ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 41(1): 53-66, March 2016

PRODUCTIVITY OF GARLIC UNDER DIFFERENT TILLAGE METHODS AND MULCHES IN ORGANIC CONDITION

M. A. KABIR[1], M. A. RAHIM[2] AND D. A. N. MAJUMDER[3]

Abstract

An experiment was conducted at the field of USDA-Alliums project, Bangladesh Agricultural University, Mymensingh to study the effect of tillage and mulches on the growth and yield of garlic. The experiment consisted of three tillage conditions (conventional, puddling and zero tillage) and four mulches (control, rice straw, water hyacinth and *Curcuma amada* leaf). The results revealed that different mulches had remarkable contributions on the growth and yield of garlic. The highest values of growth parameters as well as bulb yield were obtained from rice straw mulch identical with that of water hyacinth mulch. Different tillage also had significant influence on yield and yield contributing traits of garlic. Garlic cultivated under zero tillage showed remarkable variation in terms of percent emergence. Puddling and zero tillage practices resulted in higher yield compared to the conventional tillage. It was also noticed that both the tillage conditions as well as mulches showed profound effects on the yield and yield contributing parameters. Moreover, the highest net return (196647Tk. /ha) and the highest BCR of 2.90 was obtained from zero tillage with rice straw.

Keywords: Tillage, mulches, growth, productivity, garlic.

Introduction

Garlic (*Allium sativum* L) is an aromatic herbaceous plant and the second most widely used *Allium* after onion (Bose and Som, 1990). This crop is extensively cultivated in many countries of the world including Bangladesh as a popular spice crop. Garlic is a rich source of carbohydrate and phosphorus (Rahman *et al*., 2007). The average yield of garlic in this country is only 5.21 t/ha (BBS, 2012). The poor yield of garlic may be due to the lack of inadequate soil and water management practices with reference to soil water shortage in the soil profile. Successful garlic cultivation largely depends on the optimum cultural management practices. These include judicious manuring, efficient use of residual soil moisture and mulching.

However, a considerable amount of fallow land in Mymensingh area can be brought under garlic cultivation through utilization of residual soil moisture as well as application of reduced supplemental irrigation. But the common practice of garlic production in the dry lands of this area is to make a good tilth of soil and maintain soil moisture near field capacity. So, it is vital to compare farmers'

[1]Professor, Department of Horticulture, Hajee Mohammad Danesh Sci. & Tech. University, Dinajpur, [2]Professor, Department of Horticulture, Bangladesh Agricultural University (BAU), Mymensingh, [3]Senior Farm Manager, BRAC-Potato Seed Production Program, Birol, Dinajpur.

practice of growing garlic under dry land conditions with that of the wet land conditions in the lowland area. However, little work has been done to test the feasibility of garlic production by conserving soil moisture through the management of tillage and mulch practice. So, the present investigation was carried out to observe the effect of tillage and mulches on the yield and yield contributing characters of garlic.

Materials and Method

The experiment was conducted at the Horticulture Farm, Bangladesh Agricultural University, Mymensingh under the Agro-ecological zone of Old Brahmaputra floodplain. The experiment consisted of three tillage conditions (conventional, puddling and zero tillage) and three mulches (rice straw, water hyacinth and sotty leaf mulch). It was laid out in a split plot design assigning tillage treatments in the main plot and mulches in the sub plot with three replications. In the conventional tillage, a good tilth of soil was made by four ploughings followed by laddering and puddling was made by two ploughings followed by irrigation. On the other hand, in the zero tillage conditions the plot was arranged without any tillage practices. The chemical compositions of the soils were analyzed at the Laboratory of Soil Resources Development Institute, Dhaka (soil pH of the lands were 6.15, 6.34 and 6.83, and organic matter contents were 2.86, 2.98 and 3.52%, respectively in conventional, puddling and zero tillage). The initial soil moistures of the lands were 27.69, 36.13.and 72.10%, respectively. Only organic manure was used in the experiment and @ 20 t/ha cow dung was applied as a basal dose (Kabir, 2011a; Kabir, 2011b). In case of conventional tillage and puddling conditions, cow dung was applied in the plot and mixed well with the soil by spading. But under zero tillage conditions, it was applied on the soil. BAU garlic-1 was used as the test materials and the cloves of garlic were planted on 27 November, 2008. Immediately after planting, 10cm thick rice straw, water hyacinth and sotty leaf mulch (*Curcuma amada*) were used in respective plots as per experimental specification. The emergence of plants was recorded by counting total number of emerged plants per plot. The crop was always kept under careful observation. Irrigation was applied according to the moisture status of the soil. Ten plants were selected at random from each plot and plant heights (cm), no. of leaves per plant, leaf area (cm^2) were recorded. Length and breadth of the leaf was measured and leaf area was calculated (leaf length × leaf breadth × 0.72) according to the method developed by (Djordje *et al*., 2011 and Hunt, 1978). Growth parameters were recorded at 20 days interval from 30 to 110 days after planting. Moreover, after fifteen days of planting and before harvesting of the crop the soil moisture status of the lands were estimated due to the variations of mulches (Table 1). The crop was harvested on the 30 march, 2009. Yield of bulb per plot was measured and it was converted into yield per hectare in metric ton. The data were recorded on percent dry matter of leaves, bulbs and roots, bulbs diameter (cm), no. of cloves

