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Effect of Starter Solution and Age of Seedling on Growth and Yield of Broccoli (*Brassica Oleracea* Var. *Italica*)

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Authors' contributions

This work was carried out in collaboration among all authors. Authors TM and KK planned the experiment and lead the research. Authors IAS, TM and KK designed and carried out the research. Authors MEH performed the statistical analysis. Author IAS, SA carried out the research on the field. Authors IS, SM and AP collected the data. Authors IAS and MEH wrote the manuscript. Authors SA, IS, SM and AP 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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ABSTRACT

A study was conducted at central farm of Sher-e-Bangla Agricultural university, Dhaka during the period of October, 2017 to March, 2018 to investigate the influence of starter solution and age of seedling on the growth and yield of broccoli. The experiment consisted of two factors. Factor A: Four levels of starter solution as S_0= 0% urea solution (control), S_1= 1% urea solution, S_2= 2% urea solution, S_3= 3% urea solution and Factor B: Three levels of age of seedling as A_1= 20 days of seedling, A_2= 30 days of seedling, A_3= 40 days of seedling. Application of the treatment influenced independently and also in combination on the growth and yield of broccoli. In case of starter solution, the highest yield (24.32 t/ha) was obtained from S_2 (2% urea) treatment, whereas the lowest yield (13.21 t/ha) was recorded from S_0 (0% urea) treatment. For three level of age of

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seedling the highest yield (20.75 t/ha) was obtained from A_2 (30 days old seedling) treatment and the lowest yield (15.48 t/ha) was recorded from A_3 (40 days old seedling) treatment. In case of combined effect the highest yield (26.91 t/ha) of broccoli was obtained from the treatment combination of S_2A_2 while the lowest (13.41 t/ha) was obtained from S_0A_3 treatment combination. Economic analysis revealed that S_2A_2 treatment combination was the best in respect of net return (3,24,890 tk) with benefit cost ratio of 2.5. So it may be concluded that 2% starter solution and 30 days age seedling was best for growth and yield of broccoli.

Keywords: Benefit cost ratio; broccoli; seedling age; starter solution; yield.

1. INTRODUCTION

Broccoli *(Brassica oleracea var. Italica L*) is an important floral winter vegetable crop under Brassicaceae family, which is originated from west Europe [1]. The edible portion of broccoli plant consists of tender stem and unopened flower buds. There are three classes of broccoli, i.e. green, white and purple, among them green type broccoli is the most popular [2]. In Bangladesh broccoli was introduced about two decade ago and it is planted in early September to late November [3]. In Bangladesh, broccoli is commercially cultivated in Rajshahi, Dhaka and Gazipur district. Nowadays, broccoli attracted more attention due to its multifarious use and has great nutritional value. The yield of vegetables in our country is not satisfactory in comparison to our requirement. Lower yield of vegetables in Bangladesh is not an indication of low yielding ability of the crop, but of the fact that low yielding variety, poor crop management practices and lack of improved technologies, lack of nutrients and proper planting time etc. Urea is the main source of nitrogenous fertilizer and nitrogen is essential for its vegetative growth and development. Starter solutions are mixtures of soluble fertilizer and water used to get young plants off to a good start. Improvement in broccoli growth and yield under starter solution was observed by Roy et al. [4]. The fertilizer material easily dissolves in water and the nutrients are gladly available for plant uptake. When plant's roots are injured by transplanting, natural suffering or heavy rain, it is crucial to receive an instant, readily accessible nutrient to facilitate recovery. The starter solution supplies readily available nutrients directly to the soil-rhizosphere system. Vigorous young plants can be more tolerant to environmental stress and increase their early yield, which means more income for farmers. Vegetables like cabbage, cauliflower and tomato respond well to starter solution containing urea in minimizing transplanting shock and being expectant to a quick growth [5].

On the other hand, seedling age is an important phenomenon for the production of any crops especially vegetables [6]. Young seedlings required very intensive care for adjustment with the newly transplanted environmental condition, while aged seedlings reached more injury during uprooting and required more time for adjustment [7]. In case of both the situation yield may be hampered. On the other hand optimum aged seedlings are easily adjusted within short period in new environment. When we transplanted the seedling in actual aged it ensured highest yield and also quality yield with maximum growth and yield [8]. A detailed and systematic study is needed to find out the optimum concentration and suitable combination of starter solution and age of seedling for maximizing the yield of broccoli in Bangladesh.

