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EFFECT OF MULCHING AND DIFFERENT NITROGEN LEVEL ON THE GROWTH AND YIELD OF BROCCOLI (*Brassica oleracia*)

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ABSTRACT

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A field experiment was conducted to investigate the effect of mulching and nitrogen on the growth and yield of broccoli. The experiment was designed with four types of mulching (control, water hyacinth mulch, saw dust and black polyethylene mulch) and four different levels of nitrogen (control, 100 kg N/ha, 160 kg N/ha and 220 kg N/ha). Results revealed that mulching and nitrogen level significantly influenced the growth and yield of broccoli. Black polyethylene mulching resulted highest yield (12.77 t/ha) among four mulching treatments. On the other hand, 220 kg/ha nitrogen level resulted maximum yield (14.90 t/ha) compared with other nitrogen levels. Highest yield of broccoli (16.42 t/ha) was found in the combination of M_3N_3 treatment (black polyethylene mulch and 220 kg N/ha) and statistically similar with the result (15.95 t/ha) of M_1N_3 (water hyacinth mulch and 220 kg N/ha), whereas lowest yield (6.80 t/ha) was found for control treatment. Although, both M_3N_3 and M_1N_3 combination resulted maximum yield, M_1N_3 treatment was found economically profitable in respect of net return (Tk. 1,76,660 per hectare) with a benefit cost ratio of 3.82.

Key words: *mulching, nitrogen level, broccoli, growth, yield*

INTRODUCTION

Broccoli (*Brassica oleracia* var. *botrytis* L.) is a biennial and herbaceous vegetable crops belonging to the family Cruciferae. It is horticultural hybrid closely related to cauliflower and one of the minor winter vegetables in Bangladesh and commercially grown in the area of Dhaka and Gazipur districts. Among three types of broccoli namely, white, green and purple broccoli, green is the most popular (Shoemaker 1962). It is a rich source of vitamin A, ascorbic acid and B vitamins (thiamin, riboflavin, and niacin), calcium and iron (Thompson and Kelly, 1957; Lincolin 1987). It has been reported that it is more nutritious than other cole crops like cauliflower, cabbage and kohlrabi (Watt 1983).

Broccoli is originated from Europe (Parasad and Kumar, 1999) but can be cultivated in both sub-tropical and tropical areas. In Bangladesh, its cultivation has not been extended at farmer level due to lack of production technique and fertilization management. According to Katyal (1977), a wide range of soils from light to heavy loam or even clay well supplied with organic matter are suitable for broccoli cultivation. Like other winter vegetables, production of broccoli is influenced by the application of adequate fertilizer but a high amount of nitrogen is required in the growing season (Thompson and Kelly, 1957). It is observed that optimal curd for marketing can be resulted by the application of 125 kg N/ha (Toivonen *et al*. 1994) and 180 kg N/ha is optimal treatment for highest yield of broccoli (Haque *et al*. 1996).

Usually, broccoli is cultivated in Bangladesh during winter but it requires 250-300 mm water with more emphasis to transplanting and curd formation stage. During winter, irrigation is not only expensive, but also irrigation facilities are inadequate that resulting unprofitable production of broccoli in Bangladesh. To minimize the production cost of broccoli, mulching could be very effective that protects evaporation from soil surface. Increase in yield and nutrient content of several winter crops by mulching have been observed by Samaila *et al*. (2011) in tomato fruits, by Olfati *et al.* (2008) in carrots, by Najafabadi *et al*. (2012) in garlic and by Sekhon *et al.* (2008) and Gajc-Wolska *et al.* (2005) in sweet pepper. Soil mulching with rye, corn and buckwheat straw is found to be effective to increase the marketable yield in the total yield of broccoli (Kosterna 2014). Therefore, mulching can help in conserving soil moisture, which may be exploited to produce broccoli successfully particularly during winter.

In view of the above discussion, this research was undertaken to investigate the effect of mulching and nitrogen on broccoli yield and to identify the best combination of mulching and nitrogen level for better growth, yield and selected yield components of broccoli.