per bulb, yield of bulb per plot (kg) and yield of bulb per hectare (t/ha). The collected data were statistically analyzed and the mean differences were tested by the Least Significant Difference test (LSD) (Gomez and Gomez, 1984).

Table1. Average soil moisture content monitored in different mulches and tillage conditions at growth stage and before harvesting of plants

Different tillage	Mulches	Moisture (%)	
		Growth stage	Before harvesting
Normal or conventional tillage (N_t)	Control	16.57	10.60
	Water Hyacinth	21.30	14.34
	Straw	23.08	17.78
	Sotty leaf	20.26	12.28
Puddling(P_d)	Control	22.48	14.39
	Water Hyacinth	31.13	16.33
	Straw	30.96	18.86
	Sotty leaf	28.35	13.95
Zero tillage (Z_t)	Control	41.91	25.62
	Water Hyacinth	50.30	40.42
	Straw	48.13	38.23
	Sotty leaf	49.64	30.55

Results and Discussion

Effect of different mulches on garlic

The results presented in Table 2 showed that the effect of mulches were significant in respect of emergence of plant per plot. The highest (95.17 %) number of emergence was obtained from the rice straw mulch. No significant differences were observed between rice straw mulch (95.17 %) and water hyacinth mulch (93.64 %). The plants were grown with sotty (*Curcuma amada*) leaf mulch gave the lowest emergence (87.72 %) per plot. From the table 1, it was clear that soil moisture was low in case of sotty leaf mulch which may be the reason for low emergence of plant. The plant height increased gradually with the advancement of time and continued up to 90 days after planting (DAP((Table 2). At 90 DAP the tallest plant (72.38 cm) was obtained with rice straw mulch followed by the water hyacinth mulch (70.82 cm) and the lowest (61.89 cm) was recorded from the control. The lowest height at all

the dates of observation was found when the plants were grown without mulches or sotty leaf mulch. Garlic is a shallow rooted plant and it needs continuations moisture supply to the soil. But moisture content was not available at the root zone of the plant which may be the reason for lower height of the plant. The increase in plant heights due to various mulches in onion had been reported by Suh *et al*. (1991). Result revealed that at 90 days after planting rice straw mulch produced relatively higher number of leaves per plant (8.07) followed by water hyacinth mulch (7.93) (Table 2). Leaf area was recorded at 30, 50, 70, 90 and 110 days after planting (DAP) and differed significantly due to the application of different natural mulch materials (Table 3). The highest leaf area (39.13 cm^2) was found from rice straw mulch at 90 DAP followed by water hyacinth (37.34 cm^2) and control (29.47 cm^2). The lowest (29.10 cm^2) was observed from sotty leaf mulch. Again, at 30, 50, 70 and 110 days after planting rice straw mulch produced the highest leaf areas (11.65, 22.66, 36.01 and 35.97 cm^2, respectively) (Table 3).

On the other hand, the maximum fresh weight of leaves (17.80 g), fresh weight of bulb (18.96 g) and roots (0.73 g) per plant were obtained when the plants were grown with rice straw mulch (Table 4). The increased bulb weight produced in the rice straw was possibly for efficient use of available soil moisture, inhibition of weed growth, protection of surface soil erosion, reduction in nutrient loss from soil etc., which might conducive for yield contributing characters of plant resulting in the production of big sized bulb (Azam, 2005). On the other hand, the maximum dry weight of leaves (2.62 g), bulb (3.55 g) and roots per plants (0.22g) were found in rice straw mulch. The diameter of bulb per plant was the highest (3.40 cm) when the plants were grown with rice straw mulch, which was statically identical with water hyacinth significantly different from sotty leaf mulch (2.95 cm) and control (2.77 cm). The highest number of cloves per bulb (19.71) was recorded from water hyacinth mulch and the lowest (14.76) was found from control (Table 4). A highly significant variation in respect of yield per plot as well as yield per hectare was observed from the rice straw mulch. The highest yields per plot (2.21kg) and hectare (11.06 t) were obtained from the treatment rice straw mulch and the lowest (1.63 kg kg/plot and 8.15 ton/ha) was in the control (Table 4).

