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Influence of Starter Solution and Mulching on Growth and Yield of Broccoli

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Authors' contributions

This work was carried out in collaboration among all authors. Authors KK and MFS planned the experiment and lead the research. Authors MFS, KK and TM designed and carried out the research. Author MMH performed the statistical analysis. Author MFS carried out the research on the field. Authors MFS, SKD, SHB and JH collected the data. Authors MFS and MMH wrote the manuscript. Authors SKD, MA and MMH managed the literature searches. All authors provided critical feedback and helped shape the research, analysis and manuscript. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

A field experiment was accomplished in the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2018 to March 2019 to study on influence of starter solution and mulching on growth and yield of broccoli. The experiment comprised of four levels of starter solution viz., S_0 (Control), S_1 (1% Starter solution), S_2 (1.5% Starter solution) and S_3 (2% Starter solution) and four levels of mulching viz., M_0 (no mulch), M_1 (Black polythene), M_2 (Water hyacinth) and M_3 (Rice straw) were used in this experiment arranged in Randomized Complete Block Design (RCBD) with three replications. Data on different growth and yield attributes parameters were taken in which all the treatment showed significant variations. In the case of

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starter solution, maximum plant height (71.41 cm), number of leaves (15.35), canopy spread (78.86 cm) and weight of primary curd (416.41 g) were recorded from S_3 (2% urea solution) treatment. In the case of mulching, maximum plant height (73.02 cm), number of leaves (16.00), canopy spread (80.81 cm) and weight of primary curd (442.24 g) were recorded from M_1 (Black polythene) treatment. The highest yield (19.67 t/ha) was recorded from S_3 (2% Starter solution) whereas the lowest yield (14.83 t/ha) was obtained from S_0. Significantly higher yield (21.00 t/ha) was recorded from M_1 (Black polythene) while the lowest yield (12.88 t/ha) was obtained from M_0 treatment. In the case of the combined effects the maximum yield (24.07 t/ha) was recorded from the treatment combination of S_3M_1 while the lowest yield was (11.87 t/ha) recorded from S_0M_0 treatment. It was apparent from the above results that the treatment combination of S_3M_1 was more suitable for farmers than rest of treatment combinations.

Keywords: Broccoli; growth; mulching; starter solution and yield.

1. INTRODUCTION

Broccoli *(Brassica oleracea* var. *Italica* L) is an important winter vegetable crop under Brassicaceae family, which is originated from west Europe. It ranks at fourth place after cauliflower, cabbage and knolkhol among the cole crops. In Bangladesh it was introduced about two decades ago. Broccoli is a nutritionally important crop grown all over the world and it is a floral vegetable with an important nutritional value due to its content of vitamins, antioxidants, glucosinolates and anticarcinogenic compounds [1]. It contains protein (28.2%), carbohydrate (66.4%), fat (3.7%), minerals (Ca, P and Fe) and important vitamins like A, B and C [2]. It is fairly rich in vitamin A and C and contains appreciable amounts of calcium, phosphorus, riboflavin, thiamin, niacin, and iron [3,4]. Lincon, 1987 [4] reported that broccoli is more nutritious than any other cole crop such as cabbage, cauliflower and kohlrabi. It is environmentally better adapted and withstand comparatively at higher temperature than cauliflower. It can be grown on a wide range of soil types, ranging from light sand to heavy loam or, even clay that are well supplied with organic matter.

Broccoli produces smaller flowering shoots (side curd) from the leaf axil after the harvest of main apical curd. Consequently, a broccoli may be harvested over a considerable period of time. It has wider environmental adaptability, higher nutritive value, good taste, less risk of crop failure and various biotic and abiotic factors indicate that there is enough scope for its large-scale cultivation. Its cultivation has not been expanded much beyond the farms of different agricultural organizations. This is mainly due to lack of awareness regarding its nutritional value and method of production. Broccoli is environmentally better adapted than cauliflower and reported to withstand comparatively higher temperature than cauliflower [5].

