EFFECT OF STARTER SOLUTION AND POTASSIUM ON GROWTH AND YIELD OF CABBAGE

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EFFECT OF STARTER SOLUTION AND POTASSIUM ON GROWTH AND YIELD OF CABBAGE

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CERTIFICATE

This is to certify that thesis entitled, "*Effect Of Starter Solution And Potassium On Growth And Yield Of Cabbage*" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN HORTICULTURE,** embodies the result of a piece of *bonafide* research work carried out by **Sabrina Afroz**,**Registration No.07-02224** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma in any institute.

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

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ABSTRACT

The experiment was conducted in the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka during November 2012 to February 2013. The experiment consisted of two factors: Factor A: Four levels of Starter Solution i.e. S_0: 0% (control); S_1: 0.5%, $S_{2:}$ 1.5% and S_3: 2.5% urea and Factor B: Three levels of potassium as- K_0: (control); K_1: 180 and K_2: 220 kg K_2O/ha, respectively. The two factorial experiment was laid out in the Randomized Complete Block Design with three replications. For starter solution, the highest marketable yield (58.89 t/ha) was found from S_2, while the lowest marketable yield (42.59 t/ha) was from S_0. For potassium, the highest marketable yield (62.22 t/ha) was from K_2, whereas the lowest marketable yield (44.07 t/ha) was from K_0. For combined effect, the highest marketable yield (71.11 t/ha) was from S_2K_2 and the lowest marketable yield (37.79 t/ha) was from $S_0K_{0.}$ The highest BCR (2.35) was from S_2K_2 and the lowest (1.29) from S_0K_0. So, 1.5% starter solution with 220 kg K_2O/ha was the best for growth and yield of cabbage.

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CHAPTER I

INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata* L.) belongs to crucifera family locally known as Badhacopy. It is a popular and most common winter vegetable in Bangladesh and is grown as an important vegetable in various parts of the world. It is a short duration crop and grown for its compact head. It is also a well known and widely distributed crop within Asia and has been introduced successfully into the parts of Central America, West Africa, America, Canada and Europe (Talekar and Selleck, 1982). It is one of the five leading vegetables in our country and ranks third in respect of production and area. At present the cultivated area of cabbage is increasing day by day with production of 220 thousand metric tons (BBS, 2012). It is usually cultivated in Rabi season. Among the five leading vegetables in Bangladesh, the cabbage occupied an area of 11.37 thousand hectares of land (BBS, 2012).

Vegetable consumption in Bangladesh is very low with comparison to the other countries of the world. The total vegetable production in Bangladesh is far below the requirement. It is especially near by the town and metropolitan city because the return is nearly three times higher than that of paddy. Cabbage is a leafy vegetable rich in vitamin C and tryptophan, an important amino acid for our body. It has been reported that 100g of green edible portion of cabbage contains 92% water, 24 calories of food energy, 1.5g of protein, 9.8 g of carbohydrate, 40 mg of calcium, 0.6 mg of iron, 600 IU of carotene, 0.05 mg of thiamine, 0.05 mg of riboflavin, 0.3 mg of niacin and 60 mg of vitamin C (Rashid, 1993). It has some medicinal value against ulcer and also prevents cancer.

There are many factors associated with growth and yield of cabbage. Among them fertilizer management is one of the important factors that contribute in the production and yield of cabbage. Nitrogen is an essential nutrient for cabbage.

Urea is the main source of nitrogenous fertilizer and nitrogen is essential for its vegetative growth and development. Starter solutions are mixtures of soluble fertilizer and water used to get young plants off to a good start. The fertilizer material easily dissolves in water and the nutrients are readily available for plant uptake. Cabbage seedlings are transplanted from seedbed to the main field. The time between uprooting and establishment of young and tender seedlings in the field is very critical. Vegetables like cabbage, cauliflower and tomato respond well to starter solution containing urea in minimizing transplanting shock and being encouraged to a quick growth. The use of starter solution conta9ining urea influences vegetative growth and production.

Deficiency of soil nutrient is considered as one of the major constrains to successful upland crop production in Bangladesh (Islam and Noor, 1982). The cultivation of vegetable crops requires proper supply of plant nutrient. Potassium is an inorganic fertilizer plays a vital role for proper growth and development of cabbage. Application of potassium in appropriate time, dose and proper method is prerequisite for any cabbage cultivation (Islam, 2003). Generally a large amount of potassium is required for the growth of leafy vegetable (Opena *et al*, 1988).

Cabbage is a heavy feeder especially of potassium for vegetative growth (Thompson and Kelly, 1988). Potassium fertilizer increases the yield of cabbage, head weight and leaf per plant. Potassium deficiencies may affect such varied process as respiration, photosynthesis, chlorophyll development and water content of leaves. Potassium fertilizers are used frequently for better yield.

Considering the above perspective the present study was undertaken to investigate the effect of starter solution and potassium fertilizer with the following objectives-

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

ii. To find out the optimum level of potassium for better vegetative growth, maximum yield and economic return of cabbage.

iii. To identify suitable combination of starter solution and potassium for better vegetative growth, maximum yield and economic return of cabbage.

CHAPTER II

REVIEW OF LITERATURE

Cabbage is one of the most popular vegetables of many countries of the world as well as in Bangladesh. Considerable interest has been developed recently regarding the benefit from the use of starter solution at the time of transplanting of cabbage seedlings. It is also known to be a heavy absorber of soil moisture, which may be ensured through proper soil moisture management such as irrigation and mulching have been known to play a vital role in increasing the growth, yield and quality of cabbage. A great deal of research work has been reported on the uses of starter solution and potassium in different vegetables including cabbage and the results already achieved are of outstanding importance. The present study was undertaken to assess the effects of starter solution and potassium on growth and yield of cabbage. However, some of the most relevant works in connection with the present research programmed are reviewed here in this chapter.

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

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

Roy *et al.* (2010) conducted an experiment with starter solution and GA_3 that, The Present research work was conducted at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh during the period from October, 2001 to February, 2002 to study the effect of starter solution and GA3 on growth and yield of cabbage. The two factor experiment consisted of four levels of starter solution, viz., 0, 1.0, 1.5 and 2.0% of urea, and four concentrations of GA3, viz., 0, 25, 50 and 75ppm. The application of starter solution and different concentrations of GA3 influenced independently and also in combination on the growth and yield of cabbage. The highest yield (104.93 t/ha) was obtained from 1.5% starter solution which was significantly different from other solutions, and the lowest yield (66.86 t/ha) was recorded from the control. Significantly the highest yield (104.66 t/ha) was found from 50 ppm GA3 , while the lowest yield (66.56 t/ha) was recorded from control. In case of combined effect, the highest yield of cabbage (121.33 t/ha) was obtained from the treatment combination of 1.5% starter solution + 50 ppm GA3 followed by 1.5% starter solution + 75 ppm GA3 (115.22 t/ha), while the lowest yield (57.11 t/ha) was produced by the control treatment. Economic analysis revealed that 1.5% starter solution + 50 ppm GA3 treatment was the best treatment combination in respect of net return (Tk. 173775.00) with a benefit cost ratio of 3.52.

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 1% urea solution and at increasing concentration of urea solution the yield gradually declined 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.* (1981) 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 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 cabbage.

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

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

Chhonkar and Sharma (1966) reported that using urea in combination with single superphosphate and potassium chloride at the ratio of 1:2:1 and also ammonium sulphate 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 per cent 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.

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

2.2 Effect of different levels of potassium on growth and yield of cabbage

An experiment conducted by Tang *et al.* (2010) to study effect of different fertilizer treatments on yield, nutrients uptake and nutrients use efficiency of Chinese cabbage and cabbage. The results showed that: yield of cabbage and Chinese cabbage of the application of manure, oil cake and special fertilizer for vegetables combined with fertilizer is higher than that of the pure chemical fertilizer treatment. The yield of application of special fertilizer for vegetables combined with fertilizer of Chinese cabbage is the highest, yield of it enhanced 25.30% compared with the pure chemical fertilizer treatment; application of oil cake and special fertilizer for vegetables combined with fertilizer are of the highest N and P nutrient use efficiency, N and P nutrient use efficiency of them enhanced 21.65%, 10.77% compared with the pure chemical fertilizer treatment, respectively. The yield of application of oil cake combined with fertilizer of cabbage is higher, yield of it enhanced 9.90% compared with pure chemical fertilizer treatment; application of oil cake combined with fertilizer is of the highest N and P nutrient use efficiency, N and P nutrient use efficiency of it enhanced 29.23% and 14.9% compared with the pure chemical fertilizer treatment, respectively.

A field trial with a local variety of Chinese cabbage was carried out by Li *et al*, (2010) in Fuzhou, Fujian. China in 2007 to investigate effects of different NPK applied rates on its yield. Eleven treatments were designed, with N, P and K at four different levels, respectively. The average contribution rate of soil fertility to the yield of Chinese cabbage was 47.4%. The yields of Chinese cabbage treated by N, P and K were increased by 41.26, 14.90 and 25.53% on average, respectively. The effects on yield increase was ranked as N>K>P. The output/input ratios of N, P and K were 13.8, 13.2 and 9.7, respectively. The recommended applied rates of NPK fertilizers for the Chinese cabbage in Fuzhou were 232.0 kg N, 70.5 kg P_20_5 and 209.6 kg K_20 /ha, respectively.

A field experiment was conducted by Ghuge *et al*. (2007) during 2002-2003 in Parbhani, Maharastra, India, to assess the effect of combined use of organic and inorganic nutrient sources on the growth and yield of cabbage cv. Pride of India. The treatment comprised : recommended dose of fertilizers (RDF) at 150:80:75 kg NPK/ha (T1); 50% RDF+50%vermicompost at 2.5 t/ha (T2); 25% RDF +75%vermicompost at 3.75 t/ha (T3); 50% RDF+ 50% Terrace at 1.25 t/ha(T4); 50% RDF+ 75%Terrace at 1.875 t/ha(T5); 50% RDF + 50% organic booster at 1.0 litres per plant after transplanting in 4 splits (T6); 25% RDF +75% organic booster at 1.0 litres per plant after transplanting in 4 splits(T7);100% vermicompost at 5 t/ha(T8); 100% terrace at 2.5t/ha (T9); 100% organic booster at 2.0 liters per plant after transplanting in 4 splits(T10). T2 gave the maximum plant spread (18.87 cm2), head circumference (57.50cm), head weight (1232 g per head), chlorophyll content (652.1 micro g/g of leaf), ascorbic acid (29.93 mg/100g head) and compactness of head (79.07).

A field experiment was conducted by Pintu and Dus (2006) in a Haplaquet soil in Gaighata, West Bengal, India, to study the effects of integrated nutrient management (INM) on yield and uptake of nutrients by cabbage (*Brassica oleracea* var. Green Express). Overall, the adoption of INM practices increased the yield and nutrient uptake by cabbage. The applications of recommended levels of N, P and K with 4 t organic manure ha-1and 0.5 kg Zn ha-1 proved superior in augmenting yield and nutrient uptake. A significant positive correlation was observed between yield and uptake of N(r=0.744), Cu (r=0.928), P (r=0.935), K(r=0.949), Fe (r=0.758), Mn (r=0.744), Cu(r=0.598), and Zn (r=0.846). The uptake of N, P,K and cationic micronutrients (Fe, Mn, Cu and Zn) by cabbage accounted for 99% of the variability, while the uptake of Fe, Mn, Cu and Zn accounted for 80% of the variability in yield.

Sheng *et al.* (2006) carried out an experiment on the effects of K fertilizers on the yield, and nutrient uptake in cabbage in China. The application of K significantly increased the yield. The increments in yield due to MOP [muriatic of potash] were correlated with K rate and soil properties. At the optimum K rate, plants supplied with MOP were superior in yield, nutrient use efficiency and quality to plants supplied with SOP [sulphate of potash]. The nutrient content of plants supplied with SOP was higher than that of plants treated with MOP. SOP enhanced the uptake of Ca, Mg, Fe and Mn, whereas MOP improved the uptake of P and K, The results suggested that MOP is the optimum K source for leafy vegetables such as cabbage.

The effect of potash fertilizer on the yield of Chinese cabbage on soil P and Plant P content were studied by Liu et al. (2005). The application of potash fertilizer at 56.25-225.00 kg/ha increased the yield of cabbage by 47.2-70.3%. A yield response was not observed when potash fertilizer was applied at more than 225.0 kg/ha to Chinese cabbage. The total P contents cabbage, soil total P content, and Olsen-P at the 0-20 cm soil profile increased gradually with the increase in the potash fertilizer rate. A yield response was not observed in cabbage when potash fertilizer applied was more than 450.0 kg/ha.

Rajender (2005) studied that N (60, 120, 180 and 240 kg/ha), P (30, 60 and 90 kg/ha) and K (30 and 60 kg/ha) were supplied to cabbage hybrid Bajrang during the rabi seasons of 1998/99 and 1999/2000 in Nauni, Solan, Himachal Pradesh, India. In general, 120 kg N + 60 kg P + 60 kg K/ha and 240 kg N + 90 kg P and 60 kg K/ha recorded the highest head yields of 413.99 and 421.15 q/ha and BC ratios of 2.51 and 2.53, respectively. The yield was increased by 23.67% (1234.5 k81667 m2), quality was improved and NO content of autumn cabbage was decreased by using organic compound fertilizer. The N, P and K removal rates for 1000kg cabbage was 3.7, 1.07 and 6.0 kg, respectively. The N : P : K ratio was 1: 0.29 : 1.60. The maximum nutrient absorption rate was recorded at 60-80 days after sowing (Jiang *et al*. 2005).

