INFLUENCE OF STARTER SOLUTION AND MULCHING ON GROWTH AND YIELD OF BROCCOLI

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It is a fact that the remembrance of Allah brings peace in the heart. It is better to ponder over the verses to bring us even closer to Allah (swt).

DEDICATED TO-

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CERTIFICATE

This is to certify that the thesis entitled ***"INFLUENCE OF STARTER SOLUTION AND MULCHING ON GROWTH AND YIELD OF BROCCOLI"*** *submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE in HORTICULTURE****, embodies the result of a piece of authentic research work carried out by* ***Mutasim Fuad Shuvo,*** *Registration No.* ***12-04834*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated:
Place: Dhaka, Bangladesh

……..
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- Author

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ABSTRACT

A field experiment was accomplished in the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2018 to March 2019 to study on influence of starter solution and mulching on growth and yield of broccoli. The experiment comprised of four levels of starter solution viz., S_0 (Control), S_1 (1% Starter solution), S_2 (1.5% Starter solution) and S_3 (2% Starter solution) and four levels of mulching viz., M_0 (no mulch), M_1 (Black polythene), M_2 (Water hyacinth) and M_3 (Rice straw) were used in this experiment arranged in Randomized Complete Block Design (RCBD) with three replications. Data on different growth and yield attributes parameters were taken in which all the treatment showed significant variations. In the case of starter solution, maximum plant height (71.41 cm), number of leaves (15.35), canopy spread (78.86 cm) and weight of primary curd (416.41 g) were recorded from S_3 (2% urea solution) treatment. In the case of mulching, maximum plant height (73.02 cm), number of leaves (16.00), canopy spread (80.81 cm) and weight of primary curd (442.24 g) were recorded from M_1 (Black polythene) treatment. The maximum yield (19.67 t/ha) was recorded from S_3 (2% Starter solution) and on the other hand, the lowest yield was 14.83 t/ha) obtained from S_0. Significantly higher yield (21.00 t/ha) was recorded from M_1 (Black polythene) while the lowest yield (12.88 t/ha) M_0 treatment. In the case of the combination effects the maximum yield (24.07 t/ha) was recorded from the treatment combination of S_3M_1 while the lowest yield was (11.87 t/ha) recorded from S_0M_0 treatment. The economic analysis revealed that 2% starter solution with Black polythene treatment was the best combination in respect of net return (604339 Tk.) with a benefit cost ratio of (2.69), it was apparent from the above results that the treatment combination of S_3M_1 was more profitable than rest of treatment combinations.

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ABBREVIATIONS AND ACCORONYMS

AEZ	Agro-ecological Zone
Agric.	Agricultural
ANOVA	Analysis of Variance
BARI	Bangladesh Agricultural Research Institute
Biol.	Biology
CV	Coefficient of variance
DAT	Days After Transplanting
et al.	And others
Ex.	Experiment
FAO	Food and Agriculture Organization of the United Nations
g	Gram
Hort.	Horticulture
i.e.	That is
J.	Journal
Kg	Kilogram
LSD	Least Significance difference
mm	Millimeter
RCBD	Randomized Complete Blocked Design
Res.	Research
SAU	Sher-e-Bangla Agricultural University
Sci.	Science
spp.	Species
Technol.	Technology
UNDP	United Nations Development Programme
Viz.	Namely
%	Percent
LAI	Leaf Area Index
RGR	Relative Growth Rate
NAR	Net Assimilation Rate
MSTAT	Michigan State University Statistical Package for Data Analysis
etc.	Etcetera

CHAPTER-I
INTRODUCTION

Broccoli *(Brassica oleracea* var. *Italica* L) is an important winter vegetable crop under Brassicaceae family, which is originated from west Europe. It ranks at fourth place after cauliflower, cabbage and knolkhol among the Cole crops. In Bangladesh it was introduced about two decades ago. It is a minor vegetable in Bangladesh and commercial cultivation of broccoli has been increased especially in the area of Dhaka, Rajshahi and Gazipur districts. Broccoli is fairly rich in vitamin A and C and contains appreciable amounts of calcium, phosphorus, riboflavin, thiamin, niacin, and iron (Thompson and Kelly, 1997 and Lincoln, 1987). Watt (1983) reported that broccoli is more nutritious than any other cole crop such as cabbage, cauliflower and kohlrabi.

In our country, the average per capita vegetable consumption in a day is less than 50% to the recommendation. As population of our country increase rapidly, so to fulfill the demand of this increasing population we need to cultivate huge amount of good quality broccoli. Moreover, broccoli is environmentally better adapted and withstand comparatively at higher temperature than cauliflower. It can be grown on a wide range of soil types, ranging from light sand to heavy loam or, even clay that are well supplied with organic matter. Its cultivation is highly profitable as well. So, this research will play a vital role in improving the socio-economic condition of the farmer and attaining food security in Bangladesh.

Broccoli produces smaller flowering shoots (side curd) from the leaf axil after the harvest of main apical curd. Consequently, a broccoli may be harvested over a considerable period of time. Its has wider environmental adaptability, higher nutritive value, good taste, less risk of crop failure and various biotic and abiotic factors indicate that there is enough scope for its large-scale cultivation.

It is grown in Bangladesh during the cool or rabi season. Its cultivation has not been expanded much beyond the farms of different agricultural organizations. This is mainly due to lack of awareness regarding its nutritional value and method of production. Broccoli is environmentally better adapted than cauliflower and reported to withstand comparatively higher temperature than cauliflower (Rashid, 1976). Its preference to the consumers is increasing day by day.

Successful production of broccoli depends on various factors where fertilizer management and mulching both are important that contribute in the production and yield of broccoli. Starter solutions are mixtures of soluble fertilizer and water that facilitates the young plants to have a good start. Starter solution provides a ready source of nutrition near the absorbing zone of the seedlings just after transplanting & provides a quick recovery of transplanted seedlings. The time between uprooting and establishment of young and tender seedings in the fields is very critical. Cabbage, cauliflower, tomato responded better to starter solution in minimizing the transplanting shock and are encouraged to a quick growth (Chhonkar and Jha, 1963).

Though Bangladesh is one of the highly precipitated areas of the world with an average yearly rainfall of 200 cm, the distribution of the rain is not even in respect of time and place. Broccoli is generally cultivated in Bangladesh during the winter season when rainfall is scanty. But for the whole growing period broccoli requires 250-300 mm water with more emphasis to transplanting and curd formation stage (Ahmed and Shahjahan, 1991).

In most of the time irrigation expenses and increase the cost of production. The necessity of irrigation is not only costly but also its facilities are inadequate. Therefore, mulching in this regard may be helpful in conserving soil moisture of the preceding season.

Any practice that acts as a barrier to the evaporation of water or heat from the soil surface can be defined as mulching. Artificial mulching, covering the soil surface with plant species, crop residues or polythene sheet, which are generally used in the production of horticultural crops like potato, onion, zinger cabbage, cucurbits etc (Wilhoit *et al.,* 1990). The hay or rice straw of the previous crops can also be used as mulching. This practice suppresses weeds resulting in higher yield and quality produce

Therefore, mulching in this regard may be exploited to produced broccoli successfully particularly where rainfall and irrigation facilities are scarce and even where irrigation is available, mulching may be used as the substitute to minimize the cost of production. Mulching can minimize the requirement of water and helps in retaining moisture (Amal *et al.* 1990). Mulches also reduce the water loss from the soil by evaporation and reduce the irrigation requirements (Prihar *et al.* 1986). Mulching improves soil physical conditions by enhancing biological activity of soil flora and fauna and increase soil fertility (Lal, 1978).

Considering the above facts, the present experiment was undertaken to study the effect of starter solution and mulching material on the following objectives-

- To determine the effect of starter solution on growth and yield of broccoli.
- To select the appropriate mulching material for broccoli production as an alternative to irrigation.
- To evaluate the combined effect of starter solution and mulching material on growth and yield of broccoli with evaluate the relative cost and return in broccoli production.

CHAPTER-II
REVIEW OF LITERATURE

A brief review of the literature pertaining to the "Influence of starter solution and mulching on growth and yield of broccoli" is presented in this chapter. An attempt has been made to cite all available literature on broccoli but due to paucity of adequate published information, research work on other related vegetable crops has also been reviewed.

2.1 Review on influence of starter solution and mulching 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 GA_3 at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh during the period from October, 2001 to February, 2002 to study the effect of starter solution and GA_3 on growth and yield of cabbage. The two-factor experiment consisted of four levels of starter solution, viz., 0, 1.0, 1.5 and 2.0% of urea, and four concentrations of GA_3, viz., 0, 25, 50 and 75ppm. The application of starter solution and different concentrations of GA_3 influenced independently and also in combination on the growth and yield of cabbage. The highest yield (104.93 t/ha) was obtained from 1.5% starter solution which was significantly different from other solutions, and the lowest yield (66.86 t/ha) was recorded from the control. Significantly the highest yield (104.66 t/ha) was found from 50 ppm GA_3, while the lowest yield (66.56 t/ha) was recorded from control. In case of combined effect, the highest yield of cabbage (121.33 t/ha) was obtained from the treatment combination of 1.5% starter solution + 50 ppm GA_3 followed by 1.5% starter solution + 75 ppm GA_3 (115.22 t/ha), while the lowest yield (57.11 t/ha) was produced by the control treatment. Economic analysis revealed that

1.5% starter solution + 50 ppm GA_3 treatment was the best treatment combination in respect of net return (Tk. 173775.00) 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 and 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 ($NaNO_3$) 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, K_2SO_4 and single superphosphate. This treatment also advanced maturity by 13 days.

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) reported 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

Soniya (2018) conducted field experiments to study effect of starter solution and age of seedling on growth and yield of broccoli (*Brassica Oleracea* Var. italica) and she found that the highest yield (24.32 t/ha) was obtained from S_2 (2% urea) treatment, whereas the lowest yield (13.21 t/ha) was recorded from S_0 (0% urea) treatment. For three level of age of seedling the highest yield (20.75 t/ha) was obtained from A_2 (30 days old seedling) treatment and the lowest yield (15.48 t/ha) was recorded from A_3 (40 days old seedling) treatment. In case of combined effect the highest yield (26.91 t/ha) of broccoli was obtained from the treatment combination of S_2A_2 while the lowest (13.41 t/ha) was obtained from S_0A_3 treatment combination. Economic analysis revealed that S_2A_2 treatment

combination was the best in respect of net return (3,24,890) 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.

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.

Roy *et al.* (1990) investigated the effect of mulching using water hyacinth, straw and sawdust mulch on production of cabbage and reported significant increase in crop growth rate (CGR). Net assimilation rate (NAR). And leaf area index (LAI). Water hyacinth significantly increased the content of chlorophyll-b along with the growth of cabbage.

Lourduraj *et al.* (1996) obtained maximum plant height (81.5 cm) and number of laterals (8.6 per plant) in tomato cv. CO-3 with the application of black LDPE mulch as compared to use of organic mulch and control (without mulch).

Kalisz and Cebula (2001) reported that the application of plastic covers considerably improved plant growth i.e. increase in plant height, rosette diameter, and the total number of leaves. Area build-up were observed when soil mulch was spread 1-2 days before beginning of field experiment. When using the soil mulching with polythene black film and plant covering with non-woven polypropylene and perforated polythene film on the growth and yield of four cultivars of Chinese cabbage (Akala F_1, Optico F_1, Sumiko F_1 and Parkin F_1).

Moniruzzaman *et al.* (2007) conducted a field experiment on cauliflower var. Rupa for two consecutive years from November, 2000 to March, 2002 in sandy clay loam soil at Agricultural Research Station, Raikhali, Rangamati Hill District to observe the effect of irrigation intervals and mulch materials on its yield, yield attributes and profitability. Twenty combinations of treatments consisting of four levels of irrigation i.e. (no irrigation = control, irrigation at 7, irrigation at 14 and irrigation at 21 days interval) and five levels of mulching (no mulch (control), black polythene mulch, rice straw mulch, sun grass mulch and mango leaves` mulch) were used for this trial. Result showed that irrigation at 7 days interval and mulching with black polythene independently as well as in combination

produced maximum values for yield attributes and marketable yield of cauliflower. The highest curd yield 30.38 t/ha was obtained from 7 days irrigation interval with black polythene mulch.

Juan Diaz-Perez (2009) studied the effect of color of plastic film mulch (black, blue, gray on black, red, silver on black, and white on black mulches) and bare soil and observed that colored plastic film mulches affected root zone temperature and the accumulation of soil degree-days. Mean daily RZT (Root Zone Temperature), maximal daily RZT (21 °C up to 25 °C) and degree day accumulation in the soil were highest in dark colored mulches (blue, black, red, and gray) and lowest in light-colored mulches (silver and white). However, minimal daily RZT was found highest in silver and white mulch. The colored plastic mulches also affected plant growth and yield of broccoli significantly.

Parmar *et al.* (2013) studied the effect of different mulching materials on growth, yield and quality of water melon cv. Kiran and found that all the plant growth characters i.e. number of branches per vine (14.90), number of fruits per vine (3.23), fruit weight (3.61 kg), fruit yield (35.37 t/ha) were found superior with silver colour on black polyethylene mulch.

Nakaande (2013) conducted an experiment on “Fertigation and mulching incabbage (*Brassica oleracea* var. capitata L.). Scheduling of irrigation at 60 per cent Ep resulted in significantly higher plant height. However plant spread, number of non-wrapping leaves and wrapping leaves were highest at 80 per cent Ep. Mulching also significantly improved plant height, wrapping leaves and plant spread. Interaction of irrigation and mulching had significant effect on all other vegetative characters of cabbage.

Kwambe *et al.* (2014) reported that use of different mulches provide essential benefits in crop production. This study was carried out to determine the effect of organic and inorganic mulches on green bean (*Phaseolus vulgaris L.*) growth,

development and yield on a clay loam soil of Matsapha, Swaziland. The study indicated that black polythene; clear polythene and grass mulches significantly ($P < 0.05$) affected the growth of green bean on a clay loam soil. However, black polythene mulched plants exhibited highest growth parameters as compared to other mulch treatments.

Jasim *et al.* (2014) studied Influence of polyethylene, soil mulch and foliar application of urea complete fertilizers, seaweed in alleviating salt stress of Broccoli (*Brassica Oleracea var. Italica*) and found that the interaction between soil mulch and foliar treatments found highly significant and effect which resulted in increased leaf area as compared to control.

Mohammed *et al.* (2016) conducted an experiment to assess the effect of mulching and organic fertilizer on growth, yield and quality of Broccoli (Brassica oleracea var italica) and observed that the mulching significantly increased plant height, leaf area, leaves number/plant, number of branches/plant as compared to control.

Halappa and Sreenivas (1973) harvested 75 per cent yield of cauliflower over black polythene mulched plots in first 3 weeks, while they collected only 32 per cent yield in the control during the same period. The yield increase observed in case of 100, 200 and 300 gauge film mulches over control were 39.5, 41.01 and 44.9 per cent, respectively.

Gattorman (1992) studied the effects of plastic film mulch on yield of cabbage and found that single layer of polythene and propylene resulted either in an earlier or higher yield than that of double layer in chinese cabbage.

Burnette *et al.* (1993) studied the economic implications of nitrogen fertilization, drip irrigation and plastic culture on cole crops and tomato grown sequentially. Black plastic mulch treatment tended to produce higher yield of greater broccoli

than non-mulched treatment. The soil nitrate concentration was also found higher throughout the growing season in the mulched plots as compared to non-mulched plots.

Poll and Geven (1996) studied the effect of mulches (black paper, black polythene and straw) on iceberg and butter head lettuces, leeks, Cichorium intybus, chinese cabbage and paksoi crops in the Netherlands. They reported that mulches significantly reduced the incidence of Phytophthora porri in leek and increased yield of iceberg and butter head lettuce and winter leek. Mulch application was economically beneficial for leek, but not for lettuce. The nitrogen leaching to ground water was decreased with application of mulches.

Hossain (1999) observed that maximum gross and marketable yield (116.67 t/ha and 97.53 t/ha) were obtained from black polythene mulch and the lowest from control.

