EFFECT OF PLANTING TIME AND STARTER SOLUTION ON THE GROWTH AND YIELD OF CABBAGE (*Brassica oleracea var.capitata* L.)

BY

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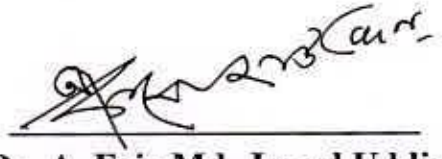

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CERTIFICATE

This is to certify that the thesis entitled, **"EFFECT OF PLANTING TIME AND STARTER SOLUTION ON THE GROWTH AND YIELD OF CABBAGE (*Brassica Olercea var.capitata* L.)"** submitted to the Department of Horticulture and Postharvest Technology, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **HORTICULTURE**, embodies the result of a piece of bona fide research work carried out by **RAJU AHMMED, Registration No.: 07-02578** under my supervision and my guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

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Dedicated to

My

Beloved Parents

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ABSTRACT

A study was conducted at central farm, Sher-e-Bangla Agricultural University, Dhaka during the period from October, 2007 to March, 2008 to investigate the influence of planting time and starter solution on the growth and yield of cabbage. The experiment consisted of four planting time viz. T_1 = 30 October, T_2 = 15 November, T_3 = 30 November and T_4 = 15 December and four levels of starter solution viz. S_0 = 0, S_1 = 0.8, S_2 = 1.6 and S_3 = 2.4% of urea respectively. Application of the treatment influenced independently and also in combination on the growth and yield of cabbage. The highest yield (73.61 t/ha) was obtained from T_2 and the lowest yield (69.5 t/ha) was recorded in T_4. The highest yield (81.01 t/ha) was obtained from S_2 and lowest yield (65.89 t/ha) was recorded from S_0. In case of combined effect, the highest yield (91.35 t/ha) of cabbage obtained from the treatment combination of T_2S_2, while the lowest (64.81 t/ha) was produced by control treatment. Economic analysis revealed that T_2S_2 was the best combination in respect of net return (Tk. 1, 89,001 /ha) with benefit cost ratio of 3.22. So, it may be concluded that 15 November planting with 1.6% starter solution was best for growth and yield of cabbage.

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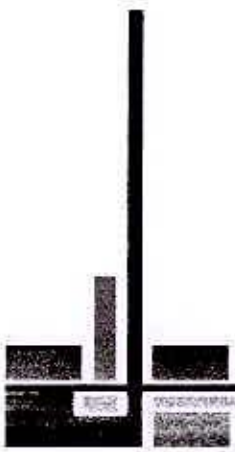
LIST OF ABBREVIATION AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BINA	=	Bangladesh Institute of Nuclear Agriculture
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food and Agricultural Organization
et al.	=	And others
TSP	=	Triple Super Phosphate
MP	=	Muriate of Potash
RCBD	=	Randomized Complete Block Design
DAT	=	Days after Transplanting
t /ha	=	ton Per hectare
g	=	Gram (s)
Kg	=	Kilogram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
Wt	=	Weight
LSD	=	Least Significant Difference
^{0}C	=	Degree Celsius
NS	=	Not significant
Max.	=	Maximum
Min.	=	Minimum
%	=	Percent
NPK	=	Nitrogen, Phosphorus and Potassium
CV	=	Coefficient of Variance
i.e.,	=	That is



Chapter 1
Introduction

Chapter 1

INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata* L.) belongs to the family Cruciferae. It is biennial and herbaceous in nature, and is extensively grown during the winter season in Bangladesh. Cabbage is the most important cole crop, and is one of the five leading vegetables of the world (Rashid, 1993). Although it originated in the sea coast of England, Denmark and north-western part of France, it has been distributed later to the sub-tropical and tropical areas (Thompson and Kelly, 1957). Though originated from temperate region, it has been distributed throughout the sub-tropical and tropical regions of the world.

Edible portion of cabbage is a large bud called head, which is formed by several fleshy leaves overlapping one another. It has been reported that 100g of green edible portion of cabbage contains 92% water, 24 calories of food energy, 1.5g of protein, 4.8g of carbohydrate, 40mg of calcium, 0.6mg of iron, 600 IU of carotene, 0.05mg of riboflavin, 0.3mg of niacin and 60mg of vitamin C (Rashid, 1993).

Among the vegetables grown in Bangladesh, cabbage ranks second in respect of production and area. At present, it is being cultivated in an area of increasing day by day with a production of 183 thousand metric tones (BBS, 2007). But yield of cabbage is very low in Bangladesh (9.79 t/ha, BBS, 2006) compared to that of other developed countries (30-70 t/ha) of the world (FAO, 1999). Production of crops depends on so many factors such as quality of seed, proper management practices including time of sowing of seeds, plant population, proper fertilizer management and intercultural operation etc. However the total production of cabbage can be raised by increasing the area under cultivation and adopting improved production technology.

Planting time is an important factor for yield of crop. Optimum planting time depends on the existing cropping pattern and prevailing environment. Cabbage need cool temperature for its optimum growth and head formation. In Bangladesh, it is planted in early September to late November. However, the temperature remains fairly high up to mid-October (max. 30-32^{0}C and min. 24-27^{0}C on average) which gradually comes down to about 20^{0}C on an average in mid-December and this cool period extends up to mid- February. For that

planting time for bean is therefore, very critical and sowing of seed should be done carefully so that the crop can take the best advantage of the entire cool period. It is, therefore, important to observe the effect of planting time for achieving optimum growth and yield of cabbage.

Fertilizer management is one of the important factors that contribute in the production and yield of any crop. Fertilizer management is also important agronomic practice which can be manipulated to maximize yield. Most soils of Bangladesh are deficient in major nutrient of growth. Urea is an important essential nutrient element for crop. Cabbage cultivation requires ample supply of nitrogen. Urea is main source of nitrogenous fertilizer and nitrogen is necessary for its vegetative growth and development. Cabbage seedlings are transplanted from seedbed to the main field. Time between uprooting and establishment of young and tender seedlings in the field is very critical. Starter are the mixture of fertilizer and mostly used as solution. It provides a ready source of nutrition near the absorbing zone of the seedlings just after transplanting. Starter solution influence quick recovery of transplanted seedlings and establishment. Vegetables like, cabbage, cauliflower and tomato respond well to starter solution minimizing the shock and being encourage to 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). Improving the existing production practices by various means especially through optimum time of planting and starter solution can be an avenue to increase the production of cabbage.
A few number of research works have been conducted in the past on the effect of different planting time and starter solution on growth and yield of cabbage not explored earlier.

Considering the above stated factors, the present study undertaken with the following objectives:

i. To find out the suitable time of planting for the maximum growth and yield of cabbage;

ii. To study the effect of urea as starter solution on growth and yield of cabbage;

iii. To define the suitable planting time along with different concentration of starter solution for better vegetative growth, maximum yield and economic return of cabbage.

Chapter 2

Review of literature

Chapter 2

REVIEW OF LITERATURE

Cabbage is one of the oldest cultivated leafy vegetables in the world as well as in Bangladesh. The farmers of Bangladesh are quite ignorant about the modern techniques to growing cabbage. Planting time is a very important factor for cabbage production. Considerable interest has been developed recently regarding the benefit from the use of starter solution at the time of transplanting cabbage seedling. A very limited number of reports on planting time and starter solution in cabbage under Bangladesh condition. However, some of most relevant research reports regarding the effects of different planting time and starter solution on the growth and yield of cabbage have been reviewed here:

2.1 Effect of planting time on growth and yield of cabbage

Field experiment conducted at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh during the period from August, 2001 –March 2002 by Hasan (2002) to investigate planting time showed significant effect on growth and yield of cabbage. The plant height , number of folded leaves, % head formation, fresh and dry weight of head, yield (56.27 t/ha) and harvest index were the highest in treatment of 25 October planting, while most of them were the lowest in 25 November planting time. Days required to head formation and head maturity were the highest (64.40 and 92.90 days) in case of 25 November and 25 September planting while they were the lowest (57.60 and 87.22 days) in 25 October and 25 November planting. Mulching also had significant effect on most of the parameter studied. Black polythene mulch the most effective on days required for head formation, % head formation and yield (58.36 t/ha) of cabbage. The growth and yield also significantly affected by pinching. The yield (55.60 t/ha) and harvest index were the highest in the plant pinched at 30 DAT, while they were the lowest (45.37 t/ha) in control.

Field experiment carried out in 1994 and 1995 in Sele Plain, Italy, by Caruso *et al.* (2000) to investigate the effects of planting time and chemical weed control on weed flora evolution and on yield and growth in cabbage cv. Precoce di Copenhagen. Three planting times (15 March, 21 April, and 29 May, in 1994; 6 April, 9 May, and 5 june, in 1995) and two weed control treatments (pre transplanting chemical application with

chlorthal-dimethyl (3.4 kg/ha) + propachlor (3.2 kg/ha) and no weed control) were compared. Harvesting done from May to July in 1994 and from June to August in 1995. Weeds were sampled on 5 dates during each year at intervals after transplanting. In comparison with the highest yield, which obtained with the first planting time (62 t/ha as an average for the 2 years), reductions of 20.4 and 45.1% were recorded for the second and the third planting times, respectively.

Nuruzzaman (1999) found significant effect of planting time on the growth and yield of cabbage. He got the highest gross and marketable yields (102.42 t/ha and 70.18 t/ha) from early planting.

An experiment conducted by the Christian Reformed World Relief Committee, Bogra to evaluate the performance of eight cabbage varieties at two different planting dates (Anonymous, 1980a). The varieties included in the 2- year trials Big Cropper, Tokyo Pride, Titan, Hercules, Saturn 45, Saf-Gard 18, Atlas-70 and Copenhagen Market. Two trials were conducted. In trail No. 1 sown on September 15, Atlas-70 and Copenhagen Market, out of eight Varieties were the earliest to harvest requiring 107 days on an average from sowing to harvest. In trial no. 2 sown on October 15, 1979, the variety Titan the highest yielder (2.58 kg/head).

Vanparys and Beke (1997) conducted an experiment with ten white cabbage cultivars (Predena, Avalon, Bingo, Cassandra, I:disun, Faun, Galaxy, Ilinova, Marathon and Zerline) for comparative study of yield and quality during 1997 at 2 sites in Belgium. Cultivars were sown on 22 and 26 April, planted out on 29 May and 4 June, harvested between 16 September and 30 October and 23 August and 27 September. The best results were found with Bingo and Avalon planted on 2 June.

In 3-year field trials, under tile condition of Gorna Oriahovitsa region in Poland, Suvandjiev and Suvandjieva (1995) investigated optimum sowing date on the yield of cabbage. Different sowing dates viz. 30 August, 10 September. 20 September and 5 October were included. They observed that sowing time had a strong influence on the winter resistance of plants and the ability to flower decreased for later sowing dates. Results of the experiments revealed that 20 September the optimum sowing date for early cabbage and the highest yield (24.87 t/ha).

The number of head forming plants and yield of cabbage were influenced by the planting dates (Futane *et al.*, 1995). The seedlings were planted on 27 October, 17 November, 7 December and 27 December, 1990 and observed that the percentage of head forming plants were lower in the plantings of 27 December than in the plantings of other dates and yield the highest with planting on 7December, while the lowest noted with the planting on 27 December (5.24 and 3.54 t/ha, respectively).

In Poland, three Dutch cabbage cultivars Lennox F_1, Galaxy F_1 and Marathon F_1, and local cultivar Kamienna Glowa were planted on 8 and 26, May 1992 and 18 May and 5 June, 1993. Cebula *et al.* (1994) observed that the marketable yield obtained (63.88-107.41 t/ha) confirmed the value of the yields were with Kamienna Glowa (76.20-165.92 t/ha) and Marathon F_1, (63.88-89.40 t/ha). Delayed planting dates brought about a significant decrease in yields in 1993 only, except for Kamienna Glowa which not affected in either year.

Shashidhar *et al.* (1994) studied the yield of cabbage affected by the planting dates. They carried out an experiment with 2-year trials at Karnataka, India and recorded the highest leaf damage occurred in the planting of first week of January. They also found that the highest average yield 87.14 t/ha when the seedlings were planted in the first week of October.