Gue, *et al*. (2004) studied that cabbage [*Brassica oleracea* var. capitata] was grown in two field trials in Hefei, Anhui, China. N-P-K was applied at rates of 0 - 60 -0, 350 - 60 -0, 450-60-0, 0-60-300, 350-60-300, and 450-60-300 kg/ha. Nitrogen and potassium and their proper combination significantly improved the yield and its nutrient use efficiency. Potassium sulfate markedly increased the content of ascorbic acid and sugars, and alleviated the unfavorable effect of irrational nitrogen application. Urea increased the content of amino acids, while nitrogen and potassium enhanced the nutritional value of the essential amino acids. Ascorbic acid and sugar contents were correlated negatively with N content in cabbage heads and positively with potassium content. It was concluded that adequate potassium and optimum combination of nitrogen and potassium will help ensure high quality and yield.

Wang *et al*. (2004) conducted a field trial in China to investigate the effects of N and K rates on the nutrient uptake and partitioning of cabbage. Sole N application increased the contents of N, B, Mn and Zn, but reduced the contents of K, Ca, Mg, Cu and Fe. Sole K increased the contents of K and other microelements in the heads, but reduced N, Ca and Mg contents. Application of N and K increased nutrient proportion in heads and leaves, which increased growth, yield, quality and nutritional value of cabbage.

Marsic *et al.* (2004) carried out an experiment to find out the effect of fertilization and broadcast mineral fertilizer application on yield and quality of 4 cabbage (*B. oleracea* var. capitata) cultivars in Ljubljana, Slovenia. Five treatments were formed: K=classical fertilization with 150 kg N/ha (broadcast incorporated); F< sub>NPK</ sub>=all nutrients (NPK) were applied via fertilization; F< sub>N</ sub>P and K were added by classical methods and total N by fertilization; F< sub>NPKJ3O%</ sub>=30% of total N Was incorporated before transplanting, total P and K and remaining N were applied via fertilization E< sub>N/30%</ sub>=total P and K and 30% of total N were incorporated before transplanting, the remaining N was applied via fertilization. During the harvest, the height and width of the cabbage, length of stalk, weight of head with leaves and without leaves, height and width of cleaned head, firmness of head and core length were measured the number of external trimmed leaves was counted. The highest average marketable yield was achieved by fertilization with soluble nutrients, combined with pre-plant broadcast N incorporation, with each individual cultivar as follows: Hermes F1 (38.7 t/ha), Parle F1 (71.1 t/ha) and Tropicana F1 (70.7 t/ha) and the lowest by fertilization with where the total amount of P and K were pre-plant broadcast incorporated, with cultivars follows: Hermes F1 (20.9 t/h), Parle F1 (50.4 t/ ha), Tropicana F1 (63.0 t/ha) and Field winner F1 (66.1 t/ha). The firmness of cabbage heads was also affected by the method of nutrient application.

Loncaric *et al.* (2003) carried out field experiments during 1999-2001 in two localities in eastern Croatia to determine the effects of fertilizers on the yield of early Savoy cabbage (*Brassica oleracea* var. sabauda). The yields of Savoy cabbage heads (fresh matter) were 29-31 t/ha under no fertilizer and 56-59 t/ha under the highest fertilizer rate. The average weights of Savoy cabbage heads were 469 and 947 g, and the dry matter contents of heads were 101 and 69 g kg/h under no fertilizer and highest fertilizer level, respectively. The total dry matter production ranged from 4.6 t/ha in the control plots to approximately 7 t/ha in plots treated with the highest fertilizer rate; the uptake of 100-206 kg N ha1, 43-73 kg P/ha and 161-261 kg K/ha was also observed. Based on yield increase, total above ground mass, and head weight, the optimum nitrogen fertilizer rate for Savoy cabbage was between 200 and 300 kg/ ha. The yield response to fertilizer application was higher on soil with lower N, P and K contents before treatment. The increase in the N fertilizer rate resulted in the increase in yield, and N content and uptake, but the increase in the rate of P and K fertilizers did not affect yields. Increased fertilizer rate resulted in lower dry matter content but higher dry matter production. Nutrient removal per ton of head yield was highest for K (4.2-5.6 kg), followed by N (3.3-3.5 kg) and (1.2-1.5 kg). Crop residues of Savoy cabbage contained 42-83 kg N, 13-24 kg P and 96 kg K/ha.

Salo and Suojala (2002) conducted trial on broadcast application of solid NPK fertilizer with cabbage (cv. Castello),). In the broadcast application, P and K were given as a single application in spring and N was split according to the existing recommendations. In the fertilization applications, nutrients were given according to the expected nutrient uptake based on previous experiments. Growth and nutrient uptake were monitored by monthly samplings. In 1998, growing season was extremely rainy, and N leaching from conventional broadcast application was expected. However, leaching seemed to have no impact in the sandy experimental soil, as broadcast application resulted in good growth of cabbage. In 1999, natural rainfall was low, and irrigation was applied according to tensiometer measurements. Treatments affect cabbage growth and nutrient uptake were still decreased by fertilization towards the middle of the growing period. At harvest, cabbage yields and nutrient uptakes were similar between the treatments. Cabbage yields averaged to over 90 t/ha in both years. At harvest, total nutrient uptakes were 213-243 kg N/ha, 36-40 kg P/ha and 302-345 kg K/ha.

Chaubey *et al*. (2001) did an experiment in Pantnagar, Uttar Pradesh, India, during winter of 1996/97 and spring-summer of 1997 to study the effect of N:P:K level (60:30:30, 120:60:60, 180:90:9O, and 240:120:120 kg/ha) on the yield and yield-contributing characters (head gross and net weight, head shape index, core length, ascorbic acid, marketable head percentage, and marketability period of heads after maturity) of 23 cultivars. The analysis of variance revealed significant differences among cultivars and fertilizer levels in both seasons for all characters studied. The yield ranged from 105.61 to 590.82 q/h. Net head weight and size increased at higher fertility levels; however, head shape index unaffected. The percentage of marketable heads and their durability also increased at higher levels of fertilizer. Winter-spring season proved to be favorable for higher cabbage productivity.

An experiment was conducted in Tianjin, China [date not given] to determine the effect potash application (at 0, 150, 225, 300 kg K/ha) on the time of ripening and yield of cabbage. Treatment with potash at 225 kg K/ha resulted in a more rapid heading, rapid maturation and improved cabbage quality compared to other treatments. This treatment produced the highest commercial yield increase of 17.4 t/ha and the highest profit for the farmer (9970 Yuan/ha). In the Tianjin region, the rate of 225 kg K/ha, along with 225 kg and 60 kg P/ha is recommended for cabbage production on soils represented by this trial. This application should bring the farmer a net profit of 9000 to 10000 Yuan/ha, depending on local market prices (Zhou *et al.* 2001).

Yang *et al*. (2001) studied the effect of water uptake, accumulated dry matter content, and matter output per liter of water in cabbage plants grown under different soil water potentials and at different fertilizer application rates during October-December 1996. For the same range of soil water potential, an increase in N application rate increased N content in cabbage leaves and roots while P and K contents decreased. The amount of N, P and K absorbed was maximum at 300 kg N/m2, medium at 0 fertilizer application rate and minimum at 1200 kg N/m^2. N/P and N/K values increased with increases in fertilizer application rate, leading to non-equilibrium of nutrient uptake and inhibition of normal growth.

Cubeta *et al*. (2000) developed three hypotheses that involved manipulation of soil calcium (Ca), potassium (K), and pH in relation to the occurrence of leaf tip burn of cabbage in eastern North Carolina, USA and tested: (1) adding K to soil will increase leaf tip burn; (2) adding Ca and K together to soil will block K-related tip burn induction, and (3) raising soil pH to levels of 6.0 to 6.5 will decrease leaf tip burn. Six experiments were conducted in commercial cabbage production fields in eastern North Carolina in 1996 and 1997 to test these hypotheses. Hypothesis I was accepted since higher rates of K significantly increased leaf K concentration, soil K content and leaf tip burn incidence compared with the control. Total cabbage yield increased as K rates increased, however, significant differences were only observed between the control and the highest rate (365 kg K/ha) in 1996, Hypothesis 2 was accepted since adding increased amounts of Ca and K did not significantly increase leaf tip burn incidence. Hypothesis 3 was rejected since a range of soil pH from 5.3 to 6.6 did not increase or decrease leaf tip burn incidence, nutrient uptake or total yield. The data suggest that leaf tip burn of cabbage can be increased (induced) with excessive K fertilization and that this practice may be associated with the disorder observed in North Carolina. The addition of Ca with K may potentially reduce the risk associated with K-related leaf tip burn of cabbage.

Liu *et al*. (1999) studied that the effect of different ratios of NPK combination on yield and nitrate accumulation of cabbage the levels of N were 0, 180, 360, and 540 kg/ha the levels of P were 0, 90,180, 270 kg/ha; the levels of K were 0, 90, 180, 270 kg/ha. The plant density of cabbage was 31 500/ha. The result was obtained with N36 + P90 + K1. The nitrate accumulation was increased with the increase of the amount of N applied. Phosphate fertilizer had no significant effect on nitrate accumulation in plant; however, potassium fertilizer had a significant effect on nitrate content in plant. Thirty and 50 days after planting were two key periods for fertilizer application on cabbage.

Rutkauskiene and Poderys (1999) studied the influence of mineral fertilizer rates on the yield and quality of cabbage was studied in the field at the Experimental station of the Lithuanian University of Agriculture in 1997-98. The highest harvest of cabbage was obtained at fertilizer rates (kg/ha) of N 240 P 120 K 180 and N300 P120, K180. Increasing the dose of nitrogen fertilizers decreased the quantity of vitamin C [ascorbic acid) and increased the concentration of nitrates in cabbage heads. Phosphorous fertilizers had no significant impact on yield and quality of heads. Potassium fertilizers decreased the yield, but increased head quality.

Vanparys (1998) studied that the effects of potassium application rate (0, 100 and 200 kg K/ha) and cultivar (Bingo, Marathon and Zerlina) were compared in white cabbage in Belgium. Seeds were sown on 22 April 1997, seedlings planted out on 30 May, fertilized on 3 June, and harvested on 7 (Bingo and Zerlina) and 11 October (Marathon). Significant differences were found between cultivars for crop stand, uniformity, leaf color, stem and head height, head color (before and after cooking), structure, crop weight and percentage of marketable heads. Significant differences between fertilizer treatments at harvesting were found for crop stand, crop height, number of leaves, head form and width, cooking color and crop weight, as well as in dry matter, vitamin C and phosphorus contents. After storage, significant differences occurred in dry matter, nitrate, chloride, vitamin C, magnesium, phosphorus contents,

Zhong *et al*. (1997) caned out a field experiment in Zhejiang, China, to investigate the K requirement of cabbage and its relation to shoot DM accumulation. The seedling stage was identified as the critical stage for K nutrition and the heading stage as the most efficient. The shoot DM contents at the different growth stages were positively correlated with the amounts of K absorbed by the shoots during the same stages and the proportions of DM in the head or mesophyll, in relation to the total amount of DM in the shoot, increased with increasing K fertilizer application, indicating that K not only promotes UM accumulation but also affects its distribution. It was also observed that 66-77% of the total amount of K, and 76-82% of shoot DM were accumulated during the heading stage. The results suggest that K fertilizers should be applied at the start of the heading stage.

Chen (1996) conducted an experiment on the effects of NPK fertilizers (control, 20:20:20 and 31:10:10) on the quality of plug seedlings of 3 cabbage cultivars (K-Y, Kaiya, Chun-Chon No.1) during the summer season in central Taiwan. Good results with regard to growth, seedling index and the G value of the absolute growth rate (AGE) were obtained for plug seedlings of Chun-Chon No.1 and Kaiya. Significant differences among the fertilizer treatments were found for plant height, number of leaves, leaf area, shoot fresh weight, leaf length, and leaf width. The best results were obtained with the 31:10:10 fertilizers, followed by the 20:20:20 fertilizer. This latter treatment gave better results with regard to the balance of seedling index and G value of AGR.

Bubnova (1995) studied that fertilizer experiments with cabbage (cv. Slava) in pots (50 x 50 x 40cm) of alluvial meadow soil with residual K contents of 10, 35 or 56 mg/kg soil. N was applied at 0, 2.25, 4.5 or 6.75 g/pot, and K at 0, 2.25, 4.5 or 9 g/pot. N had the greater effect on yield, 2.25-6.75 g N/pot giving a crop yield of 2183-3028 g/pot (an increase of 66-180%).