Campiglia *et al.* (2000) studied the effect of mulches and observed that mulching with polythene increased soil temperature at all depths compared with non-mulched soil. They also reported that mulch significantly reduced weed density (70per cent) but not the weed biomass compared with the control.

Runham *et al.* (2000) reported that use of paper mulch resulted in increased soil moisture levels in non-irrigated courgettes but not in irrigated celery compared to non-covered soil. They also found that both paper and plastic mulches gave similar or higher mean head weight in broccoli. From another experiment they concluded that soil temperature beneath the paper mulch was lower than both the non-mulched and black polythene-covered plots.

Islam *et al.* (2002) reported the effect of planting time, mulching and irrigation intervals on growth and yield of cabbage cv. Atlas-70. The treatments consisted of 3 planting times, i.e. 15 November, 30 November and 15 December and 10

levels of mulching and irrigation, i.e. no mulch and no irrigation (control), irrigation at 15 days interval, irrigation at 30 days interval, irrigation at 45 days interval, ash mulch, straw mulch, sawdust mulch, water hyacinth (Eichhornia crassipes) mulch, black polyethylene mulch, and rice husk mulch. The results indicated that highest gross yield (71.85 kg/plot) was obtained from the black polyethylene mulch followed by water hyacinth mulch (65.99 kg/plot). Considering marketable yield, both black polyethylene (103.01 t/ha) and water hyacinth mulch (90.99 t/ha) exerted statistically similar effects followed by irrigation at 15 days interval (85.86 t/ha).

Sarker *et al.* (2003) conducted an experiment to assess the effect of different source of nutrients and mulching on growth and yield of cabbage. The experiment consisted of four levels of nutrients and three mulching material and observed that the use of black polythene sheet mulch produced maximum marketable yield (70.24 t/ha). The treatment combination of organic + inorganic fertilizers with black polythene sheet mulch gave highest marketable yield (97.83 t/ha) of cabbage.

Ali (2004) carried out an experiment to study the effects of mulching and different levels of nitrogen on growth and yield of broccoli and reported that maximum average yield (16.4 t/ha) was obtained from 220 kg N/ha with black polythene mulch.

Faruque (2004) carried out an experiment to study the effects of different sources of nutrients and mulching on growth and yield of broccoli and observed that maximum average yield (18.2 t/ha) was obtained from organic + inorganic fertilizer with black polythene mulch while minimum yield was observed in without fertilizer + mulch and irrigation treatment.

Singh and Mir (2005) carried out a trial to investigate the effects of different types and colours of mulches on yield and yield-attributing traits of cabbage cv.

Pride of India and observed more head weight per plant with black and red polyethylene mulches as compared to control. The black polyethylene also suppressed drastically the weed growth by 96.82 per cent and also recorded maximum net returns of Rs 1,19380.00/ha, followed by the red polyethylene mulch (Rs 115992.00/ha).

Kashyap *et al.* (2005) conducted a field trial to study the effect of drip irrigation at different levels of evaporation replenishment rate (EPR; 60, 80, 100 and 120 per cent of USWB class A pan evaporation), with or without black plastic mulch. They reported highest broccoli yield of 25.14 t/ha under drip irrigation treatment at 120 per cent EPR with black plastic mulch, while the lowest yield of 9.22 t/ha was recorded in the furrow-irrigated plants.

Gandhi and Bains (2006) observed that tomato crop under straw mulch produced higher number of branches (8.7), fruit weight (28.08 g) and total yield (496.3 q/ha) as compared to without mulch.

Moniruzzaman *et al.* (2007) conducted a field experiment on cauliflower (var. Rupa) to observe the effect of irrigation and mulch materials on its yield, yield attributes and profitability and found that irrigation at 7 days interval and mulching with black polythene independently as well as in combination of both produced maximum values for yield attributes and marketable yield of cauliflower. The maximum curds yields of 30.38 and 29.40 t/ha were obtained from 7 days irrigation interval with black polythene mulch.

Kashyap *et al.* (2009) investigated the effect of different irrigation regimes and polythene mulch on yield, quality and water use efficiency in broccoli variety Pusa KTS-1. Treatments constituted with four drip irrigation regimes viz., 60, 80,100 and 120 per-cent of evaporation replenishment rate and two levels of mulching viz., without mulch and mulch with black polythene along with a furrow irrigation treatment. Broccoli was irrigated fortnightly based on available

soil moisture depletion. Result revealed that the head diameter (20.25 cm) and head weight (603.50 g) were maximum under drip irrigation at 120 percent evaporation replenishment with black polythene mulch.

Easmin *et al.* (2009) studied the effect of different levels of nitrogen and mulching on growth of chinese cabbage and reported that highest marketable yield per hectare of Chinese cabbage (123.27 t) was recorded in black polythene mulch and lowest yield (76.51 t) was recorded in control (without mulch). In each and every case maximum yield contributing characters and yield was observed in 250 kg N/ha and black polythene mulch and the reverse result was recorded in control condition i.e. without nitrogen and mulch.

Carvalho *et al.* (2011) studied the response of mulching material and different irrigation intervals with moderately saline water and found that mulching and irrigation intervals (12 hr) affected the cabbage yield with maximum water use efficiency (110.49 Mg/ha/mm).

Diaz-Perez *et al.* (2012) found that marketable and total floret yield and individual floret weight of broccoli were maximum with the application of wheat straw as mulch material and minimum in control.

Nakaande (2013) conducted an experiment to assess the respone of fertigation and mulching on cabbage (*Brassica oleracea var. capitata L.*)" and reported that treatment combination of F_3M_1 (75 per cent of fertilizer dose + silver-black polythene mulch) recorded significantly higher net head weight. Mulching with silver-black polythene sheet proved to be a very good practice for overall growth and yield of cabbage.

Yaghia *et al.* (2013) found that use of black plastic mulch enhanced vegetative growth of cucumber and significantly increased its productivity (70, 53 and 17 per cent) under the influence of all drip irrigation treatments (transparent plastic

mulch, black plastic mulch and without mulch) as compared to the surface furrow irrigation.

Masarirambi *et al.* (2013) reported that the white plastic and sawdust mulches conserved moisture when 'Savoy' baby cabbage grown during the warm season and based on the results of study they recommended mulching with white plastic or sawdust in order to realise near perfect growth and yield, as well to conserve soil moisture and weed suppression by white plastic.

Deshmukh *et al.* (2013) reported that the crop yield was found maximum under black plastic mulch with 80 per cent of CWR (Crop Water Requirement) through drip irrigation system, followed by paddy straw mulch and without mulch with drip system in a split plot design. The benefit cost ratio was found maximum (2.14) with 80 per cent of CWR through drip irrigation system and black plastic mulch.

Kosterna (2014a) conducted an experiment to find out the effect of different types of straw mulches on weed-control in vegetables cultivation and observed that the application of higher dose of rye and buckwheat straw in broccoli, corn and rape seed in tomato cultivation reduced number of weeds compared to control.

Kosterna, (2014b) conducted a field experiment to study the yield and quality of broccoli grown under flat covers with soil mulching and reported that increase of the content of chemical components as a result of plants covering amounted to 1.76 per cent for dry matter, 2.50 mg/100 g fresh matter (FM) for ascorbic acid, 0.65 per cent FM for total sugar and 0.15per cent FM for monosaccharides. All kinds of straw contributed to an increase in the broccoli yield and yield attributing characters.

Saloom and Sahaf (2016) carried out an experiment to investigate the effect of organic and mineral fertilization and soil mulching on quality characteristic of broccoli and found the superiority of black plastic mulch M_1 with respect to higher TSS per cent, Vitamin C content, high Folic acid, carbohydrate and protein content in curd (8.8 %), (89.62 mg./100g), (54.80 mg./100g), (7.06 %) and (26.77 %), while low nitrate content of curd (0.76 mg/g), respectively compared with control (M_0).

CHAPTER-III
MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in execution of the experiment. It includes a short description of experimental site, characteristics of soil, climate, materials used, data collection, statistical analysis and cost and return analysis. The details of these are described below.

3.1 Experimental Site

The experiment was conducted at the Horticulture Farm of Sher-e- Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period from October 2018 to February 2019. The experimental site was previously used as vegetable garden and recently developed for research work. The location of the site is 23° 74'N latitude and 90° 35' E longitude with an elevation of 8.2 meter from sea level (Anon, 1981).

3.2 Climate

The climate of the experimental site is subtropical, characterized by heavy rainfall during the months from April to September (Kharif season) and scanty rainfall during rest of the year (Rabi season). The total rainfall of the experimental site was 218 mm during the period of the experiment. The average maximum and the minimum temperatures were 24.52°C and 13.86° C respectively. Rabi season is characterized by plenty of sunshine. The maximum and minimum temperatures, humidity and rainfall during the study period were collected from the Bangladesh Meteorological Department (climate division) and have been presented in Appendix I.

3.3 Soil

The soil of the experimental area belongs to the Madhupur Tract. The analytical data of the soil sample collected from the experimental area were determined in SRDI, Soil Testing Laboratory, Dhaka and presented in appendix II.

The experimental site was a medium high land and pH of the soil was 5.6. The morphological characters of soil of the experimental plots as indicated by FAO (1988) are given below – AEZ No. 28, Soil series – Tejgaon, General soil- Non-calcarious dark grey.

3.4 Plant materials

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

3.5 Treatment of the experiment

The experiment consisted of two factors:

Factor A: Different level of starter solution (Urea)

S_0= 0% Starter solution (control)

S_1= 1 % Starter solution

S_2= 1.5% Starter solution

S_3= 2% Starter solution

Factor-B (Mulching)

M_0 =No Mulching (Control)

M_1= Black polythene

M_2=Water hyacinth

M_3=Straw

There were 16 (4 × 4) treatments combination such as S_0M_0, S_0M_1, S_0M_2, S_0M_3, S_1M_0, S_1M_1, S_1M_2, S_1M_3, S_2M_0, S_2M_1, S_2M_2, S_2M_3, S_3M_0, S_3M_1, S_3M_2, S_3M_3.

3.6 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 181.56 m^2 with length 26.7 m and width 6.8 m. The total area was divided into three equal blocks. Each block was divided into 48 plots where 16 treatments combination was allotted at random. There were 48 unit plots altogether in the

experiment. The size of each plot was 1.8m × 1.2m. The distance maintained between two blocks and two plots were 0.7 m and 0.5 m, respectively. The layout of the experiment is shown in Fig. 1.

3.7 Land preparation

The selected plot of the experiment was opened in the 2nd week of October, 2018 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.

3.8 Application of manures and fertilizers

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

Cow dung = 10 ton ha^{-1}

Urea = 300 kg ha^{-1}

TSP = 250 kg ha^{-1}

MoP = 200 kg ha^{-1}

The total amount of cow dung, TSP and M_OP 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.

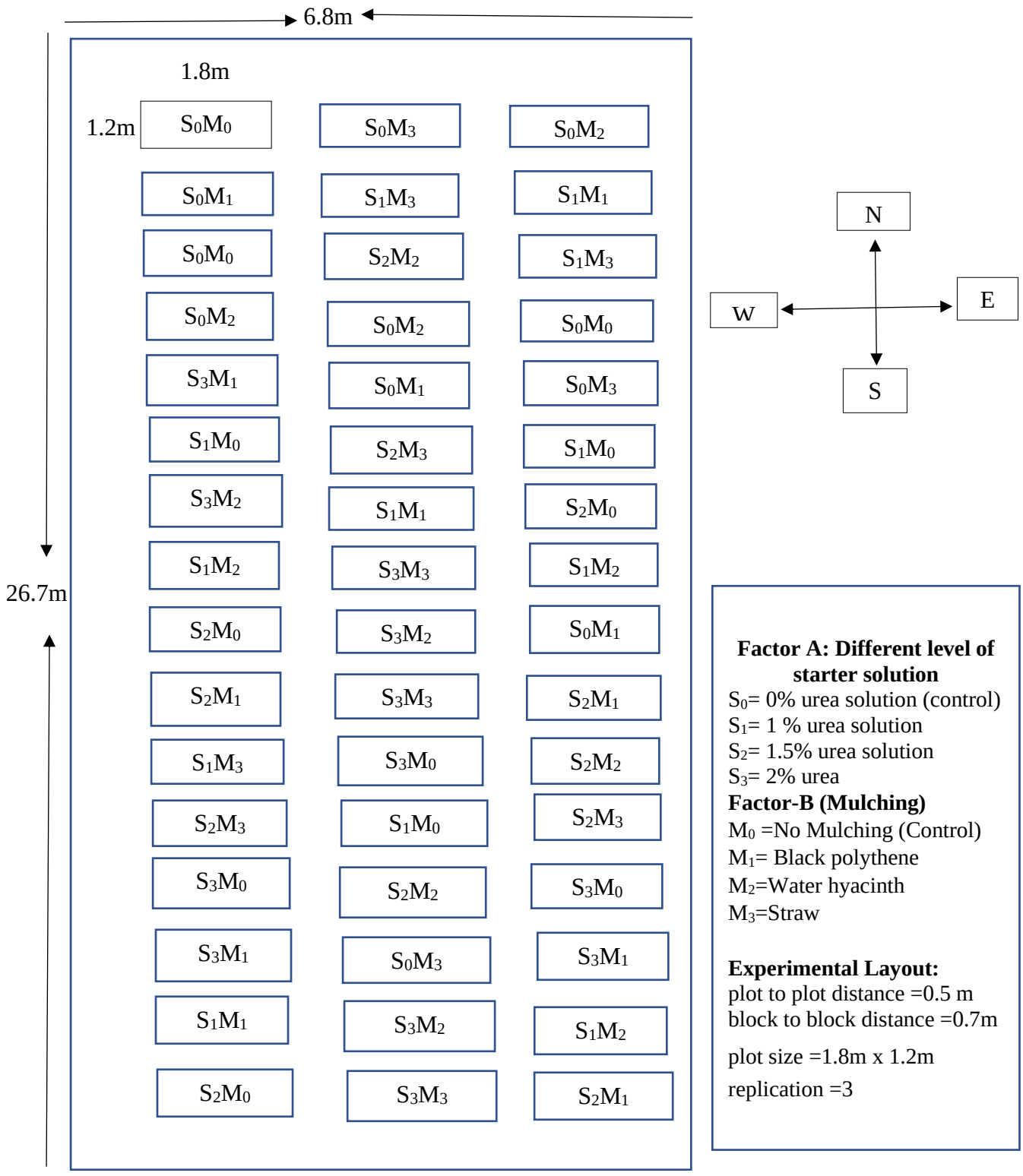


Fig 1. Layout of the experimental field

3. 9 Preparation of starter solution

At first, 1, 1.5 and 2 g of urea were weighted and were dissolved in distilled water taken in three beakers. The solutions were then made to volume up to 100ml by water. The beakers were leveled and the solutions were ready for use.

3.10 Raising of seedlings

The seedlings of broccoli were raised at Horticulture Farm, Sher-e-Bangla Agricultural University (SAU), Dhaka, under special care in four seed beds each of 3m × 1 m size. For raising seedlings, the soil was ploughed and converted into loose friable and dried masses. All weeds, stubbles and dead roots were removed. Cow dung was applied to the prepared seed beds at the rate of 10 t/ha. The seeds were sown in the seed beds of 2.5m x l m size on 21th October 2018. After sowing, the seeds were covered with a thin layer of soil. When the seeds germinated, shade by bamboo mat (Chatai) was provided to protect the young seedlings from scorching sun-shine and rain. Light watering, weeding and mulching were done as and when necessary. No chemical fertilizers were applied for raising the seedlings. Seedlings were not attacked by any kind of insects or diseases. The healthy 25 days old seedlings were transplanted in the experimental field on 19 November 2018.

3.11 Transplanting and after care

Healthy 25 days old seedlings were transplanted on 19th November, 2018 in the afternoon and light irrigation was given around each seedling for their better establishment. Each unit plot accommodated 9 plants. A number of seedlings were planted in the border of the experimental plots for gap filling.

3.12 Gap filing

Dead, injured and weak seedlings were replaced by new healthy seedlings from the stock kept on the border line of the experiment.

