EFFECT OF MULCHES AND POTASSIUM ON GROWTH AND YIELD OF GARLIC (*Allium sativum* L.)

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CERTIFICATE

This is to certify that the thesis entitled, *"EFFECT OF MULCHES AND POTASSIUM ON GROWTH AND YIELD OF GARLIC"(Allium sativum L.)* submitted to the Faculty of *AGRICULTURE*, 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 *MD. AYUB HOSSAIN TALUKDER*, **Registration No. 26200/00492** 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 have been duly acknowledged.

Dated : .....

Dhaka, Bangladesh

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Dedicated to
My
Beloved Parents who laid the foundation of my success

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The Author

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ABSTRACT

An experiment was carried out at the farm of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2005 to April 2006 to investigate the effect of mulches and potassium on the growth and yield of garlic. There were altogether 16 treatments comprising four levels of mulches viz. control (M_0), Saw dust (M_1), Water hyacinth (M_2), Rice straw (M_3) and four potassium levels viz. Control (K_0), 180 (K_1), 210 (K_2), 240 (K_3) kg K_2O per ha. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The crop was sown on 29 November, 2005 and harvested during 11 April, 2006. Data were recorded on different parameters and statistically analyzed. The results of the experiment demonstrated that mulching had significant effect on almost all the parameters studied in the experiment. Yield and yield contributing characters were found to be maximum in the plants mulched with different mulch materials than control. The highest (5.19 ton/ha) yield was produced by M_2 whereas M_0 (3.28 ton/ha) and M_1 (3.94 ton/ha) gave the lowest yield. Potassium also had the markedly significant variation in bulb yield and various yield components. The maximum (5.49 ton/ha) bulb yield was recorded at K_2 treatment and the lowest yield (3.56 ton/ha) was found in K_0. Application of potassium above 210 kg K_2O/ha decreased yield and not beneficial. Interaction effect of mulching and potassium revealed significant variation in yield and various growth parameters except plant height at 30, 45 and 75 days after sowing, number of leaves/plant at 75 days after sowing, dry weight of leaves per plant and fresh weight of roots/plant .The highest bulb yield (6.39 ton/ha) was obtained from the treatment combination of M_2K_2 and the lowest (2.29 ton/ha) was obtained from M_0K_0. The benefit cost ratio (BCR) was the maximum (2.83) in the treatment combination of M_2K_2 whereas, the minimum (1.03) was recorded from M_0K_0.

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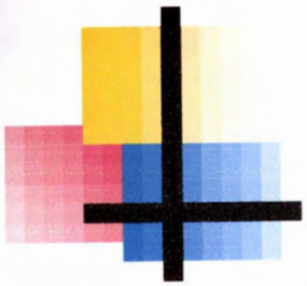
ACRONYMS AND ABBREVIATIONS

/	=	Per
CV.	=	Coefficient of variance
cv.	=	Cultivar
Fig.	=	Figure
MP	=	Muriate of Potash
i.e.		That is
DAS	=	Days After Sowing
BBS	=	Bangladesh Bureau of Statistics
BAU	=	Bangladesh Agricultural University
et al.	=	And others (at elli)
S.A.U	=	Sher-e-Bangla Agricultural University
wt.	=	Weight



CHAPTER I

INTRODUCTION

INTRODUCTION

Garlic (*Allium sativum* L.) is a fragrant herbaceous plant and is 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 originated in central Asia (Vvdensky,1946), 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, 2005).

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 (Augusti,1977). Application of garlic in Ayurvedic and Unani medicines in the treatments of diseases like chronic infection of the stomach and intestine, dysentery, typhoid, cholera and disease of lungs is well known (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 years oil, powder, kind of salt are prepared from it for adding flavour to the curries (Pruthi,1976). Aqueous extracts of garlic cloves (allicin and related essential oil viz. disulphides) significantly reduce cholesterol level tests on man (Augusti,1977).

Garlic ranks second in world production among the Alliums after onion (Purseglove,1975). The Average yield of garlic in Bangladesh is only 3.16 ton per hectare (BBS, 2005) which is very low as compared to many countries of the world. In Bangladesh about 73,000 metric tons of garlic was produced from approximately 18,140 ha of land in 2003-04 (BBS, 2005). The requirement of garlic in Bangladesh is about 85,000 metric tons (Rahim,1992). The trend of garlic production (1994-2004) in Bangladesh has been presented in Appendix I.

Major garlic producing districts of Bangladesh are Faridpur, Jessore, Rajshahi, Dinajpur, Dhaka, Pubna, Rangpur and Comilla (BBS, 2005). The highest national yield has been recorded from America (40 metric ton/ha) and the other countries and their mean production are China (13.62 ton/ha), South Korea (11.56 ton/ha), USA (19.11 ton/ha), Egypt (32.05 ton/ha), and Sudan (18.30 ton/ha) as reported by FAO, 2005. With the gradual increase of population, the demand for garlic in Bangladesh is increasing day by day, but due to the limitation of land, it is not possible to increase the area of crop production .The use of proper doses of fertilizer and improvement of the existing production practices may increase per ha yield in the different regions of our country. Moreover, necessary in depth knowledge and information regarding the use of potassium fertilizer and mulch material in garlic production under Bangladesh condition are scanty.

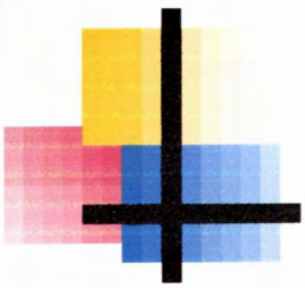
Garlic is known to be thermo photo sensitive crop and grown in Bangladesh in short day condition in winter (Jones and Mann,1963 ; Rahim and Fordham,1988). Its vegetative growth and bulb development are greatly influenced by growing environment. Soil moisture is an important factor that influences the growth, bulb development and yield of garlic. Garlic is produced in dry period of the year and soil moisture is dependent on the irrigation and its frequency. Mulching helps in retaining moisture and even acts as substitute of soil (Amal *et al.*,1990). Mulches also reduces the water loss from the soil by evaporation and from wind and reduces the irrigation requirements (Prihar,1986 ; Amal *et al.*,1990 ; Vanderwerken *et al.*,1988). It is useful to check weed growth, improve soil structure, control soil erosion, add organic matter to the soil, manipulate soil temperature variations and helps in proper utilization of nutrients.

Judicious application of fertilizer may enhance bulb yield significantly. Potassium helps in the root development and increases the efficiency of leaf in the manufacture of sugar and starch. It is essential for the translocation of sugars, potassium exerts a balancing role in the effect of both nitrogen and phosphorus. Consequently, it is especially important in a multi nutrient fertilizer application (Brady,1995). Among the yield promoting factors, application of proper doses of potassium and nitrogen is of great importance (Sotomayor,1975). Potassium

fertilizer are also used by the plants to influence better physio-morphological and biological development. Potassium improve the number and weight of bulb in case of garlic (Pimpin,1970).

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

- to ascertain the appropriate mulch material for optimum growth and development of garlic
- to find out the suitable dose of Potassium in garlic production and
- to study the combined effect of mulching and potassium on growth and yield of garlic



CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The growth, development and bulb formation of garlic are influenced by mulching and different levels of potassium. The review of literature includes reports as studied by several investigators, who found pertient in understanding the problems and which may help in the explanation and interpretation of results of the present investigation. In this chapter, an attempt has been made to review the available information in home and abroad on the effect of mulches and potassium level on the growth and yield of garlic.

2.1 Effect of mulches on growth, yield and production

Hossain (2003) carried out an experiment on the effect of mulches on the growth and yield of some garlic germplasm, who reported that the highest yield (4.32 ton / ha) obtained from water hyacinth mulch. It also increased plant height, no. of leaves, fresh and dry weight of leaves, roots and bulb, neck diameter, bulb diameter and no. of cloves / plant.

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.

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 $G_{1\,9}$ variety with water hyacinth mulch produced the highest yield (10.90 ton / ha) and G_4 variety with white polythene gave the lowest (1.90 ton / ha) yield of garlic.

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.

Bhuiya (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 ton /ha) best followed by straw mulch.

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 a 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 mulch also produced the largest and heaviest bulbs. None of the treatments had a significant effect on the number of cloves / bulb.

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.

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.

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 from 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 bulb^{-1}, 100 clove weight and yield were also significantly higher in mulched plants. All mulches provides weed control. Among the treatments, water hyacinth root gave the best results in terms of garlic yield. All types of mulch in this study compresented for reduction in garlic yield due to late planting.

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 polyethylene or organic matter, viz. 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.

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. Who found that, total bulb yield of onion was 80 % higher than no mulched treatment.

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 were 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.

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

Chung (1987) observed that mulching with polyethylene film gave the highest yield, who also found that effect of the mulch resulted in 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).

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, who 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^{-1} and 19.01 for the unmulched control.

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

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. Marketable garlic bulb yield, plant survival and keeping duration fell, 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.

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, leaf number and total shoot dry weight of sweet potato cultivar Jewel were significantly higher for unmulched plants as reported by Hockmuth and Howell (1983). Who 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).

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.

Increasing in growth and yield have 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).

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 dia) and the highest number of cloves / bulb (12.75).

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 (1977) reported that, mulching in carrots immediately

after sowing with perforated polyethylene film 0.02 mm thick greatly increased the yields and size of roots 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.

San *et al.* (1974) carried out an experiment in Brazil on garlic with and without rice straw mulch. Who 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. Sutater (1987) also reported that mulching reduced the dry soil temperature.

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. Who found that mulching increased yield and average bulb weight at all spacing and N levels.

2.2 Effect of potassium on growth, yield and production

Naik and Hosamani (2003) conducted an experiment to study the effect of different levels of N, P and K on growth and yield of garlic under rain fed condition of Dharwad, Karnataka, India. There were Twenty-four treatment combination of fertilizer comprising four levels of N (0, 50, 100 and 150 Kg / ha), three levels of P (0, 40, and 80 Kg / ha) and two levels of K (0 and 60 kg / ha). They reported that, among the fertilizer combinations, 100:40:60 kg NPK ha was found to be the optimum for increasing plant height, number of leaves / plant, number of bulb / plot, number of cloves / bulb and bulb yield / hectare.

An experiment was conducted by Das and Mohanthy (2001) to evaluate the effect of plant density (8 x 8, 10 x 8, 10 x 10 and 15 x 10 cm) and N:P:K rates (50:50:50, 75:75:75, 100:100:100 and 125:125:125 kg / ha) on the yield of garlic cv. Madrasi. Among the spacing treatments 8 X 8 (at 900 plants / plot) produced the highest yield (165.28 q / ha) followed by 10 x 8 cm among the fertilizer treatments, N:P:K at 100:100:100 kg / ha produced the highest bulb yield (153.78 q / ha), followed by 125:125:125 kg / ha. Combination of 10 x 89 cm spacing and 100:100:100 kg N:P:K / ha resulted in the maximum yield of 107.27 q / ha.

Sardar *et al.*(1999) conducted an experiment to study the effect of applying N (0, 50, 100 or 150 kg / ha) P (0, 40 or 80 kg / ha) and K (0 or 60 kg / ha) on garlic cv. Kanpur Local. They reported that, bulb yields were increased as the rate of each element applied. A fertilizer rate of 100 kg N + 80 kg P + 60 kg K / ha was recommended for garlic production.

Harun-or-Rashid (1998) conducted an experiment at the Bangladesh Agricultural University, Mymensingh on the effects of the NPKS on the growth and yield of onion at different plant spacing who reported that, the maximum bulb weight (40.50 g) and bulb yield (20.75 ton / ha) were found the combination of 125-150-30 kg N, P_2O_5, K_2O, S / ha and the minimum bulb yield (16.75ton / ha) was recorded from the control treatment (no NPKS), who reported that, application of NPKS increased the plant height, leaf number, length of bulb, bulb diameter, bulb weight as well as the bulb yield. He recommended 100-150-200-30 kg N, P_2O_5, K_2O, S / ha for the cultivation of BARI peaj-1 at BAU farm conditions. But Islam (1998) found that nitrogen at 120 kg / ha produced the maximum bulb weight and bulb yield (25.5 ton / ha).

Talukder (1998) conducted an experiment at the Bangladesh Agricultural University on the growth and yield of garlic planted in different dates who found that, the highest yield (4.36 ton / ha) was obtained from the level of potassium (200 Kg K_2O / ha),who reported potassium had significant, no. of leaves, fresh and dry weight of leaves, bulbs and roots at different DAP.

Hossain (1997) found that all parameters namely plant height, number of leaves / plant, leaf length, weight of foliage, pseudostem and bulb diameter, weight of root, dry matter contents of foliage, bulb and root, weight of bulb and yield of bulb varied significantly with application of nitrogen. A few of this characters namely, leaf length, weight of foliage, bulb diameter, weight of bulb yield were significantly influenced by potassium levels. The highest bulb yield was obtained when the plant raised with the highest nitrogen level (200 kg / ha) and lowest yield (5.61 ton / ha) was at 120 kg / ha produced the highest bulb yield (7.64 ton / ha).

Hossain (1997) conducted an experiment at the Bangladesh Agricultural University, Mymensing on the effect of different levels of nitrogen and potash on the growth and yield of garlic (*Allium sativum* L.) and who reported that, no. of leaves and breath of leaf were not found to be significantly influenced by K levels. The maximum leaf length was produced from 120 kg K_2O / ha and potassium also increased other yield contributing character.

Rizk (1997) conducted an experiment to investigate the effects of plant density and N P K fertilizers on the productivity of onion, who noted that, increasing the N P K rate increased all the vegetative growth parameters measured the yield of bulbs.

Abbas *et al.* (1994) conducted an experiment in Indonesia with a local garlic cultivar where N was applied at 0, 50, 100 or 150 kg / ha as urea and 0, 30, 60 or 90 kg K_2O as muriate of potash. Garlic yield was found to be highest with 100 kg N / ha and 90 kg k_2O / ha. However, there was no significant interaction between N and K this respect.

Katwale and Saraf (1994) stated that, the largest bulb yield was obtained from the application of N P K at the rate of 125: 60: 100 kg / ha, respectively in onion, who also reported that the rate gave the highest economics return.

Singh *et al.* (1994) carried out an experiment in Uttar Pradesh India to investigate the effective of (as urea at 0, 100,or 200 kg N / ha) on the growth of garlic cv.

Amaranle. Plants also received 50 kg P_2O_5 ha and 50 kg K_2O / ha who observed that vegetative growth and yield (62.07 q / ha) was maximum for plants receiving N at the rate of 100 kg / ha.

Sarvananan and Nambisan (1994) conducted an experiment at Kodiakanal, Madras, India on garlic. Garlic crop was given 0, 50, 100 or 150 kg N ; 0, 25, 50 or 75 kg P and 0, 25, 50 or 75 kg K / ha in various combinations. Mean bulb yield was the highest (9750 kg / ha) with 100 kg N + 75 kg P + 50 kg K / ha. Bari (1974) stated that a dose of 66:88:88 kg N, P_2O_5 and K_2O / ha gave highest yield of onion.

Vachhani and Patel (1993) conducted an experiment on effects of nitrogen (50, 100 or 150 kg N / ha), Phosphorus (25, 50 or 75 kg P_2O_5 / ha) and Potash (50, 100 or 150 kg / ha) levels on the growth and yield of onion. They reported that, plant height, number of leaves per plant, bulb weight and yield were highest with 150 kg N / ha. Increasing Phosphate application increased the number of leaves per plant and weight, size and yield of bulbs. Application of K increased only the number of leaves per plant.

Uddin (1993) while working with garlic at Bangladesh Agricultural University, Mymensingh. Who found that garlic producing 3.55 ton / ha at the level of 200 kg K_2O / ha.

In studying the effect of N, P and K on the yield of garlic bulbs in sand culture during 1987-90, the optimum N, P and K requirements were established by Wang *et al.* (1992) as 260.27 ppm P and 369.67 ppm K which gave garlic yields up to 18.52 kg m^{-2}. Garlic yield increased significantly as N, P and K supplying increased, N had greatest effect on yield.

Amado and Teixeira (1991) studied in a fallow area with or without N and all the treatments received 120 kg P_2O_5 / ha. Combined application of N P K gave the highest dry matter and bulb yield of onion. Who also reported to the amount of dry matter of the cover crop residues.