2. MATERIAL S AND METHODS

2.1 Experimental Site and Experimental Framework

The experiment was conducted at the Horticulture Research Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh during the period from October 2017 to March 2018. It was located in 24.09^0 N latitude and 90.26ºE longitudes with an elevation 8 m from the sea level as per the Bangladesh Meteorological Department, Agargaon, Dhaka-1207. Soil was having the texture of sandy loam with p^H 5.6. Factor-A had four levels of starter solution as S_0= 0% urea solution (control), S_1= 1% urea solution, S_2= 2% urea solution, S_3= 3% urea solution and Factor-B had three levels of age of seedling as A_1= 20 days of seedling, A_2= 30 days of seedling, A_3= 40 days of seedling. The two factors experiment was laid out following the 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 randomly in each

block. The size of each unit plot was 1.8 m × 1.6 m. The distance maintained between two blocks and two plots were 0.75 m and 0.5 m, respectively. Row to row distance was 30 cm and plant to plant distance was 20 cm [7].

2.2 Preparation of Starter Solution

At first, 0, 1, 2 and 3 gm of urea were weighted and were dissolved in distilled water taken in four beakers. The solutions were then made to volume up to 100 ml by water. The beakers were leveled and the solutions were ready for use.

2.3 Economic Analysis

The cost of production was analyzed in order to find out the most economic combination of starter solution and age of seedling. All input cost included the cost for lease of land and interests on running capital in computing the cost of production. The interests were calculated @ 13% in simple rate. The market price of broccoli was considered for estimating the cost and return. Analyses were done according to the procedure of Alam et al. [9]. The benefit cost ratio (BCR) was calculated as follows:

$$BCR = \frac{\text{Gross return per hectare (Tk)}}{\text{Total cost of production per hectare (Tk)}} \times 100$$

2.4 Statistical Analysis

The data obtained for different characters were statistically analyzed by using MSTAT-C computer package program to find out the significance of the difference for age of seedling and starter solution on yield and yield contributing characters of broccoli. The mean values of all the recorded characters were evaluated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment combinations of means was estimated by Duncan's Multiple Range Test (DMRT) at 5% level of probability.

3. RESULTS AND DISCUSSION

3.1 Plant Height (cm)

Plant height varied significantly for different concentration of starter solution at 20, 40 and 60 DAT. At 60 DAT, the tallest plant (73.92 cm) was recorded from s_3 (3% starter solution) treatment and the lowest plant height (62.22 cm) was observed from s_0 (0% urea solution) treatment (Fig. 1 and Table 1). The present result of the study is supported by the findings of Chhonkar and Jha [5]. This might be due to the fact that starter solution i.e. urea solution minimized the transplanting shock and increased urea uptake for the plant that has helped the plant to start a good beginning). Plant height varied significantly for different age of seedling at 20, 40 and 60 DAT due to the impact of different age of seedling. At 60 DAT, the tallest plant was observed (71.36 cm) from A_2 (30 days old seedling) treatment and the lowest plant height (63.7 cm) was recorded from A_3 (40 days old seedling) treatment (Fig. 2 and Table 2). The optimum seedling age ensures plant to growth properly through efficient utilization of moisture, temperature, light etc. Kaymak et al. [10] reported that plant transplanted at the age of 30 days showed the longest height than other transplants that is about similar of present study. Combined effect of starter solution and age of seedling showed significant differences on the plant height of broccoli. At 60 DAT, the

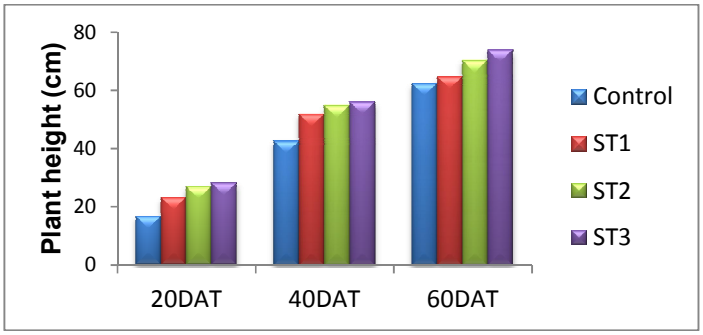

Fig. 1. Effect of starter solution on plant height of broccoli at different days after transplanting