3.13 Intercultural operation

3.13.1 Weeding

Weeding was done three times in each plot to keep clear.

3.13.2 Irrigation

Light irrigation was given just after transplanting of the seedlings. A week after transplanting the requirement of irrigation was envisaged through visual estimation. Wherever the plants of a plot had shown the symptoms of wilting the plots were irrigated on the same day with a hosepipe until the entire plot was properly wet.

3.14 Pest and Disease control

Few plants were damaged by mole crickets and cut worms after the seedlings were transplanted in the experimental plots. Cut worms were controlled both mechanically and spraying Diazinon 60 EC @ 0.55 Kg per hectare. Some of the plants were infected by *Alternaria brassicae*. To prevent the spread of the disease Rovral @ 2g /liter of water was sprayed in the field. Bird pests such as Nightingale (Common Bulbuli) visited the fields from 8 to 11 a.m. and 4 to 6 p.m. The birds were found to make puncture in the soft leaves and initiating curd and they were controlled by striking of a metalic container.

3.15 Harvesting

The harvesting was not possible on a particular date because curd initiation as well as curd maturation period in different plants were not similar probably due to use of different manures and genetic characters of varieties. The compact mature curds were only harvested. After harvesting the main curd, secondary shoots were developed from the leaf axils, and produced small secondary curds. Those were harvested over a period of time. The crop under investigation was harvested for the first time on January 15, 2019 and the last harvesting was done on February 08, 2019.

3.16 Methods of Data collection

The data pertaining to the following characters were recorded from six (6) plants randomly selected from each unit plot, except yield of curds which was recorded plot wise. Data on plant height was collected on 20, 40 and 60 days after transplanting and also at harvest. All other parameters were recorded at harvest.

3.16.1 Plant height

Plant height was measured in centimeter (cm) by a meter scale at 20, 40, and 60 days after transplanting (DAT) and at harvested from the ground level up to the tip of the longest leaf.

3.16.2 Number of leaves per plant

Number of leaves per plant of six randomly selected plants were counted at harvest. All the leaves of each plant were counted separately. Only the smallest young leaves at the growing point of the plant were excluded from counting.

3.16.3 Leaf length

A meter scale was used to measure the length of leaves. Leaf length of six randomly selected plants were measured in centimeter (cm) at harvest. It was measured from the base of the petiole to the tip of the leaf. All the leaves of each plant were measured separately. Only the smallest young leaves at the growing point of the plant were excluded from measuring.

3.16.4 Leaf breadth

Leaf breadth of six randomly selected plants were measured in centimeter (cm) at harvest from the widest part of the lamina with a meter scale and average breadth was recorded in centimeter (cm). All the leaves of each plant were measured separately. Only the smallest young leaves at the growing point of the plant were excluded from measuring.

3.16.5 Plant canopy

Plant canopy was measured by taking the diameter of the canopy of an individual plant in several directions with a meter scale and finally the average was taken and was expressed in centimeter (cm).

3.16.6 Stem length

Stem length was measured from the base of the curd to the tip after harvest. A meter scale was used to measure the stem length of curd and expressed in centimeter (cm).

3.16.7 Stem diameter

The diameter of the stem was measured at the point where the central curd was cut off Stem diameter was recorded in three dimensions with scale and the average of the three values was taken in centimeter (cm).

3.16.8 Weight of primary curd

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

3.16.9 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).

3.16.10 Number of secondary curds

When the secondary curds reached marketable size. They were counted; the small shoots were not taken into consideration.

3.16.11 Weight of secondary curd

Weight of secondary curd was recorded by weighing the total axillary curds of an individual plant and was expressed in gram (g).

3.16.12 Yield per plant

The yield per plant was calculated by adding the weight of central curd and the weight of the secondary curds harvested and the yield was weighed in gram (g).

3.16.13 Yield per unit plot

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

3.16.14 Yield per hectare

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

3.17 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 starter solution and mulching 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 (Gomez and Gomez, 1984).

3.18 Economic analysis

The cost of production was analyzed in order to find out the most economic combination of starter solution and mulching. 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

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

Plate 1. Seed sowing in seedbed

Plate 2. Preparation of starter solution

Plate 3. Transplant of seedling

Plate 4. Mulching operation

Plate 5. Data collection of harvested broccoli

CHAPTER-IV
RESULTS AND DISCUSSION

Results of the experiment entitled “Influence of starter solution and mulching on growth and yield of broccoli”, conducted during Rabi season 2018-19 at Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka are presented in this chapter. The observations pertaining to growth and yield attributes of sprouting broccoli recorded during the course of investigation were statistically analyzed and significance of results verified. The analyses of variance for all data have been presented in Appendices I to X. The results of all the main effects and only significant combination have been presented in succeeding paragraphs. Some of the characters have also been represented graphically to show the treatment effect wherever necessary to provide better understanding of the results.

4.1 Plant height

Plant height increased significantly with the increased percentage of starter solution at 20, 40 and 60 DAT (Table 1). At 20 DAT, the maximum plant height (26.17 cm) was recorded from S_3 (2% starter solution) treatment and minimum plant height (17.99 cm) was observed from S_0 (control) treatment (Table 1). At 40 DAT, the tallest plant (50.95 cm) was recorded from S_3 (2% starter solution) treatment. On the other hand, the lowest plant height (41.77 cm) was observed from S_0 treatment. At 60 DAT, the tallest plant (71.41 cm) was recorded from S_3 (2% starter solution) treatment followed by S_2 (69.70 cm) treatment while the lowest plant height (62.29 cm) was observed from S_0 (control) treatment. Plant height was found statistically different at 20 DAT to 60 DAT. 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).

Table 1: Effect of starter solution on plant height of broccoli at different days after transplanting

Treatments	Plant height (cm)		
	20 DAT	40 DAT	60 DAT
S_0	17.99 c	41.77 c	62.29 d
S_1	22.15 b	45.44 b	67.22 c
S_2	25.26 a	49.74 a	69.70 b
S_3	26.17 a	50.95 a	71.41 a
CV %	7.41	8.67	8.25
LSD (0.05)	1.48	1.66	1.61

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability
Here, S_0=0% urea solution, S_1=1% urea solution,
S_2=1.5% urea solution, S_3= 2% urea solution

Application of mulching showed significant influence on the height of broccoli plants at 20, 40 and 60 DAT (Table 2). At 20 DAT, the maximum plant height (27.79 cm) was measured from M_1 (Black polythene) treatment followed by (24.83 cm) M_2 (water hyacinth mulch) treatment and the minimum plant height (15.16 cm) was recorded from M_0 (control) treatment. Again at 40 DAT, the maximum plant height (52.87 cm) was recorded from M_1 (Black polythene) treatment followed by M_2 (49.07 cm) treatment. On the other hand, the minimum plant height (38.77 cm) was recorded from M_0 (no mulch) treatment. At 60 DAT, the maximum plant height (73.02 cm) was measured from M_1 (Black polythene) treatment followed by M_2 (69.61 cm) treatment and the minimum plant height (58.58 cm) was recorded from M_0 (control) treatment. It was revealed that the plot covered by mulching gave better plant height then control. This might be due to mulching increased crop growth rate (CGR), net assimilation rate (NAR), leaf area index (LAI) and relative growth rate (RGR). Similar result was found by Roy *et al.* (1990) on growth of cabbage.

Table 2: Effect of mulching on plant height of broccoli at different days after transplanting

Treatments	Plant height (cm)		
	20 DAT	40 DAT	60 DAT
M_0	15.16 c	38.77 d	58.58 c
M_1	27.79 a	52.87 a	73.02 a
M_2	24.83 b	49.07 b	69.61 b
M_3	23.80 b	47.19 c	69.41 b
CV %	7.41	8.67	8.25
LSD (0.05)	1.31	1.47	1.48

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, M_0 =No Mulching (Control), M_1= Black polythene, M_2=Water hyacinth, M_3=Straw

The plant height was significantly influenced by the combined effect of starter solution and mulching at 20, 40 and 60 DAT (Table 3). At 20 DAT, the highest plant height (31.46 cm) was measured from S_3M_1 (2% starter solution with black polythene) treatment combination which was statistically similar with S_2M_1 (30.75 cm), S_3M_2 (29.50 cm) and S_2M_2 (29.40 cm) respectively and the lowest plant height (13.18 cm) was recorded from S_0M_0 (control) treatment combination which was statistically similar with S_1M_0 (14.51 cm) and S_2M_0 (15.73 cm) respectively. At 40 DAT, the highest plant height (58.86cm) was measured from S_3M_1 (2% starter solution with black polythene) treatment combination which was statistically similar with S_2M_1 (57.32 cm). On the other hand, the lowest plant height (37.31 cm) was observed from S_0M_0 (control) treatment combination. At 60 DAT, the highest plant height (77.62 cm) was measured from S_3M_1 (2% starter solution and black polythene) treatment combination which was statistically similar with S_2M_1 (75.68 cm) and S_3M_2 (74.73 cm) respectively and the lowest plant height (56.55 cm) was recorded from S_0M_0 (control) treatment combination. It might be black polythene mulch maintained a higher moisture content and more uniform temperature with 2% starter solution helped in increased growth of plants.

Table 3: Combined effect of starter solution and mulching on plant height of broccoli at different days after transplanting

Treatments Combinations	Plant height (cm)		
	20 DAT	40 DAT	60 DAT
S_0M_0	13.18 l	37.31 l	56.55 k
S_0M_1	21.10 gh	43.92 g-i	65.58 gh
S_0M_2	17.98 ij	42.40 h-j	62.84 hi
S_0M_3	19.71 hi	43.46 hi	64.21 h
S_1M_0	14.51 kl	37.59 kl	58.18 jk
S_1M_1	27.84 b-d	51.38 cd	73.20 b-d
S_1M_2	22.42 f-h	45.66 f-h	67.63 fg
S_1M_3	23.83 e-g	47.13 e-g	69.88 ef
S_2M_0	15.73 j-l	39.42 j-l	58.67 jk
S_2M_1	30.75 ab	57.32 ab	75.68 ab
S_2M_2	29.40 a-c	53.78 c	73.24 b-d
S_2M_3	25.18 d-f	48.46 d-f	71.21 de
S_3M_0	17.21 i-k	40.77 i-k	60.94 ij
S_3M_1	31.46 a	58.86 a	77.62 a
S_3M_2	29.50 ab	54.44 bc	74.73 a-c
S_3M_3	26.50 c-e	49.73 de	72.33 c-e
CV %	7.41	8.67	8.25
LSD (0.05)	2.96	3.32	3.22

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:

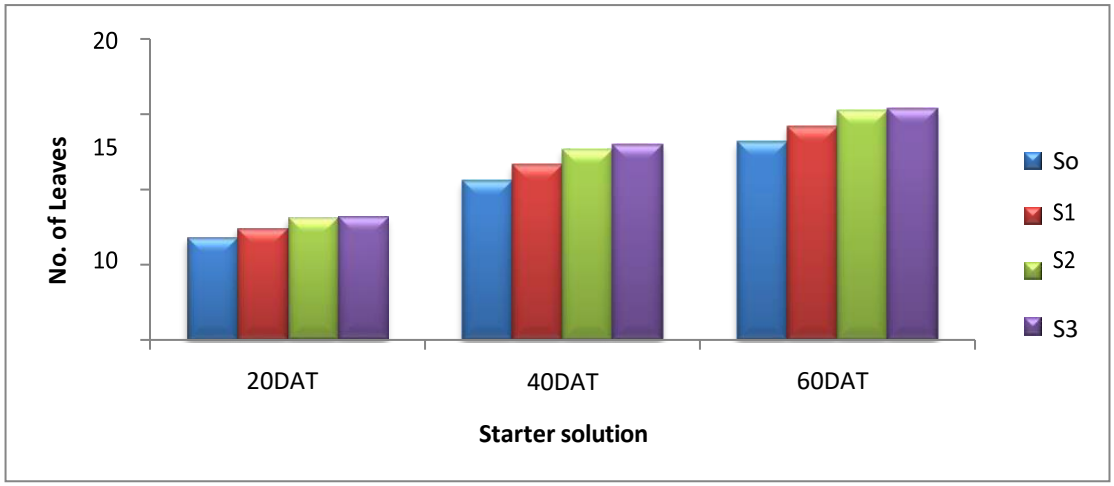
S_0= 0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution,

M_0 =No Mulching (Control), M_1= Black polythene, M_2=Water hyacinth, M_3=Straw

4.2 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 (Fig. 2). At 20 DAT, the maximum number of leaves (8.15) was recorded from S_3 (2% starter solution) treatment while the minimum number of leaves (6.78) was obtained from S_0 (control) treatment. Again at 40 DAT, the highest number of leaves (12.98) was recorded from S_3 (2% starter solution) treatment followed by S_2 (12.66) treatment and the minimum number of leaves (10.58) was obtained from S_0 (0% urea solution) treatment. At 60 DAT, the maximum number of

leaves (15.35) was recorded from S_3 (2% starter solution) treatment. On the other hand, the minimum number of leaves (13.18) was obtained from S_0 (control) treatment. The reason may be that, application of 2% starter solution might have improved absorption of nutrient, physiological activity, increased rate of photosynthesis and reduced transpiration. These results are in support of the findings of Chaudhury and Singh (1960).



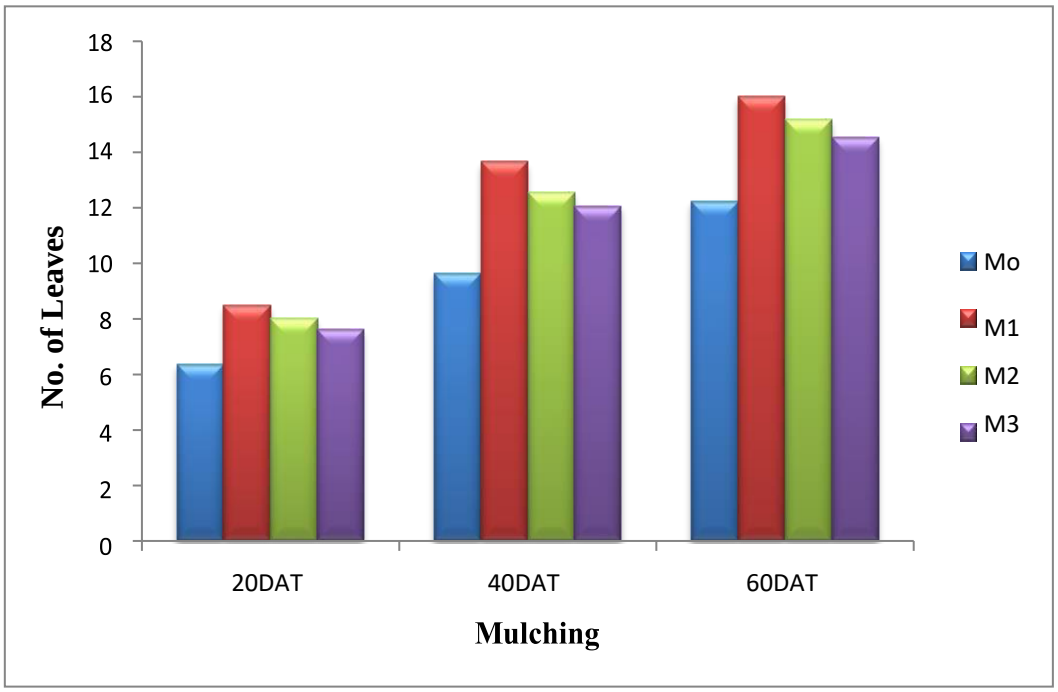
Here, S_0=0% urea S_1=1% urea, S_2=1.5% urea, S_3= 2% urea

Fig. 2: Effect of starter solution on number of leaves of broccoli at different days after transplanting

Application of mulching significantly influenced the number of leaves of broccoli plants at 20, 40 and 60 DAT (Fig. no-3). At 20 DAT, the maximum numbers of leaves (8.48) was found in M_1 (Black polythene) treatment followed by (8.00) M_2 (water hyacinth) treatment while the minimum number of leaves (6.36) was found in M_0 (control) treatment. Black Polythene and water hyacinth showed more or less similar result in number of leaves per plant of broccoli. At 40 DAT the maximum number of leaves (13.65) was observed from M_1 (Black polythene) treatment and the minimum number of leaves (9.63) was found in M_0 (control) treatment. Again at 60 DAT, the highest number of leaves (16.00) was observed from M_1 (Black polythene) treatment. On the other hand, the lowest number of leaves (12.23) was found in M_0 (control) treatment. The number of leaves per plant increased with the increase in water hyacinth mulching application. Similar

result was obtained by other investigators such as Roy *et al.* (1990) and Hossain (1999).

