

Dry weight of roots per plant of garlic showed a statistically significant variation for different clove size (Appendix VII). The maximum dry weight of roots per plant (0.24 g) was obtained from C_3 (90 g/100 cloves) which was closely followed (0.22 g) by C_2 (63 g/100 cloves). On the other hand, the minimum dry weight of roots per plant (0.17 g) was found in C_1 as 44 g/100 cloves (Table 7). It was revealed that with the increases of clove size dry weight of roots per plant showed increasing trend.

Statistically significant variation was recorded due to the application of different mulching for dry weight of roots per plant of garlic (Appendix VII). The maximum dry weight of roots per plant (0.26 g) was found in M_2 (black polythene mulch) which was closely followed (0.22 g) by M_3 (water hyacinth mulch). Again, the minimum dry weight of roots per plant (0.16 g) was obtained from M_0 (control

condition) which was closely followed (0.21 g) by M_1 as rice straw mulch (Table 7). Mia (1996) found that plant grown with mulch gave higher dry matter of roots. Hossain (2003) reported that water hyacinth mulch increased dry weight of roots.

Dry weight of roots per plant of garlic showed statistically significant variation for the interaction effect of clove size and mulching (Appendix VII). The maximum dry weight of roots per plant (0.30 g) was recorded from C_3M_2 (90 g/100 cloves + black polythene mulch). On the other hand, the minimum dry weight of roots per plant (0.14 g) was recorded from C_1M_0 as 44 g/100 cloves and no mulch (Table 8).

4.14 Economic analysis

Input costs for land preparation, seed cost, fertilizer, irrigation, manpower and mulching required for all the operations from transplanting to harvesting of garlic were recorded for unit plot and converted into cost per hectare. Production cost varied due to clove size and price of different mulch materials. Price of garlic was considered as per market rate. The economic analysis was done to find out the gross and net return and the benefit cost ratio in the present experiment and presented under the following headings:-

4.14.1 Gross return

The combination of clove size and mulching showed different gross return under the trial. The highest gross return (Tk. 248,050) was recorded from the treatment combination C_3M_2 (90 g/100 cloves + black polythene mulch) and the second highest gross return (Tk. 241,450) was found in C_2M_2 (63 g/100 cloves + black

polythene mulch). The lowest gross return (Tk. 154,550) was obtained from C_1M_0 (44 g/100 cloves + no mulch condition).

4.14.2 Net return

In case of net return different treatment combination showed different levels of net return. The highest net return (Tk. 122,805) was obtained from the treatment combination C_3M_2 and the second highest net return (Tk. 120,742) was obtained from the combination C_2M_2. The lowest (Tk. 42,576) net return was obtained from C_1M_0 (Table 9).

4.14.3 Benefit cost ratio

In the combination of clove size and mulching highest benefit cost ratio (2.00) was noted from the combination of C_2M_2 and the second highest benefit cost ratio (1.98) was estimated from the combination of C_3M_2. The lowest benefit cost ratio (1.38) was obtained from C_1M_0 (Table 9). From economic point of view, it is apparent from the above results that the combination of C_2M_2 was more profitable than rest of the combination.

Table 9. Cost and return of garlic cultivation as influenced by clove size and mulching

Treatment Combination	Cost of production (Tk./ha)	Yield of garlic (t/ha)	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio
C_1M_0	111974	2.81	154550	42576	1.38
C_1M_1	115944	3.47	190850	74906	1.65
C_1M_2	119006	3.97	218350	99344	1.83
C_1M_3	116738	3.74	205700	88962	1.76
C_2M_0	113675	3.01	165550	51875	1.46
C_2M_1	117645	3.80	209000	91355	1.78
C_2M_2	120708	4.39	241450	120742	2.00
C_2M_3	118439	4.10	225500	107061	1.90
C_3M_0	118212	3.09	169950	51738	1.44
C_3M_1	122182	3.95	217250	95068	1.78
C_3M_2	125245	4.51	248050	122805	1.98
C_3M_3	122976	4.09	224950	101974	1.83

Price of garlic @ Tk. 55,000 per ton

C_1: 44 g/100 cloves
C_2: 63 g/100 cloves
C_3: 90 g/100 cloves

M_0: No mulch (control)
M_1: Rice straw
M_2: Black polythene
M_3: Water hyacinth

CHAPTER V

SUMMARY AND CONCLUSION

The present experiment was conducted in the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from November 2007 to March 2008 to find out the effect of clove size and mulching on the growth and yield of garlic. The experiment consisted of two factors. Factor A: Three levels of clove size; C_1: 44 g/100 cloves, C_2: 63 g/100 cloves and C_3: 90 g/100 cloves; Factor B: Four types of mulches; M_0: no mulch (control), M_1: rice straw, M_2: black polythene and M_3: water hyacinth. There were 12 (3 × 4) treatment combinations and the experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different yield contributing characters and yield of garlic were recorded.

