J. Agrofor. Environ. 3 (2): 187-192, 2010 ISSN 1995-6983

# Effect of starter solution and $GA_3$ on growth and yield of cabbage

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**Abstract**: The Present research work was conducted at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh during the period from October, 2001 to February, 2002 to study the effect of starter solution and $GA_3$ on growth and yield of cabbage. The two factor experiment consisted of four levels of starter solution, viz., 0, 1.0, 1.5 and 2.0% of urea, and four concentrations of $GA_3$, viz., 0, 25, 50 and 75ppm. The application of starter solution and different concentrations of $GA_3$ influenced independently and also in combination on the growth and yield of cabbage. The highest yield (104.93 t/ha) was obtained from 1.5% starter solution which was significantly different from other solutions, and the lowest yield (66.86 t/ha) was recorded from the control. Significantly the highest yield (104.66 t/ha) was found from 50 ppm $GA_3$, while the lowest yield (66.56 t/ha) was recorded from control. In case of combined effect, the highest yield of cabbage (121.33 t/ha) was obtained from the treatment combination of 1.5% starter solution + 50 ppm $GA_3$ followed by 1.5% starter solution + 75 ppm $GA_3$ (115.22 t/ha), while the lowest yield (57.11 t/ha) was produced by the control treatment. Economic analysis revealed that 1.5% starter solution + 50 ppm $GA_3$ treatment was the best treatment combination in respect of net return (Tk. 173775/ha) with a benefit cost ratio of 3.52.
**Key words:** Cabbage, $GA_3$, starter solution, yield.

## Introduction

Starters are the mixtures of fertilizers and mostly used as solution. It provides a ready source of nutrition near the absorbing zone of the seedlings just after transplanting. Cabbage seedlings are transplanted from seedbed to the main field. The time between uprooting and establishment of young and tender seedlings in the field is very critical. Vegetables, like, cabbage, cauliflower and tomato respond well to starter solution and plant growth regulators in minimizing the transplanting shock and being encouraged to a quick growth (Chhonkar and Jha, 1963). The use of starter solution influences vegetative growth, and ultimately production. The beneficial effect has been reported by Sayre (1938). Growth regulators are organic compounds other than nutrients; small amount of which are capable of modifying growth (Leopold, 1963). Among the growth regulators, auxin causes enlargement of plant cell, and gibberellins stimulate cell division, cell enlargement or both (Nickell, 1982). Cabbage was found to show a quick growth when treated with plant growth regulators (Islam *et al.*, 1993). Application of $GA_3$ stimulates morphological characters like plant height, number of leaves, head diameter, thickness of head as well as the weight of the head. The concentrations of these chemicals interacting with the environmental conditions play important role in modifying the growth and yield components of cabbage. Considering the above factors, the present study was undertaken to find out the effect of starter solution, appropriate concentration of $GA_3$ and Starter solution along with different concentrations of $GA_3$ for better vegetative growth, maximum yield and economic return of cabbage.

