EFFECT OF MULCH MATERIALS AND PINCHING ON GROWTH, YIELD AND ECONOMIC BENEFIT OF CABBAGE

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EFFECT OF MULCH MATERIALS AND PINCHING ON GROWTH, YIELD AND ECONOMIC BENIFIT OF CABBAGE

BY

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CERTIFICATE

This is to certify that the thesis entitled, **"*Effect of mulch materials and pinching on growth, yield and economic benefit of cabbage*"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (MS) IN HORTICULTURE,** embodies the result of a piece of *bona fide* research work carried out by ***Nowrose-Bin-Reza*,** Registration No. ***09-03638*** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed during the course of this investigation has been duly acknowledged and style of this thesis have been approved and recommended for submission.

Dated June, 2015
Dhaka, Bangladesh

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The Author

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ABSTRACT

The field experiment was conducted in the Horticultural farm of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2014 to January 2015 to find out the effect of mulching and pinching on the growth, yield and economic benefit of cabbage. The experiment consisted of two factors viz., factor A: four mulch materials denote as M viz., M_0 = No mulch, M_1 = Black polythene, M_2 = Water hyacinth, M_3 = Rice straw and factor B: three pinching date denote as P viz., P_0 = No pinching, P_1 = Pinching at 25 DAT, P_2 = Pinching at 35 DAT. The experiment was laid out in Randomized Complete Block Design with three replications. In case of different mulch materials, the highest head diameter (20.27 cm), head thickness (13.19 cm), gross yield (83.57 t/ha) and marketable yield (74.88 t/ha) were found from M_1 while the lowest head diameter (17.62 cm), head thickness (11.42 cm), gross yield (55.72 t/ha) and marketable yield (46.55 t/ha) from M_0. For different time of pinching, the highest head diameter (20.49 cm), head thickness (12.87 cm) were recorded from P_0 but highest gross yield (76.40 t/ha) and marketable yield (68.00 t/ha) were recorded from P_2 whereas the lowest head diameter (17.00 cm), head thickness (11.49 cm) from P_1 but gross yield (62.14 t/ha) and marketable yield (52.86 t/ha) from P_0. Due to combined effect, the highest gross yield (95.57 t/ha) and marketable yield (87.36 t/ha) were recorded from M_1P_2 whereas the lowest gross yield (47.14 t/ha) and marketable yield (37.50 t/ha) from M_0P_0. The highest benefit cost ratio (3.97) was noted from the combination of M_1P_2 and the lowest (1.88) from M_0P_0. From growth, yield and economic point of view, it is apparent that the combination of M_1P_2 was suitable for cabbage cultivation.

LIST OF CONTENTS

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABBREVIATIONS AND ACRONYMS

@	:	At the Rate of
Abstr.	:	Abstract
AEZ	:	Agro-ecological Zone
Agric.	:	Agriculture
AVRDC	:	Asian Vegetables Research and Development
BBS	:	Bangladesh Bureau of Statistics
BCR	:	Benefit Cost Ration
cv.	:	Cultivar
DAS	:	Day After Sowing
et al.	:	et alii (and others)
FAO	:	Food and Agriculture Organization Of the United Nati
FW	:	Fresh weight
FYM	:	Farm Yard Manure
Hort.	:	Horticulture
i.e.	:	That is
J.	:	Journal
LSD	:	Least Significant Difference
MOP	:	Murate of Potash
NS	:	Non-significant
RCBD	:	Randomized Complete Block Design
Sci.	:	Science
Soc.	:	Society
Tk.	:	Taka
UK	:	United Kingdom
UNDP	:	United Nations Development Program
Viz.	:	Namely

CHAPTER I

INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata* L.) is a cole crop belongs to the family Brassicaceae locally known as 'Bhadha Kopi'. It is a popular and most common winter vegetable crop grown in Bangladesh and is grown as an important vegetable in many parts of the world. The origin of cabbage is the Western Europe and north shores of the Mediterranean Sea (Chauhan, 1986). Cabbage was reported to be grown in the subcontinent during Mughal period, but the vegetable become popular during British rule (Bose and Som, 1986). In Bangladesh, cultivation of cabbage is mainly in winter season.

Among the vegetables, cabbage ranks second in respect of production and area. It covers about 5% production under vegetable crops in 2013-2014 (BBS, 2015). Cabbage is a good source of β-carotene, vitamin C and fibre. The edible portion of cabbage plant is head which is formed by the fleshy leaves overlapping one another. It has been reported that 100 g of green edible portion of cabbage contains 92% water, 24 kilocalories of food energy, 1.5 g of protein, 4.8 g of carbohydrate, 40 mg of calcium, 0.6 mg of iron, 600 IU of carotene, 0.05 mg of riboflavin, 0.3 mg of niacin and 60 mg of vitamin C (Rashid, 1993). It has been shown to reduce the risk of some cancers, especially those in the colorectal group. Besides its nutritive value, it is a profitable crop for the farmers in Bangladesh.

Cabbage occupied an area of 11.33 thousand hectares of land during 1999-2000 growing season with a total production of 112 thousand metric tons in Bangladesh (BBS, 2000). Such a poor yield attributed to a greater extent on the method of production technology followed by the farmers.

Mulch forms a layer between the soil and the atmosphere which prevents sunlight from reaching the soil surface, thus reducing evaporation. Its purpose is any or all of the following: to conserve moisture, to improve the fertility and health of the soil, to reduce weed growth, to enhance the visual appeal of the

area. Mulches of manure or compost will be incorporated naturally into the soil by the activity of worms and other organisms. When applied correctly can dramatically improve soil productivity. In order to maximize the benefits of mulch, while minimizing its negative influences. Materials used as mulches vary and depend on a number of factors.If the temperature exceeds $25^{O}C$ this crop cannot form compact head. Mulching also provide acceptable temperature to the soil by protecting radiation from soil.

Any practices that act as a barrier to the evaporation of water or heat from soil surface can be defined as mulching. There are two types of mulching practices viz., natural mulching; breaking the upper crust of soil to disconnect the capillary pore for checking evaporation and artificial mulching; covering the soil surface with plant species, crop residues or polythene sheet. The benefit of mulching also includes regulation of soil moisture, temperature and suppressing weeds resulting in higher yield and quality of Chinese cabbage. Moisture distribution in the upper soil layer is more uniform compared with unmulched soil and more roots develop in the upper soil layer which usually has richer nutrients and useful microorganism (Knavel and Mohr, 1967; Lippert *et al.*, 1966).

Some mulching materials which are always available example in the farmer's field may use as mulch to enhance vegetative growth of cabbage by reducing soil moisture depletion and temperature (Kuo, and Tsay, I 981). Mulching offers tremendous potential for increased crop production through its noticeable effect on the soil environment which ensures proper growth and yield of crop (Lal, 1989). The efficient use of land from the economic point of view can be achieved by soil moisture management through mulching. Mulching may be practical in crop cultivation which can minimize cost of production.

Pinching-out also known as stopping is the removal of the growing point of a stem to encourage lateral shoots such removal can be either injurious or beneficial. It redirects auxin movement from the apical part to areas below the plant to stimulate lateral buds development and The edible portion of cabbage is

a large bud called head, which is formed by several fleshy leaves overlapping one another. Generally, farmers get only one head from a single plant at a time. But if the apical bud is removed carefully it could lead to the formation of a couple of axillary buds into heads leading to the increased production of more marketable heads per plant The assemblage of layers of leaves over the growing point requires the maintenance of a short stem during the heading period (North, 1957). As heading begins, leaves become broader and sessile, and more erect in their posture (Kato and Sooen, 1978).The important role of the frame leaves in providing photosynthete for plant growth that allowed younger leaves to grow more erect (Kato, 1981). Removal of inner frame leaves just as heading was beginning markedly delayed head formation and resulted in the younger leaves assuming a horizontal attitude, whereas removal of outer frame leaves had little effect on inner leaf attitude (Iannotti, 2009).

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

- To find out suitable mulch materials on growth, yield and economic return of cabbage.
- To identify the optimum pinching time on growth, yield and economic return of cabbage.
- To find out combine effect of mulch materials and pinching on growth, yield and economic return of cabbage.

