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Effects of Natural and Synthetic Mulches on Garlic (*Allium sativum* L.)

Md. Shahidul Haque, Md. Rezaul Islam, M. Abdul Karim and Md. Abdul Halim Khan
Department of Crop Botany, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh

Abstract: The experiment was carried out to study the effect of natural and synthetic mulches on yield of local and exotic garlic cultivars during the period from November, 2000 to march, 2001. The results of the experiment revealed that significant variations exist among the different mulches in respect of morphological characters, yield contributing characters and yield of garlic. Water hyacinth mulch produced the tallest plant with higher number of leaves and roots per plant, higher fresh and dry weight of bulb, length of bulb and highest yield per hectare. Bulb diameter and number of cloves per bulb were higher in black polyethylene mulch. The exotic cultivar performed better than the local cultivar in respect of plant height, number of leaves and roots per plant, fresh and dry weight of bulb and yield per hectare.

Key words: Garlic, management practice, mulching, soil amendment

Introduction

Garlic (*Allium sativum* L.) is one of the important spice crops. It is a bulbous herbaceous spice and widely grown in tropical and temperate regions. It is an important and widely cultivated crop used for food as well as medicinal purposes because of its thrombotic, lipid-lowering, cardiovascular and anticancer effects (Agarwal, 1996). Garlic is known to be thermo-photo-sensitive crop and its vegetative growth and bulb development are greatly influenced by growing environment (Jones and Mann, 1963; Rahim and Fordham, 1988). Manipulation of growing environment by cultural practices has the potentiality to improve yield. Mulching is one of the good cultural practices for the favorable manipulation of microclimate. The role of mulching on the growth and production of plants is well recognized. Mulching in the semi-arid tropics has been suggested to conserve soil moisture (Adetunji, 1990; Bristow and Abrecht, 1989; Gajri *et al.*, 1994; Zaman and Mallick, 1991), decrease soil temperature decrease runoff and soil erosion (Sur *et al.*, 1992) and sometimes even substitutes the soil (Amal *et al.*, 1990). It protects the plants from loss of soil moisture by wind and soil evaporation and reduces the irrigation requirements (Amal *et al.*, 1990; Vanderwerken *et al.*, 1988). Mulches help check weed growth and improve the soil structure and fertility by trapping nutrient-rich, wind-borne dust (Geiger *et al.*, 1992). Mulches also help in better utilization of soil nutrients meeting up the need of irrigation and thus increase crop yield. Mulching economizes use of N-fertilizer (Jones *et al.*, 1977), lessen the need of organic fertilizer (Donato and Actai, 1972) and saves labor cost.

Mulching-induced improvements in yield have often been ascribed to increased soil moisture (Adetunji, 1990; Gajri *et al.*, 1994; Zaman and Mallick, 1991). In addition, yield increases have been attributed to the ability of mulch to decrease soil temperature (Adetunji, 1990), enhance nutrient availability (Patra *et al.*, 1993) and increase root growth (Gajri *et al.*, 1994).

Most arable lands of Bangladesh suffer from inadequate soil moisture particularly during dry season (Nov. to Mar.) and exploit the moisture in soil from seasonal precipitation in rainy season (Apr. to Oct.). Garlic is cultivated during the short winter season which is characterized by lack of rainfall. Moreover, irrigation facility is not enough for the minor crops like garlic. As a result garlic suffers from lack of adequate soil moisture leading to poor yield. Thus, mulching could solve the problem of scanty soil moisture to some extent in winter conserving the moisture. Water hyacinth, ash, rice husk, saw dust etc, may be used as natural organic mulch since they are plentiful, low cost and can be obtained easily. Many scientists used synthetic mulches like transparent and colored polyethylene to increase the yield. As regards the crop yield response to mulching effects, results are variable. Straw mulch has been reported to increase yields of sorghum (Bhaskar, 1985), decrease castor bean yield (Venkateswarlu *et al.*, 1986) and have no effect on pearl millet. Polyethylene mulch increased yield of onion (Suh and Kim, 1991). Adetunji (1994) reported that with the exception of saw dust mulch, both natural and synthetic mulches significantly enhanced vegetative growth and bulb yields of onion. Inspite of sufficient research on other crops, reports on mulching in garlic is rare. This study was, therefore, conducted to observe the effectiveness of natural and synthetic mulching materials on morphology, yield attributes and yield of local and exotic cultivars of garlic.

