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EFFECT OF MULCHING AND TILLAGE ON YIELD AND KEEPING QUALITY OF GARLIC (*Allium sativum* L.)

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Abstract

An experiment was carried out at the Horticulture Farm, Bangladesh Agricultural University, Mymensingh during rabi season of 2006-2007 to study the effects of different thickness of water hyacinth mulch and tillage on the storage life of garlic. The experiment was consisted of five depths of water hyacinth mulch (0, 6, 8, 10, and 12 cm) and two methods of tillage (conventional and zero). It was laid out in the split plot design with three replications. The study revealed that the bulbs from the zero tillage showed the highest storage quality resulting in the lowest weight loss (8.45%), insect infested bulbs (6.67%) as well as rotten bulbs (2.44%) after 150 days of storage. In contrast, bulbs grown under conventional tillage with no mulch and 6 cm thick mulch had the lower storage quality compared to those of other treatment combinations. The result showed that garlic production under zero tillage with 12 cm mulch could be used for better storability.

Keywords: Tillage, thick mulch, storage, and garlic.

Introduction

Garlic (*Allium sativum* L.) is one of the most important and ancient spices. It is the second most widely used *Allium* after onion with a characteristic pungent smell. Garlic has been considered as a rich source of carbohydrates, proteins, and phosphorus (Bose and Som, 1990). Moreover, the aqueous extract of garlic cloves (containing allicin and related disulphides) reduces cholesterol level in humans (Augusti, 1977). Garlic also helps eliminating waste materials and dangerous free radicals from the human body (Durak *et al*., 2004). The production of garlic is insufficient in Bangladesh and the country is to depend on its import.

Due to thermo and photosensitive nature of garlic (Rahim, 1988), the crop is commonly planted with the onset of winter and harvested at the early summer. So, the growers store the bulbs at room temperature upto winter either for consumption or planting in the field. As a result, the shelf life of garlic is relatively short due to high temperature and humidity. Water losses, insect infestation and disease infection are the main reasons for decay and deterioration

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of garlic during storage (Shamim, 2001). In the early summer, the weight loss of bulb is accelerated by high temperature and low humidity, whereas during the rainy season, the shelf life is hampered by insects and diseases too. Schippers (1968) reported that although high humidity effectively reduced weight loss, but it favoured fungal development. Pre-harvest growing conditions are also vital for the storage life of garlic (Rahman, 2001). Tillage practices play a notable role in conserving soil moisture at different depths of the soil profile (Mondal *et al*., 2007). As garlic is grown during the rabi season, farmers have to depend either on natural precipitation or on irrigation water. Therefore, judicious mulching may be an effective role to improve garlic production as well as storage. So, the present research work was undertaken to assess the effects of tillage and different thicknesses of water hyacinth mulch on the storability 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 was consisted of five depths of water hyacinth mulch (0, 6, 8, 10, and 12 cm) and two methods of tillage (conventional and zero). 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, whereas in the zero tillage conditions, the plot was made without any tillage practices. The initial soil moistures of the lands were 30.26 and 71.42%, respectively. Cow dung @ 20 t/ha was applied as the basal dose (Kabir, 2011a; Kabir, 2011b). In case of conventional tillage conditions, cowdung was applied in the plot and mixed well with the soil by spading. But under zero tillage conditions, it was applied on the soil. The cloves of garlic were planted on 15 November 2006. Immediately after planting, 6, 8, 10, and 12 cm thick dry water hyacinth mulch was added to the plots as per the treatments. Ten plants were selected at random from each plot for the collection of data. Leaf area per plant was measured by an electronic area meter ('ΔT Leaf Area Meter', USA) in the central laboratory, BAU, Mymensingh. Leaf area was estimated at 20 days interval from 30 to 110 days after planting. Total number of plants and no. of split necked plants were counted at 120 DAP. Moreover, soil moisture percent at the same day after planting was estimated due to the variation of different thicknesses of water hyacinth mulch (Table 1). The crop was harvested on the 28th March 2007. Yield of bulb per plot was measured and it was converted into yield per hectare in metric ton. The bulbs were cured for 4 days under shade before storing in an ordinary room (Pruthi, 2006). After curing, 30 bulbs from each treatment combination were selected randomly and stored on the floor of the laboratory conditions. Observations were made at 30 days interval upto 150 days to record data on percent weight loss. Besides, percent insect infested bulbs (number) and

percent rotten bulbs (number) were also recorded after 150 days of storage. The collected data were statistically analyzed and the mean differences were tested by the Least Significant Difference test (Gomez and Gomez, 1984).