CHAPTER II

REVIEW OF LITERATURE

Cabbage is an important vegetable crop of many countries of the world as well as in Bangladesh. Considerable interest has been developed recently regarding the benefit from the use of mulching has 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 mulching in different vegetables including cabbage and the results already achieved are of outstanding importance. A good number of experiments on the effect of pinching on the growth and yield of cabbage were conducted in different parts of the country. But limited numbers of studies are found in this respect in Bangladesh. However, some of the research finding regarding the effects of mulch materials and pinching on the growth and yield of cabbage has been presented in this chapter.

2.1 Effect of mulch materials on growth and yield of cabbage

Akand (2003) conducted an experiment with organic manure and mulching trail on carrot in Horticulturc Farm, BAU, Mymensingh and observed that black polythene and cowdung significantly resulted the highest yield of carrot of his experiment.

In Poland during the period 1997-98 Kalisz and Cebula (2001) conducted an experiment to conclude the effect of soil mulched with polythene film and plant covered with non-woven polypropylene and perforated polythene film on the growth and yield of four cultivars of Chinese cabbage (Akala F_1, Optico F_1, Sumiko F_1 and Parkin F_1). Plants coverings were given directly immediately after planting the seedlings. They observed that plant height, head diameter and the number of leaves and their area build-up by the application of plastic covers considerably improved plant growth. Among the treatments, non-woven polypropylene recorded the highest (9038 and (60.74 t/ha in 1997 and 1998,

respectively) and the control treatment recorded the lowest yields (28.80 and 26.37 t/ha).

Efficiency of different mulches is again a point to be considered in an experiment while Hossain (1999) working with different mulches on cabbage in time Department of Horticulture, Bangladesh Agricultural University, Mymensingh and observed maximum gross and marketable yields (116.67 t/ha and 97.53 t/ha, respectively) from black polythene mulch and the lowest (92.33 t/ha and 4056 t/ha) was loam the control condition.

In an experiment was conducted on the effect of mulches (black paper, black polytliene, straw) on Iceberg, lettuce bulterhead lettuce. Chinese cabbage and leeks in the Netherlands, by Poll and Gaven (1996) observed that mulches increased yields of iceberg and bulterhead.

Saifullah *et al.* (1996) while working with mulches and irrigation on cabbage, in the Horticulture Farm, Bangladesh Agricultural University, Mymensingh and found that yield and most of the yield contributing characters like plant height, number of loose leaves per plant, diameter and thickness of head, weight of loose leaves, stem, roots, head, whole plant and total dry mater per head were significantly increased by the application of irrigation and mulches. Mulching was found to be more effective during the early stage of plant growth. The highest marketable yield was obtained by irrigation treatment (37.09 t/ha) followed by black polythene (33.16 t/ha), water hyacinth (26.91 t/ha), sawdust (20.66 t/ha) and straw (24.0 t/ha) and the lowest (12.68 t/ha) by the control condition. They concluded on based upon their findings that as an alternative to irrigation, water hyacinth and straw can be adopted as feasible mulches to increase the yield of Chinese cabbage and also by conserving the residual soil moisture.

Sanlipracha and Sadoodee (1995) carried out an experiment to study the effect of plastic sheets or nylon net on cabbage and reported that cabbage grown under rain protection showed better growth than control cabbage in Punjab

Agricultural University, India during September, 1992 to January 1993. The highest head weight (913.5 g) and yield (11.39 t/ha) were observed for cabbages grown under plastic sheets.

Rahman *et al.* (1995) reported similar results for black polythene mulching on cauliflower while conducting an experiment in Bangladesh Agricultural Research Institute, (Gazipur Bangladesh), adding that paddy husk had been found to be more effective in increasing the growth and yield of Cauliflower which straw mulch had adverse effects.

Hembry *et al.* (1994) conducted an experiment in Horticulture Research International, Warwick, UK to evaluate a range of ground cover mulches including black paper, black polythene and straw for their effect on weed control. They found excellent weed control and maximum yield of Chinese cabbage then growth with mulches hut straw performance the reverse situation where weeds were generally grown.

Gattorsen (1992) conducted an experiment to evaluate the effects of plastic mulch on the yield of Chinese cabbage and found that the double layer produced the higher yield than single layer mulching.

An investigation was conducted by Benoit and Ceustermans (1990) to estimate the influence of mulch in National Vegetable Research Station, UK on cabbage and found that the yield was better at double layer than that of single layer mulch, It was recorded that double layer of paper mulch had better temperature condition for the growth of the twenty outer leaves than single layer.

Roy *et al.* (1990) carried out an experiment in the department of crop botany, Bangladesh Agricultural University, Mymensingh to study the effect of water hyacinth, rice straw and sawdust, mulches on the growth of cabbage. They reported that mulches increased crop growth rate, net assimilation rate and leaf area index, Water hyacinth significantly increased chlorophyll-b content, growth and yield.

To estimate the influence of mulch on cabbage an investigation was conducted by Benoit and Ceustermans (1990) in National Vegetable Research Station, UK and found that the yield of Chinese cabbage was better at double layer than that of single layer mulch. It was recorded that double layer of paper mulch had better temperature condition for the growth of the twenty outer leaves than single layer.

Bragagnolo and Miclniezuk (1990) found that mulches increased the growth and yield of cabbage and as well as marketable yield.

Subhan (1989) carried out an experiment with mulching on cabbage in Indonesian Intitute of Horticulture, Indonesia and reported that mulching significantly increased the head weight and yield of cabbage per hectare.

Gunadi and Asandhi (1989) while working in Vegetable Research Institute, Seoul, Korea Republic, and found that straw and plastic mulches encouraged growth of early season Chinese cabbage.

An experiment was carried out by Acharya (1988) in Behar Agricultural College, India, and reported that mulching significantly increased the yield of cabbage. Similar results were also found by Oyabu *et al.* (1988) when carried out an experiment in Indonesian Institute of Horticulture, Indonesia.

To study the effect of mulches on cabbage an experiment was conducted by Yoon *et al.* (1984) in Vegetable Research Institute, Seoul, Korea Republic and reported that black polythene, straw and clear polythene gave higher rate of growth and development of cabbage considering the other treatments.

Oh *et al.* (1984) while conducting an experiment in Seoul, Korea Republic, to investigate the effect of different mulches on growth of Chinese cabbage and they found that black polythene mulch increased the growth of cabbage and ensure the optimum soil temperature for proper growth and development as well as higher yield contributing characters and yield considering the control condition.

Ashworth and Harrison (1983) conducted an experiment with mulches on cabbage in the department of botany, University of Edinburgh UK and found that mulching increased the marketable yield of cabbage.

To study the effect of mulches on the growth and yield of cabbage an experiment was carried out by Hill *et al.* (1982) in Connecticut Agricultural experiment Station, New heaven, USA. They reported that temperature and moisture regimes of soil were greatly influenced by mulching. They also stated that mulching influenced the growth of cabbage producing well developed root system, highest plant height, spread of plant, stem length, number of loose leaves and diameter of head.

2.2 Effect of pinching on growth and yield of cabbage

The growth and yield of cabbage are greatly influenced by pinching of apical bud. Though, there are many reports on the effect of pinching on different crops but on cabbage is scanty. However, some of the relevant works have been reviewed here.

Yesmin (2007) conducted an experiment at Bangladesh Agricultural University, Mymensingh on pinching of apical bud of cabbage at 30 DAT. She observed a significant variation on yield of cabbage in pinched plants with the non pinched-plants.

An experiment was conducted at Bangladesh Agricultural University, Mymensingh by Rabiul (2002) on pinching at 30 DAT of the cabbage. He observed that pinching at 30 DAT showed significant effect on most of the parameters. Pinching had a significant variation in respect of gross yield per hectare. The plants with pinching treatment resulted the highest gross yield (73.8 t ha^{-1}) and the highest marketable yields, compared with non-pinched plants.

The influence of different sources of nutrients and time of pinching of apical bud on yield of cabbage was studied at Bangladesh Agricultural University,

Mymensingh by Jahan (2001), he reported that organic and inorganic fertilizer with pinching produced maximum yield of cabbage.

A field experiment was carried out by Omer *et al.* (1997) to study the effects of pinching (45, 75, or 105 days after planting) and foliar application of B-9 [daminozide] and CCC [chlormequat] (200, 400 or 600 ppm) on the growth productivity of 2 early maturing cultivars of *Hibiscus sabdariffa*. They stated that pinching treatments increased the number of branches, fruit weight and sepal weight, and increased fixed oil and anthocyanins, yield in both cultivars.