Here, DAT= Days after transplanting;S_0=0%urea , S_1=1% urea , S_2=2% urea , S_3=3% urea

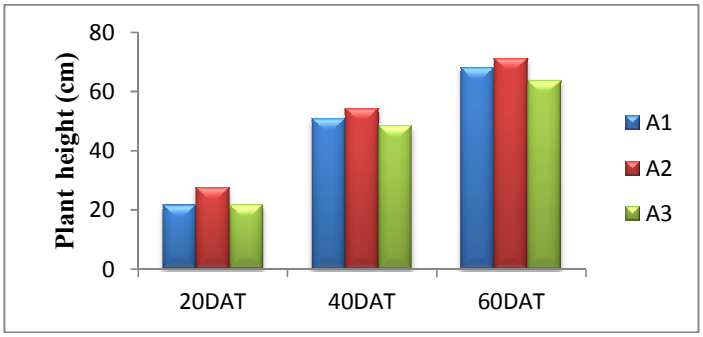

Fig. 2. Effect of age of seedling on plant height of broccoli at different days after transplant
Here, DAT= days after transplant, A_1=20 days old seedling, A_2=30 days old seedling, A_3= 40 days old seedling

Table 1. Effect of starter solution on plant height (cm) of broccoli

Treatments	Plant height (cm)			Number of leaves		
	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60DAT
S_0	16.766 d	42.603 d	62.227 d	7.1856 c	9.780 c	13.747 b
S_1	23.091 c	51.917 c	64.692 c	7.9700 bc	11.930 b	14.493 b
S_2	26.918 b	54.782 b	70.247 b	8.4800 ab	12.580 ab	15.631 a
S_3	28.153 a	56.031 a	73.926 a	9.1033 a	13.198 a	15.813 a
CV%	7.41	8.67	8.25	9.98	8.16	10.97
LSD(0.05)	0.81	0.98	0.76	0.88	0.76	0.87

Table 2. Effect of age of seedling on plant height of broccoli

Treatments	Plant height (cm)			Number of Leaves		
	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
A_1	21.685 b	51.031 b	68.194 b	7.9025 b	11.305 b	14.508 b
A_2	27.700 a	54.439 a	71.368 a	9.1392 a	14.053 a	16.708 a
A_3	21.811 b	48.530 c	63.756 c	7.5125 b	10.258 c	13.548 c
CV %	7.41	8.67	8.25	9.98	8.16	10.97
LSD (0.05)	0.70	0.84	0.66	0.76	0.63	0.75

highest plant height (79.76 cm) was obtained from S_3A_2 treatment combination and the lowest plant height (59.50 cm) was obtained from S_oA_3 treatment combination (Table 3).

3.2 Number of Leaves per Plant

Number of leaves per plant of broccoli showed significant differences due to the effect of starter solution at 20, 40 and 60 DAT. At 60 DAT, the maximum number of leaves (15.81 cm) was recorded from S_3 (3% starter solution) treatment which was statistically identical to (15.63 cm) S_2 (2% starter solution) treatment, while the minimum number of leaves (13.74 cm) was obtained from S_0 (0% urea solution) treatment (Table 1). The nutrients in starter solutions are immediately absorbed and utilized by plants. Plants respond rapidly that increase leaf number. These results are in support of the findings of Chaudhury and Singh [11]. Age of seedling showed a significant influence on number of leaves per plant at different days after transplanting. The maximum number of leaves per plant was obtained from age of seedling showed a significant influence on number of leaves per plant (16.70 cm) was recorded from A_2 (30 days old seedling) treatment, while the minimum number of leaves (13.54 cm) was recorded from A_3 (40 days old seedling) treatment (Table 2). Damato et al. [12] reported that seedling transplanted at optimum stage (4 weeks) gives higher number of leaves, root length, higher plant height etc. Significant variation was observed due to the combined effect of starter solution and age of seedling of broccoli. At 60 DAT, the maximum number of leaf (17.21 cm) was recorded from S_3A_2 treatment combination and the minimum number of leaf

was recorded (12.82 cm) from S_0A_3 treatment combination (Table 3).