MATERIALS AND METHODS

This research work was carried out during the period from October 2003 to February 2004 at the horticultural farm of Bangladesh Agricultural University, Mymensingh. Where two-factor *viz*. four types of mulching (M_0= no mulch, M_1= water hyacinth mulch, M_2= saw dust mulch, M_3= black polythene sheet mulch) and four levels of nitrogen (N_0= 0 kg N/ha, N_1= 100 kg N/ha, N_2= 160 kg N/ha, N_3= 220 kg N/ha) consisting of sixteen treatments (M_0N_0, M_0N_1, M_0N_2, M_0N_3, M_1N_0, M_1N_1, M_1N_2, M_1N_3, M_2N_0, M_2N_1, M_2N_2, M_2N_3, M_3N_0, M_3N_1, M_3N_2, M_3N_3) combinations were laid out in split plot design with three replication.

Broccoli cultivation

The experimental land was ploughed by a power tiller followed by laddering. Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MP) were applied to the experimental plots at the rate of 220, 150 and 200 kg/ha, respectively. The whole amount of TSP and MP were applied a few days before application of mulches and transplanting. The total amount of urea was applied in three equal installments at 15, 30 and 45 days after transplanting in ring method. The thickness of water hyacinth mulch and saw dust was 8-10 cm. No irrigation was given to the mulched treatments after the placement of mulches and no irrigation was also given to the non-mulched plot. Twenty-three days old seedlings were uprooted carefully from the seedbed, and healthy and uniform sized seedlings were transplanted in the experimental plots. Row to row and plant to plant spacing of 50 x 50 cm^2 were maintained. Intercultural operations *viz.* (gap filling, weeding, earthing up, irrigation, pest and disease control) were done as when necessary. During the time of harvesting only the mature curds were harvested with 2-4 cm stalk by using a sharp knife. Secondary curds developed from the leaf axils were harvested over a period of time.

The plants were randomly selected in middle rows from each unit plot avoiding border effect, except yield of curds, which was recorded plot wise. Date were collected in respect of the following parameters to assess plant growth, yield attributes and yield as affected by different treatment of the experiment. Data on height of the plant, number of the leaves and crown spread of the plants were collected at 15, 30, 45 and 60 days after transplanting (DAT) and length of leaf, fresh weight of leaves, dry weight of leaves were recorded 60 days after transplanting. All other parameters recorded during harvest and after harvest.

Statistical analysis

The means for all the treatments were calculated and the analyses of variances for most of the characters under consideration were performed by F variance test. The significance of difference between pairs of treatment means was evaluated by the least significance difference (LSD) test at 1 and 5% level of probability.

Cost and return analysis

The cost and return analysis were calculated according to the procedure of Alam *et al.* (1989) as follows:

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross return per hactare (TK)}}{\text{Total cost of production per hactare (TK)}}$$

RESULTS AND DISCUSSION

Different types of mulches, nitrogen levels and mulching-nitrogen combination significantly affected the growth and yield components of broccoli. Effect of different treatments on selected parameters are presented in Tables 1, 2 and 3.

Leaf length at harvest

At 60 days after transplanting (DAT), the highest length of leaf was observed with black polyethylene mulch (M_3) but statistically similar with the result with water hyacinth mulch (M_1) (Table 1). In case of nitrogen treatment, N_3 (220 kg N/ha) resulted highest length of leaf (Table 2). On the other hand, maximum leaf length (47.30 cm) was observed at 60 DAT as combined effect of M_3N_3 (black polyethylene mulch + 220 kg N/ha) and statistically similar with the result (46.80 cm) for M_1N_3 (water hyacinth mulch + 220 kg N/ha) (Table 3). Minimum length of leaf was found for control among all treatments in this study. This finding was in agreement with the findings of Haque *et al.* (1996) and Tremblay (1984). Again, Baki *et al.* (1997) observed that 58% of the total mobilized nitrogen was accumulated in the leaf and helped to produce longer leaves.

Length of stem

Table 1 shows statistically similar result in length of stem of broccoli for black polyethylene mulch (M_3) and water hyacinth mulch (M_1). Stem length also increased with the increase of nitrogen level and maximum length (22.43 cm) was resulted for N_3 treatment (Table 2). Combined effect of mulch and nitrogen level resulted maximum length was observed with M_3N_3 and followed by M_1N_3 but significant difference was not observed between highest and second highest length of stem (Table 3). On the other hand, control sample resulted the lowest length of stem among all treatments.