An experiment was conducted by Pressman *et al.* (1985) on pinching of the broccoli cv. Green Duke at different stages of development (plants with 3, 5, 7 or 9 leaves). Pinching hastened extension of the lateral shoots and button formation and it increased the number of side shoots only when bone at later stage of plant development. A close correlation was observed between shoot length and time buttoning and inflorescence size. Apical bud removal at any stage caused a delay buttoning and harvest. However, a gradual delay pinching did not induce a parallel postponement in buttoning and inflorescence maturation. Early pinching resulted in higher yields than late pinching.

In 3 years trials, Kolata and Jablonska (1977) performed an experiment on Brussels sprouts where plants receiving N at 100, 200 or 300 kg/ha were pinched when the bottom buds were 5-10, 10-15 or >15 mm in diameter. It was reported that only plants pinched at 5-10 mm gave maximum yields when 300 kg/ha N was applied; this rate was found excessive for control plants or those pinched at bud size >15 mm. The best time of pinching for field and sprout uniformity was bud size at 5-10 mm.

Palevitch and Pressman (1973) conducted an experiment on two varieties of broccoli where Waltham 29 and Green Duke broccoli were pinched by hand 61-91 and 65-77 days after planting, respectively and the effects were assessed on growth and cropping. They found both cvs. after pinching resulted in the uniform development of several side shoots. With Waltham 29 pinching 77 days

after planting enhanced marketable yields, compared with non-pinched plants, but they were little affected by pinching on other dates. With Green Duke there was little difference in the yields of pinched and non pinched plants. Pinching delayed harvest by 2-3 weeks but with Waltham 29 harvest, date was not affected.

An experiment was carried out by Jones (1972) with Brussels sprouth cv. Jade Cross that total dry matter production per unit area was unaffected by topping or pinching. Pinching also caused a redistribution of dry matter; which would have formed new stem and leaf tissue was directed toward sprout Production.

CHAPTER III

MATERIALS AND METHODS

To conduct an experiment successfully some experimental materials and methods have to use. In this chapter the materials and methods those were used in conducting the experiment have been presented. It includes a short description of the location, soil and climatic condition of the experimental plot, materials used for the experiment, design of the experiment, methods of data collection, statistical analysis and economic analysis. The details of the experiment and methods used are described below.

3.1 Location of the experimental field

The research work was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period from October, 2014 to January 2015. The location of the site was 23°71′ N Latitude and 90°33′ E Longitude with the elevation of 8.2 meter from the sea level (Anonymous, 1989) and presented in Appendix I.

3.2 Soil of the experimental field

The experimental plot belongs to the Modhupur Tract which was under the Agro Ecological Zone-28. The analytical data of the soil, collected from the experimental area were determined in Soil Research and Development Institute (SRDI), Soil Testing Laboratory, Farmgate, Dhaka and presented in Appendix II.

3.3 Climate of the experimental area

The experimental site was the situated in subtropical zone, the macro climate is characterized by heavy rainfall during the months from April to September (Kharif season) and scantly rainfall during the rest month of the year (Rabi season). Information regarding average monthly the maximum and minimum temperature, rainfall and relative humidity and sunshine hour as recorded by the weather yard, Bangladesh Meteorological Department (Climate Division), Agargaon, during the period of study has been presented in Appendix III.

3.4 Plant materials used

The experimental materials of research work were uniform. The variety of cabbage selected for the experiment was K-K Cross. The seeds were F_1 hybrid produced by Sakata Seed Corporation, Japan and was collected from Mollica Seed Company, Dhaka, Bangladesh.

3.5 Raising of Seedlings

Cabbage seedlings were raised in the seedbed of 3 m x 1 m size. The soil was well prepared and converted into loose friable condition to obtain good tilth. All weeds, stubbles and dead root were removed. Twenty grams of seeds were sown in two seed bed. The seeds were sown in the seed bed on 25 October, 2014. Seeds were then covered with finished light soil and shading was provided by polyethylene bags to protect the young seedlings from scorching sunshine and rainfall. Light watering weeding and mulching were done as and when necessary to provide seedlings of a good condition for growth.

3.6 Treatments of the experiment

The experiment consisted of two factors as follows:-
Factor A: It included of four mulch materials denote as M viz., M_0–No mulch, M_1 – Black polythene, M_2 – Water hyacinth and M_3 – Rice straw

Factor B: It consisted of three pinching denote as P viz., P_0 – No pinching, P_1 – Pinching at 25 DAT and P_2 – Pinching at 35 DAT

Total 12 treatment combinations were as follows: M_0P_0, M_0P_1, M_0P_2, M_1P_0, M_1P_1, M_1P_2, M_2P_0, M_2P_1, M_2P_2, M_3P_0, M_3P_1 and M_3P_2.

3.7 Layout and design of the experiment

The two factor experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. An area of 28.10 m × 8.80 m was divided into three equal blocks. Each block consisted of 12 plots where twelve (12) treatments combination of mulching and pinching were assigned randomly as per design of the experiment. There were 36 unit plots altogether in the experiment. The size of the plot was 1.8 m x 1.6 m. Block to block distance was 1.0 m and plot to plot was 0.5 m. Seedlings were transplanted on the plots with 60 cm x 40 cm spacing.

3.8 Cultivation procedure

3.8.1 Land preparation

The selected plot was fallow at the time of period of land preparation. The land was opened on November 02, 2014 with the help of the power tiller and then it was kept open to sun for seven days prior to further ploughing, cross ploughing followed by laddering. The weeds and stubbles were removed after each laddering. Simultaneously the clods were broken and the soil was made into good tilth for transplanting.

3.8.2 Application of manures and fertilizers

Well decomposed cow dung was applied to the plots at the rate of 10 t/ha and incorporated to the soil during final land preparation. In addition, Muriate of potash (MP) and Triple super phosphate (TSP) were applied @ 175 and 150 kg/ha, respectively. The total amount of urea @ 225 kg/ha was applied as top dressing around the base of the plant. Top dressing of one third of urea was applied at 15 days after transplanting and remaining urea was top dressed in two equal instalments at 30 and 45 days after transplanting (DAT). MP and TSP were applied as basal dose in the plots.

3.8.3 Transplanting of seedlings

Thirty days old healthy and uniform sized seedlings were transplanted in the experimental plots on November 25, 2014. The seedbed was watered one hour before uprooting the seedlings to minimize the damage to the roots of the seedlings. Transplanting was done in the afternoon. During transplanting of seedling, 60 cm × 40 cm spacing were followed. Twelve plants were transplanted in each unit plot. The seedlings were watered immediately after transplanting. To protect from scorching sunshine and unexpected rain, banana leaf sheath pieces were used over the transplanted seedlings. Shading and watering were continued until the seedlings were well established and it required for 6 days. A number of treated seedlings were planted on the border of the experimental plots for gap filling.

3.8.4 Gap filling

Very few seedlings were damaged after transplanting and such seedling were replaced by new seedlings from the same stock planted earlier on the border of the experimental plots. The seedlings were transplanted with a mass of root attached with soil ball to avoid transplanting shock.

3.8.5 Intercultural operations

The plants were kept under careful observation. Light watering was done every morning and afternoon following transplanting and was continued for 6 days for early and well establishment of the seedlings. Weeding and other intercultural operations were done as and when required. Earthing up was done on both sides of rows after 60 days of transplanting using the soil from the space between the rows only in M_0.

3.8.6 Pinching techniques

Pinching plants is a form of pruning that encourages branching on the plant. This means that when you pinch a plant, you are removing the main stem, forcing the plant to grow new stems from the leaf nodes below the pinch or cut. The apical buds were removed by two nail pinch at 25 days after planting in P_1 treatment assigned plots and this operation was done after 35 days of planting in P_2 assigned plots. The rest plots were kept without pinching operation.

3.8.7 Control of pest and disease

Insect attack was serious problem at the time of establishment of the seedling. Mole cricket, field cricket and cut warm attacked the young transplanted seedlings. Basudin was applied for controlling the soil born insects. Cut worms were controlled both mechanically and spraying by Dursban 20 EC @ 3%. Some of the plants were attacked by aphids and were controlled by spraying Diazinon 60 EC@560 ml/ha.