Mancini and Sario (1992) observed that the yield of cabbage influenced by the planting dates under Italian climatic condition. In a 2-year trial they planted seedlings on 2, 10, 20 October and 2 November in plots. Results of the experiment indicated that head yield declined when planting date delayed i.e. the yield of 54 t/ha against planting date of 2 October decreased (39.3 t/ha) with planting on 20 October.

Everaarts and Moel (1990) conducted a four year experiment in Alkmaar (Netherlands) where seedlings of the cultivars Castello and Vartolo were planted in May, June or July. Crops were harvested in late October. The rate of leaf appearance different between planting dates. The total number of leaves produced (excluding the head) in both the cultivars decreased with later planting and Bartolo attained a much higher leaf area index than Castello. The later planting reduced yield (heads being harvested when less mature, after a shorter growing season).

The influence of planting date and spacing on the growth and yield of cabbage studied at BINA, Mymensingh by Islam *et al.* (1990), who reported that maximum plant height, number of leaves per plant at harvest and leaf size was obtained from 20 and 30 September planting and decreased gradually with the subsequent plantings.

Booij and Dekkor (1990) conducted an experiment in the Netherlands with two cabbage cultivars Castello and Bartolo which were planted in the field on 15 May, 19 June and 15 July in 1986 and 11 May, 16 June and 10 July in 1987. Harvesting started 2 weeks after planting and continued until late October. For both the cultivars, the late plantings resulted in poorer Final yields (Assessed oil -27 October 1986 and 26 October 1987). The decrease in head weight with late planting greater for Bartolo. The onset of rapid head growth earlier and dry matter partitioning to the head greater in Castello.

Begum *et al.* (1990) reported that transplanting 30 days old cabbage seedlings at an interval of 15 days from 14 September to 13 December demonstrated a wide variation in vegetative growth and yield of seed. Planting during 14 October to 13 November resulted in increased vegetative growth and large heads than earlier or late plantings.

Han and Park (1985) found that heading of cabbage affected by sowing time. They added that the best result obtained at the planting time in September compared to planting of October under the climatic condition of Cheju Island in South Korea.

Hossain (1999) observed that the yield of cabbage influenced by different planting times and spacing. In a trial seeds were sown on 20 September, 15 October or 5 November and the seedlings were transplanted 30 days later. Sowing on 15 October and Spacing at 60 cm x 60 cm gave the highest yields (50 kg/plot) in cultivars Hercules and Titan, and spacing at 45 cm × 45 cm gave the highest yield (55 kg/plot) in cv. K-Y cross. The 3 cultivars yielded 36.9, 40.4 and 44.5 kg per 3.15 m × 2.4 m plot, respectively.

An investigation carried out at the Bangladesh Agricultural Research Institute, Joydebpur, Gazipur to explore the possibilities of extending the cultivation period of cabbage by selecting early and late varieties (Ahad and Tasaki, 1981). In August planting, the varieties Express Cross, Morishogun and K-K cross were found to be superior to all other varieties with respect to yield. These 3 varieties appeared to be quite suitable for

August planting. In October and December plantings, all the varieties performed well. Those two planting dates were considered as the normal planting time.

A trial on the date of planting conducted by the Mennonite Central Committee (MCC) in 1977 at Feni, Noakhali (Anonymous. 1980b). The results indicated that the optimum transplanting date around 1 November to 1 December for standard cabbage varieties.

According to the reports of the Christian Reformed World Relief Committee (Anonymous, 1978), planting of cabbage seedling during the period from 1 October *to* 15 November found to he suitable for Bangladesh.

Athi *et al.* (1976) planted cabbage seedling cv. Golden Acre at 10 dates from June to mid-October. Plant growth and head formation were best in September planted seedlings.

Aliaskarzada (1973) conducted an experiment in Azerbaijan and found the optimum sowing time of cabbage between 20-25 Septembers. The late sowing time showed unsatisfactory results for all the cases.

Arora (1970) reported that transplanting of cabbage seedlings in October helps harvesting crop before the appearance of aphid and thus increases the total yield than the delayed planting under Indian climatic conditions.

2.2 Influence of starter solution on the growth and yield of cabbage

Starter solution influences quick recovery of transplanted seedling and quicker establishment. Early setting or quick recovery of transplanted seedling using starter solution has been studied and reported by a number of workers.

A field experiment conducted at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh during the period from October, 2001 –February 2002 by Roy (2002) to investigate the influence of starter solution and GA_3 on growth and yield of cabbage. The experiment consists of four levels of starter solution, viz. 0, 1.0, 1.5 and 2.0 % of urea and four concentration of GA_3, viz. 0, 25, 50 and 75 ppm. The application of starter

solution and different concentration of GA_3 influenced independently and in combination on the growth and yield of cabbage. The highest yield (104.93 t/ha) obtain from 1.5 % starter solution which significant different from other solutions, and the lowest yield (66.86 t/ha) recorded from the control. Significantly higher yield (104.66 t/ha) found from 50 ppm GA_3, while the lowest yield (66.56 t/ha) recorded from control. In case of combined effect, the highest yield of cabbage (121.33 t/ha) 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), a while lowest yield (57.11 t/ha) produced by the control treatment.

The field experiment conducted at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh during the period from October, 1997 –February 1998 by Kamal (1998) to investigate the influence of starter solution and mulching on growth and yield of cabbage. The experiment consisted of two levels of starter solution (starter solution and no starter solution) and four different mulching treatments (black polythene, water hyacinth, irrigation and natural mulch, and no irrigation and no mulch).

Application of starter solution and mulching influenced independently and in combination on the growth and yield of cabbage. However, when single effect considered the characters such as fresh weight of root , plant height, fresh weight of loose leaves, dry weight and dry matter (%) of loose leaves, fresh weight of stem, thickness of head, fresh and dry weight and percent dry matter of head and yield per hectare were significant influenced by starter solution. Similarly, the effect of mulching considered. As a combined effect the positive response of starter solution on most of the characters studied. The gross and marketable yield of cabbage per hectare were found to be much higher in combination treatments (153.25 and 115.20 t/ha, respectively) followed by the treatment combination of starter solution and black polythene mulch (149.25 and 111.79 t/ha, respectively) and treatment combination of starter solution and water hyacinth mulch (142.19 and 108.68 t/ha, respectively).

Islam *et al.* (1989) 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 obtained form the treatments of 1.5% and

1% urea solution and at increasing concentration of urea solution the yield gradually declined while the untreated seedlings gave the lowest yield.

Shi *et al.* (1984) observed that addition of nitrogenous fertilizer in the starter transplanted autumn cabbage seedlings through the associated micro-flora in the soil and ultimately increased the growth. They found that the starter solution increased the marketable yield of cabbage.

Kadam *et al.* (1983) observed that a commercial starter solution suphala named used on cabbage gave maximum yield compared to non-treated control.

Henmis *et al.* (1973) reported that sodium nitrate ($NaN0_3$) or ammonium sulphate as starter solution improved the early growth and yield of cabbage seedling in the solution effective in minimizing the shock of uprooting of seedling, vigorous growth and bigger head formation which ultimately increased the total yield. They also used urea solution alone in different concentration as starter solution on Golden Acre variety of cabbage. They found that a significant increase in yield obtained due to early recovery and non mortality of cabbage seedlings occurred.

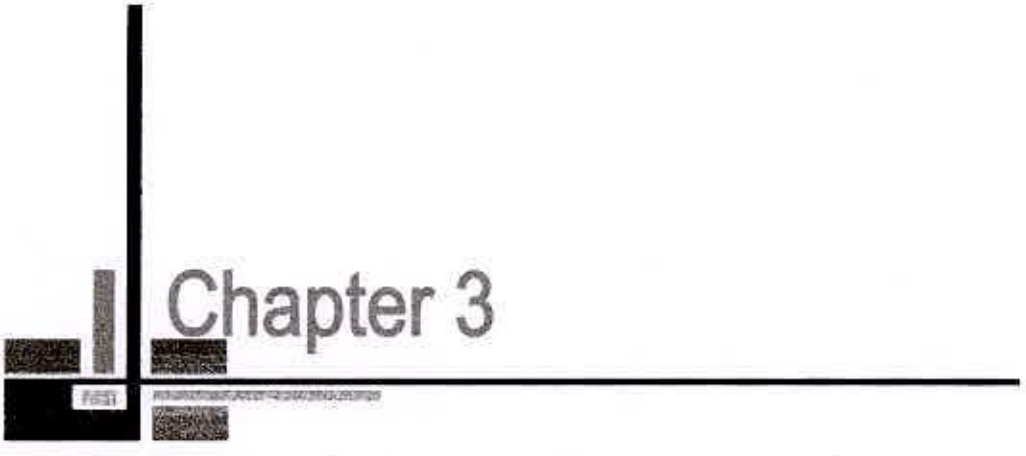
Mohanty and Nema (1970) conducted an experiment with starter solution cabbage and reported that the highest yield of cabbage obtained by using starter solution containing urea, potassium sulphate and single superphosphate applied immediately after transplanting.

Starter solution influences number and size of loose leaves, size and thickness of head. Chhonkar and Sharma (1966) reported that using urea in combination with single superphosphate and potassium chloride at the ratio of 1:2:1 and also ammonium sulphate and single superphosphate at the ratio of 1:2 as starter gave minimum number and larger size of outer leaves, bigger and heaver heads. They found that increased marketable yield of cabbage due to starter solution treatment. In another experiment Patil *et al.* (1979) revealed that starter solution used by dipping the roots of seedling in the solution effective in minimizing the shock of uprooting of seedling, vigorous growth and bigger head formation which ultimately increase the total yield.

Chhonkar and Jha (1963) reported that the transplanting operation of the seedling disturbs the soil root relationship, and crops like cabbage. Cauliflower, tomato and chilies responded well when treated with starter solution and plant growth regulators. They found that use of starter solution on cabbage increase as much as 150 per cent of yield in cabbage over control.

Chaudury and Singh (1960) reported that starter solution has influence on vigorous growth of both under ground and aerial part and also cabbage head.

Chhonker (1959) conducted an experiment with starter solution and found positive effect on early recovery, vigorous growth of root and shoot.



Chapter 3

Materials and methods

Chapter 3

MATERIALS AND METHODS

In this chapter materials and methods that were used in conducting the experiment have been presented. It includes a short description of the location or experimental site, soil and climatic condition of the experimental plot, materials used for the experiment, design of the experiment, methods of data collection, statistical analysis and economic analysis. The details of the experiment and methods used are described below.

3.1 Experimental Site

Plants of cabbage were grown at Agronomy Farm in Sher-e-Bangla Agricultural University (SAU) Dhaka-1207, Bangladesh. The experiment carried out during Rabi season (October 15, 2007 to February 15, 2008). It located in 24.09^0 N latitude and 90.26^0 E longitudes. The altitude of the location was 8m from the sea level (Bangladesh Meteorological Department, Agargaon, Dhaka-1207).

3.2 Climate

Experimental area is situated in the sub-tropical climatic zone, which is characterized by heavy rainfall during the months of April to September and scanty rainfall during the rest period of the year. Details of weather data in respect of temperature (^{0}C), rainfall (cm) and relative humidity (%) for the study period were collected from Bangladesh Meteorological Department, Agargaon, Dhaka-1207 (Appendix I).

3.3 Soil

Experimental site was located in the Modhupur Tract (AEZ-28) and the land was medium high land with adequate irrigation facilities. The soil was having a texture of sandy loam with pH was 5.6. Physical and chemical properties of soil in the experimental field of Agronomy farm, Sher-e-Bangla Agricultural University, Dhaka were given in (Appendix II).

3.4 Materials used for the experiment

Variety of cabbage selected for the experiment Atlas- 70. The seeds were F_1 hybrid produced by Sakata seed corporation, Japan and collected from Mollika Seed Company, Siddique Bazar, Dhaka.

