EFFECT OF STARTER SOLUTION AND AGE OF SEEDLING ON GROWTH AND YIELD OF BROCCOLI

ISMITA AKTER SONIYA

DEPARTMENT OF HORTICULTURE
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA -1207

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By

ISMITA AKTER SONIYA
Reg. No.: 12-05100

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APPROVED BY

Prof. Dr. Tahmina Mostarin
Department of Horticulture
SAU, Dhaka
Supervisor

Prof. Dr. Khaleda khatun
Department of Horticulture
SAU, Dhaka
Co-supervisor

Prof. Dr. Mohammad Humayun Kabir
Chairman
Examination Committee

DEPARTMENT OF HORTICULTURE

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207

Ref no :…………………………… Date…………………………………

CERTIFICATE

This is to certify that the thesis entitled "EFFECT OF STARTER SOLUTION AND AGE OF SEEDLING ON GROWTH AND YIELD OF BROCCOLI" submitted to the Faculty of Agriculture, Sher-E-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (MS)in HORTICULTURE, embodies the results of a piece of bona fide research work carried out by ISMITA AKTER SONIYA, Registration. No. 12-05100 under my supervision and guidance. No part of this 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 acknowledge

Dated: June, 2018
Dhaka, Bangladesh

Prof. Dr. Tahmina Mostarin
Department of Horticulture
Sher-e-bangla Agricultural University
Dhaka-1207
Supervisor

DEDICATED

TO

MY BELOVED PARENTS

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The Author

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Abstract

A study was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka during the period from October, 2017 to March, 2018. The experiment consisted of two factors. Factor A: Four levels of starter solution as S_0= control, S_1= 1% urea solution, S_2= 2% urea solution, S_3= 3% urea solution and Factor B: Three levels of age of seedling as A_1= 20 days old seedling, A_2= 30 days old seedling, A_3= 40 days old seedling. Application of the treatment influenced independently and also in combination on the growth and yield of broccoli. In case of starter solution, the highest yield (24.32 t/ha) was obtained from S_2 treatment, whereas the lowest yield (13.21 t/ha) was recorded from S_0 treatment. For three level of age of seedling the highest yield (20.75 t/ha) was obtained from A_2 treatment and the lowest yield (15.48 t/ha) was recorded from A_3 treatment. In case of combined effect the highest yield (26.91 t/ha) of broccoli was obtained from the treatment combination of S_2A_2 while the lowest (13.41 t/ha) was obtained from S_0A_3 treatment combination. Economic analysis revealed that S_2A_2 treatment combination was the best in respect of net return (3,24,890) with benefit cost ratio of 2.5. So it may be concluded that 2% starter solution and 30 days age seedling was best for growth and yield of broccoli.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LISTS OF PLATES

LISTS OF APPENDICES

ABBREVIATIONS AND ACRONYMS

BARI = Bangladesh Agricultural Research Institute

BCR = Benefit cost ratio

cm = Centimeter

DAT = Days after sowing

et al. = and others (*at elli*)

GA3 = Gibberellic acid

Kg/ha = Kilogram/hectare

g = gram

LER = Land Equivalent Ratio

LSD = Least Significant Difference

MoP = Murate of Potash

m = Meter

PGR = Plant growth regulator

RCBD = Randomized Complete Block Design

TSP = Triple Super Phosphate

t/ha = ton/hectare

% = percent

CHAPTER I

INTRODUCTION

Broccoli *(Brassica oleracea var. Italica L*) is an important winter vegetable crop under Brassicaceae family, which is originated from west Europe (Prasad and kumar ,1999). It ranks at fourth place after cauliflower, cabbage and knolkhol among the cole crops and newly introduce in Bangladesh .The edible portion of broccoli plant consist of tender stem and unopened flower buds. There are three classes of broccoli, i.e. green, white and purple, among them green type broccoli is the most popular (Shoemaker *et al.*, 1962). USA is the largest producer of broccoli followed by European country and India. In Bangladesh broccoli was introduced about two decade ago and it is planted in early September to late November (Ahmad and Shahjahan, 1991). In Bangladesh, broccoli is commercially cultivated in Rajshahi, Dhaka and Gazipur district.

Nowadays, broccoli attracted more attention due to its multifarious use and has great nutritional value. Vegetable consumption in Bangladesh is very low and only 80g per person per day against the minimum recommended quantity of 220g per day (Roy, 2011). The total vegetable production is far below the requirement. To fulfill the nutritional requirement of people, total production as well as number of vegetables should be increased. Broccoli is a nutritious vegetable than any other cole crops (Nieuwhof, 1969). Vitamin c content in fresh broccoli is almost twice than that in cauliflower (Lisiewska and Kmiecik, 1969). Per pound of edible portion of broccoli contains protein 9.10 g, fat 0.60 g, carbohydrate 15.20 g, calcium360.00 mg, phosphorus 211.0 mg, iron 3.60 mg, vitamin-A 970.00 I.U., ascorbic acid 327.00 mg, riboflavin 0.59 mg and thiamine 0.26 mg (Thompson and Kelly, 1985). Broccoli is more nutritious than any other Cole crops like cabbage, cauliflower and kohlrabi (Watt, 1983). Devouring broccoli enriched in antioxidants can reduce the risk of some forms of cancer and heart disease. Broccoli also has cancer-fighting properties and eating more than one serving of broccoli a week reduces the risk of prostate cancer by up to 45% (Gad & El-Moez, 2011). Thus broccoli can play a vital role in improving the nutritional status of the people of Bangladesh.

The yield of vegetables in our country is not satisfactory in comparison to our requirement. Lower yield of vegetables in Bangladesh is not an indication of low yielding ability of the crop, but of the fact that low yielding variety, poor crop management practices and lack of improved technologies, lack of nutrients and proper planting time etc. Among them fertilizer management is one of the important factors that contribute in the production and yield of broccoli. Nitrogen is an essential nutrient for broccoli. Urea is the main source of nitrogenous fertilizer and nitrogen is essential for its vegetative growth and development. Starter solutions are mixtures of soluble fertilizer and water used to get young plants off to a good start. The fertilizer material easily dissolves in water and the nutrients are readily available for plant uptake. Broccoli 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. When plant's roots are damaged by transplanting, natural trauma or heavy rain, it is crucial to receive an instant, readily available nutrient to facilitate recovery. The starter solution supplies readily available nutrients directly to the soil-rhizospher system. Small amounts of starter solution are applied to rhizosphere soils immediately after transplanting; they build up high nutrient gradients in the soil solution providing young plants with readily available nutrients before their root systems are well established, thus, enhancing initial growth. Healthy young plants can be more tolerant to environmental stress and increase their early yield, which means more income for farmers. Vegetables like cabbage, cauliflower and tomato respond well to starter solution containing urea in minimizing transplanting shock and being encouraged to a quick growth (Chonkar and Jha, 1963). The use of starter solution containing urea influences vegetative growth and production.

On the other hand, seedling age is an important phenomenon for the production of any crops especially vegetables (Bose and Som, 1986). Young seedlings required very intensive care for adjustment with the newly transplanted environmental condition, while aged seedlings reached more injury during uprooting and required more time for adjustment (Anon, 1992). In case of both the situation yield may be hampered. On the other hand optimum aged seedlings are easily adjusted within short period in new environment. So, there were no or minimum injury period of optimum aged transplanted seedlings. When we transplanted the seedling in actual aged it ensured highest yield and also quality yield with maximum growth and yield (Thompson and Kelly, 1957). Considering the above situation, the present investigation has been undertaken with the following objectives:

1. To study the effect of urea as starter solution on growth and yield of broccoli.

2. To find out the actual age of seedling for economical production of broccoli.

3. To identify suitable combination of starter solution and age of seedling for better vegetative growth, maximum yield and economic return of broccoli.

CHAPTER II

REVIEW OF LITERATURE

Broccoli is one of the most widely grown vegetables in the temperate zones and is a biennial and herbaceous “Cole” crops in Bangladesh. It is a thermo sensitive crop and grown in Bangladesh as an annual crop in winter season. Growth and curd development of broccoli are greatly influenced by growing environment. As a minor vegetable and newly introduced crop it has less attention by the researchers on various production aspects especially the use of starter solution and age of seedling. A very few studies on the growth and yield of broccoli have been carried out in Bangladesh.. Considerable interest has been developed recently regarding the benefit from the use of starter solution at the time of transplanting broccoli seedling. Age of seedling is a very important factor for broccoli production. A very limited number of reports on starter solution and age of seedling in broccoli under Bangladesh condition. However, some of most relevant research reports regarding the effects of different age of seedling and starter solution on the growth and yield of broccoli have been reviewed here.

Review on influence of starter solution on the growth and yield of broccoli

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.

Roy *et al.* (2010) conducted an experiment with starter solution and GA3 that, 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 GA3 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 GA3, viz., 0, 25, 50 and 75ppm. The application of starter solution and different concentrations of GA3 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 GA3 , 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 GA3 followed by 1.5% starter solution + 75 ppm GA3 (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 GA3 treatment was the best treatment combination in respect of net return (Tk. 173775.00) with a benefit cost ratio of 3.5.

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 was obtained from the treatments of 1.5% and 2% urea solution while the untreated seedlings gave the lowest yield.

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

Shi *et al.* (1984) observed that addition of nitrogenous fertilizer in the starter combinations resulted in initiating modification in the root system of 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.

Patil *et al.* (1979) revealed that starter solution used by dipping the roots of Seedling in the solution was 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 was obtained due to early recovery and non mortality of cabbage seedlings occurred.

Henmis *et al.* (1973) reported that sodium nitrate (NaNO3) or ammonium sulphate as starter solution improved the early growth and yield of broccoli.

Mohanty and Nema (1970) conducted an experiment with starter solution on cabbage and reported that the application of starter solutions, NAA and IBA alone or in various combinations at transplanting time had beneficial effects on the growth, yield and quality of cabbage. Of a number of treatments applied the highest yield of heads (420.35 q/ha) resulted from 0.1 p.p.m. NAA plus a 1: 1: 2 solutions of urea, K2SO4 and single superphosphate. This treatment also advanced maturity by 13 days.

Kamal (1998) conducted a field experiment at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh during the period from October, 1997- February 1998 to investigate the influence of starter solution (starter solution and no starter solution) and four different mulching treatments (black polythene, water hyacinth, irrigation and natural, and no mulch).

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 ammoniumsulphate and single superphosphate at the ratio of 1:2 as starter gave minimum number and larger size of outer leaves, bigger and heavier heads. They found that increased marketable yield of cabbage due to starter solution treatment.

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 increased as much as 150 percent of yield in cabbage over control.

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

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

El-Afifi *et al.* (2014) conducted two experiment at a Farm in El-Shahyna Village Kafrelsheikh Governorate (North Delta), Egypt, during the two successive winter seasons of 2012 and 2013 to study the effect of starter solutions of NPK fertilizers in soil and foliar application of some stimulants (amino acids and seaweed extract) as well as their interactions on growth and yield of Chinese cabbage plants (*Brassica rapa* L. subsp. pekinensis) cv. (Manoko). Four starter fertilizers treatments included three sources of N, i.e., ammonium sulfate (20.5 % N), ammonium nitrate (33.5 %) and urea (46%) as well as without starter solution and two sources of stimulants. The results indicated that, starter solutions treatments resulted in highly significant increases in stem length, stem diameter, whole stem weight, number of total leaves/ plant and fresh weights of outer leaves (inedible), inner leaves (edible), total leaves / plant and weights of total yield (whole head) and marketable yield (edible head) compared with the control treatment (without starter solution) in both seasons.

Stone (2000) showed that a higher maximum yield was obtained with starter fertilizer. Starter fertilizer (N) was supplied as an N was applied as ammonium phosphate or urea ammonium nitrate. There was no difference in fresh weight when comparing starter fertilizer of N with broadcasted N at 120 kg N ha-1 which gave the highest yield. At lower levels of applied N starter fertilizer gave a higher yield than broadcasted N. This is a reduction by ¾. Starter containing ammonium phosphate with 20 kg N ha-1 gave identical yield as 240 kg N ha-1 broadcast which is a huge reduction. This shows a much higher efficiency of starter fertilizer than broadcasted N

Shimaa and Abd-ElKader (2016) conducted field experiments to study effect of starter fertilizer as soil application, calcium nitrate as foliar application and its interaction on the growth, yield and chemical components of cabbage. The results showed that soil application starter solution increased the vegetative growth and head yield characters of cabbage plant and nutrition quality of cabbage head.

An experiment was conducted by Ma and Kaib (2006) at AVRDC to evaluate the effects of starter solutions in combination with inorganic and organic fertilizers on the initial growth and overall yield of cabbage, cherry tomato, sweet pepper and chili pepper. Small amounts of inorganic fertilizer were prepared as a liquid fertilizer and applied immediately after transplanting and/or at critical periods during crop growth. These applications significantly boosted early growth and overall yields of all vegetables tested. It also enhanced the release of nutrients from organic composts.

Stone (2006) conducted an experiment on the effects of starter and found that Starter fertilizer improved early growth and maintaining yield and quality of cauliflower.

Mitra *et al.* (1990) reported that increasing nitrogen rates increased head weight from 127 to 159 g, increased head width from 8.0 to 9.7 cm, increased length and width of hollow stem, but did not significantly increase the incidence of hollow stem. They also reported that the increase in total chlorophyll content was resulted from increasing rates of N application. It was reported that, increasing rates of N gave higher yield, but decreased sugar and dry matter contents. However, the external quality of the curd and ascorbic acid content was not affected by the rates of N.

Effect of age of seedling on growth and yield of broccoli:

Schrader (2000) reported that the age of broccoli and cauliflower transplant in autumn cultivation should not exceed 5 weeks. Otherwise there is considerable risk of the plants' prematurely entering the phase of generative growth which may result in more buttoned heads.

Wiebe (1981) reported that Sometimes a special problem of early cauliflower production is the occurence of small unmarketable curds (buttoning). A growth chamber experiment has shown that buttoning is mainly the result of retardation of leaf growth on curd initiation. Experiments with transplants raised under different growing conditions and of different age have shown, that single correlations between transplant criteria like transplant size, diameter of stem or apex and curd weight are not close enough to give a good prediction of the risk for buttoning. The prediction is somewhat better by using several criteria especially if transplants raised in different unknown temperatures, pot sizes or fertilization. After transplanting the curd size is influenced beside frost by soil density and planting technique as experiments have shown.

Damato *et al.* (1994) conducted an experiment on cell shape, transplant age, cultivars and yield in broccoli. Three holding periods (0, 7 and 14 days) were evaluated on the growth of transplants and the yield characteristics of three broccoli cultivars (Gran Vert, XPH 4142 and ML 423). Seeds were sown on August 9, 1990 and transplanted at the optimal stage (three true leaves), 7 and 14 days later. Transplants grown in TPG four radial groove) at optimal planting were higher and spindly; seedlings planted 7 days after the optimal stage showed higher shoot dry weight, root dry weight and leaf expansion; those planted the latest had lower root length and root density.