Pandey *et al.* (1991) studied with four levels of nitrogen (0, 50, 100 and 150 kg / / ha), there levels of phosphorus (0, 40 and 80 kg / ha) and two levels of potash (0 and 50 kg / ha) to determine the yield and quality of Kharif onion,who found that, the maximum yield net return were achieved with N: P: K at 150:40:50 kg / ha.

Eid *et al.* (1991) in Egypt found that, growth parameters and its components were generally with increased K application rate up to 100 kg K_2O / feddan and with micronutrient mixture (Cu, Zn and Fe). Wang *et al.* (1992) worked in china with garlic and found that the optimum N, P, and K requirements for higher yield of garlic were 260.27, 60.86 and 369.67 ppm respectively. Who also observed that garlic yield was increased significantly as N, P and K supply was increased.

In Indonesia, low land and highland garlic crops are traditionally fertilized with N: P_2O_5: K_2O at the rate of 250: 90: 150 kg / ha. Since the garlic is grown after 2 preceding rice crop, which are heavily fertilized, Asandhi (1989) conducted an experiment to determine whether omitting P and K and reducing the N rate to 120 kg / ha was possible. The results showed the P and K fertilization was needed and that decreasing the N rates reduced plant growth and garlic yield. The best method of N fertilization was the application of 80 kg N / ha at 15, 30 and 45 days after planting.

Setty *et al.* (1989) studied the effect of nitrogen, phosphorus and potash on the growth and yield of garlic at Dharwad, India during 1989. Application at three levels each of N (0, 100 and 200 kg / ha), P_2O_5 (0, 50 and 100 kg / ha) and K_2O (0, 50 and 100 kg / ha) were made. Application of N at 200 kg / ha produced significant increases in plant height, number of leaves, neck thickness, bulb size, number of cloves / bulb and yield. Application of P at 100 kg / ha increased the number of leaves, bulb size and number of cloves / bulb. Application of K at 100 kg / ha produced significant larger bulbs.

Hilman and Noordiyata (1988) conducted an experiment in a rice field at Ciwidey, Indonesia, to study equilibrium N, P and K fertilization on garlic yield. The results showed that the equilibrium N, P and K fertilization at several levels did not significantly affect bulb diameter, bulb length, number of cloves per bulb or fresh bulb weight. However, the treatments indicated a significant effect on bulb dry weight.

Hedge (1988) conducted an experiment with cv. Pusa Red and found that, application of N fertilizer increased that bulb yield, but not quality. It was also showed that the dry matter production of bulb was increased due to uptake of more N, P, K, Ca and Mg nutrients.

Soto (1988) carried out experiment with critical levels for P, K and S and response to N. the rates were 100 kg / ha each of N, P_2O_5 and K_2O and 50 kg S / ha. Nitrogen was applied at 0, 50, 100 and 150 kg / ha,who mentioned that 50 kg / ha gave the best yield response.

Results over 2 years trial conducted by Saimbhi *et al.* (1987), who indicated that, applying of N P K at the highest rate gave the greatest bulb size, maximum yield (33.89 ton / ha) and best quality of dehydrated onions. The highest N P K combinations was 100 kg N, P_2O_5 and 60 kg K_2O per hectare.

Singh (1987) in his trail with onion cv. Pusa Red at different levels and combination of N P K fertilizers observed a significant response from N but not from K. The highest yield (26.04 ton / ha) was obtained with N and P_2O_5 at 112.5 and 196.9 kg / ha respectively.

Borabash and Kochina (1987) worked in Ukraine on mineral fertilization with garlic productivity who reported that, mineral fertilization increased the assimilating leaf area, photosynthetic productivity and yield of garlic. The yields of underground bulbs and of underground bulbs + aerial bulbils at 90:90:90 kg / ha N: P_2O_5: K_2O treatments were 6.48 and 7.50 ton / ha, respectively and returns were

highest in this treatments although the 90:90:90 kg / ha treatment gave the highest yield.

Pal and Pandey (1986) conducted an experiment to investigate the different levels of fertilizer, plant growth was significantly increased by the application of 150 kg N, 250 kg and P and 75 kg K / ha (94.48 g / ha compared with 39.9 g / ha in control receiving no N PK).

Guandi and Asandhi (1986) studied the effect of fertilization on garlic cv. Lumba Hijau planted at 20 X 80 m^2 plots and fertilized with 0, 80, 160 or 240 kg / ha as urea or $(NH_4)_2 SO_4$ + 120 K_2O / ha as KCL or K_2SO_4 +120 kg / ha as triple super phosphate. They observed that higher rates of N produced greater plant heights and greater stem diameter.

Tsikalas and Manios (1985) showed that nutrient content in tomato leaf fluctuated during the growing season, N, P, K and Fe contents reached their highest levels during the 8^{th} week after transplanting and then declined. Leaf N contents was increased by N at 350 ppm but yield was height in plant receiving N at 200 ppm. K had little effect on yield and this was attributed to a high K level in the substance.

Das *et al.*(1985) conducted an experiment at the Bidhan Chandra Krisi Viswavidyalaya, Cooch Bihar, India on the effect of fertilization of N: P_2O_5 and or K_2O at 0-120: 0-60: 0-120 kg / ha. The average yield was highest (6.32 ton ha^{-1}) with N P K at 60:60:120 kg / ha.

Madan and Sandhu (1985) noticed that good plant growth and maximum bulb yield and dry matter contents were obtained with N: P_2O_5 : K_2O at 12:60:60 kg / ha in onion.

Koltunov (1984) reported that application of N:P:K at 1:1:2 (N,P_2O_5 and K_2O at 60:60:120 kg / ha) + FYM at 40 ton / ha gave the best yield of garlic bulbs suitable for long term storage.

Nelson (1983) conducted an experiment on garlic fertilization trial. May planted garlic on silt loam soil was supplied with combination of (1) N at 100, 150 or 200 kg / ha as a basal dressing 100 days after plating (2) 25 or 325 kg / ha size were improved by increasing the basal N rate, increased N side dressing improved bulb size and when yield. The different K rates had no effect on yield or bulb size.

Agarwal *et al.* (1981) conducted an experiment at the Vegetable Research Farm, Kanpur, India during 3 consecutive seasons of 1968-69 to 1970-71 with three trials on onion cv. Kkalianpur Red Round. The plant received N, P_2O_5 and K_2O at 80-160; 40-80 kg / ha. The highest yield was obtained from plots receiving 160:40 or 80:40:80 kg ha^{-1}. The application of nitrogen alone at 80 kg / ha gave significantly yield (2.02 ton / ha) and was the most economic dose.

Gupta and Gaffer (1980) conducted an experiment to study the effect of different row spacing under different combinations of nitrogen, phosphorus and potassium on the growth and yield of onion. Application of N P K exerted a significant effect on yield and yield contributing characters of onion. Economic yield was obtained from N P K application @ 46: 36: 36 kg / ha.

Minard (1978) conducted an experiment in New Zealand with garlic cloves of 2 sizes (1.0-1.9 and 2.0-2.9 g) fertilized with N at 0 or 210 kg / ha, P at 263-1250 kg ha^{-1},K at o or 750 kg / ha and lime (as ground lime stone) at 5 or 15 ton / ha. The highest yield was obtained from larger bulb size, receiving N and K at high and low rates respectively, Lazzari *et al.* (1978) found that the application of higher nitrogen fertilizer improved the yield and quality of garlic grown in a loam soil in Argentina.

Islam and Haque (1977) in Bangladesh studied the effect of N P K on an indigenous cultivar of onion, and observed that, the combined dose of nitrogen at 60 kg, phosphorus at 35 kg and potash at 35 kg / ha produce the highest yield.

Rahman *et al.* (1976) studied the effect of N P K on the local onion cv. Faridpur Bhatti in Bangladesh. Who found that, a combined dose of nitrogen at 56 kg / ha, phosphorus at 67 kg / ha and potash at 67 kg / ha produced the best results in order to get the highest yield. Higher level of nitrogen application (112 kg / ha) resulted in decreased yield but increased levels of potassium (135 kg / ha) increased the size and yield of bulbs.

Begatirenko (1975) stated that to produced 1 ton of garlic the plants removed from the soil 9.6-12.9 kg N, 5.5-8.2 kg P and 6.5-8.0 kg K. It was also reported that, annual application of FYM at 40 ton ha^{-1} + N, P_2O_5 and K_2O at 120 : 60: 120 kg / ha gave higher yield in garlic.

Rahman and Faruque (1975) studied of N P K on onion cv. White Creole and found that, an application of N:P:K @ 90:45:45 kg / ha resulted in the highest yield.

Novias *et al.* (1974) studied the effect of nitrogen fertilization, mulching and three spacing on the leaf N, P, K, Ca and Mg levels in the garlic, ammonium sulphate was applied at 0-100 kg / ha to plant spaced at 5, 7.5 or 10 cm within the row and grown with or without a mulch. Who reported that, fertilization increased leaf N, P and Mg contents and decreased the K content while the Ca content remained unaffected. Mulching increased leaf, N, P and K content while those of P and Mg remained unaffected. Spacing had little effect on leaf N, P, K, Ca and Mg contents.

Novias *et al.* (1974) stated that nitrogen fertilization increased leaf N, and Mg contents and decreased the K content, while the Ca content remained unaffected.

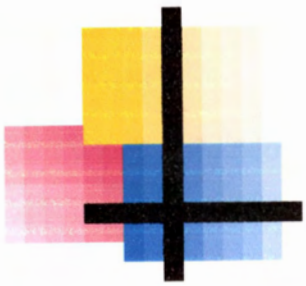
The effect of fertilization was investigated by Kusomo and Widiajanto (1973). The normal fertilizer rate of 240 kg N, 60 kg P_2O_5 and 200 kg K_2O / ha (control) was compared with 5 other fertilizer treatments. The best of these five was a compound, Rustica Blue, supplemented with urea to give 232 kg N, 120 kg P_2O_5 and 170 kg K_2O / ha, its effects, however, differed little from those of the control.

Pandey and Mundra (1971) conducted an experiment on response of onion to varying levels of N, P and K in Madhya Pradesh, India and reported that the height of plant, number of leaves, length of bulbs, diameter of bulbs, fresh and dry weight of top growth and yield of garlic bulbs / ha were significantly increased by the application of N.

Pimpin (1970) reported the results of a study conducted with garlic cv. Blance piacintin where 0, 80 and 160 kg / ha each of N, P_2O_5 and K_2O were applied in factorial combinations, N and K improved the number and weight of bulbs, but P and negative effects on these parameter.

Lazo *et al.* (1969) in their trial on the use of N P K fertilizer in onion at the rate of 50, 100, 150 kg / ha observed that nitrogen used alone or in combination with phosphorus and potash responded.

Purewal and Daragan (1961) conducted an experiment fertilization with garlic in India. The application of nitrogen increased the weight of individual bulb significantly over control.The highest response was obtained on the weight of individual bulb with 112.27 kg / ha nitrogen, phosphorus and potash did not give any response.



CHAPTER III

MATERIALS AND METHODS

MATERIALS AND METHODS

In Bangladesh, garlic is being grown in a very limited scale, but a good deal of interest has been generated for raising this crop due to its demand for spices and medicinal purpose. It is necessary to explore the possibilities of growing garlic in order to raise its yield level. Mulching and fertilizer management affects growth, development and yield of garlic. So, this experiment has undertaken to find out the effective mulch and appropriate or optimum doses of fertilizer and for exploiting the yield potential of this crop.

3.1 Experimental Site

The experiment was conducted at Sher-e-Bangla Agricultural University Farm and Laboratory of Department of Horticulture and Postharvest Technology, Soil Science and Agronomy of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period from November 2005 to April 2006. The experimental site was previously used for field crop cultivation and recently developed for research work. The location of the site is 23° 74´N latitude and 90° 35´E longitude with an elevation of 8.2 meter from sea level (Anon., 1989).

3.2 Climate

The climate of the experimental site is subtropical, characterized by heavy rainfall during the months from April to September and scanty rainfall during the rest of the year. The total rainfall of the experimental site was minimum during the study period. The average monthly maximum and minimum temperature were recorded during the experimental period. The maximum and minimum temperature, humidity rainfall and soil temperature during the study period were collected from the Bangladesh Meteorological Department (Climate Division) and have been presented (Appendix II).

3.3 Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988). The analytical data of the soil sample collected from the experimental area were

determined in the SRDI, Soil Testing Laboratory, Khamarbari, Dhaka and presented in appendix II.

The experimental site was a medium high land and pH of the soil was 5.6. The morphological characters of soil of the experimental plots as indicated by FAO (1988) are given below –

AEZ No. 28

Soil series – Tejgaon

General soil- Shallow red brown terrace soil.

3.4 Plant Materials

A local cultivar of garlic was used in this experiment. Bulbs were collected from Joypurhat district of Bangladesh. The cloves of uniform size and thick were selected for sowing. The average weight and diameter of cloves were 1.6-2.0 g and 1-1.1 cm respectively.

3.5 Treatments of the experiment

The experiment was designed to study the effects of various types of mulches and different levels of potassium on growth and yield of garlic.The experiment consisted of two factors were as follows :

Factor A : It includes four types of mulch

i. **(M_0) :** Control– No mulch material

ii. **(M_1) :** Dried saw dust

iii. **(M_2) :** Dried water hyacinth

iv. **(M_3) :** Dried rice straw

Factor B : It comprised four levels of potassium (as K_2O).

i. **(K_0) :** Control– No Potassium fertilizer

ii. **(K_1) :** 180 kg K_2O/ha

iii. **(K_2) :** 210 kg K_2O/ha

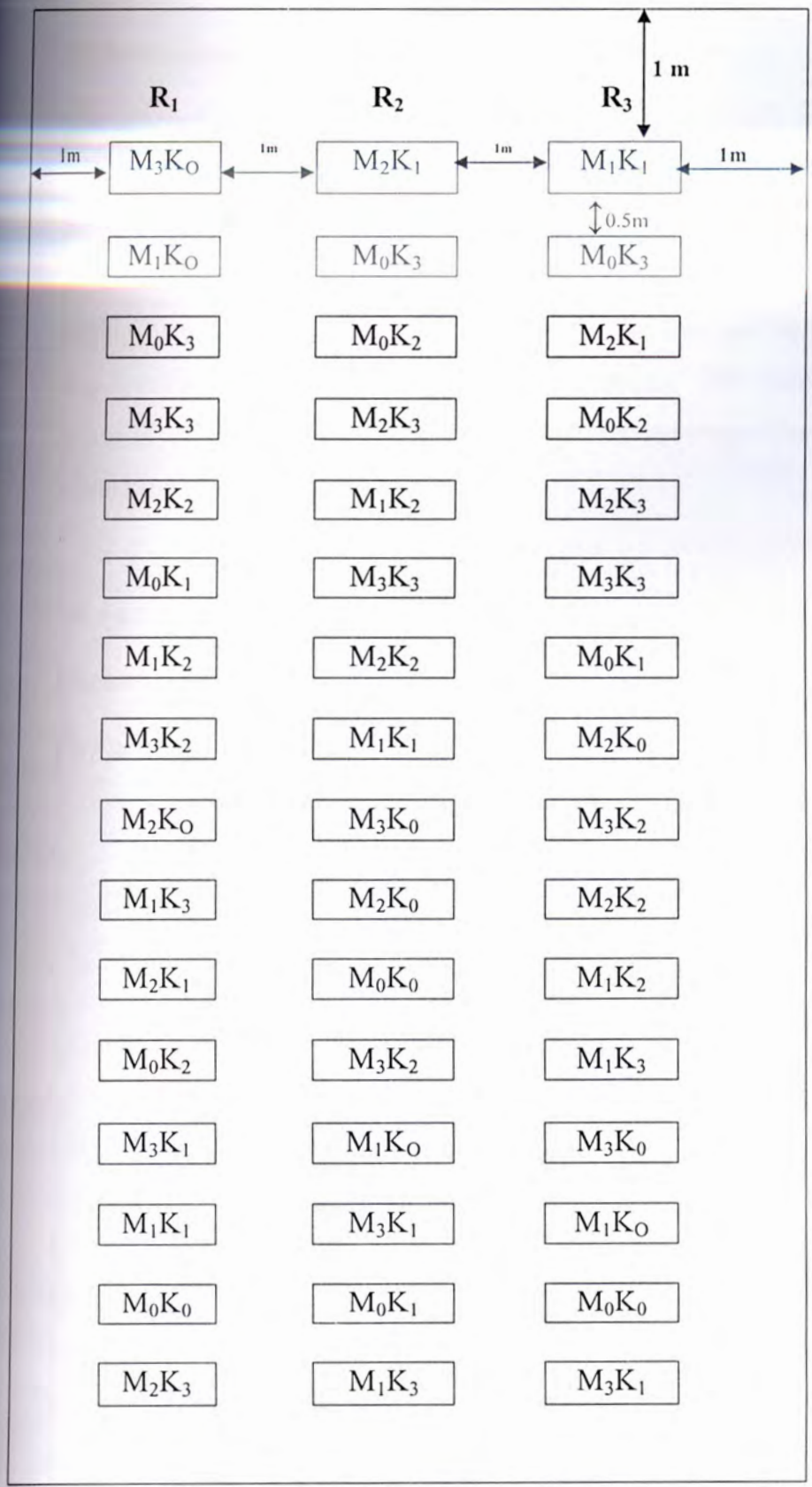
iv. **(K_3) :** 240 kg K_2O/ha

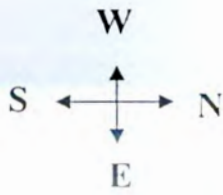
There were altogether 16 treatment combinations, such as-

$M_0 K_0$	$M_0 K_1$	$M_0 K_2$	$M_0 K_3$
$M_1 K_0$	$M_1 K_1$	$M_1 K_2$	$M_1 K_3$
$M_2 K_0$	$M_2 K_1$	$M_2 K_2$	$M_2 K_3$
$M_3 K_0$	$M_3 K_1$	$M_3 K_2$	$M_3 K_3$

3.6 Experimental design and layout

The two factorial experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. An area of 25.5mX13m was divided into three equal blocks. Each block was further divided into 16 equal size plots where 16 treatment were allotted at random. Thus there were 48 unit plots altogether in the experiment. The size of each plot was 3mX1m. Two adjacent unit plots and blocks were separated by 1 m and 0.5 m respectively. A layout of the experiment has been shown in Figure 1.