Rice straw mulch showed better performance than the control or sotty (*Curcuma amada*) leaf. The reason for higher yield in the rice straw mulch might be due to decreased soil temperature (Azam, 2005) and more efficient conservation of water, which favoured growth of the crop. High soil temperature suppressed the rate of root elongation and decreased root density in the surface layer of unmulched bare soil (Sans *et al.*, 1974). The increased root density enhanced better uptake of water and nutrients and ultimately increased plant height and yield of garlic. Furthermore, rice straw mulch prevented the weeds and thus plants grew without any competition. These results are in agreement with the experiences of Halim (2000) and Aliuddin (1986).

Effect of tillage conditions on garlic

The variations due to different tillage method under the study were highly significant in respect of percent emerged plant per plot. The highest emerged (93.67 %) plants were recorded from the zero tillage, which was statistically identical with puddling. On the contrary, the lowest (90.67 %) was recorded from the good tilth plot under dry land condition (Table 5). Plant height increased up to 90 days after planting and thereafter it declined due to senescence. The tallest plant (72.75 cm) was observed from zero tillage at 90 days after planting but a non significant difference was observed between zero tillage and puddling (Table 5). Again, the highest (8.05) number of leaves per plant was found from puddling condition at 90 DAP followed by zero tillage (7.35). The minimum number of leaves (6.93) was obtained from the well tilth plot (Table 5). The highest leaf area (36.59 cm^2) was recorded from the puddling at 90 DAP, which was statistically identical with that of the zero tillage (36.24 cm^2). On the contrary, the highest areas (11.37 and 23.26 cm^2) were recoded from zero tillage at 30 and 50 days after planting. From the table 6, it was also clear that at 30, 50, 70, 90 and 110 days after planting the lowest areas (7.59, 14.39, 24.65, 28.45 and 24.87 cm^2, respectively) were recorded from the conventional tillage. The highest fresh weight of leaves (17.40 g) and bulb (17.72 g) were observed from puddling condition. The lowest fresh weight of leaves (14.82 g) and bulb (15.45 g) was observed from conventional tillage (Table 7). But the maximum fresh weight of roots was observed from zero tillage (0.67 g) followed by puddling (0.66 g). The highest dry weight of leaves (2.57 g), bulb (3.22 g), and roots (0.20 g) were observed from puddling. The maximum diameter of bulb (3.22 cm) and the highest number of cloves per bulb (18.55) was recorded from zero tillage. A significant difference was observed on yield per plot as well as yield per hectare in respect of different tillage methods (Table 7). The maximum yields per plot (2.08 kg) and per hectare (10.38 ton) were recorded from puddling condition, which was statistically identical with zero tillage (2.00 kg and 9.97 ton). The minimum yield (1.78 kg/plot) and (8.89 t/ha) were recorded from the conventional tillage.

From the results it revealed that puddling and zero tillage produced higher yield compared to normal or conventional tillage method. Soil organic matter was higher in zero tillage and puddling than the conventional production method. Moreover, garlic is a shallow rooted plant and it needs continuous moisture supply to the soil. Zero tillage favoured greater and deeper water accumulation in the soil profile and profuse root growth (Mondal *et al*., 2007). Hence, moisture availability at root zone of the plant enhanced vegetative growth and ultimately higher yield. However, growth of the plant was restricted in conventional tillage due to lower initial moisture level in the soil. Reduced plant height might have caused lower nutrient uptake which is responsible for the poor yield of the crop (Mondal *et al*., 2007).

Table 2. Main effect of mulch on the growth of garlic at different days after planting

Treatment	Emergence (%)	Plant height (cm) at different DAP					Number of leaves/ plant at different DAP				
		30	50	70	90	110	30	50	70	90	110
M_0	93.46	29.56	40.89	54.51	61.89	59.73	4.22	5.02	6.53	6.84	6.51
M_1	95.17	37.69	47.11	62.87	72.38	68.47	5.11	5.42	7.82	8.07	7.67
M_2	93.64	36.93	46.22	62.71	70.82	66.60	4.91	5.58	7.53	7.93	7.58
M_3	87.72	33.78	41.96	55.56	62.20	58.80	4.29	5.02	6.64	6.93	6.69
LSD (0.05)	2.07	1.67	2.50	5.25	2.95	3.09	0.27	0.29	0.58	0.57	0.68
LSD (0.01)	2.82	2.27	3.39	7.14	4.00	4.20	0.37	0.40	0.79	0.78	0.92
Level of significance	**	**	**	**	**	**	**	**	**	**	**