Few plants were infected by Alternaria leaf spot disease caused caused by *Alternaria brasicae.* To prevent the spread of disease Copper oxychloride (50%) was sprayed in the field at the rate of 1.35 kg per 450 litres of water.

3.8.8 Harvesting

The crop was harvested during the period from 20 to 30 January, 2015 when the plants formed compacted heads. Harvesting was done plot wise after testing the compactness of the cabbage head by thumb. The compact head showed comparatively a hard feeling. Each head was collected by cutting at the base of the plant.

3.9 Parameters assessed

Five plants were selected at random at the time of collecting data from each plot and mean data on the following parameters were recorded:-

- Plant height (cm)
- Spread of plant (cm)
- Days to head formation
- Percentage of head formation
- Days to harvest
- Thickness of head (cm)
- Diameter of head (cm)
- Fresh weight of head (g)
- Number of heads per plant
- Weight of unfolded leaves per plant (kg)
- Length of large leaf
- Stem length (cm)
- Stem diameter (cm)
- Root length (cm)
- Gross yield per plot (kg) and hectare
- Marketable yield per plot (kg) and hectare

3.10 Data collection

Data on the following character were recorded from randomly selected five plants in each plot. Data on plant height, spread of plant and number of loose leaves per plant were counted at 45, 60 and 75 days after transplanting (DAT).

3.10.1 Plant height

The height of the plant was measured by placing a meter scale from ground level to the tip of the outer longest leaf of an individual plant. Thus, mean of five selected plants of a single plot was recorded and expressed in centimeter (cm).

3.10.2 Spread of plant

Horizontal space covered by the plant was measured in centimeter (cm) with a meter scale for determining spread of plant.

3.10.3 Number of leaves per plant

The number of loose leaves per plant was counted and mean of five plants was recorded at 54, 60 and 75 DAT. At the time of counting of number of unfolded leaves, dead leaves were excluded.

3.10.4 Days to head formation

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

3.10.5 Percentage of head formation

The number of plants forming head in a plot was expressed in percentage as follows:

$$\% \text{ of head formation} = \frac{\text{Number of plants forming head}}{\text{Number of total plants}} \times 100$$

3.10.6 Days to harvest

The date of transplanting to head harvesting was counted of selected five plants of each plot and mean value was taken for computing days required to head maturity

3.10.7 Diameter of head

Two heads out of five were selected randomly. Then sectioning of head was done vertically with a sharp knife at the middle portion. The diameter of head was measured as the horizontal distance from one side to another side of the selected head and was expressed in centimeter (cm).

3.10.8 Thickness of head

With the help of a meter scale the vertical distance from the top to the bottom of the head was measured as thickness. The thickness of head was measured in centimeter (cm).

3.10.9 Number of head per plant

The number of head per plant was counted and mean of five plants was recorded at 75 DAT.

3.10.10 Fresh weight of unfolded leaves

After harvesting the weight of unfolded leaves per plant was weighed from the selected five plants of an individual plot and the mean value was expressed in kilogram (kg).

3.10.11 Largest leaf length

Leaf length was measured by placing a meter scale from leaf base to the tip of the leaf of an individual plant and was recorded at 30 DAT, 60 DAT and at harvest. Then the average length was measured. The average leaf length of selected five plants of a single plot was recorded and was expressed in centimeter (cm).

3.10.12 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 centimeter (cm).

3.10.13 Diameter of stem

The diameter of stem was measured in cm with a scale as the horizontal distance from one side of upper most level of the stem to another side after sectioning the stem longitudinally at the middle portion.

3.10.14 Length of roots

A distance between base to the top o f the root was measured after harvesting in centimetre (cm) with the help of meter scale for determining the length of roots.

3.10.15 Gross yield per plot

Gross yield of cabbage per plot was recorded as the whole plant weight of all the plants within a plot (harvested area 1.8 m × 1.6 m) and was expressed in kilogram (kg). Gross yield included weight of head, unfolded leaves with a shoot.

3.10.16 Marketable yield per plot

The marketable yield per plot was recorded by weighing of all compact heads excluding unfolded leaves in each unit plot (1.8 m × 1.6 m) and was expressed in kilogram (kg).

3.10.17 Gross yield per hectare

Gross yield per hectare was calculated by converting the yield per plot to hectare and was expressed in tonnes (t).

3.10.18 Marketable yield per hectare

The weight of all compact head in a plot was taken and converted into yield per hectare and was expressed in tonnes (t).

3.11 Statistical analysis

The collected data on various parameters under study were statistically analysed using MSTAT package programme. The means of all the treatments were calculated and analysis of variances for all the characters was performed by F variance test. The significance of differences between the pair of treatment means was evaluated by the Least Significant Differences (LSD) test at 5% and 1% level of probability (Gomez and Gomez, 1984).

3.12 Economic analysis

The cost of production was analyzed in order to find out the most economic combination of mulch materials and pinching of cabbage. 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:

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

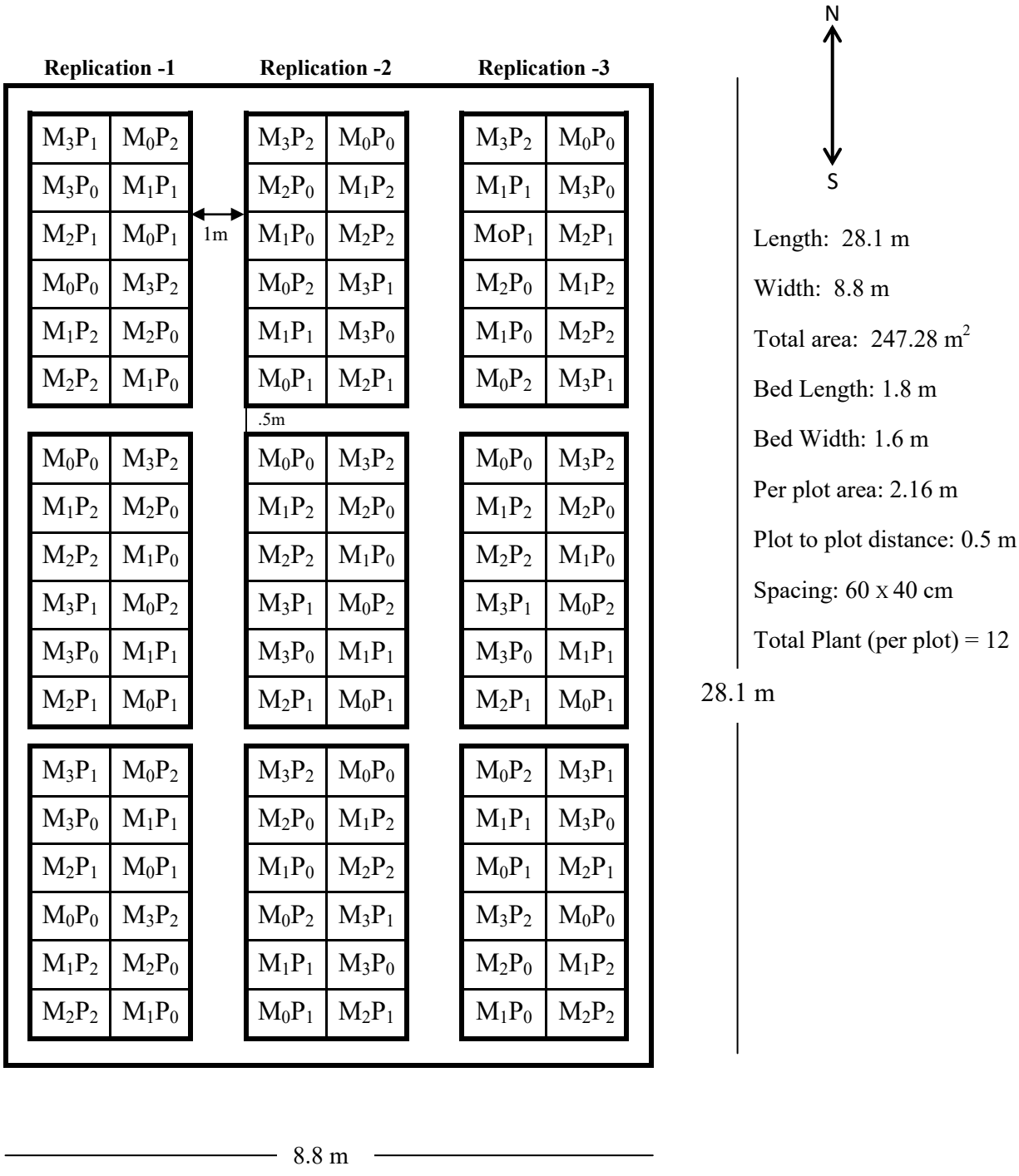

Figure 1. Sketch showing the layout of the experiment

CHAPTER IV

RESULT AND DISCUSSION

The experiment was conducted to find out the effect of mulch materials and pinching on growth, yield and economic profit of cabbage *(Brassica oleraceae* L)**.** The results obtained from the study have been presented, discussed and compared in this chapter through tables, figures and appendices. The analyses of variance of data in respect of all the parameters have been shown in Appendix IV-X. The results have been presented and discussed with the help of table and graphs and possible interpretations given under the following headings.