Such response may be accounted for the physio-chemical and biological improvement occurred in the soil including favorable temperature and moisture, nutrient availability and microbial activity that mulching have provided.



Here, M_0 =No Mulching (Control), M_1= Black polythene, M_2=Water hyacinth, M_3=Straw

Fig. 3: Effect of mulching on number of leaves of broccoli at different days after transplanting

Table 4. Combined effect of starter solution and mulching on number of leaves per plant at different days after transplanting (DAT)

Treatments Combinations	Number of leaves/plants		
	20 DAT	40 DAT	60 DAT
S_0M_0	5.93 j	9.06 m	11.60 j
S_0M_1	7.26 de	11.40 hi	14.13 de
S_0M_2	7.06 ef	11.13 ij	13.73 ef
S_0M_3	6.86 fg	10.73 j	13.26 fg
S_1M_0	6.33 i	9.53 l	12.06 ij
S_1M_1	8.33 b	13.26 de	15.53 c
S_1M_2	7.46 cd	11.73 h	14.53 d
S_1M_3	7.60 c	12.20 g	14.53 d
S_2M_0	6.53 hi	9.80 kl	12.40 hi
S_2M_1	9.13 a	14.66 b	17.13 a
S_2M_2	9.00 a	13.73 c	16.40 b
S_2M_3	7.73 c	12.46 fg	15.06 c
S_3M_0	6.66 gh	10.13 k	12.86 gh
S_3M_1	9.20 a	15.26 a	17.20 a
S_3M_2	8.46 b	13.66 cd	16.06 b
S_3M_3	8.26 b	12.86 ef	15.26 c
CV %	9.98	8.16	10.97
LSD (0.05)	0.28	0.45	0.47

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= 0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution,
M_0 =No Mulching (Control), M_1= Black polythene, M_2=Water hyacinth, M_3=Straw

The number of leaves was significantly influenced by the combined effect of starter solution and mulching at 20, 40 and 60 DAT (Table 4). At 20 DAT, the maximum number of leaves (9.20) was observed in S_3M_1 (2% starter solution and black polythene) treatment combination which was statistically similar to that of S_2M_1 (9.13) and S_2M_2 (9.0) respectively while the minimum number of leaves (5.93) was observed from S_0M_0 (control) treatment combination. At 40 DAT, the maximum number of leaves (15.26) was observed in S_3M_1 (2% starter solution with black polythene) treatment combination followed by S_2M_1 (14.66) and the minimum number of leaves (9.06) was observed from S_0M_0 (control)

treatment combination followed by S_1M_0 (9.53) treatment combination. Again at 60 DAT, the maximum number of leaves (17.20) was observed in S_3M_1 (2% starter solution with black polythene) treatment combination which was statistically identical with S_2M_1 (17.13). On the other hand, the minimum number of leaves (11.60) was found from S_0M_0 (control) treatment combination. It was appeared that number of leaves differ significantly due to the combined effect of starter solution and mulching.

4.3 Leaf length per plant

Leaf length per plant of broccoli showed statistically significant differences for different level of starter solution application at 20, 40 and 60 DAT (Table 5). At 20 DAT, the maximum length of leaf (22.29 cm) per plant was recorded from S_3 (2% urea solution) treatment while the minimum length of leaf (18.30 cm) was obtained from S_0 (control) treatment (Table 5). At 40 DAT, the maximum leaf length (41.98 cm) per plant was recorded from S_3 (2% urea solution) treatment that was statistically identical with (41.35 cm) S_2 (1.5% starter solution) treatment while the minimum leaf length (38.31 cm) was obtained from S_0 (control) treatment. Again at 60 DAT, the maximum leaf length (50.92 cm) per plant was recorded from S_3 (2% urea solution) treatment which was statistically identical with S_2 (49.98 cm) treatment. On the other hand, the minimum leaf length (45.95 cm) was obtained from S_0 (control) treatment. Here, S_3 (2% urea solution) gives longest leaf length because starter solution as nitrogen resulted in highly significant increase in longest leaf length, number of leaves, stem diameter etc. This result is in agreement with El-Afifi *et al.* (2014).

The effect of different mulching treatments on the leaf length per plant was found to be statistically significant at 20, 40 and 60 DAT (Table 6). At 20 DAT, the highest leaf length (22.46 cm) per plant was recorded from M_1 (black polythene) treatment while the lowest leaf length (17.06 cm) per plant was recorded from

M_0 treatment (control). Again at 40 DAT, the highest leaf length (42.24 cm) per plant was recorded from M_1 (black polythene) treatment which was statistically identical with (41.64 cm) M_2 (water hyacinth mulch)treatment and the minimum leaf length (37.30 cm) was recorded from M_0 (control) treatment. At 60 DAT, the highest leaf length (51.22 cm) was recorded from M_1 (black polythene) treatment followed by M_2 (50.03 cm) treatment. On the other hand, the lowest leaf length (44.73 cm) was recorded from M_0 (control) treatment.

Leaf length of broccoli was found statistically significant different due to the combined effect of starter solution and mulching at 20, 40 and 60 DAT (Table 7). At 20 DAT, the maximum leaf length (25.64 cm) per plant was recorded from S_3M_2 (2% urea with water hyacinth) treatment combination which was statistically identical with S_2M_1 (24.78 cm) treatment combination and the minimum leaf length (15.14 cm) per plant was recorded from S_0M_0 (control) treatment combination. Again at 40 DAT, the highest leaf length (45.32 cm) per plant was recorded from S_3M_2 (2% urea with water hyacinth) treatment combination which was statistically similar with S_2M_1 (44.40 cm) and on the other hand, the minimum leaf length (36.58 cm) was recorded from S_0M_0 (control) treatment combination. At 60 DAT, the maximum leaf length (54.71 cm) per plant was recorded from S_3M_2 (2% urea with water hyacinth) treatment combination which was statistically similar with (53.89 cm) S_2M_1 (1.5% starter solution with black polythene) while the minimum leaf length (43.69 cm) per plant was recorded from S_0M_0 (control).

Table 5: Effect of starter solution on leaf length of broccoli at different days after transplanting

Treatments	Leaf length at 20 DAT (cm)	Leaf length at 40 DAT (cm)	Leaf length at 60 DAT (cm)
S_0	18.30 c	38.31 c	45.95 c
S_1	20.08 b	40.12 b	48.20 b
S_2	21.50 a	41.35 a	49.98 a
S_3	22.29 a	41.98 a	50.92 a
CV %	10.68	11.58	10.45
LSD (0.05)	0.79	0.87	1.08

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

Here, S_0=0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution

Table 6: Effect of mulching on leaf length of broccoli at different days after transplanting

Treatments	Leaf length at 20 DAT (cm)	Leaf length at 40 DAT (cm)	Leaf length at 60 DAT (cm)
M_0	17.06 c	37.30 c	44.73 c
M_1	22.46 a	42.24 a	51.22 a
M_2	21.87 a	41.64 a	50.03 b
M_3	20.78 b	40.57 b	49.08 b
CV %	10.68	11.58	10.45
LSD (0.05)	0.56	0.63	1.01

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, M_0 =No Mulching (Control), M_1= Black polythene, M_2=Water hyacinth, M_3=Straw

Table 7: Combined effect of starter solution and mulching on leaf length of broccoli at different days after transplanting

Treatments combinations	Leaf length at 20 DAT (cm)	Leaf length at 40 DAT (cm)	Leaf length at 60 DAT (cm)
S_0M_0	15.14 k	36.58 h	43.69 j
S_0M_1	19.74 f-h	39.31 fg	47.42 f-h
S_0M_2	18.78 hi	38.24 gh	46.11 g-i
S_0M_3	19.53 gh	39.10 fg	46.60 g-i
S_1M_0	16.82 j	37.24 h	44.48 ij
S_1M_1	22.22 b-d	42.03 c-e	51.03 cd
S_1M_2	20.62 e-g	40.54 ef	48.18 e-g
S_1M_3	20.68 d-g	40.66 ef	49.12 d-f
S_2M_0	17.61 ij	37.34 h	45.15 ij
S_2M_1	24.78 a	44.40 ab	53.89 ab
S_2M_2	22.43 bc	42.47 cd	51.12 cd
S_2M_3	21.20 c-f	41.17 de	49.78 de
S_3M_0	18.66 hi	38.04 gh	45.59 h-j
S_3M_1	23.11 b	43.23 bc	52.54 bc
S_3M_2	25.64 a	45.32 a	54.71 a
S_3M_3	21.73 b-e	41.35 de	50.83 cd
CV %	10.68	11.58	10.45
LSD (0.05)	1.59	1.74	2.16

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=0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution

M_0 =No Mulching (Control), M_1= Black polythene, M_2=Water hyacinth, M_3=Straw

4.4 Leaf breadth

The breadth of leaf of broccoli varied significantly with the application of different levels of starter solutions at 20, 40 and 60 DAT (Table 8). At 20 DAT, the maximum breadth of leaf (10.66 cm) was found when 2% starter solution (S_3) was applied which was statistically identical to S_2 (10.37 cm) treatment and the lowest leaf breadth (8.44 cm) was measured in S_0 (control) treatment. Again at 40 DAT, the highest leaf breadth (14.45 cm) was measured from S_3 (2% starter solution) treatment. On the other hand, the lowest leaf breadth (11.98 cm) was recorded from S_0 (control) treatment. At 60 DAT, the maximum leaf breadth (18.35 cm) was measured from S_3 (2% starter solution) treatment which was statistically identical to S_2 (17.81 cm) treatment and on the other hand, the minimum leaf breadth (14.56 cm) was recorded from S_0 (control) treatment.

Mulching had a significant influence on leaf breadth of broccoli plants at 20, 40 and 60 DAT (Table 9). At 20 DAT, the maximum leaf breadth (11.25 cm) was found from M_1 (black polythene) treatment and the minimum leaf breadth (7.79 cm) was recorded in M_0 (control). Again at 40 DAT, the maximum leaf breadth (14.79 cm) was measured from M_1 (black polythene) treatment followed by M_2 (13.96 cm) treatment while the lowest leaf breadth (11.24 cm) was recorded from M_0 (no mulch) treatment. At 60 DAT, the maximum leaf breadth (19.12 cm) was found from M_1 (black polythene) treatment followed by M_2 (17.44 cm) treatment and on the other hand, the minimum leaf breadth (13.53 cm) was recorded from M_0 (no mulch) treatment. This might be due to mulching has profound influence on plant growth viz., leaf area index (LAI), net assimilation rate (NAR), crop growth rate (CGR), relative growth rate (RGR), also influence on soil temperature and moisture. Miedema (1982); Awal and Khan (1999) were found the same results in their investigations.

The leaf breadth was significantly influenced by the combined effect of starter solution and mulching at 20, 40 and 60 DAT (Table 10). At 20 DAT, the maximum leaf breadth (12.44 cm) was recorded from the treatment combination of S_3M_1 (2% starter solution with black polythene) which was statistically identical to S_2M_1 (12.25 cm) combined treatment and the minimum leaf breath (7.54 cm) was recorded from S_0M_0 (control) combined treatment. At 40 DAT, the maximum leaf breadth (16.58 cm) was observed in S_3M_1 (2% starter solution with black polythene) treatment combination followed by S_2M_1(15.49 cm) and on the other hand, the minimum leaf breadth (10.30 cm) was observed from S_0M_0 (control) combined treatment. Again at 60 DAT, the maximum leaf breadth (21.82 cm) was found from S_3M_1 (2% starter solution with black polythene) treatment combination and the minimum leaf breadth (12.95 cm) was found from S_0M_0 (control) treatment combination. It was appeared that leaf breadth differs significantly due to the combined effect of starter solution and mulching.

Table 8: Effect of starter solution on leaf breadth of broccoli at different days after transplanting

Treatments	Leaf breadth (cm)		
	20 DAT	40 DAT	60 DAT
S_0	8.44 c	11.98 d	14.56 c
S_1	9.64 b	13.27 c	16.64 b
S_2	10.37 a	13.83 b	17.81 a
S_3	10.66 a	14.45 a	18.35 a
CV (%)	9.62	10.66	11.43
LSD (0.05)	0.33	0.47	0.79

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

Here, S_0=0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution S_3= 2% urea solution.

Table 9: Effect of mulching on leaf breadth of broccoli at different days after transplanting

Treatments	Leaf breadth (cm)		
	20 DAT	40 DAT	60 DAT
M_0	7.79 c	11.24 c	13.53 c
M_1	11.25 a	14.79 a	19.12 a
M_2	10.11 b	13.96 b	17.44 b
M_3	9.95 b	13.54 b	17.26 b
CV (%)	9.62	10.66	11.43
LSD (0.05)	0.26	0.33	0.56

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

Here, M_0 =No Mulching (Control), M_1= Black polythene, M_2=Water hyacinth, M_3=Straw

Table 10: Combined effect of starter solution and mulching on leaf breadth of broccoli at different days after transplanting

Treatments combinations	Leaf breadth (cm)		
	20 DAT	40 DAT	60 DAT
S_0M_0	7.54 h	10.30 l	12.95 i
S_0M_1	9.42 e	12.65 gh	15.48 fg
S_0M_2	8.24 fg	12.41 h-j	14.58 gh
S_0M_3	8.56 f	12.54 g-i	15.23 fg
S_1M_0	7.63 gh	11.45 k	13.37 hi
S_1M_1	10.90 bc	14.44 cd	18.77 cd
S_1M_2	9.50 e	13.37 fg	16.52 ef
S_1M_3	10.51 cd	13.82 d-f	17.92 c-e
S_2M_0	8.05 f-h	11.68 i-k	14.24 g-i
S_2M_1	12.25 a	15.49 b	20.44 ab
S_2M_2	11.26 b	14.69 b-d	19.29 bc
S_2M_3	9.91 de	13.48 e-g	17.28 de
S_3M_0	7.92 f-h	11.54 jk	13.56 hi
S_3M_1	12.44 a	16.58 a	21.82 a
S_3M_2	11.43 b	15.36 bc	19.39 bc
S_3M_3	10.84 bc	14.34 de	18.63 cd
CV (%)	9.62	10.66	11.43
LSD (0.05)	0.66	0.94	1.58

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=0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution

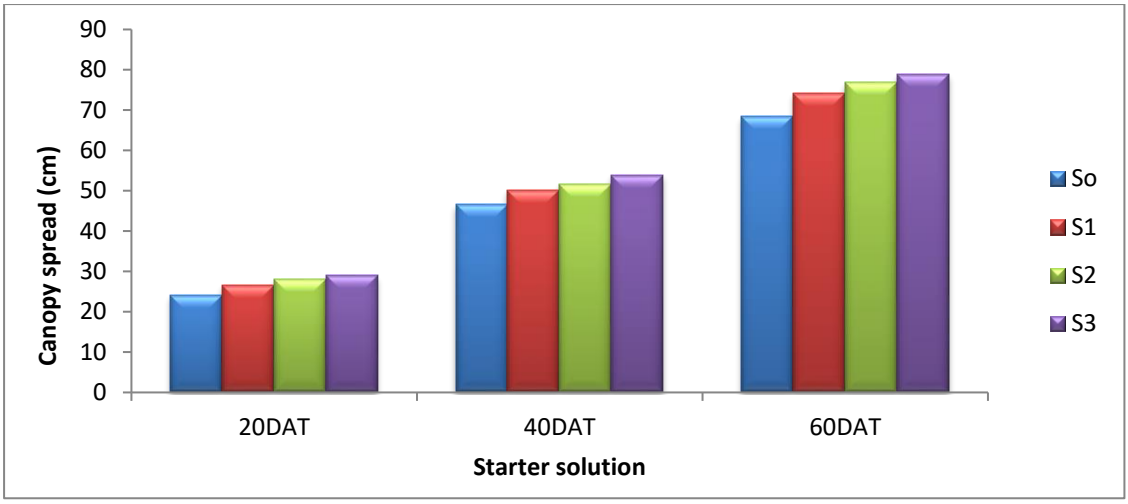
M_0 =No Mulching (Control), M_1= Black polythene, M_2=Water hyacinth, M_3=Straw

4.5 Canopy spread

Starter solution had a significant influence on canopy spread of broccoli plants at 20, 40 and 60 DAT (Fig. 4). At 20 DAT, S_3 (2% starter solution) treatment showed the maximum canopy spread (29.03 cm) followed by (28.02 cm) S_2 (1.5% starter solution) treatment and the minimum canopy spread (24.14 cm) was measured in S_0 (control). Again at 40 DAT, the maximum canopy spread (53.89 cm) was measured from 2% starter solution application (S_3) treatment while the minimum canopy spread (46.53 cm) was recorded from S_0 (control). At 60 DAT, the maximum canopy spread (78.86 cm) was measured from S_3 (2% starter solution) treatment followed by S_2 (76.80 cm) treatment while the minimum canopy spread (68.39 cm) was recorded from S_0 (0% starter solution).