3.3 Largest Leaf Length (cm)

The largest leaf length of broccoli was recorded statistically significant differences for different level of starter solution. At 60 DAT, the highest largest leaf length (52.58 cm) was recorded from S_3 (3% urea solution) treatment, while the minimum largest leaf length (49.03 cm) was obtained from S_0 (0% urea solution) treatment (Table 4). El-Afifi et al. [13] showed that nitrogen used as starter solution resulted in significant increase in largest leaf length, number of leaves, stem diameter etc. Significant variation was recorded for different age of seedling of broccoli in terms of largest leaf length at 60 DAT. At 60 DAT the highest largest leaf length (55.43 cm) was recorded from A_2 (30 days old seedling) treatment, while the minimum largest leaf length (46.77 cm) was recorded from A_3 (40 days old seedling) treatment (Table 5). Begum et al. [14] observed wide variation in vegetative growth and head yield while, transplanting of 30 days old broccoli seedlings at an interval of 15 days from 14 Septembers to 13 December. Starter solution and age of seedling showed Significant variation due to the combined effect on largest leaf length of broccoli at 60 DAT. Combined effect shows that the highest largest leaf length (56.62 cm) was recorded from S_3A_2 treatment combination which is statistically identical with S_2A_2 and S_1A_2 and the minimum largest leaf length (45.31 cm) was recorded from S_0A_3 treatment (Table 6).

3.4 Largest Leaf Breadth (cm)

Significant variation was found for largest leaf breadth due to different concentration of starter solution at 60 DAT. At 60 DAT, the maximum largest leaf breadth (21.17 cm) was recorded from S_3 (3% urea solution) treatment and the minimum largest leaf breadth (18.83 cm) was recorded from S_0 (o% urea solution) treatment which is statistically identical to S_1 (1% urea solution) treatment (Table 4). Age of seedling showed significant variation for maximum leaf breadth of broccoli at 60 DAT. At 60 DAT, the maximum largest leaf breadth of broccoli (20.48 cm) was recorded from A_2 (30 days old seedling) treatment and the minimum largest leaf breadth (15.83 cm) was recorded from A_3 (40 days old seedling) treatment (Table 5). Combined effect of starter solution and age of seedling at different days after transplanting (DAT) was found to be statistically significant on largest leaf breadth. At60 DAT, the maximum largest leaf breadth (23.50 cm) was recorded from S_3A_2 treatment

Table 3. Combined effect of starter solution and age of seedling on plant height (cm) of broccoli

Treatment combinations	Plant height (cm)			Number of leaves		
	20 DAT	40 DAT	60DAT	20DAT	40 DAT	60 DAT
S_0 A_1	15.44 g	42.3 g	62.39 g	6.85 de	9.45 f	13.07 ef
S_0 A_2	20.18 f	45.69 f	64.79 f	8.48 bc	10.77 de	15.35 c
S_0 A_3	14.67 g	39.78 h	59.50 h	6.22 e	9.12 f	12.82 f
S_1A_1	19.37 f	52.36 d	65.22 f	7.69 b-e	11.14 de	14.47 c-e
S_1 A_2	26.18 c	54.73 c	66.56 e	8.79 a-c	14.52 b	15.92 bc
S_1 A_3	23.72 e	48.66 e	62.29 g	7.43 c-e	10.13 ef	13.09 ef
S_2 A_1	25.30 cd	54.76 c	71.17 c	8.25 b-d	11.84 cd	14.87 cd
S_2 A_2	31.21 b	57.17 b	74.36 b	9.13 ab	15.06 ab	18.35 a
S_2 A_3	24.23 de	52.39 d	65.20 f	8.06 b-d	10.84 de	13.67 d-f
S_3 A_1	26.62 c	54.66 c	73.99 b	8.82 a-c	12.79 c	15.62 c
S_3 A_2	33.22 a	60.14 a	79.76 a	10.15 a	15.86 a	17.21 ab
S_3 A_3	24.62 de	53.29 cd	68.02 d	8.34 b-d	10.94 de	14.61 cd
CV %	7.41	8.67	8.25	9.98	8.16	10.97
LSD (0.05)	1.4	1.69	1.32	1.53	1.27	1.51