** Significant at 1% level; DAP = days after planting.

M_0 = No mulch M_1 = Rice straw
M_2 = Water hyacinth and M_3 = Sotty leaf mulch

Table 3. Main effect of mulch on leaf area of garlic at different days after planting

Treatment	Leaf area (cm^2) at different DAP				
	30	50	70	90	110
M_0	6.92	15.94	25.32	29.47	26.60
M_1	11.65	22.66	36.01	39.13	35.97
M_2	10.88	22.02	34.59	37.34	33.54
M_3	8.92	16.48	27.11	29.10	25.60
LSD (0.05)	1.02	1.48	3.53	4.14	3.92
LSD (0.01)	1.39	2.03	4.83	5.67	5.37
Level of significance	**	**	**	**	**

** Significant at 1% level; DAP = days after planting.

M_0 = No mulch M_1 = Rice straw
M_2 = Water hyacinth and M_3 = Sotty leaf mulch

Table 4. Main effect of different mulch materials on the yield and yield contributing characters of garlic

Treatment	Fresh weight(g) of			Dry weight(g) of			Bulb diameter (cm)	Cloves/bulb (no.)	Yield (kg/plot)	Yield (t/ha)
	Leaves per plant	Bulb	Roots per plant	Leaves per plant	Bulb	Roots per plant				
M_0	14.18	13.84	0.53	2.09	2.46	0.16	2.77	14.76	1.63	8.15
M_1	17.80	18.96	0.73	2.62	3.55	0.22	3.40	19.56	2.21	11.06
M_2	17.07	18.20	0.68	2.52	3.30	0.22	3.29	19.71	2.19	10.92
M_3	15.51	15.91	0.58	2.28	2.88	0.18	2.95	16.16	1.77	8.86
LSD (0.05)	1.77	1.67	0.05	0.22	0.28	0.02	0.17	1.44	0.19	0.96
LSD (0.01)	2.41	2.27	0.07	0.29	0.38	0.03	0.23	1.96	0.26	1.31
Level of significance	**	**	**	**	**	**	**	**	**	**

** Significant at 1% level

P_d = Puddling N_t = Normal or conventional tillage and Z_t = Zero tillage

Table 5. Main effect of tillage on the growth of garlic at different days after planting

Treatment	Emergence (%)	Plant height (cm) at different DAP					Number of leaves/plant at different DAP				
		30	50	70	90	110	30	50	70	90	110
P_d	93.16	34.43	44.97	64.97	72.75	69.20	4.83	5.08	7.82	8.05	7.42
N_t	90.67	30.47	35.85	47.57	57.65	54.10	4.38	4.85	6.58	6.93	6.68
Z_t	93.67	38.57	51.32	64.20	70.07	66.90	4.68	5.85	7.00	7.35	7.23
LSD (0.05)	1.79	1.44	2.16	4.55	2.55	2.68	0.24	0.25	0.50	0.49	0.59
LSD (0.01)	2.44	1.96	2.93	6.18	3.47	3.64	0.32	0.35	0.69	0.67	0.80
Level of significance		**	**	**	**	**	**	**	**	**	**

** Significant at 1% level; DAP = days after planting.

P_d = Puddling, N_t = Normal or conventional tillage and Z_t = Zero tillage

Table 6. Main effect of tillage on leaf area of garlic at different days after planting

Treatment	Leaf area (cm^2) at different DAP				
	30	50	70	90	110
P_d	9.82	20.18	34.32	36.59	33.78
N_t	7.59	14.39	24.65	28.45	24.87
Z_t	11.37	23.26	33.31	36.24	32.63
LSD (0.05)	0.99	3.08	3.44	5.87	4.79
LSD (0.01)	1.64	5.11	5.70	9.74	7.94
Level of significance	**	**	**	*	*

** Significant at 1% level, * Significant at 5% level; DAP = days after planting.
P_d = Puddling, N_t = Normal or conventional tillage and Z_t = Zero tillage

Table 7. Main effect of tillage on the yield and yield contributing characters of garlic.