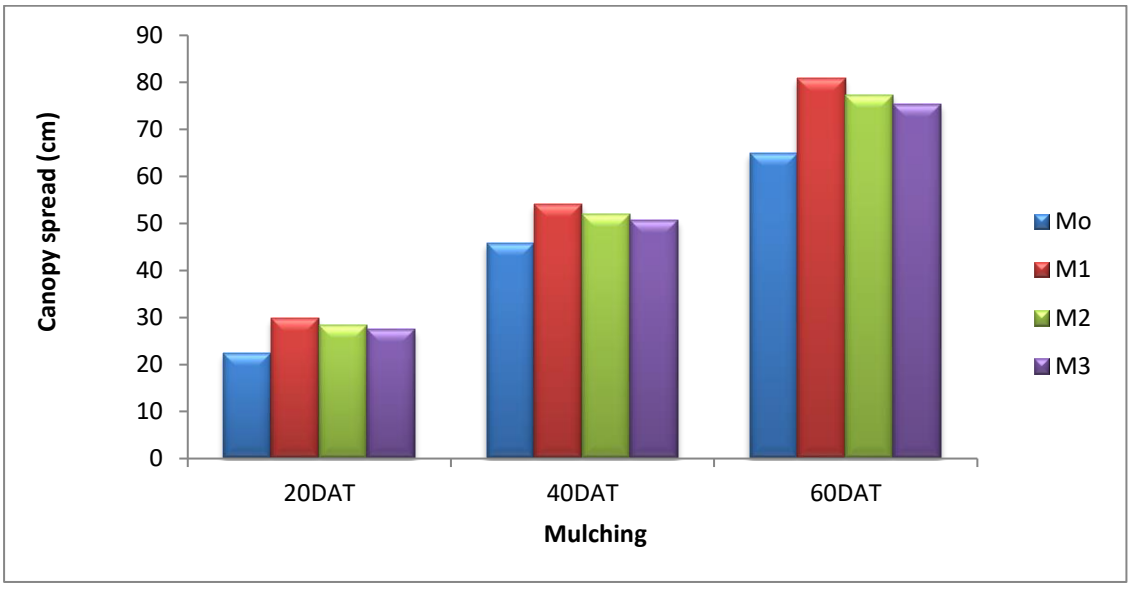
There was a significant influence on canopy spread of broccoli plants due to different mulching treatments at 20, 40 and 60 DAT (Fig. 5). At 20 DAT, M_1 (black polythene) treatment showed the maximum canopy spread (29.75 cm) and the minimum canopy spread (22.32 cm) was recorded in M_0 (control) treatment. At 40 DAT, the maximum canopy spread (54.10 cm) was found from M_1 (black polythene) treatment while the minimum canopy spread (45.76 cm) was recorded from M_0 (control) treatment. At 60 DAT, the maximum canopy spread (80.81 cm) was measured from M_1 (black polythene) treatment. On the other hand, the minimum canopy spread (64.87 cm) was recorded from M_0 (no mulch) treatment. In the present study black polythene mulched soil maintained a higher moisture content and distribute a more uniform temperature than the non-mulched soil which ultimately promoted plant growth.

Plant canopy spread was found to be significantly different due to the combined effect of starter solution and mulching at 20, 40 and 60 DAT (Table 11). At 20 DAT, the highest canopy spread (32.04 cm) was recorded from S_3M_1 (2% starter solution with black polythene) combined treatment which was statistically similar (31.64 cm) to S_3M_2 (2% starter solution and water hyacinth) combined treatment while the lowest canopy spread (21.21 cm) was recorded from S_0M_0 (control) treatment combination. At 40 DAT, the highest canopy spread (59.16 cm) was observed in S_3M_1 (2% starter solution with black polythene) combined treatment which was statistically similar with S_3M_2 (57.66 cm) and S_2M_1 (55.61 cm) respectively and on the other hand, the minimum canopy spread (43.60 cm) was observed from S_0M_0 (control) treatment combination. At 60 DAT, the highest canopy spread (85.10 cm) was observed in S_3M_1 (2% starter solution with black polythene) combined treatment which was statistically similar with S_3M_2 (84.33 cm) while the minimum canopy spread (62.56 cm) was found from S_0M_0 (control) treatment combination.



Here, S_0=0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution

Fig. 4: Effect of starter solution on canopy spread of broccoli at different days after transplanting



Here, M_0 =No Mulching (Control), M_1= Black polythene mulch, M_2=Water hyacinth, M_3=Straw

Fig. 5: Effect of mulching on canopy spread of broccoli at different days after transplanting

Table 11: Combined effect of starter solution and mulching on canopy spread of broccoli at different days after transplanting

Treatments combinations	Canopy spread (cm)		
	20 DAT	40 DAT	60 DAT
S_0M_0	21.21 m	43.60 f	62.56 n
S_0M_1	25.88 h	48.12 d-f	72.30 h
S_0M_2	24.34 j	46.92 ef	68.49 j
S_0M_3	25.12 i	47.48 d-f	70.22 i
S_1M_0	22.65 l	46.49 ef	65.66 l
S_1M_1	29.80 d	53.52 a-d	82.26 d
S_1M_2	26.66 g	49.43 c-f	74.04 g
S_1M_3	27.46 f	51.33 b-e	74.94 g
S_2M_0	21.96 l	46.10 ef	64.10 m
S_2M_1	31.30 b	55.61 a-c	83.58 bc
S_2M_2	30.56 c	53.83 a-d	82.38 cd
S_2M_3	28.28 e	51.50 b-e	77.16 f
S_3M_0	23.47 k	46.86 ef	67.16 k
S_3M_1	32.04 a	59.16 a	85.10 a
S_3M_2	31.64 ab	57.66 ab	84.33 ab
S_3M_3	28.98 e	51.8 b-e	78.84 e
CV %	9.27	9.56	12.87
LSD (0.05)	0.71	6.41	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

Note:

S_0=0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution

M_0 =No Mulching (Control), M_1= Black polythene, M_2=Water hyacinth, M_3=Straw

4.6 Stem length

The effect of different levels of starter solution was significant on stem length of broccoli plants at 20, 40 and 60 DAT (Table 12). At 20 DAT, S_3 (2% starter solution) treatment produced the maximum stem length (7.40 cm) which was statistically identical (7.32 cm) S_2 (1.5% starter solution) treatment and the minimum stem length (6.90 cm) was measured in S_0 (control) treatment. At 40 DAT, the maximum stem length (14.21 cm) was found from 2% starter solution (S_3) treatment while the minimum stem length (12.79 cm) was recorded from S_0 (0% starter solution) treatment. At 60 DAT, the maximum stem length (25.29 cm) was measured from S_3 (2% starter solution) treatment while the minimum stem length (23.31 cm) was recorded from S_0 (control) treatment.

The variation due to different mulching treatments under study was significant in respect of stem length of broccoli at 20, 40 and 60 DAT (Table 13). At 20 DAT, M_1 (black polythene) treatment produced the maximum stem length (7.46 cm) and the minimum stem length (6.74 cm) was recorded in M_0 (no mulch). Again at 40 DAT, the highest stem length (14.40 cm) was measured from M_1 (black polythene) treatment and on the other hand, the lowest stem length (12.37 cm) was recorded from M_0 (no mulch). At 60 DAT, the maximum stem length (25.65 cm) was measured from M_1 (black polythene) treatment followed by M_2 (24.57 cm) treatment while the minimum stem length (22.97 cm) was recorded from M_0 (no mulch) treatment. In case of black polythene mulch, the plant got sufficient moisture and higher temperature, probably that is why maximum stem length of plant was occurred.

The variation due to combined treatment of starter solution and mulching was significant on stem length of broccoli plant at 20,40 and 60 DAT(Table-14). At 20 DAT, the maximum stem length (7.69 cm) was recorded in S_3M_1 (2% starter solution with black polythene) treatment combination which was statistically similar to that of S_2M_1 (7.64 cm) while the minimum stem length (6.42 cm) was recorded from S_0M_0 (control) treatment combination. At 40 DAT, the maximum stem length (15.98 cm) was observed in S_3M_1 (2% starter solution with black polythene) treatment combination and on the other hand, the minimum stem length (11.93 cm) was observed from S_0M_0 (control) treatment combination. At 60 DAT, the maximum stem length (27.84 cm) was observed in S_3M_1 (2% starter solution with black polythene) treatment combination followed by S_2M_1 (26.28 cm) while the minimum stem length (22.71 cm) was found from S_0M_0 (control) treatment combination which was statistically similar with S_1M_0 (22.92 cm) treatment combination. It was appeared that stem length differs significantly due to the combined effect of starter solution and mulching.

Table 12: Effect of starter solution on stem length of broccoli at different days after transplanting

Treatments	Stem Length (cm)		
	20 DAT	40 DAT	60 DAT
S_0	6.90 c	12.79 d	23.31 d
S_1	7.13 b	13.21 c	23.94 c
S_2	7.32 a	13.66 b	24.67 b
S_3	7.40 a	14.21 a	25.29 a
CV %	9.37	10.42	7.45
LSD (0.05)	0.12	0.28	0.27

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=0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution

Table 13: Effect of mulching on stem length of broccoli at different days after transplanting

Treatments	Stem Length (cm)		
	20 DAT	40 DAT	60 DAT
M_0	6.74 c	12.37 c	22.97 d
M_1	7.46 a	14.40 a	25.65 a
M_2	7.31 b	13.64 b	24.57 b
M_3	7.24 b	13.47 b	24.02 c
CV %	9.37	10.42	7.45
LSD (0.05)	0.10	0.22	0.19

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, M_0 =No Mulching (Control), M_1= Black polythene, M_2=Water hyacinth, M_3=Straw

Table 14: Combined effect of starter solution and mulching on stem length of broccoli at different days after transplanting

Treatments combinations	Stem Length (cm)		
	20 DAT	40 DAT	60 DAT
S_0M_0	6.42 j	11.93 j	22.71 j
S_0M_1	7.12 e-g	13.26 f-h	23.77 f-h
S_0M_2	6.99 f-h	12.94 g-i	23.33 hi
S_0M_3	7.09 e-h	13.04 g-i	23.42 g-i
S_1M_0	6.73 i	12.22 j	22.92 ij
S_1M_1	7.39 b-d	13.89 c-e	24.73 cd
S_1M_2	7.16 d-g	13.31 f-h	23.99 e-g
S_1M_3	7.22 d-f	13.42 e-g	24.10 ef
S_2M_0	6.87 hi	12.49 ij	23.09 ij
S_2M_1	7.64 a	14.47 b	26.28 b
S_2M_2	7.47 a-c	14.07 b-d	25.14 c
S_2M_3	7.30 c-e	13.63 d-f	24.20 d-f
S_3M_0	6.95 g-i	12.82 hi	23.17 ij
S_3M_1	7.69 a	15.98 a	27.84 a
S_3M_2	7.60 ab	14.26 bc	25.82 b
S_3M_3	7.36 cd	13.78 c-f	24.35 de
CV %	9.37	10.42	7.45
LSD (0.05)	0.24	0.56	0.57

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=0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution

M_0 =No Mulching (Control), M_1= Black polythene, M_2=Water hyacinth, M_3=Straw

4.7 Stem diameter

Significant variation among the starter solutions had been observed in diameter of stem.at harvest (Table 15). At harvesting, the maximum stem diameter (2.43 cm) was measured from S_3 (2% starter solution) treatment while the minimum stem diameter (1.89 cm) was recorded from S_0 (control) treatment.

The stem diameter of plant was found to be significantly influenced due to the application of different types of mulches (Table 16). At harvesting, the highest stem diameter (2.47 cm) was measured from M_1 (black polythene) treatment while the lowest stem diameter (1.68 cm) treatment was recorded from M_0 (control) treatment. These results showed that mulches provided favorable condition for plant growth by preserving soil moisture and increasing soil

temperature with suppressed weed growth probably which helps to produce the maximum stem diameter compared to the control treatment.

The combined effect of different starter solutions and mulching was also found significant in respect of diameter of stem of broccoli plant at harvest (Table 17). At harvesting, the highest stem diameter (2.82 cm) was observed in S_3M_2 (2% starter solution with water hyacinth) treatment combination and the lowest stem diameter (1.55cm) were found from S_0M_0 (control) treatment combination. It was appeared that stem diameter differs significantly due to the combined effect of starter solution and mulching.

Table 15: Effect of starter solution on stem diameter of broccoli at harvest

Treatments	Stem diameter at harvest (cm)
S_0	1.89 d
S_1	2.10 c
S_2	2.30 b
S_3	2.43 a
CV %	7.31
LSD (0.05)	0.09

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

Here, S_0=0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution

Table 16: Effect of mulching on stem diameter of broccoli at harvest

Treatments	Stem diameter at harvest (cm)
M_0	1.68 d
M_1	2.47 a
M_2	2.36 b
M_3	2.22 c
CV %	7.31
LSD (0.05)	0.06

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, M_0=No Mulching (Control), M_1= Black polythene, M_2=Water hyacinth, M_3=Straw

Table 17: Combined effect of starter solution and mulching on stem diameter of broccoli at harvest

Treatments combinations	Stem diameter (cm)
S_0M_0	1.55 o
S_0M_1	2.14 i
S_0M_2	1.98 j
S_0M_3	1.90 k
S_1M_0	1.64 n
S_1M_1	2.40 f
S_1M_2	2.08 i
S_1M_3	2.30 g
S_2M_0	1.71 m
S_2M_1	2.74 b
S_2M_2	2.56 d
S_2M_3	2.22 h
S_3M_0	1.82 l
S_3M_1	2.63 c
S_3M_2	2.82 a
S_3M_3	2.48 e
CV %	7.31
LSD (0.05)	0.07

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=0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution

M_0 =No Mulching (Control), M_1= Black polythene, M_2=Water hyacinth, M_3=Straw

4.8 Diameter of primary curd

Application of starter solution exhibited a significant influence on diameter of primary curd of broccoli plants (Table 18). The maximum curd diameter (15.54 cm) was measured from S_3 (2% starter solution) treatment which was statistically identical to (15.31 cm) S_2 (1.5% starter solution) treatment while the minimum diameter of primary curd (13.82 cm) was measured from S_0 (control) treatment. It was revealed that the curd diameter increased with increased level of starter solution application. This might be due to slow and continuous nutrient supply. That helps in uniform curd formation. During curd formation continuous nutrient supply is very much essential.

The variation due to different mulching treatments under study was significant in respect of curd diameter (Table 19). The maximum curd diameter (15.81 cm) was measured from M_1 (black polythene) treatment while the minimum curd diameter (13.31 cm) was recorded from M_0 (control). Similar trend of the result was found by Rahman *et al*. (1989). Such effect may be attributed to the presence of sufficient amount of soil moisture present under black polythene mulch which subsequently has contributed in the formation of larger and comparatively broader curd of broccoli.