Tarata *et al.* (1995) observed that Autumn cabbages (cv. De Buzau) were grown with 8 different fertilizer treatments representing various combinations of N (50, 100, 200, 300 or 400 kg/ha), P (50, 100 or 150 kg/ha) and K (50, 100 or 150 kg/ha). Data are presented on leaf area per plant, foliar index (superscript 2/ha), rate of photosynthesis, photosynthetic potential (kg/ha), total biomass, and yield. The highest yields were obtained when the leaf area was 43000 superscript 2/ha and the photosynthetic potential was 90 t/ha, i.e. with fertilizer treatments of 300 kg N + 100 kg P + 100 kg K/ha. The ratio of total biomass to harvested crop was constant at 3:1, and was unaffected by fertilizer treatment or yield level.

Halim *et al.* (1994) conducted a trail in 1990-91 at Jamalpur, N was applied at 0, 100, 150 200 kg/ha, P at 0, 50, 100 or 150 kg and K at 0, 75, 150 or 225 kg K /ha in 12 combinations to cabbage cv. K-K cross. Gross yield and marketable head weight per plant were highest with 15OkgN + 100 kg P + l5Okg K or 200 kg N + 1OO kg P + 150 kg K.

Sarkar *et al*. (1994) conducted a field experiments during winter 1991-92 and 1992-93 on sandy loam soil of pH 5.1-5.8 at Kanke, cabbage cv. Pride of India was given 0, 50, 100, 150 or 200 kg K/ha. Head yield increased as K rate increased from 2998 t/ha with no K to 47.36 t/ha with 200 kg K/ha. This was mainly due to increases in average head weight and equatorial diameter. Days to maturity declined significantly as K rate increased up to 100 kg K /ha.

Hardier *et al.* (1994) studied that cabbages on clay soil received potassium sulfate at 0, 150, 300 or 450 kg K/ha, with or without 30 kg MgO/ha, applied in the furrow. N and P were applied with all treatments. Yield was higher with 150 kg K/ha than with no K, but did not increase significantly with higher rates or with Mg. The best cash return (20% more than with no K) was obtained with 150 kg

K/ha. Under all treatments, NO content of leaves and midribs decreased from the outermost to the innermost Leaves, while K content increased.

Zhang *et al.* (1993) reported that they showed the absorption and distribution of mineral nutrient elements in leaves of cabbage cv. Lubai 8. The results indicated that the mineral nutrient element content increased with plant growth, most rapidly from 30 to 70 days after emergence.

Jothi *et al.* (1993) carried out a field trail in Tamil Nadu, India, and found a cabbage yield of 117.2 t/ha with the application of N,P,K at 100,125 and 250 kg/ha, respectively.

Samanta *et al.* (1992) investigated the balance fertilizer use for cabbage in clay loam soils Orissa, India. It was reported that nitrogen (75 kg/ha) and potassium (150 kg/ha) gave highest yield (17.42 t/ha), and it was the economic dose.

An experiment was carried out at Joydebpur, Gazipur on cabbage (var. Atlas-70) during Rabi season to field out the effects of fertilizer doses and organic manure on the yield of cabbage. The application of 120 kg K/ha along with cow dung @ 5 t/ha produced highest head yield of 75 t/ha (Anonymous, 1991).

Yestistrin and Vural (1991) mentioned that the effects of various fertilizer applications on cabbage yield and quality. Nitrogen was applied at 10 or 20 kg/ha and K at 15 or 30 kg K_2O/ha. They reported that highest yield was obtained with 20 kg N + 30 kg K20/ha.

Rao and Subramanian (1991) conducted an experiment to field out the effect of potassium application on the yield and content of potassium, calcium and magnesium in cabbage at Bangalore in India. K_20 was applied @ 0, 25, 100, 150 and 200 kg/ha. They observed that the plant K concentration at all stages of growth increased significantly as the level of K_20 application dose was increased.

Farooque and Islam (1989) reported that the cabbage cultivar K-K cross gave the highest marketable yield when 8.3 t FYM, 200 kg mustard oil cake, 326 kg urea, 125 kg TSP and 200 kg MP per hectare were applied.

Lawande *et al.* (1986) conducted an experiment on nitrogen, phosphorus, potassium fertilizer application in cabbage. Plant received N at 80-240 kg/ha, P_2O_5 at 0-80 kg/ha and K_2O at 0-8 kg/ha. They noted that cabbage response to the highest N and P rates, but the responds to K was little. It was reported that the highest head of cabbage was obtained with 76.64 t/ha from the combined effect of 180 kg N/ha, 60 kg P/ha, 180 kg K/ha and cow dung 2.5t/ha (Anonymous, 1990) and it was stated that a combination of the fertilizer was important rather than application of a single fertilizer for the production of cabbage.

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted during the period from November 2012 to February 2013 to find out growth and yield of cabbage as influenced by starter solution and potassium fertilizer.The materials and methods that were used for conducting the experiment have been presented in this chapter. It includes a short description of the location of experimental site, soil and climate condition of the experimental plot, materials used for the experiment, design of the experiment, data collection procedure and procedure of data analysis.

3.1 Location of the experimental site

The experiment was conducted at the Horticulture Research Farm of Sher-e-Bangla Agricultural University (SAU). It is located in 24.09^0N latitude and 90.26^0E longitudes. The altitude of the location is 8 m from the sea level as per the data of Bangladesh Metrological Department, Agargaon, Dhaka-1207.

3.2 Experimental period

The experiment was carried out during the Rabi season from November 2012 and to February 2013. Seeds were sown on 01 November 2012 and harvesting started from 02 February 2013.

3.3 Soil type

The experimental site was situated in the subtropical zone. The soil of the experimental site lies in agro-ecological regions of “Madhupur Tract” (AEZ NO. 28). Its top soil is clay loam in texture and olive gray with common fine to medium distinct dark yellowish brown mottles. The pH 4.47 to 5.63 and organic carbon contents is 0.82.

3.4 Climatic condition of the experimental site

Experimental area is situated in the sub-tropical climate zone, which is characterized by heavy rainfall during the months of April to September and scanty rainfall during the rest period of the year. Details of the meteorological data during the period of the experiment was collected from the Bangladesh Meteorological Department, Agargoan, Dhaka and presented in Appendix II.

3.5 Planting materials

The test crop used in the experiment was cabbage variety Atlas-70.

3.6 Treatment of the experiment

The experiment consisted of two factors:

Factor A: Starter solution (four levels) as

- i S_0: 0 % urea (control)
- ii. S_1: 0.5% urea
- iii. S_2: 1.5% urea
- iv. S_3 : 2.5% urea

Factor B: Potassium fertilizer (three levels) as

- i. K_0: 0 kg K_2O/ha(control)
- ii. K_1: 180 kg K_2O/ha
- iii. K_2: 220 kg K_2O/ha

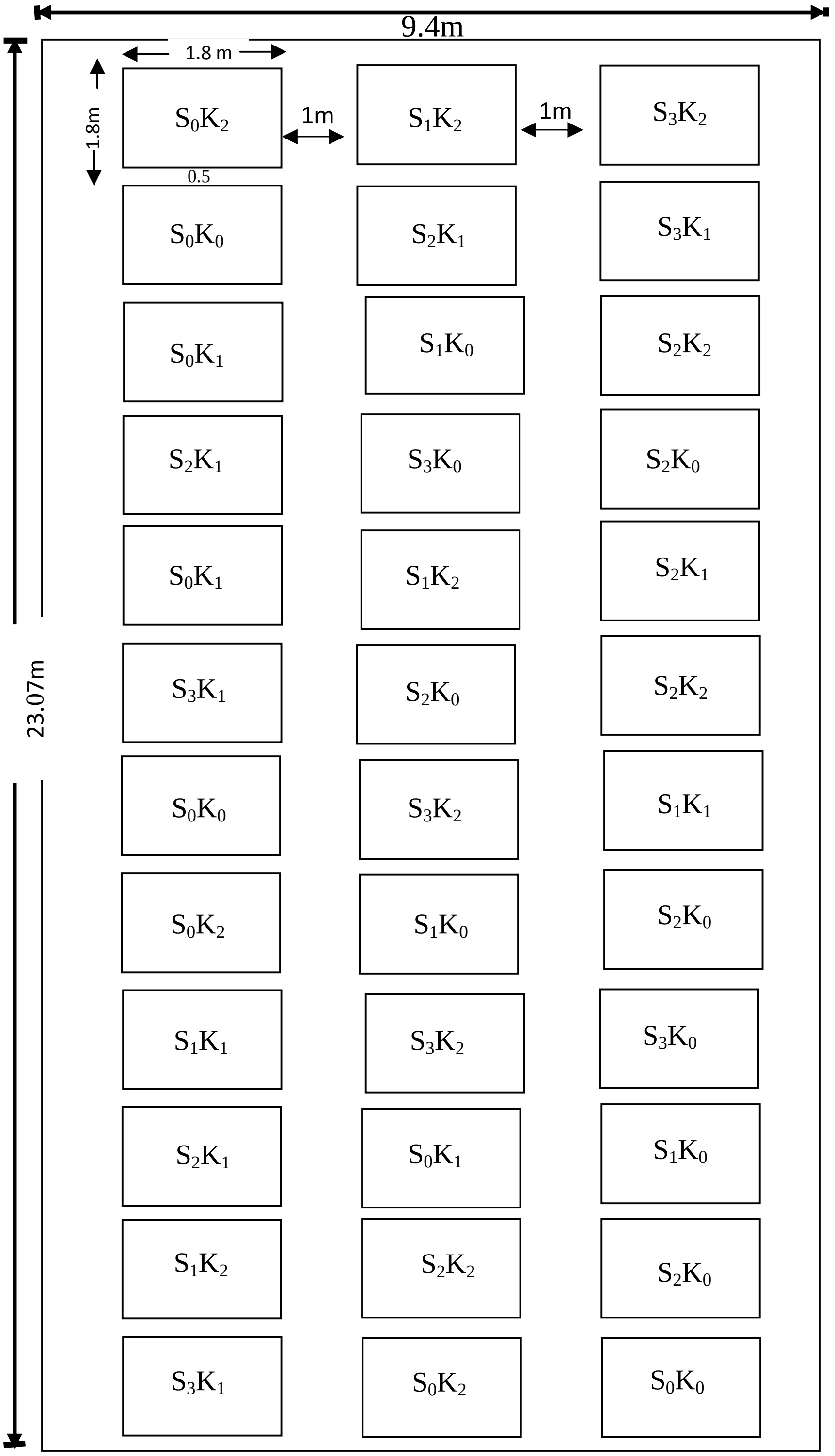
There were 12 (3 × 4) treatments combination such as S_0K_0, S_0K_1, S_0K_2, S_1K_0, S_1K_1, S_1K_2, S_2K_0, S_2K_1, S_2K_2, S_3K_0, S_3K_1 and S_3K_2.

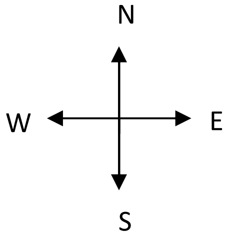
3.7 Collection of seedlings

The seeds of cabbage variety Atlas-70 were collected from Siddique Bazaar, Dhaka

3.8 Design and layout of the experiment

The two factorial experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. The total area of the experimental plot was 222.78 m^2 with length 23.7 m and width 9.4 m. The total area was divided into three equal blocks. Each block was divided into 12 plots where 12 treatments combination were allotted at random. There were 36 unit plots altogether in the experiment. The size of the each plot was 1.8 m × 1.8 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Fig 1.





Plot size: 1.8 m × 1.8 m

Plot spacing: 60cm×45cm

Between replication: 1.0m

Factor A: Starter solution
1.S_0 = 0% urea
2. S_1 = 0.5 % urea
3. S_2 = 1.5 % urea
4. S_3 = 2.5 % urea

Factor B: Potassium
1. K_0 = 0 kg K_2O/ha
2. K_1 = 180 kg K_2O/ha
3. K_2 = 220 kg K_2O/ha

Fig 1: Layout of the experimental plot

3.9 Land Preparation

The selected plot of the experiment was opened in the last week of October 2012 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. 10 Application of manure and fertilizers

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

Table 1. Dose and method of application of fertilizers in cabbage field

Fertilizers and Manures	Dose/ha	Application (%)			
		Basal	10 DAT	30 DAT	50 DAT
Cow dung	5 tones	100	--	--	--
Urea	300 kg	--	33.33	33.33	33.33
TSP	200 kg	100	--	--	--
MoP	As per treatment	100	--	--	--

The total amount of cow dung, TSP and MoP was applied as basal dose at the time. The total amount of urea was applied in three installments at 10, 30 and 50 days after transplanting(DAT).

3. 11 Preparation of starter solution

At first, 0, 0.5, 1.5, 2.5 g of urea were weighted and were dissolved in distilled water taken in four beakers. The solutions were then made to volume up to 100ml by water. The beakers were leveled and the solutions were ready for use.