Plot size : 3 m × 1 m Clove spacing: (15 × 10) cm

Plot spacing: 0.5 m

Between replication : 1 m

Mulch :

M_0 = Control

M_1 = Saw dust

M_2 = Water hyacinth

M_3 = Rice straw

Potassium :(as K_2O)

K_0 = (control)

K_1 = 180 kg potassium/ha

K_2 = 210 kg potassium/ha

K_3 = 240 kg potassium/ha

Figure 1. Field layout of the two fectorial experiment in Randomized Complete Block Design (RCBD)

3.7 Land preparation

The selected experiment plot was first opened in the month of 15 November, 2005 by a power tiller and then it was kept open to sun for 7 days prior to further ploughing. Afterwards it was prepared by ploughing and cross ploughing followed by laddering. Deep ploughing was done to have good tilth which was necessary for getting better yield of bulb.The clodes were broken into friable soil and surface was leveled until the desired tilth was obtained. The weeds and stables were removed after each laddering. Irrigation and drainage channels were prepared around the plots.

3.8 Application of manure and fertilizers

Manure and fertilizers were applied as per recommendation of fertilizer guide (BARC, 1987).

Manure and Fertilizers	Dose
Cow dung	14 ton/ha
Mastard oil cake	2 ton/ha
Urea	260 kg/ha
TSP	395 kg/ha

Cowdung, Mastard oil cake, Urea and TSP were applied as a basal dose during land preparation. Full quantity of cowdung and mastard oil cake were applied immediately after opening the land. Half dose of required quantity of urea and entire quantity of TSP were added at the time of final land preparation. Muriate of Potash (MP) was used as different treatments for the source of potassium in furrows. Half amount from rest of the required quantity of urea and MP were applied as top dressing 30 days after planting.The remainder of urea and MP were applied 60 days after sowing.

3.9 Sowing of cloves

Two outer layers of garlic cloves were seperated from each mother bulb for sowing in the field and 126 cloves were sown in each plot on 29 November, 2005 maintaining a distance of 15cm X 10 cm. The depth of sowing was around 2.5 cm from the surface of the soil. Cloves were also sown around the experimental area to cheek the border effect.

3.10 Application of mulch treatment

Mulching was done immediately after sowing cloves with Saw dust , Water hyacinth and dried Rice straw.

3.11 Intercultural operations

3.11.1 Gap filing

The experimental area was kept under careful observation. The unsprouted cloves and damaged plants were replaced by healthy seedling taken from border plant within two weeks after sowing.

3.11.2 Weeding

No weed was found in the plots covered by Saw dust, while a few weeds were noticed in plots covered by water hyacinth and straw mulches. But huge number of weed were found in control treatment. Weeding were done four times in these plots where it was necessary.

3.11.3 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. The unmulched

plots had to be irrigated more frequently than the mulch plots. As a consequence, the amount of irrigation water was much higher in unmulched plots which was calculated from the amount of water discharged from the hosepipe per minutes.

3.11.4 Plant protection

Leaf blotch disease was found in the experimental plot. Curative measures was taken by spraying Dithan M-45 at an interval of 10 days @ 60 g in 10 litres of water.

3.12 Harvesting

The crop was harvested in April 11, 2006 when the plants reached maturing showing the sign of drying out of most of leaves . Cloves was taken carefully so that no bulb was injured during lifting.

3.13 Data collection

Ten (10) plants were sampled randomly from each unit plot for the collection of data. The plants in the outer rows and at the extreme end of the middle rows were excluded from the random selection to avoid the border effect. Data were recorded on the following parameters from the sample plants during the course of experiment.

3.13.1 Plant height (cm)

Plant height was measured in centimeter (cm) by a meter scale at 30, 45, 60 and 75 days after sowing (DAS) 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.

3.13.2 Number of leaves per plant

Number of leaves of ten randomly selected plants was counted at 30, 45 60 and 75 DAS. 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.

3.13.3 Fresh weight of leaves per plant (g)

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 .

3.13.4 Fresh weight of roots per plant (g)

Fresh weight of roots per plant was taken from the mean of fresh roots of bulbs from randomly selected plants after harvesting. The mean weight was recorded in gram.

3.13.5 Fresh weight of bulb per plant (g)

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

3.13.6 Dry weight of leaves per plant (g)

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

3.13.7 Dry weight of roots per plant (g)

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

3.13.8 Dry weight of bulb per plant (g)

After lifting and sun drying for two days the bulb samples were dried 72 hours at 80^0 c in an oven. After drying, the weight of the bulb were recorded in gram.

3.13.9 Diameter of bulb (cm)

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

3.13.10 Neck diameter (cm)

Diameter of pseudostem was taken at the neck of 10 randomly selected bulbs at harvest and their average was calculated in centimeter.

3.13.11 Number of cloves per plant

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

3.13.12 Yield of bulb (kg per plot)

Bulb yield per plot was recorded by harvesting all the bulbs in each plot and taking their weight after removing roots.Yield per plot was expressed in kilogram.

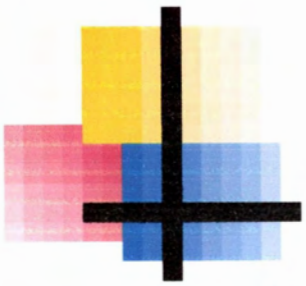
3.13.13 Yield of bulb (ton per ha)

Yield of bulb per plot was converted into yield per ha and was expressed in metric ton.

3.14 Statistical analysis

The collected data from the experiment on yield and yield components were statistically analysed following factorial experiment in RCBD wheneven necessary. The mean for all the treatments were calculated and the analysis of variance for most of the characters under consideration was performed by ' F '

variance test. The significance of difference between pair of means was expressed as least significance difference (LSD) test taking the probability at 5% level of the maximum unit of significance (Gomez and Gomez, 1984).



CHAPTER IV

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

The present study was conducted to investigate the effect of mulches and different levels of potassium on the growth and yield of garlic. The analysis of variance (ANOVA) on different yield contributing characters and yield of garlic has been presented in Appendices IV,V,VI and VII. Different mulch material showed significant variation in their effect on yield and yield contributing characters of garlic have been presented in tables 1and 4 and Figures 2, 4 and 6. The effects of potassium on yield and yield contributing characters of garlic have been presented in tables 3 and 4 and Figures 2, 5 and 7.The results of combined effect of mulches and doses of potassium on different growth parameters and yield of garlic have been presented in the tables 3 to 6.The results obtained from the experiment have been presented and discussed under the following headlines

4.1 Growth parameters

4.1.1 Plant height

Plant height was recorded at different days after sowing (DAS). It was measured that, effect of mulching was highly significant in this respect..

At 75 DAS, the highest (55.58 cm) plant height was obtained from water hyacinth mulch while saw dust and straw mulch showed 48.82 cm and 48.48 cm respectively (Figure 2.). The results of sawdust and straw were statistically different with water hyacinth mulch, but saw dust showed statistically identical reading with straw mulch. The lowest (44.44 cm) plant height was recorded from control (Mo).

This finding differs from the results of Halim (2000) and Hossain (1996), who reported that, straw mulch produced the maximum plant height at 75 DAS. Plant height was found comparatively higher with water hyacinth, this might be due to plant received more moisture at different depth which produced the maximum

vegetative growth resulting the highest plant height. It also may be accounted for effective control of soil temperature, pH and inhibition of weed growth.

Water hyacinth mulch was found more effective in increasing plant height which was also reported by Hossain (2003) and Bhuiya (1999). Water hyacinth mulch was also reported more effective in conservation of soil moisture by Hossain (1996), Uddin (1997) and Suh *et al.* (1991).

On the contrary, plant grown without mulch and straw could not accomplish full vegetative growth due to loss of soil moisture by evaporation and excessive weed growth respectively.

Different levels of potassium had significant effect on plant height at 30, 45, 60 and 75 days after sowing. The maximum (52.75 cm) plant height was recorded from 210 kg K_2O/ha at 75 DAS, followed by 240 and 180 kg K_2O/ha which gave 50.89 cm, 47.31 cm respectively while the control gave lowest (46.37 cm) value (Figure 3.).

This result differs from Hossain (1997) who stated that, plant height was not significantly influenced by different doses of potassium, but Talukder (1998) and Rashid (1998) agreed with this results. Plant height at different levels of potassium was increased up to 75 DAS, then decreased.

There was no significant interaction between mulches and different levels of potassium in respect of plant height except 60 days after sowing (DAS).The highest (61.81 cm) plant height was obtained from the treatment combination of water hyacinth mulch and 210 kg K_2O/ha, whereas the lowest (41.58 cm) plant height was found from no mulching and no potassium at 75 DAS, (Table 3.) It was observed that plant height gradually increased up to 75 DAS and then decreased due to drying of tip of the leaves.

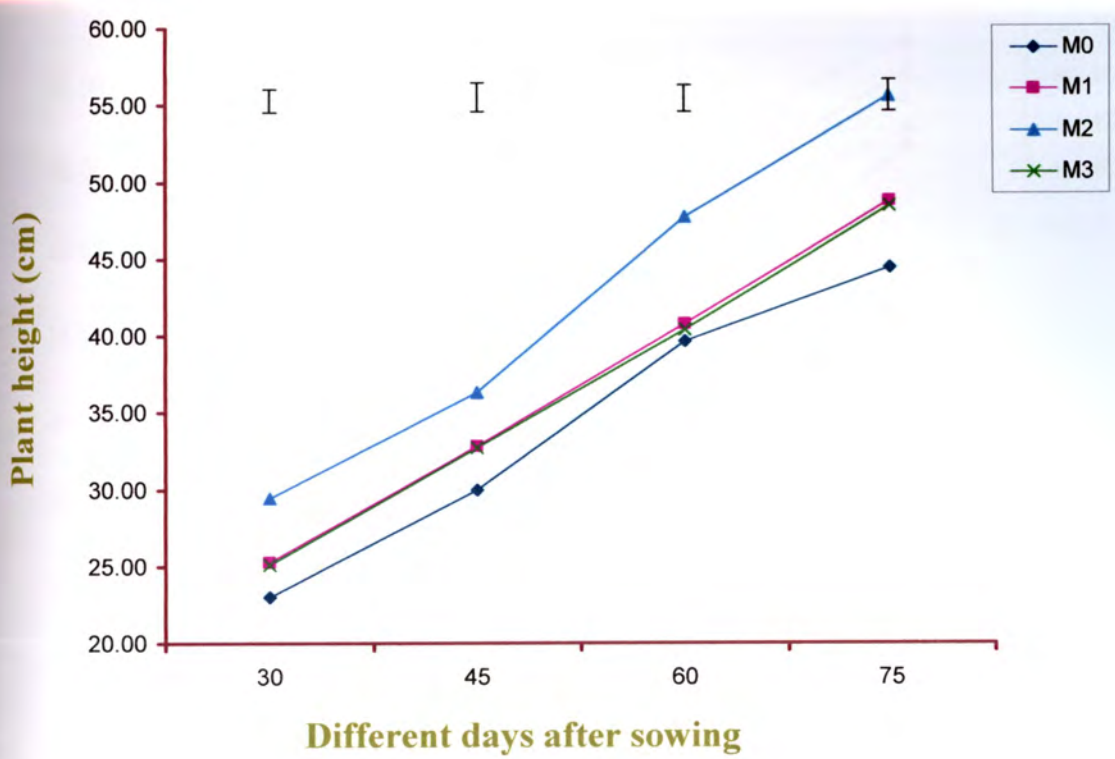


Fig. 2. Effect of mulches on plant height at different days after sowing. Vertical bars represent LSD at 5 % level of significance

$M_{0=}$ Control

$M_{1=}$ Saw dust

$M_{2=}$ Water hyacinth

$M_{3=}$ Straw

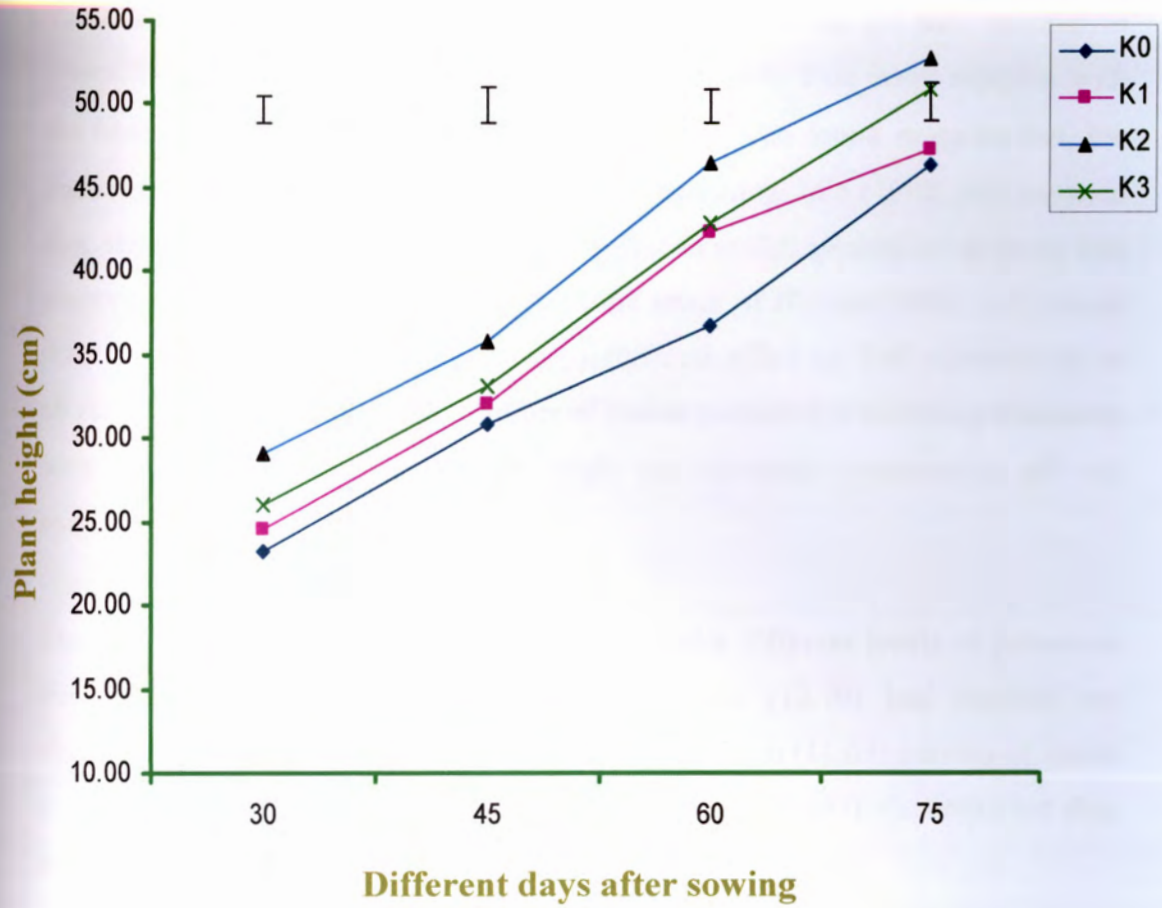


Fig. 3 Effect of potassium on plant height at different days after sowing. Vertical bar represent LSD at 5% level of significance

K_0= 0 kg K_2O/ha

K_1= 180 kg K_2O/ha

K_2= 210 kg K_2O/ha

K_3= 240 kg K_2O/ha

4.1.2 Number of leaves per plant

It was found that treatment means in terms of number of leaves/plant was highly significant at 30, 45, 60 and 75 DAS, water hyacinth mulch gave the highest (12.79) number of leaves followed by saw dust (12.02) and straw (11.75) mulch at 75 DAS (Figure 4.). No mulch or control gave the lowest (11.62) number of leaves that was statistically identical with straw mulch. This result supports with the findings of Hossain (2003) and Hasan (1999), who found in garlic that, the highest number of leaves with water hyacinth mulching. Mia (1996) also reported that, slight increase in the number of leaves due to mulch application in onion was observed, but this result is different from the result of Bhuiya (1999), who found that, different mulch treatments had no significant effect on leaf number/plant at all stage of growth. The highest number of leaves produced in mulching treatments were possibly due to greater plant height and favorable temperature, pH and moisture conditions of the soil.