3.5 Raising of seedlings

Cabbage seedlings were raised at Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, under special care in two seed beds each of 5m×1m size. Soil of the seed bed ploughed, prepared well and clods were broken into small pieces and converted into loose, friable to obtain good tilth. All weeds, stubbles and dead roots of the previous crops were removed carefully. Seedbeds were dried in the sun to prevent the damping off disease. Twenty grams of seed were sown in each seed bed on 5 October, 20 October, 5 November and 20 November 2007 to get seedlings of 25 days old at the time of transplanting. After sowing, the seeds were covered with finished light soil. Seed were completely germinated within 7 days after sowing. Shading given by bamboo mat (chati) over the seedbed to protect the young seedlings from scorching sunlight and rainfall. Weeding, mulching and irrigation were done from time to time to provide a favorable condition for good growth and raising quality seedlings.

3.6 Design and layout of the experiment

Two factor experiments were laid in the Randomized Complete Block Design (RCBD) with three replications (Figure 1). Experimental plot divided into three blocks. Each block consisted of 16 unit plots. Different combination of planting time and starter solution were assigned randomly to each block as per design of the experiment. Size of unit plot 2.4m×1.8m. Distance of 0.75m between the block and 0.5m between the plots were kept.

3.7 Treatment of the experiment

Present study consisted of two factors at different levels. The treatments were as follows:

Treatments:

Factor –A:	Factor-B:
Four Planting Time:	Four different levels of starter solution:
T_1 = 30 October	S_0 = 0% Urea
T_2 = 15 November	S_1 = 0.8% Urea
T_3 = 30 November	S_2 = 1.6% Urea
T_4 = 15 December	S_3 = 2.4% Urea

Total No. of plot : 48 (3x16)

Unit size of plot : 2.4m x 1.8m

3.8 Methods of cabbage cultivation

3.8.1 Land preparation

Experimental field opened with a tractor drawn disc plough. Subsequently cross ploughing done five times with a country plough followed by laddering to make the land suitable for transplanting the seedlings. All weeds, stubbles and residues were eliminated from the field. Finally, a good tilth achieved.

3.8.2 Application of manures and fertilizers

Well decomposed cowdung applied @ 10 t/ha and incorporated to the soil of the plot during final land preparation. 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). Whole amount of TSP, MP and half of Urea were applied before final land preparation. Rest amount of urea were applied to the 20 days interval after transplanting.

3.8.3 Preparation of starter solution

At first, 0, 0.8, 1.6 and 2.4 g of urea were weighed and were dissolved in distilled water taken in four different beakers. The solution then made to volume up to 100 ml by adding further distilled water. Beakers were leveled and the solution ready for use.

3.8.4 Transplanting of seedlings

Twenty five days old healthy and uniform size seedlings were transplanted in the experimental plots on 30 October, 15 November, 30 November, and 15 December. Seedlings were uprooted carefully from the seedbed to avoid damage to the root system. Planting done in the afternoon. Bottom part of the seedlings dipped for 5 minutes in urea solution prior to transplanting. A spacing of 60 cm between the rows and 45 cm between the plants were maintained. Thus unit plot accommodate 16 plants. Seedlings were watered immediately after transplanting. Transplants were shaded by banana leaf sheath to protect them from scorching sunshine up to 3 days until they were set in the soil. Transplants were kept open at night to allow them receiving dew. A number of treated seedlings were planted on the border of the experimental plots for gap filling.

3.8.5 Intercultural operation

Plants were kept under careful observation. Light watering done even morning and afternoon following transplanting and that continued for 6 days for early and well establishment of the seedlings. Weeding and other intercultural operations were done as and when required. Earthing up around the plants done at 25 days after transplanting taking the soil from the space between the rows in the plots. Very few seedlings were damaged after transplanting and such seedling were replaced by new seedlings from the same stock planted earlier on the border of the experimental plots. Seedlings were transplanted, deeping in starter solution with roots to avoid transplanting shock.

3.8.6 Control of pest and diseases

Despite application of Moral; mole cricket and cut warms damage few plants and they were transplanted in the field. Cut warms were controlled both mechanically and spraying Darsban 20EC @ 3%. Some of the plants were attacked by aphids and were controlled by spraying Diazinon 60EC @ 0.56 liter/ha. Birds were found to puncture the soft leaves and young head, and were controlled by biting a kerosene tin frequently during day time.

3. 8.7 Harvesting

Harvesting of the crop not possible on a particular date because head initiation as well as head maturation period in plants were not similar. Crop harvested during the period from 1 January to 29 February for four planting.

3.9 Data Collection

i. Plant height
ii. Total number of leaves
iii. Days to first head formation
iv. Days to head maturity
v. Percentage of head formation.
vi. Length of stem
vii. Thickness of head
viii. Diameter of head
ix. Fresh weight of head
x. Dry weight of head
xi. Percent dry weight of head
xii. Biomass production per plant
xiii. Economic yield per plant
xiv. Yield per plot and hectare

3.10 Method of data collection

Data on the following characters were recorded from the randomly selected six plants in each plot. Data on plant height, and number of leaves were counted at 20, 35 and 50 days after transplanting (DAT) and also at harvest, respectively. All other parameters were recorded at harvest. The following parameters were set up for recording data and for the interpretation of the results.

3.10.1 Plant height

Height of the plant measured by placing a meter scale from ground level to the tip of the outer longest leaf of an individual plant. Thus mean of six selected plants of a single plot recorded and expressed in centimeter.

3. 10.2 Total number of leaves per plant

Number of folded and unfolded leaves per plant counted and mean of six plants recorded at harvesting by sectioning of head. At the counting of unfolded leaves, dead leaves were included.

3.10.3 Days to first starting of head formation

Days to starting of head formation counted from the date of transplanting to the starting of head formation and recorded.

3.10.4 Days to head maturity

Date of transplanting to head harvesting counted for days required to head maturity.

3.10.5 Percentage of head formation

Number of plants forming head in a plot expressed in percentage as follows:

$$\text{Head formation (\%)} = \frac{\text{Number of head formed plant in a plot}}{\text{Number of total plant in a plot}} \times 100$$

3.10.6 Length of stem

Length of stem at harvest measured in centimeter with the help of a meter scale as the distance from the ground level to the base of the unfolded leaf.

3.10.7 Thickness of head

Thickness of head measured in centimeter with the help of a meter scale as the vertical distance from one side to another side of the head.

3.10.8 Diameter of head

Three heads out of six were selected randomly. Then sectioning of head done vertically with a sharp knife at the middle portion. Diameter of head measured as the horizontal distance from one side to another side of the selected head and expressed in centimeter.

3.10.9 Fresh weight of head per plant

From the average of six selected plants the fresh weight of head per plant recorded in kilogram.

3.10.10 Dry weight of head per plant

A sample of one kilogram of chopped head collected from the head of six plants and dried under direct sunshine for 72 hours and then dried in an oven at 70°C for three days. Dry weight of head recorded in gram with an electric balance.

3.10.11 Percent dry meter of head

Percent dry meter of head calculated from dry weight of head by the following formula:

$$\text{Dry matter of head (\%)} = \frac{\text{Dry weight of head}}{\text{Fresh weight of head}} \times 100$$

3. 10.12 Biomass or biological yield of individual plant

Yield of cabbage including loose leaves and roots measured in kilogram.

3.10.13 Economic yield per plant

It is the weight of cabbage head excluding roots and outer leaves measured in kilogram.

3. 10.14 Yield per plot and hectare

Harvesting done plot wise after testing the compactness of the cabbage head. Personal judgment involved in it. Cabbage head were collected from inner rows of plants of each unit plot to avoid any border effect and their weight recorded. Total head weights were recorded in each unit plot and expressed in kilogram. Yield per plot finally converted to per hectare and expressed in ton (t).

3.11 Statistical analysis

Recorded data on different parameters were statistically analyzed using MSTAT software to find out the significance of variation resulting from the experimental treatments. The mean for the treatments calculated and analysis of variance for each of the characters performed by F (variance ratio) test. Differences between the treatment means were evaluated by LSD test at 5% probability.

3.12 Economic analysis

Cost of production analyzed in order to find out the most economic treatment of planting time and starter solution combinations. All input cost including the cost of lease of land and interest on running capital were considered in computing the cost of production. The interests were calculated @ 13% for eight months. Market price of cabbage considered for estimating the gross and return. Analysis done details according to the procedure of Alam *et al.* (1989). The benefit cost ratio (BCR) calculated as follows:

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

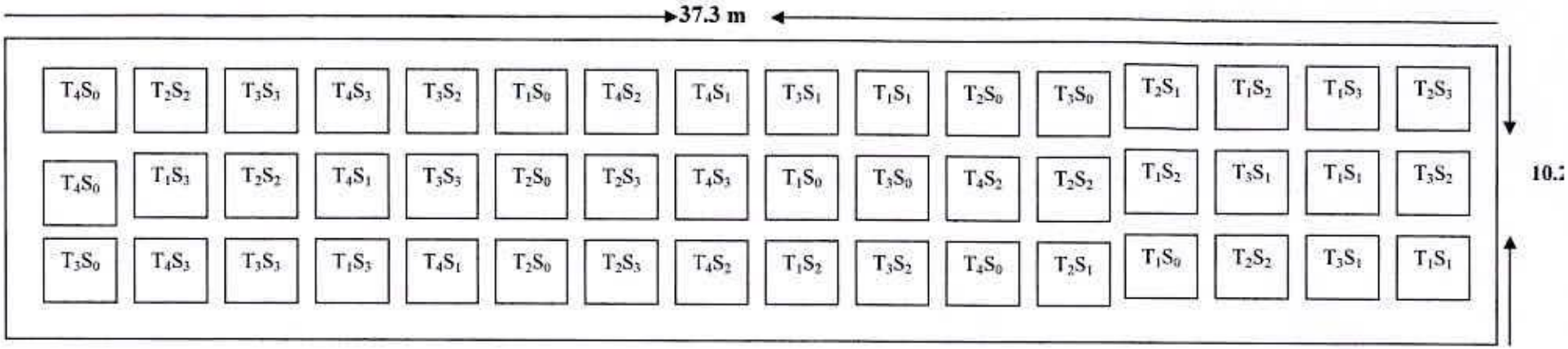


Figure 1. Layout of experimental design.

Factor A: Planting time

T_1= 30 October

T_2 = 15 November

T_3 = 30November

T_4 = 15 December

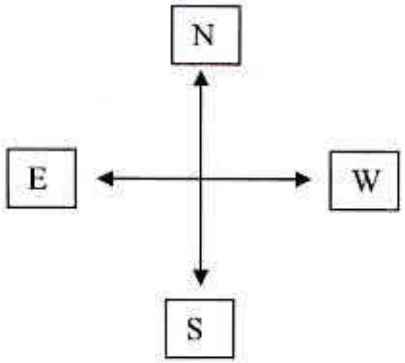
Factor B: Levels of starter solution

S_0 = 0% Urea (no urea)

S_1 = 0.8% Urea

S_2 = 1.6% Urea

S_3 = 2.4% Urea



Length = 1.8m × 16 + 0.5m × 17

= 37.3 m.

Breadth = 2.4m × 3 + 0.75m × 4

= 10.2 m.

Total area = 37.3 m. × 10.2 m.