Grabowska *et al.* (2007) reported that In the two-factor field experiment conducted in 2002-2004 the effect of transplant age and the time of storage on the yield of broccoli cv. 'Lord F1'wasinvestigated. Transplants were stored in freon cold room without access to light at +2ºC and a relative air humidity of 80-85%. Both investigated factors had no significant effect on crop acceleration. Plants obtained from 4-week old trans-plants gained marketable yield significantly higher than plants obtained from10-week old transplants. Significantly higher yield was obtained from trans-plants stored in a cooling room as compared to non-stored transplants. No unit-vocal effect of the transplant age on the percentage of hollow stems was demonstrated.

Kaymak *et al.* (2004) conducted an experiment at Atatürk University, College of Agriculture, Erzurum, Turkey in 2003 and 2004 on Effect of transplant age on growth and yield of broccoli (*Brassica oleracea* var. *italica*). They transplanted seedling at the age of 30, 40 and 50 days . Transplant age affected growth, harvest time and yield of broccoli significantly. While the highest main head weight (385.1 g), diameter (9.3 cm), length (8.8 cm) and total yield (6054.0 g/lot); lateral shoots number (650.3), weight (39.6 g), diameter (6.4 cm) and length (5.7 cm) were obtained from 30 day-old transplants, the lowest values were obtained from 50 days old transplants in both the years. The effect of transplant age varied with cultivars. Results suggest that 30 days may be a reasonable target age for transplanting broccoli.

Yarali *et al.* (2007) suggested that using young transplants resulted in higher yield and quality. They suggested that 30 days is a reasonable target age for transplanting broccoli to have better yield and the oldest transplants reduced yield of broccoli.

Wlazlo and Kunicki (2003) suggested that use of young transplants resulted in higher yield and better quality.

Babik (2000) conducted an experiment on transplanting age of broccoli .boccoli cv. Cruiser F (RS) was sown in 10-day intervals in order to obtain transplants at age of 20, 30, 40 and 50 days. Yield and mean weight of the central head of broccoli was influenced by time of head formation. Earliness of broccoli was affected by transplant age and method of plant raising. The earliest, but lowest yield was obtained from the oldest transplants (50 days old) grown on a seedbed .Shorter growing periods of 30 or 20 days delayed harvest but increased yield and head weight. A 20-day growing period was not sufficient for raising well developed transplants on a seedbed.

Todorova (2009) conducted an experiment and the investigation was carried out in the Institute of Agriculture, Kyustendil during the period 2007-2009 in a field experiment of late production of four hybrids broccoli. The main purpose was to establish the dependence between transplant age and some of productive behaviors. As a result of the study it was established that hybrid Parthenon F1 produced the highest yield 2546.7 kg/ha average the period using 30 days transplants. The lowest yields was obtained from Fiesta F1 (1145.0 kg/da), using 45-days transplants. 30 days transplant age obtained better results for all the hybrids.

Diputado *et al.* (1989) conducted an experiment on The effect of sowing date and cultivar on the maturity characteristics of broccoli. They reported that Curd and total dry weight production varied with age of seedling and with cultivars.

In Lithuania, an experiment was carried out by Staugaitis and Viskelis (2005) to the changes of the macro-element amounts and the influence of seedling age in the heads and plant residues of Chinese cabbage. The Chinese cabbage crop was supplied with P90K150, and N rates as follows: No, N45, N<;0, N135, Nixo, and N225. Chinese cabbage hybrid Manoko F_1 was planted in the last ten days of July. The soil texture was loamy sand on light loam. On the average, there were 3.87% N, 0.67% P, 4.40% K, 0.82% Ca, and 0.20% Mg in the dry matter of Chinese cabbage. The amounts of the different nutrients were influenced by the climatic conditions and N application. N amount depended mostly on the rate of N fertilizer; the amounts of P, K, Ca and Mg were most infiucnccd by the climatic conditions. No to N225 increased the amounts of N, Ca and Mg, but had little influence on the amounts of P and K. The optimum N rate for Chinese cabbage was N135, because the higher rates did not increase the yield of heads. The crop planted with 30 days old seedling produced 44 t ha'1 yields, total plant mass being 76.6 t ha^{-1}.

Singh (2001) reported that Plant growth was best and the percentage and quality of marketable heads were highest when 3-week-old seedlings were used as transplants, but these seedlings gave the poorest stand. An improvement in stand to 96% was obtained with 4-week-old seedlings, but growth was reduced, so that the yields per acre from 3- and 4-week-old transplants were similar. With seedlings older than 4 weeks the reduction in growth was greater than the increase in stand, and the yield per acre was significantly reduced. With 3-week-old seedlings the best results were obtained with 2 plants per hill, but 1 per hill was most satisfactory when 4-week-old seedlings were transplanted. The use of an NPK starter solution, and the hardening of the seedlings by withholding water for 1 week prior to transplanting, had no significant effects.-B.R. Coll., Bichpuri, Agra

Damato and Trotta (2000) order to ensure a continuous supply of broccoli to the frozen industry, 3 cultivars (Gran Vert, XPH 4142 and ML 423) were seeded on August 6 and 19 and September 2 and 16. Seedlings were planted at their optimal stage (three true leaves), 7 and 14 day old. Production began on November 20 and ended on April 9. Yield and weight of central head (CH) decreased when sowing date was delayed and holding period was increased. The production from first and second sowing date is enough to assure profit to the grower and to supply the processors until mid March but with no production for the first fortnight of February. The yield was more concentrated if the sowing dates were delayed and the holding period was reduced. ‘Gran Vert’ and ‘ML 423’ were the earliest and latest cultivars tested. No hollow stem and a light bractiness was observed on CH of ‘Gran Vert’ whereas ‘XPH 4142’ and ‘ML 423’ showed hollow stem and bractiness, respectively. Sowing dates and holding period could ensure a continuous supply to the processors from November to the beginning of April but the product in the first fortnight of February and April was scarce.

Cristiaini *et al.* (2005) conducted the experiment from November/2000 to April/2001, in São Manuel, São Paulo State, Brazil. The effect of cell size of two polyestyrene trays and age of seedling at transplanting date was observed, on the production of cauliflower, hybrid Shiromaru II. Trays with 128 and 288 cells, corresponding to 34.6 and 9.7 cm^3/cell, respectively, were used with seedlings transplanted at 27; 34; 41 and 48 days after sowing date. The treatments were arranged in a factorial 2 x 4, in a randomized block design, with five replication. Leaf number and area, fresh and dry weight of the seedlings at transplanting date was evaluated. The experimental plot was represented by ten plants. The commercial curd production (%), leaf number, curd weight and diameter were evaluated after harvest. Total yield represents the sum of the fresh weight of all commercial curds. Seedlings produced in 128 cells tray resulted in greater commercial curd percentage (64%) when compared to trays with 288 cells (45%), greater curd weight (337 g and 247 g when produced in trays with 128 or 288 cells, respectively) and greater total commercial curds (36.9 t/ha and 19.9 t/ha when produced in 128 or 288 cells trays). Seedlings transplanted 32 days after planting date resulted in plants with the greatest curd weight (319 g). Based on the obtained results, it is recommended to produce cauliflower seedlings in trays with 128 cells .

Begum *et al.* (1990) observed wide variation in vegetative growth and head yield while, transplanting of 30 days old broccoli seedlings at an interval of 15 days from 14 Septembers to 13 December. They concluded that planting during 14

October to 13 November resulted in increased vegetative growth and larger curd than earlier planting.

Sterrett *et al.* (1990) carried out an experiment to explore the potential of sprouting broccoli with thirteen cultivars at East Virginia, USA. They reported that sowing time markedly influenced the yield, yield components and time of harvest. Yield of some broccoli cultivars exceeded the target from the first sowing date i.e. August 10th but it was below the target for the other two sowing dates i.e. August 19th to September 10th. They also observed that when sowing was delayed by 36 days, yield decreased by 36% in the first year and 66% in the second year.

Lewandowska (1992) observed that adequate transplant age ensures continuous and uniform growth of plants after planting, which results in the higher effectiveness and the yield quality. Occasionally, during early spring cultivation there is a necessity to extend the transplant production period due to unfavorable weather conditions, however in autumn transplants should be planted at their optimal development phase. Planting older transplants shortens the vegetative growth period of plants in the field and accelerates the plant's entering the phase of generative initiation which does not always favor the right curd development.

Lamont (1992) reported that In case of age-advanced cauliflower transplants it may influence curd future growth more negatively (Vavrina 1998), than in case of closely related species - broccoli**.**

Wurr and Jane (1984) have found that A transplants with well developed strong root system, are probably much better prepared for a stress connected with planting in the field and such plants usually produce and higher quality marketable curds. This trend was observed for all three cauliflower varieties and is consistent with the results obtained by other authors Wurr et al. 1986. However, some discrepancies of particular author's findings exist in this aspect.

Lewandowska (1992) claims that younger transplants give higher yield, however in that particular case this might be a result of higher age differentiation (3-7weeks) than in presented experiments. He demonstrated higher yield of better quality cauliflower with younger transplant age (age unspecified). The study involved three cultivars of 3,4,5,6 and 7wees of age. Lewandowska further noted that as transplant age increased, so did the time to early and mid harvest It seems that searching for cost cuts (us-in smaller pots, shortening production period) at the stage of transplant production does not deserve recommendation.

jones *et al.* (1991) studied broccoli transplant age (specified only as 3 to 7 weeks), in spring and fall crops for two years in Kentucky. This work found transplants of 5weeks or older produced higher early fall yields in one of the two years . He found that containerized cauliflower transplants of 5 weeks produced higher early and total yields in one of two fall trials and higher early yields in the soaring (in general).

In a study that stretched the limits of transplant age, Lamont (1992) compared broccoli transplant of 31 and 29 weeks to plants of 2 and 6 weeks of age, respectively, in trials in north Caroline .he found minor statistical differences in head weight and diameter in a spring trial only, but considered the differences too small to be of concern to the consumer.

Damato *et al*. (1994) used three cultivars of broccoli in a study with transplants 5,6, and 7 weeks old for fall production in Italy. These author find a linier decrease in individual head weight with increasing age, but treatment effect on head weight was not significant when tested via mean separation. time to first harvest increased significantly with increasing age, however the incidence of hollow stem lessened with increasing age in this study.

Wurr and Jane (1984) conducted two experiments studied the effect of transplanting plants of different sizes of cauliflower cv all the year round—Lero on the time of curd initiation, the growth of plant parts and the extent of buttoning, defined here as the production of small unmarketable curds less than 9 cm in diameter. Larger plants, transplanted later, produced more buttons but did not initiate curds earlier. It was not necessary for a plant to have initiated a curd before transplanting in order to produce a button. Larger plants at transplanting had a lower weight of leaf than smaller plants after curd initiation and consequently produced smaller leaves, so that curds were smaller when exposed and were therefore classed as buttons. An increase in the amount of buttoning with later transplanting occurred irrespective of whether the relative growth rates of plant parts remained proportional. It is suggested that if transplanting has been delayed, holding plants in a cold store once they have reached a specific leaf number would prevent them from getting too large, reduce the check to leaf growth and so reduce the incidence of buttoning.

Krężel and Kołota (2009) Summary two parallel experiments in two factorial design using the method of random sub-blocks in four replications were conducted in 2002-2004 at the experimental Station of the Horticulture Department of University of Environ-mental and Life Sciences in Wrocław. The effect of seedlings age (3, 4, 5-weekly) and diameter of pots (25, 32, 44, 55 mm) on the yield of Chinese cabbage cultivar Optiko grown in spring and autumn was evaluated. The highest marketable yield in spring and autumn during the harvest from all objects at the same time was obtained from 5-weekly seedlings grown in pots with a diameter of 55 mm. The use of younger seedlings from pots with smaller diameters was decreased the yielding of cabbage and influenced on forming the smaller heads. Spring cultivation period in comparison to autumn was allowed to obtain higher marketable yield of Chinese cabbage with a smaller share of not fully-grown head cabbage in total yield but a greater share of decay head.

Bewick (1994) conducted an experiment and he reported that In Florida 90 percent of the cabbage crop is transplanted. In the fall four-to-five-week-old plants are used, while in the winter six-to-eight-week-old plants are used. Recent research showed that transplant age and size of the transplant cell are critical factors in determining cabbage tolerance of pre-emergence herbicides.

Salter and Fradgley (1968) reported that the effects of six cultural treatments on (a) marketable yield, (b) percentage marketable plants and (c) percentage perfect quality curds produced, were studied on representative varieties of three groups of autumn cauliflower in experiments carried out over a period of five years. The treatments included a comparison of the use of graded and ungraded seed, transplanting and direct-drilling of the crop, different transplant ages, and selection for uniformity at planting or thinning time, and plant density and nitrogen levels during the early seedling stage of growth. In general the yields and quality of drilled and transplanted crops were similar with all varieties each year and neither the use of graded seed nor the nitrogen treatments had any significant effect on yield or curd quality. Both increasing plant density in the seedbed and increasing age of transplant caused a reduction in yield on most occasions. The effects of the treatments on yield and quality are discussed in relation to their effects on the maturity characteristics of the crops.

Sari *et al*. (2000) Effects of sowing times on Broccoli cultivation was studied in the Area of South Eastern Anatolian Project (GAP), during the growing seasons of 1994–1995 and 1995–1996. Five different sowing times between the Middle of June and Middle of August, with 15 days intervals were tested using two early (Sultan and SG1) and one late (Marathon) hybrid varieties. The most suitable sowing time was determined to be between the middle of June and beginning of July, plants of which period was best transplanted in August, under the condition of controlled irrigation. The yield obtained from the preferable growing period was approximately 1 kg/plant and 40 t/ha for which a plant density of 4 plants/m^2 was used. While the primary heads produced 20–25 %, the lateral receptacles contributed to the total yield at a ratio of 75–80%. A continuous harvest of five months between October and March, was determined to be applicable in the GAP Area.

Bianco *et al.*(1996) reported that the planting dates have significant effect on yield and other yield contributing characters of broccoli. The yield decreased with delay planting. Head yield is higher when crops are planted earlier and show a linear decreasing trend with delay in planting dates.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from October, 2017 to March, 2018 to study the effect of starter solution and age of seedling on growth and yield of broccoli. The materials and methods that were used for conducting the experiment have been presented in this chapter. It includes a short description of the location of experimental site, soil and climate condition of the experimental plot, materials used for the experiment, design of the experiment, data collection and data analysis procedure.

Location of the experimental site

The experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University (SAU), Dhaka. It was located in 24.090N latitude and 90.260E longitudes. The altitude of the location was 8 m from the sea level as per the Bangladesh Meteorological Department, Agargaon, Dhaka-1207.