The combined effect of different starter solutions and mulching was also found significant in respect of diameter of primary curd of broccoli (Table 20). The maximum primary curd diameter (16.62 cm) was measured from S_3M_1 (2% starter solution with black polythene) combined treatment which was statistically similar to that of S_3M_2 (16.01 cm) and S_2M_1 (16.16 cm) combined treatment respectively while the minimum curd diameter (12.02 cm) was recorded from S_0M_0 (no starter solution and no mulch) combined treatment followed by S_1M_0 (13.45 cm) treatment combination.

4.9 Weight of primary curd

Starter solution exhibited a significant influence on weight of primary curd of broccoli plants (Table 18). The maximum primary curd weight (416.42 g) was measured from S_3 (2% starter solution) treatment which was statistically identical to (406.12 g) S_2 (1.5% starter solution) treatment while the minimum primary curd weight (324.71 g) was recorded from S_0 (control) treatment. It was revealed that the primary curd weight increased with starter solution application.

There was a significant influence of mulching on weight of primary curd of broccoli per plant (Table 19). The maximum primary curd weight (442.24 g) was measured from M_1 (black polythene) treatment followed by M_2 (395.22 g) treatment while the minimum weight of primary curd (286.33 g) was recorded from M_0 (control) treatment. The results of the present study are comparable to

the findings of Runham *et al.* (2000) also found that mulches gave higher curd weight in broccoli than non-mulched plots. Awal and Khan (1999) reported that mulching increased the weight of primary curd over the control. Similar trend was found by other scientists like Ali (2004).

The combined effect of starter solution and mulching had significant influence on the primary curd weight of broccoli (Table 20). The maximum primary curd weight (492.33 g) was measured from S_3M_1 (2% starter solution with black polythene) combined treatment which was statistically similar to (483.93 g) S_2M_1 (1.5% starter solution with black polythene) treatment combination while the minimum weight of primary curd (266.96 g) was recorded from S_0M_0 (control) treatment combination. Weight of primary curd is important for increasing total production of broccoli.

Table 18: Effect of starter solution on primary curd diameter, primary curd weight, no. of secondary curd per plant and weight of secondary curd of broccoli at different days after transplanting

Treatments	Primary curd diameter (cm)	Primary curd weight (g)	No. of secondary curd per plant	Weight of secondary curd (g)
S_0	13.82 c	324.71 c	3.79 d	73.00d
S_1	14.97 b	370.38 b	4.23 c	81.04 c
S_2	15.31 a	406.12 a	4.63 b	94.05 b
S_3	15.54 a	416.42 a	4.80 a	101.84 a
CV %	11.93	9.87	10.34	11.25
LSD (0.05)	0.32	18.21	0.13	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=0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution

Table 19: Effect of mulching on primary curd diameter, primary curd weight, no. of secondary curd per plant and weight of secondary curd of broccoli at different days after transplanting

Treatments	Primary curd diameter (cm)	Primary curd weight (g)	No. of secondary curd per plant	Weight of secondary curd (g)
M_0	13.31 c	286.33 c	3.26 d	62.92 d
M_1	15.81 a	442.24 a	5.06 a	107.85 a
M_2	15.30 b	395.22 b	4.66 b	93.58 b
M_3	15.22 b	393.84 b	4.48 c	85.59 c
CV %	11.93	9.87	10.34	11.25
LSD (0.05)	0.21	13.02	0.11	1.43

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, M_0 =No Mulching (Control), M_1= Black polythene, M_2=Water hyacinth, M_3=Straw

Table 20: Combined effect of starter solution and mulching on primary curd diameter, primary curd weight, no. of secondary curd per plant and weight of secondary curd of broccoli at different days after transplanting

Treatments combinations	Primary curd diameter (cm)	Primary curd weight (g)	No. of secondary curd per plant	Weight of secondary curd (g)
S_0M_0	12.02 i	266.96 j	3.08 k	52.76 o
S_0M_1	14.77 ef	367.56 fg	4.18 g	82.40 i
S_0M_2	14.04 gh	318.93 hi	3.93 h	77.19 k
S_0M_3	14.47 fg	345.39 gh	3.97 h	79.66 j
S_1M_0	13.45 h	288.97 ij	3.18 k	59.60 n
S_1M_1	15.70 b-d	425.13 c-e	4.96 d	93.40 e
S_1M_2	15.52 cd	377.09 fg	4.28 g	84.63 h
S_1M_3	15.22 de	390.32 ef	4.51 f	86.53 g
S_2M_0	13.86 gh	292.29 ij	3.32 j	66.12 m
S_2M_1	16.16 ab	483.93 ab	5.40 b	120.83 b
S_2M_2	15.65 b-d	430.49 cd	5.17 c	102.60 d
S_2M_3	15.58 b-d	417.75 de	4.62 f	86.64 g
S_3M_0	13.91 gh	297.11 ij	3.45 i	73.19 l
S_3M_1	16.62 a	492.33 a	5.70 a	134.76 a
S_3M_2	16.01 a-c	454.35 bc	5.25 c	109.90 c
S_3M_3	15.62 b-d	421.88 c-e	4.81 e	89.53 f
CV %	11.93	9.87	10.34	11.25
LSD (0.05)	0.62	31.42	0.11	1.10

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=0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution

M_0 =No Mulching (Control), M_1= Black polythene, M_2=Water hyacinth, M_3=Straw

4.10 Number of secondary curd per plant

The secondary curds were those, which develop after harvest of the primary curd. Number of secondary curd of broccoli plant is important for increasing total production. Application of starter solution exhibited a significant influence on number of secondary curd of broccoli plants (Table 18). The maximum number of secondary curds (4.80) was observed from S_3 (2% starter solution) treatment followed by S_2 (4.63) treatment while the minimum number of secondary curd (3.79) was observed from S_0 (0% starter solution). It was revealed that the number of secondary curd increased with starter solution application.

Mulching exhibited a significant influence on number of secondary curd of broccoli plants (Table 19). The maximum numbers of secondary curds (5.06) were observed from M_1 (black polythene) treatment while the minimum numbers of secondary curds (3.26) was observed in M_0 (control) treatment.

The results on the combined effect of starter solutions and mulching on the number of secondary curd per plant was significantly influenced (Table 20). The maximum number of secondary curds (5.70) was observed from S_3M_1 (2% starter solution with black polythene) combined treatment followed by S_2M_1 (5.40) while the minimum number of secondary curd (3.08) was recorded from S_0M_0 (control) treatment combination.

4.11 Weight of secondary curd

Starter solution exhibited a significant influence on weight of secondary curd of broccoli plants (Table 18). The maximum secondary curd weight (101.84 g) was measured from S_3 (2% starter solution) treatment followed by S_2 (94.05 g) treatment while the minimum secondary curd weight (73.00 g) was recorded from S_0 (control) treatment. It was revealed that the secondary curd weight increased with starter solution application.

Mulching showed a significant influence on weight of secondary curd of broccoli plants (Table 19). The maximum secondary curd weight (107.85 g) was measured from M_1 (black polythene) treatment while the minimum weight of secondary curd (62.92 g) was recorded from M_0 (control). It was revealed that the secondary curd weight increased with mulching application. Mulching retain soil moisture that helps to increase primary curd weight of broccoli. Runham *et al*. (2000) also found that mulches gave higher curd weight in broccoli then non-mulched plots.

Weight of secondary curd was significantly influenced by the combined effect of starter solution and mulching (Table 20). The maximum secondary curd weight (134.76 g) was measured from S_3M_1 (2% starter solution with black polythene) treatment combination while the minimum weight of secondary curd (52.76 g) was recorded from S_0M_0 (no starter solution and no mulch) combined treatment followed by S_1M_0 (59.60 g) treatment combination. Weight of secondary curd is important for increasing total production of broccoli.

4.12 Yield per plant

Different concentrations of starter solution influenced significantly on yield of curd per plant of broccoli was recorded after harvest. (Table 21). The highest yield of curd per plant (472.21 g) was recorded from S_3 (2% urea solution) treatment which is statistically identical with (455.65 g) S_2 (1.5% starter solution) treatment whereas the lowest yield of curd per plant (356.05 g) was recorded from S_0 (control) treatment (Table 21). Here, S_3 (2% urea solution) treatment gives highest yield per plant while S_2 (1.5% urea solution) treatment increases more vegetative growth. Mital *et al.* (1975). reported that increasing nitrogen rates increase head weight, increases 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 curd per plant showed significant variation due to different mulching at harvest. (Table 22). The highest yield of curd per plant (504.18 g) was found from M_1 (black polythene) treatment followed by M_2 (443.37 g) treatment while the lowest yield of curd per plant (309.25 g) was recorded from M_0 (no mulch) treatment.

Combined effect of different concentrations of starter solution and mulching showed significant differences on yield of curd per plant of broccoli. (Table 23). The highest yield per plant (577.69 g) was recorded from S_3M_1 (2% starter solution with black polythene) combined treatment which is statistically identical with (556.51 g) S_2M_1 (1.5% starter solution with black polythene) while the lowest yield of curd per plant (285.04 g) was found from S_0M_0 (control) treatment combination.

4.13 Yield per plot

Significant variation was recorded yield per plot of broccoli due to different concentrations of starter solution. (Table 21). The highest yield per plot (4.24 kg) was recorded from S_3 (2% urea solution) treatment whereas the lowest yield per plot (3.20 kg) was recorded from S_0 (control) treatment. The findings of the present study also corroborate with the findings of Islam *et al* (1989). They reported that starter solution significantly influenced the production of marketable yield of cabbage. They also stated that the highest yields were noticed from the treatment of 1.5% solution. However, the untreated seedlings give the lowest yield. The findings are also in accordance with that of Patil *et. al* (1979).

Application of different mulching showed significant variation on yield per plot. The highest yield per plot (4.53 kg) was found from M_1 (black polythene) treatment while the lowest yield per plot (2.78 kg) was recorded from M_0 (control) treatment (Table 22). Halappa and Sreenivas (1973) reported that black polythene mulch helped in the retention of soil moisture, prevented deterioration of soil structure, reduced differences between maximum and minimum soil

temperature and increased cauliflower yield by 40%. In this experiment black polythene mulch possibly maintained a higher moisture content and a more uniform temperature distribution resulting in maximum yield of broccoli.

Combined effect of different concentrations of starter solution and mulching showed significant differences on yield per plot of broccoli. (Table 23). The highest yield per plot (5.19 kg) was recorded from S_3M_1 (2% starter solution with black polythene) treatment combination which was statistically similar with (5.00 kg) S_2M_1 (1.5% starter solution with black polythene). Again the lowest yield per plot (2.56 kg) was found from S_0M_0 (control) treatment combination.

Table 21: Effect of starter solution on yield per plant and yield per plot at harvest

Treatments	Yield/Plant (g)	Yield /Plot(kg)
S_o	356.05 c	3.2045 c
S_1	409.46 b	3.6852 b
S_2	455.68 a	4.1011 a
S_3	472.21 a	4.2498 a
CV %	10.63	10.56
LSD (0.05)	18.17	0.16

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

Here, S_0=0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution

Table 22: Effect of mulching on yield per plant and yield per plot at harvest

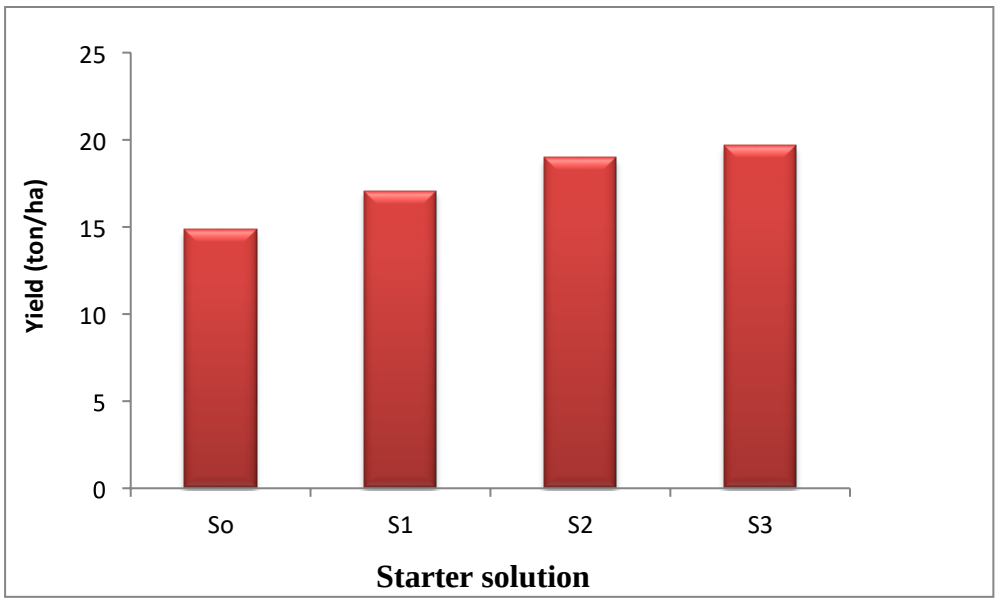
Treatments	Yield/Plant (g)	Yield /Plot(kg)
M_0	309.25 c	2.7832 c
M_1	504.18 a	4.5376 a
M_2	443.37 b	3.9904 b
M_3	436.59 b	3.9293 b
CV %	10.63	10.56
LSD (0.05)	15.22	0.18

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, M_0 =No Mulching (Control), M_1= Black polythene, M_2=Water hyacinth, M_3=Straw

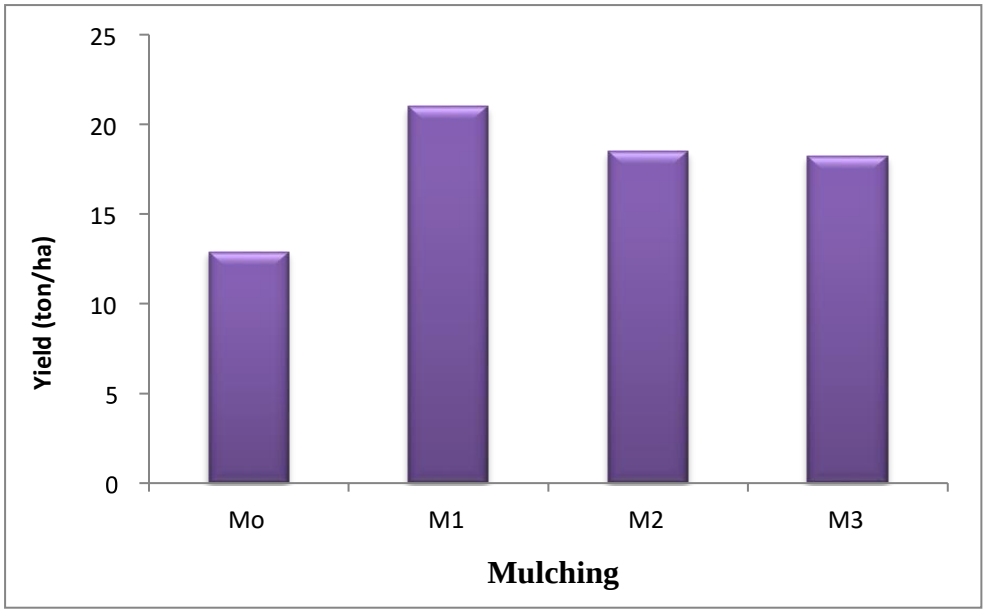
4.14 Yield

Significant variation was recorded on yield (ton/ha) of broccoli due to different concentrations of starter solution. (Fig. 6). The highest yield (19.67 ton/ ha) was recorded from S_3 (2% urea solution) treatment whereas the lowest yield (14.83 ton/ha) was recorded from S_0 (control) treatment. Here, S_3 (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 Raman *et al.* (1989).



Here, S_0=0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution

Fig. 6: Effect of starter solution on yield of broccoli at harvest



Here, M_0 =No Mulching (Control), M_1= Black polythene, M_2=Water hyacinth, M_3=Straw

Fig. 7: Effect of mulching on yield of broccoli at harvest

Different mulching showed significant variation on yield (ton/ha) (Fig. 7). The highest yield (21.00 ton/ha) was found from M_1 (black polythene) treatment, while the lowest yield (12.88 ton/ha) was recorded from M_0 (control) treatment.