= 380.46 sq. m.

plot to plot distance = 50cm

Block to block/replication to replication = 75cm

Unit plot size = 2.4m × 1.8m

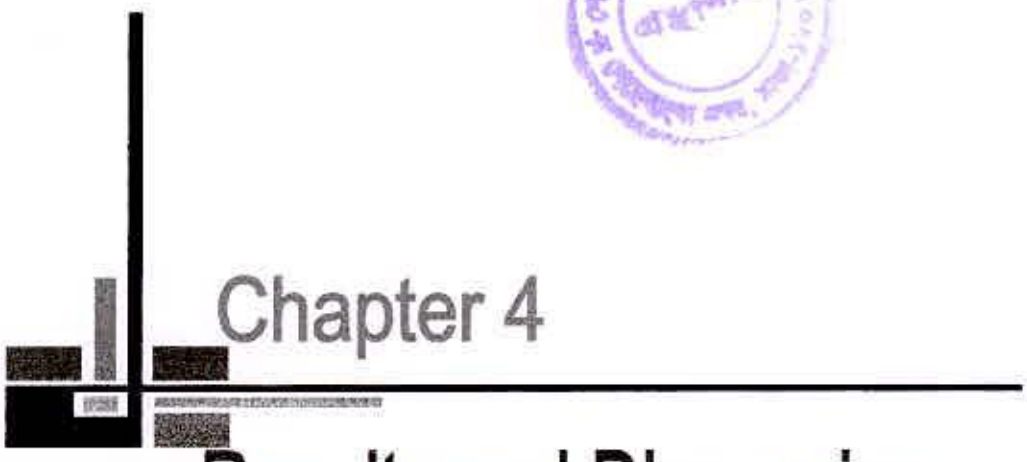
Plant to plant distance = 60cm

Spacing =60 cm× 45cm

Row to row distance = 45cm

Total number of plant per plot = 16

Total number of plant per hectare = 37037



Chapter 4

Results and Discussion

Chapter 4

RESULT AND DISCUSSION

Result obtain from the present experiment on the effect of planting time and starter solution and their interaction effect on growth and yield of cabbage have been noted in different tables and figures in this chapter. Analyses of variances of all parameters have been discussed and possible interpretations have been made under following headings:

4.1 Plant height

Planting time showed significant effect on plant height (Figure 2). Tallest plant (23.56 cm) was obtained from T_3 (30 November) which was statistically similar with T_2 (15 November) and lowest (17.19 cm) was found in T_1 (30 October) planted crops which was statistically similar with T_4 (15 December) planted crops at 20 days after transplanting (DAT). In case of 35 DAT, T_3 showed the tallest plant (25.63 cm) and T_2 showed the second highest plant (25.49 cm) which was similar T_1& T_4. Tallest plant (30.80 cm) was observed T_3 and smallest plant (29.60 cm) was observed in T_1 & T_4 at 50 DAT. T_3 showed that the tallest in all cases including harvest period. This might be due to the fact that 30 November (T_3) planted crops possibly got favorable condition for better growth than those of other planting dates.

Plant height of cabbage at 20, 35 and 50 days after transplanting (DAT) were significantly influenced by the treatments of the experiment, i.e. planting time and different concentrations of starter solution and also by their combinations. Plant height was increased with increasing period of time. Tallest plant was observed in 1.6% starter solution (S_2) treatment followed by 0.8% and 2.4% starter solution, respectively. Shortest plant was given by control (S_O) treatment (Figure 3).

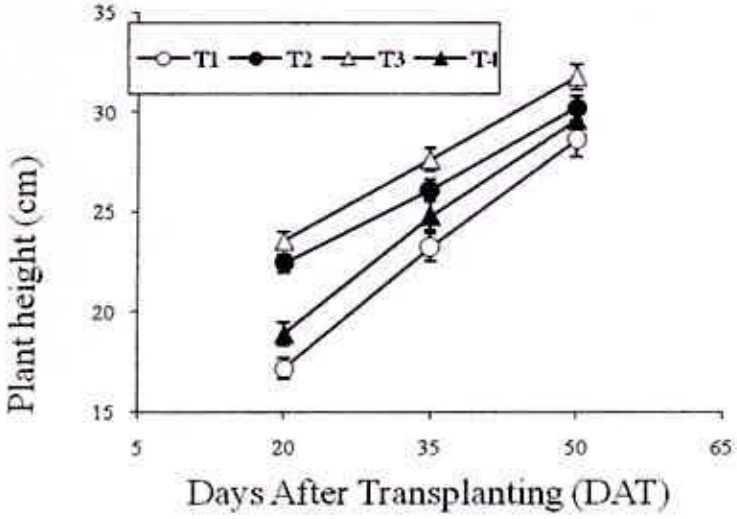


Figure 2. Effect of planting time on the plant height of cabbage (vertical bar indicate standard deviation). DAT = Days after transplanting; T_1 = 30 October, T_2 = 15 November, T_3 = 30 November, T_4 = 15 December

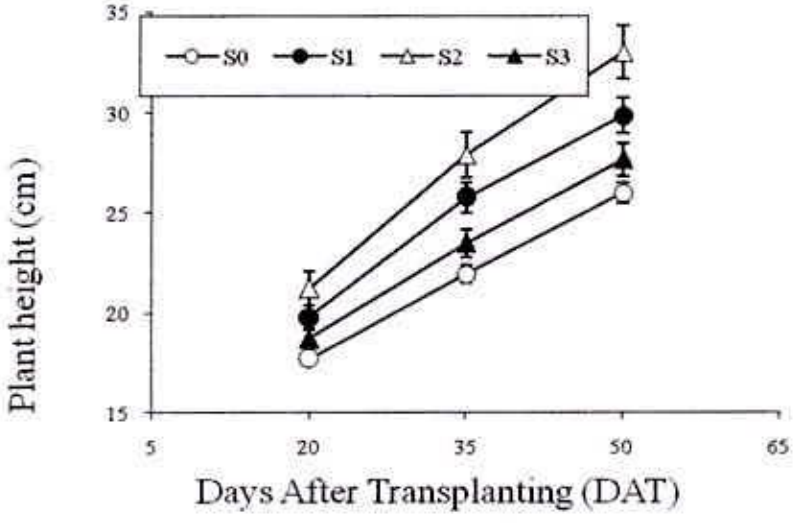


Figure 3. Effect of starter solution on the height of cabbage (vertical bar indicate standard deviation). DAT = Days after transplanting; S_0 = 0% urea, S_1=0.8 % urea, S_2=1.6 % urea, S_3 =2.4 % urea

Maximum plant height of 21.25, 27.90 and 32.99 cm were found at 20, 35 and 50 days after transplanting, respectively in the 1.6% starter solution (S_2) treatment and the shortest plants of 19.70 cm, 23.50 cm and 27.76 cm were found at 20, 35 and 50 days after transplanting, respectively in the control treatment (S_0).

Plant height was found statistically different at 20 DAT to 50 DAT. 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 was found to be significantly different due to the combined effect of planting time and starter solution at different days after transplanting (Table 5). It was revealed that the tallest plant (34.40 cm) was found in plants treated with T_3 (30 November) with 1.6 % starter solution (T_3S_2) treatments. Lowest plant height (26.20 cm) was observed from the control treatment (T_4S_0) due to favorable environment condition.

Table 1: Effect of planting time on the growth of cabbage

Planting time[x]	Total number of leaves	Days to first head formation	Days to head maturity	Percentage of head formation	Length of stem (cm)	Thickness of head (cm)
T_1	72.50 a	35.25 a	79.83 a	66.14 c	4.63 c	13.41 a
T_2	72.33 a	33.25 c	74.91 b	85.41 a	5.97 a	14.33 a
T_3	70.66 b	34.25 b	80.08 a	71.35 b	3.97 d	13.66 a
T_4	71.91 a	34.16 b	78.75 a	71.56 b	5.15 b	12.33 b
CV (%)	1.92	2.46	1.97	7.11	7.38	7.90
Lsd $_{(0.05)}$	2.30	1.40	1.40	8.73	0.60	1.76

[x] T1 = 30 October, T_2 = 15 November, T_3 = 30 November, T_4 = 15 December

Table 2: Effect of planting time on the yield of cabbage

Planting time[x]	Diameter of head (cm)	Biomass production per plant (kg)	Dry weight of head (g)	Percentage of dry matter of head	Economic yield per plant (kg)	Yield per plot (kg)
T_1	21.08 ab	2.36 a	73.50 b	7.35 b	1.88 b	30.20 b
T_2	21.58 a	2.62 a	75.47 a	7.55 a	1.97 a	31.80 a
T_3	19.91 c	2.32 a	75.93 a	7.59 a	1.95 a	31.46 a
T_4	20.50 bc	2.48 a	75.75 a	7.57 a	1.87 b	29.91 b
CV (%)	5.32	15.02	1.35	1.36	2.87	3.50
Lsd $_{(0.05)}$	0.921	0.306	1.69	0.16	0.09	1.80

[x] T_1 = 30 October, T_2 = 15 November, T_3 = 30 November, T_4 = 15 December

4.2 Total number of leaves per plant

Total number of leaves per plant was significantly influenced by planting time at every date of transplanting (Table 1). At harvest, highest number of leaves (72.50) per plant was found in T_1 (30 October) and lowest number of leaves (70.66) per plant was found in T_3 (30 November) but the others are statistically similar to T_1 (30 October).

Different concentrations of starter solution exhibited a significant influence on number of leaves per plant at different days after transplanting (Table 3). Number of leaves per plant was increased with the time. During the plant growth, maximum number of leaves per plant was found at harvesting stage in 1.6% starter solution (S_2) followed by 2.4% starter solution (S_3) and 0.8% starter solution (S_1), respectively.

Maximum numbers of leaves (73.75) were found in (S_2) starter solution and the lowest number of leaves was (70.58) found in (S_0) starter solution. It might be due to vigorous growth of plants by using starter solution. These results are in support of the findings of Chaudhury and Singh (1960).

Combined effect of planting time and starter solution at different days after transplanting (DAT) was found to be statistically significant on the number of leaves per plant (Table 6). Maximum number of leaves (76.00) per plant was found in (T_4S_2) treatment combination and the second highest number of leaves (74.00) per plant was found in (T_2S_2) treatment combination. Lowest number of leaves (70.00) per plant was found in (T_3S_0) control treatment. Because of the favorable environment condition and good agronomic practice prevail in the field.

Table 3: Effect of starter solution on growth and yield contributing characters of cabbage

Starter solution[y]	Total number of leaves	Days to first head formation (days)	Days to head maturity (days)	Head formation (%)	Length of stem (cm)	Thickness of head (cm)
S_0	71.41b	38.16a	80.83a	70.83bc	4.67b	13.33a
S_1	70.58b	35.25b	80.08a	71.87b	4.95b	13.58a
S_2	73.75a	30.08d	71.83b	84.58a	5.32a	13.66a
S_3	71.66b	33.41c	80.83a	67.18c	4.79b	13.16a
CV (%)	1.92	2.46	1.97	7.11	7.38	7.90
Lsd $_{(0.05)}$	2.30	1.40	1.40	8.73	0.60	1.76

[y] S_0 = 0% urea, S_1=0.8 % urea, S_2=1.6 % urea, S_3 =2.4 % urea

Table 4: Effect of starter solution on yield contributing characters of cabbage

Starter Solution[y]	Diameter of head (cm)	Biomass production per plant (kg)	Dry weight of head (g)	Dry matter of head (%)	Economic yield per plant (kg)	Yield per plot (kg)
S_0	19.91c	2.15b	71.04c	7.10c	1.77c	28.46c
S_1	20.91ab	2.44b	74.52b	7.45b	1.86b	30.00 b
S_2	21.66a	2.90a	80.54a	8.05a	2.18a	34.85a
S_3	20.58bc	2.29b	80.54b	7.45b	1.87b	30.06b
CV (%)	5.32	15.02	1.35	1.36	2.87	3.50
Lsd $_{(0.05)}$	0.921	0.306	1.69	0.16	0.091	1.80

[y] S_0 = 0% urea, S_1=0.8 % urea, S_2=1.6 % urea, S_3 =2.4 % urea

4.3 Days to first head formation

Planting time significantly influenced on days to starting head formation. In 30 October (T_1) planted crops, it required 35.25 days to start head formation, which was the highest among the planting times, while the lowest (33.25 days) was obtained from 15 November (T_2) planted crops (Table 1). The 15 November (T_2) planted crops got enough low temperature than that of other planting time and the 30 October (T_1) planted crops failed to get enough low temperature. S_0, T_1 (30 October) took long time for head formation than the other planting time. This result also supported by Hasan *et al.* (2002).

Days to head formation was significantly influenced by the starter solution (Table 3). Minimum days to head formation (30.08 days) were obtained from the treatment of 1.6% starter solution (S_2). Days to head formation was equally better in all the treatments of starter solution except in the control where it showed the maximum days to head formation (38.16 days). This result also supported by Henmis *et al.* (1973).

Treatment Combinations of planting time and starter solution significantly influenced the days to head formation (Table 6). Lowest days to head formation (29.33 days) was obtained from the treatment combination of (T_2S_2) i.e., 15 November with 1.6% starter solution followed by (T_1S_2) i.e., 30 October with 1.6% starter solution (30.00 days). Highest days to head formation (39.33 days) were recorded from the control treatment (T_3S_0).