3.12 Raising of seedling

The seedlings were raised at the Horticultural Farm, SAU, Dhaka under special care in a 3 m × 1 m size seed bed. The soil of the seed bed was well ploughed with a spade and prepared into loose friable dried masses and to obtain good tilt to provide a favorable condition for the vigorous growth of young seedlings. Weeds, stubbles and dead roots of the previous crop were removed. The seedbed was dried in the sun to destroy the soil insect and protect the young seedlings from the attack of damping off disease. To control damping off disease, cupravit fungicide was applied. Decomposed cow dung was applied to the prepared seedbed at the rate of 5 t/ha. Ten (10) grams of seeds were sown in seedbed on 1st November, 2012. After sowing, the seeds were covered with finished light soil. At the end of germination shading was done by bamboo mat (chatai) over the seedbed to protect the young seedlings from scorching sunshine and heavy rainfall. Light watering, weeding was done as and when necessary to provide seedlings with ideal condition for growth.

3.13 Transplanting of seedlings

Thirty day old healthy and uniform sized seedlings were transplanted in the experimental plots on 1st December, 2012. The seedlings were uprooted carefully from the seedbed to avoid damage to the root system. Planting was done in the afternoon. The bottom part of the seedlings was dipped for 5 minutes in urea solution prior to transplanting. Seedlings were sown in plot with maintaining distance between row to row was 60 cm and plant to plant was 45 cm. The seedlings were watered immediately after transplanting. The transplants were shaded by banana leaf sheath to protect them from scorching sunshine up to 6 days until they were set in the soil. Transplants were kept open at night to allow them receiving dew. A number of treated seedlings were planted on the border of the experimental plots for gap filling.

3.14 Intercultural operation

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

3.14.1 Gap filling

The transplanted seedlings in the experimental plot were kept under careful observations.Very few seedlings were damaged after transplanting and such seedling were replaced by new seedlings from the same stock. Replacement was done with healthy seedling having a ball of earth which was also planted on the same date by the side of the unit plot. The transplants were kept under shade and watering was done up to 7 days for their proper establishment.

3. 14. 2 Weeding

The hand weeding was done as and when necessary after transplanting to keep the plots free from weeds.

3. 14. 3 Earthing up

Earthing up was after transplanting on both sides of rows by taking the soil from the space between the rows by a small spade.

3. 14 .4 Irrigation

Light watering was given by a watering can at every morning and afternoon after transplanting. Following transplanting and it was continued for a week for rapid and well establishment of the transplanted seedlings. After this a routine irrigation was given at 3 days intervals.

3. 14. 5 Pest and disease control

Due to soil treatment prior to sowing, insect and pest attack was very low. Some plants were infected by aphid and these were controlled by spraying Diazinon 60 Ec @ 0.56 lit/ha. The diseased leaves were also collected from the infested plant and removed from the field.

3.15 Harvesting

Harvesting of the cabbage was not possible on a certain or particular date because the head initiation as well as head at marketable size in different plants were not uniform. Only the compact marketable heads were harvested with fleshy stalk by using as sharp knife. Before harvesting of the cabbage head, compactness of the head was tested by pressing with thumbs.

3.16 Collection of data

Five plants were randomly selected from the rows of each unit plot. Data were collected in respect of the following parameters to assess plant growth; yield attributes and yields as affected by different treatments of the experiment. Data on plant height, number of loose leaves, plant spread and length of largest leaf were collected at 30, 40 and 50 days after transplanting (DAT). All other yield contributing characters and yield parameters were recorded during harvest and after harvest.

3.16.1 Plant height

Plant height was measured from sample plants by using meter scale in centimeter from the ground level to the tip of the longest leaf and mean value was calculated. Plant height was also recorded at 10 days interval starting from 30 DAT up to 50 DAT to observe the growth rate of plants.

3.16.2 Number of loose leaves per plant

The total number of loose leaves per plant was counted from each selected plant. Data were recorded as the average of 5 plants selected at random of each plot at 10 days interval starting from 30 DAT up to 50 DAT.

3.16.3 Plant spread

The spread of plant was counted from each selected plant. Data were recorded as the average of 5 plants selected at random of each plot at 10 days interval starting from 30 DAT up to 50 DAT.

3.16.4 Length of largest leaf

The distance from the base of the petiole to the tip of largest leaf was considered length of leaf. It was measured with a meter scale and was recorded in centimeter (cm). Data were recorded as the average of 5 plants selected at random of each plot at 10 days interval starting from 30 DAT up to 50 DAT.

3.16.5 Length of stem

The length of stem was taken from the ground level to base of the head of plant during harvesting. A meter scale used to measure the length of stem and was expressed in centimeter (cm).

3.16.6 Diameter of stem

The diameter of the stem was measured at the point where the central head was cut off. The diameter of the stem was recorded in three dimensions with scale and the average of three figures was taken into account in centimeter (cm).

3.16.7 Fresh weight of stem per plant

The fresh weight of stem was recorded from the average of five (5) selected plants in grams (g) with a beam balance during harvest.

3.16.8 Dry matter content of stem

At first stem of selected plant were collected, cut into pieces and was dried under sunshine for a 3 days and then dried in an oven at 70^0C for 72 hours before taking dry weight till it was constant. The dry matter contents of stem were computed by simple calculation from the weight recorded by the following formula:

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

3.16.9 Length of root

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

3.16.10 Fresh weight of roots per plant

Fresh weight of roots was recorded by weighting the total roots and was recorded in gram (g).

3.16.11 Thickness of head

The thickness of head was measured in centimeter (cm) with a meter scale as the vertical distance from the lower to the upper most leaves of the head after sectioning the head vertically at the middle position and mean value was calculated.

3.16. 12 Diameter of head

The heads from sample plants were sectioned vertically at the middle position with a sharp knife. The diameter of the head was measured in centimeter (cm) with a meter scale as the horizontal distance from one side to another side of the widest part of the sectioned head and mean value was recorded.

3.16.13 Gross weight of head per plant

The heads from sample plants were harvested, cleaned and weighted with folding and unfolded leaves. The gross weight of every head were measured with a weighing scale and mean values was counted.

3.16.14 Fresh weight of head per plant

After harvest of head from selected plants from each unit plot the unfolded leaves were removed from the head and weighted by a weighing machine and recorded the weight of head as fresh weight of head per plant.

3.16.15 Dry matter content of head

At first head from selected plant were collected, cut into pieces and was dried under sunshine for a few days and then dried in an oven at 70^0C for 72 hours before taking dry weights till it was constant. The dry matter contents of head were computed by simple calculation from the weight recorded by the following formula:

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

3.16.16 Marketable yield per hectare

The marketable yield per hectare was measured by multiplying fresh weight of head with total number of plant within a plot and was divided it with plot area. It was converted into yield per hectare and was expressed in ton.

3.17 Statistical analysis

The data obtained for different characters were statistically analyzed to find out the significance of the difference for different level of starter solution and potassium fertilizers on growth and yield contributing characters of cabbage. 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 different levels of starter solution and potassium. 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 @ 14% in simple rate. The market price of cabbage 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:

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

CHAPTER 4

RESULT AND DISCUSSION

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

4.1 Plant height

Significant variation was recorded on plant height of cabbage due to different concentrations of starter solution (Appendix III). At 30, 40 and 50 DAT, the tallest plant (21.58, 38.52 and 45.92 cm respectively) was recorded from S_2 which was statistically similar (19.05, 36.57 and 44.01 cm, respectively) to S_3 and the shortest plant (16.62, 30.41 and 37.32 cm, respectively) was recorded from S_0 (Fig 2).

Different levels of potassium fertilizer showed significant variation for plant height of cabbage at 30, 40 and 50 DAT (Appendix III). At 30, 40 and 50 DAT, the tallest plant (19.86, 38.27 and 44.28 cm, respectively) was recorded from K_2, which was statistically similar (18.99, 36.41 and 42.28 cm, respectively) to K_1, whereas the shortest plant (17.93, 31.47 and 37.67 cm, respectively) was recorded from K_0 (Fig 3).

Combined effect of different concentrations of starter solution and potassium fertilizer showed significant differences on plant height of cabbage at 30, 40 and 50 DAT (Appendix III and Table 2). At 30, 40 and 50 DAT, the tallest plant (21.63, 42.53 and 49.07 cm, respectively) was obtained from S_2K_2, while the shortest plant (17.23, 30.33 and 34.23 cm, respectively) was recorded from S_0K_0.

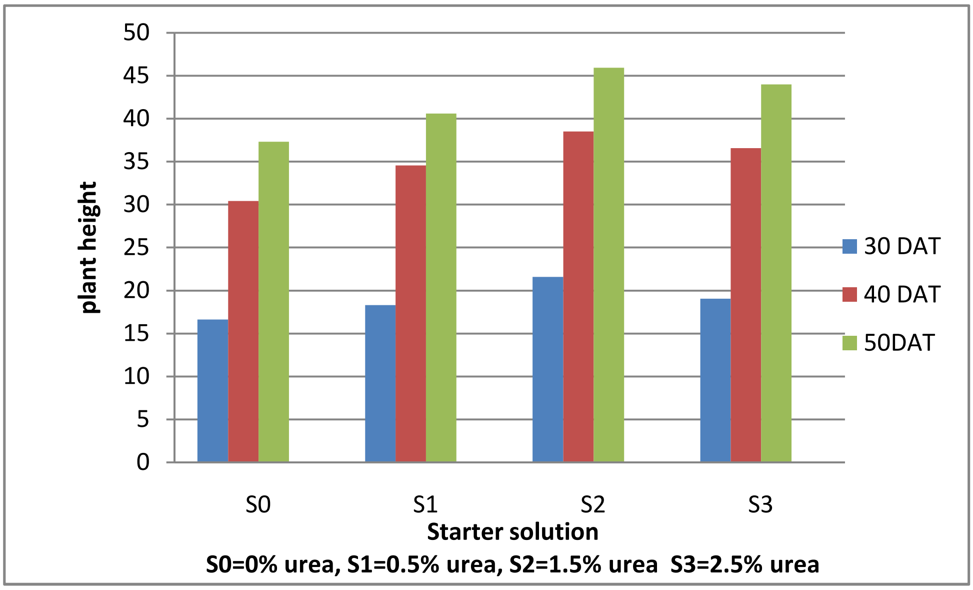


Fig 2 Main effect of starter solution on the plant height of cabbage.

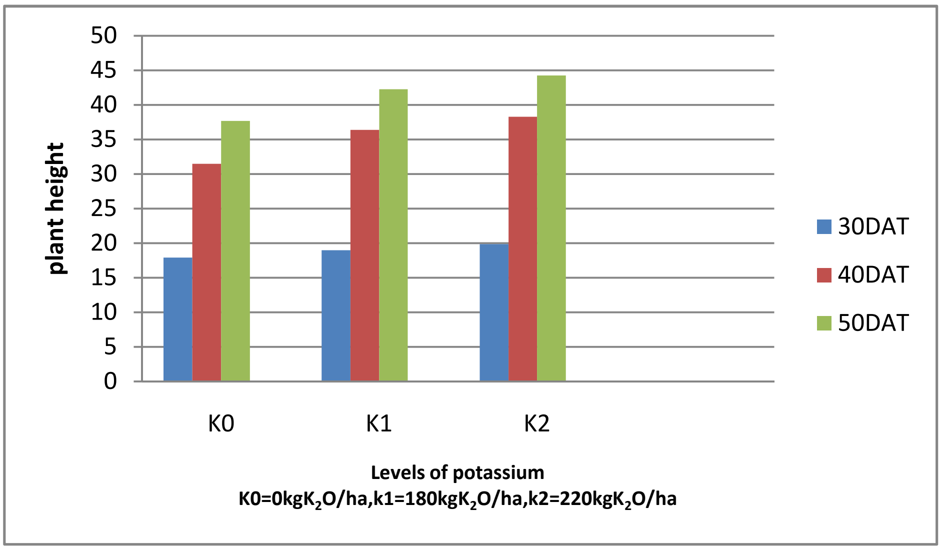


Fig 3 Main effect of potassium on the plant height of cabbage

4.2 Number of loose leaves per plant

Significant variation was recorded on number of loose leaves per plant of cabbage due to different concentrations of starter solution (Appendix III). At 30, 40 and 50 DAT, the maximum number of loose leaves per plant (12.28, 20.74 and 24.72 cm respectively) was recorded from S_2 which was statistically similar (11.16, 18.92 and 22.60 cm, respectively) to S_3 and the minimum number of loose leaves per plant (9.66, 14.70 and 17.30 cm, respectively) was recorded from S_0 (Fig. 4).

Different levels of potassium fertilizer showed significant variation for number of loose leaves per plant of cabbage at 30, 40 and 50 DAT (Appendix III). At 30, 40 and 50 DAT, the maximum number of loose leaves per plant (11.79, 20.28 and 22.86 cm, respectively) was recorded from K_2 which was statistically similar (10.27, 18.61 and 20.42 cm, respectively) to K_1, whereas the minimum number of loose leaves per plant (9.61, 16.27 and 18.56 cm, respectively) was recorded from K_0 (Fig 5).

Combined effect of different concentrations of starter solution and potassium fertilizer showed significant differences on number of loose leaves per plant of cabbage at 30, 40 and 50 DAT (Appendix III and Table 2). At 30, 40 and 50 DAT, the maximum number of loose leaves per plant (14.20, 22.37 and 25.73 cm, respectively) was obtained from S_2K_2, while the minimum number of loose leaves per plant (7.93, 14.10 and 16.69 cm, respectively) was recorded from S_0K_0 .