Fresh and dry weight of leaves

Significant difference was not observed in fresh and dry weight of leaves of broccoli for black polyethylene mulch (M_3) and water hyacinth mulch (M_1) (Table 1). However, N_3 treatment resulted in highest weight of leaves in fresh and dry condition among nitrogen levels (Table 2). Again, significant difference in weight of leaves in both conditions was not observed for M_3N_3 and M_1N_3 combinations. The lowest weight was also found in control sample for all treatments. This result was supported by the findings of Karitonas (1999) who stated that fresh and dry weight of leaves largely depend on nitrogen level.

Root length

Black mulch significantly affected the length of root than other mulches but statistically not differed from the result for M_1 (Table 1). Nitrogen level also significantly affected the length of root and maximum length was found for N_3 treatment, whereas lowest was for control (Table 2). Highest and second highest root lengths were revealed for M_3N_3 and M_1N_3 treatment respectively, which were statistically similar.

Table 1. Effects of mulching on the growth and yield component of broccoli

Parameters	Different types of mulches				Level of significance	LSD (0.05)	LSD (0.01)	CV (%)
	M_0	M_1	M_2	M_3				
Length of leaf at harvest (cm)	33.27	42.37	35.27	43.79	**	3.11	4.72	4.88
Length of stem (cm)	18.97	22.03	20.65	22.34	**	2.06	3.12	3.68
Fresh weight of leaves (g)	315.50	409.51	337.93	435.66	**	18.54	28.08	3.22
Dry weight of leaves (g)	46.45	53.35	47.32	54.72	**	3.06	4.63	3.56
Length of root (cm)	28.83	31.00	29.68	32.04	**	1.80	2.72	3.68
Number of lateral roots	17.66	32.03	21.18	31.73	**	1.26	1.90	4.84
Days required for curd formation	62.50	58.54	61.33	57.31	**	4.02	6.09	4.06
Diameter of primary curd (cm)	12.41	14.43	12.94	14.85	**	1.05	1.59	7.17
Weight of primary curd (g)	179.75	209.82	186.75	228.35	**	14.97	22.68	3.89
Number of secondary cards/plant	4.74	5.69	4.99	6.37	**	0.51	0.77	6.29
Weight of secondary cards/plant (g)	74.14	89.69	78.98	91.29	**	4.09	6.19	4.10
Percent dry weight of curd	8.00	8.71	8.16	8.92	**	0.41	0.62	5.40
Yield per plant (g)	254.31	299.51	265.91	319.57	**	9.44	14.31	4.60
Yield per plot (kg)	4.06	4.79	4.25	5.12	**	0.15	0.23	4.79

**: Significant at 1% level of probability; M_0: No mulch; M_1: water hyacinth mulch; M_2: saw dust mulch; M_3: black polyethylene mulch

Number of lateral roots

Among all mulches, natural mulch namely, water hyacinth mulch (M_1) was found very effective to increase the number of lateral roots of broccoli (Table 1). It was found that increased nitrogen level significantly affected the lateral root numbers of broccoli plant. Table 3 shows that interaction of mulch and nitrogen level also affected the lateral root numbers and most affected by M_3N_3 (37.09) which was followed by M_1N_3 treatment (36.35). From this finding, it could be suggested that mulch kept the soil loose and cool, provided better aeration, available plant nutrients and soil moisture for better growth and development of roots. The present finding was in line with the observation of Runham *et al.* (2000).

Days required for curd formation

Table 1 indicates that black polyethylene mulch had only significant effect on lowering the days required for curd formation of broccoli. Minimum days (58.09) for curd formation were also observed with increased amount of nitrogen level (220 kg N/ha). Ying *et al.* (1997) also reported that increased nitrogen level advanced the harvesting date of broccoli. Days required for curd formation of broccoli for combined treatment of M_3N_3 was minimum (55.01 days) and followed by M_1N_3 (57.06 days). However, control treatment resulted in maximum days for curd formation.