Characteristics of soil

Experimental site belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28 and the selected plot of the land was medium high in nature with adequate irrigation facilities and remained fallow during the previous season. The soil texture of the experimental was sandy loam. The nutrient status of the farm soil under the experimental plot with in a depth 0-20 cm were collected and analyzed in the Soil Research and Development Institute Dhaka, and result have been presented in Appendix II **.**

Climatic condition of the experimental site

Experimental area is situated in the sub-tropical climate zone, which is characterized by heavy rainfall , high humidity, high temperature during kharif season (April-August) and scarce rainfall, low humidity, low temperature and short day period Rabi season (October –March). Details of the meteorological data in respect of temperature, rainfall, relative humidity, average sunshine and for the period of the experiment was collected from the Bangladesh Meteorological Department, Agargoan, Dhaka and presented in Appendix III

Planting materials

The test crop used in the experiment was broccoli variety Premium and the seeds were collected from Siddique Bazar, Dhaka.

Treatment of the experiment

The experiment consisted of two factors

Factor A: Different level of starter solution

S_0= control

S_1= 1% urea solution

S_2= 2% urea solution

S_3= 3% urea solution

Factor B: Age of seedling

A_1=20 days of seedling

A_2=30 days of seedling

A_3=40 days of seedling

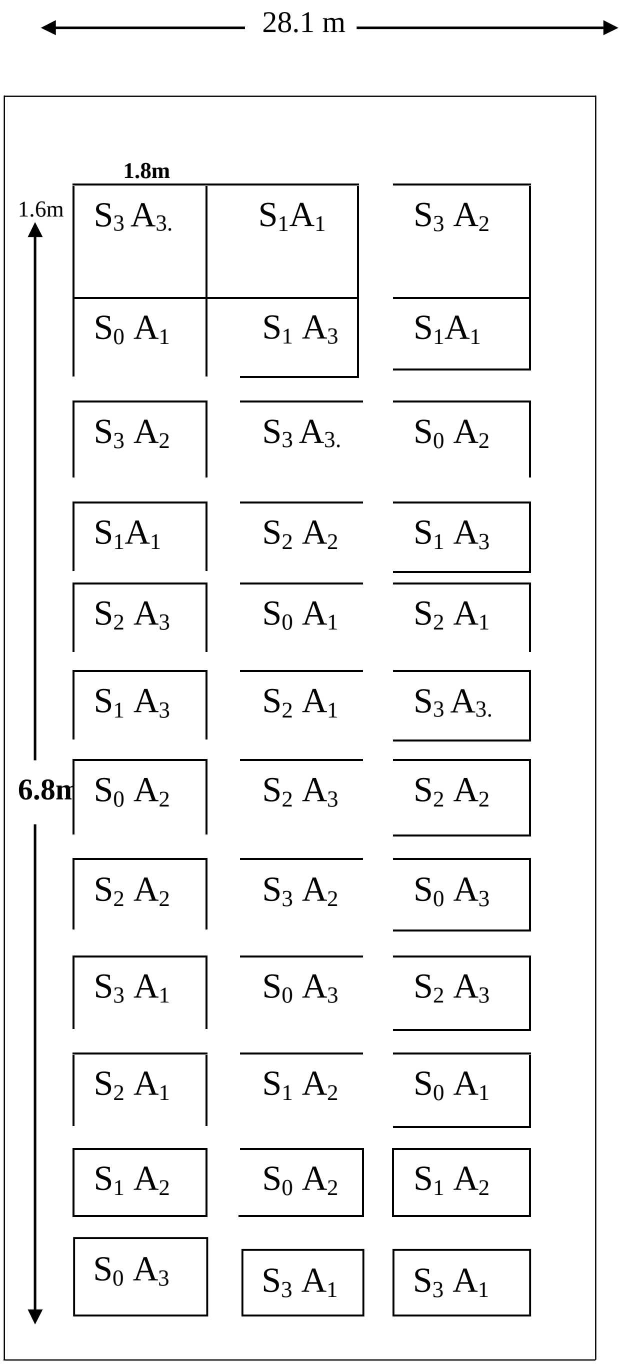
There were 12 (3 × 4) treatments combination such as S_0A_1 , S_0A_2 , S_0A_3 , S_1A_1, S_1A_2, S_1A_3 , S_2A_1 , S_2A_2 , S_2A_3 , S_3A_1 , S_3A_2 , S_3A_3.

Collection of seedlings

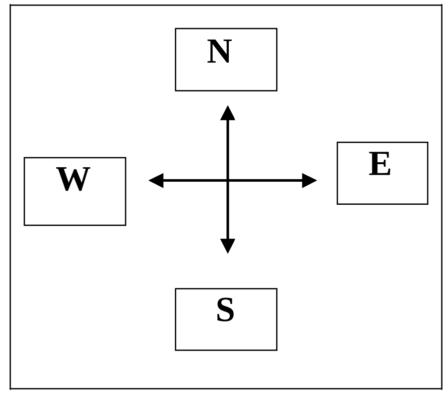
The seedlings of broccoli were grown in seedbed at horticulture farm of SAU, Dhaka.

Design and layout of the experiment

The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The total area of the experimental plot was 191.08 m^2 with length 28.1 m and width 6.8m. The total area was divided into three equal blocks. Each block was divided into 12 plots where 12 treatments combination were allotted at random. There were 36 unit plots altogether in the experiment. The size of the each plot was 1.8m × 1.6m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.



Legend



Treatments:

Factor A: starter solution

S_0=control
S_1= 1% urea
S_2-=2% urea
S_3=3% urea

Factor B: Age of seedling

A_1=20 days of seedling
A_2=30 days of seedling
A_3=40 days of seedling

Experimental Layout:
plot to plot distance =0.5 m
block to block distance =0.7m
plot size =1.8m× 1.6m
replication =3

Fig 1. Layout of the experimental field

Preparation of the main field

The selected plot of the experiment was opened in the 1st week of November, 2017 with a power tiller, and left exposed to the sun for a week. Subsequently cross ploughing was 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 was achieved. The soil was treated with insecticides (cinocarb 3G @ 4 kg/ha) at the time of final land preparation to protect young plants from the attack of soil inhibiting insects such as cutworm and mole cricket.

Application of manures and fertilizers

Manures and fertilizers were applied to the experimental plot considering the recommended fertilizer doses of BARI (2005).

Cowdung = 10 ton ha^{-1}

Urea = 300 kg ha^{-1}

TSP = 250 kg ha^{-1}

MoP = 200 kg ha^{-1}

The total amount of cowdung, TSP and MoP was applied as basal dose at the time of land preparation. The total amount of urea was applied in three installments at 10, 30 and 50 days after transplanting.

3. 10 Preparation of starter solution

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

Raising of seedlings

The seedlings of broccoli were raised at Horticulture Farm, of Sher-e-Bangla Agricultural University (SAU), Dhaka, under special care in four seed beds each of 3 m × 1 m size. Soil of the seed bed was 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 of disease. Seed were sown in each seed bed on 20th October, 1st November and 10th November. After sowing, the seeds were covered with finished light soil. Seeds were completely germinated within 5-6 days after sowing. Shading was given by bamboo mat (chatai) 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 for good growth and raising quality seedlings.

Transplanting of seedlings

Healthy and uniform seedlings of 20 days, 30 days and 40 days old seedlings were transplanting in the experimental plots on 30 November, 2017. The seedlings were uprooted carefully from the seed bed to avoid damage to the root system. To minimize the damage to the roots of seedlings, the seed beds were watered on hour before uprooting the seedlings. Transplanting was done in the afternoon. The seedlings were watered immediately after transplanting. Seedlings were sown in the plot with maintaining distance between row to row and plant to plant was 60 cm and 45 cm, respectively. The young transplants were shaded by banana leaf sheath during day time to protect them from scorching sunshine up to 7 days until they were set in the soil. They (transplants) were kept open at night to allow them receiving dew. A number of seedlings were also planted in the border if the experimental plots for gap filling.

Intercultural operation

After raising seedlings, various intercultural operations such as gap filling, weeding, earthing up, irrigation pest and disease control etc. were accomplished for better growth and development of the broccoli seedlings.

Gap filling

The transplanted seedlings in the experimental plot were kept under careful observation. 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 same as planting time treatment. Those seedlings were transplanted with a big mass of soil with roots to minimize transplanting shock. Replacement was done with healthy seedling having a boll of earth which was also planted on the same date by the side of the unit plot. The transplants were given shading and watering for 7 days for their proper establishment.

Weeding

The hand weeding was done at 15, 30, 45 and 60 days after transplanting (DAT) to keep the plots free from weeds.

Earthing up

Earthling up was done at 20 and 40 days after transplanting on both sides of rows by taking the soil from the space between the rows by a small spade.

Irrigation

Light watering was given by a watering cane at every morning and afternoon. Following transplanting and it was continued for a week for rapid and well establishment of the transplanted seedlings.

Pest and disease control

In spite of Cirocarb 3G applications during final land preparation few young plants were damaged due to attack of mole cricket and cut worm. Cut worms were controlled both mechanically and spraying Darsban 29 EC @ 3%. Birds pest such as nightingales (common Bulbuli) were seen visiting the broccoli field very frequently. The nightingale visited the fields in the morning and afternoon. The birds very found to puncture the soft levels and newly initiated curd and were controlled by striking a kerosene tin of metallic container frequently during day time.

Harvesting

Only the compact mature curds were harvested with 15 cm long fleshy stalk by using as sharp knife. To prevent the rotting of stem the cut portion were slanted, so that rain water could not stay. The curds were harvested in compact condition before the flower buds opened (Thomson and Kelly, 1985). Before harvesting of the broccoli head, compactness of the head was tested by pressing with thumbs. After harvesting the main curd, secondly the shoots were developed from the leaf axils, which also developed into small secondary curds and were harvested over a period of time.

Data collection

Five plants were randomly selected from each unit plot except yields of curds, which was recorded plot wise. Data were collected in respect of the following parameters to assess plant growth; yield attributes and yields as affected by different treatments of the experiment. Data on plant height, number of leaves, leaf breadth and length of large leaf were collected at 20, 40, 60 days after transplanting (DAT) and at harvest after transplanting. All other yield contributing characters and yield parameters were recorded during harvest and after harvest.

Plant height

Plant height was measured from sample plants in centimeter from the ground level to the tip of the longest leaf and mean value was calculated. Plant height was also recorded at 20 days interval starting from 20 days after transplanting (DAT) upto 60 days and at harvest to observe the growth rate of plants.

Number of leaves per plant

The total number of leaves per plant was counted from each selected plant with the observation of fully open leaves. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot at 20 days interval starting from 20 days after transplanting (DAT) up to 60 days and at harvest.

Diameter of stem

The diameter of the stem was measured at the point where the central curd was cut off. The diameter of the stem was recorded by slide calipers.

Canopy spread

Plant canopy was measured by taking the diameter of the canopy of an individual plant at different directions and finally the average was taken.

Largest leaf length

Largest leaf length was measured from sample plants in centimeter from the ground base of the petiole to the tip of the longest leaf and mean value was calculated. Largest leaf length was also recorded at 20 days interval starting from 20 days after transplanting (DAT) up to 60 days after transplant and at harvest to observe the growth rate of plants.

Largest leaf breadth

Data on largest leaf breadth were recorded as the average of 5 plants selected at random from the inner rows of each plot at 20 days interval starting from 20 days after transplanting (DAT) up to 60 days after transplant .

Length of root

The length of root was considered from the base of the tip of the root. It was measured in centimeter (cm) with a meter scale after harvesting.

Weight of primary curd

The weight of primary or central curd per plant was recorded in gram (g) by a beam balance.

Diameter of primary curd

The diameter of primary curd was measured in several directions with meter scale and the average of all directions was finally recorded and expressed in centimeter (cm).

Length of curd

The length of curd was considered from the cutting point to the top of the head. It was measured in centimeter (cm) with a meter scale after harvesting.

Diameter of stem of curd

The diameter of the stem was measured at the point where the central curd was cut off. The diameter of the stem was recorded by slide calipers.

Number of secondary head

The number of secondary head excluding the small shoots was counted when they reached marketable size.

Weight of secondary head

The total marketable head of an individual plant were taken and weight was recorded in gram (g) by a weighting balance.

Dry matter (%) of leaves

At first 100 gm leaves of selected plant was collected, cut into pieces and was dried under sunshine for a few days and then dried in an oven at 70^{0}C for 72 hours before taking dry weight till it was constant. The dry weight was recorded in gram (g) with a beam balance. The dry matter contents of leafs were computed by simple calculation from the weight recorded by the following formula:

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

3.15.15. Dry matter (%) of head

Sample of 100 g head was taken, cut into pieces and was dried under direct sunshine for 3 days and then was dried in an oven at 70 for 72 hours before taking the dry weight till it was constant. The dry weight was recorded in gram (g) with a beam balance. The dry matter contents of leafs were computed by simple calculation from the weight recorded by the following formula:

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

Yield per plant

The yield per plant was calculated by averaging the weight of harvested curds and secondary curds of five randomly selected plants

Yield per plot

The yield per unit plot was calculated by adding the weight of all the central curds and secondary curds produced in the respective plot. The yield of all plants in each unit plot was recorded and was expressed in kilogram (kg).

Yield per hectare

The yield per hectare was calculated by converting from the per plot yield data to per hectare and was expressed in ton (t).

Statistical analysis

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

Economic analysis

The cost of production was analyzed in order to find out the most economic combination of starter solution and age of seedling. All input cost included the cost for lease of land and interests on running capital in computing the cost of production. The interests were calculated @ 13% in simple rate. The market price of broccoli was considered for estimating the cost and return. Analyses were done according to the procedure of Alam *et al*. (1989). The benefit cost ratio (BCR) was calculated as follows

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

CHAPTER IV

RESULTS AND DISCUSSION

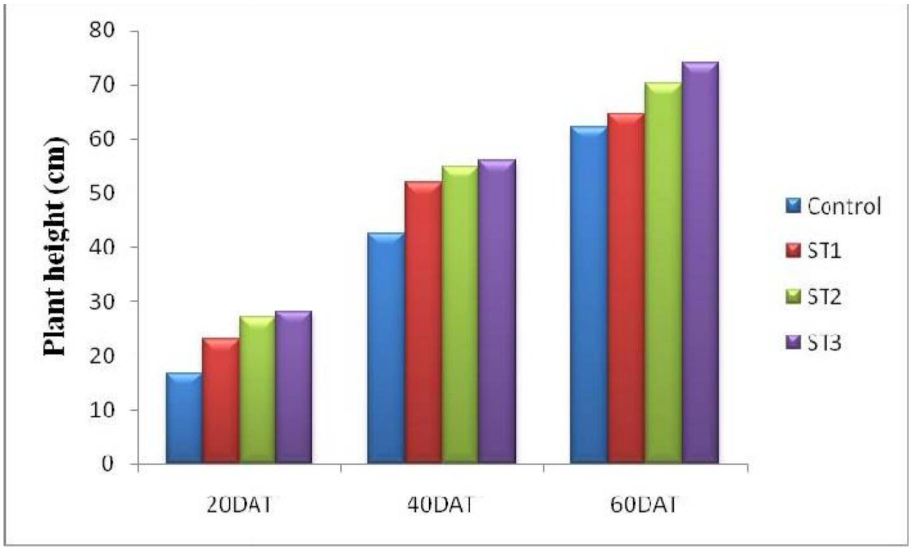
The experiment was conducted to observe the effect of starter solution and age of seedling on growth and yield of broccoli under the soil and agro climatic condition of Sher-e-Bangla Agricultural University (SAU), Dhaka. Data on different growth and yield parameter were recorded. The analyses of variance (ANOVA) of the data on different growth and yield parameters are presented in Appendix IV-IX. The results have been presented and discusses with the help of table and graphs and possible interpretations have been given under the following headings.