In a column means having similar letter(s) are statistically similar and those having dis similar letter(s) differ significantly at 0.05 level of probability

Here, S_0= 0% urea, S_1=1% urea, S_2=2% urea, S_3= 3% urea

A_1= 20 days old seedling, A_2=30 days old seedling, A_3=40 days old seedling

combination which was statistically identical (22.47 cm) to S_2A_2 and S_3A_1 treatment combination, while the minimum largest leaf breadth (14.18 cm) was recorded from S_0A_3 treatment combination (Table 6).

Table 4. Effect of starter solution on largest leaf length, largest leaf breadth, stem diameter and root length of broccoli

Treatments	Largest leaf length (cm)	Largest leaf breadth (cm)	Stem diameter (cm)
S_0	49.00 d	15.98 c	2.10 c
S_1	50.69 c	16.66 c	2.31 b
S_2	51.75 b	19.71 b	2.45 b
S_3	52.58 a	21.17 a	2.65 a
CV%	10.45	11.43	5.67
LSD(0.05)	0.81	1.03	0.18

3.5 Stem Diameter (cm)

Stem diameter of broccoli varied significantly for different concentrations of starter solution at 60 DAT. At 60 DAT, the highest stem diameter (2.65 cm) was recorded from S_3 (3% urea solution) treatment, whereas the lowest stem diameter (2.10 cm) was recorded from S_0 (0% urea solution) treatment (Table 4). This result has similarity with [12]. They reported that starter solutions treatments resulted in highly significant increases in stem length, stem diameter, number of total leaves per plant and fresh weights of outer leaves (inedible), inner leaves (edible), weights of total yield (whole head) and marketable yield (edible head) compared with the control treatment (without starter solution) in both seasons. Stem diameter of broccoli showed significant variation due to different age of seedling at 60 DAT. Stem diameter of broccoli showed significant variation due to different age of seedling at 60 DAT. However, at 60 DAT, the highest stem diameter (2.88 cm) was found from A_2 (30 days old seedling) treatment, while the lowest length of stem diameter (2.04 cm) was recorded from A_3 (40 days old seedling) treatment (Table 5). Stem diameter of broccoli showed significant differences due to the Combined effect of different concentrations of starter solution and age of seedling .At 60 DAT the highest stem diameter (3.07 cm) was recorded from S_3A_2 treatment combination which was statistically identical with S_2A_2, S_1A_2 and S_0A_2 treatment combination, again the lowest stem diameter (1.59 cm) was found from S_0A_3 treatment combination (Table 6).

3.6 Weight of Primary Head per Plant (g)

Starter solution varied significantly on weight of primary head of broccoli at harvest. At harvest the highest primary weight of head (465.46 g) was recorded from S_2 (2% urea solution) treatment, whereas the lowest weight of primary head (261.89 g) was recorded from S_0 (0% urea solution) treatment (Table 7). This result is in agreement with [4] where they conducted experiment and reported 1.5% starter solution which gives highest yield from other solutions, and the lowest yield (66.86 t/ha) was recorded from the control. Weight of primary head per plant varied significantly due to different age of seedling at harvest. The highest weight of primary head (397.18 gm) was found from A_2 (30 days old seedling) treatment, while the lowest

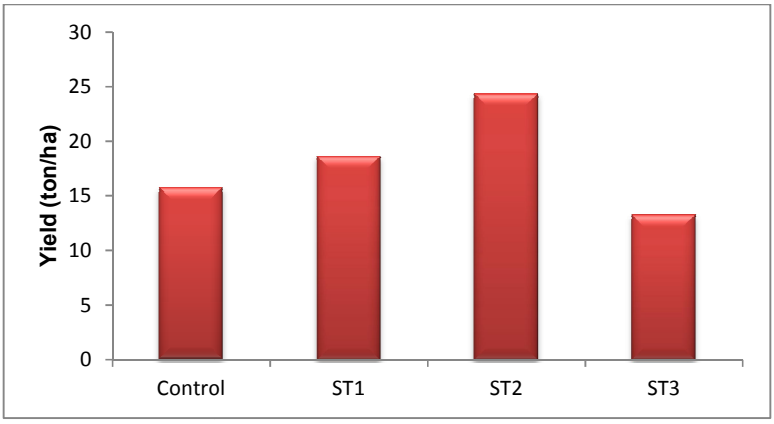

Fig. 3. Effect of starter solution on yield (t/ha) of broccoli at different days after transplant
Here, DAT= Days after transplanting; S_0=0%urea, S_1=1% urea, S_2=2% urea, S_3=3% urea