Successful production of broccoli depends on various factors where fertilizer management and mulching both are important that contribute in the production and yield of broccoli. Starter solutions are mixtures of soluble fertilizer and water that facilitates the young plants to have a good start. Starter solution provides a ready source of nutrition near the absorbing zone of the seedlings just after transplanting & provides a quick recovery of transplanted seedlings. The time between uprooting and establishment of young and tender seedings in the fields is very critical. Cabbage, cauliflower, tomato responded better to starter solution in minimizing the transplanting shock and are encouraged to a quick growth [6]. Nitrogen used as starter solution resulted in significant increase in largest leaf length, number of leaves, stem diameter etc. [7].

Broccoli is generally cultivated in Bangladesh during the winter season when rainfall is scanty. But for the whole growing period broccoli requires 250-300 mm water with more emphasis to transplanting and curd formation stage [8]. Any practice that acts as a barrier to the evaporation of water or heat from the soil surface can be defined as mulching. Artificial mulching, covering the soil surface with plant species, crop residues or polythene sheet, which are generally used in the production of horticultural crops like potato, onion, zinger cabbage, cucurbits etc [9]. This practice suppresses weeds resulting in higher yield and quality produce. It is one of the best management practices, which conserve soil moisture [10], regulates the soil temperature [11]. Mulching can minimize the requirement of water and helps in retaining moisture [12]. Mulches also reduce the water loss from the soil by

evaporation and reduce the irrigation requirements [13]. Mulching improves soil physical conditions by enhancing biological activity of soil flora and fauna and increase soil fertility [14].

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was conducted at the Horticulture Farm of Sher-e- Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period from October 2018 to February 2019. The experimental site was located on an elevation of 8 meters above the sea level in Agro-ecological zone of "Madhupur Tract" (AEZ-28), The soil was sandy loam and medium high land in texture with the pH value of 5.62 [15].

2.2 Experiment Frame Work

The research was consisted of two factors: Factor A: Starter solution (urea solution at four levels) as- S_0= 0% Starter solution (control) S_1= 1 % Starter solution, S_2= 1.5% Starter solution S_3= 2% Starter solution and factor B: Mulching (four levels) as- M_0 =No Mulching (Control) M_1= Black polythene M_2=Water hyacinth M_3=Straw. The two factors experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. The experiment was divided into three equal blocks where each block was divided into 16 plots. Then 16 treatment combinations were allotted at randomly in each block. The size of each unit plot was 1.8 m × 1.2 m. The distance maintained between two blocks and two plots were 0.7 m and 0.5 m, respectively. The seedlings were transplanted with maintaining distance row to row 60 cm and plant to plant 40 cm.

2.3 Application of Starter Solution

The seedlings were treated with starter solution just before being transplanted. The roots of the uprooted seedlings were merged into starter solution just for a while (about 5 minutes) and then immediately transplanted [16].

2.4 Application of Mulching

Black polythene was spread on the plot just before transplanting where water hyacinth and rice straw were used as mulch materials just a week after transplant.

2.5 Statistical Analysis

The data obtained for different parameters were statistically analyzed by MSTAT-C computer package. The significance of the difference among the treatment combinations means was compared by LSD test at 5% level of probability [17].

3. RESULTS AND DISCUSSION

3.1 Plant Height (Cm)

Plant height increased with the increasing percentage of starter solution at 20, 40 and 60 DAT (Table 1). At 20, 40 and 60 DAT (days after transplanting), the maximum plant height (26.17 cm, 50.95 cm and 71.41 cm respectively) was recorded from S_3 while the minimum plant height at 20, 40 and 60 DAT (17.99 cm, 41.77 cm and 62.29 cm respectively) was recorded from S_0 (Table 1). The present result of the study is supported by the findings of Chhonkar and Jha, 1963 [6]. At 20, 40 and 60 DAT, the maximum plant height (27.79 cm, 52.87 cm and 73.02 cm respectively) was recorded from M_1 where minimum plant height (15.16 cm, 38.77 cm and 58.58 cm respectively) was recorded from M_0 (Table 2). The combination between starter solution and mulching treatments affects significantly on plant height (Table 3). Maximum plant height at 20,40, 60 DAT (31.46 cm, 58.86 cm and 77.62 cm respectively) was recorded from S_3M_1 where minimum plant height (13.18 cm, 37.31 cm and 56.55 cm respectively) was recorded from S_0M_0.