Table 1. Average soil moisture content (0-15cm) monitored in different thicknesses of water hyacinth and tillage conditions after 120 days of planting.

Different tillage	Mulches	Moisture (%)
Conventional tillage (C_t)	Control	20.60
	6cm	23.33
	8cm	25.78
	10cm	27.28
	12cm	27.39
Zero tillage (Z_t)	Control	41.33
	6cm	48.84
	8cm	53.95
	10cm	57.62
	12cm	59.32

Note: Each value is the average of three readings.

Results and Discussion

Soil moisture content after 120 days of planting

There were variations in percent moisture content attributable to different thicknesses of mulch and tillage conditions. From the Table 1, it is clear that the zero tillage conserved more moisture (41.33 - 59.32%) than the conventional one (20.60 - 27.39%) after 120 days of planting. The highest soil moisture content (59.32%) was recorded from zero tillage with 12cm thick mulch and the lowest (20.60%) was observed from the conventional tillage with no mulch. As a result, moisture content was available at the root zone of the plant which may be the reason for producing intact necked plant under the zero tillage condition.

Effect of tillage on growth and yield of garlic

Treatment means in terms of leaf area was significant due to the tillage at 30, 50, 70, and 110 DAP (Table 2). The highest leaf area (42.27cm^3) was recorded from zero tillage (Z_t) at 90 days after planting. On the other hand, the lowest area (9.68cm^3) was recorded in control at 30 DAP. The results also revealed that there was a non-significant difference between the conventional and zero tillage conditions in respect of yield per hectare.

Effect of mulching on growth and yield of garlic

Leaf area of garlic was significantly influenced by the thicknesses of mulch at different DAP. The results presented in the Table 3 indicated that that leaf area increased with the advance of time from 30 to 90 days after planting. The highest leaf areas (14.47, 26.63, 40.95, 48.60, and 44.67 cm^3) were recorded from the 10 cm thick mulch at 30, 50, 70, 90, and 110 DAP, respectively. Nevertheless, the lowest areas (8.06, 17.37, 23.72, 26.62, and 25.03 cm^3) were observed in control plots at 30, 50, 70, 90, and 110 DAP, respectively. Again, the highest yield (9.17 t/ha) was recorded in 10 cm thick mulch and the lowest (5.20 ton/ha) yield was found in the control.

Table 2. Main effect of tillage on the growth and yield of garlic.

Treatment	Leaf area (cm^3) at different DAP					Yield (t/ha)
	30	50	70	90	110	
C_t	9.68	21.31	33.53	39.90	36.44	7.71
Z_t	14.14	24.37	36.32	42.27	39.15	7.80
LSD (5%)	1.00	2.98	2.44	4.93	2.70	0.51
CV (%)	9.94	6.98	6.00	6.22	9.77	8.55

C_t = Conventional tillage and Z_t = Zero tillage, DAP =Days after planting.

Table 3. Main effect of different thicknesses of mulch on the growth and yield of garlic.

Treatment	Leaf area (cm^3) at different DAP					Yield (t/ha)
	30	50	70	90	110	
D_0	8.06	17.37	23.72	26.62	25.03	5.2
D_1	11.06	21.57	34.53	40.08	37.15	7.25
D_2	13.07	25.20	39.90	47.25	42.92	9.08
D_3	14.47	26.63	40.95	48.60	44.67	9.17
D_4	12.93	23.43	35.52	42.88	39.20	8.09
LSD (5%)	1.45	1.95	2.57	3.13	4.52	0.80
CV (%)	9.94	6.98	6.00	6.22	9.77	8.55

D_0 = without mulch, D_1 = 6cm, D_2 = 8cm, D_3 = 10cm, D_4= 12cm thick mulch.

Combined effects of mulching and tillage on growth and yield of garlic

Significant combined effects were found due to the combinations of different thicknesses of mulches and tillage conditions in respect of leaf area. The 10cm

thick mulch and zero tillage conditions (D_3Z_t) produced the highest area of leaf (52.87 cm^3) at 90 DAP. On the contrary, the minimum (6.89 cm^3) value was recorded from D_0Z_t at 30 days after planting (Table 4). The combined effects of different thick mulch and tillage conditions on bulb yield were significant. The maximum (9.92 t/ha) and the minimum yields of bulb (4.23 t/ha) were obtained from the D_3Z_t and D_0Z_t, respectively.

Table 4. Combined effects of different thicknesses of water hyacinth mulch and tillage on the growth and yield of garlic.