Diameter of primary curd

Table 1 shows that significant difference was not found in diameter of primary curd between M_1 and M_3 treatments and the highest diameter (14.85 cm) was observed for M_3 mulch. But with the increased amount of nitrogen, diameter of curd increased significantly and maximum result was found for N_3 treatment and minimum was for control. Mitra *et al.* (1990), Santamia *et al.* (1994) and Haque *et al.* (1996) also reported increased curd size with the increasing dose of nitrogen. Table 3 indicates that there was no significant difference in curd diameters among M_1N_2, M_1N_3, M_3N_2 and M_3N_3 treatments. However, maximum diameter of curd (17.70 cm) was observed with M_3N_3 treatment.

Table 2. Effects of mulching on the growth and yield component of broccoli

Parameters	Different levels of nitrogen				Level of significance	LSD (0.05)	LSD (0.01)	CV (%)
	N_0	N_1	N_2	N_3				
Length of leaf at harvest (cm)	32.89	37.53	39.95	44.35	**	1.26	1.71	4.88
Length of stem (cm)	19.68	20.53	21.34	22.43	**	0.30	0.40	3.68
Fresh weight of leaves (g)	244.10	332.80	422.61	499.09	**	10.16	13.76	3.22
Dry weight of leaves (g)	39.94	47.38	54.49	60.03	**	1.51	2.05	3.56
Length of root (cm)	28.44	30.03	30.78	32.30	**	0.94	1.27	3.68
Number of lateral roots	21.42	23.81	26.86	30.50	**	1.05	1.42	4.84
Days required for curd formation	62.12	60.30	59.17	58.09	**	1.54	2.09	4.06
Diameter of primary curd (cm)	10.40	13.10	15.08	16.05	**	0.82	1.12	7.17
Weight of primary curd (g)	132.74	180.29	223.27	268.36	**	4.90	6.64	3.89
Number of secondary cards/plant	2.94	5.06	6.49	7.30	**	0.29	0.39	6.29
Weight of secondary cards/plant (g)	64.16	76.77	88.97	104.21	**	1.48	2.01	4.10
Percent dry weight of curd	7.58	8.48	9.28	8.45	**	0.38	0.52	5.40
Yield per plant (g)	197.32	256.99	312.24	372.75	**	8.64	11.71	4.60
Yield per plot (kg)	3.15	4.11	4.99	5.97	**	0.15	0.20	4.79

**: Significant at 1% level of probability; N_0: control; N_1: 100 kg N/ha; N_2: 160 kg N/ha; N_3: 220 kg N/ha

Weight of primary curd

It was observed that curd weight of broccoli greatly depends on mulches. Maximum weight of curd (228.35 g) was found for M_3 treatment, which was not statistically differed from the result (209.82 g) for M_1 treatment (Table 1). Curd weight also increased with the increase amount of nitrogen application. Similar result was reported by Baki *et al.* (1997) who found increased weight of curd due to high dose of nitrogen fertilizer. Highest primary curd weight (298.99 g) and second highest weight (289.48 g) result were observed for M_3N_3 and M_1N_3 treatment respectively, which are statistically similar. Control sample showed lowest weight of primary curd of broccoli in this study.

Number and weight of secondary curd/plant

Both of number and weight of secondary curd per plant significantly affected by different mulches and nitrogen levels (Tables 1 and 2). M_1 and M_3 treatments resulted maximum number (7.30 no) and highest weight (104.21 g) of secondary curds per plant. Both of two parameters also influenced by high level of nitrogen application (Table 2). M_3N_3 treatment was found effective to increase the number and weight of secondary curd per plant and statistically similar to results for M_1N_3 treatment. However, lowest value in yield was observed in control.

Percent dry weight of curd

Dry weight of curd also largely influenced by mulches and higher levels of nitrogen (Tables 1 and 2). Black polyethylene (M_3) and high level of nitrogen (N_3) increased the dry weight of curd significantly compared to other treatments. In contrast, Mitra *et al.* (1990) reported that increased nitrogen dose lowered the percent dry weight of curd. As a combined effect, highest result (10.04%) in dry weight of curd was recorded for M_3N_2 (polyethylene mulch + 160 kg N/ha) treatment and (9.78% dry weight) followed by M_1N_1 (water hyacinth + 160 kg N/ha). This indicates that medium nitrogen level with mulching is enough for resulting higher dry weight of curd.