At the different days after planting (DAP) the tallest plant (25.61 cm, 32.16 cm, 35.83 cm and 45.61 cm) was recorded from C_3 and the shortest (22.64 cm, 28.44 cm, 32.36 cm and 40.08 cm) was found from C_1. At the different days after planting (DAP) the highest number of leaves per plant (4.32, 5.27, 6.27 and 7.75) was recorded from C_3 and at the same DAP the lowest (3.87, 4.65, 5.81 and 6.75) was found from C_1. At the different days after planting (DAP) the highest diameter of garlic neck (3.28 cm, 3.88 cm, 4.91 cm and 6.53 cm) was recorded from C_3 and at the same DAP the lowest (2.65 cm, 3.22 cm, 4.11 cm and 5.42 cm) was found from C_1. The longest leaf length (52.52 cm) was recorded from C_3 and the shortest leaf length (41.59 cm) was observed from C_1. The maximum fresh weight of leaves

per plant (28.97 g) was recorded from C_3 and the minimum (21.31 g) was observed from C_1. The maximum dry weight of leaves per plant (3.71 g) was recorded from C_3 and the minimum (2.85 g) was observed from C_1. The highest diameter of bulb (3.14 cm) was recorded from C_3 again the lowest (2.67 cm) was observed from C_1. The maximum number of cloves per bulb (23.50) was recorded from C_3 and the minimum (18.00) was observed from C_1. The highest fresh weight of bulb (15.09 g) was recorded from C_3 and the lowest (13.87 g) was observed from C_1. The highest dry weight of bulb (6.69 g) was recorded from C_3 and, the lowest (5.70 g) was observed from C_1. The maximum fresh weight of roots per plant (0.75 g) was recorded from C_3 and the minimum (0.52 g) was observed from C_1. The maximum dry weight of roots per plant (0.24 g) was recorded from C_3 and the minimum (0.17 g) was observed from C_1. The highest yield of bulb (3.91 ton/ha) was recorded from C_3 and the lowest (3.49 ton/ha) was observed from C_1.

At 30, 45, 60 and 75 DAP the tallest plant (28.06 cm, 33.73 cm, 39.11 cm and 46.80 cm) was recorded from M_2 again, the shortest (20.48 cm, 26.44 cm, 30.28 cm and 38.57 cm) was observed from M_0. At 30, 45, 60 and 75 DAP the highest number of leaves per plant (4.66, 5.72, 7.10 and 8.52) was recorded from M_2 and the lowest (3.49, 4.30, 5.09 and 5.39) was observed from M_0. At 30, 45, 60 and 75 DAP the highest diameter of garlic neck (3.59 cm, 4.53 cm, 5.62 cm and 7.12 cm) was recorded from M_2 again the lowest (2.11 cm, 2.44 cm, 3.41 cm and 4.68 cm) was observed from M_0. The longest leaf length (55.89 cm) was recorded from M_2 again, the shortest (37.09 cm) was observed from M_0. The maximum fresh weight of leaves per plant (31.51 g) was recorded from M_2 again the minimum (19.83 g)

was observed from M_0. The maximum dry weight of leaves per plant (3.90 g) was recorded from M_2 and the minimum (2.76 g) was observed from M_0. The highest diameter of bulb (3.30 cm) was recorded from M_2 and the lowest (2.57 cm) was observed from M_0. The maximum number of cloves per bulb (24.33) was recorded from M_2 again, the minimum (17.45) was observed from M_0. The highest fresh weight of bulb (15.42 g) was recorded from M_2 again, the lowest (12.63 g) was observed from M_0. The highest dry weight of bulb (7.44 g) was recorded from M_2 again, the lowest (5.48 g) was observed from M_0. The maximum fresh weight of roots per plant (0.82 g) was recorded from M_2 and the minimum (0.48 g) was observed from M_0. The maximum dry weight of roots per plant (0.26 g) was recorded from M_2 again, the minimum (0.16 g) was observed from M_0. The highest yield of bulb (4.29 ton/ha) was recorded from M_2 again, the lowest (2.97 ton/ha) was observed from M_0.