## Materials and Methods

The research work was conducted at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh during the period from October, 2001 to February, 2002 to study the effect of starter solution and $GA_3$ on growth and yield of cabbage. The cultivar of cabbage used in this experiment was Atlas-70, the seeds were $F_1$ hybrid and produced by Sakata Seed Corporation of Japan. Cabbage seedlings were raised in two seedbeds of 5 m × 1 m size. The two factor experiment consisted of four levels of starter solution (Factor A) and four levels of concentration of $GA_3$ solution (Factor B). The factors were as follows: Factor A: levels of starter solution: i. 0% urea - No starter solution ($S_0$); ii. 1.0% urea - Starter solution ($S_1$); iii. 1.5% urea -Starter solution ($S_2$); iv. 2.0% urea - Starter solution ($S_3$); Factor B: Levels of concentration of $GA_3$ Solution, i.0 ppm GA3 - No $GA_3$ Solution ($G_0$); ii. 25 ppm $GA_3$ - $GA_3$ solution ($G_1$); iii. 50 ppm $GA_3$ - $GA_3$ solution ($G_2$); iv. 75 ppm $GA_3$ - $GA_3$ solution ($G_3$). The experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. Well decomposed cowdung was applied @ 10 t/ha and was incorporated to the soil of the plot during final land preparation.p Urea, triple super phosphate (TSP) and muriate of potash (MP) were applied to the experimental plots @ 325, 150 and 200 kg/ha, respectively (BARC, 1997). Thirty days old healthy and uniform sized seedlings were transplanted in the experimental plots on 28 November, 2001. The seedlings were uprooted carefully from the seedbed to avoid damage to the root system. Intercultural operations were done as and when necessary. Data were collected on Plant height, Number of leaves per plant, days to head formation, Days to head maturity, Number of outer loose leaves per plant, Number of folder leaves, Length of stem, Fresh weight of stem, Diameter of stem, Number of roots per plant, Length of root, Fresh weight of roots, Thickness of head, Diameter of head, Biomass or biological yield of individual plant, Gross weight of head, Economic yield per plant, Dry weight of head, Yield per plot and Yield per hectare. The collected data on various parameters under study were statistically analyzed using MSTAT statistical programme. The significance of difference between pairs of treatment means was evaluated by the least significance difference (LSD) test at 1 and 5 per cent levels of probability (Gomez an Gomez, 1984). Cost and return analysis were done in details according to the procedure of Alam *et al*. (1989).

## Results and Discussion

The present experiment was conducted to invested the effect of starter solution and $GA_3$ and their possible combined effect on the growth and yield of cabbage. The results are presented in Tables and necessary discussions have been made under the following sub-headings:

**Plant height and number of leaves per plant:** The plant height and number of leaves per plant of cabbage at different days after transplanting (DAT) were significantly influenced

by the treatments of starter solution. Plant height and number of leaves per plants were increased with increasing period of time. The tallest plant (38.82) and maximum (24.32) number of leaves per plant were observed in 1.5% starter solution ($S_2$) treatment. The shortest plant (10.39cm) and minimum (6.11) number of leaves per plant were given by the control ($S_0$) treatment. This might be due to the fact that starter solution i.e. urea solution reduced the transplanting shock and enhanced urea uptake for the plants from the very beginning. The present result of the study is supported by the findings of Chhonkar and Jha (1963).

Plant height and number of leaves per plant at different days after transplanting (DAT) were also significantly influenced by the application of different concentration of $GA_3$. The highest (39.20 cm) plant and maximum (21.40) number of leaves per plant were found at 40 days after transplanting, respectively with the concentration of 75 ppm $GA_3$ ($G_3$) treatment. The shortest plants of 10.68 cm and minimum (7.16) number of leaves per plant were found at 8 DAT, respectively in control.

Plant height and number of leaves per plant were found to be significantly different due to the combined effect of starter solution and concentration of $GA_3$ at different days after transplanting (Table 1). It was revealed that the tallest plant (42.37 cm) and maximum (24.05) number of leaves per plant were found in plants treated with 1.5% starter solution + 75 ppm $GA_3$ ($S_2G_3$) treatments. The lowest plant height (10.23 cm) and minimum number of leaves per plant (6.10) were observed from the control treatment ($S_0G_0$). Plant height was significantly different from the beginning to harvest due to the use of starter solution and $GA_3$.

**Days to head formation, Days to head maturity, Number of loose leaves/plant, Number of folded leaves/plant, Length of stem (cm) and Fresh weight of stem (g):** Days to head formation, days to head maturity, number of loose leaves/plant, number of folded leaves/plant, length of stem (cm), fresh weight of stem (g) were significantly influenced by the starter solution. The minimum days to head formation (44.45 days), days to head maturity (70.77) and the maximum number of loose leaves/plant (15.93), number of folded leaves/plant (39.43), length of stem (6.59cm) as well as fresh weight of stem (48.29g) were obtained from the treatment of 1.5% starter solution. The days to head formation and days to head maturity where it showed the minimum number of loose leaves/plant, number of folded leaves/plant, length of stem (cm) and fresh weight of stem (g) were found in the control treatments.