4.1 Plant height (cm)

Mulch materials of different types showed significant effect on plant height of cabbage (Figure 1). At 45, 60 and 75 DAT, the tallest plant (17.95, 28.40 and 36.96 cm, respectively) was recorded from M_1 (black polythene) treatment. On the other hand, at 45, 60 and 75 DAT, the shortest plant (13.37, 25.60 and 33.28 cm, respectively) was measured in M_0 (no mulch) treatment. Kalisz and Cebula (2001) also found the similar result.

Pinching at different times showed significant effect on plant height of cabbage (Figure 2). At 45, 60 and 75 DAT, the tallest plant (16.15, 29.45 and 36.75 cm, respectively) was recorded from P_0 (no pinching) treatment whereas, the shortest plant (15.01, 25.40 and 33.04 cm, respectively) was measured in P_2 (pinching at 35 DAT) treatment.

Combined of mulch materials and pinching significantly influenced the plant height of cabbage (Table 1). At 45, 60 and 75 DAT, the tallest plant (18.57, 31.10 and 40.17 cm, respectively) was recorded from M_1P_0 (black polythene with no pinching) treatment combination while, the shortest plant (12.20, 24.13 and 31.20 cm, respectively) was measured in M_0P_2 (no mulch with pinching at 35 DAT) treatment combination.

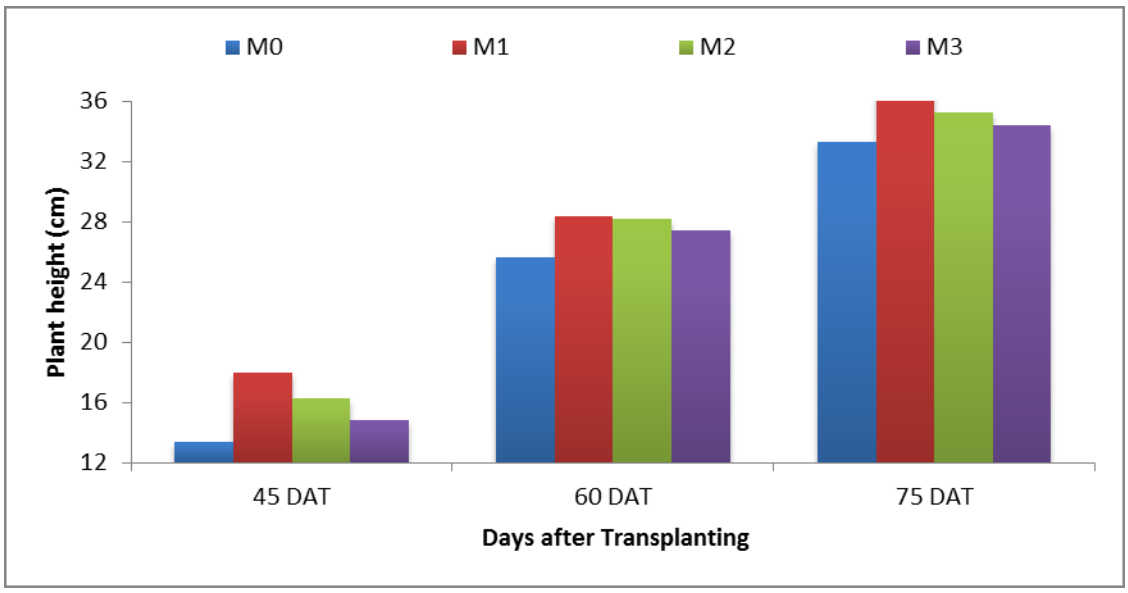

Figure 2. Effect of mulch materials on plant height (cm) of cabbage

M0 – No mulch, M1 – Black polythene, M2 – Water hyacinth, M3 – Rice straw

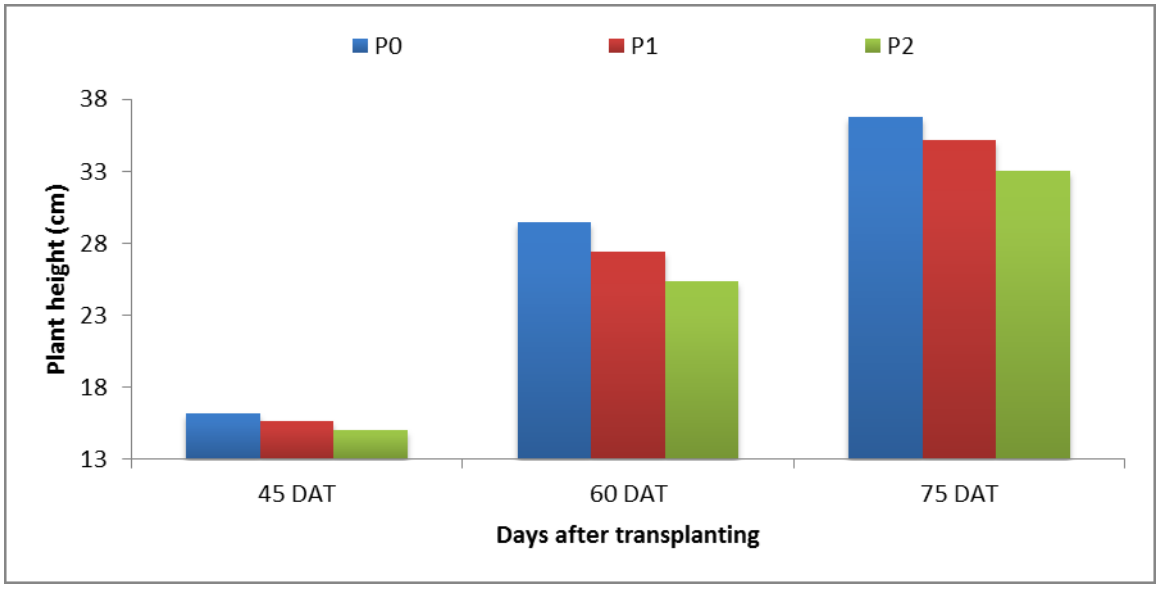

Figure 3. Effect of pinching on plant height (cm) of cabbage

P_0 – No pinching P1 – Pinching at 25 DAT, P2 – Pinching at 35 DAT

Table 1. Combined effect of mulch materials and pinching on plant height (cm) of cabbage at different days after transplanting (DAT)

Treatments	Plant height (cm)		
	45 DAT	60 DAT	75 DAT
M_0P_0	14.10 i	27.37 e	35.13 e
M_0P_1	13.82 j	25.31 h	33.52 g
M_0P_2	12.20 k	24.13 i	31.20 h
M_1P_0	18.57 a	31.10 a	40.17 a
M_1P_1	17.77 b	28.03 d	37.14 b
M_1P_2	17.50 c	26.07 g	33.57 g
M_2P_0	16.70 d	30.17 b	36.13 c
M_2P_1	16.10 e	29.17 c	35.51 d
M_2P_2	15.93 e	25.31 h	34.10 f
M_3P_0	15.23 f	29.17 c	35.58 d
M_3P_1	14.92 g	27.07 f	34.45 f
M_3P_2	14.40 h	26.07 g	33.28 g
$LSD_{(0.05)}$	0.25	0.15	0.36
CV (%)	5.67	6.39	5.49

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
Note: M_0 – No mulch, M_1 – Black polythene, M_2 – Water hyacinth, M_3 – Rice straw and P_0 – No pinching, P_1 – Pinching at 25 DAT, P_2 – Pinching at 35 DAT

4.2 Spread of plant (cm)

Mulch materials of different types showed significant effect on spread of plant of cabbage (Figure 3). At 45, 60 and 75 DAT, the largest spread of plant (33.76, 47.76 and 51.38 cm, respectively) was recorded from M_1 (black polythene) treatment and the smallest spread of plant (27.20, 43.07 and 45.68 cm, respectively) was measured in M_0 (no mulch) treatment.