The tallest plant (29.58 cm, 35.47 cm, 41.36 cm and 49.57 cm) was recorded from C_2M_2 at 30, 45, 60 and 75 DAP, respectively and the shortest (18.01 cm, 24.00 cm, 28.57 cm and 35.70 cm) was recorded from C_1M_0. The highest number of leaves per plant (5.06, 6.10, 7.67 and 9.07) was recorded from C_3M_2 at 30, 45, 60 and 75 DAP, respectively and the lowest (3.30, 3.93, 5.00 and 5.00) was recorded from C_1M_0. The highest diameter of garlic neck (4.07 cm, 4.90 cm, 5.97 cm and 7.70 cm) was recorded from C_3M_2 and the lowest (1.93 cm, 2.07 cm, 3.03 cm and 3.90 cm) was recorded from C_1M_0. The longest leaf length (60.33 cm) was recorded from C_3M_2 and the shortest (34.20 cm) was recorded from C_1M_0. The maximum fresh weight of leaves per plant (33.90 g) was recorded from C_3M_2 and the

minimum (16.37 g) was recorded from C_1M_0. The maximum dry weight of leaves per plant (4.37 g) was recorded from C_3M_2 and the minimum (2.50 g) was recorded from C_1M_0. The highest diameter of bulb (3.45 cm) was recorded from C_3M_2 and the lowest (2.21 cm) was recorded from C_1M_0. The maximum number of cloves per bulb (27.00) was recorded from C_3M_2 and the minimum (14.67) was recorded from C_1M_0. The highest fresh weight of bulb (15.85 g) was recorded from C_3M_2 and the lowest (11.73 g) was recorded from C_1M_0. The highest dry weight of bulb (7.95 g) was recorded from C_3M_2 and the lowest (4.74 g) was recorded from C_1M_0. The maximum fresh weight of roots per plant (0.95 g) was recorded from C_3M_2 and the minimum (0.44 g) was recorded from C_1M_0. The maximum dry weight of roots per plant (0.30 g) was recorded from C_3M_2 and the minimum (0.14 g) was recorded from C_1M_0. The highest yield of bulb (4.51 ton/ha) was recorded from C_3M_2 and the lowest (2.81 ton/ha) was recorded from C_1M_0. The highest benefit cost ratio (2.00) was noted from the combination of C_2M_2 and the lowest benefit cost ratio (1.38) was obtained from C_1M_0. From economic point of view, it was apparent from the above results that the combination of C_2M_2 was more profitable than rest of the combination.

Considering the situation of the present findings, following areas of study may be suggested for the future:

1. Such study was needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance.
2. Another clove size may be included for drawing conclusion.

3. Another locally available mulch material may be used for further study in order to get higher yield.

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APPENDICES

Appendix I. Characteristics of Horticulture Farm soil is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture Garden , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: SRDI

Appendix II. Monthly record of air temperature, rainfall, relative humidity, soil temperature and sunshine of the experimental site during the period from September 2007 to February 2008

Month	*Air temperature (°c)		*Relative humidity (%)	*Rain fall (mm) (total)
	Maximum	Minimum		
September, 2007	28.33	19.35	76	67
October, 2007	27.56	17.76	78	34
November, 2007	25.82	16.04	78	00
December, 2007	22.4	13.52	74	00
January, 2008	24.5	12.40	68	00
February, 2008	27.1	16.70	67	30

* Monthly average,

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka – 1212

Appendix III. Analysis of variance of the data on plant height of garlic as influenced by clove size and mulching

Source of variation	Degrees of freedom	Mean square			
		Plant height (cm) at			
		30 DAP	45 DAP	60 DAP	75 DAP
Replication	2	0.238	0.553	0.324	1.106
Clove size (A)	2	30.390**	45.955**	41.825**	100.494**
Mulching (B)	3	87.734**	83.777**	118.178**	107.044**
Interaction (A×B)	6	2.704**	2.035**	3.417*	3.891**
Error	22	0.744	0.557	1.153	1.217

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on number of leaves per plant of garlic as influenced by clove size and mulching

Source of variation	Degrees of freedom	Mean square			
		Number of leaves per plant at			
		30 DAP	45 DAP	60 DAP	75 DAP
Replication	2	0.001	0.003	0.021	0.018
Clove size (A)	2	0.695**	1.201**	0.634**	3.127**
Mulching (B)	3	2.140**	3.068**	6.179**	16.625**
Interaction (A×B)	6	0.156**	0.042**	0.179**	0.054*
Error	22	0.031	0.012	0.037	0.025

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on diameter of garlic neck as influenced by clove size and mulching

Source of variation	Degrees of freedom	Mean square			
		Diameter of garlic neck (mm) at			
		30 DAP	45 DAP	60 DAP	75 DAP
Replication	2	0.001	0.0001	0.004	0.014
Clove size (A)	2	1.175**	1.340**	1.948**	3.743**
Mulching (B)	3	4.547**	7.615**	7.442**	10.458**
Interaction (A×B)	6	0.060**	0.031*	0.888*	0.075*
Error	22	0.010	0.016	0.026	0.027