weight of primary head (301.67 gm) was recorded from A_3 (40 days old seedling (Table 8) treatment. Todorova [15] also reported that hybrid Parthenon F1 produced the highest yield 2546.7 kg/ha average the period using 30 days transplants while the lowest yields was obtained from Fiesta F1 (1145.0 kg/da), using 45-days transplants. Combined effect of different concentrations of starter solution and age of seedling showed significant differences on weight of primary head of broccoli at harvest. At harvest the highest weight of primary head (505.23 gm) was recorded from S_2A_2 treatment combination and the lowest weight of primary head (225.45 gm) was found from S_0A_3 treatment combination (Table 9).

Table 5. Effect of starter solution on largest leaf length, largest leaf breadth, stem diameter and root length of broccoli

Treatments	Largest leaf length (cm)	Largest leaf breadth (cm)	Stem diameter (cm)
A_1	50.818 b	18.83 b	2.21 b
A_2	55.437 a	20.48 a	2.88 a
A_3	46.773 c	15.83 c	2.04 c
CV%	10.45	11.43	5.67
LSD(0.05)	0.70	0.87	0.16

Table 6. Combined Effect of starter solution and age of seedling on largest leaf length, largest leaf breadth, stem diameter and root length of broccoli

Treatment combinations	Largest leaf length (cm)	Largest leaf breadth (cm)	Stem diameter (cm)
S_0 A_1	48.47 cd	16.13 d	1.92 c
S_0 A_2	53.23 b	17.65 cd	2.79 a
S_0 A_3	45.31 f	14.18 e	1.59 d
S_1A_1	49.42 c	17.44 cd	2.14 bc
S_1 A_2	55.81 a	18.33 bc	2.83 a
S_1 A_3	46.85 e	14.22 e	1.98 c
S_2 A_1	52.07 b	19.95 b	2.34 b
S_2 A_2	56.09 a	22.47 a	2.86 a
S_2 A_3	47.11 de	16.71 cd	2.15 bc
S_3 A_1	53.31 b	21.82 a	2.44 b
S_3 A_2	56.62 a	23.50 a	3.07 a
S_3 A_3	47.82 de	18.21 bc	2.45 b
CV %	10.45	11.43	5.67
LSD (0.05)	1.41	1.74	0.32

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability; Here, S_0= 0% urea,S_1=1% urea,S_2=2% urea,S_3= 3% urea; A_1= 20 days old seedling, A_2=30 days old seedling, A_3=40 days old seedling

Table 7. Effect of starter solution on yield contributing characters and yield of broccoli

Treatments	weight of primary head per plant (gm)	Number of secondary curd	Weight of secondary head per plant (gm)	Yield (t/ha)
S_0	261.89 d	3.23 c	55.01 d	13.19 d
S_1	362.30 b	4.02 b	85.88 b	18.58 b
S_2	465.46 a	6.10 a	118.05 a	24.32 a
S_3	292.84 c	3.54 bc	84.69 c	15.72 c
CV%	12.87	9.37	10.42	12.43
LSD(0.05)	1.61	0.65	0.89	1.02