The variation in total number of leaves/plant under different levels of potassium was found statistically significant .The maximum (12.70) leaf number was obtained from 210 kg K_2O/ha at 75 DAS. The minimum (11.03) number of leaves produced in control (Figure 5.). Vachhani and Patel (1993) also reported that, application of K_2O increased the number of leaves/plant.

Interaction effect of mulches and potassium levels on number of leaves produced/plant was found to be significant at different DAS except 75 DAS. The maximum (13.83) number of leaves/plant was recorded from water hyacinth mulch and potassium level of 210 kg K_2O/ha and the minimum (10.36) number of leaves/plant was recorded in control treatment at 75 DAS (Table 3.). This indicated that, the number of leaves/plant was higher up to 75 DAS, when mulched with water hyacinth and applied 210 kg K_2O/ha in the plot.

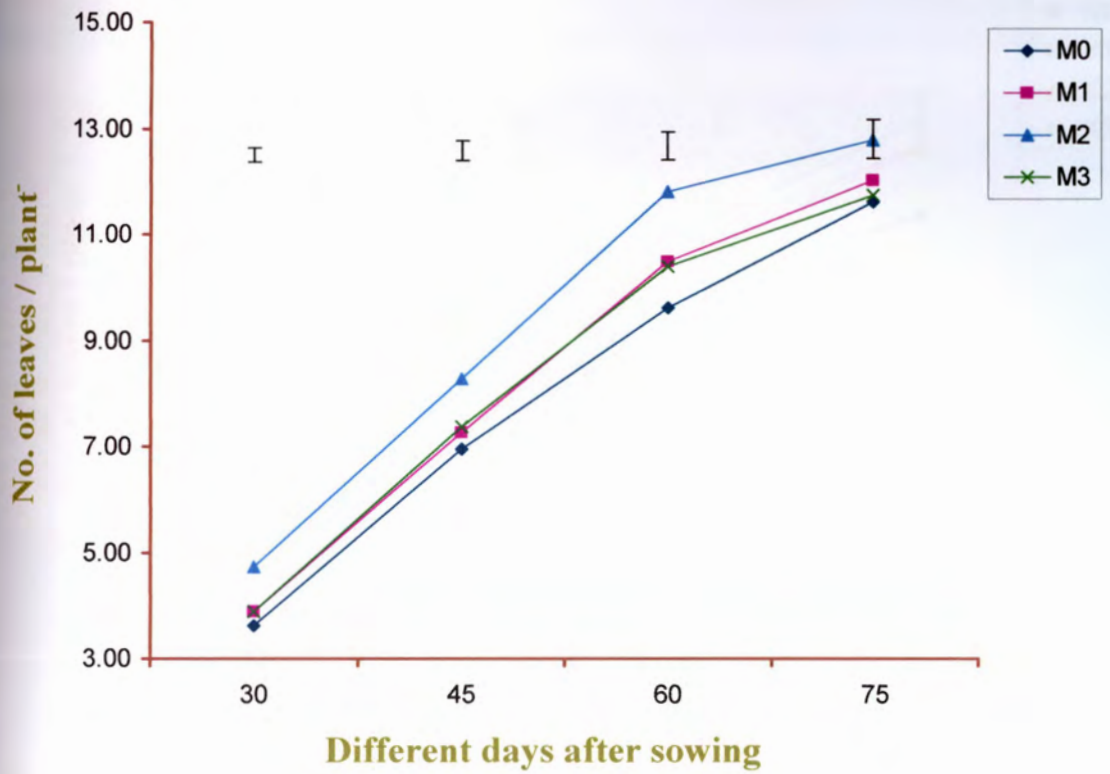


Fig. 4. Effect of mulches on number of leaves/ plant at different days after sowing. Vertical bar represent LSD at 5% level of significance

$M_{0=}$ Control

$M_{1=}$ Saw dust

$M_{2=}$ Water hyacinth

$M_{3=}$ Straw

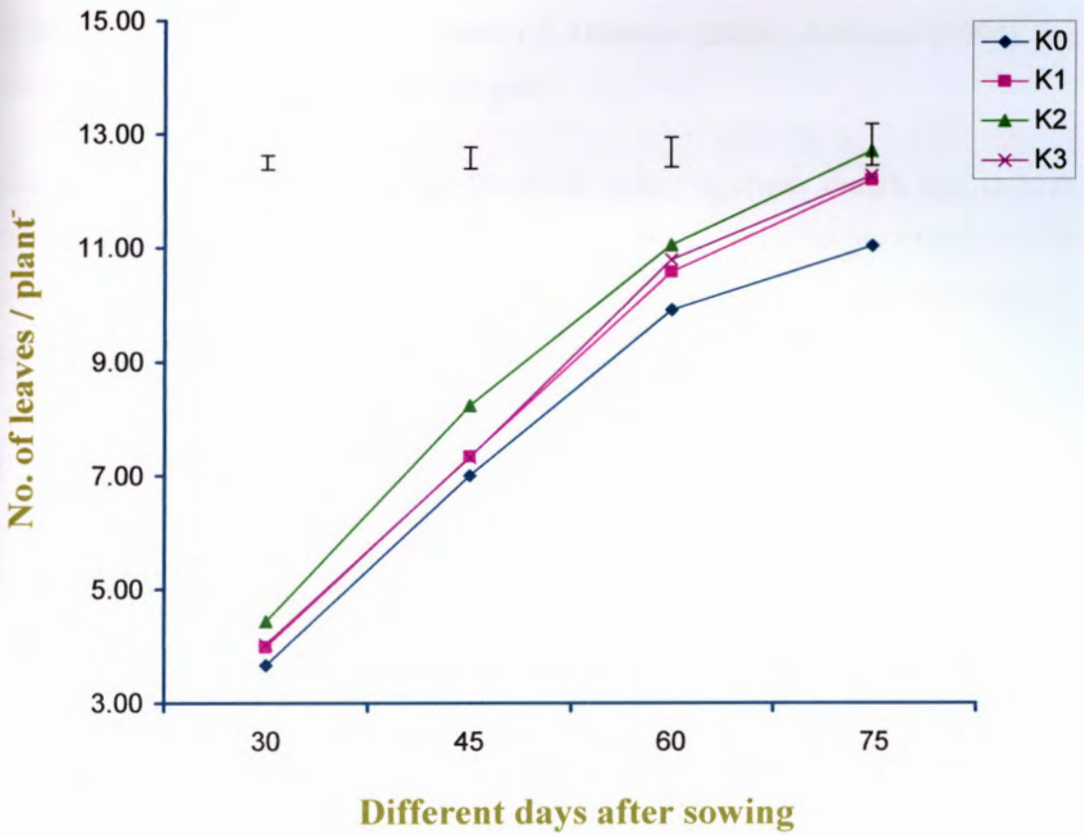


Fig. 6. Effect of potassium on number of leaves/plant at different days after sowing. Vertical bar represent LSD at 5% level of significance

K_0= 0 kg K_2O/ha

K_1= 180 kg K_2O/ha

K_2= 210 kg K_2O/ha

K_3= 240 kg K_2O/ha

4.1.3 Fresh weight of leaves

Remarkable significant variations in respect of fresh weight of leaves were recorded due to the effect of mulching. The plants grown with water hyacinth mulch gave the maximum fresh weight of leaves (8.07 g) followed by straw mulch (6.93 g) and saw dust mulch (6.00 g). The minimum fresh weight of leaves (5.44 g) was obtained from control (Table 1.). Hossain (2003), Adetunji (1994) and Bhuiya (1999) found similar result in garlic.

Maximum weight of leaves as produced by water hyacinth mulch due to high moisture content (above 80%) at different depth of soil. Availability of moisture at root zone of the plants might be increased vegetative growth as well as weight of leaves.

Highly significant differences were recorded in fresh weight of leaves among the different potassium level. The maximum (7.57 g) fresh weight of leaves/plant was observed from 210 kg K_2O/ha (Table 2.) and the minimum (5.83 g) fresh weight of leaves was found at control. Amin (1998) found that no significant variation in fresh weight of leaves/plant due to different potassium levels but Rizk (1997) and Talukder (1998) agree with this result. Fresh weight of leaves were increased up to 75 DAP then decreased due to senescence.

It appeared from Appendix VI and Table 3. that there existed a significant interaction effect among mulches and different levels of potassium. The highest (9.40 g) fresh weight of leaves/plant was found from the treatment combination of mulching with water hyacinth plot and 210 kg K_2O/ha at 75 DAS, whereas the lowest (5.19 g) fresh weight of leaves/plant was observed where no mulch and potassium were used.

4.1.4 Dry weight of leaves

Significant difference was also observed in respect of dry weight of leaves plant due to the effect of mulching. It was apparent from the (Table 1.) that water

hyacinth mulch gave the highest (1.24 g) dry weight of leaves, while control treatment produced the lowest (0.87 g). Saw dust (1.04 g) and straw (1.02 g) were statistically identical to each other. These results differ from the findings of Uddin (1997), who reported that, black polythene mulch gave maximum weight of dry leaves. But similar trend of results were reported by Halim (2000) and Hossain (1996), who found in garlic, the highest dry weight of leaves was with water hyacinth mulch.

Application of different levels of potassium showed significant effect in respect of dry weight of leaves/plant. It showed that, 210 kg K_2O/ha application resulted in the maximum (1.22 g) dry weight of leaves. Plants raised with any potassium fertilizer showed the lowest (0.88 g) dry weight of leaves (Table 2.). This findings is in the agreement with the reports of Talukder (1998).

The combined effect of mulches and different leaves of potassium in respect of dry weight of leaves was statistically significant. The highest (1.47 g) dry weight of leaves/plant was recorded from mulch of water hyacinth and 210 kg K_2O/ha and treatment combination of no mulch and no potassium gave the lowest (0.70 g) dry weight of leaves/plant (Table 3.). The influence of interaction between different mulch material and different doses of potassium was not significant.

4.1.5 Fresh weight of roots

The effect of mulching on the fresh weight of roots/plant was highly significant. The maximum root weight (1.87 g) was obtained from water hyacinth mulch followed by saw dust (1.48 g) and straw mulch (1.46 g).Saw dust mulch showed statistically identical reading with straw mulch. The minimum root weight (1.23 g) was recorded from control treatment (Table 1.). Similar results were also reported by Hossain (2003) and Halim (2000). 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.

It was found that treatment means in terms of fresh weight of leaves/plant was

significantly influenced by the application of different levels of potassium. Result presented in (Table 2.) revealed that @ 210 kg K_2O/ha gave the highest(1.81 g) weight of fresh root/plant while control treatment produced the lowest (1.27 g) weight of root/plant. Rizk (1997) also found similar results in his experiment.

There were statistically non significant interaction was found among different mulches and potassium levels on the fresh weight of roots per plant. The highest fresh weight of roots/plant (2.13 g) was observed at the water hyacinth mulch and 210 kg K_2O/ha treatment combination. The plots which are non mulched and without application of potassium produced the lowest (1.04 g) fresh weight of root/plant (Table 3.).

4.1.6 Dry weight of roots

The data as the mean sum of square of dry weight of roots/plant were analyzed and shown in Appendix. The data revealed that the single effect of different mulch were significant in this respect.

It was observed from the (Table 1.) that the plant produced the maximum (0.28 g) dry weight of roots/plant which were grown with water hyacinth followed by saw dust (0.20 g) mulch. The minimum (0.18 g) dry weight of root were obtained from straw mulch and control treatment This results also supported to the findings of Hossain (2003), Mia (1996) and Baten *et al.* (1995).

Dry weight of roots significantly varied in different levels of potassium. Results revealed that K_2O @ 210 kg/ha gave the highest (0.33) dry weight of roots/plant followed by @ 240 kg K_2O/ha (Table.2).The control treatment showed the lowest (0.16 g) dry weight of roots/plant which supports the results of Naik and Hosamani (2003), who reported that, the optimum dose of K_2O can increased dry weight of roots per plant.

The dry weight of roots/plant was varied significantly with different mulches and application of different levels of potassium. The maximum (0.42 g) dry weight of

roots was recorded in water hyacinth mulch with 210 kg K_2O/ha, the minimum (0.13 g) dry weight was found in treatment combination of no mulch with 180 kg K_2O/ha which showed statistically similar reading with no mulch with no potassium (Table 3.), this also might be due to mulching.

4.2 Yield attributes

4.2.1 Fresh weight of bulb

The variation in term of fresh weight of bulb/plant among different mulch treatments were found to be highly significant. It was observed that, the maximum (16.25 g) individual fresh bulb weight was obtained from water hyacinth mulch followed by straw mulch (14.80 g) and saw dust mulch (14.45) and the lowest (13.69 g) fresh weight of bulb was obtained form control (Table 1.) These results agree with the results of Hossain (2003), Halim (2000) and Bhuiya (1999), who reported that, fresh weight of bulb/plant was significantly influenced by water hyacinth.

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 characters and yield of large sized bulb.

Different levels of potassium exerted highly significant influence on the fresh weight of bulb. Fresh bulb weight increased gradually with the increase of K_2O level up to the rate of 210 kg K_2O/ha (Table 2.). The Maximum (16.92 g) weight of fresh bulb was achieved from the level of K_2O (210 kg/ha) and the control produced the lowest (13.69 g) weight of bulb. This results differs from Vachhani and Patel (1993), who stated that, the application of K_2O have no influence to increasing fresh weight of bulb in onion, but phosphorus have positive influence in this manner.

There was highly significant effect between the mulches and potassium levels in respect of fresh weight of bulb. The data in table 6. showed that maximum (19.65 g) fresh weight of bulb was produced from the treatment combination of water hyacinth mulch and 210 kg K_2O/ha level. The minimum (13.14 g) fresh weight of bulb was found from M_0K_0 treatment combination which showed statistically identical reading with combination of no mulch with 180 kg K_2O/ha (13.20 g) and no mulch with 240 kg K_2O/ha, this might be due to mulching.