Materials and Methods

The experiment was conducted at the experimental field laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh, during the period from 14th November 2000 to 25th March 2001. A local and an exotic cultivar (probably imported from India) of garlic were used in this study. The selected experimental land was first opened by a tractor with disc plough. It was then thoroughly prepared by ploughing and cross ploughing with power tiller followed by laddering. The clods were broken into friable soil and the surface was leveled until the desired tilth was obtained. All the weeds, their rhizomes and stubbles were collected and removed from the plots.

Well-decomposed cow dung (10 t ha^{-1}), urea (120 kg ha^{-1}), triple superphosphate (TSP) (90 kg ha^{-1}) and muriate of potash (MP) (180 kg ha^{-1}) were applied to the field. Entire amount of cow dung, urea, TSP and MP was applied during final land preparation and thoroughly mixed with soil. Five different mulches (dried water hyacinth, black polyethylene, transparent polyethylene, saw dust and rice husk) and two control treatments (non-irrigated control and irrigated control) comprised the study. The two-factor experiment was laid out in randomized complete block design (RCBD) with three replications.

The entire experimental plot was divided into three blocks, each of which then divided into 14 unit plots. The size of the unit plot was 1.5x1.5 m^2. Two adjacent unit plots and blocks were separated by 0.5 and 1.0 m, respectively. The treatment combinations were distributed randomly among the unit plots of each block so that all of treatments were placed once in each block.

The cloves for planting were selected from uniform healthy bulbs of garlic. The outer dry scale leaves of bulbs were removed and cloves were separated from each other for planting in the field. One hundred and fifty cloves were planted in each unit plot maintaining a spacing of 15x10 cm. The cloves were planted at about 4 cm depth of soil. Mulching with water hyacinth, rice husk and saw dust was done immediately after planting. Transparent and black polyethylene sheets with small holes, which were made previously maintaining proper spacing were spread over the plot so that the plantlets could emerge easily through the holes. Then the cloves were planted singly through the holes in the soil at required depth with a pointed stick. Irrigation was done by water cane in irrigated control plots. While the other control plots were kept non-irrigated. Frequency of irrigation was dependent upon the moisture status of the soil.

Data were collected from five randomly selected plants at an interval of 15 days starting from 30 days after planting till the final harvest. The observations were under taken on plant height, number of leaves $plant^{-1}$, total number of leaves and number of roots $plant^{-1}$. Fresh weight of bulb per plant (g), dry weight of bulb per plant (g), bulb diameter (cm), bulb length (cm), number of cloves per bulb, yield per plot (kg) and yield (t ha^{-1}) were estimated at the time of final harvest. The final harvest of the crop was done on 25th March 2001 after the attainment of maturity, showing the sign of drying outmost of the leaves and softening of neck of the bulb.

The collected data on different parameters under study were statistically analyzed. The pair comparisons were made by LSD test at 5 and 1% levels of probability. The significance of the difference between the pair of means was evaluated by Duncan's multiple range test (DMRT) using MSTAT-C program in computer.

Results and Discussion

Plant height: Plant height of garlic as influenced by different mulches was recorded from 30 to 130 DAP (Fig. 1). It revealed that application of different mulches favorably influenced plant height. The plant height increased steadily, reached to its maximum at 120 DAP and then decreased slightly in all the treatments. The tallest plant (55.48 cm) was obtained from the plots mulched with water hyacinth (M_1) followed by black polyethylene mulch (M_2). The shortest (31.33 cm) plant was recorded from transparent polyethylene mulch (M_3). The two cultivars showed a significant variation in plant height at different growth stages (Fig. 2). It was observed that the exotic cultivar (V_2) produced the taller (44.98 cm) plants compared to the local cultivar (V_1). No significant interaction effect was observed between different mulches and cultivars on plant height except at 30 and 60 DAP (data not shown).