3.2 Number of Leaves Per Plant

Leaf number varied significantly with increasing amount of starter solution for 20, 40 and 60 DAT (Table 1). At 20, 40 and 60 DAT, the maximum number of leaves (8.15, 12.98 and 15.35 respectively) was recorded from S_3. The reason may be that, application of 2% starter solution might have improved absorption of nutrient, physiological activity, increased rate of photosynthesis and reduced transpiration. These results are in support of the findings of Chaudhury and Singh, 1960 [18]. On the other hand, the minimum number of leaves (6.78, 10.58 and 13.18 respectively) was recorded from S_0. Again, at 20, 40 and 60 DAT, the maximum number of leaves (8.48, 13.65 and 16.00 respectively) was recorded from M_1 where the minimum number of leaves (6.36, 9.63 and 12.23

respectively) was recorded from M_0 (Table 2). The number of leaves was significantly influenced by the combined effect of starter solution and mulching at 20, 40 and 60 DAT (Table 3). At 20, 40 and 60 DAT, the maximum number of leaves (9.20, 15.26 and 17.20 respectively) was recorded from S_3M_1 where the minimum number of leaves (5.93, 9.06 and 11.60 respectively) was recorded from S_0M_0.

3.3 Leaf Length Per Plant (Cm)

At 20, 40 and 60 DAT, the maximum length of leaf (22.29 cm, 41.98 cm and 50.92 cm respectively) was measured from S_3 while the minimum length of leaf (18.30 cm, 38.31 cm and 45.95 cm respectively) was measured from S_0 (Table 1). This result is in agreement with El-Afifi et al., 2014 [7]. At 20, 40 and 60 DAT, the maximum length of leaf (22.46 cm, 42.24 cm and 51.22 cm respectively) was measured from M_1 where minimum length of leaf (17.06 cm, 37.30 cm and 44.73 cm respectively) was measured from M_0 (Table 2). Leaf length of broccoli plant showed statistically significant difference due to the combined effect of starter solution and mulching at 20, 40 and 60 DAT (Table 3). At 20, 40 and 60 DAT, the maximum length of leaf (25.64 cm, 45.32 cm and 54.71 cm respectively) was measured from S_3M_2 (2% starter solution with water hyacinth mulch) where the minimum length of leaf (15.14 cm,36.58 cm and 43.69 cm respectively) was measured from S_0M_0.

3.4 Leaf Breadth (Cm)

The breadth of leaf of broccoli varied significantly with the application of different levels of starter solutions at 20, 40 and 60 DAT (Table 4). At 20, 40 and 60 DAT, the highest breadth of leaf (10.66 cm, 14.45 cm and 18.35 cm respectively) was recorded from S_3 where the lowest breadth of leaf (8.44 cm, 11.98 cm and 14.56 cm respectively) was recorded from S_0. Again, in the case of mulching, at 20, 40 and 60 DAT, the highest breadth of leaf (11.25 cm, 14.79 cm and 19.12 cm respectively) was recorded from M_1, where the lowest breadth of leaf (7.79 cm, 11.24 cm and 13.53 cm respectively) was recorded from M_0 (Table 5). This might be due to mulching has profound influence on plant growth parameters like leaf area index (LAI), net assimilation rate (NAR), crop growth rate (CGR), relative growth rate (RGR), also influence on soil temperature and moisture. Miedema, 1982 [19]; Awal and Khan, 1999 [20] found the same results in their investigations. The leaf breadth was significantly influenced by the combined effect of starter solution and mulching at 20, 40 and 60 DAT (Table 6). At 20, 40 and 60 DAT, the highest breadth of leaf (12.44 cm, 16.58 cm and 21.82 cm respectively) was recorded from S_3M_1, where the lowest breadth of leaf at 20, 40 and 60 DAT (7.54 cm, 10.30 cm and 12.95 cm respectively) was recorded from S_0M_0.