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on yield contributing characters of leaves per plant of garlic as influenced by clove size and mulching

Source of variation	Degrees of freedom	Mean square			
		Leaf length (cm)	Fresh weight of leaves per plant (g)	Diameter of bulb (cm)	Number of cloves per bulb
Replication	2	0.499	0.276	0.004	0.344
Clove size (A)	2	410.35**	192.01**	0.701**	95.351**
Mulching (B)	3	567.65**	206.69**	0.823**	73.610**
Interaction (A×B)	6	22.07**	4.921**	0.026**	2.957*
Error	22	3.122	1.084	0.007	0.954

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data on yield contributing characters and yield of leaves per plant of garlic as influenced by clove size and mulching

Source of variation	Degrees of freedom	Mean square					
		Fresh weight of bulb (g)	Fresh weight of roots (g) per plant	Dry weight of roots (g) per plant	Dry weight of leaves per plant (g)	Dry weight of bulb (g)	Yield of bulb (t/ha)
Replication	2	0.148	0.007	0.0001	0.010	0.021	0.001
Clove size (A)	2	4.471**	0.186**	0.014**	2.278**	3.052**	0.579**
Mulching (B)	3	14.62**	0.186**	0.015**	1.988**	6.372**	2.873**
Interaction (A×B)	6	0.983*	0.014**	0.003**	0.098**	0.160**	0.014*
Error	22	0.457	0.003	0.0001	0.020	0.033	0.005

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VIII. Production cost of garlic per hectare

A. Input cost

Treatment Combination	Labour cost	Ploughing cost	Clove cost Cost	Mulch material	Cowdung	Fertilizers	Insecticide/ pesticides	Sub Total (A)
C_1M_0	15000.00	6000.00	3500.00	0.00	15000.00	8500.00	8000.00	56000.00
C_1M_1	15000.00	6000.00	3500.00	3500.00	15000.00	8500.00	8000.00	59500.00
C_1M_2	15000.00	6000.00	3500.00	6200.00	15000.00	8500.00	8000.00	62200.00
C_1M_3	15000.00	6000.00	3500.00	4200.00	15000.00	8500.00	8000.00	60200.00
C_2M_0	15000.00	6000.00	5000.00	0.00	15000.00	8500.00	8000.00	57500.00
C_2M_1	15000.00	6000.00	5000.00	3500.00	15000.00	8500.00	8000.00	61000.00
C_2M_2	15000.00	6000.00	5000.00	6200.00	15000.00	8500.00	8000.00	63700.00
C_2M_3	15000.00	6000.00	5000.00	4200.00	15000.00	8500.00	8000.00	61700.00
C_3M_0	15000.00	6000.00	9000.00	0.00	15000.00	8500.00	8000.00	61500.00
C_3M_1	15000.00	6000.00	9000.00	3500.00	15000.00	8500.00	8000.00	65000.00
C_3M_2	15000.00	6000.00	9000.00	6200.00	15000.00	8500.00	8000.00	67700.00
C_3M_3	15000.00	6000.00	9000.00	4200.00	15000.00	8500.00	8000.00	65700.00

C_1: 44 g/100 cloves	M_0: No mulch (control)
C_2: 63 g/100 cloves	M_1: Rice straw
C_3: 90 g/100 cloves	M_2: Black polythene
	M_3: Water hyacinth

Appendix VIII. Contd.

B. Overhead cost (Tk./ha)

Treatment Combination	Cost of lease of land for 6 months (13% of value of land Tk. 7,00000/year	Miscellaneous cost (Tk. 5% of the input cost	Interest on running capital for 6 months (Tk. 13% of cost/year	Sub total (Tk) (B)	Total cost of production (Tk./ha) [Input cost (A)+ overhead cost (B)]
C_1M_0	45500	3640	6834	55974	111974
C_1M_1	45500	3868	7076	56444	115944
C_1M_2	45500	4043	7263	56806	119006
C_1M_3	45500	3913	7125	56538	116738
C_2M_0	45500	3738	6938	56175	113675
C_2M_1	45500	3965	7180	56645	117645
C_2M_2	45500	4141	7367	57008	120708
C_2M_3	45500	4011	7229	56739	118439
C_3M_0	45500	3998	7215	56712	118212
C_3M_1	45500	4225	7457	57182	122182
C_3M_2	45500	4401	7644	57545	125245
C_3M_3	45500	4271	7506	57276	122976

C_1: 44 g/100 cloves	M_0: No mulch (control)
C_2: 63 g/100 cloves	M_1: Rice straw
C_3: 90 g/100 cloves	M_2: Black polythene
	M_3: Water hyacinth