Plant height was comparatively higher (55.48 cm) with water hyacinth mulch probably due to the retention of maximum available soil moisture. Plants with transparent polyethylene mulch could not accomplish vegetative growth compared to water hyacinth mulch due to excessive weed infestation as was observed in this study. Transparent plastic mulch allowed much of the incident radiation to enter into the soil but permitted little of the out going radiation to go back out of the soil thus creating a favorable condition for weed growth. Baten *et al.* (1995) stated that water hyacinth root-mulch produced tallest plants among the natural mulches used. In the present study with both natural and synthetic mulches, water hyacinth mulch was found to be superior to other mulches in producing taller plants.

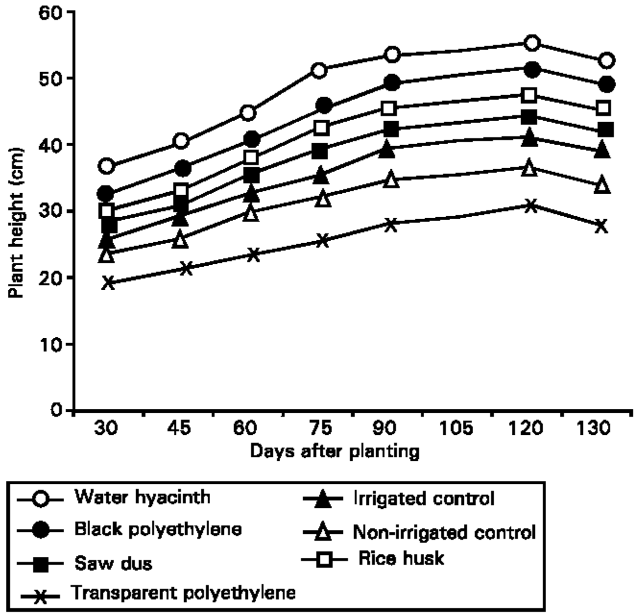

Fig. 1: Effect of different mulches on plant height at different stages of growth. Significant at 5% level

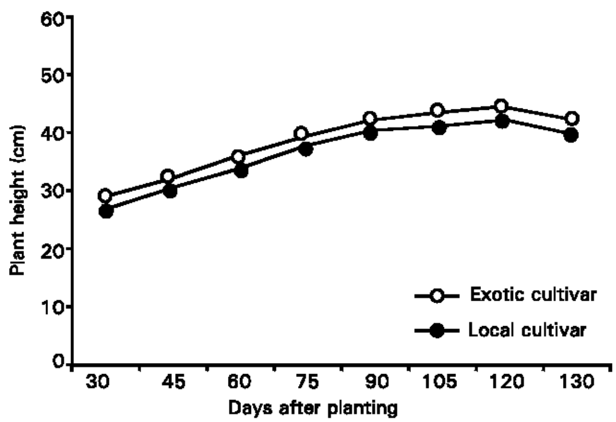

Fig. 2: Varietal difference in plant height at different stages of growth. Significant at 1% level.

Number of leaves: The number of leaves per plant was significantly different among the treatments at all growth stages and water hyacinth mulch had a superiority in generating leaves over the other treatments (Table 1). At 130 DAP, water hyacinth mulch had the highest number (9.4) of leaves per plant followed by black polyethylene (8.9) and rice husk (8.8) mulch, respectively. The least number of leaves per plant was found in transparent polyethylene (4.6) which was lower than irrigated (M_7) and non-irrigated (M_6) controls. There was a highly significant difference in number of leaves per plant between two cultivars at all stages of plant growth except for 30 DAP. The exotic cultivar always generated higher number of leaves than the local cultivar and the maximum number (7.5 plant^{-1}) was recorded at 130 DAP (Table 2). The interaction effect of different natural and synthetic mulches and two cultivars of garlic on the number of leaves per plant was significant at 30, 45 and 130 DAP only (data not shown). This result supports the previous

Table 1: Number of leaves per garlic plant at different stages of plant growth as influenced by different mulches