Table 1. Effect of mulches on fresh wt. of leaves, roots, bulb and dry wt. of leaves and roots / plant

Mulching	Fresh weight of leaves / plant(g)	Dry weight of leaves / plan (g)	Fresh weight of root / plant (g)	Dry weight of root / plant (g)	Fresh weight of bulb / plant (g)
Control	5.44	0.87	1.23	0.18	13.69
Sawdust	6.00	1.04	1.48	0.20	14.45
Water hyacinth	8.07	1.24	1.87	0.28	16.25
Straw (Dried)	6.93	1.02	1.46	0.18	14.80
LSD at 5%	0.423494	0.117911	0.166751	0.037287	0.520679
LSD at 1%	0.570249	0.15877	0.224535	0.050208	0.701111
Level of significance	**	**	**	**	**
CV %	5.43	3.93	9.30	11.87	2.99

** = Indicate significant at 1% level of probability
* = Indicate significant at 5% level of probability
NS= Not significant

Table 2. Effect of potassium on fresh wt. of leaves, roots, bulb and dry wt. of leaves and roots / plant

Potassium	Fresh weight of leaves / plant (g)	Dry weight of leaves / plan (g)	Fresh weight of root / plant (g)	Dry weight of root / plant (g)	Fresh weight of bulb / plant (g)
Control	5.83	0.88	1.27	0.16	13.95
180 kg K_2O ha^{-1}	6.68	1.01	1.34	0.17	14.19
210 kg K_2O ha^{-1}	7.57	1.22	1.81	0.33	16.92
240 kg K_2O ha^{-1}	6.35	1.06	1.61	0.19	14.13
LSD at 5%	0.4234	0.1179	0.16675	0.04567	0.368176
LSD at 1%	0.5702	0.1587	0.27499	0.06149	0.495761
Level of significance	**	**	**	**	**
CV %	5.43	9.39	9.30	11.87	2.99

**= Indicate significant at 1% level of probability
*= Indicate significant at 5% level of probability
NS= Not significant

Table 3. Combined effect of mulches and potassium on plant height, no. of leaves / plant, fresh and dry wt. of leaves and roots / plant

Treatments Mulching x Potassium	Plant Height (cm)				No. of leaves / Plant				Fresh wt of leaves(g)	Dry wt. of leaves(g)	Fresh wt. of roots (g)	Dry wt. of roots (g
	30 DAS	45 DAS	60 DAS	75 DAS	30 DAS	45 DAS	60 DAS	75 DAS				
$M_0 K_0$	20.02	27.04	34.10	41.58	2.87	6.15	9.20	10.36	5.19	0.70	1.04	0.13
$M_1 K_0$	22.52	30.94	35.24	46.17	3.70	6.60	10.37	11.57	5.27	0.80	1.23	0.14
$M_2 K_0$	27.79	34.10	42.73	50.63	4.73	7.83	10.53	11.80	6.67	1.11	1.56	0.20
$M_3 K_0$	22.47	31.45	35.01	47.11	3.40	7.40	9.50	10.40	6.20	0.90	1.26	0.16
$M_0 K_1$	21.36	29.10	41.12	43.45	3.60	6.67	9.33	11.77	5.23	0.77	1.11	0.13
$M_1 K_1$	25.15	32.62	41.02	46.46	3.83	7.30	10.27	12.23	5.40	1.03	1.24	0.15
$M_2 K_1$	27.96	34.50	45.68	53.38	4.77	8.17	12.43	12.67	8.10	1.20	1.75	0.24
$M_3 K_1$	23.93	31.84	41.71	45.94	3.73	7.20	10.23	12.09	7.97	1.03	1.27	0.15
$M_0 K_2$	27.24	33.33	44.32	47.59	4.23	7.93	10.00	12.57	5.83	1.06	1.47	0.31
$M_1 K_2$	28.19	35.54	43.97	51.59	4.07	7.93	10.53	12.23	7.13	1.27	1.93	0.32
$M_2 K_2$	32.49	39.87	54.82	61.81	5.00	9.20	12.63	13.83	9.40	1.47	2.13	0.42
$M_3 K_2$	28.22	34.20	42.75	50.03	4.47	7.83	11.02	12.17	7.93	1.10	1.70	0.26
$M_0 K_3$	23.39	30.38	39.00	45.15	3.80	7.10	9.97	11.80	5.51	0.95	1.30	0.13
$M_1 K_3$	25.21	32.20	42.70	51.08	3.93	7.20	10.76	12.03	6.20	1.06	1.50	0.19
$M_2 K_3$	29.46	36.70	47.64	56.50	4.43	7.93	11.63	12.87	8.10	1.17	2.04	0.27
$M_3 K_3$	25.77	33.26	42.14	50.85	3.94	7.07	10.80	12.33	5.60	1.06	1.60	0.16
LSD at 5%	2.437642	3.087816	2.844065	3.379736	0.35764	0.537755	0.743865	1.015675	0.598911	0.166751	0.235821	0.05273
LSD at 1%	3.282365	4.157846	3.829627	4.550927	0.481575	0.724105	1.001639	1.367639	0.806454	0.224535	0.317541	0.07100
Level of sig.	NS	NS	**	NS	**	**	**	NS	**	NS	NS	**
CV %	5.69	5.62	4.05	4.11	5.33	4.31	4.21	5.06	5.43	9.39	9.30	11.87

** = Indicate significant at 1% level of probability

* = Indicate significant at 5% level of probability

NS= Not significant

4.2.2 Dry weight of bulb

Dry weight of individual bulb was measured and observed, there were significant variations due to influence of mulching. The plant grown with water hyacinth mulch gave the maximum (2.78 g) dry weight which showed statistically identical reading with straw mulch (2.39 g). Saw dust mulch produced (2.04 g) and the lowest (1.82 g) dry weight of bulbs was obtained from control treatment (Table 4.). This result is different from the results of Rekwaska (1997), Hasan (1999) and Uddin (1997), who reported that, black plastic film produced highest dry weight of bulb compared with water hyacinth and straw mulch. Increased dry weight of bulb due to water hyacinth mulching was achieved positively with better growing condition and in addition to more organic matter supplement to the soil which received by plant from water hyacinth.

The dry weight of bulb at different levels of potassium exhibited highly significant variations. The maximum (3.19 g) dry weight of bulb was produced from the treatment of 210 kg K_2O/ha(Table 5). The control treatment produced the minimum (1.68 g) dry bulb weight. Similar results also obtained by Amin (1998), but Vachhani and Patel (1993) noted potassium @ 150 kg K_2O/ha performed higher dry weight of bulb in onion.

From table 6. and Appendix VI it was revealed that various mulches and different levels of potassium influenced markedly on dry weight of bulb. Combination of water hyacinth and 210 kg K_2O/ha gave the highest (4.20 g) dry weight of bulb and the lowest (1.42 g) value was obtained from the combination of no mulch with no potassium .Water hyacinth mulch and 210 kg K_2O/ha combination enhanced the vigorous growth and development of plant and ultimately, higher dry matter was accumulated in the bulbs.

4.2.3 Bulb diameter

The diameter of bulb was also influenced significantly by the effect of different mulches. The maximum (4.35 cm) bulb diameter was recorded from water hyacinth mulch (Table 4.). Saw dust mulch (3.71 cm) showed statistically identical

reading with straw mulch (3.70 cm), on the other hand lowest (3.15 m) bulb diameter was obtained from control treatment.

The production of large sized bulb by different mulches may be due to availability of better growing condition under such treatments. This result is differ from the results of Bhuiya (1999) who stated that, bulb diameter was not influenced significantly by different mulches. But this results agree with Hossain (2003), Uddin (1997) and Iroc *et al.* (1991).

Diameter of bulb was significantly affected by different potassium treatments. The highest bulb diameter (4.39 cm) was obtained from the treatment of 210 kg K_2O / ha, while the lowest bulb diameter (3.26 cm) was found from the treatment of without potassium fertilizer (Table 5). Data as the mean sum of square revealed that bulb diameter showed a general trend of gradual increase with increasing potassium levels except in treatment @ 240 kg K_2O/ha, in this case with the increasing of potassium level up to @ 210 kg K_2O/ha bulb diameter was increased. Sufficient potassium nutrient supplied from the 210 kg K_2O/ha treatment possibly enhanced plant growth and development thus producing wider bulb. Amin (1998), Setty *et al.* (1989) and Uddin (1993) also found larger bulb from increased potassium level.

Diameter of bulb was recorded after harvest. The combined effect of different mulches and potassium levels in respect of diameter of bulb was significant. Comparatively the highest (4.87cm) diameter of bulb was observed from water hyacinth and 210 kg K_2O/ha treatment combination while the lowest (2.26 cm) diameter of bulb was found from no mulch with no potassium (Table 6). Such effect of water hyacinth mulch and 210 kg K_2O/ha application 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.

4.2.4 Neck diameter

Different mulches showed significant variation on neck diameter. The highest (0.64 cm) neck diameter was found from water hyacinth mulch followed by straw mulch (0.57 cm) and saw dust mulch (0.54 cm). The lowest (0.38 cm) value was obtained from control (Table 4). Baten *et al.* (1995) also found similar trend of results in case of neck diameter.

There was significant effect of different levels of potassium on neck diameter in garlic. It was observed that K_2O @ 210 kg K_2O/ha application resulted in the highest (0.66 cm) neck diameter and plant raised with out any potassium fertilizer resulted in the lowest (0.47 cm) neck diameter, which showed statistically similar reading with K_2O @ 240 kg K_2O/ha (Table 5.).

Differences in neck diameter caused by the interaction effect of different treatment combinations were significant. However, it appeared that treatment combination of water hyacinth mulch and 210 kg K_2O/ha performed the maximum (0.81 cm) neck diameter. The minimum (0.38 cm) neck diameter obtained from no mulch and no potassium treatment combination Table 6.

4.2.5 Number of cloves per bulb

Significant variation was found due to use of different mulch materials on number of cloves/bulb.

The application of water hyacinth mulch produced the highest (22.75) number of cloves/bulb and the lowest (16.42) numbers of cloves was found from control treatment (Table 4.). Halim (2000), Rekowaska, (1997) and Asandhi (1989) stated the similar results, who reported that, mulch increased the number of cloves/bulb in garlic. It might be due to presence of sufficient amount of soil moisture with water hyacinth mulch which subsequently had contributed in the formation of maximum number of cloves/bulb by cold condition of soil surface which encourage in favour of bulb formation.

The variation in number of cloves/bulb was statistically significant due to the application of different doses of potassium. The plants grown with the dose of potassium 210 kg K_2O/ha produced the highest number of cloves (21.42). The lowest number of cloves (17.92) was observed in case of control (Table 5.). Naik and Hosamani (2003), Hossain (1998) and Setty *et al.* (1989) reported that no. of cloves/bulb was increased with the increasing K_2O of at a certain level.

The clove number/ bulb differed as highly significant among different mulches and different potassium levels. It was observed that the maximum (24.67) number of cloves/bulb was obtained from the treatment of water hyacinth mulch and 210 kg K_2O/ha, followed by treatment combination of water hyacinth mulch with 180 kg K_2O/ha level. The minimum (15.0) clove number/bulb was found from no mulch with no potassium (Table 6).

4.2.6 Yield per plot

Yield of garlic/plot was recorded to be statistically significant due to different mulch materials. The highest yield/plot was achieved from mulch (0.50 kg/plot). Saw dust mulch (0.47 kg/plot) showed statistically identical reading with water hyacinth mulch (0.46 kg/plot) and the lowest yield/plot was obtained from control (0.36 kg/plot). The straw mulched plot gave highest yield which was possibly due to better physical and physio-chemical conditions of soil than non mulched plots (Table 4.).

These results agree with the findings of Halim (2000) and Hossain (1996), Hossain (2003), Bhuiya (1999). Singh *et al.* (1987) also noted that, water hyacinth mulch produced the highest yield/plot.

Yield of bulb/plot was recorded to be significantly influenced by different levels of potassium. The highest yield of garlic/plot (0.55 kg/plot) to be found in the treatment of 210 kg K_2O/ha. Control treatment showed the lowest yield of garlic/plot (0.44 kg/plot) (Table 5.). Talukder (1998) and Amin (1998) agree with this result.

The combined effect of different types of mulch materials and potassium levels were found to influence significantly on the yield/plot. The maximum (0.65 kg/plot) yield of garlic were recorded from the treatment combination of water hyacinth as mulch and 210 kg K_2O/ha. The lowest (0.23 kg/plot) yield was found in the treatment combination of no mulch and 180 kg K_2O/ha were used (table 6.).

Table 4. Effect of mulches on dry wt. of bulb, bulb dia., neck dia, no. of cloves / bulb and yield / plot

Mulching	Dry weight of bulb / plant(g)	Diameter of bulb (cm)	Neck diameter (cm)	No. of cloves / bulb	Yield of bulb (kg p / plot)
Control	1.82	3.15	0.38	16.42	0.36
Sawdust	2.04	3.71	0.54	19.33	0.47
Water hyacinth	2.78	4.35	0.64	22.75	0.46
Straw (Dried)	2.39	3.70	0.57	19.17	0.50
LSD at 5%	0.207603	0.281508	0.052731	1.585009	0.064582
LSD at 1%	0.279544	0.379059	0.071004	2.134267	0.086962
Level of significance	**	**	**	**	**
CV %	7.84	6.38	9.35	6.92	13.14

** = Indicate significant at 1% level of probability
* = Indicate significant at 5% level of probability
NS= Not significant

Table 5. Effect of potassium on dry wt. of bulb, bulb dia., neck dia, no. of cloves / bulb and yield / plot

Potassium	Dry weight of bulb / plant(g)	Diameter of bulb (cm)	Neck diameter (cm)	No. of cloves / bulb	Yield of bulb (kg / plot)
Control	1.68	3.26	0.47	17.92	0.44
180 kg K_2O ha^{-1}	1.90	3.55	0.54	19.00	0.34
210 kg K_2O ha^{-1}	3.19	4.39	0.66	21.42	0.55
240 kg K_2O ha^{-1}	2.26	3.72	0.47	19.33	0.46
LSD at 5%	0.146797	0.199056	0.037287	1.12077	0.045667
LSD at 1%	0.197668	0.268035	0.050208	1.509155	0.061492
Level of significance	**	**	**	**	**
CV %	7.84	6.38	9.35	6.92	13.14

**= Indicate significant at 1% level of probability
*= Indicate significant at 5% level of probability
NS= Not significant

Table 6. Combined effect of mulches and potassium on fresh and dry wt. of bulb, bulb dia, neck dia, no. of cloves / bulb, yield / plot and yield / ha

Treatments Mulching X Potassium	Fresh wt bulb (g)	Dry wt bulb (g)	Diameter of bulb (cm)	Neck Diameter (cm)	Number of cloves / bulb	Yield (kg / plot)	Yield (ton / ha)
$M_0 K_0$	13.14	1.42	2.26	0.38	15.00	0.51	2.29
$M_1 K_0$	13.83	1.57	3.22	0.48	19.00	0.39	3.00
$M_2 K_0$	14.90	2.00	4.11	0.58	21.67	0.41	4.81
$M_3 K_0$	13.93	1.73	3.46	0.45	16.00	0.45	4.13
$M_0 K_1$	13.20	1.70	2.82	0.41	14.67	0.23	3.79
$M_1 K_1$	14.20	1.90	3.63	0.51	18.00	0.30	3.66
$M_2 K_1$	15.10	2.17	4.23	0.66	23.00	0.26	5.03
$M_3 K_1$	14.27	1.83	3.50	0.56	20.33	0.56	4.45
$M_0 K_2$	15.23	2.27	4.17	0.53	19.67	0.48	4.75
$M_1 K_2$	16.23	2.58	4.30	0.65	21.00	0.65	6.00
$M_2 K_2$	19.65	4.20	4.87	0.81	24.67	0.65	6.39
$M_3 K_2$	16.57	3.71	4.23	0.64	20.33	0.42	4.80
$M_0 K_3$	13.20	1.90	3.37	0.22	16.33	0.22	2.29
$M_1 K_3$	13.53	2.10	3.70	0.52	19.33	0.52	3.10
$M_2 K_3$	15.37	2.73	4.20	0.52	21.67	0.52	4.55
$M_3 K_3$	14.42	2.30	3.62	0.62	20.00	0.57	4.47
LSD at 5%	0.736351	0.293595	0.398112	0.074573	2.241541	0.091333	0.535163
LSD at 1%	0.991521	0.395335	0.536071	0.100415	3.018309	0.122983	0.720615
Level of sig.	**	**	**	**	**	**	**
CV %	2.99	7.84	6.38	9.35	6.92	13.14	7.59

** = Indicate significant at 1% level of probability

* = Indicate significant at 5% level of probability

NS= Not significant

4.2.7 Yield per hectare

Different mulch material showed highly significant variations in respect of yield of garlic/ha. Water hyacinth mulch performed the highest (5.19 ton/ha) yield followed by straw mulch (4.46 ton/ha) and saw dust mulch (3.94 ton/ha). The lowest (3.28 ton/ha) yield was recorded from control (Figure 5.). In case of straw mulch yield was declined at final harvest. This result was also found by Bhuiya (1999), Uddin (1997) and Mia (1996) but different results reported by Halim (2000), Baten *et al.* (1995) who reported straw mulch gave highest yield of garlic / hectare.