Significant variation was observed due to the combined effect of starter solution and mulching on yield (ton/ha) of broccoli (Table 23). The highest yield (24.07 ton/ha) was recorded from S_3M_1 (2% starter solution with black polythene) treatment combination which was statistically identical with (23.19 ton/ha) S_2M_1 (1.5% starter solution with black polythene). Again the lowest yield (11.87 ton/ha) was found from S_0M_0 (control) treatment combination.

Table 23. Effect of starter solution and mulching on yield per plant, yield per plot and yield

Treatment combination	Combined effect of starter solution and mulching		
	Yield/plant (g)	Yield/plot (Kg)	Yield (ton/ha)
S_0M_0	285.04 j	2.56 j	11.87 j
S_0M_1	405.93 ef	3.65 ef	16.91 ef
S_0M_2	352.68 gh	3.17 gh	14.69 gh
S_0M_3	380.57 fg	3.42 fg	15.85 fg
S_1M_0	310.07 ij	2.79 ij	12.92 ij
S_1M_1	476.60 c	4.28 c	19.85 c
S_1M_2	417.41 e	3.75 e	17.39 e
S_1M_3	433.76 de	3.90 de	18.07 de
S_2M_0	316.69 h-j	2.85 ij	13.19 ij
S_2M_1	556.51 a	5.00 a	23.19 a
S_2M_2	487.21 bc	4.38 bc	20.30 bc
S_2M_3	462.33 cd	4.16 cd	19.26 cd
S_3M_0	325.20 hi	2.92 hi	13.55 hi
S_3M_1	577.69 a	5.19 a	24.07 a
S_3M_2	516.21 b	4.64 b	21.51 b
S_3M_3	469.73 cd	4.22 cd	19.57 cd
CV %	10.63	10.56	9.23
LSD (0.05)	32.24	0.32	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.

S_0=0% urea solution, S_1=1% urea solution, S_2=1.5% urea solution, S_3= 2% urea solution, M_0 =No Mulching (Control), M_1= Black polythene mulch, M_2=Water hyacinth mulch, M_3=Straw mulch

4.15 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.

4.15.1 Gross return

The combination of starter solution and mulching showed different values in terms of gross return under the trial (Table 24 and Appendix VIII-IX). The highest gross return (Tk. 962800) was found from the treatment combination S_3M_1 and the second highest gross return (Tk. 927600) was obtained from S_2M_1 treatment combination. The lowest gross return (Tk. 474800) was obtained from S_0M_0.

4.15.2 Net return

In case of net return, different treatment combination showed different levels of net return under the present trial (Table 24 and Appendix VIII-IX). The highest net return (Tk. 604339) was obtained from the treatment combination S_3M_1 and the second highest net return (Tk. 569583) was found from the combination S_2M_1. The lowest (Tk. 141980) net return was found from S_0M_0 treatment combination.

4.15.3 Benefit Cost Ratio

The combination of different concentration of starter solution and mulching for benefit cost ratio was different in all treatment combination (Table 24). The highest benefit cost ratio (2.69) was found from the treatment combination S_3M_1 and the second highest benefit cost ratio (2.59) was found from S_2M_1 treatment combination. The lowest benefit cost ratio (1.43) was found from the S_0M_0

(control) treatment combination. From the economic point of view, it was apparent from the above results that the treatment combination of S_3M_1 was more profitable than rest of treatment combinations.

Table 24. Cost and return of broccoli cultivation as influenced by starter solution and mulching

Treatments combinations	Cost of production (Tk / ha)	Yield (t/ha)	Gross return (Tk /ha)	Net return (Tk /ha)	BCR
S_0M_0	332820	11.87	474800	141980	1.43
S_0M_1	357240	16.91	676400	319160	1.89
S_0M_2	355020	14.69	587600	232580	1.65
S_0M_3	356130	15.85	634000	277870	1.78
S_1M_0	333375	12.92	516800	183425	1.55
S_1M_1	357575	19.85	794000	436425	2.22
S_1M_2	355575	17.39	695600	340025	1.95
S_1M_3	356685	18.07	722800	366115	2.03
S_2M_0	333597	13.19	527600	194003	1.58
S_2M_1	358017	23.19	927600	569583	2.59
S_2M_2	355797	20.30	812000	456203	2.28
S_2M_3	356907	19.26	770400	413493	2.16
S_3M_0	334041	13.55	542000	207959	1.62
S_3M_1	358461	24.07	962800	604339	2.69
S_3M_2	356241	21.51	860400	504159	2.42
S_3M_3	357351	19.57	782800	425449	2.19

Here, S_0= 0% urea, S_1=1% urea, S_2=1.5% urea, S_3= 2% urea
M_0 =No Mulching (Control), M_1= Black polythene, M_2=Water hyacinth, M_3=Straw
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. 40000/ton
Net return =Gross return – Total cost of production
Benefit cost ratio = Gross return ÷ Total cost of production

CHAPTER V
SUMMARY AND CONCLUSION

A field experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh, during the period from October 2018 to March 2019 to study the "Influence of starter solution and mulching on growth and yield of broccoli." The experiment comprised of four levels of starter solution viz., S_0 (0% Urea (Control)), S_1 (1% Urea), S_2 (1.5% Urea) and S_3 (2% Urea) and four levels of mulching viz., M_0 (control), M_1 (black polythene), M_2 (water hyacinth) and M_3 (rice straw). Thus, there were sixteen treatments and the experiment was laid out in randomized complete block design with three replications.

All the growth and yield contributing characters like plant height, number of leaves, leaf length, leaf breadth, plant canopy, stem length of curd, stem diameter, diameter of primary curd, weight of primary curd, number of secondary curd per plant, weight of secondary curd, yield per plant, yield per plot and yield per hectare varied significantly due to starter solution and mulching.

Application of starter solution exhibited a significant influence on the plant height, number of leaves, leaf length, leaf breadth, plant canopy, stem length of curd, stem diameter, diameter of primary curd, weight of primary curd, number of secondary curd per plant, weight of secondary curd of broccoli plants at 20, 40 and 60 days after transplanting (DAT).

Application of mulching exhibited a significant influence on the plant height, number of leaves, leaf length, leaf breadth, plant canopy, stem length of curd, stem diameter, diameter of primary curd, weight of primary curd, number of secondary curd per plant, weight of secondary curd of broccoli plants at 20, 40 and 60 days after transplanting (DAT).

By the treatment combinations at 20, 40 and 60 DAT the plant height, number of leaves, leaf breadth, plant canopy, stem length of curd, diameter of primary curd, weight of primary curd, number of secondary curd per plant, weight of secondary curd of broccoli plants was significantly influenced. In all the cases combination of S_3M_1 were gave better results. But S_3M_2 treatment combination gave better result in the case of leaf length and stem diameter.

Yield parameters like yield per plant, yield per plot and yield per hectare varied significantly due to starter solution, mulching and treatment combinations of starter solution and mulching. Yield per plant is important for increasing total yield. Application of starter solution exhibited a significant influence on yield per plant. The maximum yield (19.67 ton/ha) was recorded from S_3 (2% Starter solution). Mulching exhibited a significant influence on total yield per plant. The maximum yield (21.00 t/ha) was recorded from M_1 (Black polythene). Yield per plant was significantly influenced by the treatment combinations of starter solution and mulching of broccoli. The maximum yield (24.07 t/ha) was recorded from the treatment combination of S_3M_1.

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. Black polythene gave best results for both vegetative growth and yield of broccoli.
3. So, it can be concluded that combination of 2% urea solution and Black polythene 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

REFERENCES

Agarwal, S. K. and De. 1977. Effect of application of nitrogen, mulching and antitranspirants on the growth and yields of barley. *Indian. J. Agril. Sci*., **47**(4): 190-194.

Ahmed, K. U. and Shahjahan, M. 1991. Homestead vegetable production. Training Manual, OFRD, BARI, Gazipur. Pp. 1-24.

Alam, M. S., Iqbal, T. M. T., Amin, M. and Gaffar, M. A. 1989. Krishitattic Fasaler Utpadan O Unnayan (in Bengali). T. M. Jubair Bin Iqbal, Sirajgonj. p. 231-239.

Ali, R. M. 2004. Effect of mulching and different levels of N fertilizers on growth and yield of broccoli. M.Sc. thesis, Department of Horticulture, Bangladesh Agricultural University, Mymensingh, Bangladesh. pp. 79-83.

Amal, K. A., Muslin, A. A. and Khan, A. H. 1990. Effect of different mulches on the growth of potato (*Solanum tuberosum* L.). *Bangladesh J. Bot.*, **19**(1): 56-60.

Anonymous, 1981. Annual Report, Bangladesh Agricultural Research Institute, Joydebpur, Dhaka, p. 29.

Awal, M. A. and Khan, M. A. H. 1999. Alteration of soil temperature and moisture through mulching on the morphophysiological differentiation in maize. *Pakistan J. Biol. Sci.,* **2**(4): 1164-1167.

BARI. 2005. Krishi Projukti Hatboi, Bangladesh Agricultural Research Institute, Joydevpur, Gazipur. p. 304.

Braga-nolo, N. and Mielniezuk, Y. 1990. Soil mulching by wheat straw and its relation to soil temperature and moisture. *Revista Brasilerira de Ciencia do Solo.,* **14**(3):369-373. [Cited from Wheat, Barley and Triticale Abstr., 51(416), 1992]

Burnette, R. R., Coffey, L. D. and Brooker, J. R. 1993. Economic implications of nitrogen fertilization, drip irrigation and plastic culture on cole crops and tomato grown sequentially. *Tennessee Farm Home Sci*., **168**: 5-13.

Campiglia, E. O., Temperini, R., Mancinelli and Saccardo, F. 2000. Effects of soil solarization on weed control on cauliflower and fennel production in open field. *Acta Hort*., 533: 249-255.

Carvalho, Jose F. de., Abelardo, A. A., Montenegro Tales, M., Soares, Enio F. de F. Silva, Suzana, M. G. L. and Montenegro, 2011. Effect of mulching and different irrigation intervals with moderately saline water on cabbage yield. *Revista Brasileira de Engenharia Agrícola e Ambi ental,* **15** (3): 256–263.

Chaudhury, B. and Singh. S. N. 1960. Seed treatment with plant regulators and their effect on the growth and yield of tomato (*Lycopercicon esculentum* Mill.). *Indian. J. Hort*., **17**(1): 48-55.

Chhonkar, V. S. 1959. Starter solution the answer to transplanting troubles, *Indian J. Hort.,* **4**(1): 7-9.

Chhonkar, V. S. and Jha, R. N. 1963. The use of starter solutions and plant growth regulators in transplanting of cabbage and their response on growth and yield. *Indian J. Hort*., **20**(2): 122-128.

Chhonkar. V. S. and Sharma, S. B. 1966. Studies on the effect of starters and plant growth regulators on growth, yield and quality of cauliflower (*Brassica oleracea* var. hotrvuis L). *Indian. Hort*., **23**: 81-87.

Deshmukh Y. K., Sinha, J., Sinha, G. and Verma, P. D. 2013. Effect of mulches and level of irrigation on soil temperature, soil moisture depletion and crop yield of bottle gourd. *Int. J. Applied Eng. Tech.*, **3** (3): 29-35

Diaz-Perez, J. C., Phatak, S. C., Ruberson, J. and Morse, R. 2012. Mulches increase yield and improve weed control in organic Broccolli. *Acta Hort.*, 933-943.

Easmin, D., Islam, M. J. and Begum, K. 2009. Effect of different levels of nitrogen and mulching on growth of chinese cabbage (*Brassica campestris* var. *Pekinensis*). *Prog. Agric.*, **20** (1 & 2): 27-33.

El-Afifi, S. T., Zaghloul, M. M., El- Sawy, M. B. I. and Hashim, A. M. A. 2014. The effect of starter solutions in soil and foliar spray with some stimulants on growth and productivity of chinese cabbage. *Plant Production, Mansoura Univ.*, **5** (1): 21- 40.

FAO. 1988. Land Resources Appraisal of Bangladesh for Agricultural Development. Report No.2. Agio-ecological Regions of Bangladesh. Food and Agriculture Organization of the United Nations, Rome, Italy. pp. 212-221.

Faruque, A. C. 2004. Effect of different sources of nutrients and mulching on growth and yield of broccoli. M.S. thesis, Department of Horticulture, Bangladesh Agricultural University, Mymensingh, Bangladesh. pp. 80-83.

Gandhi, N. and Bains, G. S. 2006. Effect of mulching and date of transplanting on yield contributing characters of tomato. *J. Res. Punjab Agric. Uni.,* **43**: 6-9.

Gattorman, G. W. 1992. Effect of various types of plastic film on soil temperature and vegetable yield. Norsk-Land Bruksforsking. *Hort. Abst*., **76** (1): 51-60.

Gomez. K. A. and Gomez, A. A. 1984. Statistical Procedures for Agricultural Research. 2nd edition. John Willy and Sons, New York. pp. 28-192.

Halappa, G. and Sreenivas, L. 1973. Effect of black polythene film mulch on soil conditions and yield of cauliflower. *Mysore* J. *Agril. Sci.,* **7**(4): 510-519.

Hashem, M. A. 2005. Effect of manuring and mulching on the growth and yield of broccoli. M.S. thesis, Department of Horticulture, Bangladesh Agricultural University, Mymensingh, Bangladesh. pp. 64-65

Henmis, S., Abe, I. and Endo, T. 1973. The effect of starter solutions on the growth and yields of tomatoes and cabbage transplanted by machine. *Bulletin of the Hort. Station*., **8**:27-40.

Hossain, M. E. 1999. Effect of different sources of nutrients and mulching on growth and yield of cabbage. M.S. thesis, Department of Horticulture, Bangladesh Agricultural University, Mymensingh, Bangladesh. pp. 29-68.

Islam, M. M., Rahim, M. A. and Alam, M. S. 2002. Effect of planting time, mulching and irrigation on growth and yield of cabbage. *Bangladesh J. Training and Devel.*, **15 (**1/2): 169174.

Islam, M. N., Farooque A. M. and Mondal, M. F. 1989. Effect of starter solution on the growth and yield of cabbage. *Bangladesh Hort.,* **17**(2).

Jasim, Ali Husain, Moham, Hameed, F., Wasan, M. and Timman, Abo Al. 2014. Influence of polyethylene mulch foliar application of urea complete fertilizers, seaweed in alleviating salt stress of broccoli (*Brassica oleracea* var. *Italica*). *J. Bio., Agric. Healt.,* **4** (25): 25-32.

Juan Diaz-Perez, C. 2009. Root zone temperature, plant growth and yield of broccoli (*Brassica oleracea* cv. *italica*) as affected by plastic film mulches. *Scientia Hort.*, **12** (2): 156-163.

Kadam, P. Y., Bhore, D. P. and Shirsath. N. S. 1983. Effect of sulphate as starter solution on cabbage. *.1nt. Maharastra Agric. Univ*., **8**(2): 236-237.

Kalisz, A. and Cebula, S. 2001. Direct plant covering and soil mulching in the spring production of some Chinese cabbage cultivars growth and yield. *Folia Hort.*, **13** (2): 3-12.

Kamal, M. M. 1998. Effect of starter solution and mulching on the growth and yield of cabbage. M.S. thesis, Dept. Hort., Bangladesh Agriculture University, Mymensingh. Bangladesh. pp. 4-7.

Kashyap, S., Phookan, D. B., Baruah, P. and Bhuyan, P. 2009. Effect of drip irrigation and polythene mulch on yield, quality, water-use efficiency and economics of broccoli production. *Indian J. Hort.*, **66** (3): 323-325.

Kashyap, S.; Borboraphookan, D. and Barua, P. 2005. Effect of drip irrigation and black plastic mulch on growth, yield and water use of broccoli (*Brassica oleracea* var. *italica* L.). *Res. Crops*. **6** (3): 555-559.