Treatment	Fresh weight(g) of			Dry weight(g) of			Bulb diameter (cm)	Cloves/bulb (no.)	Yield (kg/plot)	Yield (t/ha)
	Leaves per plant	Bulb	Roots per plant	Leaves per plant	Bulb	Roots per plant				
P_d	17.40	17.72	0.66	2.57	3.22	0.20	3.10	17.70	2.08	10.38
N_t	14.82	15.45	0.56	2.18	2.79	0.18	2.99	16.38	1.78	8.89
Z_t	16.20	17.02	0.67	2.39	3.14	0.20	3.22	18.55	2.00	9.97
LSD (0.05)	1.53	1.44	0.05	0.19	0.24	0.02	0.15	1.25	0.17	0.84
LSD (0.01)	2.08	1.96	0.06	0.25	0.33	0.03	0.20	1.70	0.23	1.14
Level of significance	**	**	**	**	**	**	**	**	**	**

P_d = Puddling N_t = Normal or conventional tillage and Z_t = Zero tillage
** Significant at 1% level,

Combined effect of tillage methods and mulches

Significant interaction and combined effects were found due to the combination of different mulches and tillage in respect of percent emergence. The results presented in the fig. 1 showed that the maximum emergence (97.63%) was obtained from the rice straw mulch with zero tillage followed by water hyacinth mulch with zero tillage (96.37 %), control with puddling (96.10 %) and rice straw mulch with puddling (95.07 %). It was observed that at 90 days after planting the tallest plant (78.07 cm) and the maximum number of leaves (8.60)

was found from rice straw mulch with puddling. On the other hand, the lowest plant height (51.40 cm) and minimum number (6.0) of leaves per plant were obtained in conventional tillage with sotty leaf mulch and zero tillage with no mulch, respectively (Fig. 2 & 3). The treatment combination of rice straw mulch with zero tillage (M_1Z_t) gave the highest leaf area (43.47 cm^2) at 90 DAP followed by puddling with rice straw (42.37 cm^2) and puddling with water hyacinth mulch (40.30 cm^2). Again, at 30, 50 , 70 and 110 days after planting the maximum leaf areas (13.67, 28.37, 41.70 and 40.47 cm^2, respectively) were also recorded from the combination of zero tillage with rice straw mulch (Table 8). On the other hand, the lowest area (5.87 cm^2) was noted from the conventional tillage with no mulch at 30 days after planting, whereas it was lowest in conventional tillage with sotty leaf mulch at 50, 70, 90 and 110 days after planting (Table 8). Treatment combinations of mulches and tillage also exhibited highly significant variation in respect of fresh weight of leaves. When the plants were grown under zero tillage with rice straw mulch, it produced the maximum (19.20 g) fresh weight of leaves, bulb (20.93g) and roots (0.83g). However, the minimum fresh weight of leaves (11.67 g), bulb (10.73 g) and roots (0.47 g) were recorded from the combination of zero tillage with no mulch (Table 9).

The highest dry weight of leaves per plant (2.83 g), dry weight of bulb (4.15 g) and the maximum (0.25g) dry weight of roots were observed from rice straw mulch with zero tillage and the lowest dry weight of leaves (1.72g), bulb (1.78 g) and roots (0.09g) were recorded from the treatment combination of no mulch with zero tillage (Table 9). Significant interaction and combined effect of different thickness of mulch and tillage were recorded on diameter of bulb that ranged from 2.39 cm to 3.77 cm. The highest number of cloves per bulb (22.20) was recorded in the treatment combination of zero tillage with rice straw mulch whereas, the lowest number of cloves per bulb (11.27) was found in the treatment combination of zero tillage with no mulch. The maximum and the minimum ((2.40 and 1.22 kg, respectively) yield of bulb were obtained from the treatment combinations of zero tillage with rice straw and zero tillage with no mulch. No significant differences were observed among the combinations of zero tillage with rice straw (2.40 kg), zero tillage with water hyacinth mulch (2.38 kg) and puddling with rice straw mulch (2.37 kg). The treatment combination of zero tillage with rice straw mulch produced the highest yield (12.00 t/ha) while the lowest yield (6.12 t/ha) was obtained from the combination of zero tillage with no mulch (Table 9).