Days to head formation, days to head maturity, number of loose leaves/plant, number of folded leaves/plant, length of stem (cm), fresh weight of stem (g) were significantly varied with the application of $GA_3$. The minimum days to head formation (43.54 days), days to head maturity (69.95) and the maximum number of loose leaves/plant (16.47), number of folded leaves/plant (39.95), length of stem (6.52cm) as well as fresh weight of stem (46.30g) were obtained from the treatment of of $GA_3$ solution. The maximum days to head formation and days to head maturity where it showed the minimum number of loose leaves/plant, number of folded leaves/plant, length of stem (cm) and fresh weight of stem (g) were found in the control.

The treatment combinations of starter solution and $GA_3$ significantly influenced the days to head formation. The minimum days to head formation (40.73 days), days to head maturity (66.53) and the maximum number of loose leaves/plant (18.45), number of folded leaves/plant (41.03), length of stem (6.73 cm) as well as fresh weight of stem (48.51g) were obtained from the treatment of $GA_3$ solution and 1.5% starter solution. The maximum days to head formation and days to head maturity where it showed the minimum number of loose leaves/plant, number of folded leaves/plant, length of stem (cm) and fresh weight of stem (g) were found in the control (Table 2).

**Diameter of stem, number of lateral roots/plant, length of root (cm), fresh weight of root (g)/plant, thickness of head (cm), diameter of head of cabbage (cm):** The diameter of stem, number of lateral roots/plant, length of root (cm), fresh weight of root (g)/plant, thickness of head (cm), diameter of head of cabbage had significant variations among the starter solution treatments. The thickest stem (3.05 cm) and the highest number of lateral roots/plan (35.87 cm), length of root (23.89 cm), fresh weight of root (12.61g)/plant, thickness of head (15.69), diameter of head (23.74) were obtained from the treatment of 1.5% starter solution whereas the lowest values were obtained for all the parameters from the control treatment.

Application of $GA_3$ significantly influenced for all the mentioned parameters. The thickest stem (2.2.83cm) and the highest number of lateral roots/plan(35.08), length of root (23.23cm), fresh weight of root (11.95g)/plant, thickness of head (14.92), diameter of head (23.81), were obtained from the treatment of 75ppm $GA_3$ ($G_3$) while the lowest were obtained from the control ($G_o$) treatment.

The treatment combination of starter solution and $GA_3$ significantly influenced the thickness of stem. The thickest stem (3.49 cm) was observed in the treatment combination of 1.5% starter solution + 75 ppm $GA_3$ ($S_2G_3$) and it was statistically identical with 1.5% starter solution + 50 ppm $GA_3$ ($S_2G_2$) treatment. On the other hand, the lowest (1.40 cm) stem diameter was found from no starter solution + 0 ppm $GA_3$ ($S_0G_0$) treatment combination (Table 3).

**Biomass per plant (kg), gross weight of head (kg), economic yield/plant (kg), dry weight of head (g), yield /plot (kg) and yield (t/ha):** Starter solution had significant influence on the biomass production of cabbage (Table 4). The highest biomass per plant (4.06 kg) gross weight of head (3.56kg), economic yield/plant (2.86kg), dry weight of head (170.65kg), yield/plot (45.33kg), and yield t/ht (99.87) were produced by 1.5% starter solution which was statistically similar to 1.0% starter solution while the lowest values were given by the control ($S_0$) treatment.

The treatment combination of starter solution and $GA_3$ influenced the biomass production per plant (Table 6). The highest biomass production (4.51 kg), gross weight of head (4.00kg), economic yield/plant (3.32 kg), dry weight of head (195.275g), yield/ Plot (52.41 kg) and yield t/ha (115.66) were obtained from the treatment combination of 1.5% starter solution + 50 ppm $GA_3$ ($S_2G_2$) followed by

the treatment combination of 1.5% starter solution + 75 ppm $GA_3$ (4.20 kg). The lowest production on all the parameters was observed in the control treatment ($S_0G_0$).