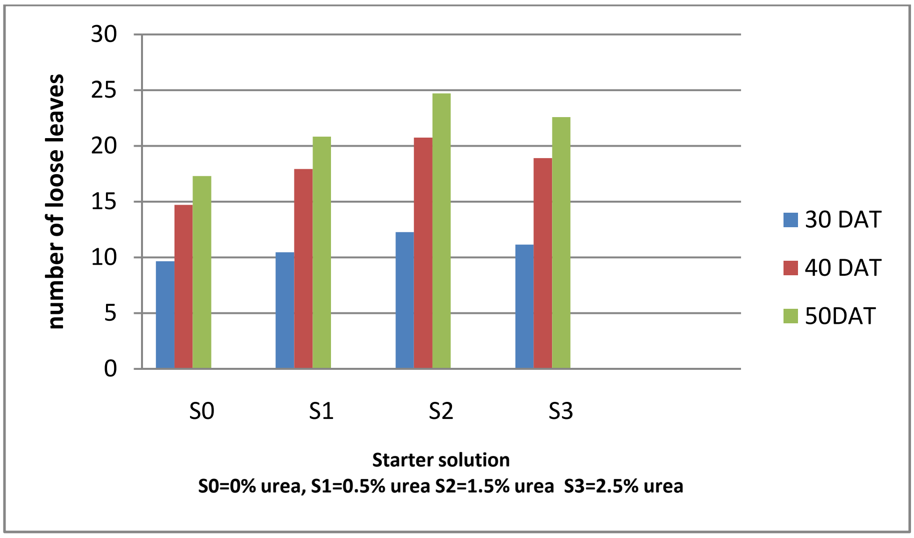


Fig 4 Effect of starter solution on number of loose leaves per plant

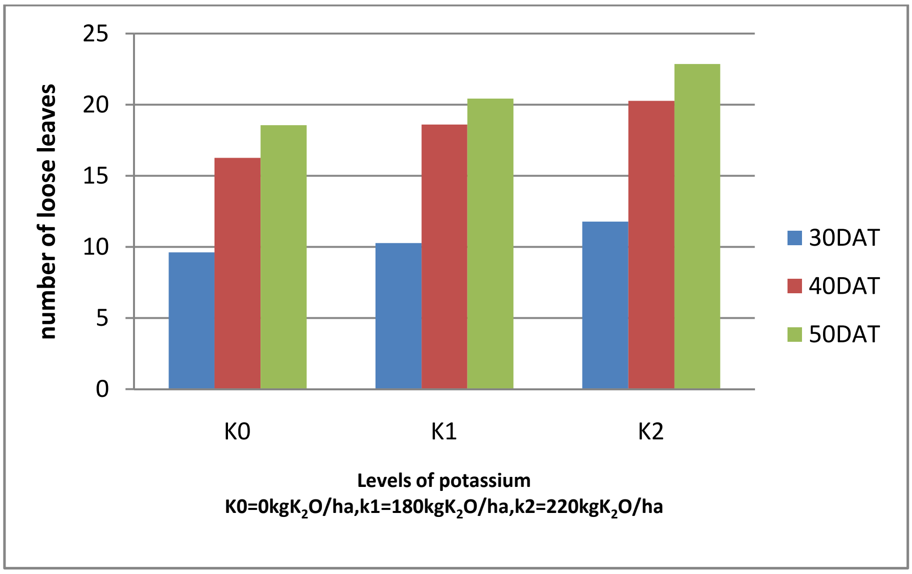


Fig 5 Effect of potassium on number of loose leaves per plant

Table 2 Combined effects of starter solution and potassium on plant height and number of loose leaves per plant

Treatments	Plant height at (cm)			Number of loose leaves at(cm)		
	30 DAT	40 DAT	50 DAT	30 DAT	40 DAT	50 DAT
S_0Ko	17.23 e	30.33 c	34.23 g	7.93 f	14.10 g	16.69 i
S_0K_1	17.50 e	30.42 c	38.47 f	10.50 de	16.00 ef	17.23i
S_0K_2	18.23 de	30.47 c	39.27 f	10.53 de	17.00 e	18.01 h
S_1Ko	17.57 e	30.97 c	36.17 g	9.733 e	15.80 f	18.13 g
S_1K_1	18.23 cd	36.33 b	43.23 d	11.33 bcd	19.47 c	20.90 ef
S_1K_2	19.10 cd	37.43 b	42.40 d	10.33 de	20.57 bc	21.02 de
S_2Ko	20.30 cd	32.87 c	39.13 f	10.43 de	18.20 d	24.40 ab
S_2K_1	19.90 bc	40.67 ab	47.67 b	12.20 b	21.67 ab	21.03 de
S_2K_2	21.63 a	42.53 a	49.07 a	14.20 a	22.37 a	25.73 a
S_3Ko	19.30 cd	30.80 c	41.13 e	10.33 de	17.00 e	20.43 ef
S_3K_1	19.33 bcd	38.87 ab	45.73 b	11.03 cd	21.57 bc	23.12 b
S_3K_2	19.67 ab	41.03 ab	46.51 c	12.10 bc	21.20 abc	23.20 bc
LSD(0.05)	1.335	3.80	1.247	1.100	1.197	1.412
Level of significance	ns	**	**	**	*	**
CV%	4.14	6.28	1.75	5.96	3.75	3.86

S_0: 0 % urea (control),S_1: 0.5% urea ,S_2: 1.5% urea, S_3 : 2.5% urea

K_0: 0 kg K_2O/ha(control),K_1: 180 kg K_2O/ha,K_2: 220 kg K_2O/ha

4.3 Plant spread

Significant variation was recorded on plant spread of cabbage due to different concentrations of starter solution (Appendix Ⅳ). At 30, 40 and 50 DAT, the maximum plant spread (27.90, 38.79 and 49.53 cm respectively) was recorded from S_2 which was statistically similar (26.62, 38.66 and 49.04 cm, respectively) to S_3 and the minimum plant spread (21.59, 31.02 and 40.26 cm, respectively) was recorded from S_0 (Table 3).

Different levels of potassium fertilizer showed significant variation for maximum plant spread cabbage at 30, 40 and 50 DAT (Appendix Ⅳ). At 30, 40 and 50 DAT, the maximum plant spread of cabbage (27.27, 38.60 and 49.50 cm, respectively) was recorded from K_2 which was statistically similar (26.80, 38.33 and 48.45 cm, respectively) to K_1, whereas the minimum number of plant spread (22.21, 31.26 and 40.63 cm, respectively) was recorded from K_0 (Table 4).

Combined effect of different concentrations of starter solution and potassium fertilizer showed significant differences on plant spread of cabbage at 30, 40 and 50 DAT (Appendix Ⅳ and Table 5). At 30, 40 and 50 DAT, the maximum plant spread (29.45, 42.61 and 55.44 cm, respectively) was obtained from S_2K_2, while the minimum plant spread (19.2, 27.33 and 38.17 cm, respectively) was recorded from S_0K_0.

4.4 Length of largest leaf

Significant variation was recorded for length of largest leaf of cabbage due to different concentrations of starter solution (Appendix IV). At 30, 40 and 50 DAT, the maximum length of largest leaf (22.54, 29.91 and 35.66 cm respectively) was recorded from S_2 which was statistically similar (21.15, 29.60 and 34.69 cm, respectively) to S_3 and the minimum length of largest leaf (18.06, 23.11 and 30.22 cm, respectively) was recorded from S_0 (Table 3).

Different levels of potassium fertilizer showed significant variation for length of largest leaf of cabbage at 30, 40 and 50 DAT (Appendix IV). At 30, 40 and 50 DAT, the maximum length of largest leaf per plant (21.31, 29.38 and 35.38 cm, respectively) was recorded from K_2 which was statistically similar (21.19, 28.44 and 35.23 cm, respectively) to K_1, whereas the minimum length of largest leaf per plant (19.20, 23.85 and 29.69 cm, respectively) was recorded from K_0 (Table 4).

Combined effect of different concentrations of starter solution and potassium fertilizer showed significant differences on length of largest leaves per plant of cabbage at 30, 40 and 50 DAT (Appendix IV and Table 5). At 30, 40 and 50 DAT, the maximum length of largest leaves per plant (23.15, 33.20 and 37.46 cm, respectively) was obtained from S_2K_2, while the minimum length of largest leaf (17.87, 21.70 and 28.67 cm, respectively) was recorded from S_0K_0.

Table 3 Effect of starter solution on plant spread and length of largest leaf

Treatments	plant spread at (cm)			length of largest leaf at (cm)		
	30 DAT	40 DAT	50 DAT	30 DAT	40 DAT	50 DAT
S_0	21.59 d	31.02 c	40.26 d	18.06 d	23.11 c	30.22 d
S_1	25.61 c	35.78 b	45.31 c	20.52 c	26.27 b	33.17 c
S_2	27.90 a	38.79 a	49.53 a	22.54 a	29.91 a	35.66 a
S_3	26.62 b	38.66 a	49.04 b	21.15 b	29.60 a	34.69 b
LSD(0.05)	0.6214	0.1275	0.4148	0.2206	0.8612	0.1157
Level of significance	**	**	**	**	**	**
CV%	2.50	3.36	2.92	2.80	3.23	3.35

S_0: 0 % urea (control),S_1: 0.5% urea ,S_2: 1.5% urea, S_3 : 2.5% urea

Table 4 Effect of potassium on plant spread and length of largest leaf

Treatments	plant spread at (cm)			length of largest leaf at (cm)		
	30 DAT	40 DAT	50 DAT	30 DAT	40 DAT	50 DAT
K_0	22.21 b	31.26 c	40.63 c	19.20 b	23.85 c	29.69 c
K_1	26.80 a	38.33 b	48.45 b	21.19 a	28.44 b	35.25 a
K_2	27.27 a	38.60 a	49.50 a	21.31 a	29.38 a	35.38 b
LSD(0.05)	0.5381	0.1104	0.3592	0.1391	0.7458	0.1002
Level of significance	**	**	**	**	**	**
CV%	2.50	3.36	2.92	2.80	3.23	3.35

K_0: 0 kg K_2O/ha(control),K_1: 180 kg K_2O/ha,K_2: 220 kg K_2O/ha

Table 5 Combined effects of starter solution and potassium on plant spread and length of largest leaf of cabbage

Treatments	plant spread at (cm)			length of largest leaf at (cm)		
	30 DAT	40 DAT	50 DAT	30 DAT	40 DAT	50 DAT
S_0Ko	19.2 g	27.33 i	38.17 i	17.87 h	21.7 f	28.67 i
S_0K_1	23.16 e	33.60 f	42.48 f	18.31 f	24.40 e	31.80 f
S_0K_2	22.40 e	32.12 h	40.12 h	18.00 g	23.23 e	30.20 h
S_1Ko	21.10 f	30.65 i	40.32 h	18.27 fg	23.22 e	26.20 j
S_1K_1	27.60 c	38.20 e	48.21 d	21.60 d	27.00 d	37.10 b
S_1K_2	28.14 bc	38.50 d	47.38 e	21.70 d	28.60 c	36.20 c
S_2Ko	26.18 d	33.75 f	41.43 g	21.87 d	24.30 e	32.50 e
S_2K_1	28.07 bc	41.05 b	51.72 c	22.60 b	31.30 b	37.01 b
S_2K_2	29.45 a	42.61 a	55.44 a	23.15 a	33.20 a	37.46 a
S_3Ko	22.38 e	33.30 g	42.60 f	18.77 e	26.20 d	31.40 g
S_3K_1	28.38 abc	40.45 c	51.40 c	22.26 c	31.05 b	35.60 d
S_3K_2	29.11 ab	41.18 b a	53.12 b	22.41 bc	32.47 ab	37.06 b
LSD(0.05)	1.076	0.22	0.72	0.28	1.49	0.20
Level of significance	**	**	**	**	**	**
CV%	2.50	3.36	2.92	2.80	3.23	3.35

S_0: 0 % urea (control),S_1: 0.5% urea ,S_2: 1.5% urea, S_3 : 2.5% urea

K_0: 0 kg K_2O/ha(control),K_1: 180 kg K_2O/ha,K_2: 220 kg K_2O/ha

4.5 Length of Stem

Significant variation was recorded on length of stem of cabbage due to different concentrations of starter solution under the present trial (Table 6 and Appendix V). The highest length of stem (8.15 cm) was recorded from S_2 which was closely followed (7.89 cm) by S_3 whereas the lowest length of stem (6.36 cm) was recorded from S_0.

Different levels of potassium fertilizer showed significant variation on length of stem of cabbage (Table 7 and Appendix V). The highest length of stem (7.95 cm) was found from K_2 which was closely followed (7.50 cm) by K_1 while the lowest length of stem (6.65 cm) was recorded from K_0.

Combined effect of different concentrations of starter solution and potassium fertilizer showed significant differences on length of stem of cabbage (Table 8 and Appendix V). The highest length of stem (8.99 cm) was recorded from S_2K_2 again the lowest length of stem (6.19 cm) was found from $S_0K_{0.}$

4.6 Diameter of stem

Significant variation was recorded for diameter of stem of cabbage due to different concentrations of starter solution under the present trial (Table 6 and Appendix V). The highest diameter of stem (2.63 cm) was recorded from S_2 which was closely followed (2.60 cm) by S_3, closely followed (2.51 cm) by S_1 whereas the lowest diameter of stem (2.10 cm) was recorded from S_0.