Plant height (cm)

Starter solution has great impact on plant height. Plant height increased with the increasing percentage of starter solution at 20, 40 and 60 DAT (Appendix IV). At 60 DAT, the tallest plant (73.92 cm) was recorded from s_3 (3% starter solution) treatment and the lowest plant height (62.22 cm) was observed from s_0 (control) treatment (Fig. 2 and Appendix IV). Plant height was found statistically different at 20 DAT to at harvest. This might be due to the fact that starter solution i.e. urea solution minimized the transplanting shock and increased urea uptake for the plant that has helped the plant to start a good beginning. The present result of the study is supported by the findings of Chhonkar and Jha (1963).

Plant height varied significantly for different age of seedling at 20, 40 and 60 DAT due to the impact of different age of seedling. At 60 DAT, the tallest plant was observed (71.36 cm) from A_2 (30 days old seedling) treatment and the lowest plant height (63.7 cm) was recorded from A_3 (40 days old seedling) treatment (Fig. 3 and Appendix IV). This might be due to the fact that 30 days old seedling possibly got all the condition favored for better growth than those of other aged seedling. From data it is cleared that 30 days old seedling produced the longest plant followed by 20 days old seedling and delayed planting means 40 days old seedling produced the lowest plant height. Broccoli is a short day crop and grown in winter season for its optimum growth and curd development because it is a thermo sensitive crop. Its growth and curd development are greatly influenced by growing environment which was governed by age of seedling. The optimum seedling age ensures plant to growth properly through efficient utilization of moisture, temperature, light etc. kaymak (2004) reported that plant transplanted at the age of 30 days showed the longest height than other transplants that is about similar of present study.

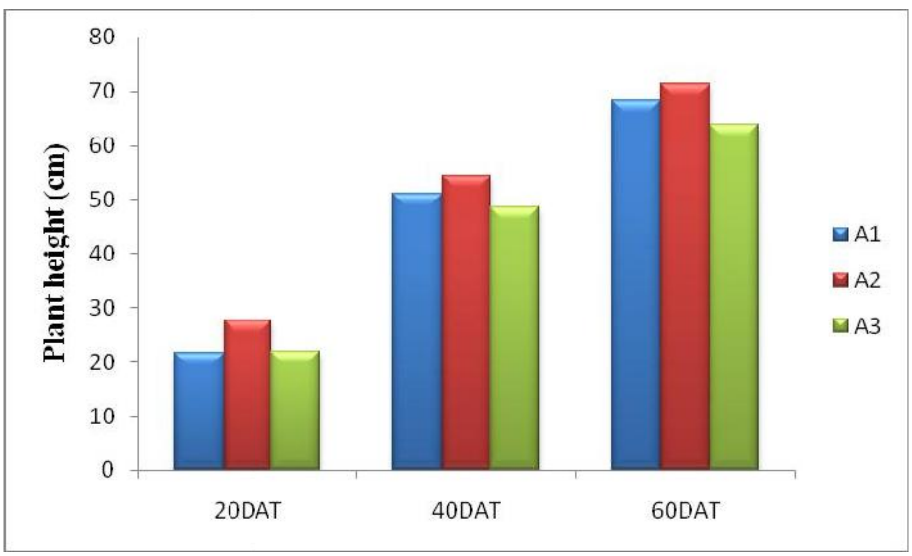
Combined effect of starter solution and age of seedling showed significant differences on the plant height of broccoli at 20, 40 and 60 DAT. At 60 DAT, the highest plant height (79.76 cm) was obtained from S_3A_2 treatment combination and the lowest plant height (59.50 cm) was obtained from S_oA_3 treatment combination (Table. 1 and Appendix IV). Here, increased amount of urea (3% urea solution) with 30 days old seedling gave the highest plant height.



here,

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

Fig. 2: Effect of starter solution on plant height of broccoli at different days after transplanting.



here,
DAT= days after transplant, A_1=20 days old seedling, A_2=30 days old seedling, A_3= 40 days old seedling

Fig.3: Effect of age of seedling on plant height of broccoli at different days after transplant.

Table 1. Combined effect of starter solution and age of seedling on plant height at different days after transplant (DAT) of broccoli

Treatment combinations	Plant height (cm)		
	20 DAT	40 DAT	60DAT
$S_0 A_1$	15.44 g	42.3 g	62.39 g
$S_0 A_2$	20.18 f	45.69 f	64.79 f
$S_0 A_3$	14.67 g	39.78 h	59.50 h
$S_1 A_1$	19.37 f	52.36 d	65.22 f
$S_1 A_2$	26.18 c	54.73 c	66.56 e
$S_1 A_3$	23.72 e	48.66 e	62.29 g
$S_2 A_1$	25.30 cd	54.76 c	71.17 c
$S_2 A_2$	31.21 b	57.17 b	74.36 b
$S_2 A_3$	24.23 de	52.39 d	65.20 f
$S_3 A_1$	26.62 c	54.66 c	73.99 b
$S_3 A_2$	33.22 a	60.14 a	79.76 a
$S_3 A_3$	24.62 de	53.29 cd	68.02 d
CV %	7.41	8.67	8.25
LSD (0.05)	1.4	1.69	1.32

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

Note:

S_0=control, S_1=1% urea, S_2=2% urea, S_3= 3% urea

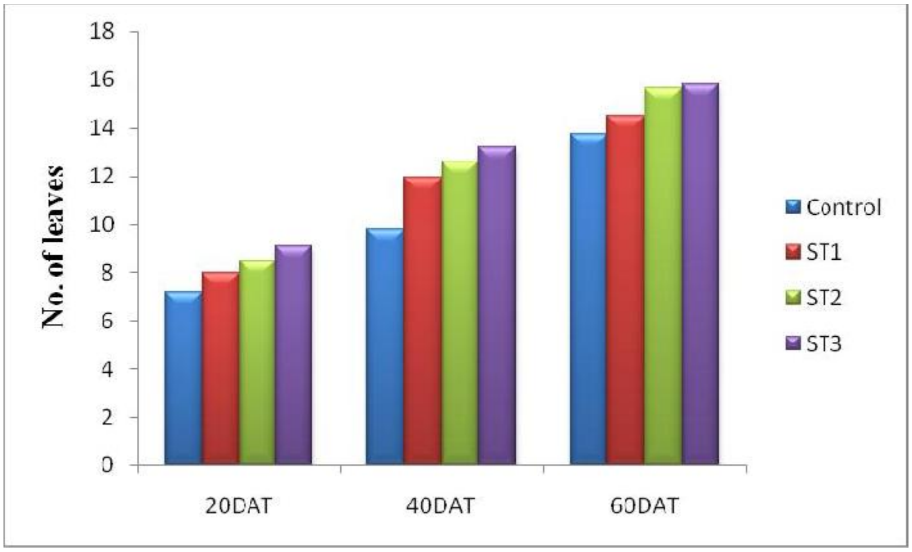
A_1= 20 days old seedling, A_2=30 days old seedling, A_3=40 days old seedling

Number of leaves per plant

Number of leaves per plant is an important parameter for crop plant because of its physiological role in photosynthetic activities. Leaf number varied significantly with increasing amount of starter solution for 20, 40 and 60 DAT (Appendix IV). At 60 DAT, the maximum number of leaves (15.81 cm) was recorded from S_3 (3% starter solution) treatment which was statistically identical to (15.63 cm) S_2 (2% starter solution) treatment, while the minimum number of leaves (13.74 cm) was obtained from S_0 (control) treatment (Fig. 4 and Appendix IV). It might be due to vigorous growth of plants by using starter solution. The nutrients in starter solutions are immediately absorbed and utilized by plants. Plants respond rapidly that increase leaf number. These results are in support of the findings of Chaudhury and Singh (1960).

Age of seedling showed a significant influence on number of leaves per plant at different days after transplanting. Number of leaves per plant was increased with the time at 20, 40 and 60 DAT (Appendix IV). At 60 DAT, the maximum number of leaves (16.70 cm) was recorded from A_2 (30 days old seedling) treatment, while the minimum number of leaves (13.54 cm) was recorded from A_3 (40 days old seedling) treatment (Fig. 5 and Appendix IV). Damato and trotta (1990) reported that seedling transplanted at optimum stage (4 weeks) gives higher number of leaves, root length, higher plant height etc, while seedlings planted 7 days after the optimal stage showed higher shoot dry weight, root dry weight and leaf expansion; those planted the latest had lower root length and root density.

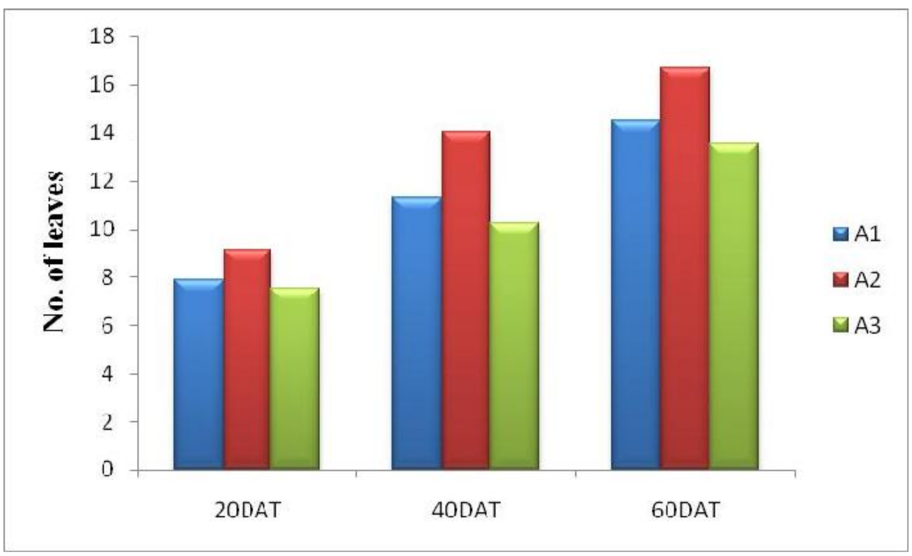
Significant variation was observed due to the combined effect of starter solution and age of seedling of broccoli at 20, 40 and 60 DAT (Appendix IV). At 60 DAT, the maximum number of leaf (17.21 cm) was recorded from S_3A_2 treatment combination and the minimum number of leaf was recorded (12.82 cm) from S_0A_3 treatment combination (Table 2 and Appendix IV).



here,

DAT= days after transplant, S_0=control, S_1=1% urea, S_2=2% urea, S_3= 3% urea

Fig.4: Effect of starter solution on number of leaves of broccoli at different days after transplant.



here,

DAT= days after transplant , A_1=20 days old seedling, A_2=30 days old seedling, A_3= 40 days old seedling

Fig.5: Effect of age of seedling on number of leaves of broccoli at different days after transplant

Table 2. Combined effect of starter solution and age of seedling on number of leaves per plant at different days after transplant (DAT) of broccoli

Treatment combinations	Number of leaf per plant		
	20DAT	40DAT	60DAT
$S_0 A_1$	6.85 de	9.45 f	13.07 ef
$S_0 A_2$	8.48 bc	10.77 de	15.35 c
$S_0 A_3$	6.22 e	9.12 f	12.82 f
S_1A_1	7.69 b-e	11.14 de	14.47 c-e
$S_1 A_2$	8.79 a-c	14.52 b	15.92 bc
$S_1 A_3$	7.43 c-e	10.13 ef	13.09 ef
$S_2 A_1$	8.25 b-d	11.84 cd	14.87 cd
$S_2 A_2$	9.13 ab	15.06 ab	18.35 a
$S_2 A_3$	8.06 b-d	10.84 de	13.67 d-f
$S_3 A_1$	8.82 a-c	12.79 c	15.62 c
$S_3 A_2$	10.15 a	15.86 a	17.21 ab
$S_3 A_3$	8.34 b-d	10.94 de	14.61 cd
CV %	9.98	8.16	10.97
LSD (0.05)	1.53	1.27	1.51

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

Note:

$S_{0=}$control, S_1=1% urea, S_2=2% urea, S_3= 3% urea

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

Largest leaf length (cm)

Largest leaf length of broccoli was recorded statistically significant differences for different level of starter solution at 20, 40 and 60 DAT (Table 3 and Appendix IV). At 60 DAT, the highest largest leaf length (52.58 cm) was recorded from S_3 (3% urea solution) treatment, while the minimum largest leaf length (49.03 cm) was obtained from S_0 (control) treatment (Table 3). Here, S_3 (3% urea solution) gives largest leaf length because starter solution as nitrogen resulted in highly significant increase in largest leaf length, number of leaves, stem diameter etc. This result is in agreement with El-Afifi *et al.* (2014).

Significant variation was recorded for different age of seedling of broccoli in terms of largest leaf length at 20, 40 and 60 DAT (Table 4 and Appendix IV). At 60 DAT, the highest largest leaf length (55.43 cm) was recorded from A_2 (30 days old seedling) treatment, while the minimum largest leaf length (46.77 cm) was recorded from A_3 (40 days old seedling) treatment (Table 4). Begum *et al.* (1990) observed wide variation in vegetative growth and head yield while, transplanting of 30 days old broccoli seedlings at an interval of 15 days from 14 Septembers to 13 December. They concluded that planting during 14 October to 13 November resulted in increased vegetative growth and larger curd than earlier planting.

Starter solution and age of seedling showed Significant variation due to the combined effect on largest leaf length of broccoli at 20, 40 and 60 DAT (Table 5 and Appendix IV). At 60 DAT, the highest largest leaf length (56.62 cm) was recorded from S_3A_2 treatment which is statistically identical with S_2A_2 and S_1A_2 and the minimum largest leaf length (45.31 cm) was recorded from S_0A_3 treatment (Table 5).