Katyal, S. L. 1977. Vegetable Growing in India. Mohan Primlani Oxford and IBS Publishing Co., New Delhi, p.45.

Kosterna, E. 2014a. Effect of different types of straw mulches on weed control in vegetable cultivation. *J. Ecol. Eng.*, **15**: 109–117.

Kosterna, E. 2014b. The yield and quality of broccoli grown under flat covers with soil mulching. *Plant Soil Environ.,* **60** (5):228-233.

Kwambe, X. M., Masarirambi, M. T., Wahome, P. K. and Oseni, T. O. 2014. The effects of organic and inorganic mulches on growth and yield of green bean (*Phaseolus vulgaris* L.) in a semi-arid environment. *Int. J. Scholarly Res. Gat.*, **2** (5).81-89.

Lal, R. 1978. Influence of within and between row mulching on soil temperature, soil moisture, root development and yield of maize (*Zea mays* L.) in tropical soil. *Field Crop Res.*, **1:** 147-151.

Lal, R. 1989. Conservation tillage for sustainable agriculture:tropie versus temperature environments. *Adu. Agron.*, **42**:147-151.

Lincoln, C. P. 1987. Vegetable characteristics, production and marketing. John Wiley and Sons. Inc. New York. p. 217.

Lourduraj, A. C., Sreenarayanan, V. V., Rajendran, R., Ravi, V., Padmini, K. and Pandiarajan, T. 1996. Effect of plastic mulching on tomato yield and economics. *South Indian Hort.*, **44:** 139-142.

Ma, C. H. and Kaib, T. 2006. Development of starter solution technology as a balanced fertilization practiced in vegetable production. *Acta Hort.*, **13**:167-172.

Masarirambi, M. T., Mndzebele, M. E., Wahome, P. K. and Oseni, T. O. 2013. Effect of white plastic and sawdust mulch on 'Savoy' baby cabbage (*Brassica oleracea* var. *bullata*) growth, yield and soil moisture conservation in summer in Switzerland. *Amer. Eurasian J. Agric. & Environ. Sci.*, **13** (2): 261-268.

Miedema, P. 1982. The effects of low temperature on Zea mays. *Adv. Agron.*, **35**: 93-128.

Mital, R. K., Singh, T., Bhugat, M. and Maheshwari, K. P. 1975. Response of broccoli to nitrogen and row spacing. *Ind. J. Agron.*, **20** (3): 278-279.

Mohammed, G. H., Sarhanand, T. Z. and Teli, J. A. 2016. Effect of mulching and organic fertilizer on growth, yield and quality of broccoli (*Brassica oleracea* var *italica*). *J. Zankoy Sulaimani*, 18- 19.

Mohanty, B. and Nema, B. K. 1970. Effect of starters and plant growth regulators on growth, yield and quality of cabbage, (*Brassica oleracea* var. *capitata*). *Punjab J. Hort*., **10**(3 & 4): 291-297.

Moniruzzaman, M. S., Faisal, S. M., Sarkar, M. A. R., Hossain, M., Ismail Ali, M. and Afsar Talukder, M. A. H. 2007. Effect of Irrigation and different mulches on yield and profitability of cauliflower. *Asian J. Plant Sci.*, **6** (2): 338-343.

Nakaande, M. K. 2013. Fertigation and mulching studies in cabbage (*Brassica oleracea* var *capitata* L.) Vellanikkara Department of Olericulture, College of Horticulture, M. Sc Dissertation. Naya Prokash; Calcutta 700006; India, P. 157-160.

Parmar, H. N., Polara, N. D. and Viradiya, R. R. 2013. Effect of mulching material on growth yield and quality of watermelon (*Citrullus lanatus Thunb*) cv. Kiran. *Universal J. Agric. Res.*, **1** (2): 30- 37.

Patil, S. S. D., Bhore, D. P. and Patil, A. V. 1979. Studies on the effect of urea as a starter solution on the yield of cabbage (*Brassica oleracea* var. *capitata* L.). *J. Maharastra Agric. Univ*., **4**(3): 320-321.

Poll, J. T. K. and Geven, C. G. M. 1996. Effect of mulches on yield and quality of green vegetables. Profestationvor de Akkerbouw en de Groenteteelt in de Vollegrond Verslag, 212: 87.

Prihar, S. S., Sandhu, K. S. and Khera, K. L. 1986. Potentialities of increasing maize and sugarcane yields with straw mulching in Punjab. *Indian J. Ecol*., **4(**2):167-176.

Rahman, M. A., Guha, D., Golder, P. C. and Satter, M. A. 1989. Effect of irrigation and mulch on the growth and yield of cabbage in the hilly region. *Bangladesh Hort.*, **17**(1): 37-39.

Rashid, M. M. 1976. Vegetables of Bangladesh (In Bengali). First Edition, Bangla Academy, Dhaka, p. 283.

Roy, A. K., Muhsi, A. A. A. and Khan, A. H. 1990. Effect of different mulches on the growth of potato. *Bangladesh J. Bot*., **19**(1): 41-46.

Roy, R., Rahim, M. A. and Alam, M. S. 2010. Effect of starter solution and GA on growth and yield of cabbage. *J. Agrofor. Environ.*, **3**(2): 187-192.

Runham, S. R., Town, S. J., Fitzpatrick, J. C. and Verhoyen, M. N. J. 2000. Evaluation over four seasons of paper mulch used for weed control in vegetables. *Acta Hort.*, **513**: 193-201.

Saloom, Y. F. and Sahaf, F. H. AL. 2016. Effect of organic and mineral fertilization and soil mulching on quality characteristic of broccoli. *Iraqi J. Agric. Sci.*, **47**:14-19.

Sarker, M. Y., Begum, F., Hasan, M. K., Raquibullah, S. M. and Kader, M. A. 2003. Effect of different sources of nutrients and mulching on growth and yield contributing characters of cabbage. *Asian J of Plant Sci.*, **2**: 175-179.

Shi, X., Xi, Z. B. and Zhu, J. P. 1984. Characteristics of nutrients absorption by autumn cabbage and fertilizer application method. Rep. *Sanghai Agric. Sci. Tech.,* 4 & 5: 17-18 [Cited from Hort. Abst., **55**(9):7233, 1985].

Shimaa, M. H. and Abd-ElKader, D. Y. 2016. Influence of starter fertilizer and calcium nitrate rates on vegetative growth, yield and nutritional quality of cabbage. *Alexandria Science Exchange Jour*., **37**(4):812-819.

Singh, A. K. and Mir, M. S. 2005. Effect of different mulches on yield and yield attributing traits of cabbage (*Brassica oleracea* var. *capitata)* cv. "Pride of India" under cold arid region of Ladakh. *Environ. and Ecology.*, **23** (2): 398-402.

Singh, S. B. and Misra, R. S. 1976. Effect of various mulches on the growth and yield of cauliflower. *Prog. Hort*., **7**(2): 65-71.

Soniya, I. A. 2018. Effect of Starter Solution and age of Seedling on Growth and Yield of Broccoli (*Brassica Oleracea* Var. *italica*). M.S. thesis, Department of Horticulture, Sher-E-Bangla Agricultural University, Dhaka -1207.

Stone, D. A. 2000. The effects of starter fertilizers on the growth and nitrogen use efficiency of onion and lettuce. *Soil Use and Management.,* **16**, 42-48.

Stone, D. A. 2006. Nitrogen requirement of wide-spaced row crops in the presence of starter fertilizer Soil Use and Management**, 16**(4):285-289.

Thompson, H. C. and Kelly, W. C. 1988. Vegetables Crops. Fifth edition, Tata McGraw Hill Publishing Company Ltd., New Delhi, India, p. 611.

Thompson, H. C. and Kelly, W. C. 1997. Vegetable Crops. McGraw-Hill Book Company, New York. p. 308.

Watt, B. K. 1963. Nutritive Value of Fruits and vegetables. USDA, Hand book No 8. [Cited from vegetable production, Nonnecke I. L., An Avi Book Published by Van Nostrand Reinhold, New York. 369-414 (1989)].

Watt, B. K. 1983. Nutritive value of fruits and vegetables. USAID, Handbook No. 8.

Wilhoit, J. H., R. D. Morse and D. H. Vaughan. 1990. Strip-tillage production of summer cabbage using high residue lands. *Appl. Agric. Res.,* **5**(4): 338-342.

Yaghia, T., Arslana, A. and Naoumb, F. 2013. Cucumber (*Cucumis sativus*, L.) water use efficiency (WUE) under plastic mulch and drip irrigation. *Agric. Water Management.,* **12**: 149–157.

APPENDIX

Appendix I. Monthly record of air temperature, rainfall, relative humidity and sunshine of the experimental site during the period from October 2018 to February 2019

Year	Month	Air temperature (°c)			Relative humidity (%)	Rainfall (mm)
		Maximum	Minimum	Average		
2018	October	30.97	23.31	27.14	75.25	208
	November	29.45	18.63	24.04	69.52	00
	December	26.85	16.23	21.54	70.61	00
2019	January	24.52	13.86	19.19	68.46	04
	February	28.88	17.98	23.43	61.04	06

Source: Bangladesh Meteorological Department (climate division) Agargoan, Dhaka-1212.

Appendix II. Characteristics of Horticulture Farm soil as analyzed by Soil Resources Development Institute (SRDI), Khamar Bari, Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture Garden, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil scries	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Fallow - Broccoli

Appendix II (contd.)

B. Physical and chemical properties of the initial soil

Characteristics	Value
Particle size analysis	
% Sand	27
% Silt	43
% clay	30
Textural class	silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (mc/100 g soil)	0.10
Available S (ppm)	45

Source: SRDI

Appendix III: Analysis of variance on plant height and number of leaves per plant of broccoli

Source of variation	Degrees of freedom (df)	Mean Square of					
		Plant height at 20 DAT (cm)	Plant height at 40 DAT (cm)	Plant height at 60 DAT (cm)	No. of leaves/plant at 20 DAT	No of leaves/plant 40 DAT	No of leaves/plant at 60 DAT
Replication	2	5.533	66.809	0.353	0.486	3.021	0.787
Factor A (solution)	3	11.377*	88.242**	7.767**	3.380*	26.481*	44.896**
Factor B (mulching)	3	16.576*	95.986**	12.098**	5.015*	29.095*	49.280**
A x B	9	21.049*	67.771*	4.026*	2.704*	22.282*	19.005*
Error	30	6.566	21.538	1.152	0.713	7.458	6.046

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

Appendix IV: Analysis of variance on leaf length and leaf breadth of broccoli

Source of variation	Degrees of freedom (df)	Mean Square of					
		Leaf length at 20 DAT (cm)	Leaf length at 40 DAT (cm)	Leaf length at 60 DAT (cm)	Leaf breadth at 20 DAT (cm)	Leaf breadth at 40 DAT (cm)	Leaf breadth at 60 DAT (cm)
Replication	2	8.902	20.701	0.041	5.472	249.51	2.290
Factor A (solution)	3	18.875*	94.121**	1.262*	101.372**	1406.03**	29.637**
Factor B (mulching)	3	25.623**	104.005**	4.093**	125.430**	5201.43**	24.808**
A x B	9	31.516*	78.951*	1.406*	61.426*	411.14*	19.771*
Error	30	7.932	31.059	0.643	21.988	132.67	7.142

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

Appendix V: Analysis of variance on canopy spread, stem length of broccoli

Source of variation	Degrees of freedom (df)	Mean Square of					
		Canopy spread at 20 DAT (cm)	Canopy spread at 40 DAT (cm)	Canopy spread at 60 DAT (cm)	Stem length at 20 DAT (cm)	Stem length at 40 DAT (cm)	Stem length at 60 DAT (cm)
Replication	2	2.108	0.021	9.991	443.5	0.184	1.208
Factor A (solution)	3	64.250**	16.195**	97.014**	2409.3**	1.504**	21.686**
Factor B (mulching)	3	75.811**	10.876**	42.570**	45510.2*	1.251**	78.063**
A x B	9	35.811*	15.697**	44.302*	6428.8**	1.488**	0.935^{NS}
Error	30	23.237	1.005	15.549	535.4	0.196	1.917

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

Appendix VI: Analysis of variance on stem diameter, primary curd weight, primary curd length and primary curd diameter of broccoli

Source of variation	Degrees of freedom (df)		Mean Square of		
		Stem diameter at harvest (cm)	Primary curd weight (g)	Primary curd length (cm)	Primary curd diameter (cm)
Replication	2	2.554	2.321	34.176	23.042
Factor A (solution)	3	98.936**	33.389**	74.404**	126.647**
Factor B (mulching)	3	89.951**	29.186*	91.871**	113.002**
A x B	9	48.768*	20.602*	79.167**	59.758*
Error	30	15.443	6.867	26.971	19.452

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

Appendix VII: Analysis of variance on number of secondary curd per plant, weight of secondary curd, yield per plant, yield per plot and yield per hectare

Source of variation	Degrees of freedom (df)	Mean Square of				
		No of secondary curd per plant	Weight of secondary curd (g)	Yield/Plant (g)	Yield/Plot (kg)	Yield/ha (ton)
Replication	2	46.382	0.108	0.503	4.257	2.534
Factor A (Solution)	3	132.332**	9.543**	19.348 *	64.867 **	15.653**
Factor B (mulching)	3	125.010**	11.631**	21.646 *	86.432**	21.543**
A x B	9	129.268**	7.807*	8.677 **	31.977*	13.764**
Error	30	38.018	2.064	5.009	9.296	1.821

* 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 and pesticide cost (Tk.)	Cowdung cost (Tk.)	Fertilizer cost (Tk.)	Starter solution and mulching	Subtotal cost (Tk.) A
S_0M_0	25000	50000	27000	25000	70000	15000	0	212000
S_0M_1	25000	50000	27000	25000	70000	15000	22000	234000
S_0M_2	25000	50000	27000	25000	70000	15000	20000	232000
S_0M_3	25000	50000	27000	25000	70000	15000	21000	233000
S_1M_0	25000	50000	27000	25000	70000	15000	500	212500
S_1M_1	25000	50000	27000	25000	70000	15000	22500	234500
S_1M_2	25000	50000	27000	25000	70000	15000	20500	232500
S_1M_3	25000	50000	27000	25000	70000	15000	21500	233500
S_2M_0	25000	50000	27000	25000	70000	15000	700	212700
S_2M_1	25000	50000	27000	25000	70000	15000	22700	234700
S_2M_2	25000	50000	27000	25000	70000	15000	20700	232700
S_2M_3	25000	50000	27000	25000	70000	15000	21700	233700
S_3M_0	25000	50000	27000	25000	70000	15000	1100	213100
S_3M_1	25000	50000	27000	25000	70000	15000	23100	235100
S_3M_2	25000	50000	27000	25000	70000	15000	21100	233100
S_3M_3	25000	50000	27000	25000	70000	15000	22100	234100

Here, S_0 = 0% Urea (Control), S_1= 1% Urea, S_2= 1.5% Urea and S_3= 2% Urea
M_0 =No Mulching (Control), M_1= Black polythene, M_2=Water hyacinth and M_3=Straw

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	Interest 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_0M_0	97000	14225	54220	140445	440000
S_0M_1	97000	15225	54720	142145	446645
S_0M_2	97000	15125	54700	142265	444765
S_0M_3	97000	15175	54720	142000	445500
S_1M_0	97000	14250	54300	141000	442000
S_1M_1	97000	15250	54320	143070	448070
S_1M_2	97000	15175	54280	143300	446800
S_1M_3	97000	15200	54300	143200	447200
S_2M_0	97000	14260	54200	140060	425260
S_2M_1	97000	15260	54965	142500	447700
S_2M_2	97000	15160	54950	142700	445900
S_2M_3	97000	15210	54980	144000	448200
S_3M_0	97000	14280	54310	140190	425790
S_3M_1	97000	15280	54780	142160	447760
S_3M_2	97000	15180	54700	143180	446780
S_3M_3	97000	15230	54780	143110	447710

Here, S_0 = 0% Urea (Control), S_1= 1% Urea, S_2= 1.5% Urea and S_3= 2% Urea
M_0 =No Mulching (Control), M_1= Black polythene, M_2=Water hyacinth and M_3=Straw