3.5 Plant Canopy Spread (Cm)

At 20, 40 and 60 DAT, the maximum plant canopy spread (29.03 cm, 53.89 cm and 78.86 cm respectively) was measured from S_3 where the minimum canopy spread (24.14 cm, 46.53 cm and 68.39 cm respectively) was measured from S_0 (Table 4). Again at 20, 40 and 60 DAT, the maximum canopy spread (29.75 cm, 54.10 cm and 80.81 cm) was measured from M_1 where the minimum canopy spread (22.32 cm, 45.76 cm and 64.87 cm respectively) was measured from M_0 (Table 5). Plant canopy spread was found to be significantly different due to the combined effect of starter solution and mulching at 20, 40 and 60 DAT (Table 6). At 20, 40 and 60 DAT, the maximum plant canopy spread (32.04 cm, 59.16 cm and 85.10 cm respectively) was measured from S_3M_1 where the minimum canopy spread (21.21 cm, 43.60 cm and 62.56 cm respectively) was measured from S_0M_0 [19].

3.6 Stem Diameter

Significant variation among the starter solutions had been observed in diameter of stem at harvest (Table 4). At harvesting, the maximum stem diameter (2.43 cm) was measured from S_3 (2% starter solution) treatment while the minimum stem diameter (1.89 cm) was recorded from S_0 (control) treatment. The stem diameter of plant was found to be significantly influenced due to the application of different types of mulches (Table 5). At harvesting, the maximum stem diameter (2.47 cm) was measured from M_1 (black polythene mulch) treatment while the minimum stem diameter (1.68 cm) was recorded from M_0. The combined effect of different starter solutions and mulching was also found significant in respect of diameter of stem of broccoli plant at harvest (Table 6). At harvesting, the maximum stem diameter (2.82 cm) was observed in S_3M_2 (2% starter solution with water hyacinth mulch) treatment combination and the minimum stem diameter (1.55cm) was recorded from S_0M_0 (control) treatment combination.

Table 1. Effect of starter solution on plant height, no. of leaves per plant and leaf length per plant of broccoli at different days after transplant

Treatments	Plant height (cm)			No. of leaves per plant			Leaf length per plant (cm)		
	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
S_0	17.99 c	41.77 c	62.29 d	6.78 c	10.58 d	13.18 c	18.30 c	38.31 c	45.95 c
S_1	22.15 b	45.44 b	67.22 c	7.43 b	11.68 c	14.16 b	20.08 b	40.12 b	48.20 b
S_2	25.26 a	49.74 a	69.70 b	8.10a	12.66 b	15.25a	21.50 a	41.35 a	49.98 a
S_3	26.17 a	50.95 a	71.41 a	8.15a	12.98 a	15.35 a	22.29 a	41.98 a	50.92 a
CV %	7.41	8.67	8.25	9.98	8.16	10.97	10.68	11.58	10.45
LSD (0.05)	1.48	1.66	1.61	0.14	0.22	0.23	0.79	0.87	1.08

In a column means having similar letter (s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of probability here; S_0=0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution; M_0 =No Mulching (Control), M_1= Black polythene mulch, M_2=Water hyacinth mulch, M_3=Straw mulch

Table 2. Effect of mulching on plant height, no. of leaves per plant and leaf length per plant of broccoli at different days after transplant

Treatments	Plant height (cm)			No. of leaves			Leaf length per plant (cm)		
	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60DAT
M_0	15.16 c	38.77 d	58.58 c	6.36 d	9.63 d	12.23 d	17.06 c	37.30 c	44.73 c
M_1	27.79 a	52.87 a	73.02 a	8.48 a	13.65 a	16.00 a	22.46 a	42.24 a	51.22 a
M_2	24.83 b	49.07 b	69.61 b	8.00 b	12.56 b	15.18 b	21.87 a	41.64 a	50.03 b
M_3	23.80 b	47.19 c	69.41 b	7.61 c	12.06 c	14.53 c	20.78 b	40.57 b	49.08 b
CV %	7.41	8.67	8.25	9.98	8.16	10.97	10.68	11.58	10.45
LSD (0.05)	1.31	1.47	1.48	0.12	0.25	0.28	0.56	0.63	1.01