	Number of leaves plant^{-1}							
Treatments	30 DAP	45 DAP	60 DAP	75 DAP	90 DAP	105 DAP	120 DAP	130 DAP
M_1	4.1a	5.1a	5.9a	6.6a	7.3a	8.3a	9.0a	9.4a
M_2	3.9a	4.9b	5.5b	6.1b	6.9b	7.8b	8.4b	8.9b
M_3	2.5c	2.9a	3.1e	3.4d	3.8d	4.1d	4.4e	4.6e
M_4	4.0a	4.5d	5.1c	5.9b	6.6c	7.3c	7.8c	8.2c
M_5	4.1a	4.7c	5.4b	6.1b	6.9bc	7.6c	8.2b	8.8b
M_6	3.0b	3.1e	3.3d	3.5d	3.8d	4.2d	4.9d	5.2d
M_7	2.7c	3.1e	3.4d	3.9c	4.1d	4.4d	4.9d	5.3d

Values with different letters within a column differ significantly at 1% level of probability (DMRT), M_1 = Dried water hyacinth, M_2 = Black polyethylene, M_3 = Transparent polyethylene M_4 = Saw dust, M_5 = Rice husk, M_6 = Non-irrigated control M_7 = Irrigated control

Table 2: Comparative study of the number of leaves per plant in two cultivars of garlic at different growth stages

	Number of leaves plant^{-1}							
Cultivar	30 DAP	45 DAP	60 DAP	75 DAP	90 DAP	105 DAP	120 DAP	130 DAP
V_1	3.4	3.9 b	4.4 b	5.0 b	5.5 b	6.0 b	6.6 b	7.0 b
V_2	3.5	4.1 a	4.6 a	5.2 a	5.8 a	6.4 a	7.0 a	7.5 a
Level of significance	NS	0.01	0.01	0.01	0.01	0.01	0.01	0.01

NS = Non significant, V_1 = Local cultivar, V_2 = Exotic cultivar

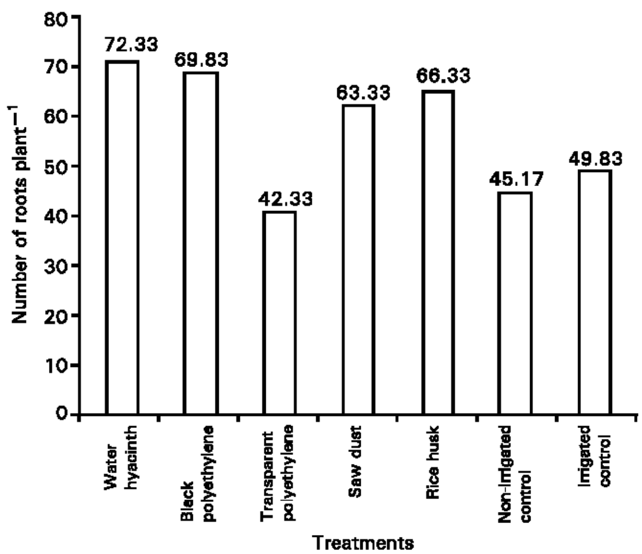

Fig. 3: Effect of different mulches on number of roots per plant Significant at 1% level

Table 3: Effect of different mulches on yield and yield components of garlic

Treatments	Length of bulb (cm)	Diameter of bulb (cm)	Number of clover bulb^{-1}	Fresh weight of bulb (g)	Dry weight of bulb (g)
M_1	3.41a	3.40b	30.00ab	13.81a	5.29a
M_2	3.22b	3.83a	31.83a	13.36ab	4.65b
M_3	2.29e	1.65f	10.50d	2.62e	0.90g
M_4	3.05c	3.05c	27.83b	12.37b	3.45d
M_5	3.15b	3.15c	28.67ab	12.70ab	4.19c
M_6	2.75d	2.08e	14.67c	4.37d	1.58f
M_7	2.80d	2.68d	17.33c	7.10c	2.17e

Values with different letters within a column differ significantly at 1% level of probability (DMRT), M_1 = Water hyacinth, M_2 = Black polyethylene, M_3 = Transparent polyethylene, M_4 = Saw dust, M_5 = Rice husk, M_6 = Non-irrigated control, M_7 = Irrigated control

Table 4: Effect of cultivars on yield and yield components of garlic

Cultivars	Length of bulb (cm)	Diameter of bulb (cm)	Number of cloves bulb^{-1}	Fresh weight of bulb (g)	Dry weight of bulb (g)
V_1	2.87b	2.75b	21.81b	8.41b	3.05b
V_2	3.03a	2.91a	24.14a	10.78a	3.29a
Significance	0.01	0.01	0.01	0.01	0.01