Treatments	Leaf area (cm^3) at different DAP					Yield (t/ha)
	30	50	70	90	110	
$D_0 C_t$	8.91	17.40	26.60	30.23	28.07	6.17
$D_0 Z_t$	6.89	17.33	20.83	23.00	22.00	4.23
$D_1 C_t$	13.20	21.63	36.90	42.20	39.67	7.82
$D_1 Z_t$	9.22	21.50	32.17	37.97	34.63	6.68
$D_2 C_t$	11.17	24.00	40.77	50.63	48.60	9.07
$D_2 Z_t$	14.97	26.40	41.13	52.37	50.73	9.08
$D_3 C_t$	11.83	22.60	35.67	44.83	39.67	8.42
$D_3 Z_t$	17.10	30.67	44.13	52.87	46.17	9.92
$D_4 C_t$	9.62	21.10	32.43	41.23	37.60	7.07
$D_4 Z_t$	16.23	25.77	38.60	44.53	40.80	9.12
LSD (5%)	2.05	2.76	3.63	4.43	6.40	1.14
CV (%)	9.94	6.98	6.00	6.22	9.77	8.55

D_0 = without mulch, D_1 = 6cm, D_2 = 8cm, D_3 = 10cm and D_4= 12cm thick mulch.

C_t = Conventional tillage and Z_t = Zero tillage.

Effect of tillage on studied characters of garlic at storage

The maximum number of split necked plants/plot (13.01%) was found from the conventional tillage at 120 DAP (Table 5). Conversely, the intact necked plants were produced under the zero tillage condition, which is the probable reason for the high storability of garlic bulbs. After 150 days of storage, the conventional tillage (C_t) showed the highest rate of insect infested bulbs (11.31%) while the lowest (6.67%) was in the zero tillage (Table 5). Different tillage conditions showed significant variation in percent rotten bulbs at 150 days of storage. The highest rotten bulb (4.44%) was found from the conventional tillage but the lowest (2.44%) was recorded from the zero tillage (Table 5). From the results, it was revealed that garlic grown under zero tillage showed better storage performance than when it was grown with the conventional tillage conditions. The present investigation is in partial agreement with the conclusion of Thompson *et al*. (1972) who claimed that a number of factors influenced the storage life of onion bulb.

Effect of mulching on studied characters of garlic at storage

The percent split necked plant was significant due to the thicknesses of mulch. The maximum no. of split necked plants/plot (14.48%) was recorded from the control (no mulch) which differed significantly from the remaining treatments. On the contrary, the lowest value (2.09%) in this regard was observed from the 12cm mulch (Table 6). The highest percentage of insect infested bulbs (9.99) after 150 days of storage was observed at 6cm mulch (D_1), whereas, the lowest infested bulbs (7.22%) was found in 12cm mulch at the same storage. Again, the highest percentage of rotten bulb (3.89) was recorded from 6cm thick mulch whereas the lowest value (2.78%) was recorded from 12cm mulch (Table 6). The results showed that maximum insect infested bulbs and highest rotten bulbs were in 6cm water hyacinth mulch. On the contrary, 12cm mulch exhibited high storage capability compared to other treatments. The possible reasons may be that the bulbs obtained from the 6cm thick mulch or control relatively had higher no. of split necked bulbs, which lead for more infestation in the store by insects. So, there was a trend to decrease of insect infested bulbs and rotten bulbs with the increase of thickness of mulches.

Table 5. Percent split necked plants, percent number of insect infested bulbs and percent rotten bulbs as influenced by tillage conditions

Treatments	% Split necked plant at 120 DAP	% insect infested bulbs at 150 DAS	% rotten bulbs at 150 DAS
C_t	13.01	11.31	4.44
Z_t	0.00	6.67	2.44
LSD (5%)	0.97	0.29	0.36
CV (%)	12.44	12.51	24.21

C_t = Conventional tillage, Z_t = Zero tillage.
DAP = Days after planting and DAS = Days after storage.

Table 6. Percent split necked plants, percent number of insect infested bulbs and percent rotten bulbs as influenced by thicknesses of water hyacinth mulch.

Treatments	% Split necked plant at 120 DAP	% insect infested bulbs at 150 DAS	% rotten bulb at 150 DAS
D_0	14.48	9.42	3.33
D_1	6.98	9.99	3.89
D_2	5.17	9.98	3.33
D_3	3.79	8.33	3.89
D_4	2.09	7.22	2.78
LSD (5%)	1.54	0.47	0.56
CV (%)	12.44	12.51	24.21

D_0 = Control, D_1 = 6cm, D_2 = 8cm, D_3 = 10cm and D_4= 12cm thickness of mulch
DAP = Days after planting and DAS = Days after storage.