Pinching at different times showed significant effect on spread of plant of cabbage (Figure 4). At 45, 60 and 75 DAT, the largest spread of plant (31.83, 47.08 and 50.23 cm, respectively) was recorded from P_0 (no pinching) treatment whereas, the smallest (29.32, 44.92 and 48.09 cm, respectively) was measured in P_2 (pinching at 35 DAT) treatment.

Combined effect of mulch materials and pinching was significantly influenced by spread of plant of cabbage (Table 2). At 45, 60 and 75 DAT, the largest spread of plant (35.52, 49.33 and 52.85 cm, respectively) was recorded from

M_1P_0 (black polythene with no pinching) treatment combination while, the smallest (26.10, 42.60 and 44.87 cm, respectively) was measured in M_0P_2 (no mulch with pinching at 35 DAT) treatment combination.

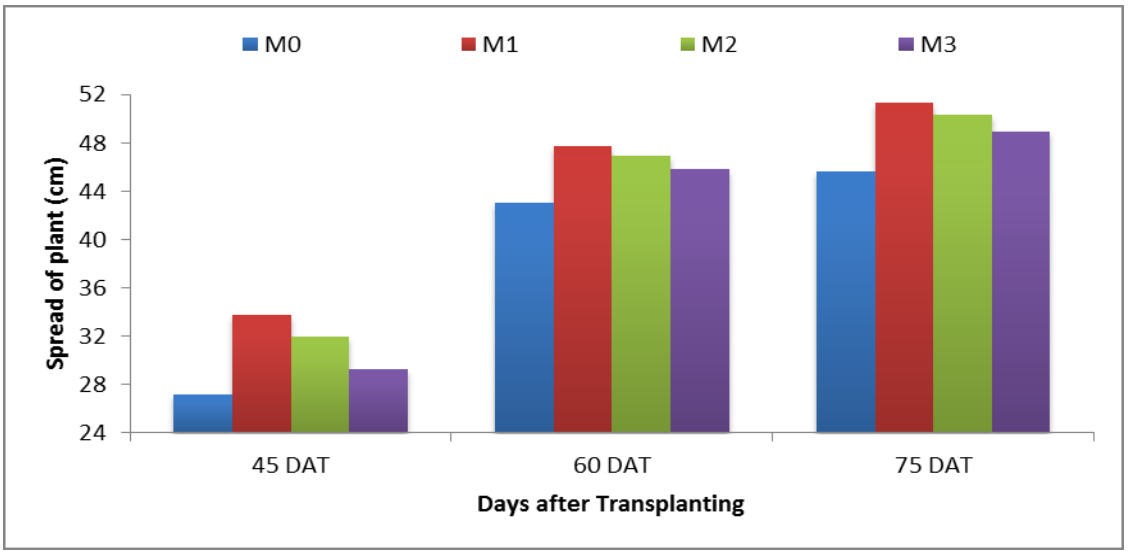

Figure 4. Effect of mulch materials on spread of plant (cm) of cabbage

M_0 – No mulch, M_1 – Black polythene, M_2 – Water hyacinth, M_3 – Rice straw

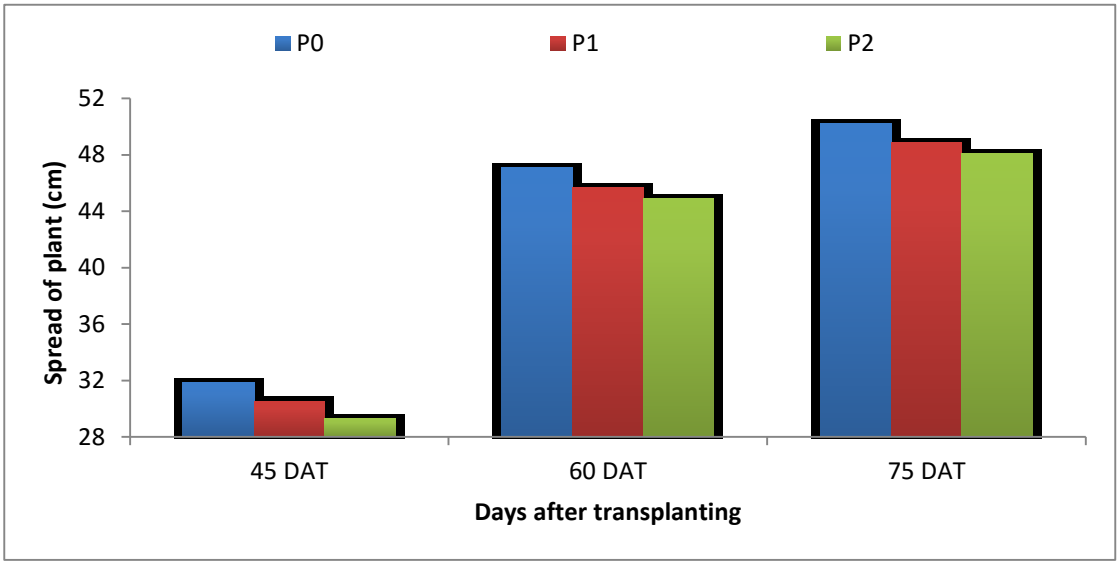

Figure 5. Effect of pinching on spread of plant (cm) of cabbage

P_0 – No pinching, P_1 – Pinching at 25 DAT, P_2 – Pinching at 35 DAT

Table 2. Combined effect of mulch materials and pinching on spread of plant (cm) of cabbage at different days after transplanting (DAT)

Treatments	Spread of plant (cm)		
	45 DAT	60 DAT	75 DAT
M_0P_0	28.00 g	43.93 g	47.03 h
M_0P_1	27.51 h	42.67 h	45.13 i
M_0P_2	26.10 i	42.60 h	44.87 i
M_1P_0	35.52 a	49.33 a	52.85 a
M_1P_1	33.10 c	47.63 c	50.93 b
M_1P_2	32.67 c	46.33 d	50.37 c
M_2P_0	34.07 b	48.25 b	51.10 b
M_2P_1	31.87 d	46.73 d	50.49 c
M_2P_2	30.00 e	45.73 e	49.33 e
M_3P_0	29.73 e	46.83 d	49.93 d
M_3P_1	29.67 e	45.77 e	48.93 f
M_3P_2	28.51 f	45.00 f	47.80 g
$LSD_{(0.05)}$	0.44	0.55	0.32
CV (%)	5.49	5.93	7.19

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
No mulch, M_1 – Black polythene, M_2 – Water hyacinth, M_3 – Rice straw and P_0 – No pinching, P_1 – Pinching at 25 DAT, P_2 – Pinching at 35 DAT

4.3 Number of leaves per plant

Mulch materials of different types showed significant effect on number of leaves per plant of cabbage (Figure 5). At 45, 60 and 75 DAT, the highest number of leaves per plant (13.77, 16.12 and 19.70, respectively) was recorded from M_1 (black polythene) treatment. On the other hand, at 45, 60 and 75 DAT, the lowest number of leaves per plant (10.25, 12.58 and 16.16, respectively) was measured in M_0 (no mulch) treatment.

Pinching at different times showed significant effect on number of leaves per plant of cabbage (Figure 6). At 45, 60 and 75 DAT, the maximum number of leaves per plant (13.04, 15.39 and 18.95, respectively) was recorded from P_0 (no pinching) treatment whereas, the minimum (11.19, 13.54 and 17.10, respectively) was measured in P_2 (pinching at 35 DAT) treatment.