V_1 = Local cultivar, V_2 = Exotic cultivar

Table 5: Interaction effect of different mulches and cultivars on yield and yield contributing characters of garlic

Interactions	Length of bulb (cm)	Bulb dia (cm)	Number of cloves bulb^{-1}	Fresh weight of bulb (g)	Dry weight of bulb (g)
M_1V_1	3.31b	3.30	29.67	12.12c	4.89
M_1V_2	3.50a	3.50	30.33	15.51a	5.71
M_2V_1	3.10be	3.67	30.33	11.82c	4.58
M_2V_2	3.33bc	4.00	33.33	14.91ab	4.71
M_3V_1	2.10h	1.60	10.00	1.92h	0.86
M_3V_2	2.50g	1.76	11.00	3.33g	0.94
M_4V_1	3.00e	3.00	26.33	10.92c	3.35
M_4V_2	3.10de	3.10	29.33	13.82b	3.54
M_5V_1	3.10de	3.10	27.33	11.20c	4.12
M_5V_2	3.20cd	3.20	30.33	14.20b	4.26
M_6V_1	2.70f	2.00	14.00	4.72f	1.46
M_6V_2	2.80f	2.17	15.33	5.89ef	1.69
M_7V_1	2.80f	2.60	15.00	6.20e	2.10
M_7V_2	2.80f	2.77	19.67	7.82d	2.24

Values with different letters within a column differ significantly at 5% level of probability (DMRT), M_1 = Dried water hyacinth, M_2 = Black polyethylene, M_3 = Transparent polyethylene, V_1 = Local cultivar, M_4 = Saw dust, V_2 = Exotic cultivar, M_5 = Rice husk, M_6 = Non-irrigated control, M_7 = Irrigated control

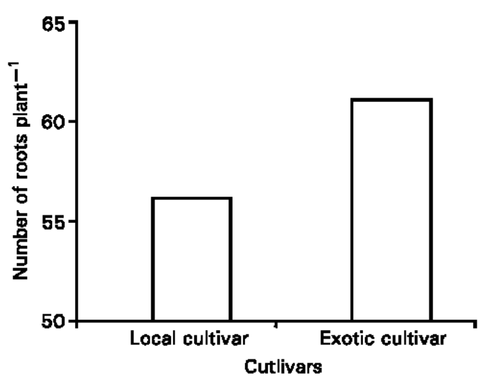

Fig. 4: Effect of cultivars on number of roots per plant. Significant at 1% level

finding of Hossain (1996). Mia (1996) reported that the slight increase in the number of leaves per plant induced by mulch treatments was possibly due to greater plant height and favorable moisture conditions of the soil.

Number of roots per plant: Number of roots per plant was counted after careful up rooting of the plants on 130 DAP (Fig. 4). Different mulch treatments under study showed highly significant variation in number of roots per plant. The application of water hyacinth mulch produced the highest (72.33) number of roots per plant followed by black polyethylene (69.83) and rice husk (66.33), mulch. The lowest number (42.33) of roots per plant was found with transparent polyethylene (Fig. 3). The higher number of roots per plant (61.0) was found in the exotic cultivar and the lowest number of roots per plant (55.9) was found in the local cultivar (Fig. 5). The interaction effect of mulches and cultivars were non-significant (data not shown). Similar increase of rooting was observed by Baten *et al.* (1995). They noted that water hyacinth mulch