In a column means having similar letter (s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of probability here; S_0=0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution; M_0 =No Mulching (Control), M_1= Black polythene mulch, M_2=Water hyacinth mulch, M_3=Straw mulch

Table 3. Combined effect of starter solution and mulching on plant height, no. of leaves per plant and leaf length per plant of broccoli at different days after transplant

Treatment combinations	Plant height (cm)			No. of leaves per plant			Length of leaf per plant (cm)		
	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
S_0M_0	13.18 l	37.31 l	56.55 k	5.93 j	9.06 m	11.60 j	15.14 k	36.58 h	43.69 j
S_0M_1	21.10 gh	43.92 g-i	65.58 gh	7.26 de	11.40 hi	14.13 de	19.74 f-h	39.31 fg	47.42 f-h
S_0M_2	17.98 ij	42.40 h-j	62.84 hi	7.06 ef	11.13 ij	13.73 ef	18.78 hi	38.24 gh	46.11 g-i
S_0M_3	19.71 hi	43.46 hi	64.21 h	6.86 fg	10.73 j	13.26 fg	19.53 gh	39.10 fg	46.60 g-i
S_1M_0	14.51 kl	37.59 kl	58.18 jk	6.33 i	9.53 l	12.06 ij	16.82 j	37.24 h	44.48 ij
S_1M_1	27.84 b-d	51.38 cd	73.20 b-d	8.33 b	13.26 de	15.53 c	22.22 b-d	42.03 c-e	51.03 cd
S_1M_2	22.42 f-h	45.66 f-h	67.63 fg	7.46 cd	11.73 h	14.53 d	20.62 e-g	40.54 ef	48.18 e-g
S_1M_3	23.83 e-g	47.13 e-g	69.88 ef	7.60 c	12.20 g	14.53 d	20.68 d-g	40.66 ef	49.12 d-f
S_2M_0	15.73 j-l	39.42 j-l	58.67 jk	6.53 hi	9.80 kl	12.40 hi	17.61 ij	37.34 h	45.15 ij
S_2M_1	30.75 ab	57.32 ab	75.68 ab	9.13 a	14.66 b	17.13 a	24.78 a	44.40 ab	53.89 ab
S_2M_2	29.40 a-c	53.78 c	73.24 b-d	9.00 a	13.73 c	16.40 b	22.43 bc	42.47 cd	51.12 cd
S_2M_3	25.18 d-f	48.46 d-f	71.21 de	7.73 c	12.46 fg	15.06 c	21.20 c-f	41.17 de	49.78 de
S_3M_0	17.21 i-k	40.77 i-k	60.94 ij	6.66 gh	10.13 k	12.86 gh	18.66 hi	38.04 gh	45.59 h-j
S_3M_1	31.46 a	58.86 a	77.62 a	9.20 a	15.26 a	17.20 a	23.11 b	43.23 bc	52.54 bc
S_3M_2	29.50 ab	54.44 bc	74.73 a-c	8.46 b	13.66 cd	16.06 b	25.64 a	45.32 a	54.71 a
S_3M_3	26.50 c-e	49.73 de	72.33 c-e	8.26 b	12.86 ef	15.26 c	21.73 b-e	41.35 de	50.83 cd
CV %	7.41	8.67	8.25	9.98	8.16	10.97	10.68	11.58	10.45
LSD (0.05)	2.96	3.32	3.22	0.28	0.45	0.47	1.59	1.74	2.16

In a column means having similar letter (s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of probability here; S_0=0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution; M_0 =No Mulching (Control), M_1= Black polythene mulch, M_2=Water hyacinth mulch, M_3=Straw mulch

Table 4. Effect of starter solution on leaf breadth and canopy spread at different days after transplant and stem diameter at harvest of broccoli