Combined effect of mulch materials and pinching significantly influenced the number of leaves per plant of cabbage (Table 3). At 45, 60 and 75 DAT, the

highest number of leaves per plant (14.79, 17.14 and 20.70, respectively) was recorded from M_1P_0 (black polythene with no pinching) treatment combination. In comparison, the lowest number of leaves per plant (9.15, 11.50 and 15.06, respectively) was measured in M_0P_2 (no mulch with pinching at 35 DAT) treatment combination.

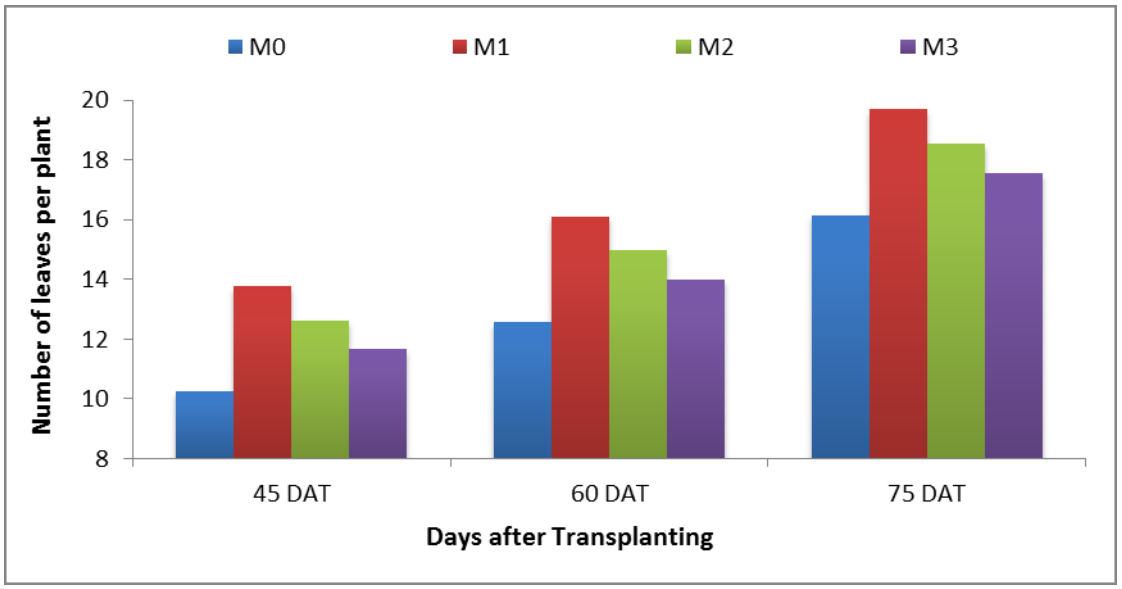

Figure 6. Effect of mulch materials on number of leaves per plant of cabbage

M_0 – No mulch, M1 – Black polythene, M2 – Water hyacinth, M3 – Rice straw

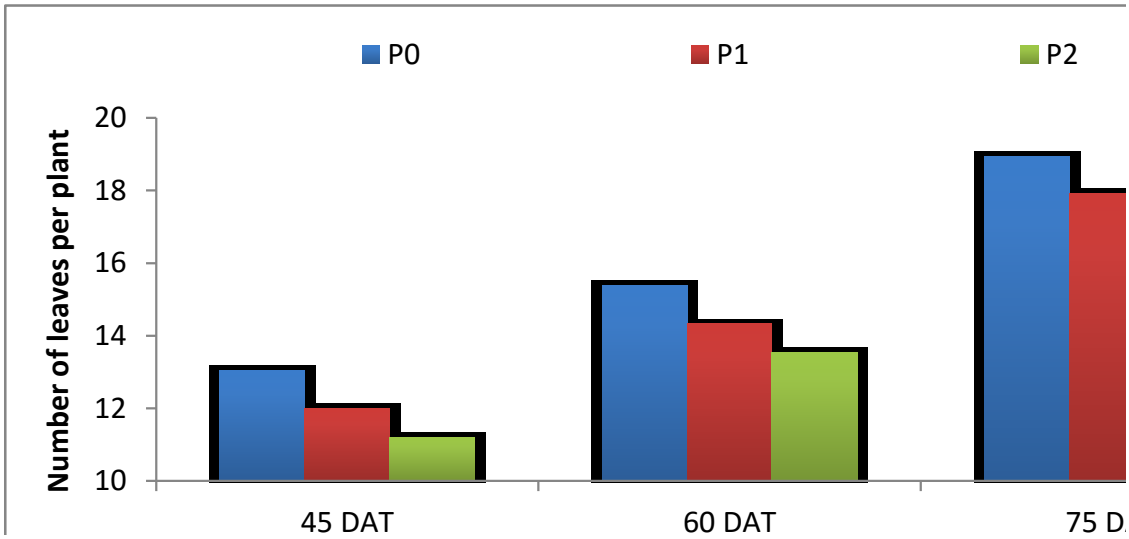

Figure 7. Effect of pinching on number of leaves per plant of cabbage

P_0- No pinching, P1 – Pinching at 25 DAT, P2 – Pinching at 35 DAT

Table 3. Combined effect of mulch materials and pinching on number of leaves per plant of cabbage at different days after transplanting (DAT)

Treatments	Number of leaves per plant		
	45 DAT	60 DAT	75 DAT
M_0P_0	11.36 f	13.71 f	17.27 f
M_0P_1	10.23 h	12.53 h	16.14 h
M_0P_2	9.150 i	11.50 i	15.06 i
M_1P_0	14.79 a	17.14 a	20.70 a
M_1P_1	13.51 b	15.87 b	19.48 b
M_1P_2	13.00 c	15.35 c	18.91 c
M_2P_0	13.46 b	15.81 b	19.37 b
M_2P_1	12.39 d	14.74 d	18.30 d
M_2P_2	12.03 e	14.38 e	17.94 e
M_3P_0	12.56 d	14.91 d	18.47 d
M_3P_1	11.83 e	14.18 e	17.74 e
M_3P_2	10.57 g	12.92 g	16.48 g
$LSD_{(0.05)}$	0.26	0.32	0.31
CV (%)	6.78	8.35	7.46

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
M_0 – No mulch, M_1 – Black polythene, M_2 – Water hyacinth, M_3 – Rice straw and P_0 – No pinching, P_1 – Pinching at 25 DAT, P_2 – Pinching at 35 DAT

4.4 Days to head formation

Mulch materials of different types showed significant effect on days to head formation of cabbage (Table 4). The maximum days required to head formation (46.38) was recorded from M_0 (no mulch) treatment. In comparison, the minimum days required to head formation (38.45) was measured in M_1 (black polythene) treatment.

Pinching at different times showed significant influence on days required to head formation of cabbage (Table 5). The most days required to head formation (50.26) was recorded from P_2 (pinching at 35 DAT) treatment. In comparison, the least days required to head formation (35.92) was measured in P_0 (no pinching) treatment.

Combined effect of mulch materials and pinching was significantly influenced by the days to head formation of cabbage (Table 6). The most days required to head formation (53.06) was recorded from M_0P_2 (no mulch with pinching at 35

DAT) treatment combination. In comparison, the least days required to head formation (30.00) was measured in M_1P_0 (black polythene with no pinching) treatment combination.

4.5 Percent of head formation

Mulch materials of different types showed significant effect on percent of head formation of cabbage (Table 4). The maximum percentage of head formation (87.00 %) was recorded from M_1 (black polythene) treatment. In comparison, the minimum percentage of head formation (74.67 %) was measured in M_0 (no mulch) treatment.

Pinching done at different times showed significant influence on percent of head formation of cabbage (Table 5). The highest percentage of head formation (88.67 %) was recorded from P_0 (no pinching) treatment. In comparison, the lowest percentage of head formation (74.50 %) was measured in P_2 (pinching at 35 DAT) treatment.

Combined effect of mulch materials and pinching significantly influenced the days to head formation of cabbage (Table 6). The maximum percentage of head formation (92.67 %) was recorded from M_1P_0 (black polythene with no pinching) treatment combination. In comparison, the minimum percentage of head formation (67.33 %) was measured in M_0P_2 (no mulch with pinching at 35 DAT) treatment combination.

4.6 Days to harvest

Mulch materials of different types showed significant effect on days to head maturity of cabbage (Table 4). The maximum days required to head maturity (90.54) was recorded from M_0 (no mulch) treatment. In comparison, the minimum days required to head maturity (80.73) was measured in M_1 (black polythene) treatment.