Table 7. Percent split necked plants, percent insect infested bulbs and percent rotten bulbs as influenced by thicknesses of water hyacinth mulch and tillage conditions.

Treatments	% Split necked plant at 120 DAP	% insect infested bulbs at 150 DAS	% rotten bulbs at 150 DAS
$D_0 C_t$	28.97	14.40	5.56
$D_0 Z_t$	0.00	4.44	1.11
$D_1 C_t$	13.97	12.20	4.44
$D_1 Z_t$	0.00	7.78	3.33
$D_2 C_t$	10.34	12.20	4.44
$D_2 Z_t$	0.00	7.78	2.22
$D_3 C_t$	7.58	9.99	4.44
$D_3 Z_t$	0.00	6.67	3.33
$D_4 C_t$	4.18	7.78	3.33
$D_4 Z_t$	0.00	6.67	2.22
LSD (5%)	2.17	0.65	0.80
CV (%)	12.44	12.51	24.21

D_0 = without mulch, D_1 = 6cm, D_2 = 8cm, D_3 = 10cm, D_4= 12cm thickness of mulch
C_t = Conventional tillage and Z_t = Zero tillage, DAP = Days after planting and DAS = Days after storage.

Combined effects of mulching and tillage on studied characters of garlic at storage

It was revealed that the maximum split necked plants/plot (28.97%) was recorded from the no mulch with the conventional tillage, which was significantly different from other combinations. Nevertheless, the zero tillage garlic showed unbroken necked plants with all the treatment combinations of mulch. The highest insect infested bulbs (14.40%) were recorded in the no mulch with the conventional tillage at 150 days of storage. Conversely, no mulch with the zero tillage gave the lowest number of infested bulbs (4.44%) at the same storage period (Table 7). Again, the conventional tillage with no mulch leads the maximum rotten bulbs (5.56%) after 150 days of storage and the lowest value (1.11%) was recorded from the zero tillage with no mulch. The yield of garlic was very low under the zero tillage condition with no mulch. So,

12 cm thickness of water hyacinth mulch was found superior for higher yield and storability of garlic (Table 4 and 7).

Percent weight loss of bulbs

Percent weight loss was found statistically significant due to different tillage conditions. Weight loss increased gradually with the advancement of time from 30 upto 150 days after storage. Therefore, the highest weight loss (12.79%) was observed from the conventional tillage at 150 DAS, whereas the lowest (8.45%) was in the zero tillage (Fig. 1). Different thicknesses of water hyacinth mulch showed significant variation in percent weight loss of bulbs at different periods of storage. It was observed that the stored bulbs of all treatments lost their weight progressively. The percent weight loss was highest (11.61%) after 150 days of storage with 6cm mulch. Conversely, the lowest weight loss (9.13%) was recorded from the 12cm mulch at the same period (Fig. 2). There was significant variation between the combined effects of different thicknesses of water hyacinth mulch and tillage conditions on the weight loss of bulbs. The highest weight loss (15.17%) was recorded from the no mulch with the conventional tillage after 150 days of storage. On the other hand, the lowest value (6.43%) was obtained from the no mulch with the zero tillage followed by 12cm mulch with zero tillage (8%) at the same length of storage (Table 8).

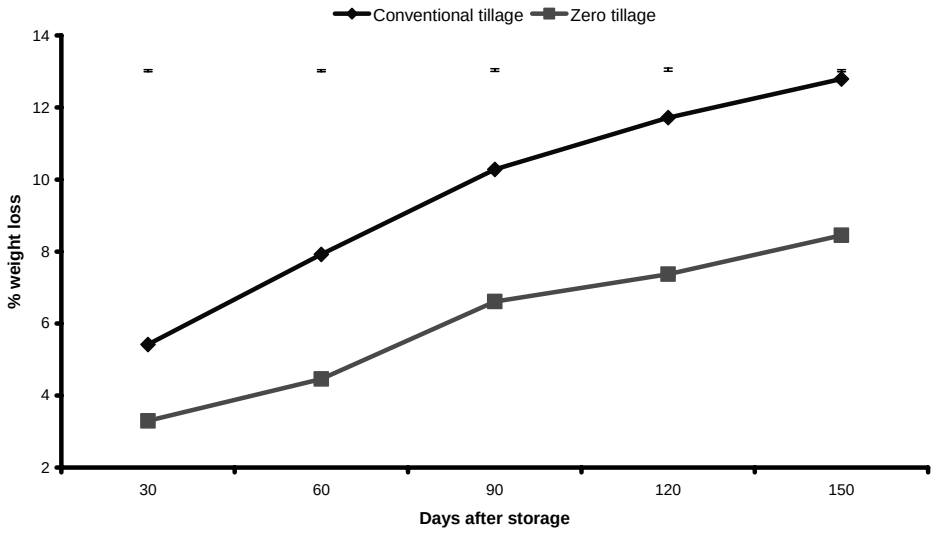

Fig. 1. Percent weight loss of garlic bulbs at different periods of storage as influenced by tillage conditions. Vertical bars indicate LSD at 0.05 level of significance.