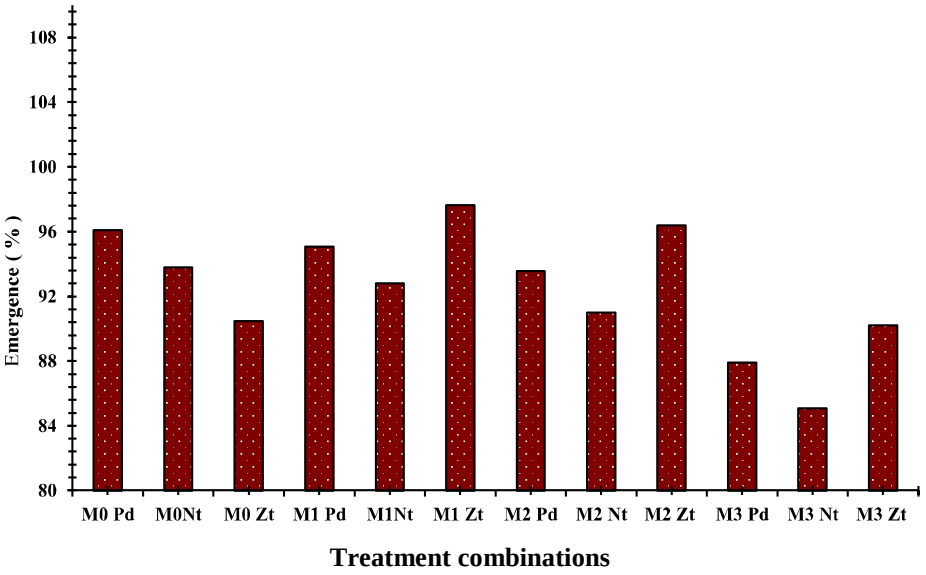

Fig. 1. Combined effect of mulch and tillage on the emergence of garlic.

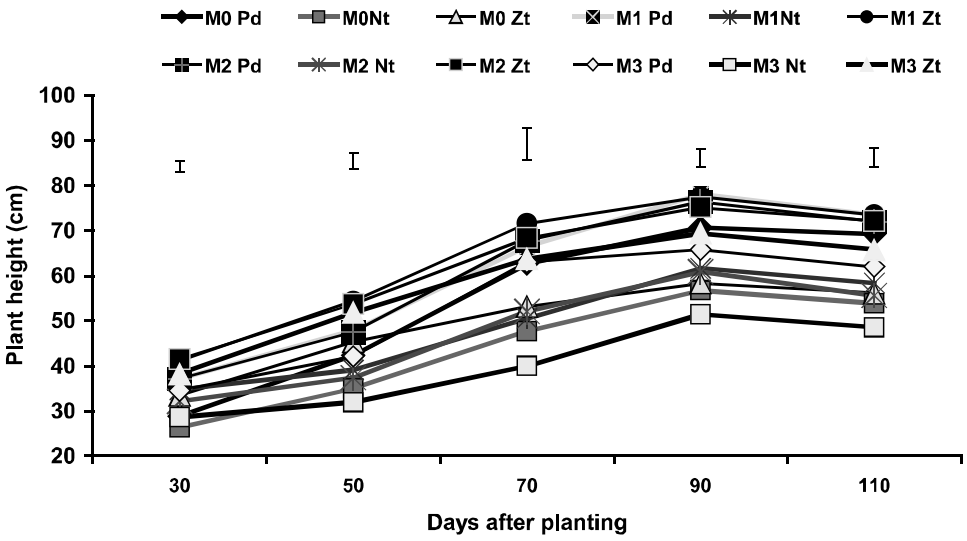

Fig. 2. Combined effect of mulch and tillage on the plant height of garlic at different days after planting. Vertical bars represent LSD at 0.05 level of significance.

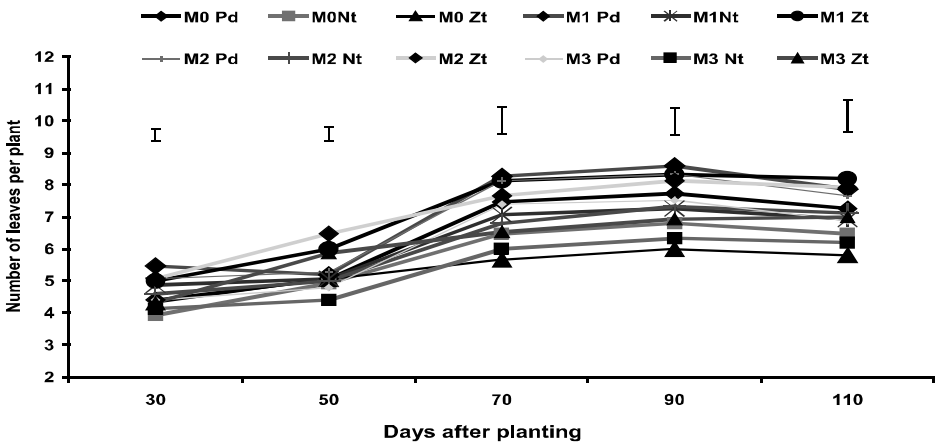

Fig. 3. Combined effect of tillage and mulch on the number of leaves per plant of garlic at different days after planting. Vertical bars represent LSD at 0.05 level of significance.