Different levels of potassium fertilizer showed significant variation on diameter of stem of cabbage (Table 7 and Appendix V). The highest diameter of stem (2.58 cm) was found from K_2 which was closely followed (2.52 cm) by K_1, while the lowest diameter of stem (2.24 cm) was recorded from $K_{0.}$

Combined effect of different concentrations of starter solution and potassium fertilizer showed significant differences on diameter of stem of cabbage (Table 8 and Appendix V). The highest diameter of stem (2.78 cm) was recorded from S_2K_2 and the lowest diameter of stem (2.02cm) was found from $S_0K_{0.}$

Table 6 Effect of starter solution on yield contributing characters of cabbage

Treatments	Stem length (cm)	Stem diameter (cm)	Fresh weight of stem (g)	Dry matter content of stem (%)	Length of root (cm)	Fresh weight of root (g)
S_0	6.36 d	2.10 d	40.69 d	9.13 b	16.86 c	15.27 c
S_1	7.37 c	2.51 b	52.67 c	10.16 ab	20.10 b	19.07 b
S_2	8.15 a	2.63 a	60.12 a	10.71 a	21.72 a	21.86 a
S_3	7.89 b	2.60 ab	55.68 b	10.38 a	20.04 b	19.66 b
LSD(0.05)	0.28	0.11	0.90	1.17	0.96	0.68
Level of significance	**	**	**	*	**	**
CV%	6.87	8.88	1.76	11.88	4.98	3.68

S_0: 0 % urea (control),S_1: 0.5% urea ,S_2: 1.5% urea, S_3 : 2.5% urea

Table 7 Effect of Potassium on yield contributing characters of cabbage

Treatments	Stem length (cm)	Stem diameter (cm)	Fresh weight of stem (g)	Dry matter content of stem (%)	Length of roots (cm)	Fresh weight of roots (g)
K_0	6.65 c	2.24 b	50.73 c	9.00 b	18.12 b	15.71 c
K_1	7.50 b	2.52 a	51.80 b	10.51 a	20.43 a	20.26 b
K_2	7.95 a	2.58 a	54.34 a	10.78 a	20.49 a	20.92 a
LSD(0.05)	0.219	0.089	0.78	1.016	0.83	0.59
Level of significance	**	**	**	**	**	**
CV%	6.87	8.88	1.76	11.88	4.98	3.68

K_0: 0 kg K_2O/ha(control),K_1: 180 kg K_2O/ha,K_2: 220 kg K_2O/ha

Table 8 Combined effects of starter solution and K on yield contributing characters of cabbage

Treatments	Stem length (cm)	Stem diameter (cm)	Fresh weight of stem (g)	Dry matter content of stem (%)	Length of roots (cm)	Fresh weight of roots (g)
S_0Ko	6.19 gh	2.02 g	39.60 h	8.37 b	15.40 d	13.10 f
S_0K_1	6.77 ef	2.17 fg	40.07 h	8.433 b	17.58 c	15.47 e
S_0K_2	7.06 e	2.25 efg	42.40 g	8.600 b	17.58 c	17.22 d
S_1Ko	6.57 fg	2.36 def	55.25 d	8.367 b	17.37 c	15.51 e
S_1K_1	6.58 efg	2.52 cd	57.67 c	11.04 a	22.13 ab	20.66 c
S_1K_2	7.02 ef	2.68 abc	45.10 f	11.07 a	20.80 b	21.03 c
S_2Ko	8.16 c	2.75 ab	59.27 b	8.700 b	21.39 ab	17.16 d
S_2K_1	8.22 c	2.05 g	58.41 bc	11.53 a	21.10 ab	23.53 b
S_2K_2	8.99 a	2.78 a	62.67 a	11.90 a	22.66 a	24.89 a
S_3Ko	8.06 cd	2.75 ab	48.80 e	8.567 b	18.29 c	17.08 d
S_3K_1	6.04 h	2.77 ab	61.22 a	11.04 a	21.17 ab	21.38 c
S_3K_2	8.72 ab	2.55 bcd	57.03 c	11.53 a	20.66 b	20.52 c
LSD(0.05)	0.44	0.19	1.56	2.03	1.66	1.18
Level of significance	Ns	ns	**	**	**	**
CV%	6.87	8.88	1.76	11.88	4.98	3.68

S_0: 0 % urea (control), S_1: 0.5% urea , S_2: 1.5% urea, S_3 : 2.5% urea

K_0: 0 kg K_2O/ha(control), K_1: 180 kg K_2O/ha, K_2: 220 kg K_2O/ha

4.7 Fresh weight of stem

Significant variation was recorded for fresh weight of stem of cabbage due to different concentrations of starter solution under the present trial (Table 6 and Appendix V). The highest fresh weight of stem (60.12 g) was recorded from S_2 which was statistically similar (55.68 g) with S_3 and closely followed (52.67 g) by S_1, whereas the lowest fresh weight of stem (40.69 g) was recorded from S_0 (control)

Different levels of potassium fertilizer showed significant variation on fresh weight of stem of cabbage (Table 7 and Appendix V). The highest fresh weight of stem (54.34 g) was found from K_2 which was closely followed (51.80 g) by K_1, while the lowest fresh weight of stem (50.73 g) was recorded from K_0.

Combined effect of different concentrations of starter solution and potassium fertilizer showed significant differences on fresh weight of stem of cabbage (Table 8 and Appendix V). The highest fresh weight of stem (62.67 g) was recorded from S_2K_2, again the lowest fresh weight of stem (39.60 g) was found from S_0K_0.

4.8 Dry matter content of stem

Significant variation was recorded for dry matter content of stem of cabbage due to different concentrations of starter solution under the present trial (Table 6 and Appendix V). The highest dry matter content of stem (10.71%) was recorded from S_2 which was statistically similar (10.38%) with S_3 and closely followed (10.16 %) by S_1, whereas the lowest dry matter content of stem (9.13%) was recorded from S_0.

Different levels of potassium fertilizer showed significant variation on dry matter content of stem of cabbage (Table 7 and Appendix V). The highest dry matter content of stem (10.78%) was found from K_2 which was closely followed (10.51%) by K_1, while the lowest dry matter content of stem (9.0 %) was recorded from K_0.

Combined effect of different concentrations of starter solution and potassium fertilizer showed significant differences on dry matter content of stem of cabbage (Table 8 and Appendix V). The highest dry matter content of stem (11.90%) was recorded from S_2K_2, again the lowest dry matter content of stem (8.37%) was found from S_0K_0.

4.9 Length of roots

Significant variation was recorded for length of roots of cabbage due to different concentrations of starter solution under the present trial (Table 6 and Appendix V). The maximum length of roots (21.72cm) was recorded from S_2 which was statistically similar (20.10 cm) with S_1 and closely followed (20.04 cm) by S_3, whereas the minimum length of roots (16.86 cm) was recorded from S_0.

Different levels of potassium fertilizer showed significant variation on length of roots of cabbage (Table 7 and Appendix V). The maximum length of roots (20.49 cm) was found from K_2 which was closely followed (20.43 cm) by K_1, while the minimum length of root (18.12 cm) was recorded from K_0.

Combined effect of different concentrations of starter solution and potassium fertilizer showed significant differences on length of roots of cabbage (Table 8 and Appendix V). The maximum length of roots (22.66 cm) was recorded from S_2K_2 and the minimum length of root (15.40 cm) was found from S_0K_0.

4.10 Fresh weight of roots

Significant variation was recorded for fresh weight of roots of cabbage due to different concentrations of starter solution under the present trial (Table 6 and Appendix V). The highest fresh weight of roots (21.86 g) was recorded from S_2 which was statistically similar (19.66 g) with S_3 and closely followed (19.07 g) by S_1, whereas the lowest fresh weight of roots (15.27 g) was recorded from S_0.

Different levels of potassium fertilizer showed significant variation on fresh weight of roots of cabbage (Table 7 and Appendix V). The highest fresh weight of roots (20.92 g) was found from K_2 which was closely followed (20.26 g) by K_1, while the lowest fresh weight of roots (15.71 g) was recorded from K_0.

Combined effect of different concentrations of starter solution and potassium fertilizer showed significant differences on fresh weight of roots of cabbage (Table 8 and Appendix V). The highest fresh weight of roots (24.89 g) was recorded from S_2K_2, again the lowest fresh weight of roots (13. 10 g) was found from $S_0K_{0.}$

4.11 Thickness of head

Significant variation was recorded for thickness of head of cabbage due to different concentrations of starter solution under the present trial (Table 9 and Appendix VI). The highest thickness of head (12.93 cm) was recorded from S_2 which was statistically similar (12.24 cm) with S_3 and closely followed (12.11 cm) by S_1, whereas the lowest thickness of head (10.93 cm) was recorded from S_0.

Different levels of potassium fertilizer showed significant variation on thickness of head of cabbage (Table 10 and Appendix VI). The highest thickness of head (13.05 cm) was found from K_2 which was closely followed (12.19 cm) by K_1, while the lowest thickness of head (10.92 cm) was recorded from K_0.

Combined effect of different concentrations of starter solution and potassium fertilizer showed significant differences on thickness of head of cabbage (Table 11 and Appendix VI). The highest thickness of head (14.29 cm) was recorded from S_2K_2, again the lowest thickness of head (10.30 cm) was found from S_0K_0.

4.12 Diameter of head

Significant variation was recorded for diameter of head of cabbage due to different concentrations of starter solution under the present trial (Table 9 and Appendix VI). The highest diameter of head of cabbage (13.0 cm) was recorded from S_2 which was statistically similar (12.02 cm) with S_3 and closely followed (11.09 cm) by S_1, whereas the lowest diameter of head (10.25 cm) was recorded from S_0.

Different levels of potassium fertilizer showed significant variation on diameter of head of cabbage (Table 10 and Appendix VI). The highest diameter of head (12.56 cm) was found from K_2 which was closely followed (11.78 cm) by K_1, while the lowest diameter of head (10.44 cm) was recorded from K_0

Combined effect of different concentrations of starter solution and potassium fertilizer showed significant differences on diameter of head of cabbage (Table 11 and Appendix VI). The highest diameter of head (14.67 cm) was recorded from S_2K_2, and the lowest diameter of head (9.54 cm) was found from S_0K_0.

Table 9 Effect of starter solution on yield contributing characters and yield of cabbage

Treatments	Thickness of head (cm)	Diameter of head (cm)	Gross weight of head (kg)	Fresh weight of head (kg)	Dry matter of head (%)	Marketable yield (ton)
S_0	10.93 b	10.25 c	1.24 d	1.15 d	8.81 c	42.59 d
S_1	12.11 a	11.09 bc	1.48 c	1.31 c	9.17 bc	48.51 c
S_2	12.93 a	13.00 a	1.78 a	1.59 a	10.23 a	58.89 a
S_3	12.24 a	12.02 ab	1.56 b	1.43 b	9.58 b	52.96 b
LSD(0.05)	1.030	1.388	0.03	0.03	0.55	0.03
Level of significance	**	**	**	**	**	**
CV%	8.74	12.25	2.89	3.12	6.01	3.04

S_0: 0 % urea (control),S_1: 0.5% urea ,S_2: 1.5% urea, S_3 : 2.5% urea

Table 10 Effect of potassium on yield contributing characters and yield of cabbage

Treatments	Thickness of head (cm)	Diameter of head (cm)	Gross weight of head (kg)	Fresh weight of head (kg)	Dry matter content of head (%)	Marketable yield (ton)
K_0	10.92 b	10.44 b	1.32c	1.19 c	8.67 c	44.07 c
K_1	12.19 a	11.78 a	1.58b	1.44 b	9.48 b	53.33 b
K_2	13.05 a	12.56 a	1.75a	1.68 a	10.19 a	62.22 a
LSD(0.05)	0.8916	1.20	0.02	0.03	0.48	0.03
Level of significance	**	**	**	**	**	**
CV%	8.74	12.25	2.89	3.12	6.01	3.04

K_0: 0 kg K_2O/ha(control),K_1: 180 kg K_2O/ha,K_2: 220 kg K_2O/ha

Table 11 Combined effects of starter solution and potassium yield contributing characters and yield of cabbage

Treatments	Thickness of head (cm)	Diameter of head (cm)	Gross weight of head (kg)	Fresh weight of head (kg)	Dry matter content of head(%)	Marketable yield (ton)
S_0Ko	10.30 d	9.54 c	1.13 i	1.02 h	8.01 ef	37.79 l
S_0K_1	11.10 cd	10.47 c	1.18 i	1.15 g	9.04 de	42.59 k
S_0K_2	11.40 cd	10.75 c	1.42 f	1.27 ef	9.39cd	47.03 h
S_1Ko	12.82 abc	10.71 c	1.24 h	1.17 g	8.64 ef	43.33 j
S_1K_1	10.33 d	11.17 bc	1.56 de	1.41 d	9.36 cde	52.23 d
S_1K_2	13.19 ab	11.39 bc	1.89 b	1.72 b	9.50 cde	63.70 b
S_2Ko	11.98 bcd	11.11 bc	1.59 d	1.36d	9.64 cd	50.37 f
S_2K_1	12.53 abc	13.22 ab	1.66 c	1.50 c	10.04 bc	58.37 c
S_2K_2	14.29 a	14.67 a	2.10 a	1.92 a	11.00 a	71.11 a
S_3Ko	11.08 cd	10.40 c	1.34 g	1.24 f	8.37 f	45.92 i
S_3K_1	13.33 ab	12.24 bc	1.52e	1.30 e	9.50 cde	48.15 g
S_3K_2	12.31 bc	13.43 ab	1.59d	1.40d	10.88 ab	51.85 e
LSD(0.05)	1.78	2.40	0.05	0.06	0.96	0.06
Level of significance	ns	ns	**	**	ns	**
CV%	8.74	12.25	2.89	3.12	6.01	3.04

S_0: 0 % urea (control),S_1: 0.5% urea ,S_2: 1.5% urea, S_3 : 2.5% urea

K_0: 0 kg K_2O/ha(control),K_1: 180 kg K_2O/ha,K_2: 220 kg K_2O/ha

4.13 Gross weight of head

Significant variation was recorded for gross weight of head of cabbage due to different concentrations of starter solution under the present trial (Table 9 and Appendix VI). The highest gross weight of head (1.78 kg) was recorded from S_2, which was statistically similar (1.56 kg) with S_3 and closely followed (1.48 kg) by S_1, whereas the lowest gross weight of head (1.24 kg) was recorded from S_0.