**Economics analysis:** The total cost of production per hectare ranged between Tk. 69750 to Tk. 76224. Among treatments, the variation was due to the cost of different concentration of starter solution and different concentration of $GA_3$ (Table 7). The highest cost of production of Tk. 76224 was involved in 1.0% starter solution + 75 ppm $GA_3$ ($S_1G_3$), 1.5% starter solution + 75 ppm $GA_3$ ($S_2G_3$) and 2.0% starter solution + 75 ppm $GA_3$ ($S_3G_3$) treatment.

**Table 1.** Combined effect of starter solution and $GA_3$ on the plant height of cabbage

| Starter solution × Conc. of $GA_3$ | Plant height (cm) at different days after planting | | | | | Number of leaves at different days after planting | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 8 DAT | 16 DAT | 24 DAT | 32 DAT | 40 DAT | 8 DAT | 16 DAT | 24 DAT | 32 DAT | 40 DAT |
| $S_0G_0$ | 10.23 | 14.16 | 17.77 | 20.41 | 27.31 | 6.10 | 9.47 | 10.50 | 12.03 | 14.10 |
| $S_0G_1$ | 10.34 | 14.15 | 18.43 | 21.93 | 30.75 | 6.11 | 9.36 | 10.51 | 12.14 | 16.54 |
| $S_0G_2$ | 10.36 | 14.15 | 18.67 | 22.37 | 34.1 | 6.11 | 9.38 | 10.47 | 12.28 | 18.22 |
| $S_0G_3$ | 10.27 | 14.14 | 18.98 | 23.18 | 35.91 | 6.11 | 9.28 | 10.52 | 12.59 | 18.30 |
| $S_1G_0$ | 10.87 | 16.71 | 23.78 | 27.06 | 33.92 | 7.53 | 10.21 | 12.03 | 15.64 | 18.03 |
| $S_1G_1$ | 10.92 | 16.84 | 24.52 | 29.14 | 37.12 | 4.53 | 10.15 | 12.43 | 16.07 | 20.24 |
| $S_1G_2$ | 10.98 | 16.85 | 26.03 | 30.58 | 38.32 | 7.55 | 10.31 | 12.61 | 16.43 | 21.17 |
| $S_1G_3$ | 10.92 | 16.84 | 26.32 | 32.32 | 40.33 | 7.47 | 10.26 | 12.52 | 16.88 | 22.03 |
| $S_2G_0$ | 11.09 | 17.56 | 26.29 | 31.59 | 36.13 | 8.08 | 11.01 | 13.86 | 17.06 | 20.62 |
| $S_2G_1$ | 11.05 | 17.3 | 26.73 | 32.94 | 37.58 | 8.04 | 11.14 | 13.79 | 17.25 | 22.01 |
| $S_2G_2$ | 11.07 | 17.62 | 26.55 | 32.93 | 39.2 | 8.07 | 11.28 | 13.84 | 18.47 | 23.95 |
| $S_2G_3$ | 11.17 | 17.77 | 26.88 | 32.41 | 42.37 | 8.04 | 11.19 | 13.81 | 18.92 | 24.05 |
| $S_3G_0$ | 10.55 | 15.92 | 23.98 | 26.23 | 33.23 | 6.93 | 9.75 | 12.00 | 14.53 | 17.77 |
| $S_3G_1$ | 10.58 | 15.9 | 24.87 | 28.32 | 36.25 | 7.03 | 9.74 | 11.42 | 15.29 | 20.14 |
| $S_3G_2$ | 10.55 | 15.92 | 24.49 | 28.86 | 37.72 | 7.02 | 9.83 | 11.44 | 15.78 | 20.70 |
| $S_3G_3$ | 10.6 | 15.74 | 24.74 | 28 | 38.2 | 7.03 | 9.94 | 11.55 | 15.93 | 21.22 |
| LSD (0.01) | -- | 1.994 | 3.674 | 3.347 | 5.693 | 1.252 | 1.197 | 2.303 | 1.914 | 2.145 |
| CV (%) | 4.78 | 5.52 | 6.91 | 5.32 | 7.01 | 7.78 | 5.26 | 8.79 | 5.52 | 4.79 |