4.4 Days to head maturity

Planting time showed significant effect in respect of days to required head maturity. The 30 October (T_1) planted crops required the longest time (80.08 days) which was statistically similar with 30 November (T_3) & 15 December (T_4) planted crops (Table 1).The minimum time (74.91 days) was taken by the 15 November (T_2) planted crops. This result also supported by Hasan *et al.* (2002).

Days to head maturity of cabbage varied significantly due to starter solution treatment (Table 3). Minimum days to head maturity (71.8 days) was obtained from the application of 1.6% starter solution (S_2) followed by 2.4% (80.8 days) and 0.8% (80 days) starter solution

treatments, respectively. Highest days to head maturity (81.0 days) was found in the control treatment (S_o).

Treatment combination of planting time and starter solution influenced the days to head maturity of cabbage (Table 6). Lowest days to head maturity (70 days) was obtained from the treatment combination of (T_2S_2) i.e., 15 November with 1.6% starter solution followed by (T_1S_2) i.e., 30 October with 1.6% starter solution (73.6 days). Highest days to head maturity (83.33 days) were obtained from the control treatment (T_1S_0).

4.5 Percentage of head formation

Different levels of planting time showed significant effect in respect of percent head formation. Maximum head formation (85.41%) was found in 15 November (T_2) planted crop and the minimum (66.1 %) was observed in 30 October (T_1) planting (Table 1). Futane *et al.* (1995) found similar trend of results in this respect. It was probable that 15 November (T_2) planted crops received comparatively prolonged cool temperature with available soil moisture which influenced maximum head formation.

Percentage of head formation of cabbage varied significantly due to starter solution treatment. Maximum head formation (84.58%) was found in 1.6% starter solution (S_2) planted crop and minimum (67.1%) was observed in 2.4% starter solution treatment (S_3) planting crops. The control treatment (S_0) was observed in (70.8%) (Table 3).

Interaction effect of planting time and starter solution show significant effect on percent head formation (Figure 4). Maximum head formation (95.8%) was recorded in treatment combination of (T_2S_2) i.e., 15 November planted crops with 1.6% starter solution and minimum (47.9%) was found in (T_1S_3) i.e., 30 October planted crops with 2.4% starter solution and followed by (T_1S_1), (T_3S_1), (T_1S_0), respectively.

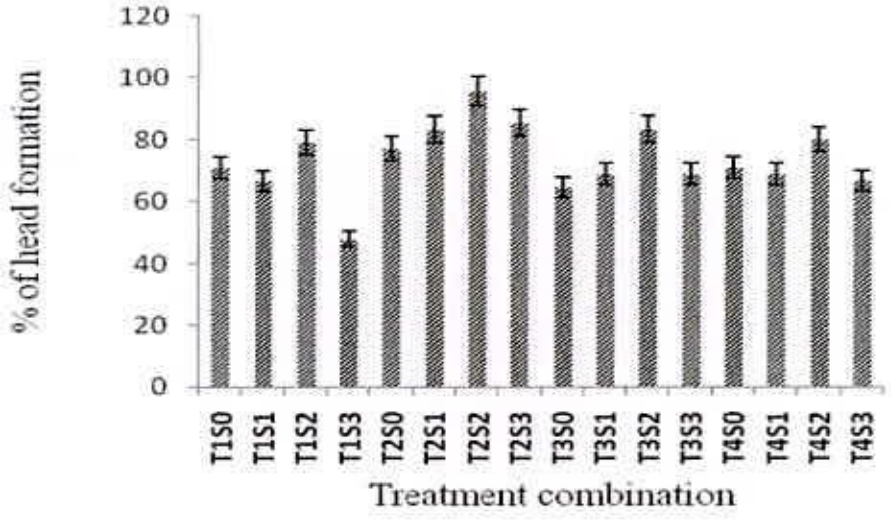


Figure 4. Combined effect of planting time and starter solution on percentage of head formation of cabbage.
T_1 = 30 October, T_2 = 15 November, T_3 = 30 November, T_4 = 15 December, S_0 = 0% urea, S_1=0.8 % urea, S_2=1.6 % urea, S_3 =2.4 % urea

4.6 Length of stem (cm)

Length of stem was significantly influenced by the different days of planting time (Table 1). Maximum length of stem (5.9 cm) was found in (T_2) planting time and minimum length of stem (3.9 cm) was found in (T_3) planting time.

Length of stem was significantly influenced by the starter solution (Table 3). Length of stem was equally better in all types of starter solution. However, the longest stem (5.3 cm) was recorded from 1.6% starter solution (S_2) while the shortest stem (4.6 cm) was found in the control treatment (S_0) followed by 2.4% (S_3) (4.7 cm) and 0.8% (S_1) (4.9 cm) starter solution treatments, respectively.

Treatment combination of planting time and starter solution significantly affected the length of stem (Table 6). Longest stem (7.0 cm) was found in (T_2S_2) i.e.; 15 November with 1.6% starter solution. Shortest stem (3.58 cm) was found in (T_3S_3) i.e.; 30 November with 2.4% starter solution, but it was statistically similar to the control treatment (T_3S_0).

Table 5: Effect of planting time and starter solution on plant height of cabbage

Interaction (planting time[x] x starter solution[y])	Plant height (cm)		
	At 20 DAT	At 35 DAT	At 50 DAT
T_1S_0	17.43 cd	24.93 c-f	30.96 bcd
T_1S_1	15.73 d	27.86 abc	31.33 bc
T_1S_2	18.40 c	27.93 ab	31.20 bc
T_1S_3	17.20 cd	21.80 g	29.70 cde
T_2S_0	21.70 b	22.80 fg	26.66 fg
T_2S_1	23.06 ab	25.40 b-f	29.76 cde
T_2S_2	23.60 ab	27.60 a-d	33.10 ab
T_2S_3	21.36 b	23.36 fg	28.90 c-f
T_3S_0	22.93 ab	24.80 d ef	27.23 efg
T_3S_1	23.53 ab	25.53 b-f	28.43 d-g
T_3S_2	24.46 a	29.40 a	34.40 a
T_3S_3	23.30 ab	24.93 c-f	29.50 cde
T_4S_0	16.73 cd	23.33 fg	26.20 g
T_4S_1	16.90 cd	24.26 efg	29.16 c-f
T_4S_2	18.50 c	26.70 a-e	33.26 ab
T_4S_3	17.06 cd	23.90 efg	31.26 bc
CV (%)	6.80	7.01	5.15
Lsd $_{(0.05)}$	2.283	2.581	2.581

[x] T_1 = 30 October, T_2 = 15 November, T_3 = 30 November, T_4 = 15 December; [y] S_0 = 0% urea, S_1=0.8 % urea, S_2=1.6 % urea, S_3 =2.4 % urea ;

4.7 Thickness of head (cm)

Planting time showed significant effect in respect of thickness of cabbage head. Highest thickness (14.3 cm) was found in 15 November (T_2) planted crop which was statistically similar with T_3 (30 November) & T_1 (30 October) planted crops while the lowest thickness (12.3 cm) of head was found from 15 December (T_4) planted crops (Table 1). The 15 November (T_2) planted crops received comparatively low temperature during vegetative growth stage which produced maximum number of large sized folded leaf of cabbage. It was possible that due to the favorable growth factors, the crop obtained from 15 November (T_2) planting produced the thickest cabbage head.

Thickness of cabbage head was insignificantly influenced due to starter solution (Table 3). Highest thickness of head (13.66 cm) was obtained from the plants having 1.6% starter solution (S_2). This was followed by 13.58 cm in 0.8% starter solution (S_1). Lowest thickness of head (13.16 cm) was found in S_3 treatment. This result is agreement with the findings of Kamal *et al.* (2002).

Combined effect of planting time and starter solution showed significant influence on thickness of head of cabbage (Table 6). The maximum thickness of head (15.0 cm) was found in the treatment combination of (T_2S_2) i.e.; 15 November with 1.6% starter solution. On the other hand, the lowest thickness of head of cabbage (11.33 cm) was obtained from the control treatment (T_4S_0).

4.8 Diameter of head

It was observed from the results of the present experiment that planting time significantly influenced on the diameter of cabbage head. Widest diameter (21.58 cm) of head was found in 15 November (T_2) planted crops which were statistically identical to 30 October (T_1) planted crops (Table 1). Narrowest diameter (19.91 cm) of head was obtained from 30 November (T_3) planted crops. It was probably due to the fact that 15 November (T_2) planted crops received favorable climate for head formation than the other planting time which resulted in bigger head formation.

Diameter of head of cabbage was insignificantly varied with the use of starter solution (Table 3). Maximum diameter (21.66 cm) of head was obtained from the plants having 1.6% starter solution (S_2). This was followed by 20.91 cm in 0.8% starter solution (S_1) and which was statistically similar to the other treatment. This result is agreement with the findings of Chhonker and Sharma (1966).

Combined effect of planting time and starter solution showed also significant influence in respect of diameter of head of cabbage (Table 6). Maximum diameter of head (22.33 cm) was found from the treatment combination of 30 October with 1.6% starter solution (T_1S_2) followed by 15 November with 1.6% starter solution (T_2S_2) (22.00 cm). On the other hand, lowest diameter of head (19.00 cm) was obtained from the control treatment (T_3S_0).

Table 6: Effect of planting time and starter solution on yield contributing characters of cabbage

Interaction (planting time[x] × starter solution[y])	Total number of leaves	Days to first head formation	Days to head maturity	Length of stem (cm)	Thickness of head (cm)	Diameter of head (cm)	Dry weight of head (g)	Percentage of dry matter of head	Yield per plot (kg)
T_1S_0	71.67b-d	39.33a	83.33a	4.70c-g	13.33a-c	21.00abc	66.67f	6.67g	28.00f
T_1S_1	73.67a-c	36.00cd	81.00ab	4.98c-f	14.00ab	21.66ab	73.08de	7.31ef	30.40dc
T_1S_2	72.00b-d	30.00f	73.67c	4.17g-i	14.00ab	22.33a	79.08b	7.91b	32.27cd
T_1S_3	72.67b-d	35.67cd	81.33ab	4.67e-g	12.33bc	21.33abc	75.17c	7.52cd	30.13c
T_2S_0	72.00b-d	36.33bc	74.33c	5.42b-d	14.33ab	20.00bcd	71.33e	7.14f	28.00f
T_2S_1	71.33b-d	35.00cd	76.00c	5.67bc	14.33ab	21.33abc	74.25cd	7.43c-e	29.87ef
T_2S_2	74.00ab	29.33f	70.00d	7.08a	15.00a	22.00a	82.00a	8.20a	39.47a
T_2S_3	72.00b-d	32.33e	79.33b	5.75b	13.67ab	21.00abc	74.33cd	7.43c-e	29.87ef
T_3S_0	70.00de	39.33a	82.67a	3.83hi	14.33ab	19.00d	73.50cd	7.35de	29.87ef
T_3S_1	68.67e	34.67d	82.33a	4.08g-i	13.67ab	19.66cd	75.42c	7.54c	30.40de
T_3S_2	73.00bc	30.33f	73.67c	4.42f-h	13.33a-c	21.00abc	80.50ab	8.05ab	34.93b
T_3S_3	71.00c-e	32.67e	81.67ab	3.58i	13.33a-c	20.00bcd	74.33cd	7.43c-e	30.67dc
T_4S_0	72.00b-d	37.67b	83.00a	4.75d-g	11.33c	19.66cd	72.67de	7.27ef	28.00f
T_4S_1	68.67e	35.33cd	81.00ab	5.08b-f	12.33bc	21.00abc	75.33c	7.53cd	29.33ef
T_4S_2	76.00a	30.67f	70.00d	5.62bc	12.33bc	21.33abc	80.58ab	8.06ab	32.73c
T_4S_3	71.00c-e	33.00e	81.00ab	5.17b-e	13.33a-c	20.00bcd	74.42cd	7.44c-e	29.60ef
Cv (%)	1.92	2.46	1.97	7.38	7.90	5.32	1.35	1.36	3.50
Lsd $_{(0.05)}$	2.305	1.406	1.406	0.6081	1.769	1.843	1.694	0.1668	1.803

[x] T_1 = 30 October, T_2 = 15 November, T_3 = 30 November, T_4 = 15 December; [y] S_0 = 0% urea, S_1=0.8 % urea, S_2=1.6 % urea, S_3 =2.4 % urea ;

4.9 Dry weight of head

Dry weight of cabbage head per plant was significantly affected by different levels of planting time. The 30 November (T_3) planted crops gave maximum dry weight (75.9 g) of head per plant which was statistically similar with 15 November (T_2) & 15 December (T_4) planted crops (Table 2). Lowest dry weight of head (73.5 g) was obtained from 30 October (T_1) planted crops.