Treatments	Leaf breadth (cm)			Canopy spread (cm)			Stem diameter at harvest (cm)
	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT	
S_0	8.44 c	11.98 d	14.56 c	24.14 d	46.53 c	68.39 d	1.89 d
S_1	9.64 b	13.27 c	16.64 b	26.64 c	50.19 b	74.22 c	2.10 c
S_2	10.37 a	13.83 b	17.81 a	28.02 b	51.76 ab	76.80 b	2.30 b
S_3	10.66 a	14.45 a	18.35 a	29.03 a	53.89 a	78.86 a	2.43 a
CV %	9.62	10.66	11.43	9.27	9.56	12.87	7.31
LSD (0.05)	0.33	0.47	0.79	0.35	3.20	0.63	0.09

In a column means having similar letter (s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of probability here; S_0=0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution; M_0 =No Mulching (Control), M_1= Black polythene mulch, M_2=Water hyacinth mulch, M_3=Straw mulch

Table 5. Effect of mulching on leaf breadth and canopy spread at different days after transplant and stem diameter at harvest of broccoli

Treatments	Leaf breadth (cm)			Canopy spread (cm)			Stem diameter at harvest (cm)
	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT	
M_0	7.79 c	11.24 c	13.53 c	22.32 d	45.76 c	64.87 d	1.68 d
M_1	11.25 a	14.79 a	19.12 a	29.75 a	54.10 a	80.81 a	2.47 a
M_2	10.11 b	13.96 b	17.44 b	28.30 b	51.96 ab	77.31 b	2.36 b
M_3	9.95 b	13.54 b	17.26 b	27.46 c	50.552 b	75.29 c	2.22 c
CV %	9.62	10.66	11.43	9.27	9.56	12.87	7.31
LSD (0.05)	0.26	0.33	0.56	0.44	2.14	0.59	0.06

In a column means having similar letter (s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of probability here; S_0=0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution, M_0 =No Mulching (Control), M_1= Black polythene mulch, M_2=Water hyacinth mulch, M_3=Straw mulch

Table 6. Combined effect of starter solution and mulching on leaf breadth and canopy spread at different days after transplant and stem diameter at harvest of broccoli

Treatment combinations	Leaf breadth (cm)			Canopy spread (cm)			Stem diameter at harvest (cm)
	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT	
S_0M_0	7.54 h	10.30 l	12.95 i	21.21 m	43.60 f	62.56 n	1.55 o
S_0M_1	9.42 e	12.65 gh	15.48 fg	25.88 h	48.12 d-f	72.30 h	2.14 i
S_0M_2	8.24 fg	12.41 h-j	14.58 gh	24.34 j	46.92 ef	68.49 j	1.98 j
S_0M_3	8.56 f	12.54 g-i	15.23 fg	25.12 i	47.48 d-f	70.22 i	1.90 k
S_1M_0	7.63 gh	11.45 k	13.37 hi	22.65 l	46.49 ef	65.66 l	1.64 n
S_1M_1	10.90 bc	14.44 cd	18.77 cd	29.80 d	53.52 a-d	82.26 d	2.40 f
S_1M_2	9.50 e	13.37 fg	16.52 ef	26.66 g	49.43 c-f	74.04 g	2.08 i
S_1M_3	10.51 cd	13.82 d-f	17.92 c-e	27.46 f	51.33 b-e	74.94 g	2.30 g
S_2M_0	8.05 f-h	11.68 i-k	14.24 g-i	21.96 l	46.10 ef	64.10 m	1.71 m
S_2M_1	12.25 a	15.49 b	20.44 ab	31.30 b	55.61 a-c	83.58 bc	2.74 b
S_2M_2	11.26 b	14.69 b-d	19.29 bc	30.56 c	53.83 a-d	82.38 cd	2.56 d
S_2M_3	9.91 de	13.48 e-g	17.28 de	28.28 e	51.50 b-e	77.16 f	2.22 h
S_3M_0	7.92 f-h	11.54 jk	13.56 hi	23.47 k	46.86 ef	67.16 k	1.82 l
S_3M_1	12.44 a	16.58 a	21.82 a	32.04 a	59.16 a	85.10 a	2.63 c
S_3M_2	11.43 b	15.36 bc	19.39 bc	31.64 ab	57.66 ab	84.33 ab	2.82 a
S_3M_3	10.84 bc	14.34 de	18.63 cd	28.98 e	51.8 b-e	78.84 e	2.48 e
CV %	9.62	10.66	11.43	9.27	9.56	12.87	7.31
LSD (0.05)	0.66	0.94	1.58	0.71	6.41	1.27	0.07