$S_0$: 0% starter solution (Control), $S_1$ : 1.0% starter solution, $S_2$ : 1.5% starter solution, $S_3$ : 2.0% starter solution, $G_0$ : 0 ppm $GA_3$ (Control), $G_1$ : 25 ppm $GA_3$, $G_2$ : 50 ppm $GA_3$ , $G_3$ : 75 ppm $GA_3$

**Table 2.** Combined effect of starter solution and $GA_3$ on the growth of cabbage

| Starter solution × Conc. of $GA_3$ | Days to head formation | Days to head maturity | Number of loose leaves/plant | Number of folded leaves/plant | Length of stem (cm) | Fresh weight of stem (g) |
|---|---|---|---|---|---|---|
| $S_0G_0$ | 51.87 | 82.49 | 10.30 | 25.12 | 5.01 | 31.50 |
| $S_0G_1$ | 49.15 | 81.00 | 12.20 | 32.51 | 5.99 | 33.51 |
| $S_0G_2$ | 46.92 | 73.11 | 13.43 | 37.27 | 6.05 | 37.00 |
| $S_0G_3$ | 48.24 | 75.07 | 12.84 | 36.95 | 6.15 | 37.19 |
| $S_1G_0$ | 50.56 | 78.91 | 12.37 | 34.08 | 5.28 | 33.10 |
| $S_1G_1$ | 45.43 | 73.01 | 15.40 | 38.54 | 6.51 | 43.50 |
| $S_1G_2$ | 43.35 | 70.03 | 17.21 | 41.24 | 6.50 | 47.51 |
| $S_1G_3$ | 44.41 | 71.07 | 17.83 | 37.92 | 6.73 | 48.05 |
| $S_2G_0$ | 50.70 | 78.03 | 13.09 | 36.09 | 6.00 | 35.51 |
| $S_2G_1$ | 43.74 | 69.56 | 15.72 | 39.63 | 6.50 | 48.51 |
| $S_2G_2$ | 40.73 | 66.53 | 18.45 | 41.03 | 6.73 | 53.63 |
| $S_2G_3$ | 42.65 | 68.94 | 16.46 | 40.98 | 7.13 | 55.50 |
| $S_3G_0$ | 52.35 | 80.12 | 11.93 | 34.28 | 6.35 | 37.66 |
| $S_3G_1$ | 45.23 | 71.29 | 14.13 | 36.73 | 6.60 | 42.87 |
| $S_3G_2$ | 43.15 | 70.13 | 16.78 | 40.26 | 6.81 | 47.08 |
| $S_3G_3$ | 44.40 | 70.51 | 15.57 | 37.99 | 6.50 | 48.30 |
| LSD (0.01) | 5.768 | 7.501 | 1.964 | 5.254 | 1.309 | 4.717 |
| CV (%) | 5.53 | 4.53 | 5.99 | 6.34 | 9.25 | 4.94 |

$S_0$: 0% starter solution (Control), $S_1$ : 1.0% starter solution, $S_2$ : 1.5% starter solution, $S_3$ : 2.0% starter solution, $G_0$ : 0 ppm $GA_3$ (Control), $G_1$ : 25 ppm $GA_3$, $G_2$ : 50 ppm $GA_3$ , $G_3$ : 75 ppm $GA_3$