Dry weight of head varied significantly with the application of starter solution (Table 4). Maximum dry weight of cabbage head (80.54 g) was found in 1.6% starter solutions (S_2) followed by 2.4% starter solution (S_3) (80.54g). Lowest dry weight of head (71.04 g) was found in the control treatment (S_0).

Treatment combination of planting time and starter solution influenced the dry weight of cabbage head (Table 6). Maximum dry weight of cabbage (82.0 g) was obtained from the treatment combination of 15 November with 1.6% starter solution (T_2S_2) followed by the application of 30 November with 1.6% starter solution (80.5 g) (T_3S_2). Minimum dry weight of head (66.67 g) was given by the control (T_1S_0) treatment.

4.10 Percent dry matter of head

Main effect of planting time show significant effect in respect of percent dry matter of head. Maximum dry matter (7.59 %) of head was found in 30 November (T_3) planted crops and minimum (7.35 %) was obtained from the plants that were planted on 30 October (T_1) (Table 2).

Percent dry matter of head varied significantly with the application of starter solution (Table 4). Maximum percent dry matter of head of cabbage (8.0) was found in 1.6% starter solution (S_2). Lowest dry weight of head (7.1 g) was found in the control treatment (S_0).

Treatment combination of planting time and starter solution influenced the percent dry matter of cabbage head (Table 6). Maximum percent dry matter of cabbage (8.2) was obtained from the treatment combination of 15 November with 1.6% starter solution (T_2S_2) followed by the application of 30 November T_3 with 1.6% starter solution (8.0). Minimum dry weight of head (6.6) was given by the control (T_1S_0) treatment.

4.11 Biomass production per plant (kg)

Planting time had significant effect on biomass production of cabbage. Highest biomass production per plant was (2.62 kg) found in 15 November (T_2) and lowest biomass production per plant was (2.36 kg) found in 30 October (T_1).

Starter solution had significant influence on the biomass production of cabbage (Table 4). Highest biomass per plant (2.90 kg) was produced by 1.6% starter solution (S_2) while lowest biomass per plant (2.15 kg) was given by the control (S_0) treatment which was statistically similar to other treatment.

Treatment combination of planting time and starter solution influenced the biomass production per plant (Figure 5). Highest biomass production (3.25 kg) was obtained from the treatment combination of (T_2S_2) i.e., 15 November with 1.6% starter solution. Lowest production of biomass per plant (2.00 kg) was observed in the control treatment (T_3S_0).

4.12 Economic yield per plant

Main effect of planting time show significant effect in respect of Economic yield per plant. Maximum Economic yield per plant (1.97 kg) of head was found in 15 November (T_2) planted crops and minimum (1.8 kg) was obtained from the plants that were planted on 30 October (T_1) (Table 2).

There was significant variation in economic yield per plant due to the application of starter solution (Table 4). Maximum economic yield (2.18 kg) was produced by 1.6% starter solution. Minimum economic yield per plant (1.77 kg) was obtained from the control treatment (S_0).

Variation due to planting time and starter solution treatment combination for economic yield per plant of cabbage was significant (Figure 5). Highest yield (2.47 kg) per plant was obtained from 15 November with 1.6% starter solution (T_2S_2) and was followed by 30 November with 1.6% starter solution (T_3S_2). While the lowest economic yield (1.75 kg) was recorded from control treatment (T_1S_0).

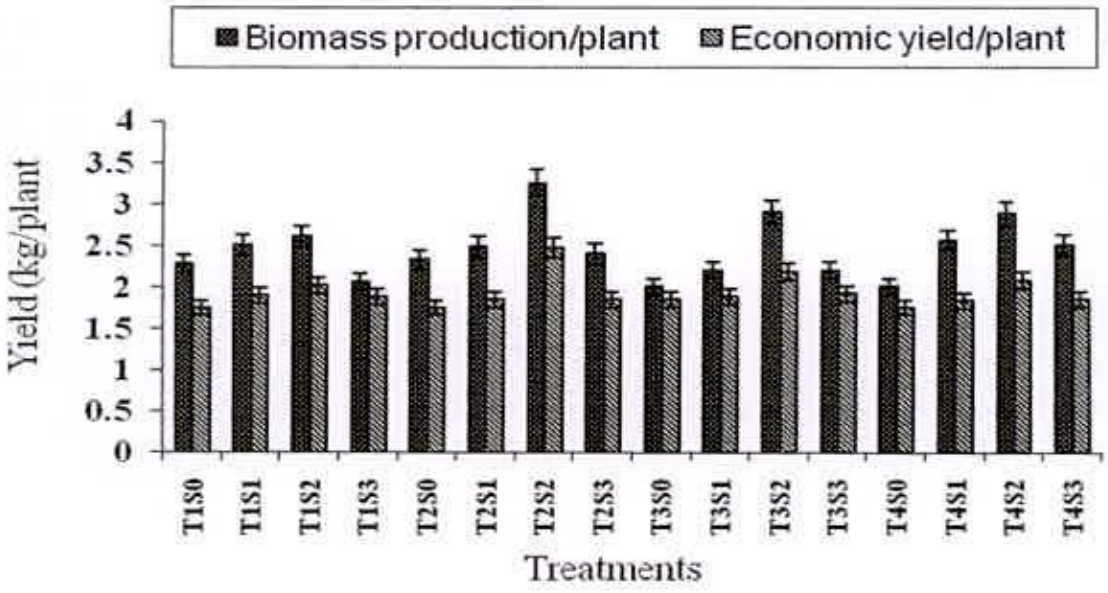


Figure 5. Combined effect of planting time and starter solution on the biomass production and economic yield of cabbage.

T_1 = 30 October, T_2 = 15 November, T_3 = 30 November, T_4 = 15 December, S_0 = 0% urea, S_1=0.8 % urea, S_2=1.6 % urea, S_3 =2.4 % urea

4.13 Yield per plot (kg)

Marketable yield of cabbage per plot was significantly influenced by planting time. Maximum marketable yield (31.80 kg per plot) was obtained from 15 November (T_2) planted crops and the lowest (29.9 kg per plot) was found in 15 December (T_4) planting (Table 2). Higher marketable yield of cabbage per plot by 15 November (T_2) planted crops may be attributed due to the favorable growing conditions availed by the plant resulting in bigger and compact head production.

Application of starter solution before transplanting of cabbage seedlings significantly influenced the yield of cabbage per plot (Table 4). Maximum yield per plot (34.85 kg) was obtained from 1.6% starter solution (S_2). The lowest yield (28.46 kg) was obtained from the control (S_0) treatment. It was possible that starter solution reduced transplanting shock and provided healthy growth of plant as well as supplied optimum nutrient to the plants and that helped in the production of the highest yield per plant. This is supported by Chhonker and Jha (1963).

Treatment combination of planting time and starter solution significantly influenced the head yield per plot (Table 6). Maximum head yield per plot (39.47 kg) was obtained from the treatment combination of 15 November with 1.6% starter solution (T_2S_2) 1.6% starter solution. Lowest yield per plot (28.0 kg) was obtained from the control (T_1S_0) treatment.

4.14 Yield per hectare

Marketable yield of cabbage per hectare was significantly influenced by different planting time. Maximum marketable yield (73.6 t/ha) was obtained when the crop was planted on 15 November (T_2) and lowest marketable yield (69.6 t/ha) was found from the late planting of 15 December (T_4) which was statistically similar by the yield (T_1) 30 October planting (Figure 6).

Yield of cabbage per hectare was significantly influenced by the starter solution (Figure 7). Highest yield (81.0 t/ha) was recorded in 1.6% starter solution (S_2) followed by 2.4% (S_3) & 0.8% (S_1) starter solution treatment giving 69.6 t/ha & 69.4 t/ha. Lowest yield (65.8 t/ha) was recorded from the plants having no treatments i.e. the control (So) treatment. Because of starter solution reduce the transplanting shock and enhance urea uptake. So that it produced higher yield. This result is agreement with the findings of Roy, (2002).

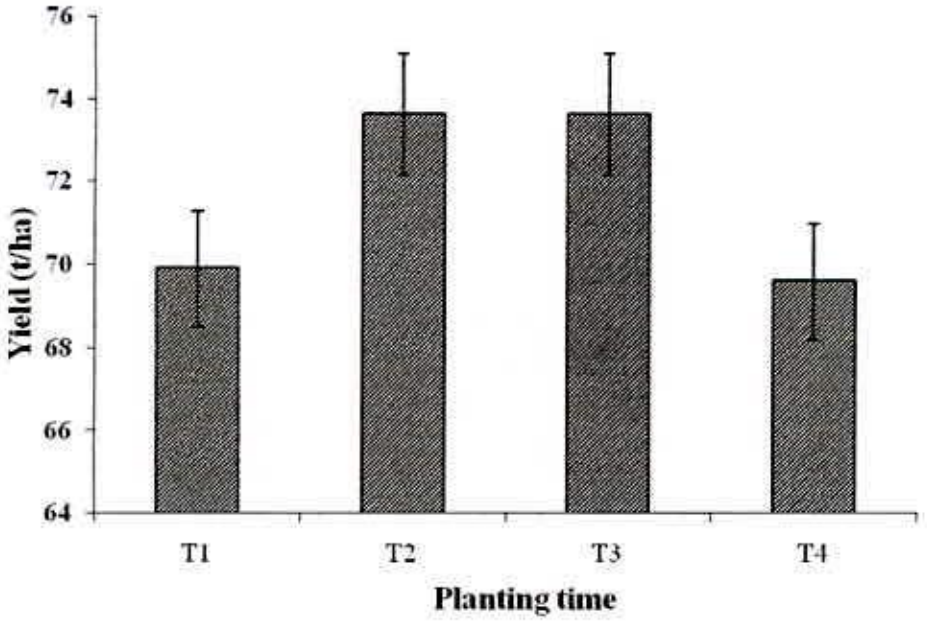


Figure 6. Effect of planting time on yield of cabbage.
T_1 = 30 October, T_2 = 15 November, T_3 = 30 November, T_4 = 15 December

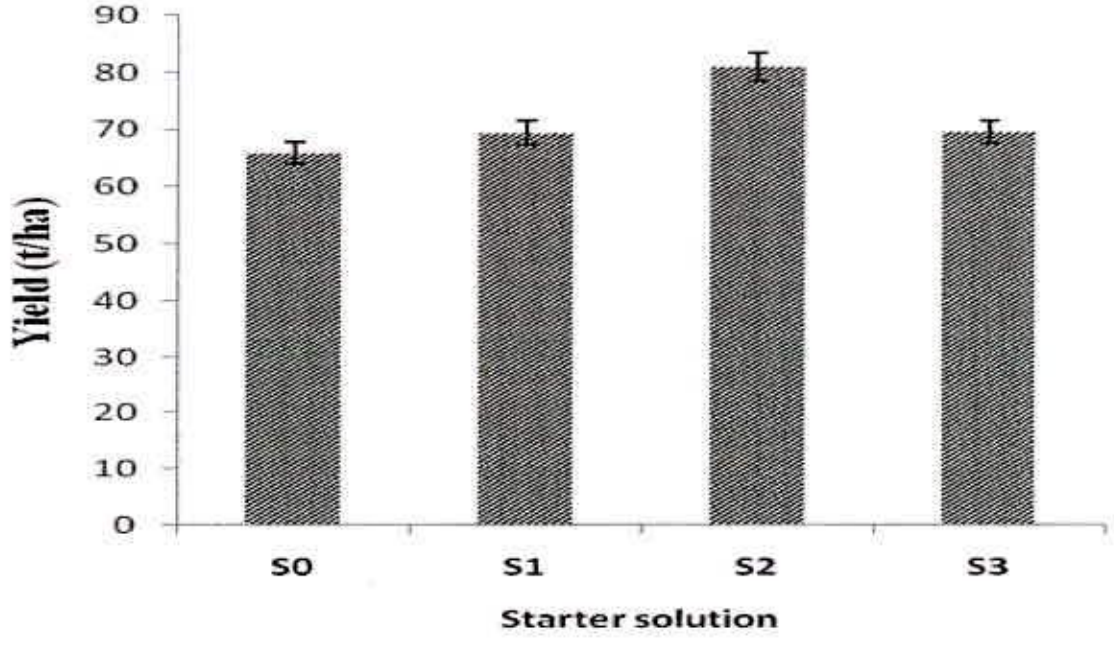


Figure 7. Effect of starter solution on the yield of cabbage.
S_0 = 0% urea, S_1=0.8 % urea, S_2=1.6 % urea, S_3 =2.4 % urea

Findings of the present study also collaborate with the findings of Islam *et al.* (1989). They reported that starter solution significantly influenced the production of marketable yield of cabbage. They also stated that the highest marketable yield was noticed from the treatments of 1.6% and 0.8% starter solutions. However, the untreated seedlings gave the lowest yield. The findings are also in accordance with that of Patil *et al.* (1979).