In a column means having similar letter (s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of probability here; S_0=0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution; M_0 =No Mulching (Control), M_1= Black polythene mulch, M_2=Water hyacinth mulch, M_3=Straw mulch

Table 7. Effect of starter solution on primary curd diameter, primary curd weight, yield per plant and yield per hectare of broccoli

Treatments	Primary curd diameter (cm)	Primary curd weight (g)	Yield per plant (g)	Yield per hectare (t)
S_0	13.82 c	324.71 c	356.05 c	14.83 c
S_1	14.97 b	370.38 b	409.46 b	17.06 b
S_2	15.31 a	406.12 a	455.68 a	18.98 a
S_3	15.54 a	416.42 a	472.21 a	19.67 a
CV %	11.93	9.87	10.63	9.23
LSD (0.05)	0.32	18.21	18.17	0.75

In a column means having similar letter (s) are statistically identical and those having dissimilar Letter (s) differ significantly at 0.05 level of probability here; S_0=0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution; M_0 =No Mulching (Control), M_1= Black polythene mulch, M_2=Water hyacinth mulch, M_3=Straw Mulch

Table 8. Effect of mulching on primary curd diameter, primary curd weight, yield per plant and yield per hectare of broccoli

Treatments	Primary curd diameter (cm)	Primary curd weight (g)	Yield per plant (g)	Yield per hectare (t)
M_0	13.31 c	286.33 c	309.25 c	12.88 c
M_1	15.81 a	442.24 a	504.18 a	21.00 a
M_2	15.30 b	395.22 b	443.37 b	18.47 b
M_3	15.22 b	393.84 b	436.59 b	18.19 b
CV %	11.93	9.87	10.63	9.23
LSD (0.05)	0.21	13.02	15.22	0.53

In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly at 0.05 level of probability here; S_0=0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution; M_0 =No Mulching (Control), M_1= Black polythene mulch, M_2=Water hyacinth mulch, M_3=Straw mulch

Table 9. Combined effect of starter solution and mulching on primary curd diameter, primary curd weight, yield per plant and yield per hectare of broccoli

Treatment combinations	Primary curd diameter (cm)	Primary curd weight (g)	Yield per plant (g)	Yield per hectare (t)
S_0M_0	12.02 i	266.96 j	285.04 j	11.87 j
S_0M_1	14.77 ef	367.56 fg	405.93 ef	16.91 ef
S_0M_2	14.04 gh	318.93 hi	352.68 gh	14.69 gh
S_0M_3	14.47 fg	345.39 gh	380.57 fg	15.85 fg
S_1M_0	13.45 h	288.97 ij	310.07 ij	12.92 ij
S_1M_1	15.70 b-d	425.13 c-e	476.60 c	19.85 c
S_1M_2	15.52 cd	377.09 fg	417.41 e	17.39 e
S_1M_3	15.22 de	390.32 ef	433.76 de	18.07 de
S_2M_0	13.86 gh	292.29 ij	316.69 h-j	13.19 ij
S_2M_1	16.16 ab	483.93 ab	556.51 a	23.19 a
S_2M_2	15.65 b-d	430.49 cd	487.21 bc	20.30 bc
S_2M_3	15.58 b-d	417.75 de	462.33 cd	19.26 cd
S_3M_0	13.91 gh	297.11 ij	325.20 hi	13.55 hi
S_3M_1	16.62 a	492.33 a	577.69 a	24.07 a
S_3M_2	16.01 a-c	454.35 bc	516.21 b	21.51 b
S_3M_3	15.62 b-d	421.88 c-e	469.73 cd	19.57 cd
CV %	11.93	9.87	10.63	9.23
LSD (0.05)	0.62	31.42	32.24	1.51

In a column means having similar letter (s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of probability here; S_0=0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution; M_0 =No Mulching (Control), M_1= Black polythene mulch, M_2=Water hyacinth mulch, M_3=Straw mulch