Table 8. Combined effects of mulch and tillage on leaf area of garlic at different days after planting

Treatment combinations	Leaf area (cm^2) at different DAP				
	30	50	70	90	110
M_0 P_d	7.74	17.63	31.90	33.80	31.63
M_0N_t	5.87	13.43	23.90	28.43	25.30
M_0 Z_t	7.13	16.77	20.17	26.17	22.87
M_1 P_d	11.63	23.17	38.47	42.37	39.33
M_1N_t	9.65	16.43	27.87	31.57	28.10
M_1 Z_t	13.67	28.37	41.70	43.47	40.47
M_2 P_d	10.48	22.67	37.60	40.30	37.57
M_2 N_t	8.65	16.53	27.70	31.60	26.60
M_2 Z_t	13.50	26.87	38.47	40.13	36.47
M_3 P_d	9.413	17.23	29.30	29.90	26.60
M_3 N_t	6.177	11.17	19.13	22.20	19.47
M_3 Z_t	11.167	21.03	32.90	35.20	30.73
LSD (0.05)	1.76	2.57	6.11	7.17	6.78
LSD (0.01)	2.41	3.52	8.37	9.83	9.29
Level of significance	**	**	**	**	**

DAP = days after planting, ** Significant at 1% level, PD= paddling, M_o= No mulch, M_1= Rice strand, M_2= water hyacynth, M_3= soft leaf mulch, N_t= normal or convention and Z_t= Zero tillage.

Table 9. Combined effects of different mulch materials and tillage on the yield and yield contributing characters of garlic

Treatment	Fresh weight(g) of			Dry weight (g) of			Bulb diameter (cm)	Cloves/bulb (no.)	Yield (kg/plot)	Yield (t/ha)
	Leaves per plant	Bulb	Roots per plant	Leaves per plant	Bulb	Roots per plant				
$M_0 P_d$	16.20	15.73	0.61	2.39	2.87	0.19	2.97	16.67	1.89	9.47
M_0N_t	14.67	15.07	0.53	2.16	2.73	0.16	2.96	16.33	1.77	8.87
$M_0 Z_t$	11.67	10.73	0.47	1.72	1.78	0.09	2.39	11.27	1.22	6.12
M_1P_d	19.00	19.87	0.75	2.80	3.60	0.23	3.37	18.60	2.37	11.87
$M_1 N_t$	15.20	16.07	0.61	2.23	2.91	0.19	3.07	17.87	1.86	9.32
$M_1 Z_t$	19.20	20.93	0.83	2.83	4.15	0.25	3.77	22.20	2.40	12.00
$M_2 P_d$	17.80	19.07	0.69	2.63	3.46	0.22	3.09	19.73	2.24	11.17
$M_2 N_t$	16.33	16.27	0.58	2.40	2.90	0.19	3.15	17.93	1.94	9.68
$M_2 Z_t$	17.07	19.27	0.77	2.51	3.53	0.25	3.63	21.47	2.38	11.90
$M_3 P_d$	16.60	16.20	0.59	2.45	2.95	0.18	2.97	15.80	1.81	9.03
$M_3 N_t$	13.07	14.40	0.54	1.91	2.61	0.17	2.79	13.40	1.54	7.68
$M_3 Z_t$	16.87	17.13	0.61	2.48	3.09	0.18	3.09	19.27	1.98	9.87
LSD (0.05)	3.07	2.89	0.09	0.37	0.49	0.04	0.29	2.50	0.33	1.67
LSD (0.01)	4.17	3.93	0.13	0.51	0.66	0.05	0.40	3.40	0.45	2.27
Level of significance	**	**	**	**	**	**	**	**	**	**

** Significant at 1% level

M_0 = No mulch
M_1 = Rice straw
M_2 = Water hyacinth and
M_3 = Sotty leaf mulch

P_d = Puddling
N_t = Normal or conventional tillage and
Z_t = Zero tillage

Economic analysis

It is evident from the Table 10 that the total cost of production was the highest (135768Tk. /ha) in conventional tillage with sotty leaf and the lowest expenditure of production (98469Tk./ha) was recorded from zero tillage with no mulch. But, the highest value of gross return (300000Tk. /ha) was obtained from the zero tillage with rice straw mulch. The lowest value of gross return (153000Tk. /ha) and net return (54531Tk. /ha) was obtained from the zero tillage with no mulch. Moreover, the highest net return (196647Tk. /ha) and the highest BCR of 2.90 was obtained from zero tillage with rice straw. Garlic production under zero tillage with water hyacinth

mulch gave the next highest net return of Tk.193703 and gave second highest BCR of 2.87. So, garlic cultivation under zero tillage covering either by rice straw or water hyacinth mulch was a very advantageous production system.