Treatment combination of planting time and starter solution significantly influenced the yield of cabbage (Fig. 8). The highest yield (91.35 t/ha) was produced from the treatment combination of 15 November (T_2) with 1.6% starter solution (T_2S_2). Lowest yield (64.8 t/ha) was recorded from the treatment combination of 15 December and no starter solution (T_4S_0).

Starter solution used by dipping the roots of seedlings in the solution before transplanting might have effectively minimized the shock of uprooting cabbage seedling, formed vigorous and bigger head which ultimately increased the total yield. Starter solution also enhanced the early recovery and non-mortality of cabbage seedlings. Findings are also in accordance with that of Henmis *et al.* (1973). In this experiment, the treatment combination of 15 November (T_2) with 1.6% starter solution (T_2S_2) was found to produce the highest yield of cabbage (91.35 t/ha). This result also supported by Roy, (2002).

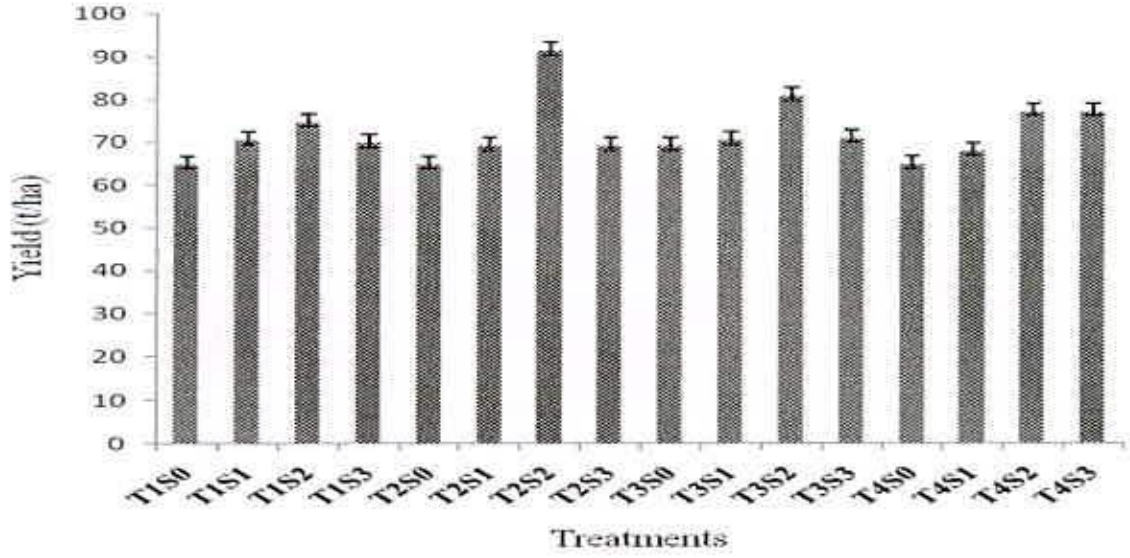


Figure 8. Combined effect of planting time and starter solution on the yield of cabbage. (T_1 = 30 October, T_2 = 15 November, T_3 = 30 November, T_4 = 15 December, S_0 = 0% urea, S_1=0.8 % urea, S_2=1.6 % urea, S_3 =2.4 % urea)

4.15 Economic analysis of cabbage production

4.15.1. Cost of production

Total cost of production ranged between Tk. 84900.85/ha and Tk. 85050.94 /ha (Table 7). Among the treatment combinations, the variation was due to the cost of different starter solution but there was no variation in cost of production due to different planting time. Highest cost of production (Tk. 85050.94/ha) was involved in the (T_2S_3) treatment combination of starter solution and planting time while lowest (Tk. 84900.85/ha) was involved in no starter solution (T_2S_0) with different planting time.

4.15.2. Gross return

Gross return from different treatment combination ranged between Tk. 230076/ha to Tk. 274050/ha. Gross return was the total income through sale of cabbage (marketable yield) @ 3550, 3000, 2750, 2000 Tk. /t for T_1, T_2, T_3 and T_4 treatment respectively. Gross return varied only due to the market demand of cabbage (Table 7). Higher price was obtained for early production, where as late production caused lower price.

4.15.3. Net return

Net return was calculated as the difference between the production cost and gross return. It also varied from Tk. 189001.6 to Tk. 44719.15/ha (Table 7). Highest net return was obtained from the treatment combination of T_2S_2. Comparatively higher net income was obtained from 30 October (T_1) planted crops with other planting time which range between Tk.180101.1/ha and Tk. 145174.7/ha. On the other hand, lowest net return was recorded in 15 December (T_4) planted crops. Result also revealed that the highest net return (Tk.189001.6 /ha) was found in highest marketable yield (91.35 t/ha). Lowest net return was obtained from the second lowest marketable yield (64.81 t/ha) originated from the treatment combination of 15 December (T_4) planted crop with no starter solution. So, net return was also affected by market value of cabbage. Second highest net return (Tk. 180101.1/ha) was found in the treatment combination of T_1S_2. So, it indicated that 15 November (T_2) planted crop with 1.6% starter solution (S_2) always contributed to higher net return.

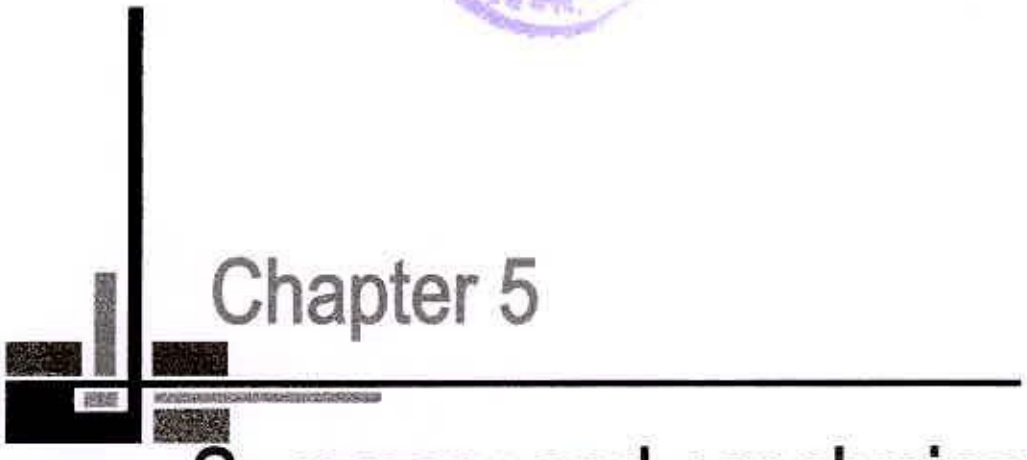
Table: 7 Cost and return of cabbage cultivation as influenced by planting time and starter solution

Treatment combination[x]	Total cost of production (TK/ha)	Yield of cabbage (t/ha)	Gross return (TK/ha)	Net return (TK/ha)	Benefit cost ratio (BCR)
T_1S_0	84900.85	64.81	230076	145174.7	2.70
T_1S_1	85045.81	70.37	249814	164767.7	2.93
T_1S_2	85048.36	74.69	265150	180101.1	3.11
T_1S_3	85050.94	69.75	247613	162561.6	2.91
T_2S_0	84900.85	64.81	194430	109529.2	2.29
T_2S_1	85045.81	69.14	207420	122374.2	2.43
T_2S_2	85048.36	91.35	274050	189001.6	3.22
T_2S_3	85050.94	69.14	207420	122369.1	2.43
T_3S_0	84900.85	69.14	190135	105234.2	2.23
T_3S_1	85045.81	70.37	193518	108471.7	2.27
T_3S_2	85048.36	80.86	222365	137316.6	2.61
T_3S_3	85050.94	70.98	195195	110144.1	2.29
T_4S_0	84900.85	64.81	129620	44719.15	1.52
T_4S_1	85045.81	67.90	135800	50754.19	1.59
T_4S_2	85048.36	77.16	154320	69271.64	1.81
T_4S_3	85050.94	77.16	154320	69269.06	1.81

[x] T_1 = 30 October, T_2 = 15 November, T_3 = 30 November, T_4 = 15 December, S_0 = 0% urea, S_1=0.8 % urea, S_2=1.6 % urea, S_3 =2.4 % urea; Seed 600 g @ 2000 Tk./kg; Ploughing 5 times @ 1000 Tk./ ploughing; cow dung (10 t/ha) @ 400 Tk./t; Urea (325 kg/ha) @ 14 Tk./kg; TSP (150 kg/ha) @ 76 Tk./ha; MP (200kg/ha) @ 46 Tk./ha.; Labor cost @ 120 Tk./day/labor

4.15.4 Benefit cost ratio (BCR)

The height benefit cost ratio (3.22) was obtained by the treatment combination of T_2S_2 which was calculated from the 15 November planted crop with 1.6% starter solution (Table 7).



Chapter 5

Summary and conclusion

Chapter 5

SUMMARY AND CONCLUSION

Experiment was conducted at the Agronomy Farm, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from October, 2007 to March, 2008 to study the effect of planting time and starter solution on growth and yield of cabbage. There were four planting time i.e., 30 October, 15 November, 30 November and 15 December; four types of starter solution viz., no starter solution (S_0), 0.8% starter solution (S_1), 1.6% starter solution (S_2) and 2.4% starter solution (S_3) treatments. Thus there were 16 treatments and the experiment was laid out in RCBD design with three replications. The unit plot size was 2.4m×1.4m which accommodated 16 plants. The crop was harvested from 28 December, 2007 to 10 March, 2008.

From each plot, six plants were randomly selected and identified with tag for data collection. The yield was recorded from all the plants of a plot. Observations were made on plant height, total number of leaves, days to head formation, days to head maturity, percentage of head formation, length of stem, thickness of head, diameter of head, fresh weight of head, dry weight of head, percentage dry matter of head, biomass production per plant, economic yield per plant and yield per plot and hectare. Collected data were statistically analyzed and the means were compared with lest significant difference (LSD) value.

Experimental result reveled that all parameters studied were significantly influenced by planting time when 15 November (T_2) all most all the character attain height value. Maximum yield per plot (31.80 kg) and yield per hectare (73.61 ton) were obtain from 15 November (T_2) planting time and the lowest yield per plot (29.91 kg) and per hectare (69.59 t) were from the T_4 (15 December) planting time.

Application of starter solution played a vital role on the growth and yield of cabbage. Different levels of starter solution significantly influenced all the characters recorded. Maximum yield per plot (34.85kg) and yield per hectare (81.01 t) were recorded from 1.6% starter solution (S_2) and the lowest yield per plot (28.46 kg) and per hectare (65.89 t) were recorded in the control treatment.