**Table 3.** Combined effect of starter solution and GA3 on the growth and yield of cabbage

| Starter solution × Conc. Of GA3 | Diameter of stem (cm) | Number of lateral roots/plant | Length root (cm) | Fresh weight roots (g)/plant | Thickness of head (cm) | Diameter of head (cm) |
|---|---|---|---|---|---|---|
| $S_0G_0$ | 1.40 | 25.39 | 16.84 | 8.02 | 12.15 | 14.77 |
| $S_0G_1$ | 1.78 | 27.40 | 17.11 | 8.36 | 13.09 | 18.10 |
| $S_0G_2$ | 1.86 | 32.62 | 18.58 | 9.02 | 13.26 | 20.03 |
| $S_0G_3$ | 1.91 | 31.05 | 17.25 | 8.72 | 13.16 | 19.03 |
| $S_1G_0$ | 1.73 | 33.34 | 17.33 | 9.99 | 12.84 | 19.01 |
| $S_1G_1$ | 2.37 | 34.17 | 18.31 | 10.45 | 13.74 | 22.09 |
| $S_1G_2$ | 2.88 | 35.40 | 24.89 | 13.17 | 14.94 | 24.35 |
| $S_1G_3$ | 2.89 | 35.62 | 23.66 | 11.56 | 14.58 | 24.09 |
| $S_2G_0$ | 2.33 | 34.09 | 20.38 | 11.43 | 13.08 | 19.50 |
| $S_2G_1$ | 3.06 | 35.09 | 24.67 | 12.57 | 16.04 | 22.34 |
| $S_2G_2$ | 3.30 | 37.01 | 25.43 | 13.32 | 16.97 | 27.25 |
| $S_2G_3$ | 3.49 | 37.30 | 25.07 | 13.13 | 16.66 | 25.88 |
| $S_3G_0$ | 2.00 | 30.47 | 20.41 | 10.78 | 12.52 | 18.30 |
| $S_3G_1$ | 2.13 | 34.12 | 22.29 | 10.84 | 13.63 | 20.85 |
| $S_3G_2$ | 2.84 | 35.29 | 24.00 | 12.29 | 14.50 | 23.60 |
| $S_3G_3$ | 3.03 | 34.31 | 22.25 | 10.79 | 14.40 | 22.25 |
| LSD (0.01) | 0.369 | 3.070 | 4.359 | 2.593 | 2.129 | 2.808 |
| CV (%) | 6.68 | 4.11 | 9.18 | 10.59 | 6.73 | 5.86 |

$S_0$ : 0% starter solution (Control), $S_1$ : 1.0% starter solution, $S_2$ : 1.5% starter solution, $S_3$ : 2.0% starter solution, $G_0$ : 0 ppm $GA_3$ (Control), $G_1$ : 25 ppm $GA_3$, $G_2$ : 50 ppm $GA_3$ , $G_3$ : 75 ppm $GA_3$

**Table 4.** Main effect of starter solution on the yield components and yield of cabbage

| Starter solution (%) | Biomass/ plant (kg) | Gross weight of head (kg) | Economic yield/plant (kg) | Dry weight of head (g) | Yield /Plot (kg) | Yield (t/ha) |
|---|---|---|---|---|---|---|
| 0 | 3.28 | 2.35 | 1.85 | 114.15 | 28.88 | 66.86 |
| 1.0 | 3.85 | 3.29 | 2.53 | 159.37 | 41.42 | 88.97 |
| 1.5 | 4.06 | 3.56 | 2.86 | 170.65 | 45.33 | 104.93 |
| 2.0 | 3.55 | 3.25 | 2.35 | 142.12 | 38.72 | 95.25 |
| LSD (0.01) | 0.411 | 0.251 | 0.159 | 10.98 | 0.722 | 3.124 |

The biomass per plant varied significantly due to $GA_3$ treatments (Table 5). The maximum biomass per plant (3.96 kg), gross weight of head (3.55 kg), economic yield/plant (2.80 kg), dry weight of head (171.95 g), yield/ Plot (45.22 kg) and yield (990.87 t/ha) were produced by 1.5% starter solution while the lowest values were obtained by the control ($S_o$) treatment.