Table 3. Effect of starter solution on largest leaf length (cm) of broccoli

Treatments	Largest leaf length (cm)		
	20 DAT	40 DAT	60 DAT
S_0	19.01 d	39.51 d	49.00 d
S_1	21.13 c	41.96 c	50.69 c
S_2	22.44 b	43.32 b	51.75 b
S_3	24.07 a	44.83 a	52.58 a
CV%	10.68	11.58	10.45
LSD(0.05)	0.86	1.15	0.81

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

here,
S_0=control, S_1=1% urea , S_2= 2% urea, S_3 = 3% urea

Table 4. Effect of age of seedling on largest leaf length of broccoli

Treatments	Largest leaf length (cm)		
	20 DAT	40 DAT	60 DAT
A_1	20.895 b	42.544 b	50.818 b
A_2	24.258 a	43.978 a	55.437 a
A_3	19.845 c	40.702 c	46.773 c
CV %	10.68	11.58	10.45
LSD (0.05)	0.75	0.97	0.70

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

here,

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

Table 5. Combined effect of starter solution and age of seedling on largest leaf length of broccoli at different days after transplant

Treatment combinations	Largest leaf length (cm)		
	20DAT	40 DAT	60DAT
S_0 A_1	18.34 fg	39.55 fg	48.47 cd
S_0 A_2	21.12 d	40.77 ef	53.23 b
S_0 A_3	17.57 g	38.23 g	45.31 f
S_1A_1	20.82 de	42.07 c-e	49.42 c
S_1 A_2	23.16 c	42.89 cd	55.81 a
S_1 A_3	19.41 ef	40.92 d-f	46.85 e
S_2 A_1	21.29 d	43.32 bc	52.07 b
S_2 A_2	25.52 b	45.19 ab	56.09 a
S_2 A_3	20.53 de	41.44 c-f	47.11 de
S_3 A_1	23.13 c	45.23 ab	53.31 b
S_3 A_2	27.23 a	47.060 a	56.62 a
S_3 A_3	21.87 cd	42.22 c-e	47.82 de
CV %	10.68	11.58	10.45
LSD (0.05)	1.50	1.96	1.41

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

here,

$S_{0=}$ control, S_1=1% urea, S_2=2% urea, S_3= 3% urea

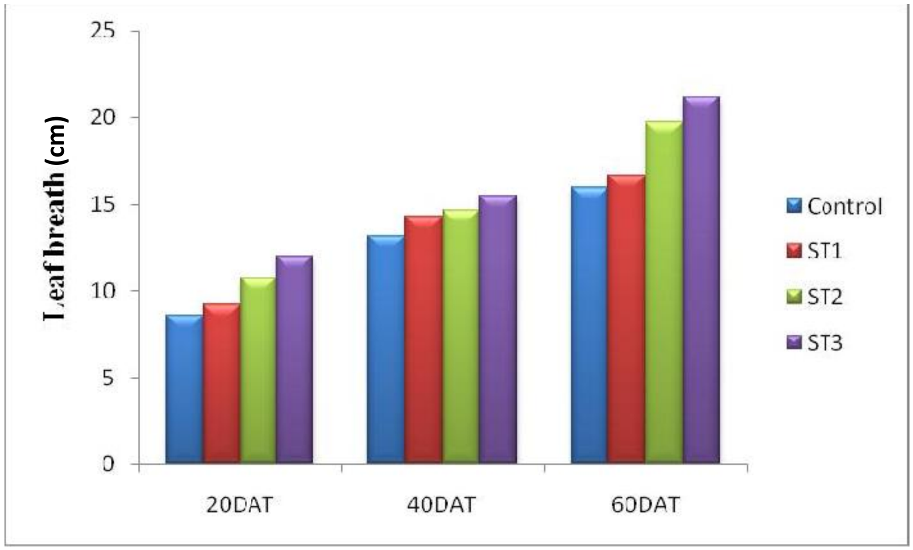
A_1= 20 days old seedling, A_2=30 days old seedling, A_3=40 days old seedling

Largest leaf breadth (cm)

Significant variation was found of leaf breadth due to different concentration of starter solution at 20, 40 and 60 DAT (Fig. 6, Table 6 and Appendix V). At 60 DAT, the maximum largest leaf breadth (21.17 cm) was recorded from S_3 (3% urea solution) treatment and the minimum largest leaf breadth (18.83 cm) was recorded from S_0 (control) treatment (Fig. 6) which is statistically identical to S_1 (1% urea solution) treatment,

Age of seedling showed significant variation for maximum leaf breadth of broccoli at 20, 40 and 60 DAT (Fig. 7 , Table 6 and Appendix V). At 60 DAT, the maximum largest leaf breadth of broccoli (20.48 cm) was recorded from A_2 (30 days old seedling) treatment and the minimum largest leaf breadth (15.83 cm) was recorded from A_3 (40 days old seedling) treatment (Fig. 7 and Table 6).

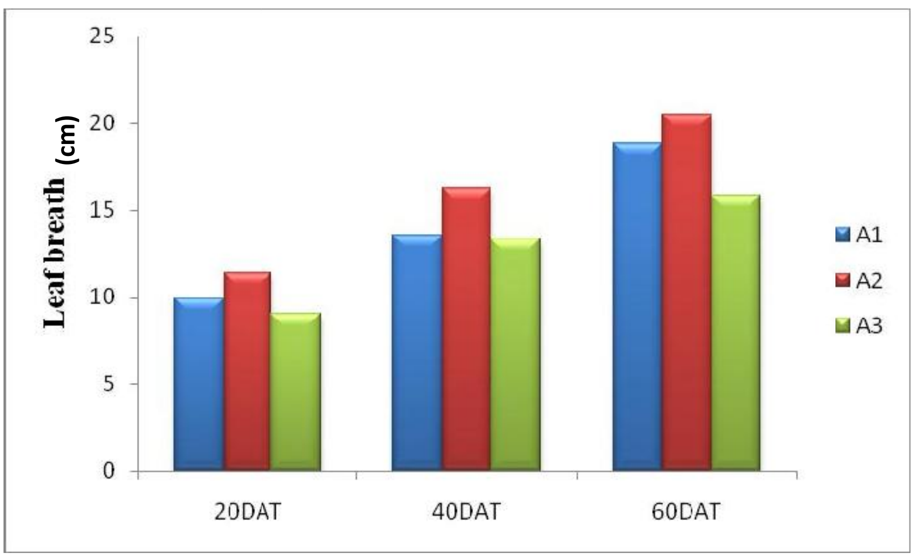
Combined effect of starter solution and age of seedling at different days after transplanting (DAT) was found to be statistically significant on largest leaf breadth .At 20, 40 and 60 DAT, leaf breadth was increasing (Table 6 and Appendix V). At 60 DAT, The maximum largest leaf breadth (23.50 cm) was recorded from S_3A_2 treatment combination which was statistically identical (22.47 cm) to S_2A_2 and S_3A_1 treatment combination, while the minimum largest leaf breadth (14.18 cm) was recorded from S_0A_3 treatment combination (Table 6).



here,

DAT= days after transplant, S_0= control, S_1=1% urea, S_2=2% urea, S_3= 3% urea

Fig.6. Effect of starter solution on growth of largest leaf breadth of broccoli at different days after transplant.



here,

DAT= days after transplant, A_1= 20 days old seedling, A_2=30 days old seedling, A_3=40 days old seedling

Fig.7. Effect of age of seedling on growth of largest leaf breadth of broccoli at different days after transplant.

Table 6. Effect of starter solution and age of seedling on largest leaf breadth of broccoli at different days after transplant

Treatments	Largest leaf breadth (cm)		
	20 DAT	40 DAT	60 DAT
	Effect of starter solution		
S_0	8.59 c	13.15 c	15.98 c
S_1	9.20 c	14.26 b	16.66 c
S_2	10.74 b	14.65 ab	19.71 b
S_3	11.97 a	15.50 a	21.17 a
CV%	9.62	10.66	11.43
LSD(0.05)	1.03	0.94	1.03
Treatments	Effect of age of seedling		
A_1	9.92 b	13.53 b	18.83 b
A_2	11.38 a	16.29 a	20.48 a
A_3	9.07 b	13.35 b	15.83 c
CV %	9.62	10.66	11.43
LSD (0.05)	0.89	0.81	0.87
Treatment combinations	Combined effect of starter solution and age of seedling		
$S_0 A_1$	8.450 ef	12.12 gh	16.13 d
$S_0 A_2$	9.23 d-f	15.26 b-d	17.65 cd
$S_0 A_3$	8.10 f	12.07 h	14.18 e
$S_1 A_1$	9.05 d-f	13.51 e-h	17.44 cd
$S_1 A_2$	10.11 c-e	16.55 ab	18.33 bc
$S_1 A_3$	8.44 ef	12.73 f-h	14.22 e
$S_2 A_1$	10.56 cd	13.72 d-g	19.95 b
$S_2 A_2$	12.44 ab	16.23 a-c	22.47 a
$S_2 A_3$	9.23 d-f	14.02 d-f	16.71 cd
$S_3 A_1$	11.65 bc	14.79 c-e	21.82 a
$S_3 A_2$	13.75 a	17.13 a	23.50 a
$S_3 A_3$	10.51 cd	14.59 de	18.21 bc
CV %	9.62	10.66	11.43
LSD (0.05)	1.79	1.63	1.74

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

here,

S_0=control, S_1=1% urea, S_2=2% urea, S_3= 3% urea

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

Stem diameter (cm)

Stem diameter of broccoli varied Significantly for different concentrations of starter solution at 20, 40 and 60 DAT (Table 7 and Appendix VI). At 60 DAT,The highest stem diameter (2.65 cm) was recorded from S_3 (3% urea solution) treatment, whereas the lowest stem diameter (2.10 cm) was recorded from S_0 (control) treatment (Table 7). Here, the maximum stem diameter was obtained from S_3 (3% urea solution), this might be due to the fact that increased amount of starter solution as nitrogen increased stem diameter. This result has similarity with El-Afifi *et al* (2014) They reported that four starter fertilizers treatments included three sources of N, i.e., ammonium sulfate (20.5 % N), ammonium nitrate (33.5 %) and urea (46%) as well as without starter solution and two sources of stimulants. The results indicated that, starter solutions treatments resulted in highly significant increases in stem length, stem diameter, whole stem weight, number of total leaves/ plant and fresh weights of outer leaves (inedible), inner leaves (edible) , total leaves / plant and weights of total yield (whole head) and marketable yield (edible head) compared with the control treatment (without starter solution) in both seasons.

Stem diameter of broccoli showed significant variation due to different age of seedling at 20, 40 and 60 DAT (Appendix VI). At 60 DAT, the highest stem diameter (2.88 cm) was found from A_2 (30 days old seedling) treatment, while the lowest length of stem diameter (2.04 cm) was recorded from A_3 (40 days old seedling) treatment (Table 7).

Stem diameter of broccoli showed significant differences due to the Combined effect of different concentrations of starter solution and age of seedling. At 60 DAT, the highest stem diameter (3.07 cm) was recorded from S_3A_2 treatment combination which was statistically identical with S_2A_2, S_1A_2 and S_0A_2 treatment combination, again the lowest stem diameter (1.59 cm) was found from S_0A_3 treatment combination (Table7).

Canopy spread (cm)

Significant variation was recorded on canopy spread of broccoli due to different concentrations of starter solution at 20, 40 and 60 DAT (Table 7 and Appendix VI). At 60 DAT, The highest canopy spread (79.04 cm) was recorded from S_3 (3% urea solution) treatment, whereas the lowest canopy spread (62.53cm) was recorded from S_0 (control) treatment (Table 7). This finding has similarity with Yarli *et al.* (2007). This might be because there is little risk of plant injury (burning) when using starter solutions. Dry fertilizer in close contact with plant roots can result in serious injury, while starters can be added directly to plant roots that helps plants vegetative growth.

Different age of seedling showed significant variation on canopy spread of broccoli (Appendix VI). At 60 DAT, the highest canopy spread (74.57cm) was found from A_2 (20 days old seedling) treatment while the lowest canopy spread (66.13 cm) was recorded from A_3 (40 days old seedling) treatment (Table 7). 30 days old seedling showed highest result that has similarity with Lewandowska (1992). Lewandowska (1992) observed that adequate transplant age ensures continuous and uniform growth of plants after planting, which results in the higher effectiveness and the yield quality. Planting older transplants shortens the vegetative growth period of plants in the field and accelerates the plant's entering the phase of generative initiation which does not always favor the right curd development.

Starter solution and age of seedling showed Significant variation on canopy spread of broccoli at 20, 40 and 60 DAT (Appendix VI). At 60 DAT, the highest canopy spread (83.85 cm) was recorded from S_3A_2 treatment combination again the lowest canopy spread of stem (60.55 cm) was found from S_0A_3 treatment combination (Table 7).

Root length (cm)

Starter solution significantly influenced on root length of broccoli at different days after transplant (Table 7 and Appendix VI). At 60 DAT, the highest root length (24.48 cm) was recorded from S_3 (3% urea solution) treatment, whereas the lowest root length (21.06cm) was recorded from S_0 (control) treatment (Table 7). Here, maximum root length was obtained from S_3 (3% urea solution) treatment, this might be due to the fact that increased amount of starter solution as nitrogen increased root length. Starter solutions minimize transplant shock. When plants are moved from a protected environment to the open garden or field, there is an interruption in the normal processes of growth. Most often the root system is disturbed. But using starter solution of urea gives a good start of root growth. This result has similarity with El-Afifi *et al*. (2014).

Significant variation was observed due to different age of seedling on root length of broccoli at different days after transplant (Appendix VI). At 60 DAT, the highest root length (26.77cm) was found from A_2 (30 days old seedling) treatment, while the lowest root length (19.27cm) was recorded from A_3 (40 days old seedling) treatment (Table 7).

Significant variation was observed due to the combined effect of starter solution and age of seedling at 20, 40 and 60 DAT on root length of broccoli (Appendix VI). At 60 DAT, the highest root length (28.45 cm) was recorded from S_3A_2 treatment combination which was statistically identical (27.61cm) to S_2A_2 treatment combination, again the lowest root length (17.95cm) was found from S_0A_3 treatment combination (Table 7).

Dry matter (%) of leaf

Dry matter (%) of fresh leaf of broccoli varied significantly due to different concentrations of starter solution at 20, 40 and 60 DAT (Table 7 and Appendix V). At 60 DAT, the highest dry matter (%) of leaf (15.13 %) was recorded from

S_3 (3% urea solution) treatment, whereas the lowest dry matter (%) of fresh leaf (10.55 %) was recorded from S_0 (control) treatment (table 7).

Dry matter (%) of fresh leaf of broccoli varied significantly due to different age of seedling at 20, 40 and 60 DAT (Appendix V). At 60 DAT, the highest dry matter (%) of fresh leaf (14.32 %) was found from A_2 (30 days old seedling) treatment, while the lowest dry matter (%) of leaf (11.26 %) was recorded from A_3 (40 days old seedling) treatment (Table 7).

Combined effect of different concentrations of starter solution and age of seedling showed significant differences on dry matter (%) of fresh leaf of broccoli at 20, 40 and 60 DAT. At 60 DAT, the highest dry matter (%) of fresh leaf (17.47 %) was recorded from S_2A_2 treatment combination again the lowest dry matter (%) of leaf (9.5 %) was found from S_0A_3 treatment combination (Table 7).