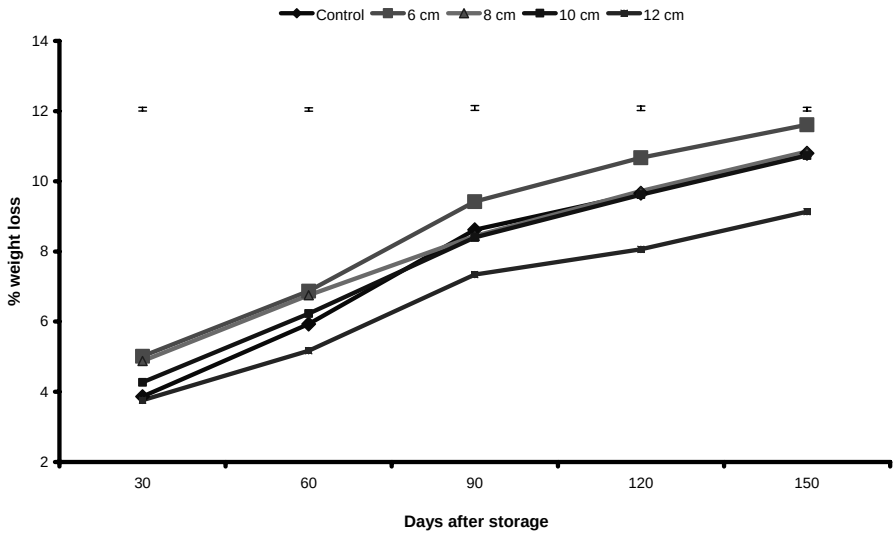

Fig. 2. Percent weight loss of garlic bulbs at different periods of storage as influenced by thickness of water hyacinth mulch. Vertical bars represent LSD at 0.05 level of significance.

Table 8. Percent weight loss of bulbs at different periods of storage as influenced by thicknesses of water hyacinth mulch and tillage conditions.

Treatments	Weight loss (%) at different DAS				
	30	60	90	120	150
$D_0 C_t$	5.91	9.02	12.53	13.77	15.17
$D_0 Z_t$	1.82	2.84	4.71	5.56	6.43
$D_1 C_t$	6.06	8.62	11.40	13.27	13.90
$D_1 Z_t$	3.97	5.12	7.45	8.07	9.31
$D_2 C_t$	5.70	8.43	9.76	11.63	12.67
$D_2 Z_t$	4.05	5.07	7.11	7.81	9.04
$D_3 C_t$	4.92	7.23	9.32	10.70	11.97
$D_3 Z_t$	3.63	5.22	7.47	8.54	9.49
$D_4 C_t$	4.50	6.28	8.37	9.25	10.27
$D_4 Z_t$	3.02	4.05	6.32	6.87	8.00
LSD (5%)	0.16	0.15	0.21	0.21	0.17
CV (%)	4.31	3.64	4.07	3.85	2.83

D_0 = without mulch, D_1 = 6cm, D_2 = 8cm, D_3 = 10cm and D_4= 12cm thickness of mulch
C_t = Conventional tillage and Z_t = Zero tillage, DAS = Days after storage

Correlation matrix

Correlation matrix was also computed to investigate the interrelationships among the different studied characters. It was revealed that no. of split necked

plants/plot and weight loss (%) at 150 days after storage had a positive correlation with the number of insect infested bulbs (%) and the number of rotten bulbs (%) at the same time of storage. The result also showed that no. of insect infested bulbs (%) was positively and significantly correlated with the number of rotten bulbs (%) at 150 days after storage (Table 9).

Table 9. Correlation matrix among the studied characters of garlic.

Traits	Percent weight loss at 150 DAS	Percent insect infested bulbs at 150 DAS	Percent rotten bulbs at 150 DAS
Percent split necked plant at 120 DAP	0.856 **	0.696 **	0.515 **
Percent weight loss at 150 DAS	–	0.784 **	0.650 **
Percent insect infested bulbs at 150 DAS	–	–	0.627 **

** Significant at 1% level of probability
DAP = Days after planting and DAS = Days after storage

Conclusion

The results showed that garlic production under zero tillage with 12cm mulch could be used for higher storability.

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