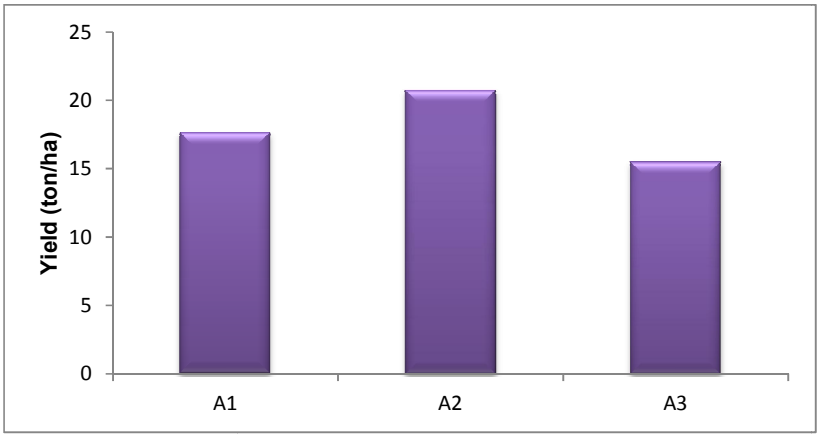

Fig. 4. Effect of age of seedling on yield (t/ha) of broccoli at different days after transplant
Here, DAT= days after transplant, A_1=20 days old seedling, A_2=30 days old seedling, A_3 =40 days old seedling

Table 8. Effect of age of seedling on yield contributing characters and yield of broccoli

Treatments	Weight of primary head per plant (gm)	Number of secondary curd	Weight of secondary head per plant (gm)	Yield (t/ha)
A_1	338.01 b	4.24 ab	85.87 b	17.64 b
A_2	397.18 a	4.70 a	101.00 a	20.75 a
A_3	301.67 c	3.73 b	70.86 c	15.48 c
CV%	12.87	9.37	10.42	12.43
LSD(0.05)	1.4	0.58	0.77	0.88

Table 9. Combined effect of starter solution and age of seedling on yield contributing characters and yield of broccoli

Treatment combination	Weight of primary head per plant (gm)	Number of secondary curd	Weight of secondary head per plant (gm)	Yield (t/ha)	Net return	Benefit cost ratio
S_0 A_1	280.56 i	3.29 e	82.23 f	15.10 ef	279355	1.58
S_0 A_2	352.79 f	3.36 de	95.56 d	18.68 d	458355	1.96
S_0 A_3	225.45 l	3.05 e	48.76 k	11.45 h	96855	1.20
S_1A_1	360.51 e	4.12 de	86.66 e	18.63 d	455262	1.95
S_1 A_2	410.66 d	4.50 cd	107.81 c	21.60 c	603762	2.26
S_1 A_3	315.73 h	3.46 de	63.16 h	15.52 e	299762	1.62
S_2 A_1	470.81 b	6.11 ab	118.36 b	24.54 b	799931	2.57
S_2 A_2	505.23 a	6.86 a	140.57 a	26.91 a	868431	2.82
S_2 A_3	420.33 c	5.34 bc	95.22 d	21.52 c	598931	2.25
S_3 A_1	240.16 k	3.45 de	56.23 j	12.32 gh	138220	1.28
S_3 A_2	320.06 g	4.08 de	60.05 i	15.83 e	313720	1.65
S_3 A_3	245.16 j	3.09 e	76.28 g	13.40 fg	192220	1.40
CV %	12.87	9.37	10.42	12.43	11.34	9.67
LSD (0.05)	2.80	1.16	1.55	1.77	1.56	1.38

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability
Here, S_0= 0% urea, S_1=1% urea, S_2=2% urea, S_3= 3% urea
A_1= 20 days old seedling, A_2=30 days old seedling, A_3=40 days old seedling

3.7 Number of Secondary Head

Significant variation was recorded on number of secondary head of broccoli due to different concentrations of starter solution at harvest. At harvest the highest number of secondary head (6.10) was recorded from S_2 (3% urea solution) treatment, whereas the lowest number of secondary of head (3.23) was recorded from S_0 (0% urea solution) treatment (Table 7). Age of seedling showed significant variation on number of secondary head of broccoli at harvest. At harvest, the highest number of secondary head (4.70) was found from A_2 (30 days old seedling) treatment, while the lowest number of secondary head (3.75) was recorded from A_3 (40 days old seedling) treatment (Table 8). Significant variation was observed due to the combined effect of starter solution and age of seedling at harvest on number of secondary head of broccoli. At harvest the highest number of secondary head (6.86) was recorded from S_2A_2 treatment combination. Again, the lowest number of secondary head (3.05) was found from S_0A_3 treatment combination (Table 9).