3.7 Diameter of Primary Curd (Cm)

Application of starter solution exhibited a significant influence on diameter of primary curd of broccoli plants (Table 7) during harvest. The maximum curd diameter (15.54 cm) was measured from S_3 (2% starter solution) treatment while the minimum diameter of primary curd (13.82 cm) was measured from S_0 (control) treatment. In the case of mulching, the maximum curd diameter (15.81 cm) was measured from M_1 (black polythene) treatment while the minimum curd diameter (13.31 cm) was recorded from M_0 (Table 8). Similar trend of the result was found by Rahman et al., 1989 [21]. The combined effect of different starter solutions and mulching was also found significant in respect of diameter of primary curd of broccoli (Table 9). The maximum primary curd diameter (16.62 cm) was measured from S_3M_1 (2% starter solution with black polythene mulch) combined treatment while the minimum curd diameter (12.02 cm) was recorded from S_0M_0 (control) treatment combination.

3.8 Weight of Primary Curd (G)

The maximum weight of primary curd (416.42 g) was measured from S_3 (2% starter solution) treatment while the minimum primary curd weight (324.71 g) was recorded from S_0 (control) treatment (Table 7). There was a significant influence of mulching on weight of primary curd of broccoli per plant (Table 8). The maximum primary curd weight (442.24 g) was measured from M_1 (black polythene) treatment while the minimum weight of primary curd (286.33 g) was recorded from M_0 (control) treatment. The results of the present study are comparable to the findings of Runham et al., 2000 [22] also found that mulches gave higher curd weight in broccoli than non-mulched plots. The combined effect of starter solution and mulching had significant influence on the primary curd weight of broccoli (Table 9). The maximum primary curd weight (492.33 g) was measured from S_3M_1 (2% starter solution with black polythene) combined treatment while the minimum weight of primary curd (266.96 g) was recorded from S_0M_0 (control) combined treatment.

3.9 Yield Per Plant (G)

In the case of starter solution treatment, the highest yield of curd per plant (472.21 g) was recorded from S_3 (2% urea solution) treatment whereas the lowest yield of curd per plant (356.05 g) was recorded from S_0 (control) treatment (Table 7). These results have similarity with Thompson and Kelly, 1997 [23]. In the case of mulching, the highest yield of curd per plant (504.18 g) was found from M_1 (black polythene) treatment while the lowest yield of curd per plant (309.25 g) was recorded from M_0 (control) treatment (Table 8). Combined effect of different concentrations of starter solution and mulching showed significant differences on yield of curd per plant of broccoli (Table 9). The highest yield per plant (577.69 g) was recorded from S_3M_1 (2% starter solution with black polythene) combined treatment while the lowest yield of curd per plant (285.04 g) was found from S_0M_0 (control) treatment combination.

3.10 Yield Per Hectare (T)

Significant variation was recorded yield (t/ha) of broccoli due to different concentrations of starter solution (Table 7). The highest yield (19.67 t/ha) was recorded from S_3 (2% urea solution) treatment whereas the lowest yield (14.83 t/ha) was recorded from S_0 (control) treatment. This result has similarity with Raman et al. (1989). Different mulching showed significant variation on yield (t/ha) solution (Table 8). The highest yield (21.00 t/ha) was found from M_1 (black polythene) treatment, while the lowest yield (12.88 t/ha) was recorded from M_0 (control) treatment. Significant variation was observed due to the combined effect of starter solution and mulching on yield (t/ha) of broccoli (Table 9). The highest yield (24.07 t/ha) was recorded from S_3M_1 (2% starter solution with black polythene) treatment combination while the lowest yield (11.87 t/ha) was found from S_0M_0 (control) treatment combination [24].

4. CONCLUSION

Considering the above result of this experiment, the following conclusion and recommendation can be drawn:

1. Application of 2% urea solution showed better performance for almost all the parameters in broccoli production.
2. Black polythene gave best results for both vegetative growth and yield of broccoli.
3. It can be concluded that combination of 2% urea solution and black polythene mulch is better for broccoli cultivation

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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