Yield per plant and plot

Yield of broccoli was found to be significantly affected by mulches and nitrogen levels (Tables 1 and 2). Black polyethylene (M_3) and high level of nitrogen (N_3) increased the yield of broccoli significantly compared to control and other treatments. This result was similar with the finding of Everaarts *et al.* (1996) who observed increased yield of broccoli with nitrogen treatment of 260 kg N/ha. Table 3 indicates that M_3N_3 treatment increased the production of broccoli per both of plant and plot and second highest result in yield was recorded for M_1N_3 treatment that was statistically similar with highest result. However, lowest value in yield was observed in control.

Table 3. Effects of combined treatment on the growth and yield component of broccoli

Combined treatment	Growth and yield components of broccoli													
	Length of leaf at harvest (cm)	**Length of stem (cm)**	**Fresh weight of leaves (g)**	**Dry weight of leaves (g)**	**Length of root (cm)**	**Number of lateral roots**	**Days required for curd formation**	**Diameter of primary curd (cm)**	**Weight of primary curd (g)**	**Number of secondary cards/plant**	**Weight of secondary cards/plant (g)**	**Percent dry weight of curd**	**Yield per plant (g)**	**Yield per plot (kg)**
M_0N_0	28.00	16.99	180.98	34.10	26.50	13.36	65.69	9.65	114.45	2.03	54.00	7.22	170.12	2.72
M_0N_1	30.00	18.66	280.57	44.50	27.99	15.20	62.80	11.98	169.37	4.62	67.34	8.04	236.71	3.78
M_0N_2	34.10	19.30	360.33	49.70	29.93	19.07	61.21	13.70	195.49	5.90	79.52	8.32	275.01	4.40
M_0N_3	41.00	20.96	440.12	57.50	30.92	23.01	60.30	14.33	239.70	6.44	95.73	8.42	335.43	8.36
M_1N_0	35.78	20.96	284.33	45.03	28.9	28.23	59.40	10.63	140.57	3.68	69.97	7.86	210.54	3.36
M_1N_1	42.22	21.66	349.44	48.32	30.55	30.14	59.02	13.79	185.27	4.69	82.83	8.62	268.10	4.28
M_1N_2	44.70	22.47	468.76	58.62	31.67	33.40	58.11	16.10	223.96	6.60	96.59	9.78	320.55	5.12
M_1N_3	46.80	23.03	535.52	61.45	32.79	36.35	57.06	17.20	289.48	7.80	109.37	8.58	398.85	6.38
M_2N_0	30.90	19.78	190.59	34.67	27.32	16.73	63.79	10.21	120.34	2.28	60.82	7.24	181.16	2.89
M_2N_1	33.30	20.03	320.22	45.92	29.93	19.65	61.27	12.53	170.63	5.06	73.14	8.48	243.77	3.90
M_2N_2	34.60	20.99	380.62	50.62	29.99	22.80	60.28	14.03	210.76	5.97	82.09	8.98	292.85	4.68
M_2N_3	42.30	21.80	460.32	58.08	31.50	25.57	60.00	14.99	245.29	6.66	99.89	7.96	345.89	5.53
M_3N_0	36.89	21.00	320.53	45.98	30.95	27.37	59.03	11.11	155.61	3.78	71.85	8.01	227.46	3.63
M_3N_1	44.60	21.80	380.97	50.78	31.66	30.28	58.13	14.11	195.92	5.90	83.79	8.80	279.40	4.47
M_3N_2	46.40	22.60	480.73	59.02	31.56	32.19	57.11	16.50	262.89	7.50	97.68	10.04	360.57	5.76
M_3N_3	47.30	23.96	560.42	63.12	33.99	37.09	55.01	17.70	298.99	8.30	111.86	8.84	410.85	6.60
Level of significance	**	**		**	**	**	**	**	**	**	**	**	**	**
LSD (0.05)	2.528	0.595	20.31	3.02	1.88	2.093	3.086	1.649	9.80	0.5764	2.959	0.768	17.29	0.291
LSD (0.01)	3.426	0.807	27.53	4.10	2.55	2.836	4.182	2.235	13.29	0.7811	4.010	1.04	23.43	0.395
CV (%)	4.88	3.68	3.22	3.56	3.68	4.84	4.06	7.17	3.89	6.29	4.10	5.40	4.60	4.79