3.8 Weight of Secondary Head per Plant (g)

Weight of secondary head of broccoli varied significantly due to different concentrations of starter solution at harvest. The highest weight of secondary head (118.05 g) was recorded from S_2 (2% urea solution) treatment, whereas the lowest weight of secondary head (55.01 g) was recorded from S_0 (0% urea solution) treatment (Table 7). Henmiet et al. [16] reported that sodium nitrate (NaNO3) or ammonium sulphate as starter solution improved the early growth and yield of broccoli. Significant variation was recorded for different age of seedling on weight of secondary head per plant of broccoli at harvest. The highest weight of secondary head (101 g) was found from A_2 (30 days old seedling) treatment, while the lowest weight of secondary head (70.86 g) was recorded from A_3 (40 days old seedling) treatment (Table 8). Grabows et al.[17] reported that plants obtained from 4-week old trans-plants gained marketable yield significantly higher than plants obtained from 10-week old transplants. Combined effect of different concentrations of starter solution and age of seedling showed significant differences on weight of secondary head of broccoli at harvest. The highest weight secondary head (140.57g) was recorded from S_2A_2 treatment combination, again the lowest weight of secondary head (48.76 g) was found from S_0A_3 treatment combination (Table 9).

3.9 Yield (t/ ha)

Significant variation was recorded yield **(**t/ha) of broccoli due to different concentrations of starter solution at harvest. At harvest the highest yield (24.32 t/ ha) was recorded from S_2 (2% urea solution) treatment, whereas the lowest yield (13.21 t/ha) was recorded from S_0 (0 % urea solution) treatment (Table 7). Here, S_2 (2% urea solution) showed highest yield because it has optimum amount of nitrogen for reproductive growth. Otherwise, more concentration of nitrogen as starter solution gave more vegetative growth but less reproductive growth. This result has similarity with [18]. They conducted an experiment with starter solution on cabbage and Found that starter solution has a significant effect on the production of marketable Yield of cabbage. They also found that the highest marketable yield was obtained from the treatments of 1.5% and 2% urea solution and while the untreated seedlings gave the lowest yield. Different age of seedling showed significant variation on yield (t/ha) solution at harvest. At harvest, the highest yield (20.75 t/ ha) was found from A_2 (30 days old seedling) treatment, while the lowest yield (15.48 t/ ha) was recorded from A_3 (40 days old seedling) treatment (Table 8). This might be probably 30 days old seedling gets all the environmental condition needs for its growth and development. Kaymak et al.[10] reported that the effect of transplant age on weight, diameter and length of head were significant, while the highest main head weight, diameter and length were obtained from 30 day old seedling, the lowest values were recorded on 50 day-old seedlings. Significant variation was observed due to the combined effect of starter solution and age of seedling at harvest. At harvest the highest yield (26.91 t/ha) was recorded from S_2A_2 treatment combination again the lowest yield (11.50 t/ha) was found from S_3A_3 treatment combination (Table 9).

3.10 Net Return

In case of net return, different treatment combination showed different levels of net return under the present trial. The highest net return (Tk. 8,68,431) was obtained from the treatment combination S_2A_2 treatment combination and the second highest net return

(Tk. 7,99,931) was found from the combination S_2A_1 (Table 9). The lowest (Tk. 96,855) net return was found from S_0A_3 treatment combination.

3.11 Benefit Cost Ratio

The highest benefit cost ratio (2.82) was found from the treatment combination S_2A_2 and the second highest benefit cost ratio (2.57) was found from S_2 A_1 treatment combination and the lowest (1.20) was found from the S_0A_3 (control) treatment combination (Table 9). From the economic point of view, it was apparent from the above results that the treatment combination of S_2A_2 was more profitable than rest of treatment combinations.

4. CONCLUSION

Both crop yield and economic benefit of crop are significant for the crop production. Starter solution represents higher yield in broccoli plant than without no starter solution. According to the results of the present research, it may be accomplished that efficient production of broccoli is increased by the application of starter solution and appropriate age of seedling. Thus, the combined application of starter solution and appropriate age of seedling may be helpful for higher and better qualitative broccoli production in considering crop productivity and economic return of broccoli. On the basis of benefit cost ratio, it may be suggested that combination of 2% urea solution and 30 days old seedling is suitable for broccoli cultivation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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