From the Appendix IV, V, VI and VII it was clear that mulching were possibly attributed by better physical and physio-chemical conditions of the soil produced higher yield than non-mulched plots.

There was significant variation in the yield of garlic/ha due to the effect of different potassium levels. The treatment of 210 kg K_2O/ha gave the highest (5.49 ton/ha) yield and the control treatment gave the lowest (3.56 ton/ha) yield which showed statistically similar result (3.61 ton/ha) with potassium @ 240 kg K_2O/ha (Figure 7.). Hossain (1997), Talukder (1998) and Amin (1998) also found similar trend of result. The plants grown with 210 kg K_2O/ha received more potash nutrient as a result, their growth was enhanced and ultimately yield per ha was increased.

The yield of garlic per hectare showed highly significant variation. Considering all treatments the highest yield of garlic (6.39 ton/ha) was found due to water hyacinth and 210 kg K_2O/ha level treatment combination followed by water hyacinth and 180 kg K_2O/ha potassium (6.00 ton/ha).The lowest (2.29 ton/ha) yield per hectare obtained from no mulch with no potassium combination.(Table 6.)

This result might be due presence of sufficient amount of soil moisture water hyacinth mulch and 210 kg K_2O/ha, which subsequently had contributed in the formation of the highest yield of garlic.

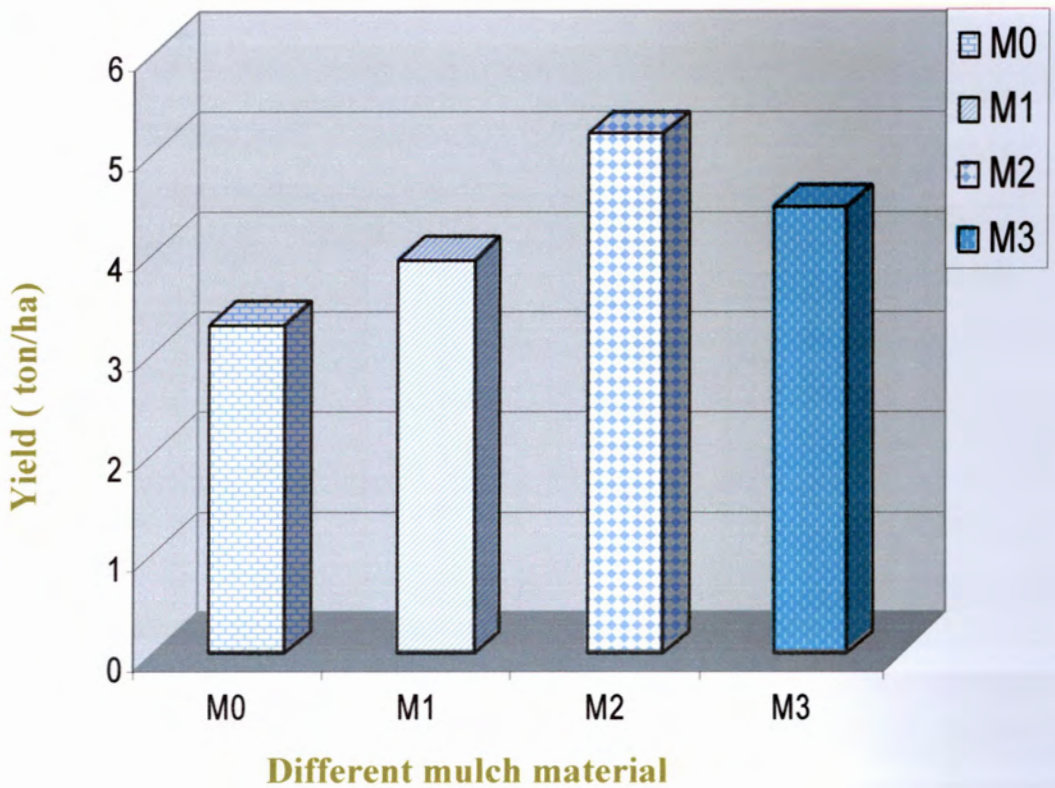


Fig. 4. Effect of mulches on yield of garlic (ton/ha).Vertical bar represent LSD at 5% level of significance

$M_{0=}$ Control

$M_{1=}$ Saw dust

$M_{2=}$ Water hyacinth

$M_{3=}$ Straw

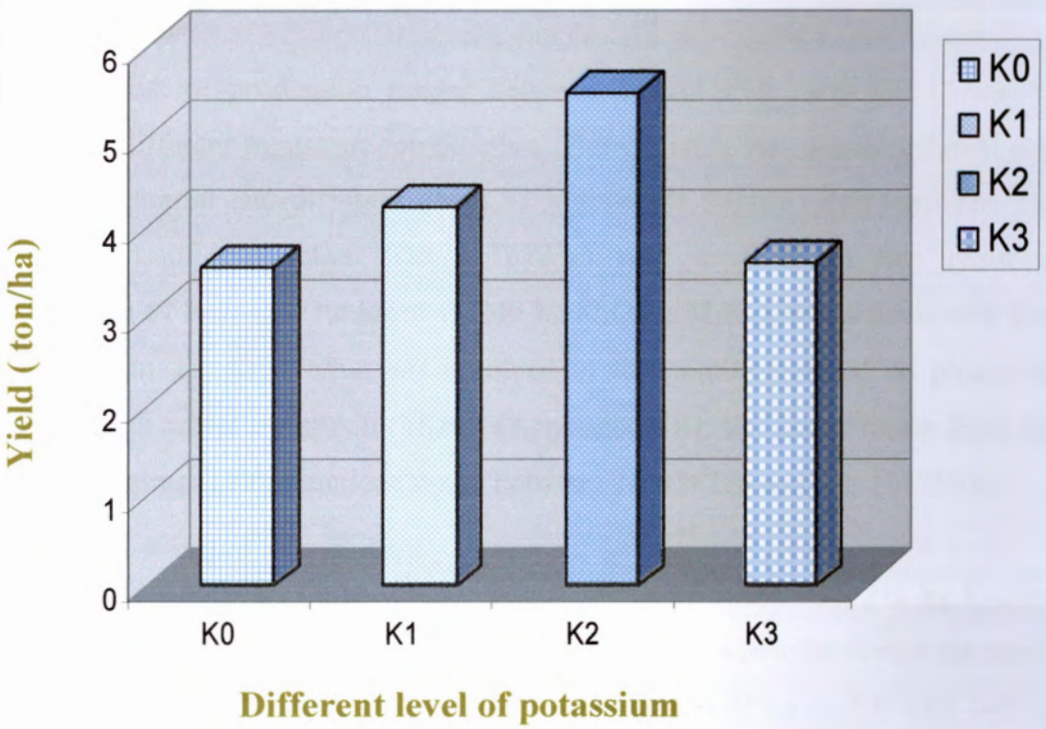


Fig. 7. Effect of potassium on yield of garlic (ton/ha).Vertical bar represent LSD at 5% level of significance

K_0= 0 kg K_2O/ha

K_1= 180 kg K_2O/ha

K_2= 210 kg K_2O/ha

K_3= 240 kg K_2O/ha

4.3 Economic Analysis

The cost and return analysis were done and have been presented in Table 7 and Appendix VIII. Materials (A), non materials (B) and overhead cost were recorded for all the treatments of unit plot and calculated on per hectare basis (Yield/ha), the price of garlic bulbs at the local market rates were considered.

The total cost of production ranges between Tk. 211679 and Tk. 157486/ha among the different treatment combination. The variation was due to different cost of mulch material and different doses of Muriate of Potash (MP) fertilizer. The highest cost of production Tk. 211679/ha was involved in the treatment combination of Saw dust mulch with 240 kg K_2O/ha(M_1K_3), while the lowest cost of production Tk 157486/ha was involved in the combination of no potassium fertilizer with water no mulch (M_0K_0) (Appendix VIII. C). Gross return from the different treatment combinations range between Tk 479250 and Tk. 171750/ha.

Among the different treatment combinations water hyacinth with 210 kg K_2O/ha treatment (M_2K_2) gave the highest return Tk. 309923/ha while the lowest net return Tk. 6180 was obtained from the treatment combination of no mulch with 240 kg K_2O/ha treatment (M_0K_3).

The benefit cost ratio (BCR) was found to be the highest (2.83) in the treatment combination of water hyacinth mulch with 210 kg K_2O/ha (M_2K_2). The lowest BCR (1.03) was recorded from the combination of no mulch with 240 kg K_2O/ ha (M_0K_3). Thus it was apparent that, water hyacinth with 210 kg K_2O/ha (M_2K_2) treatment gave the highest yield (6.39 ton/ha) and the highest gross return (Tk. 479250). Therefore, it may be suggested that water hyacinth may be used as a cheap mulch in garlic cultivation, but the place where irrigation water as well as water hyacinth are not available and costly in those region black rice straw and saw dust mulch can be used successfully for commercial garlic production. However, further studies in this relation should be carried out in other regions of the country before final recommendation.

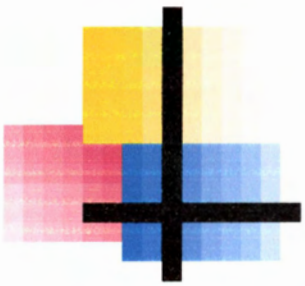
Table 7. Cost and return of Garlic due to fertilizer management and mulching treatments

Treatment combination	Yield (ton/ha)	Gross return (Tk/ha)	Total cost of production (Tk/ha)	Net return (Tk/ha)	Benefit cost ratio (BCR)
M_0K_0	2.29	171750	157486	14264	1.09
M_0K_1	3.79	284250	163752	120498	1.73
M_0K_2	4.75	356250	164978	191272	2.15
M_0K_3	2.29	171750	165570	12180	1.03
M_1K_0	3.00	225000	203334	21666	1.10
M_1K_1	3.66	274500	209601	64899	1.30
M_1K_2	6.00	450000	210827	239173	2.13
M_1K_3	3.10	232500	211679	20821	1.09
M_2K_0	4.81	360750	161834	198916	2.22
M_2K_1	5.03	377250	168100	215450	2.24
M_2K_2	6.39	479250	169327	309923	2.83
M_2K_3	4.55	341250	170219	171031	2.00
M_3K_0	4.13	309750	165503	144247	1.87
M_3K_1	4.45	333750	171769	161981	1.94
M_3K_2	4.80	360000	172933	187067	2.08
M_3K_3	4.47	335250	173888	161362	1.92

M_0 = No mulch (Control)
M_1 = Saw dust
M_2 = Water hyacinth
M_3 = Straw

K_0 = No Potassium (Control)
K_1 = 180 kg K_2O/ha
K_2 = 210 kg K_2O/ha
K_3 = 240 kg K_2O/ha

Note: Sale of Garlic @ Tk. 75.00 per kg
Total income = Yield (ton/ha) × Tk 75,000.00
BCR = Gross return ÷ Total cost of production



CHAPTER V

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

An investigation was carried out to study the effect of various mulches and different levels of potassium on growth and yield of garlic at the farm of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2005 to April 2006. There were different mulches viz. saw dust, water hyacinth, rice straw and control. It also included four levels of potassium viz. 0, 180, 210 and 240 kg K_2O per ha respectively.

Two factorial experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The size of unit plot was 3m X 1m. From each unit plot 10 plants were randomly selected and tagged to record data on yield and plant characters such as plant height (cm), number of leaves/plant, fresh and dry weight of leaves, roots and bulb (g), bulb diameter (cm), number of cloves/plant and yield. The data were statistically analyzed for evaluation of the effect of different treatments and treatment combinations by LSD.

The results of the experiment revealed that all the parameters studied were significantly influenced by mulching. Mulches played an important role on growth, yield and yield contributing characters studied at different DAS as well as harvest. Water hyacinth mulch performed the maximum plant height and number of leaves at different DAS. It also increased fresh and dry weight of leaves, roots and bulb/plant, bulb diameter (4.35 cm), neck diameter, (0.64 cm), number of cloves/plant (22.75), bulb yield (5.19 ton/hectare).The minimum values of these characters including yield (3.28 ton/hectare) were recorded from control treatment.

Potassium also had marked influence on growth and yield contributing characters in garlic. From the results, it was observed that there were significant variations in respect of plant height and number of leaves/plant. The treatment 210 kg K_2O/ha resulted the highest values of these parameters at different DAS. Plants grown with 210 kg K_2O/ha also gave the highest fresh and dry weight of leaves, roots and

bulb/plant, bulb diameter (4.39 cm), neck diameter (0.66 cm) number of cloves/plant(21.42) yield (0.55 kg/plot) and yield (5.49 ton/ha), where as control treatment gave minimum values.

Combined effect of mulching and potassium was significant on different parameters except plant height at 30, 45 and 60 DAS, number of leaves at 75 DAS . dry weight of leaves per plant and fresh weight of roots per plant. Regarding the parameters such as plant height at 60 DAS number of leaves at 30, 45 and 75 DAS, fresh weight of leaves per plant, dry weight of roots per plant, fresh and dry weight of bulb, bulb diameter (4.87 cm) neck diameter 0.81 cm) and number of cloves per plant, (24.67) the maximum values were found from water hyacinth mulch and 210 kg K_2O/ha. The highest bulb yield (0.65 kg/plot) and bulb yield (6.39 ton/ha) was found from treatment combination of water hyacinth mulch and K_2O @ 210 kg/ha. The lowest values of all parameters were recorded from control treatment (M_0K_0).

In economic analysis, it was revealed that the highest BCR (2.83) was obtained from water hyacinth with 210 kg K_2O/ha, while lowest BCR (1.03) was recorded from no mulch with 240 kg K_2O/ha.

The best performace was obtained from M_2K_2 treatment that was considered to be the best combination of fertilizer management and mulching for maximising yield of garlic. Considering Benefit Cost Ratio (BCR), it may be suggested that water hyacinth may be as cheap mulch, but the place where water hyacinth are not available and costly in those region rice straw mulch and saw dust can be used for commercial garlic production. In order to confirm the result of this study, further experiment is suggested since this experiment was conducted in one year and in a certain place only.

REFERENCES

Abbas, M., S. Rajat , S. S. Tomar and Sharma K. K. (1994). Effect of nitrogen and potassium on the growth and yield of garlic. *J. Potassium Res.*. **10** (4) : 33-34 [Cited from Hort. Abstr., 66 (6) : 4950, 1996].

Adetunji, I. A. (1994). Response of onion to soil solarization and organic mulching in semi-arid tropics. Scientia Hort. , **60** (1/2) : 161-166.

Akand, M. H. (2003). Effect of organic manure and mulching on the growth and yield of carrot. MS. Thesis, Dept. of Hort., Bangladesh Agricultural University, Mymensingh. pp. 59-60.

Aliudin, T. (1986). Effect of soil tillage and application of mulch on yield of field grown garlic. Bulletin-Horticultura, 8(8) :15-22. [Cited from Hort. Abst., **59** (4) : 2856, 1989].

Agrawal, M. L., Kinra K. Z. and Singh H.N.(1981). Manurial requirement of onion in gangetic alluvium of Uttar Prodesh. *Indian j. Agril. Res.*, **15** (1) : 5-10.

Amado, T. J. and. Teixeira L. A. I. (1991). cover crop effects on nitrogen supply and onion yield. Onion Newsletter for the Tropics, No. 3 : 13-15.

Amal, K. A. Musln A. A. and Khan A. H. (1990). Effect of different mulches on the growth of potato *(Solanum tuberosum L.). Bangladesh J. Bot.*, **19** (1) : 56-60.

Amin, M. D. R. (1998). Effect of different levels of nitrogen and potassium on the growth and yield of garlic. An MS Thesis, Department of Horticulture., Bangladesh Agricultural Univertisity, Mymensingh. pp. 38-43.

Anonymous, (1989). Annual Weather Report, IPSA. Meteorological Station, IPSA, Salna, Gazipur. pp. 8-15.