Different levels of potassium fertilizer showed significant variation on gross weight of head of cabbage (Table 9 and Appendix VI). The highest gross weight of head

(1.75 kg) was found from K_2 which was closely followed (1.58 kg) by K_1, while the lowest gross weight of head (1.32 kg) was recorded from K_0.

Combined effect of different concentrations of starter solution and potassium fertilizer showed significant differences on gross weight of head of cabbage (Table 11 and Appendix VI). The highest gross weight of head (2.10 kg) was recorded from S_2K_2, again the lowest gross weight of head (1.13 kg) was found from $S_0K_{0.}$

4.14 Fresh weight of head

Significant variation was recorded for fresh weight of head of cabbage due to different concentrations of starter solution under the present trial (Table 9 and Appendix VI). The highest fresh weight of head (1.59 kg) was recorded from S_2 which was statistically similar (1.43 kg) with S_3 and closely followed (1.31 kg) by S_1, whereas the lowest fresh weight of head (1.15 kg) was recorded from S_0.

Different levels of potassium fertilizer showed significant variation on fresh weight of head of cabbage (Table 10 and Appendix VI). The highest fresh weight of head (1.68 kg) was found from K_2 which was closely followed (1.44 kg) by K_1, while the lowest fresh weight of head (1.19 kg) was recorded from K_0.

Combined effect of different concentrations of starter solution and potassium fertilizer showed significant differences on fresh weight of head of cabbage (Table 11 and Appendix VI). The highest fresh weight of head (1.92 kg) was recorded from S_2K_2, again the lowest fresh weight of head (1.02 kg) was found from S_0K_0.

4.15 .Dry matter content of head

Significant variation was recorded for dry matter content of head of cabbage due to different concentrations of starter solution under the present trial (Table 9 and Appendix VI). The highest dry matter content of head (10.23%) was recorded from S_2 which was statistically similar (9.58%) with S_3 and closely followed (9.17%) by S_1, whereas the lowest dry matter content of head (8.81%) was recorded from S_0.

Different levels of potassium fertilizer showed significant variation on dry matter content of head of cabbage (Table 10 and Appendix VI). The highest dry matter content of head (10.19 %) was found from K_2 which was closely followed (9.48%) by K_1 ,while the lowest dry matter content of head (8.67%) was recorded from K_0.

Combined effect of different concentrations of starter solution and potassium fertilizer showed significant differences on dry matter content of head of cabbage (Table 6 and Appendix VI). The highest dry matter content of head (11.0 %) was recorded from S_2K_2, again the lowest dry matter content of head (8.01 %) was found from S_0K_0.

4.16. Marketable yield per hectare

Significant variation was recorded for marketable yield per hectare of cabbage due to different concentrations of starter solution under the present trial (Table 9 and Appendix VI). The highest marketable yield per hectare (58.89 ton) was recorded from S_2 which was statistically similar (52.96 ton) with S_3 and closely followed (48.51 ton) by S_1, whereas the lowest marketable yield per hectare (42.59 ton) was recorded from S_0 .

Different levels of potassium fertilizer showed significant variation on marketable yield per hectare of cabbage (Table 11 and Appendix VI). The highest marketable yield per hectare (62.22 ton) was found from K_2 which was closely followed (53.33 ton) by K_1 , while the lowest marketable yield per hectare (44.07 ton) was recorded from K_0.

Combined effect of different concentrations of starter solution and potassium fertilizer showed significant differences on marketable yield per hectare of cabbage (Table 11 and Appendix VI). The highest marketable yield per hectare (71.11 ton) was recorded from S_2K_2, again the lowest marketable yield per hectare (37.79 ton) was found from S_0K_0.

4.17 Economic analysis

Input costs for land preparation, seed cost, fertilizer & manure cost and manpower required for all the operations from transplanting of seedling to harvesting of tomato were recorded for unit plot and converted into cost per hectare. Prices of cabbage were considered in market rate basis. The economic analysis was done to find out the gross and net return and the benefit cost ratio in the present experiment and presented under the following headings-

4.17.1 Gross return

The combination of different concentrations of starter solution and potassium fertilizer showed different value in terms of gross return under the trial (Table 12). The highest gross return (Tk. 426660) was obtained from the treatment combination S_2K_2 and the second highest gross return (Tk. 382200) was found in S_1K_2. The lowest gross return (Tk. 226740) was obtained from S_0K_0.

4.17.2 Net return

The combination of different concentrations of starter solution and potassium fertilizer showed different value in terms of net return under the trial (Table 12). The highest net return (Tk. 245190) was obtained from the treatment combination S_2K_2 and the second highest gross return (Tk. 201355) was found in S_1K_2. The lowest gross return (Tk. 50511) was obtained from S_0K_0.

Table 12 Cost and return of cabbage production due to starter solution and potassium

Treatments	Cost of production(Tk./ha)	Yield of Cabbage(t/ha)	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio
S_0Ko	176,229	37.79	226740	50,511	1.29
S_0K_1	179,151	42.59	255540	76,389	1.43
S_0K_2	180,163	47.03	282180	102,017	1.57
S_1Ko	176,974	43.33	259980	83,006	1.47
S_1K_1	179,723	52.23	313380	133,657	1.74
S_1K_2	180,845	63.70	382200	201,355	2.11
S_2Ko	177,957	50.37	302220	124,263	1.69
S_2K_1	180,768	58.37	350220	169,452	1.94
S_2K_2	181,470	71.11	426660	245,190	2.35
S_3Ko	178,692	45.92	275520	96,828	1.54
S_3K_1	181,504	48.15	288900	107,396	1.59
S_3K_2	182,515	51.85	311100	128,585	1.70

Price of cabbage @Tk 6000/ton

S_0: 0 % urea (control),S_1: 0.5% urea ,S_2: 1.5% urea, S_3 : 2.5% urea

K_0: 0 kg K_2O/ha(control),K_1: 180 kg K_2O/ha,K_2: 220 kg K_2O/ha

4.18.3 Benefit cost ratio (BCR)

In the different concentrations of starter solution and potassium fertilizer the highest benefit cost ratio (2.35) was noted from the combination of S_2K_2 and the second highest benefit cost ratio (2.11) was estimated from the combination of S_1K_2. The lowest benefit cost ratio (1.29) was obtained from S_0K_0 (Table 12). From economic point of view, it is apparent from the above results that the combination of S_2K_2 was better than rest of the combination.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka during the period from November 2012 to February 2013 to find out growth and yield of cabbage as influenced by starter solution and potassium fertilizer. The test crop used in the experiment was cabbage variety Atlas-70. The experiment consisted of two factors: Factor A: Starter solution (four levels) as- S_0: 0 % urea (controlled); S_1: 0.5% urea, S_2: 1.5% urea, S_3: 2.5% urea and Factor B: Potassium fertilizer (three levels) as- K_0: 0 kg k_2O (controlled); K_1: 180 kg K_2O and K_2: 220 kg K_2O. The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth, yield parameters and yield were recorded.

At 30, 40 and 50 DAT the tallest plant (21.58, 38.52 and 45.92 cm, respectively) was recorded from S_2 and the shortest plant (16.62, 30.41 and 37.32 cm, respectively) was recorded from S_0. At 30, 40 and 50 DAT the maximum number of loose leaves per plant (12.28, 20.74 and 24.72) was found from S_2, whereas, the minimum number (9.66, 14.70 and 17.30) from $S_{0.}$ At 30, 40 and 50 DAT, the highest plant spread (27.90, 38.79 and 49.53 cm, respectively) was recorded from S_2 and the lowest plant spread (21.59, 31.02 and 40.26 cm, respectively) was recorded from S_0. At 30, 40 and 50 DAT, the highest length of largest leaf (22.54, 29.91 and 35.66 cm, respectively) was recorded from S_2 and the lowest length of largest leaf (18.06, 23.11 and 30.22 cm, respectively) was recorded from S_0.The highest length of stem (8.15 cm) was recorded from S_2, whereas the lowest (6.36 cm) was recorded from S_0.The highest diameter of stem (2.63 cm) was recorded from S_2, whereas the lowest (2.10 cm) was recorded from $S_{0.}$ The highest fresh weight of stem (60.12 g) was recorded from S_2, whereas the lowest (40.69 g) was recorded from $S_{0.}$ The highest dry matter content of stem (10.71 %) was recorded from S_2, whereas the lowest (9.13 %) was recorded from $S_{0.}$ The highest length of roots (21.72 cm) was recorded from S_2, whereas the lowest (16.86 cm) was recorded from $S_{0.}$ The highest fresh weight of roots (21.86 g) was recorded from S_2, whereas the lowest (15.27 g) was recorded from $S_{0.}$The highest thickness of head (12.93 cm) was found from S_2, while the lowest (10.93 cm) from S_0. The highest diameter of head (13.00 cm) was recorded from S_2, while the lowest (10.25 cm) was recorded from S_0. The highest gross weight of head (1.78 kg) was recorded from S_2, whereas the lowest (1.24 kg) was recorded from S_0 The highest fresh weight of head (1.59 kg) was found in treatment S_2 and lowest fresh weight of head (1.15 kg) found in $S_{0.}$The highest dry matter content of head (10.23%) was recorded from S_2, while the lowest dry matter content of head (8.81%) was recorded from S_0. The highest marketable yield (58.89 t/ha) was recorded from S_2, while the lowest marketable yield (42.59 t/ha) from S_0.

At 30, 40 and 50 DAT the tallest plant (19.86, 38.27and 44.28 cm, respectively) was recorded from K_2 and the shortest plant (17.93, 31.47 and 37.67 cm, respectively) was recorded from K_0. At 30, 40 and 50 DAT the maximum number of loose leaves per plant (11.79, 20.28 and 22.86 cm) was found from K_2, whereas, the minimum number (9.61, 16.27 and 18.56 cm) from $K_{0.}$ At 30, 40 and 50 DAT the highest plant spread (27.27, 38.60 and 49.50 cm, respectively) was recorded from K_2 and the lowest plant spread (22.21, 31.26 and 40.63 cm, respectively) was recorded from K_0. At 30, 40 and 50 DAT the highest length of largest leaf (21.31, 29.38 and 35.23 cm, respectively) was recorded from K_2 and the lowest leaf length (19.20, 23.85 and 29.69 cm respectively) was recorded from K_0.The highest length of stem (7.95 cm) was recorded from K_2, whereas the lowest (6.65 cm) was recorded from K_0. The highest diameter of stem (2.58cm) was recorded from K_2, whereas the lowest (2.24 cm) was recorded from $K_{0.}$ The highest fresh weight of stem (54.34 g) was recorded from K_2, whereas the lowest (50.73g) was recorded from K_0.The highest dry matter content of stem (10.78 %) was recorded from S_2, whereas the lowest (9.0 %) was recorded from $K_{0.}$ The highest length of root (20.49 cm) was recorded from K_2, whereas the lowest (18.12 cm) was recorded from $K_{0.}$ The highest fresh weight of root (20.92 g) was recorded from K_2, whereas the lowest (15.71 g) was recorded from $K_{0.}$The highest thickness of head (13.05 cm) was found from K_2, while the lowest (10.92 cm) from K_0. The highest diameter of head (12.56 cm) was recorded from K_2, while the lowest (10.44cm) was recorded from K_0.The highest gross weight of head (1.75 kg) was recorded from K_2, whereas the lowest (1.32 kg) was recorded from K_0 The highest fresh weight of head (1.68 kg) was found in treatment K_2 and lowest fresh weight of head was (1.19 kg) found in $K_{0.}$ The highest dry matter content of head (10.19 %) was recorded from K_2, while the lowest dry matter content of head (8.67 %) was recorded from K_0. The highest marketable yield (62.22 t/ha) was recorded from K_2, while the lowest marketable yield (44.07 t/ha) from K_0.