Combination of planting time and starter solution exhibited significant variation for all the parameter studied. Most of the character expressed maximum values under 15 November planting time and 1.6% starter solution (T_2S_2). Maximum yield per plot (39.47 kg) and yield per hectare (91.35 t) were noted from the treatment combination of 15 November planting time and 1.6% starter solution (T_2S_2) and the lowest yield per plot (28.0 kg)and per hectare (64.81 t) were recorded in the control treatment(T_4 S_0).

Maximum cost of production Tk. 85050.94/ha in the treatment combination of T_1S_3, T_2S_3, T_3S_3 and T_4S_3 but the height net return of Tk. 189001.6/ha were obtained from T_2S_2 treatment. Maximum benefit cost ratio (BCR) 3.22 was recorded from T_2S_2 treatment combination.

Findings of the experiment indicated that the yield of cabbage head was greatly involved by planting time and starter solution. Head yield was increased due to planting time and starter solution over control. But the highest financial benefit was obtained from T_2S_2 treated plot. The result obtained from the investigation exhibited a great influence of planting time and starter solution on the production of cabbage.

Considering the present study, further studied followed areas may be suggested:

i. Further investigation is needed in different agro-ecological zones of Bangladesh. Under variable field condition to confirm the result of the present experiment before recommending it to the growers,
ii. Soaking the bases of the seedlings with starter solution prior to transplanting had a marked effect in increasing the yield of cabbage. The findings of the present study will also help decide the justification of using starter solution in cabbage.

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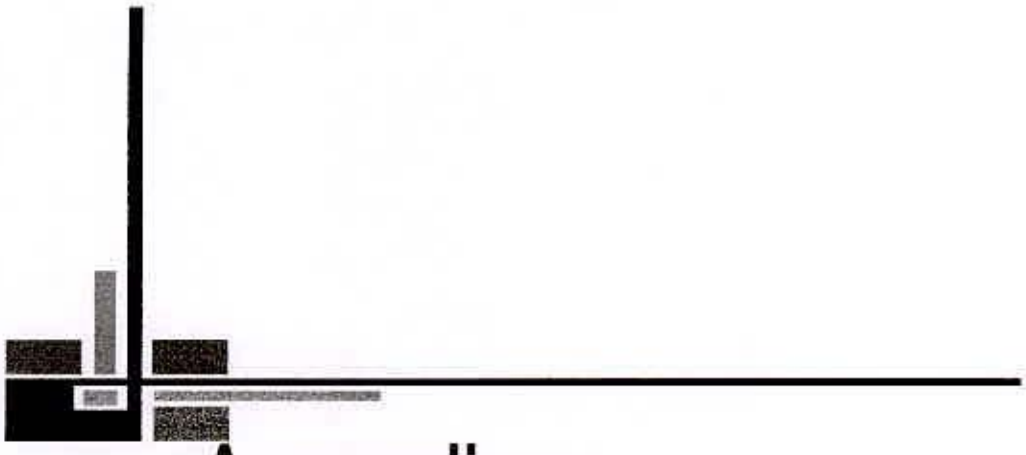

Appendices

APPENDICES

Appendix I: Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from October 2007 to March 2008

Month	Air temperature (^{0}C)			Average RH (%)	Total rainfall (mm)
	Maximum	Minimum	Mean		
October 07	35.6	19.5	27.55	64.5	320
November 07	31.8	16.8	24.3	67.0	111
December 07	28.2	11.3	19.75	63.0	0
January 08	29.0	10.5	19.75	61.5	23
February 08	30.6	10.8	27.0	54.5	56
March 08	34.6	16.5	30.5	61.5	45

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1207

Appendix II. Results of Physical and chemical properties of soil of the experimental plot

Physical properties

Constituents	Amount (%)
Sand	32.45
Silt	61.35
Clay	6.10
Textural class	Sandy loam

Chemical analysis

Soil properties	Amount
Soil pH	5.6
Organic carbon (%)	1.32
Total nitrogen (%)	0.075
Available P (ppm)	19.5
Exchangeable K (%)	0.2

Source: Soil Resources and Development Institute (SRDI), Farm gate, Dhaka.

Appendix: III Analysis of variance of different characters of cabbage

Sources of variation	Degree of freedom	Plant height (cm) at DAT[x]			Total number of leaves	Days to first head formation	Days to head maturity	Percentage of head formation	Length of stem	Thickness of head (cm)	Diameter of head (cm)	Dry weight of head	Percentage of dry matter of head	Biomass production per plant (kg)	Economic yield per plant (kg)	Yield per plot	Yield per ha
		20	35	50													
Replication	2	6.946	6.319	11.042	5.333	0.333	1.396	7.454	0.039	0.438	0.021	6.954	0.070	0.121	0.001	0.881	4.785
Factor A	3	135.18**	1.64**	3.97NS	8.24**	8.02**	68.57**	817.56**	8.57**	8.29**	6.24**	15.24**	0.153**	0.213NS	0.03**	10.30**	49.60**
Factor B	3	6.77*	48.15**	56.19**	21.74**	137.57**	231.18**	689.53**	0.94**	0.63**	6.35**	186.75**	1.86**	1.28**	0.38**	92.06**	519.37**
Interaction (A×B)	9	1.21**	5.83NS	7.70**	7.55**	2.41**	9.35**	107.78**	0.61**	1.59NS	0.22NS	7.01**	0.07**	0.09**	0.03**	8.72**	44.58**
Error	30	1.874	3.143	2.395	1.911	0.711	2.374	27.420	0.133	1.126	1.221	1.032	0.010	0.135	0.003	1.169	5.013

[x]DAT = Days after transplanting, **= Significant at 1% level, *= Significant at 1% level, NS= Not Significant

Appendix IV: Production of cabbage per hectare

1. Input cost

a) Material cost

Treatment combination[x]	Seed	Starter solut-ion	Manure and fertilizer				Bamboo	Insecticide and pesticide	Subtotal (a)
			cow dung	Urea	TSP	MP			
T_1S_0	6000	0	4000	4550	11400	9200	1200	2000	38350
T_1S_1	6000	2.16	4000	4550	11400	9200	1200	2000	38352.16
T_1S_2	6000	4.32	4000	4550	11400	9200	1200	2000	38354.32
T_1S_3	6000	6.50	4000	4550	11400	9200	1200	2000	38356.50
T_2S_0	6000	0	4000	4550	11400	9200	1200	2000	38350
T_2S_1	6000	2.16	4000	4550	11400	9200	1200	2000	38352.16
T_2S_2	6000	4.32	4000	4550	11400	9200	1200	2000	38354.32
T_2S_3	6000	6.50	4000	4550	11400	9200	1200	2000	38356.50
T_3S_0	6000	0	4000	4550	11400	9200	1200	2000	38350
T_3S_1	6000	2.16	4000	4550	11400	9200	1200	2000	38352.16
T_3S_2	6000	4.32	4000	4550	11400	9200	1200	2000	38354.32
T_3S_3	6000	6.50	4000	4550	11400	9200	1200	2000	38356.50
T_4S_0	6000	0	4000	4550	11400	9200	1200	2000	38350
T_4S_1	6000	2.16	4000	4550	11400	9200	1200	2000	38352.16
T_4S_2	6000	4.32	4000	4550	11400	9200	1200	2000	38354.32
T_4S_3	6000	6.50	4000	4550	11400	9200	1200	2000	38356.50

[x] T_1 = 30 October, T_2 = 15 November, T_3 = 30 November, T_4 = 15 December, S_0 = 0% urea, S_1=0.8 % urea, S_2=1.6 % urea, S_3 =2.4 % urea; Seed 600 g @ 2000 Tk./kg; Ploughing 5 times @ 1000 Tk./ ploughing; cow dung (10 t/ha) @ 400 Tk./t; Urea (325 kg/ha) @ 14 Tk./kg; TSP (150 kg/ha) @ 76 Tk./ha; MP (200kg/ha) @ 46 Tk./ha.; Labor cost @ 120 Tk./day/labor

b) Non-material cost

Treatment combi-nation[x]	Ploughing	Fertilizer application, removal of weeds, stabbles etc.	Transplanting, shading and watering	Weeding and earthing up	Insecticide spraying	Harvesting and marketing	Subtotal (b)	Total input cost (a+b)
T_1S_0	5000	2880	5760	2880	1200	1200	18920	57270
T_1S_1	5000	2880	5760	3000	1200	1200	19040	57392.16
T_1S_2	5000	2880	5760	3000	1200	1200	19040	57394.32
T_1S_3	5000	2880	5760	3000	1200	1200	19040	57396.50
T_2S_0	5000	2880	5760	2880	1200	1200	18920	57270
T_2S_1	5000	2880	5760	3000	1200	1200	19040	57392.16
T_2S_2	5000	2880	5760	3000	1200	1200	19040	57394.32
T_2S_3	5000	2880	5760	3000	1200	1200	19040	57396.50
T_3S_0	5000	2880	5760	2880	1200	1200	18920	57270
T_3S_1	5000	2880	5760	3000	1200	1200	19040	57392.16
T_3S_2	5000	2880	5760	3000	1200	1200	19040	57394.32
T_3S_3	5000	2880	5760	3000	1200	1200	19040	57396.50
T_4S_0	5000	2880	5760	2880	1200	1200	18920	57270
T_4S_1	5000	2880	5760	3000	1200	1200	19040	57392.16
T_4S_2	5000	2880	5760	3000	1200	1200	19040	57394.32
T_4S_3	5000	2880	5760	3000	1200	1200	19040	57396.50

[x] T_1 = 30 October, T_2 = 15 November, T_3 = 30 November, T_4 = 15 December, [y] S_0 = 0% urea, S_1=0.8 % urea, S_2=1.6 % urea, S_3 =2.4 % urea; Seed 600 g @ 2000 Tk./kg; Ploughing 5 times @ 1000 Tk./ ploughing; cow dung (10 t/ha) @ 400 Tk./t; Urea (325 kg/ha) @ 14 Tk./kg; TSP (150 kg/ha) @ 76 Tk./ha; MP (200kg/ha) @ 46 Tk./ha.; Labor cost @ 120 Tk./day/labor

2. Overhead cost and total cost of production (TK)

Treatment combi-nation[x]	Cost for lease of land (for 6 months)	Miscellaneous cost (5 % of input cost)	Interest on input cost for 6 months @ 13 % in year	Sub-total	Total cost of production (input+overhead)
T_1S_0	15000	2863.50	9767.35	27630.85	84900.85
T_1S_1	15000	2869.62	9784.03	27653.65	85045.81
T_1S_2	15000	2869.71	9784.32	27654.04	85048.36
T_1S_3	15000	2869.82	9784.62	27654.44	85050.94
T_2S_0	15000	2863.50	9767.35	27630.85	84900.85
T_2S_1	15000	2869.62	9784.03	27653.65	85045.81
T_2S_2	15000	2869.71	9784.32	27654.04	85048.36
T_2S_3	15000	2869.82	9784.62	27654.44	85050.94
T_3S_0	15000	2863.50	9767.35	27630.85	84900.85
T_3S_1	15000	2869.62	9784.03	27653.65	85045.81
T_3S_2	15000	2869.71	9784.32	27654.04	85048.36
T_3S_3	15000	2869.82	9784.62	27654.44	85050.94
T_4S_0	15000	2863.50	9767.35	27630.85	84900.85
T_4S_1	15000	2869.62	9784.03	27653.65	85045.81
T_4S_2	15000	2869.71	9784.32	27654.04	85048.36
T_4S_3	15000	2869.82	9784.62	27618.44	85050.94

[x] T_1 = 30 October, T_2 = 15 November, T_3 = 30 November, T_4 = 15 December, S_0 = 0% urea, S_1=0.8 % urea, S_2=1.6 % urea, S_3 =2.4 % urea; Seed 600 g @ 2000 Tk./kg; Ploughing 5 times @ 1000 Tk./ ploughing; cow dung (10 t/ha) @ 400 Tk./t; Urea (325 kg/ha) @ 14 Tk./kg; TSP (150 kg/ha) @ 76 Tk./ha; MP (200kg/ha) @ 46 Tk./ha.; Labor cost @ 120 Tk./day/labor