Arboleya, J. C. Garcia, and Burba L. (1994). Response of garlic at high density with mulch and fertilization. III Curso taller sobre production, commercialization, e industrialization de ajo (Proyecto, AJO – INTA), Mendoza, Argentina pp. 273-276. [Cited from CD ROM Service, BAU Library, Mymensingh].

Asandhi, A. A. (1989). The effect of several types of mulches and cabbage waste on garlic. Bulletin-penelitian-Hortikultura, **18** (1) : 11-16 [Cited from Hort. Abst. 61(3):1137-1991].

Asandhi, A. A., Djatnika, I., Pasetriyani, N.and Mulyaningsih. (1980). The effect of several types of mulches and cabbage waste on garlic. Bulletin Penelitian Hortikultura, **18** (1) : 11-16 [Cited from Hort Abstr., 61 (3) : 240, 1991].

Augusti, K. T. (1977). Hyopcholesterolaemic effect of garlic (*Allium sativum* L.) . *Indian J. Exp. Bio.*, **15** (6) : 489-490.

Awal, M. A.,. Hossain, M. M and Rashid, M. M. (1978). The effect of method of seed bed preparation, mulching and inter tillage on the growth and yield of 'Mukhi Kachu' ; Bangladesh Horticulture, **6** (1-2) : 9-13.

Bari, M. A. (1974). Effect of NPK and irrigation on the yield of onion (*Allium cepa* L.) M.Sc.(Ag).Thesis, Department of Horticulture., Bangladesh Agricultural Univertisity, Mymensingh. pp. 38-41.

Baten, M., Nahar, B. S., Sarker S. C. and H. Khan, M. A. (1995). Effect of different mulches on the growth and yield of late planed garlic (*Allium sativum* L.). *Pakistan J. Sci and Ind Res.*, 38(3-4): 138-141.

BBS. (2005). Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics. Statistic Division, Ministry of Planning, Govt. of Peoples Republic of Bangladesh. Dhaka. Bangladesh. pp. 74.

Begatirenko, A. K. (1975). Application of fertilizer to garlic crop. *Ref. Zhurnal*, **5** (56) : 653. [Cited from Hort Abstr., 47 (12) : 949. 1977].

Benoit, F. and Ceustermans, N. (1975). Some preliminary results with the plastic mulching of early carrots. Thinbouwberihte, 39(12) :481-484.[Cited from Hort. Abstr., 46 (8) : 7763, 1976]

Bhattarai, S. P. and Subedi, P.P. (1996). Studies on normal season onion variety nutrition and management trial at outreach sites during 1993/94 season. *Lumle Reg. Agril. Res. Centre*, Kaski, Nepal, **96** (10) : 49. [Cited from Hort. Abst., 67 (10) : 8439, 1997].

Bhuiya, M. A. K.(1999). Effect of plating time and mulch and irrigation on the growth and yield of garlic. MS Thesis, Department of Horticulture., Bangladesh Agricultural Univertisity, Mymensingh. p. 6.

Borabash, O. Yu. And Kochina, T. N. (1987). The effect of mineral fertilization on garlic productivity. Ref. Zhurnal, pp.12-16. [Cited from Hort Abstr., 60(5) : 380, 1990].

Bose, T. K. and Som, M. G. (1990). Vegetative crops in India, (1st edn.), Naya Prakash Culcutta, India, pp. 583-601.

Brady, N. C. (1995). The Nature and properties of soils. Pentice Hall of India pvt. Ltd. New Delhi. P. 369.

Calendacion, A. N., Garrity, D. P., Batugal, P. A. and DE Data, S. K. (1990). Increased Productivity and Profitability through a potato-wet seeded rice ratoon cropping system. *Philippines J. Crop Sci.*, **15** (2) : 85-98.

Chung, D. H. (1987). Effect of Polyethylene film mulching. sulpher application and different levels of nitrogen and potassium on growth, flower stock elongation, bulbing and leaf tip yellowing of garlic (*Allium sativum* L.) cv. Enising, *Journal of Korean society for Horticultura*, **28** (1) : 1-8. [Cited from Hort Abstr., 58 (10) : 6584, 1988].

Cho, J. T., Choung, T. W. Song, Y. J. and Youn, K. B. (1982). The effect of a polyethylene film mulch and time of its removal on the growth and yield of garlic. *Res. Rep. of Rural Dev. Hortic.*, South Korea, 24, 123.

Das, J. N. and Mohanthy, B. K. (2001). Effet of plant density and mineral nutrition on the yield of garlic (*Allium sativum* L.) cv. Madrasi. *Vegetable Sci.,* India, **28** (28) : 92-9

Das, A. K., Som, M. G., Sandhu, M. K. and Bose, T. K. (1985). Responces to varying levels of N, P and K on growth and yield of multiple clove garlic (*Allium sativum* L.). *Indian Agric.*, **29**(3) : 183-189.

Donnari, M. A., Rosell, R. A. and Torre, L. (1978). Garlic productivy, II Real Evapotranspiration really necesidad de agua). Thrrialba, 28(4) :331-337 [Cited from Hort, Abst. 49(12): 9338 (1979)].

Duranti, A. and Barbicri, G. (1986). The response of garlic (*Allium sativum* L.) for storage to variations in irrigation regime and in planting density. (Risposta nel regime irrigua e nella densita di impianto). *Rivista della Ortofloro-frutticoltura Italiana*, **70**(4): 285-298.[Cited from Hort. Abst. 57(7) :5417 (1987)].

El-Beheidi, M. A., Kamal, N. H. and Abou El-Magd, M. M. (1983). Effect of water regime and nitrogen fertilizer on some mineral contents, yield and amino acid contents of garlic plan. *Annals of Agril. Sci.*, Moshtohar (1) :149-169.

Eid, S. M., Shafsakh, N. S. and Abo-sedera, F. A. (1991). Effect of potassium fertilizer and foliar application of certain micronutrient combinations on growth, yield and composition of garlic plant. *Annals Agril. Sci.*, Moshtohor, Egypt, 29(2) : 981-993. [Cited from soil and fertilizers, **57**(8) : 12361, 1994].

FAO. (1988). Production Year Book. Food and Agricultural of the United Nations. Rome, Italy. 42: 190-193.

FAO. (2005). Reports of Food and Agricultural Organization of the United Nations, Italy. Rome. 51:155

Gomez, K. A. and Gomez, A.. A. (1994). Statistical Procedures for Agricultural Research (2nd edn.). A wiley Interscience Publication . John Wiley and Sons, New York

Gunadi, N. and Asandhi, A. A.(1986). Effect of source and dosage of nitrogen fertilizer and source of potash fertilizer on growth and yield of garlic. Bulletin Penelitian Horticultura, Indonesia, 13(3) : 23-32. [Cited from Hort. Abst., 58 (4) : 321, 1988].

Gupta, G. S. S. and Gaffar, M. A. (1980). Effect of row spacing and different combinations of N P K fertilizer on the yield of onion. *Bangladesh Hort.*, **8** (2) : 8-12.

Halim, M. A. (2000). Effect of mulches on the growth and yield of some garlic germplasm. An MS Thesis, Department of Horticulture., Bangladesh Agricultural Univertisity, Mymensingh. pp. 34-36.

Hasan, M. J. (1999). Effect of soil moisture management and nitrogen levels on growth and yield of garlic. An M.S Thesis, Department of Horticulture, Bangladesh Agricultural University, Mymensingh. pp. 49-52.

Harun-or-Rashid, A. R. M. (1998). Effect of N P K S on growth and yield of onion at different plant spacing. MS thesis. Department of Horticulture, Mymensingh, p. 72.

Hedge, D. M. (1988). Effect of irrigation and nitrogen fertilizers on yield, quality, nutrient uptake and water use of onion (*Allium cepa L.*). *Singapore J. Pri. Ind.*, **16** (2) : 111-123.

Hilman, Y. and Noordiyata, I..(1988). Equilibrium N, P and K fertilization trial on garlic in rice field. Bulletin Peneletian Horticulture, 16 (1) : 48-53.[Cited from Hort. Abst., 60 (7) : 5116, 1990].

Hockmuth G. J. and Howell, J. G. (1983). Effect of black plastic mulch and raised beds on sweet potato growth and root yield in a northern region. *Hort. Science*, **18**(4) : 467-468.

Hossain, M. B. (2003). Effect of planting time and mulch on growth and yield of some garlic germplasm. MS Thesis. Department of Hoticulture, Bangladesh Agricultural University, Mymensingh. pp. 79-80.

Hossain, M. M. (1997). Effect of different levels of nitrogen and potash on the growth and yield of garlic (*Allium sativum* L.). Department of Horticulture, Bangladesh Agricultural University, Mymensingh. pp.48-49.

Hossain, M. I. (1996). Effect of mulches and different manual practices involving equal cost on the growth, yield and storability of garlic. MS Thesis, Department of Horticulture, Bangladesh Agricultural University, Mymensingh. pp. 64-65.

Iroc, A., Sisson L. C. and Sodium, P. P. (1991). Effects of different mulching material on garlic (*Allium sativum* L.). Bulletin Penelitian Horikultura, 7 (1) : 107-108. [Cited from Hort. Abst., 15 (3) : 95, 1992].

Imam, S. A., Hossain A. H. M.D., Shikha, L. C and Midmore, D. J.(1990). Agronomic management of potato/ sugarcane intercropping and its economic implications. *Field Crop Res.*, **25** (1-2) : 111-112.

Islam, M. T. and Haque, M. A. (1997). Effect of nitrogen, phosphorus and potash on the yield of onion, *Bangladesh Hort.*, pp. 5-8.

Islam, M. K. (1998). Effects of set size, plant spacing and nitrogen levels on the growth and yield of onion cv. Taherpuri, M.S. Thesis, Department of Horticulture, Bangladesh Agricultural University, Mymensingh. p. 131.

Jha, R. C., Maurya, K. R. and Pandey, R. D. (1986). Influence of mulches on the yield of ginger in Bihar. *Indian cocoa, Arec. and Spi. J.*, India, **9**(4) : 87-90.

Jones, H. A. and Mann, L. K. (1963). Onions and their Allies. Leonard Hill (Book) Limited, London, p. 286.

Katwale, T. R. and Saraf, R. K. (1994). Studies on response of onion to verifying levels of fertilizer doses during monsoon season in satpura Plateau. *Orissa. J. Hort.*, **22**(1-2) : 13-18.

Koltunov, V. A. (1984). Effect of different fertilizer rates on garlic productivity and storability. Ref. Zhurnal, 55:4, 55, 374.[Cited from Hort. Abst. 55(8) : 612, 1985].

Kumar, C. R. M and Sadanandan, N. (1988). Influence of mulching on the physiochemical properties of the soil and quality of tuber in taro. *J. root Crops*, **14** (2) :55-62.

Kurian, J. C. (1995). Plant that Heal (1st edn.), Oriental watchman publishing House, Punc, India, p.31.

Kusomo, S. and Widiajanto, D. D. (1973). Fertilizer use on garlic. Bulletein Horticulture. 'Tgahort' , 11: 2-7. [Cited from Hort. Abst., 46 (3) : 2096, 1979].

Lazzari, M. A., Rosell, R. A and Landriscini, M. R. (1978). Garlic production. I. Nitrogen fertilizers and irrigation. Turrialba, 28(3) : 245-251.[Cited from Soil and Fertilizers, 42 (12) : 8401, 1979].

Lazo, F. D., Queddeng, A. and Caliwag, C. M. (1969). The effect of varying amounts of commercial fertilizerson the yield of Granex onion. *Philipp. J. Plant Ind.*, 34: 44.

Madan, S. P. S. and Sandhu, J. S. (1985). Influence of nitrogen, phosphorus and potash levels on the growth of bulb yield and dry matter production of white onion variety. Punjab vegetable grower, 20: 1974.

Maity, T. K. D., Sengupta, M. G. S., Japan, P. K. and Bose, T. K. (1988). Growth and yield of Zingiber officinalae Rose as influenced by some agronomic practices in the plains of West Bengal, India, Acta Horticulture, 188A: 117-122.

Menezes, M. J. A. De., Navais, R. E. D. E,. Santos, H. L. and Dos, L. M. S. (1974). The effect of nitrogen fertilization, plant spacing and mulching on the yield of garlic cultivar Amarante, Revista ceres, 21 (115) : 203-112. [Cited from Hort. Abst., 45(9) : 6470, 1975].

Mia, M. H. A. (1996). Effects of mulch and different levels of N and K on the growth, bulb yield and seed yield of onion, MS Thesis, Department of Horticulture, BAU, Mymensingh, pp. 75-76.

Moon, W. and Lee, B. Y. (1985). Studies on factors affecting secondary growth in garlic(*Allium sativum* L.). *J. Korean Soc. Hort. Sci.* **23** (1) : 26-103.

Minard, H. R. G. (1978). Effect of clove size, spacing, fertilizers and lime on yield and nutrient of garlic (*Allium sativum* L.). New Zealand *J. Expt. Agric.*, **6** (2) : 139-143.

Naik, B. H. and Hosamani, R. M. (2003). Standardization of fertilization for garlic production under transitional tract of Karnataka. *J. Agril. Sci.*, India, **16** (1) : 103-107.

Nelson, M. (1983). Garlic fertilization trial. New Zealand Comm. Grow., 38(2) : 28.

Novias. R. F. DE., Menerez Sobrinho J. A. DE., Sanlos, H. L. D. and Sams L. M. A. (1974). The effect of nitrogen fertilization, mulching and three planting distance on the N, P, K, Ca and Mg levels in the garlic cultivar Amaranta. Revista ceres. 21 (118) : 486-499. [Cited from Hort. Abst. 46(2) : 103, 1976].

Oh, D. H., Hwang, N. Y., Chori, J. S. N. B. J. and Soh J. D. (1991). The responses and optimum rates of N P K fertilizer application to garlic. Research of the Rural Development Administration, Soil and Fertilizer, 33 (1) : 46-51.

Pandey, U. B., Singh, L., Kumar, R., Singh L., Kumar, R.and Raychaudhury, S. P. (1991). Response of different levels of N, P, K on the yield and quality of Kharif onion. Recent Advances in Medicinal, Aromatic and Spice Crops, 1: 231-34.

Pal, R. K. and Pandey D. (1986). Effect of different levels on nitrogen, phosphorus and potassium on the growth and yield of garlic. *Prog. Hort.*, **18**(3-4) : 256-259.

Pandey, R. C. and Mundra, R. S. (1971). Note on response of onion (*Allium cepa* L.) to varying levels of N, P and K. *Indian J. Agril. Sci.*, **41**(2) : 107-108.

Pereira, E. B., Fornazier, M. J., Souja, J. L. DE., Ventura, J. A. and Nogueira F. D. (1987). Effect of organic fertilization with compost on the garlic crop. Horticultura Brassileira.

Pimpin, F. (1970). Studies on the mineral fertilizing of garlic. *Rivista di Agronomial, Italy*, **3** : 182-188. [Cited from Hort. Abst., 42 (2) 477, 1972].

Prihar, S. S. (1986). Fertilization and water use efficiency in relation to mulching. Dehradum [Cited from *Indian Journal of Agronomy*, **32** (4) : 452-452, 1987].

Pruthi, J. S. (1976). Spices and Condiments, National Book Trust of India, New Delhi. pp.125-132.

Purseglove, J. W. (1975). Tropical crops. Monocotyledons. ELBS, London. pp. 52-56.

Purewal, S. S. and Daragan K. S. (1961). Effect of fertilization and spacing on the development and yield of garlic (*Allium sativum* L.). *Indian J. Agron.*, **5**: 262-268.

Rahim, M. A. (1992). Spices and plantation crops in national economy. In: Horticulture in National Development. Proceedings of Sixth National Horticulture Convention and Symposium. Bangladesh Soc. Hort. Sci., pp. 24-29.

Rahim, M. A. and Fordham. R. (1988). Effects of storage temperature on the initiation and delopment of garlic cloves (*Allium sativum* L.). Scientia Horticulturae, 37 : 25-38.

Rahman, M. M. and Faruque, A. H. M. (1975). Effect of different doses of N P K on the yield of (*Allium cepa* L.). *Bangladesh Hort.* **3** (1) : 41-44.

Rahman, S. M., Talukder, R. and Miah, A. M. (1976). Effect of nitrogen, phosphoric acid potash on the bulb size and yield of onion. *Bangladesh Hort.*, **4**(1) : 7-11.