**: Significant at 1% level of probability; M_0: No mulch; M_1: water hyacinth mulch; M_2: saw dust mulch; M_3: black polyethylene mulch; N_0: control; N_1: 100 kg N/ha; N_2: 160 kg N/ha; N_3: 220 kg N/ha

Economic analysis

The details economic analysis is presented in Table 4.

Table 4. Cost and return of broccoli production due to mulching and different levels of nitrogen

Combined treatment	Yield (t/ha)	Total production cost (Tk./ha)	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio (BCR)
M_0N_0	6.80	49,763.19	1,02,000	52,236.81	2.04
M_0N_1	9.46	52,899.13	1,41,900	89,000.87	2.68
M_0N_2	11.00	54,333.44	1,65,000	1,10,666.56	3.03
M_0N_3	13.41	56,885.95	2,01,150	14,464.06	3.53
M_1N_0	8.42	45,907.14	1,26,300	71,392.86	2.30
M_1N_1	10.72	57,483.96	1,60,800	1,03,316.04	2.79
M_1N_2	12.82	59,477.39	1,92,300	1,32,822.61	3.23
M_1N_3	15.95	62,589.01	2,39,250	1,76,660.98	3.82
M_2N_0	7.24	58,150.06	1,08,600	50,449.94	1.86
M_2N_1	9.75	60,726.88	1,46,250	85,523.12	2.40
M_2N_2	11.71	62,720.32	1,75,650	1,12,929.68	2.80
M_2N_3	13.83	64,714.16	2,07,450	1,42,735.84	3.20
M_3N_0	9.09	61,728.46	1,36,350	74,621.54	2.20
M_3N_1	11.17	64,305.28	1,67,550	1,03,244.72	2.60
M_3N_2	14.42	66,298.72	2,16,300	1,50,001.28	3.26
M_3N_3	16.42	68,292.56	2,46,300	1,78,007.44	3.60

M_0: No mulch; M_1: water hyacinth mulch; M_2: saw dust mulch; M_3: black polyethylene mulch; N_0: control; N_1: 100 kg N/ha; N_2: 160 kg N/ha; N_3: 220 kg N/ha

The total production cost varied because of different mulches and variable doses of nitrogen and ranged from Tk. 49,763.19 to Tk. 68,292.56 per hectare. Highest production cost resulted for M_3N_3 treatment and lowest was obtained from control. The gross return from different treatment combinations ranged between Tk. 1,02,000 to Tk. 2,46,300 per hectare. On the other hand, the highest net return (Tk. 1,78,007.44/ha) was obtained from M_3N_3 treatment followed by M_1N_3 treatment (Tk. 1,76,660.98) and the lowest net return (Tk. 52,236.81/ha) was found for control. Therefore, M_1N_3 treatment resulted highest BCR (3.82) followed by M_3N_3 treatment (3.60) and lowest BCR (1.86) was observed for M_2N_0 treatment.

SUMMARY AND CONCLUSION

The mulching and nitrogen level had significant effect on the growth and yield components of broccoli. From this study, it was clear that higher production of broccoli could be produced by using suitable mulches and optimum doses of nitrogen. Though M_3N_3 (black polyethylene mulch + 220 kg N/ha) yielded the highest but involved high cost and was not readily available. From the economic point of view, the maximum benefit cost ratio (BCR) was obtained from M_1N_3 (water hyacinth mulch + 220 kg N/ha) followed by M_3N_3 and lowest BCR was found from M_2N_0 (saw dust mulch + 0 kg N/ha) treatment.

Therefore, the findings of this study indicated that treatment combination of M_1N_3 was found most profitable among treatments and could be recommended for the maximum net return in broccoli production under soil and climatic condition of the Old Brahmaputra Agro-ecological Zone in Mymensingh region.

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