Table 10. Cost and return analysis of garlic due to different tillage and mulch materials

Treatment	Yield (t/ha)	Gross return (Tk. /ha	Total cost of production (Tk.)	Net return (Tk.)	BCR
M_0 P_d	9.47	236750	125445	111305	1.89
M_0N_t	8.87	221750	128109	93641	1.73
M_0 Z_t	6.12	153000	98469	54531	1.55
M_1 P_d	11.87	295750	130329	165421	2.27
M_1 N_t	9.32	233000	132993	100007	1.75
M_1 Z_t	12.00	300000	103353	196647	2.90
M_2 P_d	11.17	279250	132327	146923	2.11
M_2 N_t	9.68	242000	134991	107009	1.79
M_2 Z_t	11.90	297500	103797	193703	2.87
M_3 P_d	9.03	225750	133104	92646	1.69
M_3 N_t	7.68	192000	135768	56232	1.41
M_3 Z_t	9.87	246750	104574	142176	2.36

Rate of fresh garlic @25Tk./kg.

** Significant at 1% level
M_0 = No mulch
M_1 = Rice straw
M_2 = Water hyacinth and
M_3 = Sotty leaf mulch
P_d = Puddling
N_t = Normal or conventional tillage and
Z_t = Zero tillage

References

Azam, M. G. 2005. Effect of different mulches on growth and yield of onion. An M. S. Thesis, Department of Crop Botany, BAU, Mymensingh. 51p.

Aliuddin, T. 1986. Effect of soil tillage and application of mulch on yield of field grown garlic. Bull. *Penelitian Hortikultura*. **14**(1):23-37[Cited from Hort. Abst., **59**(4): 319,1989]

BBS. 2012. Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning. Government of the People's Republic of Bangladesh.

Bose, T. K. and M. G. Som .1990. *Vegetable Crops in India* (1st edn.), Naya Prakash, Calcutta, India, Pp. 583-601.

Djordje M., B.Vukasin, S. Dubravka, J. G. Varga, B. Damir, J. Slavica and Z Vlade. 2011. Effect of plant density on the characteristics of photosynthetic apparatus of garlic (*Allium sativum var. vulgare* L.). *Afr. J. Biotech*. **10**(71): 15861-15868

Gomez, K. A. and A. A.Gomez. 1984. *Statistical Procedure for Agricultural Research*. John Wiely and Sons. Inc. New York. Pp. 67-215.

Halim, A. 2000. Effects of mulches on the growth and yield of some garlic germplasms. An M. S. Thesis, Department of Horticulture, BAU, Mymensingh. 103p.

Hunt, R. 1978. *Plant Growth Analysis*. Edward Arnold Ltd., London, Studies in Biology. P. 67.

Kabir, M. A., M. A. Rahim and D. A. N. Majumder. 2011a. Effect of different levels of organic manures on the growth and yield of garlic. *J. Agrof. and Env. Bangladesh*. **5**(1): 73-76.

Kabir, M. A., M. A. Rahim and D. A. N. Majumder. 2011b. Effect of organic manure on the growth and yield of garlic under zero tillage conditions. *J. Agrof. and Env. Bangladesh*. **5**(1): 139-142.

Mondal, N. A., S. M. A. Hossain, S. U. Bhuiya and M. Jahiruddin. 2007. Tillage and mulch effects on soil environment, growth and yield of rainfed barley. Ann. Bangladesh Agric. **11**(2): 33-44.

Rahman M. K., M. A. Rahim and M. S. Alam. 2007. Effect of planting time and mulch on growth and yield of garlic. *J. Agrof. and Env*. **1**(1): 79-81.

Sans, L. M. A., M. Sobrinho, J. A. De, R. E. De, and H. I. V. Santors. 1974. The effect of mulching on soil humidity and other characteristics under a crop garlic. *Revista Ceres.* **21**(114): 91-104.

Suh, J. K., Y.B. Kim, Y. S. Lee, and K.Y. Han. 1991. A study of the improvement of the mulching cultivation method for onion *(AIlium cepa* L). Influence of mulch materials and times on growth, and yield. Res. Rep. of the Rural Dev. Adm. Hort. **33**(2): 31-36