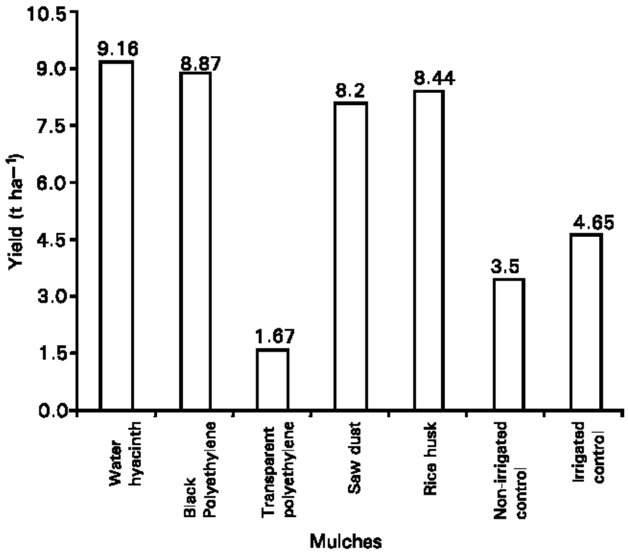

Fig. 5: Effect of different mulches on bulb yield per hectare in garlic

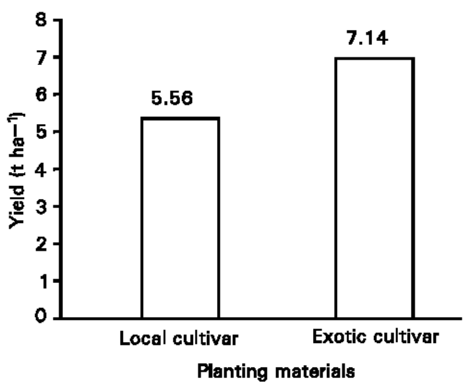

Fig. 6: Effect of planting materials on bulb yield of garlic per hectare (Significant at 1% level)

produced the maximum number of roots. The production of higher number of roots by different mulching treatments may be due to availability of better growing conditions under such treatments. In transparent mulching, excessive weed population might have competed for nutrient and moisture resulting in poor root growth of the crop.

Length of bulb: Bulb length significantly differed among the treatments (Table 3). The longest bulb (3.41 cm) was found in water hyacinth mulch followed by black polyethylene (3.22 cm) and rice husk (3.15 cm). The shortest bulb (2.29 cm) was found in transparent polyethylene. The two cultivars had significantly different bulb length. The longer bulb (3.03 cm) and the shorter bulb (2.87 cm) were found in exotic and local variety, respectively (Table 4). The interaction effects of different mulches and varieties were statistically significant at 1% level (Table 5). The highest length of bulb (3.5 cm) was found in M_1V_2 followed respectively M_2V_2 (3.33 cm) and M Y $_1$(3.31 cm). The lowest bulb length (2.1 cm) was found in M_2V_1. Longer bulb from water hyacinth mulch was also reported by Baten *et al.* (1995).

Diameter of bulb: Different mulches showed significant variation in bulb diameter (Table 3). The highest bulb diameter (3.40 cm) was recorded with water hyacinth mulch followed by black polyethylene (3.83 cm). Effect of rice husk (3.15 cm) and saw dust (3.05 cm) mulches were statistically similar. While, the irrigated (2.68 cm) and non-irrigated (2.08 cm) controls were statistically identical. On the other hand, plants under transparent polyethylene mulch had the lowest (1.65 cm) bulb diameter. The bulb diameter differed significant between the cultivars (Table 4). The highest (2.91 cm) bulb diameter was recorded in V_2 (exotic garlic). The interaction effect of mulches and cultivars was non-significant (Table 5). Beten *et al.* (1995) and Mia (1996) also reported similar results of higher bulb diameter with water hyacinth mulch.

Number of cloves bulb^{-1}: The variation in the number of cloves bulb^{-1} due to the application of different mulching treatments was highly significant (Table 3). The black polyethylene mulch produced the highest (31.83) number of cloves bulb^{-1} followed by water hyacinth (30.00), rice husk (28.67) and saw dust (27.83), respectively. The lowest (10.5) number of cloves was found with transparent polyethylene mulch treatment. The result of this study indicated that the number of cloves per bulb was statistically different in two varieties (Table 4). The higher number of cloves per bulb (24.14) was recorded in V_2. The results obtained from the interaction between the two varieties and different mulches were found to be non-significant (Table 5). Uddin (1997) also observed that black polyethylene mulching gave the maximum number of cloves in garlic. The higher number of cloves per bulb in the exotic cultivar may be related to its inherent character.