Rekowska, E. (1997). The effect of soil mulching on the yield and quality of garlic developing inflorescence stalks. *Folia Horticulturae*, **9** (1) : 59-65.[Collected from CD ROM, BAU Library].

Roy, A. K., Musli, A. A. A. and Khan, A. H. (1990). Effect of different mulches on the growth of potato. *Bangladesh J. Bot.*, **19** (1) : 41-46.

Rizk, F. A. (1997). Productivity of onion plant (*Allium cepa* L.) as affected by method of planting and N P K application, *Egyptian J. Hort.*, **24**(2) : 219-238.

Saimbhi, M. S., Gill, B. S. and Sandhu, K. S. (1987). Fertilizer requirement of processing onion (*Allium cepa* L.). cv. Punjab – 48. *J. Res., Punjab Agric. Univ.*, **24** (3) : 407-410.

San, L. M. A., Menezessobrinho, J. A. DE., Novais R. F. DE. and Santos, H. L. D. (1974). The effect of mulching on soil humidity and other characteristics under a crop of garlic. Revista ceres, 21 (114) : 91-104. [Cited from Hort. Abst., 45 (4) : 2324, 1975].

Sarder, S., Singh, S. K. and Singh S. (1999). Effect of fertilizer on garlic (*Allium sativum* L.). *Crop Res.*, India, **18**(3) : 387-389.

Sarvananan, A. and Nambisan K. M. P. (1994). Effect of fertilizer application on soil available nutrients, yield and nutrient uptake of garlic in acidic latarite soils of Kodaikanal, *Madras Agril. J.*, **81** (8) : 434-436.

Setty, B. S., Sulkeri and Hulamani N. C. (1989). Effect of N, P and K on growth and yield of garlic (*Allium sativum* L.). *Karnataka J. Agril. Sci.*, **2**(3) : 160-164.

Shya, Y. T. (1979). Effect of different mulching material on the quality and yield of *Dioscorea alata* L. *J. Agril. Res*, China, **28** (2) :117-123.[Collected from CD ROM, BAU Library].

Singh, U. V. (1987). Note on the effect of N, P and K on yield of onion. Plant Sci. 10 :159-161.

Soto, J. A. (1988). Nutritional requirements of onion (*Allium cepa* L.). in the soils of Northern Cartago II. Critical levels for P, K and S and response to N . *Agron. Costarricense*, **12** (1) : 53-57.

Sotomayor, R. I. (1975). Garlic Fertilization. *Progress Agricola*, Chile. **7** (1) : 34. [Cited from Hort Abstr., 47 (1) : 53, 1977].

Suh, J. K., Kim, Y. B., Lee, Y. S., Lee, K. S. and Han, K. Y. (1991). Study of important of mulching cultivar, method in onion, *Res. Rep. Rural Dev. Adm. Hort.*, **33**(3) : 31-36. [Cited from Hort. Abst., 64 (7) ; 5350, 1994.].

Sumi, S., Castellane, P., Bellingieri, P. and Churata Masca, M. G. C. (1986). Mulching and rates of simple super phosphate in a garlic crop. *Horticultura Brasileira*, **4** (1) : 32-34.[Cited from Hort. Abst., 57(2) : 10979, 1987.].

Sutater, T. (1987). Shading and mulching effect on potato yield. Bulletin Penelitioan Horticultura, Indonesia, 15(2) : 191-198. [Cited from Potato Abst., 15(3) : 95, 1990.]

Taja,H., Zaag, P. and Vander, P. (1992). Organic residues management in the hot tropics: influence on the growth and yield of potato and maize. *Tropical Agriculture*, **68**(2) ; 111-118. [Cited from Potato Abstr., 16(4) : 131. 1994].

Talukder, A. F. M. M. H. (1998). Effect of different levels of nitrogen and potassium on the growth and yield of garlic planted in different dates. MS Thesis, Department of Horticulture, Bangladesh Agricultural University, Mymensingh. pp 115-116.

Tsikalas, P. E. and Manios, V. (1985). Effect on the content of nutrient elements in tomato leaves. *Georgike Ereuna* **9**(2) : 291-299 [Cited from soil and Fertilizers. 51 (10) : 1363, 1988].

Thomson, H. C. and Kelly, W. C.(1957). Vegetables Crops. MC. Graw Hill Book CO. New York. pp. 368-370.

Uddin, M. A. (1997).Effect of planting time ,nitrogen and potash levels on the growth and yield of garlic. MS Thesis, Department of Horticulture, Bangladesh Agricultural University, Mymensingh. pp 93-95.

Uddin, A. F. M. J. (1993). Effect of mulching and fertilizer management practices on the growth and yield of garlic (*Allium sativum* L.).. MS Thesis, Department of Horticulture, Bangladesh Agricultural University, Mymensingh. pp. 69-70.

UNDP. (1988). Land Resource Apprisal of Bangladesh for Agricultural Development Report 2: Agro-ecological Regions of Bangladesh, FAO, Rome, Italy, pp. 577.

Vachhani, M. U. and Patel, Z. G. (1993). Growth and yield of onion (*Allium cepa* L.) as influence by nitrogen, phosphorus and potash under South Gujrat condition. *Prog. Hort.*, **25**(3-4) : 166-167.

Vanderwerken, J. E. and Wilcox Lee, D. (1988). Influence of plastic mulch and type and frequency of irrigation on growth and yield of bell pepper. *Hort. Sci.* **23** (6,1) : 985-988.

Vvdensky, A. I. (1946). The genus Allium in USSR. Herbertia, II : 65-218.[Collected from CD ROM, BAU Library].

Wang, X. Y., Hou, x. Zhang and Xu, W.C. (1992). Study on the pattern of fertilizer requirement for garlic bulbs. Northern Hort., 1:10-12 [Cited from Hort. Abstr. 65(5): 470, 1994].

Zehnder, H. W. and Haugh-Goldsteir, J. (1989). Colorado potato beetle (Coloptera : Chrysomelidae) population development and effect on yield of potatoes with and without straw mulch. *J. Econ. Entom.*, USA., **88**(5) : 1982-1987.

APPENDICES

Appendix-I. Trend of garlic production in Bangladesh (1994-2004)

Year	Area (.000 ha)	Production (.000 ton)	Yield (ton / ha)
1994-95	12.95	40	3.08
1995-96	12.95	39	3.01
1996-97	12.95	39	3.01
1997-98	13.03	39	2.99
1998-99	13.23	40	3.02
1999-2000	13.39	39	2.91
2000-01	13.55	39	2.87
2001-02	14.03	39	2.80
2002-03	12.40	43	3.17
2003-04	18.14	73	4.04

Source : BBS, 2005

Appendix II.Characteristics of S. A. U. Farm soil analyzed by Soil Resources Development Institute (SRDI), Khamar Bari, Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	S.A.U Farm ,SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	Medium high land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Fellow-Garlic

B. Physical and chemical properties of the initial soil

Characteristics	Value
Partical size analysis	
% Sand	25
% Silt	29
% clay	46
Textural class	Clay-loam
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 III. Monthly record of air temperature, rainfall, relative humidity, soil temperature and Sunshine of the experimental site during the period from November 2005 to April 2006

Year	Month	*Air temperature (°c)			*Relative humidity (%)	** Rainfall (mm)	*Soil temperature (°c)			**Sun shine (hr)
		Maximum	Minimum	Mean			5 cm depth	10 cm depth	20 cm depth	
2004	November	29.0	19.8	24.45	72	3	13.8	14.4	14.8	208.9
	December	27.0	15.6	21.3	66	0	12.6	13.3	13.9	233.2
2005	January	25.3	13.4	14.35	59	0	11.5	11.6	13.0	194.1
	February	31.2	19.4	25.3	65	0	12.8	12.8	13.7	204.8
	March	33.2	21.9	27.55	53	0	16.8	16.8	17.8	221.5
	April	33.7	23.8	28.75	67	181	18.4	18.4	19.2	210.2

*Monthly average
**Monthly total

Source : Bangladesh Meteorological Department (Climate division)
Agargoan, Dhaka-1212

Appendix IV. Analysis of variance of the data on plant height as influenced by different mulch materials and different levels of potassium

Source of variation	Degree of freedom (d.f.)	Mean sum of square			
		Plant Height at 30 DAS (cm)	Plant Height at 45 DAS (cm)	Plant Height at 60 DAS (cm)	Plant Height at75 DAS (cm)
Replication	2	1.174	8.207	11.767	1.419
Potassium	3	74.570**	51.735**	192.506**	108.081**
Mulching	3	86.787**	80.683**	169.602**	255.813**
Potassium Mulching	9	1.296NS	2.085NS	8.678**	7.421NS
Error	30	2.137	3.429	2.909	4.108

**= Indicate significant at 1% level of probability
*= Indicate significant at 5% level of probability
NS= Not significant

Appendix V. Analysis of variance of the data on No. of leaves per plant as influenced by different mulch materials and different levels of potassium

Source of variation	Degree of freedom (d.f.)	Mean sum of square			
		No. of leaves / plant at 30 DAS (cm)	No. of leaves / plant at 45 DAS (cm)	No. of leaves / plant at 60 DAS (cm)	No. of leaves/ plant at 75 DAS (cm))
Replication	2	0.020	0.002	0.551	0.002
Potassium	3	1.196**	3.338**	2.899**	6.074**
Mulching	3	2.804**	3.892**	9.857**	3.296**
Potassium Mulching	9	0.205**	0.260**	0.628**	0.427**
Error	30	0.046**	0.104**	0.199**	0.371^{NS}

**= Indicate significant at 1% level of probability
*= Indicate significant at 5% level of probability
NS= Not significant

Appendix VI. Analysis of variance of the data on fresh and dry wt. of leaves, roots, bulb / plant and bulb diameter as influenced by different mulch materials and different levels of potassium

Source of variation	Degree of freedom (d.f)	Mean sum of square						
		Fresh weight of leaves (g)	Dry weight of leaves (g)	Fresh weight of roots (g)	Dry weight of roots (g)	Fresh weight of bulb (g)	Dry weight of bulb (g)	Diameter of bulb (cm)
Replication	2	0.186	0.002	0.005	0.000	0.555	0.039	0.131
Potassium	3	6.432**	0.245**	0.731**	0.078**	24.165**	5.317**	2.766**
Mulching	3	15.831**	0.273**	0.852**	0.029**	13.857**	2.103**	2.884**
Potassium Mulching	9	1.392**	0.014^{NS}	0.021^{NS}	0.002**	1.091**	0.367**	0.190**
Error	30	0.129	0.010	0.020	0.001	0.195	0.031	0.057

**= Indicate significant at 1% level of probability
*= Indicate significant at 5% level of probability
NS= Not significant

Appendix VII. Analysis of variance of the data on neck diameter, no. of cloves / bulb, yield / plot and yield / ha. as influenced by different mulch materials and different levels of potassium

Source of variation	Degree of freedom (d.f.)	Mean sum of square			
		Neck diameter (cm)	No. of cloves / bulb	Yield of bulb (ton / ha)	Yield of bulb (ton / ha)
Replication	2	0.002	1.896	0.001	0.061
Potassium	3	0.090**	25.722**	0.090**	9.670**
Mulching	3	0.141**	80.722**	0.043**	7.872**
Potassium Mulching	9	0.014**	4.704**	0.050**	0.953**
Error	30	0.002	1.807	0.003	0.103

**= Indicate significant at 1% level of probability
*= Indicate significant at 5% level of probability
NS= Not significant

Appendix VIII. Production cost of garlic per hectare

(A)Material cost (Tk./ha)

Cost of different materials								
Treatment combinations	Seed (Tk/ha)	Fertilizer and manure (Tk/ha)					Mulching (Tk/ha)	Sub total 1 (A) (Tk/ha)
		Cow dung	MOC	Urea	TSP	MP		
M_0K_0	44,444	8400	3200	2080	6320	-	-	93,244
M_0K_1	44,444	8400	3200	2080	6320	4800	-	98,044
M_0K_2	44,444	8400	3200	2080	6320	5600	-	98,844
M_0K_3	44,444	8400	3200	2080	6320	6400	-	99,644
M_1K_0	44,444	8400	3200	2080	6320	-	40,000	1,33,244
M_1K_1	44,444	8400	3200	2080	6320	4800	40,000	1,38,044
M_1K_2	44,444	8400	3200	2080	6320	5600	40,000	1,38,844
M_1K_3	44,444	8400	3200	2080	6320	6400	40,000	1,39,644
M_2K_0	44,444	8400	3200	2080	6320	-	2700	95,944
M_2K_1	44,444	8400	3200	2080	6320	4800	2700	1,00,744
M_2K_2	44,444	8400	3200	2080	6320	5600	2700	1,01,544
M_2K_3	44,444	8400	3200	2080	6320	6400	2700	1,02,344
M_3K_0	44,444	8400	3200	2080	6320	-	6000	99,244
M_3K_1	44,444	8400	3200	2080	6320	4800	6000	1,04,044
M_3K_2	44,444	8400	3200	2080	6320	5600	6000	1,04,844
M_3K_3	44,444	8400		1980	1490	6400	6000	1,05,644

Garlic clove @ Tk. 80/kg.
Cow dung @ Tk. 600/ton.
Urea @ Tk.8/kg.
TSP @ Tk.16/kg.
MP @ Tk.16/kg.
Water hyacinth @ Tk.1500/ton.
Rice straw @ Tk.1500/ton
Saw dust @ Tk. 3/kg
Mustard oil cake @ Tk. 1600/ton

Appendix VIII. Contd.

(B) Non-material cost (Tk./ha)

Treatment combination	Land preparation	Fertilizer and manure application	Mulching practices	Clove sowing	Intercultural operation	Harvesting	Sub total	Total input cost 1 (A) + 1 (B)
M_0K_0	10500	-	-	5600	10,000	8050	33,650	1,26,894
M_0K_1	10500	820	-	5600	10,000	8050	34,470	1,32,514
M_0K_2	10500	1120	-	5600	10,000	8050	34,770	1,33,614
M_0K_3	10500	1120	-	5600	10,000	8050	34,770	1,34,414
M_1K_0	10500	-	1120	5600	10,000	8050	34,770	1,68,014
M_1K_1	10500	820	1120	5600	10,000	8050	35,590	1,73,634
M_1K_2	10500	1120	1120	5600	10,000	8050	35,890	1,74,734
M_1K_3	10500	1120	1120	5600	10,000	8050	35,890	1,75,534
M_2K_0	10500	-	1200	5600	10,000	8050	34,850	1,30,794
M_2K_1	10500	820	1200	5600	10,000	8050	35,670	1,36,414
M_2K_2	10500	1120	1200	5600	10,000	8050	35,970	1,37,514
M_2K_3	10500	1120	1200	5600	10,000	8050	35,970	1,38,314
M_3K_0	10500	-	1190	5600	10,000	8050	34,840	1,34,084
M_3K_1	10500	820	1190	5600	10,000	8050	35,660	1,39,704
M_3K_2	10500	1120	1190	5600	10,000	8050	35,960	1,40,804
M_3K_3	10500	1120	1190	5600	10,000	8050	35,960	1,41,604

Labour cost @ Tk. 70/day.

Appendix VIII. Contd.

(C) Overhead cost and total cost of production (Tk./ha)

Treatment combination	Cost of lease of land	Miscellaneous cost (5% of input cost)	Interest on running capital for 6 months (13% of the total input cost)	Total	Total cost of production (input cost + interest on running capital, Tk/ha)
M_0K_0	16000	6344	8248	30,592	1,57,486
M_0K_1	16000	6625	8613	31,238	1,63,752
M_0K_2	16000	6680	8684	31,364	1,64,978
M_0K_3	16000	6720	8436	31,156	1,65,570
M_1K_0	16000	8400	10,920	35,320	2,03,334
M_1K_1	16000	8681	11,286	35,967	2,09,601
M_1K_2	16000	8736	11,357	36,093	2,10,827
M_1K_3	16000	8736	11,409	36,145	2,11,679
M_2K_0	16000	6539	8501	31,040	1,61,834
M_2K_1	16000	6820	8866	31,686	1,68,100
M_2K_2	16000	6875	8938	31,813	1,69,327
M_2K_3	16000	6915	8990	31,905	1,70,219
M_3K_0	16000	6704	8715	31,419	1,65,503
M_3K_1	16000	6985	9080	32,065	1,71,769
M_3K_2	16000	7037	9152	32,189	1,72,993
M_3K_3	16000	7080	9204	32,284	1,73,888