**Table 5.** Main effect of $GA_3$ on the yield components and yield of cabbage

| Concentration of $GA_3$ (ppm) | Biomass/ plant (kg) | Gross weight of head (kg) | Economic yield/ plant (kg) | Dry weight of head (g) | Yield/ Plot (kg) | Yield (t/ha) |
|---|---|---|---|---|---|---|
| 0 | 3.12 | 2.69 | 1.91 | 115.97 | 28.75 | 66.56 |
| 25 | 3.79 | 2.80 | 2.27 | 148.27 | 37.81 | 81.23 |
| 50 | 3.96 | 3.55 | 2.80 | 171.95 | 45.22 | 104.66 |
| 75 | 3.86 | 3.43 | 2.60 | 150.10 | 42.57 | 86.66 |
| LSD (0.01) | 0.411 | 0.251 | 0.159 | 10.98 | 0.722 | 3.124 |

The treatment combination of 1.5% starter solution + 50 ppm $GA_3$ ($S_2G_2$) gave the highest gross return of Tk. 242660 and net return of Tk. 173775. On the other hand, the lowest gross return of Tk. 114220 and net return of Tk. 44470 were recorded from the control treatment.

The benefit cost ratio (BCR) was found to be the highest (3.52) in treatment combination of 1.5% starter solution + 50 ppm $GA_3$ ($S_2G_2$), while the lowest benefit cost ratio (1.64) was recorded from the control treatment.

From the economic point of view, it is apparent from the above results that the application of 1.5% starter solution + 50 ppm $GA_3$ was much profitable than the rest of the treatments from the soil under the Old Brahmaputra Agro-ecological Zone (AEZ-9).

The results of the experiment revealed that all parameters studied were significantly influenced by starter solution. When 1.5% starter solution was applied, all the characters attained highest values followed by 1.0% and 2.0% starter solutions, respectively. The lowest values in all the parameters were found in the control treatment. Maximum yield/plot (45.33 kg) and yield/ha (104.93 tonnes) were obtained from 1.5% starter solution treatment and the lowest yield/plot (28.88 kg) and yield/ha (66.86 tonnes) were from the control treatment. Application of $GA_3$ played an important role on the growth and yield of cabbage. Different concentrations of $GA_3$ significantly influenced all the characters recorded. The maximum, yield/plot (45.22 kg) and yield/ha (104.66 tonnes) were recorded from 50 ppm $GA_3$. The lowest yield/plot (28.75

kg), yield/ha (66.56 tonnes) were recorded in the control treatment. The combination of starter solution and different concentrations of $GA_3$ exhibited significant variation for all the parameters studied. Most of the characters expressed maximum values under 1.5% starter solution + 50 ppm $GA_3$. The maximum yield/plot (52.41 kg) and yield/ha (121.33 tonnes) were noted from the treatment combination of 1.5% starter solution + 50 ppm $GA_3$. On the other hand, the minimum yield/plot (24.67 kg) and yield/ha (57.11 tonnes) were recorded from on starter solution + 0 ppm $GA_3$. The maximum cost of production of Tk. 76224/ha was involved in the treatment combination of 1.0% starter solution + 75 ppm $GA_3$ ($S_1G_3$), 1.5% starter solution + 75 ppm $GA_3$ ($S_2G_3$) and 2.0% starter solution + 75 ppm $GA_3$ ($S_3G_3$) treatment but the highest net return of Tk.173775/ha was obtained from 1.5% starter solution + 50 ppm $GA_3$ ($S_2G_2$) treatment. The maximum benefit cost ratio 3.52 was recorded from 1.5% starter solution + 50 ppm $GA_3$ ($S_2G_2$) treatment combination.