Fresh weight of bulb: The variation in fresh weight of individual bulb recorded at the final harvest was significantly different among various mulch treatments (Table 3). The highest fresh weight of bulb was found in plants grown under water hyacinth mulch (13.81 g) followed by black polyethylene (13.36 g), rice husk (12.70 g) and saw dust mulches (12.37 g), respectively. The lowest (2.62 g) was obtained with transparent polyethylene mulch. The two cultivars had significantly different fresh weight of individual bulb (Table 4). The highest bulb weight of 10.78 g was obtained from exotic cultivar (V_2) compared to 8.41 g in local cultivar. The interactive effect of cultivars with different mulches was statistically significant ($P<0.05$). The highest fresh weight of bulb (15.51 g) was found in M_1V_2 (water hyacinth mulch x exotic cultivar) followed by M_2V_2 (14.91 g), M_5V_2 (14.20 g) and M_4V_2 (13.82 g). The lowest fresh weight of bulb (1.92 g) was observed due to the M_3V_1 (transparent polyethylenexlocal variety) interaction. Similar results were also reported by Hossain (1996) and Hassan (1999). They found that the fresh weight of bulb per plant was favorably influenced by water hyacinth mulch.

Dry weight of bulb: Mulching treatment greatly influenced the dry weight of individual bulb. The plants grown with water hyacinth mulch had maximum dry weight of bulb (5.29 g) while those grown under transparent polyethylene mulch had the lowest bulb dry weight (Table 3). The dry weight of bulb was significantly ($P<0.01$) different in the two cultivars. The higher dry weight of bulb (3.29 g) was found in V_2 and the lower dry weight of bulb (3.05 g) was found in V_1 (Table 4). The results of the interaction effects of varieties and different mulches were found non-significant (Table 5). Water hyacinth mulch increased bulb dry matter in the present study. Hassan (1999) observed the same result but Uddin (1997) reported that black polyethylene mulch gave the highest dry weight of bulb compared with water hyacinth and straw mulch. Increased dry weight of bulb due to water hyacinth mulching was achieved due to better growing condition received by the plants in terms of soil moisture and soil temperature during the course of development.

Yield per hectare ha^{-1}: There was highly significant variation in garlic yield ha^{-1} due to the effect of different mulches (Fig. 5). Water hyacinth mulch gave the maximum (9.16 t ha^{-1}) yield followed by black polyethylene (8.87 t ha^{-1}), rice husk (8.44 t ha^{-1}) and saw dust (8.20 t ha^{-1}). Irrigated (4.65 t ha^{-1}) and non-irrigated (3.50 t ha^{-1}) controls were statistically similar. The lowest yield (1.67 t ha^{-1}) was observed with transparent polyethylene mulches. The yield per hectare was statistically different in two cultivars (Fig. 6). The higher yield (7.14 t ha^{-1}) was found in the exotic cultivar compared to in the local cultivar (5.56 t ha^{-1}). The result obtained from the interaction between the varieties and different mulches were found to be significant (Fig. 5). The highest yield (10.29 t ha^{-1}) was found in M_1V_2 followed by M_2V_2 (9.89 t ha^{-1}), M_1V_1 (8.02 t ha^{-1}) and M_1V_1 (7.84 t ha^{-1}) were statistically similar. The lowest yield (1.22 t ha^{-1}) was found in M_3V_1 interaction. Mulch induced yield increase of garlic was also reported by Baten *et al.* (1995) and Hossain (1996). A yield increase with the water hyacinth mulch may be attributed to soil moisture conservation, recycling of plant nutrients, entrapment of eolian materials and stimulation of microbial activity. The yield reduction by the application of the transparent polyethylene mulch may be due to the competition of the crop with weed that grew under it. The higher bulb yield in the exotic cultivar may be associated to its genetic character.

The result of the experiment revealed that different mulches and cultivars had significant effects on the growth and yield of garlic. However, transparent polythene mulch reduced the plant height and suppressed yield contributing characters of garlic. The exotic cultivar raised under water hyacinth mulch had highest yield (10.29 t ha^{-1}). The present study indicates that the natural mulch, especially water hyacinth can be recommended for garlic cultivation. Moreover, the exotic cultivar has a potentiality to improve garlic production in Bangladesh. However, further trials in different garlic growing areas of Bangladesh are necessary before recommending the exotic cultivar in Bangladesh because its yield potential may be lost or decreased due to environmental effect.

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