Table 7. Effect of starter solution and age of seedling on stem diameter, canopy spread, root length and dry matter (%) of leaf

Treatments	Effect of starter solution			
	Stem diameter (cm)	Canopy spread (cm)	Root length (cm)	Dry matter (%) of leaf
S_0	2.10 c	62.53 d	21.06 d	10.55 d
S_1	2.31 b	68.02 c	22.08 c	12.06 c
S_2	2.45 b	72.20 b	23.49 b	13.26 b
S_3	2.65 a	79.04 a	24.48 a	15.13 a
CV%	5.67	8.76	9.31	9.27
LSD(0.05)	0.18	0.76	0.88	0.73
Treatment	Effect of age of seedling			
A_1	2.21 b	70.65 b	22.30 b	12.67 b
A_2	2.88 a	74.57 a	26.77 a	14.32 a
A_3	2.04 c	66.13 c	19.27 c	11.26 c
CV %	5.67	8.76	9.31	9.27
LSD (0.05)	0.16	0.66	0.76	0.63
Treatment combinations	Combined Effect of starter solution and age of seedling			
$S_0 A_1$	1.92 c	63.29 g	20.12 g	11.21 f-h
$S_0 A_2$	2.79 a	63.77 g	25.12 bc	10.88 gh
$S_0 A_3$	1.59 d	60.55 h	17.95 h	9.56 i
S_1A_1	2.14 bc	67.88 e	22.11 ef	12.36 ef
$S_1 A_2$	2.83 a	72.59 d	25.92 b	13.60 c-e
$S_1 A_3$	1.98 c	63.61 g	18.23 h	10.23 hi
$S_2 A_1$	2.34 b	72.21 d	22.86 de	12.91 de
$S_2 A_2$	2.86 a	78.29 b	27.61 a	15.33 b
$S_2 A_3$	2.15 bc	66.11 f	20.02 g	11.55 fg
$S_3 A_1$	2.44 b	79.23 b	24.12 cd	14.21 bc
$S_3 A_2$	3.07 a	83.65 a	28.45 a	17.47 a
$S_3 A_3$	2.45 b	74.25 c	20.88 fg	13.73 cd
CV %	5.67	8.76	9.31	9.27
LSD (0.05)	0.32	1.32	1.52	1.27

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

here,

S_0=control, S_1=1% urea, S_2=2% urea, S_3= 3% urea

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

Diameter of stem of head (cm)

Significant variation was recorded on diameter of stem of broccoli head due to different concentrations of starter solution. At 60 DAT, the highest diameter of stem of head (3.93 cm) was recorded from S_3 (3% urea solution) treatment, whereas the lowest diameter of stem of head (2.90 cm) was recorded from S0 (control) treatment, which is statistically identical to S_3 (3% urea solution) treatment.

Different age of seedling showed significant variation on diameter of stem of broccoli head. At 60 DAT, the highest diameter of stem of head (3.69 cm) was found from A_2 (30 days old seedling) treatment, while the lowest diameter of stem of head (2.77 cm) was recorded from A_3 (40 days old seedling) treatment.

Combined effect of different concentrations of starter solution and age of seedling showed significant differences on diameter of stem of broccoli head. At 60 DAT, the highest diameter of stem of head (4.43 cm) was recorded from S_2A_2 treatment combination which was statistically similar to S_2A_1 treatment combination, again the lowest diameter of stem of head (17.95cm) was found from S_0A_3 treatment combination.

Diameter of head (cm)

Different concentrations of starter solution varied Significantly on diameter of head of broccoli at 20, 40 and 60 DAT (Table 8 and Appendix VI). At 60 DAT, the highest diameter of head (15.73 cm) was recorded from S_2 (2% urea solution) treatment which was statistically identical to S_3 (3% urea solution) treatment whereas the lowest diameter of head (2.77cm) was recorded from S0 (control) treatment (Table 8).

Significant variation was recorded for different age of seedling on diameter of head of broccoli. at 20, 40 and 60 DAT (Appendix VI). At 60 DAT, the highest diameter of head (15.63 cm) was found from A_2 (30 days old seedling) treatment, while the lowest diameter of head (13.13 cm) was recorded from A_3 (40 days old seedling) treatment (Table 8).

Combined effect of different concentrations of starter solution and age of seedling showed significant differences on diameter of head of broccoli at 20, 40 and 60 DAT (Appendix VI). At 60 DAT, the highest diameter of head (17.29 cm) was recorded from S_2A_2 treatment combination which is statistically similar to S_3A_2 and S_1A_2 treatment combination again, the lowest diameter of head (10.48 cm) was found from S_0A_3 treatment combination which is statistically identical to S_0A_1, S_0A_3 and S_1A_3 treatment combination (Table 8).

Length of head (cm)

Significant variation was recorded on length of head of broccoli due to different concentrations of starter solution at 20, 40 and 60 DAT (Table 8 and Appendix VI). At 60 DAT, the highest length of head (15.21 cm) was recorded from S_2 (2% urea solution) treatment, whereas the lowest length of head (11.36cm) was recorded from S_0 (control) treatment (Table 8).

Length of head showed significant variation due to different age of seedling of broccoli. at 20, 40 and 60 DAT (Appendix VI). At 60 DAT, the highest length of head (14.69cm) was found from A_2 (30 days old seedling) treatment, while the lowest length of curd (12.02 cm) was recorded from A_3 (40 days old seedling) (Table 8).

Significant variation was observed due to the combined effect of starter solution and age of seedling at 20, 40 and 60 DAT on length of head of broccoli (Appendix VI). At 60 DAT, the highest length of head (16.55 cm) was recorded from S_2A_2 treatment combination again, the lowest length of head (10.48 cm) was found from S_0A_3 treatment combination which is statistically similar to S_0A_1 and S_0A_3 treatment combination(Table 8).

Dry matter (%) of head

Dry matter (%) of fresh head of broccoli varied significantly due to different concentrations of starter solution at 20, 40 and 60 DAT (Table 8 and Appendix V). At 60 DAT, the highest dry matter (%) of fresh curd (13.54 %) was recorded from S_2 treatment, whereas the lowest dry matter (%) of fresh curd (9.52 %) was recorded from S_0 (control) treatment (Table 8).

Different age of seedling showed significant variation on dry matter (%) of fresh curd of broccoli. at 20, 40 and 60 DAT (Appendix V). At 60 DAT, the highest dry matter (%) of fresh curd (12.30 %) was found from A_2 (30 days old seedling) treatment while the lowest dry matter (%) of fresh curd (8.90 %) was recorded from A_3 (40 days old seedling) treatment (Table 8).

Combined effect of different concentrations of starter solution and age of seedling showed significant differences on dry matter (%) of fresh curd of broccoli at 20, 40 and 60 DAT (Appendix V). At 60 DAT, the highest dry matter (%) of fresh curd of broccoli (15.69 %) was recorded from S_2A_2 treatment combination again the lowest matter (%) of fresh curd (6.44 %) was found from S_0A_3 treatment combination (Table8).

Table 8. Effect of starter solution and age of seedling on diameter of stem of head, length of curd and dry matter (%) of curd

Treatments	Diameter of stem of head (cm)	Length of head (cm)	Dry matter (%) of leaf	Diameter of head (cm)
	Effect of starter solution			
S_0	2.77 c	11.36 c	8.09 d	12.33 c
S_1	3.45 b	13.56 b	11.04 b	14.05 b
S_2	3.93 a	15.21 a	13.54 a	15.73 a
S_3	2.90 c	13.82 b	9.52 c	15.10 a
CV%	7.17	8.62	9.56	7.54
LSD(0.05)	0.42	0.97	0.64	0.90
	Effect of age of seedling			
A_1	3.33 b	13.74 b	10.44 b	14.16 b
A_2	3.69 a	14.69 a	12.30 a	15.63 a
A_3	2.77 c	12.02 c	8.90 c	13.13 c
CV %	7.17	8.62	9.56	7.54
LSD (0.05)	0.21	0.83	0.55	0.78
Treatment combinations	Combine effect of starter solution and age of seedling			
$S_0 A_1$	2.89 c-e	11.25 ef	8.18 f	12.40 f
$S_0 A_2$	3.10 cd	12.35 de	9.66 de	12.80 ef
$S_0 A_3$	2.32 e	10.48 f	6.44 g	11.80 f
S_1A_1	3.45 bc	14.78 bc	10.56 cd	14.12 de
$S_1 A_2$	4.05 b	14.61 bc	13.23 b	15.97 a-c
$S_1 A_3$	2.87 c-e	11.29 ef	9.33 e	12.07 f
$S_2 A_1$	4.13 ab	15.32 b	13.73 b	15.29 b-d
$S_2 A_2$	4.43 a	16.50 a	15.69 a	17.29 a
$S_2 A_3$	3.25 cd	13.81 b-d	11.21 c	14.63 cd
$S_3 A_1$	2.85 c-e	13.63 cd	9.29 ef	14.83 cd
$S_3 A_2$	3.19 cd	15.31 b	10.63 cd	16.47 ab
$S_3 A_3$	2.66 de	12.53 de	8.64 ef	14.02 de
CV %	7.17	8.62	9.56	7.54
LSD (0.05)	0.63	0.67	1.12	1.56

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

S_0=control, S_1=1% urea, S_2=2% urea, S_3= 3% urea

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

Weight of primary head per plant (g)

Starter solution varied significantly on weight of primary head of broccoli at 20, 40 and 60 DAT (Table 9 and Appendix VI). At 60 DAT, the highest primary weight of head (465.46 g) was recorded from S_2 (2% urea solution) treatment, whereas the lowest weight of primary head (261.89 g) was recorded from S_0 (control) treatment (Table 9). Here, optimum amount of starter solution like S_2 (2% urea solution) enhanced weight of primary head per plant, number of head, weight of secondary head etc. This result is in agreement with Roy *et al.* where they conducted experiment consisted of four levels of starter solution, viz., 0, 1.0, 1.5. The application of starter solution and influenced 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.

Weight of primary head per plant varied significantly due to different age of seedling at 20, 40 and 60 DAT (Appendix VI). At 60 DAT, the highest weight of primary head (397.18 gm) was found from A_2 (30 days old seedling) treatment, while the lowest weight of primary head (301.67gm) was recorded from A_3 (40 days old seedling) treatment (Table 9). Diputado *et al*. (1989) reported that Curd and total dry weight production varied with age of seedling and with cultivars. Todorova (2011) also reported that hybrid Parthenon F1 produced the highest yield 2546.7 kg/ha average the period using 30 days transplants while the lowest yields was obtained from Fiesta F1 (1145.0 kg/da), using 45-days transplants. 30 days transplant age obtained better results for all the hybrids.

Combined effect of different concentrations of starter solution and age of seedling showed significant differences on weight of primary head of broccoli at 20, 40 and 60 DAT (Appendix VI). At 60 DAT, the highest weight of primary head (505.23 gm) was recorded from S_2A_2 treatment combination again the lowest weight of primary head (225.45 gm) was found from S_0 A_3 treatment combination (Table 9).

Number of secondary head

Significant variation was recorded on number of secondary head of broccoli due to different concentrations of starter solution at harvest (Table 9 and Appendix VI). At harvest the highest number of secondary head (6.10) was recorded from S_2 (3% urea solution) treatment, whereas the lowest number of secondary of head (3.23) was recorded from S_0 (control) treatment (Table 9).

Age of seedling showed significant variation on number of secondary head of broccoli. at harvest (Appendix VI). At harvest, the highest number of secondary head (4.70) was found from A_2 (30 days old seedling) treatment, while the lowest number of secondary head (3.75) was recorded from A_3 (40 days old seedling) treatment (Table 9).

Significant variation was observed due to the combined effect of starter solution and age of seedling at harvest on number of secondary head of broccoli (Appendix VI). At harvest the highest number of secondary head (6.86) was recorded from S_2A_2 treatment combination treatment combination again the lowest number of secondary head (3.05) was found from S_0 A_3 treatment combination (Table 9).

Weight of secondary head per plant (g)

Weight of secondary head of broccoli varied significantly due to different concentrations of starter solution at harvest (Table 9 and Appendix VI). At harvest, the highest weight of secondary head (118.05 g) was recorded from S_2 (2% urea solution) treatment, whereas the lowest weight of secondary head (55.01 g) was recorded from S_0 (control) treatment (Table 9). S_2 (2% urea solution) showed highest weight of secondary head that has an agreement with Henmis *et al.* (1973). They reported that sodium nitrate (NaNO3) or ammonium sulphate as starter solution improved the early growth and yield of broccoli.

Significant variation was recorded for different age of seedling on weight of secondary head per plant of broccoli. at 20, 40 and 60 DAT (Appendix VI). At 60 DAT, the highest weight of secondary head (101 g) was found from A_2 (30 days old seedling) treatment, while the lowest weight of secondary head (70.86 g) was recorded from A_3 (40 days old seedling) treatment (Table 9). Grabwoska *et al* (2007) reported that plants obtained from 4-week old trans-plants gained marketable yield significantly higher than plants obtained from 10-week old transplants.

Combined effect of different concentrations of starter solution and age of seedling showed significant differences on weight of secondary head of broccoli at 20, 40 and 60 DAT, (Appendix VI). At 60 DAT the highest weight secondary head (140.57g) was recorded from S_2A_2 treatment combination, again the lowest weight of secondary head (48.76 g) was found from S_0 A_3 treatment combination (Table 9).

Table 9. Effect of starter solution and age of seedling on weight of primary head per plant, number of secondary head and weight of secondary head

Treatments	Weight of primary head per plant (g)	Number of secondary head	Weight of secondary head per plant (g)
	Effect of starter solution		
S_0	261.89 d	3.23 c	55.01 d
S_1	362.30 b	4.02 b	85.88 b
S_2	465.46 a	6.10 a	118.05 a
S_3	292.84 c	3.54 bc	84.69 c
CV%	12.87	9.37	10.42
LSD(0.05)	1.61	0.65	0.89
	Effect of age of seedling		
A_1	338.01 b	4.24 ab	85.87 b
A_2	397.18 a	4.70 a	101.00 a
A_3	301.67 c	3.73 b	70.86 c
CV %	12.87	9.37	10.42
LSD (0.05)	1.4	0.58	0.77
Treatment combinations	Combined effect of starter solution and age of seedling		
$S_0 A_1$	280.56 i	3.29 e	82.23 f
$S_0 A_2$	352.79 f	3.36 de	95.56 d
$S_0 A_3$	225.45 l	3.05 e	48.76 k
S_1A_1	360.51 e	4.12 de	86.66 e
$S_1 A_2$	410.66 d	4.50 cd	107.81 c
$S_1 A_3$	315.73 h	3.46 de	63.16 h
$S_2 A_1$	470.81 b	6.11 ab	118.36 b
$S_2 A_2$	505.23 a	6.86 a	140.57 a
$S_2 A_3$	420.33 c	5.34 bc	95.22 d
$S_3 A_1$	240.16 k	3.45 de	56.23 j
$S_3 A_2$	320.06 g	4.08 de	60.05 i
$S_3 A_3$	245.16 j	3.09	76.28 g
CV %	12.87	9.37	10.42
LSD (0.05)	2.80	1.16	1.55

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

here,

S_0=control, S_1=1% urea, S_2=2% urea, S_3= 3% urea

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

Yield per plant (g)

Different concentrations of starter solution solution varied significantly on yield of head per plant of broccoli was recorded at 20, 40 and 60 DAT (Table 10 and Appendix VII). At 60 DAT, the highest yield of head per plant (583.51 g) was recorded from S_2 (2% urea solution) treatment, whereas the lowest yield of head per plant (316.90 g) was recorded from S_0 (control) treatment (Table 10). Here, S_2 (2% urea solution) gives highest yield per plant while S_3 (3% urea solution) increases more vegetative growth. This results have similarity with Mitra *et al.* They reported that increasing nitrogen rates increase head weight, increase head width from 8.0 to 9.7 cm, length and width of hollow stem. It was reported that, increasing rates of N gave higher yield, but decreased sugar and dry matter contents.