**Table 6.** Combined effect of starter solution and $GA_3$ on the yield components and yield of cabbage

| Starter solution × Conc. of $GA_3$ | Biomass/ plant (kg) | Gross weight of head (kg) | Economic yield/plant (kg) | Dry weight of head (g) | Yield /Plot (kg) |
|---|---|---|---|---|---|
| $S_0G_0$ | 2.60 | 2.30 | 1.61 | 88.12 | 24.67 |
| $S_0G_1$ | 3.39 | 2.32 | 1.67 | 115.05 | 26.77 |
| $S_0G_2$ | 3.52 | 2.41 | 2.10 | 127.77 | 33.74 |
| $S_0G_3$ | 3.60 | 2.38 | 2.00 | 125.56 | 30.35 |
| $S_1G_0$ | 3.27 | 2.43 | 2.00 | 125.38 | 30.29 |
| $S_1G_1$ | 3.99 | 2.97 | 2.30 | 160.45 | 39.27 |
| $S_1G_2$ | 4.06 | 3.91 | 2.91 | 189.03 | 48.26 |
| $S_1G_3$ | 4.06 | 3.86 | 2.90 | 162.62 | 47.85 |
| $S_2G_0$ | 3.41 | 3.35 | 2.11 | 125.73 | 31.60 |
| $S_2G_1$ | 4.10 | 2.99 | 2.90 | 186.65 | 46.73 |
| $S_2G_2$ | 4.51 | 4.00 | 3.32 | 195.27 | 52.41 |
| $S_2G_3$ | 4.20 | 3.91 | 3.11 | 174.95 | 49.77 |
| $S_3G_0$ | 3.20 | 2.66 | 1.90 | 124.55 | 28.45 |
| $S_3G_1$ | 3.67 | 2.91 | 2.21 | 130.92 | 37.65 |
| $S_3G_2$ | 3.76 | 3.88 | 2.89 | 175.71 | 46.45 |
| $S_3G_3$ | 3.57 | 3.55 | 2.40 | 137.28 | 42.32 |
| LSD (0.01) | 0.829 | 0.502 | 0.318 | 21.96 | 5.444 |
| CV (%) | 9.95 | 7.15 | 5.83 | 6.67 | 6.28 |

$S_0$ : 0% starter solution (Control), $S_1$ : 1.0% starter solution, $S_2$ : 1.5% starter solution, $S_3$ : 2.0% starter solution, $G_0$ : 0 ppm $GA_3$ (Control), $G_1$ : 25 ppm $GA_3$, $G_2$ : 50 ppm $GA_3$ , $G_3$ : 75 ppm $GA_3$

**Table 7.** Cost and return of cabbage production due to starter solution and $GA_3$

| Treatment combinations | Total cost of production (Tk.) | Gross return (Tk.) | Net return (Tk.) | Benefit cost ratio (BCR) |
|---|---|---|---|---|
| $S_0G_0$ | 69750 | 114220 | 44470 | 1.64 |
| $S_0G_1$ | 61323 | 123960 | 62637 | 2.02 |
| $S_0G_2$ | 68661 | 156180 | 87519 | 2.27 |
| $S_0G_3$ | 76000 | 140520 | 64520 | 1.85 |
| $S_1G_0$ | 53984 | 140220 | 86236 | 2.60 |
| $S_1G_1$ | 61547 | 181800 | 120253 | 2.95 |
| $S_1G_2$ | 68885 | 223420 | 154535 | 3.24 |
| $S_1G_3$ | 76224 | 221520 | 145296 | 2.91 |
| $S_2G_0$ | 53984 | 146280 | 92296 | 2.71 |
| $S_2G_1$ | 61547 | 216040 | 154493 | 3.51 |
| $S_2G_2$ | 68885 | 242660 | 173775 | 3.52 |
| $S_2G_3$ | 76224 | 230440 | 154216 | 3.02 |
| $S_3G_0$ | 53984 | 131720 | 77736 | 2.44 |
| $S_3G_1$ | 61547 | 174320 | 112773 | 2.83 |
| $S_3G_2$ | 68885 | 215040 | 146155 | 3.12 |
| $S_3G_3$ | 76224 | 195920 | 119696 | 2.57 |

The findings of the experiment indicated that the yield of cabbage head was greatly improved by starter solution and by different concentrations of $GA_3$. Head yield was increased due to starter solution and concentration of $GA_3$ over control. But the highest financial benefit was obtained from 1.5% starter solution along with 50 ppm $GA_3$ treated plot. The results obtained from the investigation exhibited a great influence of starter solution and $GA_3$ on the production of cabbage.

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