At 30, 40 and 50 DAT the tallest plant (21.43, 42.53 and 49.07 cm respectively) was recorded from S_2K_2 and the shortest plant (17.23, 30.33 and 34.23 cm respectively) was recorded from S_0K_0. At 30, 40 and 50 DAT, the maximum number of loose leaves per plant (14.20, 22.37 and 25.73 cm) was found from S_2K_2, whereas, the minimum number (7.93, 14.10 and 16.69 cm) from $S_0K_{0.}$ At 30, 40 and 50 DAT the highest plant spread (29.45, 42.61 and 55.44 cm, respectively) was recorded from S_2K_2 and the lowest plant spread (19.2, 27.33 and 38.17 cm, respectively) was recorded from $S_0K_{0.}$ The highest length of stem (8.99 cm) was recorded from S_2K_2, whereas the lowest (6.19 cm) was recorded from S_0K_0. The highest diameter of stem (2.78 cm) was recorded from S_2K_2, whereas the lowest (2.02 cm) was recorded from $S_0K_{0.}$ The highest fresh weight of stem (62.67 g) was recorded from S_2K_2, whereas the lowest (39.60 g) was recorded from $S_0K_{0.}$ The highest dry matter content of stem (11.90 %) was recorded from S_2K_2, whereas the lowest (8.37 %) was recorded from $S_0K_{0.}$ The highest length of root (22.66 cm) was recorded from S_2K_2, whereas the lowest (15.40 cm) was recorded from $S_0K_{0.}$ The highest fresh weight of root (24.89 g) was recorded from S_2K_2, whereas the lowest (13.10 g) was recorded from $S_0K_{0.}$The highest thickness of head (14.29 cm) was found from S_2K_2, while the lowest (10.30cm) from S_0K_0. The highest diameter of head (14.67 cm) was recorded from S_2K_2, while the lowest (9.54 cm) was recorded from $S_0K_{0.}$ The highest gross weight of head (2.10 kg) was recorded from S_2K_2, whereas the lowest (1.13 kg) was recorded from S_0K_0. The fresh weight of head (1.92 kg) was found in treatment S_2K_2

and lowest marketable yield per plant was (1.02 kg) found in $S_0K_{0.}$The highest dry matter content of head (11.0 %) was recorded from S_2K_2, while the lowest dry matter content of head (8.01%) was recorded from S_0K_0. The highest marketable yield (71.11 t/ha) was recorded from S_2K_2, while the lowest marketable yield (37.79 t/ha) from $S_0K_{0.}$

Considering the combination of different levels of starter solution and potassium fertilizer, the highest gross return (Tk. 426660) was obtained from the treatment combination S_2K_2 and the lowest gross return (Tk. 226740) was obtained from S_0K_0. The highest net return (Tk. 245190) was found from the treatment combination S_2K_2 and the lowest (Tk. 50511) net return was obtained S_0K_0. The highest benefit cost ratio (2.35) was noted from the combination of S_2K_2 and the lowest benefit cost ratio (1.29) was obtained from S_0K_0. From economic point of view, it is apparent from the above results that the combination of S_2K_2 was better than rest of the combination.

Conclusion

Among the combination of different levels of starter solution and potassium fertilizer 1.5 % urea and 220 kg K_2O induced superior growth, yield contributing characters and yield of cabbage as well as highest economic return.

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Another starter solution with different concentration might be considered before final recommendation.
2. Another level of potassium fertilizer may be used in future study.

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APPENDICES

Appendix I. Soil characteristics of experimental field as analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture farm field , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. Physical and chemical properties of the initial soil

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

Appendix II. Monthly record of air temperature, relative humidity, rainfall and sunshine hour of the experimental site during the period from October 2012 to March 2013

Month	*Air temperature (ºc)		*Relative humidity (%)	Total Rainfall (mm)	*Sunshine (hr)
	Maximum	Minimum			
October, 2012	26.5	19.4	81	22	6.9
November, 2012	25.8	16.0	78	00	6.8
December, 2012	22.4	13.5	74	00	6.3
January, 2013	24.5	12.4	68	00	5.7
February, 2013	27.1	16.7	67	30	6.7
March, 2013	31.4	19.6	54	11	8.2

* Monthly average,

* Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka – 1207

Appendix III. Analysis of variance of the data on plant height and number of loose leaves per plant of cabbage as influenced by different levels of starter Solution and potassium

Source of variation	Degrees of freedom	Plant height at (cm)						Number of loose leaves per plant at (cm)					
		30 DAT		40 DAT		50 DAT		30 DAT		40 DAT		50 DAT	
		Mean square	F-value	Mean square	F-value	Mean square	F-value	Mean square	F-value	Mean square	F-value	Mean square	F-value
Replication	2	1.86	2.99	4.07	0.81	2.63	4.85	0.019	0.04	0.22	0.44	1.78	2.56
Factor A	3	11.93	19.19	65.60	13.03	131.14	242.04	11.09	26.32	44.00	88.08	34.14	49.10
Factor B	2	6.87	11.06	164.56	32.68	173.37	319.99	15.58	36.96	59.03	118.17	38.59	55.49
AB	6	0.65	1.049	16.84	3.34	5.24	9.67	2.02	4.80	1.32	2.65	2.79	4.02
Error	22	0.62	2.99	5.03		0.542		0.422		0.500	0.0432	0.695	0.0072

Appendix IV. Analysis of variance of the data on plant spread and length of largest leaves of cabbage as influenced by different levels of starter solution and potassium

Source of variation	Degrees of freedom	Plant spread at (cm)						Length of largest leaf at(cm)					
		30 DAT		40 DAT		50 DAT		30 DAT		40 DAT		50 DAT	
		Mean square	F- value	Mean square	F- value	Mean square	F- value	Mean square	F- value	Mean square	F- value	Mean square	F- value
Replication	2	42.10	104.25	47.79	2794.69	54.52	302.23	51.17	1910.83	39.35	50.74	49.76	3606.15
Factor A	3	66.92	165.72	119.08	6963.09	165.47	917.32	31.50	1176.30	91.99	118.61	50.67	3672.06
Factor B	2	93.86	232.43	208.11	12168.95	263.52	1460.87	16.98	633.93	104.76	135.08	126.01	9132.67
AB	6	4.84	12.00	3.04	177.82	20.09	111.41	2.85	106.45	7.34	9.46	13.20	956.76
Error	22	0.40		0.02		0.18		0.03		0.78		0.01	

Appendix V. Analysis of variance of the data on yield contributing characters of cabbage as influenced by different levels of starter solution and potassium

Source of variation	Degrees of freedom	Stem length (cm)		Stem diameter (cm)		Fresh weight of stem (g)		Dry matter content of stem (%)		Length of root (cm)		Fresh weight of root (g)	
		Mean square	F-value	Mean square	F-value	Mean square	F- value	Mean square	F-value	Mean square	F-value	Mean square	F-value
Replication	2	0.09	0.42	0.08	0.87	6.93	8.16	3.94	2.74	3.71	3.86	10.09	20.67
Factor A	3	2.83	12.49	2.02	22.40	622.48	733.08	4.17	2.89	37.29	38.81	67.66	138.61
Factor B	2	2.34	10.36	0.41	4.59	41.30	48.65	11.02	7.66	21.99	22.88	96.34	197.38
AB	6	1.12	4.94	0.17	1.91	77.93	91.77	5.48	3.80	3.31	3.45	3.89	7.98
Error	22	0.23		0.09		0.849		1.44		0.961	3.86	0.49	

Appendix VI. Analysis of variance of the data on yield contributing characters and yield of cabbage as influenced by different levels of starter solution and Potassium

Source of variation	Degrees of freedom	Thickness of head		Diameter of head		Gross weight of head		Fresh weight of head		Dry matter content of head (%)		Marketable yield (ton)	
		Mean square	F- value	Mean square	F- value	Mean square	F- value	Mean square	F- value	Mean square	F- value	Mean square	F- value
Replication	2	1.31	1.18	20.96	10.39	0.003	15.40	0.005	1656.99	0.21	0.64	0.005	12.074
Factor A	3	6.19	5.58	12.63	6.27	0.447	2460.15	0.318	114447.48	3.31	10.25	487.875	1241654.83
Factor B	2	13.77	12.41	13.83	6.86	0.555	3053.049	0.439	157950.27	6.99	21.67	597.798	1521412.25
AB	6	0.87	0.79	1.46	0.72	0.038	207.35	0.036	12978.94	0.46	1.42	44.633	113591.05
Error	22	1.10		2.02		0.000		0.000		0.32		0.000	

Appendix VII. Per hectare production cost of cabbage

A. Input cost

Treatment combination	Labour cost (Tk)	Ploughing cost(Tk)	Seed cost(Tk)	Water for plant establishment (Tk)	Starter solution cost(Tk)	Manure and fertilizers(Tk)				Insecticide/ pesticides (Tk)	Sub total (A)
						Cowdung	Urea	TSP	MP		
S_0Ko	32,000	18,000	6,000	12,000	0	5000	1,200	2700	0	10,000	86,900
S_0K_1	32,000	18,000	6,000	12,000	0	5000	1,200	2700	2,700	10,000	89,600
S_0K_2	32,000	18,000	6,000	12,000	0	5000	1,200	2700	3,600	10,000	90,500
S_1Ko	32,000	18,000	6,000	12,000	300	5000	1,200	2700	0	10,000	87,200
S_1K_1	32,000	18,000	6,000	12,000	300	5000	1,200	2700	2,700	10,000	89,900
S_1K_2	32,000	18,000	6,000	12,000	300	5000	1,200	2700	3,600	10,000	90,800
S_2Ko	32,000	18,000	6,000	12,000	900	5000	1,200	2700	0	10,000	87,800
S_2K_1	32,000	18,000	6,000	12,000	900	5000	1,200	2700	2,700	10,000	90,500
S_2K_2	32,000	18,000	6,000	12,000	900	5000	1,200	2700	3,600	10,000	91,400
S_3Ko	32,000	18,000	6,000	12,000	1,500	5000	1,200	2700	0	10,000	88,400
S_3K_1	32,000	18,000	6,000	12,000	1,500	5000	1,200	2700	2,700	10,000	91,100
S_3K_2	32,000	18,000	6,000	12,000	1,500	5000	1,200	2700	3,600	10,000	92,000

S_0: 0 % urea (control),S_1: 0.5% urea ,S_2: 1.5% urea, S_3 : 2.5% urea

K_0: 0 kg K_2O/ha(control),K_1: 180 kg K_2O/ha,K_2: 220 kg K_2O/ha

B. Overhead cost (Tk./ha)

Treatment combination	Cost of lease of land (14% of value of land Tk. 12,00000/year)	Miscellaneous cost (Tk. 5% of the input cost)	Interest on running capital for 6 months (Tk. 14% of cost/year)	Sub total (Tk) (B)	Total cost of production (Tk./ha) [Input cost (A)+ overhead cost (B)]
S_0Ko	70,000	5,445	13,884	89,329	176,229
S_0K_1	70,000	5,535	14,016	89,551	179,151
S_0K_2	70,000	5,580	14,083	89,663	180,163
S_1Ko	70,000	5,625	14,149	89,774	176,974
S_1K_1	70,000	5,645	14,178	89,823	179,723
S_1K_2	70,000	5,735	14,310	90,045	180,845
S_2Ko	70,000	5,780	14,377	90,157	177,957
S_2K_1	70,000	5,825	14,443	90,268	180,768
S_2K_2	70,000	5,745	14,325	90,070	181,470
S_3Ko	70,000	5,835	14,457	90,292	178,692
S_3K_1	70,000	5,880	14,524	90,404	181,504
S_3K_2	70,000	5,925	14,590	90,515	182,515

S_0: 0 % urea (control),S_1: 0.5% urea ,S_2: 1.5% urea, S_3 : 2.5% urea

K_0: 0 kg K_2O/ha(control),K_1: 180 kg K_2O/ha,K_2: 220 kg K_2O/ha

Appendix VIII: Some Commonly Used Abbreviations and Symbols

Abbreviations	Full word
%	Percent
@	At the rate
AEZ	Agro-Ecological Zone
Agric.	Agriculture
Agril.	Agricultural
Agron.	Agronomy
ANOVA	Analysis of variance
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BD	Bangladesh
BINA	Bangladesh Institute of Nuclear Agriculture
CEC	Cation Exchange Capacity
cm	Centi-meter
CV%	Percentage of coefficient of variation
df	Degrees of Freedom
DMRT	Duncan's Multiple Range Test
EC	Emulsifiable concentration
et al	and others
etc	Etcetera
FAO	Food and Agriculture Organization
g	Gram
hr.	Hours
j.	Journal
Kg/ha	kilogram per hectare
kg	Kilogram

m	Meter
m^2	square meter
MOA	Ministry of Agriculture
MSE	Mean square of the error
No.	Number
ppm	parts per million
RCBD	randomized complete block design
Rep.	Replication
Res.	Research
SAU	Sher-e-Bangla Agricultural University
Sc.	Science
SE	Standard Error
Univ.	University
var.	Variety