Yield of head per plant showed significant variation due to different age of seedling at 20, 40 and 60 DAT (Table 10 and Appendix VII). At 60 DAT, the highest yield of head per plant (498.16 g) was found from A_2 (30 days old seedling) treatment, while the lowest yield of head per plant (372.52 g) was recorded from A_3 (40 days old seedling) treatment (Table 10). Wlazlo and Kunicki (2003) reported that use of younger transplant resulted in higher yield and better quality. Babik (2000) conducted an experiment on transplanting age of broccoli where yield and mean weight of the central head of broccoli was influenced by time of head formation. The earliest, but lowest yield was obtained from the oldest transplants (50 days old) grown on a seedbed. Shorter growing periods of 30 or 20 days delayed harvest but increased yield and head weight. A 20-day growing period was not sufficient for raising well developed transplants on a seedbed.

Combined effect of different concentrations of starter solution and age of seedling showed significant differences on yield of head per plant of broccoli solution at 20, 40 and 60 DAT (Table 10 and Appendix VII). At 60 DAT, the highest yield per plant (645.80 g) was recorded from S_2A_2 treatment combination again the lowest yield of curd per plant (274.21 g) was found from S_0A_3 treatment combination (Table 10).

Yield per plot (kg)

Significant variation was recorded yield per plot of broccoli due to different concentrations of starter solution solution at 20, 40 and 60 DAT (Table 10 and Appendix VII). At 60 DAT, the highest yield per plot (7.00 kg) was recorded from S_2 (2% urea solution) treatment, whereas the lowest yield per plot (3.80 kg) was recorded from S_0 (control) treatment (Table 10).

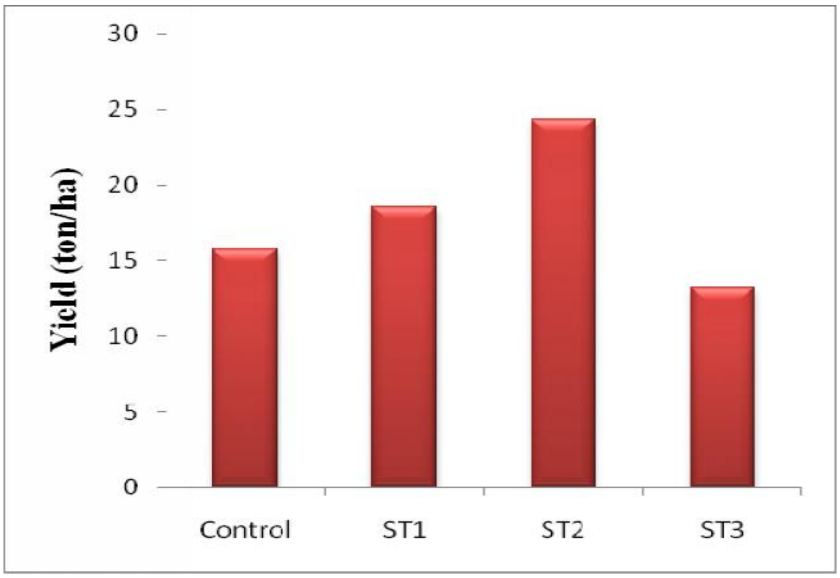
Different age of seedling showed significant variation on yield per plot solution at 20, 40 and 60 DAT (Appendix VII).. At 6o DAT, the highest yield per plot (6.06 kg) was found from A_2 (30 days old seedling) treatment, while the lowest yield per plot (4.47kg) was recorded from A_3 (40 days old seedling) treatment (Table 10). Babik *et al.* (2001) suggested that using young transplants resulted in higher yield and quality. They suggested that 30 days is a reasonable target age for transplanting broccoli to have better yield and the oldest transplants reduced yield of broccoli.

Combined effect of different concentrations of starter solution and age of seedling showed significant differences on yield per plot of broccoli solution at 20, 40 and 60 DAT (Table 10 and Appendix VII). At 60 DAT, the highest yield per plot (7.75 kg) was recorded from S_2A_2 treatment combination again the lowest yield per plot (3.30 kg) was found from S_3A_3 treatment combination(Table 10) .

Yield (t/ ha)

Significant variation was recorded yield **(**t/ha) of broccoli due to different concentrations of starter solution at harvest. At harvest the highest yield (24.32 t/ ha) was recorded from S_2 (2% urea solution) treatment, whereas the lowest yield

(13.21 t/ha) was recorded from S_0 (control) treatment (Table 7). Here, S_2 (2% urea solution) showed highest yield because it has optimum amount of nitrogen for reproductive growth. Otherwise, more concentration of nitrogen as starter solution gave more vegetative growth but less reproductive growth. This result has similarity with Islam *et al.* (1989). They conducted an experiment with starter solution on cabbage and Found that starter solution has a significant effect on the production of marketable Yield of cabbage. They also found that the highest marketable yield was obtained from the treatments of 1.5% and 2% urea solution and while the untreated seedlings gave the lowest yield.

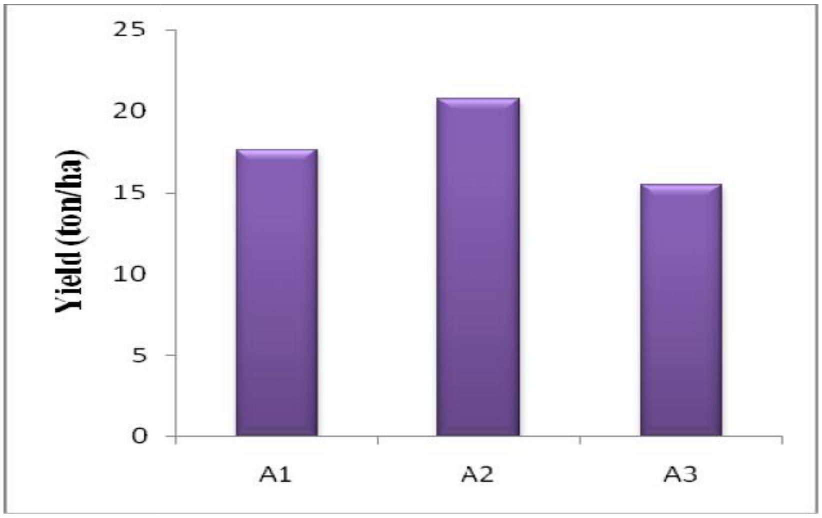


here,

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

Figure 8. Effect of starter solution on yield (t/ha) of broccoli at different days after transplant.

Different age of seedling showed significant variation on yield (t/ha) solution at harvest. At harvest, the highest yield (20.75 t/ ha) was found from A_2 (30 days old seedling) treatment, while the lowest yield (15.48 t/ ha) was recorded from A_3 (40 days old seedling) treatment (Table 8) . This might be probably 30 days old seedling gets all the environmental condition needs for its growth and development. Kaymak *et al.* (2004) reported that the effect of transplant age on weight, diameter and length of head were significant, while the highest main head weight, diameter and length were obtained from 30 day old seedling, the lowest values were recorded on 50 day-old seedlings.



here,

DAT= days after transplant, A_1=20 days old seedling, A_2=30 days old seedling, A_3 =40 days old seedling

Fig 9. Effect of age of seedling on yield (t/ha) of broccoli at different days after transplant.

Significant variation was observed due to the combined effect of starter solution and age of seedling at harvest. At harvest the highest yield (26.91 t/ha) was recorded from S_2A_2 treatment combination again the lowest yield (11.50 t/ha) was found from S_3A_3 treatment combination (Table 9).

Table 10. Effect of starter solution and age of seedling on yield per plant, yield per plot and yield (t/ha)

Treatments	Yield per plant (g)	Yield per unit plot(kg)	Yield (t/ha**)**
	Effect of starter solution		
S_0	316.90 d	3.80 d	13.19 d
S_1	448.14 b	5.37 b	18.58 b
S_2	583.51 a	7.00 a	24.32 a
S_3	377.53 c	4.53 c	15.72 c
CV%	11.74	12.87	12.43
LSD(0.05)	1.30	0.58	1.02
Treatments	Effect of age of seedling		
A_1	423.88 b	5.08 b	17.64 b
A_2	498.16 a	6.06 a	20.75 a
A_3	372.52 c	4.47 c	15.48 c
CV %	11.74	12.87	12.43
LSD (0.05)	1.13	0.51	0.88
Treatment combinations	Combined effect of starter solution and age of seedling		
$S_0 A_1$	362.79 g	4.35 de	15.10 ef
$S_0 A_2$	448.35 e	5.38 cd	18.68 d
$S_0 A_3$	274.21 j	3.30 f	11.45 h
S_1A_1	447.17 e	5.36 cd	18.63 d
$S_1 A_2$	518.37 c	6.22 bc	21.60 c
$S_1 A_3$	378.88 f	4.55 de	15.52 e
$S_2 A_1$	589.17 b	7.07 ab	24.54 b
$S_2 A_2$	645.80 a	7.75 a	26.91 a
$S_2 A_3$	515.56 d	6.20 bc	21.52 c
$S_3 A_1$	296.39 i	3.55 ef	12.32 gh
$S_3 A_2$	380.11 f	4.92 d	15.83 e
$S_3 A_3$	321.44 h	3.86 ef	13.40 fg
CV %	11.74	12.87	12.43
LSD (0.05)	2.26	1.03	1.77

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

here,

$S_{0=}$ control, S_1=1% urea, S_2=2% urea, S_3= 3% urea

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

Economic analysis

Input costs for land preparation, fertilizer, irrigation and manpower required for all the operations from seed sowing to harvesting of broccoli were calculated for unit plot and converted into cost per hectare (Appendix VIII- IX). Price of broccoli was considered as per market rate. The economic analysis presented under the following headings.

Gross return

The combination of starter solution and age of seedling showed different values in terms of gross return under the trial (Table 11). The highest gross return (Tk. 13,45,500) was found from the treatment combination S_2A_2 and the second highest gross return (Tk. 12,77,000) was obtained from S_2A_1 treatment combination. The lowest gross return (Tk. 572500) was obtained from S_0A_3.

Net return

In case of net return, different treatment combination showed different levels of net return under the present trial (Table 11). The highest net return (Tk. 8,68,431) was obtained from the treatment combination S_2A_2 and the second highest net return (Tk. 7,99,931) was found from the combination S_2A_1. The lowest (Tk. 96,855) net return was found from S_0A_3 treatment combination.

Benefit Cost Ratio

The combination of different concentration of starter solution and age of seedling for benefit cost ratio was different in all treatment combination (Table 11). The highest benefit cost ratio (2.82) was found from the treatment combination S_2A_2 and the second highest benefit cost ratio (2.57) was found from S_2 A_1 treatment combination. The lowest benefit cost ratio (1.20) was found from the S_0A_3 (control) treatment combination. From the economic point of view, it was apparent from the above results that the treatment combination of S_2A_2 was more profitable than rest of treatment combinations.

Table 11. Cost and return of broccoli cultivation as influenced by starter solution and age of seedling

Treatments	Cost of production (Tk / ha)	Yield (t/ha)	Gross return (Tk /ha)	Net return (Tk /ha)	BCR
$S_0 A_1$	475645	15.10	755000	279355	1.58
$S_0 A_2$	475645	18.68	934000	458355	1.96
$S_0 A_3$	475645	11.45	572500	96855	1.20
$S_1 A_1$	476238	18.63	931500	455262	1.95
$S_1 A_2$	476238	21.60	1080000	603762	2.26
$S_1 A_3$	476238	15.52	776000	299762	1.62
$S_2 A_1$	477069	24.54	1277000	799931	2.57
$S_2 A_2$	477069	26.91	1345500	868431	2.82
$S_2 A_3$	477069	21.52	1076000	598931	2.25
$S_3 A_1$	477780	12.32	616000	138220	1.28
$S_3 A_2$	477780	15.83	791500	313720	1.65
$S_3 A_3$	477780	13.40	670000	192220	1.40

here,

S_0=control, S_1=1% urea, S_2=2% urea, S_3= 3% urea

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

Total cost of production was done in details according to the procedure of Krishitattik Fasaler Upadan O Unnayan (in Bengali), 1988 by Alam *et al*..pp :231-239

sale of marketable fruit @ Tk. 50000/ton

Net return =Gross return – Total cost of production

Benefit cost ratio = Gross return Total cost of production

CHAPTER V

SUMMARY AND CONCLUSION

Experiment was conducted at the Horticulture Farm, Sher-e-bangla Agricultural University, Sher-e-bangla Nagar, [Dhaka-1207 during the period from October, 2017 to March, 2018] to study the effect of starter solution and age of seedling on growth and yield of broccoli. In the experiment, the treatments consist of four levels of starter solution and three levels of age of seedling . Factor A: four level of starter solution as S_0=control, S_1=1% starter solution S_2 = 2% starter solution and S_3 = 3% starter solution. Factor B: Age of seedling (four level) as A_1=20 days old seedling, A_2= 30 days old seedling and A_3= 40 days old seedling. Thus, there were 12 treatments and the experiment was laid out in RCBD design with three replications. The unit plot size was 1.8mx1.6m which accommodated 12 plants. The crop was harvested from 19 february, 2018 to 3o March, 2018. From each plot, five 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, largest leaf length, largest leaf breadth, length of stem, diameter of head, fresh weight of head, dry weight of head, number of secondary curd, weight of primary head, weight of secondary head, percentage dry matter of head, economic yield per plant and yield per plot and hectare

At 60 DAT the tallest plant (70.24 cm) was recorded from S_3 (3% urea solution) treatment and the shortest plant (62.22 cm) was recorded from S_0 (control) treatment .At 60 DAT the maximum number of leaves was recorded (15.63) and the minimum number of leaf (13.74) was from S_0 (control) treatment. At 60 DAT the highest largest leaf length (51.75 cm) was recorded from S_3 (3% urea solution) treatment and the lowest largest leaf length (39.51cm) was recorded from S_0 (control) treatment. The highest diameter of stem (2.65 cm) was recorded from S_3 (3% urea solution) treatment whereas the lowest (2.10 cm) was recorded from S_0 (control) treatment. The highest leaf breadth at 60 DAT (21.17cm) was recorded from S_3 (3% urea solution) treatment and the lowest leaf breadth (15.98 cm) was recorded from S_0 (control) treatment. The highest dry weight of leaf (15.13%) was recorded from S_3 (3% urea solution) treatment whereas the lowest (10.55%) was recorded from S_0 (control) treatment. The highest length of roots (24.48 cm) was recorded from S_3 (3% urea solution) treatment whereas the lowest (21.06 cm) was recorded from S_0 (control) treatment. The highest diameter of head (15.73cm) was recorded from S_3 (3% urea solution) treatment while the lowest (12.33 cm) was recorded from S_0 (control) treatment. The highest dry weight matter (%) of head (9.19 gm) was recorded from S_3 (3% urea solution) treatment while the lowest dry weight of curd (6.55 gm) was recorded from S_0 (control) treatment. The highest weight primary of curd (465.46gm) was recorded from S_2 (2% urea solution) treatment and the lowest (261.89 gm) was recorded from S_0 (control) treatment The highest number of secondary curd (6.1) was recorded from S_2 (2% urea solution) treatment and the lowest was from (3.23). The highest weight of secondary curd (118.05gm) was recorded from S_2 (2% urea solution) treatment and the lowest was from (55.01 gm) S_0 (control) treatment. Application of starter solution played a vital role on the growth and yield of broccoli. Different levels of starter solution significantly influenced all the characters recorded. Maximum yield per plot (7.00kg) and yield per hectare (24.32ton/ha) were recorded from 2% starter solution (S_2) and the lowest yield per plot (3.92kg) and per hectare (13.21ton/ha) were recorded in the control treatment S_0 (control) treatment.

At 60 DAT the tallest plant (71.36cm) was recorded from A_2 (30 days old seedling) treatment and the shortest plant (63.75 cm) was recorded from A_3 (40 days old seedling) treatment. At 60 DAT the maximum number of leaves was recorded (16.70) from A_2 (30 days old seedling) treatment and the lowest (13.54) from A_3 (40 days old seedling). At 60 DAT the highest largest leaf length (55.43cm) was recorded from A_2 (30 days old seedling) treatment and the lowest largest leaf length (46.77cm) was recorded from A_3 (40 days old seedling) treatment. The highest diameter of stem (2.88 cm) was recorded from A_2 (30 days old seedling) treatment whereas the lowest (2.04cm) was recorded from A_3 (40 days old seedling) treatment. The highest leaf breadth at 60 DAT (20.48 cm) was recorded from A_2 (30 days old seedling) treatment and the lowest leaf breadth (15.83cm) was recorded from A_3 (40 days old seedling) treatment. The highest dry matter (%) of leaf (14.32 gm) was recorded from A_2 (30 days old seedling) treatment whereas the lowest (11.26gm) was recorded from A_3 (40 days old seedling) treatment. The highest length of roots (26.77 cm) was recorded from A_2 (30 days old seedling) treatment whereas the lowest (19.27 cm) was recorded from A_3 (40 days old seedling) treatment. The highest diameter of head (15.63cm) was recorded from A_2 (30 days old seedling) treatment while the lowest (13.13 cm) was recorded from A_3 (40 days old seedling). The highest dry matter (%) of curd (8.43 gm) was recorded from A_2 (30 days old seedling) treatment while the lowest was from (7.96 gm) was recorded from A_3 (40 days old seedling) treatment. The highest weight of primary curd (397.18gm) was recorded from A_2 (30 days old seedling) treatment and the lowest (301.67 gm) was recorded from A_3 (40 days old seedling) treatment.

The highest number of secondary curd (4.7) was recorded from A_2 (30 days old seedling) treatment and the lowest was from (3.73). The highest weight of secondary curd (101.00gm) was recorded from A_2 (30 days old seedling) treatment and the lowest was from (70.86gm) A_3 (40 days old seedling) treatment. The Maximum yield per plot (7.75kg) and yield per hectare (26.91 ton/ha) were obtained from A_2 (30 days old seedling) treatment and the lowest yield per plot (3.86kg) and per hectare (13.41ton/ha) were from A_3 (40 days old seedling) treatment.

Due to combine effect of starter solution and age of seedling the tallest plant (79.76cm) was recorded from S_3A_2 treatment combination and the shortest plant (59.50 cm) was recorded from S_0A_3 treatment combination at 60 DAT. At 60 DAT, the maximum number of leaves per plant (17.2) was found from S_3A_2 treatment combination, whereas the minimum number (12.82) from S_0A_3 treatment combination. At 60 DAT the highest largest leaf breadth was recorded

(23.50 cm) from S_3A_2 treatment combination and lowest largest leaf breadth (14.18 cm) was from S_0A_3 treatment combination. The highest canopy spread (83.65 cm) was recorded from S_3A_2 treatment combination and the lowest canopy spread (60.55cm) was recorded from S_0A_3 treatment combination. The highest diameter of stem (3.07 cm) was recorded from S_3A_2 treatment combination whereas the lowest (1.59 cm) was recorded from S_0A_3 treatment combination. The highest matter (%) of leaf (17.47 gm) was recorded from S_3A_2 treatment combination whereas the lowest (9.56gm) was recorded from S_0A_3 treatment combination. The highest dry matter (%) curd (110.75 gm) was recorded from S_2A_2 treatment combination whereas the lowest (7.44gm) was recorded from S_0A_3 treatment combination. The highest length of root (28.45 cm) was recorded from S_3A_2 treatment combination whereas the lowest (17.95 cm) was recorded from S_0A_3 treatment combination. The highest diameter of head (17.29 cm) was recorded from S_2A_2 treatment combination while the lowest (11.80 cm) was recorded from S_0A_3 treatment combination. The highest number of secondary curd (6.86) was recorded from S_2A_2 treatment combination and the lowest (3.05) was from S_0A_3 treatment combination. The highest weight of secondary curd (140.57gm) was recorded from S_2A_2 treatment combination and the lowest (76.28gm) was from S_0A_3 treatment combination. The highest weight of primary curd (505.23 gm) was recorded from S_2A_2 treatment combination and the lowest (245.16 gm) was from S_0A_3 treatment combination. Combination of age of seedling and starter solution exhibited significant variation for all the parameter studied. Combination of age of seedling starter solution and age of seedling exhibited significant variation for all the parameter studied. Most of the character expressed maximum values under 2% starter solution and 30 days old seedling (S_2A_2). Maximum yield per plot (7.75kg) and yield per hectare (26.91 ton/ha**)** were noted from the treatment combination of 2% starter solution and 30 days old seedling (S_2A_2**)** and the lowest yield per plot (3.86kg) and per hectare (13.41t/ha**)** were recorded in the treatment combination (S_0A_3).

CONCLUSION

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

1. Application of 2% urea solution showed better performance for maximum parameters of broccoli.
2. Age of seedling (30 days old seedling) gave best results for both vegetative growth and yield of broccoli.
3. So, it can be concluded that combination of 2% urea solution and 30 days old seedling is suitable for broccoli cultivation.

Considering the situation of the present experiment, further study might be conducted in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performances. The experiment was however, conducted in one season only and hence the results should be considered as a tentative. It is imperative that similar experiment should be carried out with more variables to reconfirm the recommendation.

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Appendix II. Analytical data of soil sample of the experimental plot

A. Morphological Characteristics

Morphological features	characteristics
Location	Horticulture Garden, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land Type	Medium high land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood Level	Above flood level
Drainage	Well drained

B. Mechanical analysis

Constituents	Percent
Sand	27
Silt	43
Clay	30

C. Chemical analysis

Soil properties	Amount
Soil pH	5.8
Organic carbon (%)	0.45
Total nitrogen (%)	0.03
Available P (ppm)	20
Exchangeable K (%)	0.1
Available S (ppm)	45

Appendix III: Monthly records of air temperature, relative humidity, rainfall and sunshine

year	month	Air temperature			Relative humidity (%)	Rainfall (mm)	sunshine (hours)
		Maximum	Minimum	Mean			
2016	October	31.25	21.55	24.40	78.55	22	6.8
	November	29.5	18.6	24.0	69.5	0.0	6.9
	December	26.9	16.2	21.5	70.6	0.0	6.3
2017	January	24.5	13.9	19.2	68.5	0.0	5.7
	February	28.9	18.0	23.4	61.06	30	6.7
	March	33.6	29.5	31.6	72.7	11	8.3

Source: Bangladesh Meteorological Department (climate & weather division), Agargaon, Dhaka-1207

Appendix IV: Analysis of variance on plant height, number of leaves at different days after transplanting of broccoli

Source of variation	Degrees of freedom (df)	Mean Square of						
		Plant height (cm) 20DAT	Plant height (cm) 40DAT	Plant height (cm) 60DAT	Leaf number 20DAT	Leaf number 40DAT	Leaf number 60DAT	Largest leaf length (cm) 20DAT
Replication	2	5.533	66.809	0.353	0.486	3.021	0.787	8.902
starter Solution (A)	3	57.377^{**}	88.242^{**}	7.767^{**}	13.380^{**}	26.481^{*}	44.896^{**}	87.875^{**}
seedling age (B)	2	36.576^{**}	95.986^{**}	12.098^{**}	17.015^{**}	29.095^{*}	49.280^{**}	85.623^{**}
Interaction (A x B)	6	31.049^{*}	67.771^{*}	4.026^{*}	12.704^{*}	22.282^{*}	19.005^{*}	55.516^{*}
Error	22	11.566	21.538	1.152	4.713	7.458	6.046	17.932

* Significant at 0.05 level of probability; **Significant at 0.01 level of probability and ^{NS} Non-significant

Appendix V: Analysis of variance on largest leaf length, largest leaf breadth, dry matter (%) of fresh leaf and dry matter (%) of fresh curd of broccoli

Source of variation	Degrees of freedom (df)	Mean Square of						
		Largest leaf length (cm) 40DAT	Largest leaf length (cm) 60DAT	largest leaf breadth (cm) 20 DAT	largest Leaf breadth (cm) 40DAT	largest Leaf breadth (cm) 60DAT	dry matter (%) of fresh leaf	dry matter (%) of fresh curd
Replication	2	20.701	0.041	5.472	249.51	2.290	2.108	0.021
Factor A (Solution)	3	94.121**	1.262*	101.372**	1406.03**	29.637**	64.250**	6.195**
Factor B (S. Age)	2	104.005**	4.093**	125.430**	5201.43**	24.808**	75.811**	0.876NS
A x B	6	78.951*	1.406*	61.426*	411.14*	19.771*	35.811*	0.697NS
Error	22	31.059	0.643	21.988	132.67	7.142	23.237	1.005

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix VI: Analysis of variance on primary weight of curd, number of secondary curd, weight of secondary head per plant, length of curd, diameter of curd, diameter of stem, canopy spread and root length of broccoli

Source of variation	Degrees of freedom (df)	Mean Square of							
		weight Primary of curd (g)	Number of secondary head	weight of Secondary head (g)	Length of curd (cm)	Diameter of curd (cm)	Diameter of stem (cm)	Canopy spread (cm)	Root length (cm)
Replication	2	9.991	443.5	0.184	1.208	0.458	1.003	2.554	2.321
Factor A (Solution)	3	97.014**	2409.3**	1.504**	1.686	4.714*	8.215**	98.936**	33.389**
Factor B (S. Age)	2	12.570	45510.2**	1.251**	78.063**	5.989*	5.517**	89.951**	29.186*
A x B	6	44.302*	6428.8**	1.488**	0.935NS	4.353*	3.415*	48.768*	20.602*

Error	22	15.549	535.4	0.196	1.917	1.452	1.136	15.443	6.867

* Significant at 0.05 level of probability; **Significant at 0.01 level of probability and ^{NS} Non-significant

Appendix VII: Analysis of variance on diameter of stem of curd, yield per plant, yield per hectare

Source of variation	Degrees of freedom (df)	Mean Square of			
		Diameter of stem of head	Yield/plant (g)	Yield/plot (kg)	Yield/ha (ton)
Replication	2	34.176	23.042	46.382	0.108
Factor A (Solution)	3	24.404	126.647**	132.332**	9.543**
Factor B (S. Age)	2	11.871	113.002**	125.010**	11.631**
A x B	6	8.167	59.758*	129.268**	7.807*
Error	22	26.971	19.452	38.018	2.064

* Significant at 0.05 level of probability; **Significant at 0.01 level of probability and ^{NS} Non-significant

Appendix VIII: Cost of production of broccoli per hectare

Treatment combinations	Labour cost (Tk.)	ploughing cost (Tk.)	Seed cost (Tk.)	Insecticide/ pesticide (Tk.)	Cowdung (Tk.)	Manure and fertilizer cost (Tk.)			starter solution	subtotal (Tk.) (A)
						Urea	MoP	TSP		
$S_0 A_1$	21000	175000	21000	25000	50000	5400	3600	7500	0	308500
$S_0 A_2$	21000	175000	21000	25000	50000	5400	3600		0	308500
$S_0 A_3$	21000	175000	21000	25000	50000	5400	3600		0	308500
S_1A_1	21000	175000	21000	25000	50000	5400	3600	3600	500	309000
$S_1 A_2$	21000	175000	21000	25000	50000	5400	3600	3600	500	309000
$S_1 A_3$	21000	175000	21000	25000	50000	5400	3600	3600	500	309000
$S_2 A_1$	21000	175000	21000	25000	50000	5400	3600	3600	1200	309700
$S_2 A_2$	21000	175000	21000	25000	50000	5400	3600	3600	1200	309000
$S_2 A_3$	21000	175000	21000	25000	50000	5400	3600	3600	1200	309000
$S_3 A_1$	21000	175000	21000	25000	50000	5400	3600	3600	1800	310300
$S_3 A_2$	21000	175000	21000	25000	50000	5400	3600	3600	1800	309000
$S_3 A_3$	21000	175000	21000	25000	50000	5400	3600	3600	1800	309000

here,

S_0=control, S_1=1% urea solution, S_2=2% urea solution, S_3= 3% urea solution

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

Appendix IX: Overhead cost of broccoli per hectare

Treatment Combinations	Cost of lease of land for 6 months (13% of value of land Tk. 15,00000/year	Miscellaneous cost (Tk. 5% of the input cost	In terest on running capital for 6 months (Tk. 13% of cost/year	Sub total (Tk) (B)	Total cost of production (Tk./ha) [Input cost (A)+ overhead cost (B)]
$S_0 A_1$	97000	15425	54720	167145	475645
$S_0 A_2$	97000	15425	54720	167145	475645
$S_0 A_3$	97000	15425	54720	167145	475645
S_1A_1	97000	15450	54788	167238	476238
$S_1 A_2$	97000	15450	54788	167238	476238
$S_1 A_3$	97000	15450	54788	167238	476238
$S_2 A_1$	97000	15485	54884	167369	477069
$S_2 A_2$	97000	15485	54884	167369	477069
$S_2 A_3$	97000	15485	54884	167369	477069
$S_3 A_1$	97000	15515	54965	167480	477780
$S_3 A_2$	97000	15515	54965	167480	477780
$S_3 A_3$	97000	15515	54965	167480	477780

here,

S_0=control, S_1=1% urea, S_2=2% urea, S_3= 3% urea

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

Plate 1: Photograph of broccoli field

P late 2: Photograph of harvested broccoli