Pinching at different times showed significant influence on days required to head maturity of cabbage (Table 5). The most days required to head maturity (92.03)

was recorded from P_2 (pinching at 35 DAT) treatment. In comparison, the least days required to head maturity (77.69) was measured in P_0 (no pinching) treatment.

Combined effect of mulch materials and pinching significantly influenced the days to head maturity of cabbage (Table 6). The most days required to head maturity (96.67) was recorded from M_0P_2 (no mulch with pinching at 35 DAT) treatment combination. In comparison, the least days required to head maturity (72.93) was measured in M_1P_0 (black polythene with no pinching) treatment combination.

Table 4. Effect of mulch materials on days to head formation, percentage of head formation, days to head maturity, thickness of head (cm), diameter of head (cm) and weight of fresh head of cabbage

Treatments	Days to head formation	% of head formation	Days to head maturity	Thickness of head (cm)	Diameter of head (cm)	Weight of fresh head (kg)
M_0	46.38 a	74.67 d	90.54 a	11.42 d	17.62 d	1.30 d
M_1	38.45 d	87.00 a	80.73 d	13.19 a	20.27 a	1.95 a
M_2	43.45 c	82.33 b	83.37 c	12.13 b	18.72 b	1.69 b
M_3	43.95 b	78.00 c	85.46 b	11.94 c	18.27 c	1.49 c
$LSD_{(0.05)}$	0.17	0.83	1.50	0.12	0.13	0.08
CV (%)	5.23	4.61	6.04	5.60	5.42	2.59

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
Note: M_0 – No mulch, M_1 – Black polythene, M_2 – Water hyacinth and M_3 – Rice straw

Table 5. Effect of pinching on days to head formation, percentage of head formation, days to head maturity, thickness of head (cm), diameter of head (cm) and weight of fresh head of cabbage

Treatments	Days to head formation	% of head formation	Days to harvest	Thickness of head (cm)	Diameter of head (cm)	Weight of fresh head (kg)
P_0	35.92 c	88.67 a	77.69 c	12.87 a	20.49 a	1.78 a
P_1	43.00 b	78.33 b	85.36 b	11.49 c	18.67 b	1.59 b
P_2	50.26 a	74.50 c	92.03 a	12.15 b	17.00 c	1.45 c
$LSD_{(0.05)}$	0.15	0.72	1.30	0.10	0.12	0.07
CV (%)	5.23	4.61	6.04	5.60	5.42	2.59

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
Note: P_0 – No pinching, P_1 – Pinching at 25 DAT and P_2 – Pinching at 35 DAT

4.7 Thickness of head (cm)

Mulch materials of different types showed significant effect on thickness of head of cabbage (Table 4). The thickest head (13.19 cm) was recorded from M_1 (black polythene) treatment. In comparison, the thinnest head (11.42 cm) was measured in M_0 (no mulch) treatment.

Pinching done at different times showed significant influence on thickness of head of cabbage (Table 5). The thickest head (12.87 cm) was recorded from P_0 (no pinching) treatment. In comparison, the thinnest head (11.49 cm) was measured in P_1 (pinching at 25 DAT) treatment.

Combined effect of mulch materials and pinching significantly influenced the thickness of head of cabbage (Table 6). The thickest head of cabbage (14.33 cm) was recorded from M_1P_0 (black polythene with no pinching) treatment combination. In comparison, the thinnest head of cabbage (10.40 cm) was measured in M_0P_1 (no mulch with pinching at 25 DAT) treatment combination.

4.8 Diameter of head (cm)

Mulch materials of different types showed significant effect on diameter of head of cabbage (Table 4). The largest diameter of head (20.27 cm) was recorded from M_1 (black polythene) treatment. In comparison, the smallest diameter of head (17.62 cm) was measured in M_0 (no mulch) treatment.

Pinching done at different times showed significant influence on diameter of head of cabbage (Table 5). The highest diameter of head (20.49 cm) was recorded from P_0 (no pinching) treatment. In comparison, the lowest diameter of head (17.00 cm) was measured in P_2 (pinching at 35 DAT) treatment.

Combined effect of mulch materials and pinching significantly influenced the diameter of head of cabbage (Table 6). The largest diameter of head of cabbage (22.13 cm) was recorded from M_1P_0 (black polythene with no pinching) treatment combination. In comparison, the smallest diameter of head of cabbage

(15.90 cm) was measured in M_0P_1 (no mulch with pinching at 25 DAT) treatment combination.

4.9 Weight of fresh head (kg)

Mulch materials of different types showed significant effect on weight of fresh head of cabbage (Table 4). The maximum weight of fresh head (1.95 g) was recorded from M_1 (black polythene) treatment. In comparison, the minimum weight of fresh head (1.30 g) was measured in M_0 (no mulch) treatment.

Pinching operation at different times had significant influence on weight of fresh head of cabbage (Table 5). The highest weight of fresh head (1.78 g) was recorded from P_0 (pinching at 35 DAT) treatment. In comparison, the lowest weight of fresh head (1.45 g) was measured in P_2 (no pinching) treatment.

Combined effect of mulch materials and pinching significantly was influenced by the weight of fresh head of cabbage (Table 6). The maximum weight of fresh head of cabbage (2.23 g) was recorded from M_1P_2 (black polythene with pinching at 35 DAT) treatment combination. In comparison, the minimum weight of fresh head of cabbage (1.10 g) was measured in M_0P_0 (no mulch with no pinching) treatment combination.

Table 6. Combined effect of mulch materials and pinching on days to head formation, percentage of head formation, days to head maturity, thickness of head (cm), diameter of head (cm) and weight of fresh head of cabbage

Treatments	Days to head formation	% of head formation	Days to head formation	Thickness of head (cm)	Diameter of head (cm)	Weight of a fresh head (kg)
M_0P_0	40.21 g	83.67 e	83.02 e	12.23 e	20.40 b	1.10 i
M_0P_1	45.87 e	73.00 i	91.93 b	10.40 i	15.90 i	1.30 h
M_0P_2	53.06 a	67.33 k	96.67 a	11.63 g	16.56 h	1.50 f
M_1P_0	30.00 k	92.67 a	72.93 i	14.33 a	22.13 a	1.70 d
M_1P_1	38.07 h	85.00 d	80.93 f	12.37 d	18.40 f	1.92 b
M_1P_2	47.29 d	83.33 e	88.33 c	12.87 b	20.27 b	2.23 a
M_2P_0	37.15 i	90.00 b	75.93 h	12.70 c	19.67 c	1.60 e
M_2P_1	43.98 f	80.33 f	82.52 e	11.70 g	17.27 g	1.70 d
M_2P_2	49.22 c	76.67 g	91.67 b	12.00 f	19.23 d	1.78 c
M_3P_0	36.33 j	88.33 c	78.87 g	12.23 e	19.77 c	1.40 g
M_3P_1	44.07 f	75.00 h	86.07 d	11.50 h	16.43 h	1.47 fg
M_3P_2	51.45 b	70.67 j	91.44 b	12.10 f	18.60 e	1.62 e
$LSD_{(0.05)}$	0.17	0.83	1.50	0.12	0.13	0.08
CV (%)	5.23	4.61	6.04	5.60	5.42	2.59

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

Note: M_0 – No mulch, M_1 – Black polythene, M_2 – Water hyacinth, M_3 – Rice straw and P_0 – No pinching, P_1 – Pinching at 25 DAT, P_2 – Pinching at 35 DAT

4.10 Number of heads per plant

Mulch materials of different types showed significant effect on number of heads per plant of cabbage (Table 7). The highest number of heads per plant (2.3) was recorded from M_1 (black polythene) treatment. In comparison, the lowest number of heads per plant (1.89) was measured in M_0 (no mulch) treatment.

Pinching operation at different times showed significant effect on number of unfolded leaves per plant of cabbage (Table 8). The maximum number of unfolded leaves per plant (2.6) was recorded from P_2 (pinching at 35 DAT) treatment. In comparison, the minimum number of unfolded leaves per plant (1.0) was measured in P_0 (no pinching) treatment.

Combined effect of mulch materials and pinching significantly was influenced by the number of heads per plant of cabbage (Table 9). The highest number of

heads per plant of cabbage (2.40) was recorded from M_1P_1 (black polythene with pinching at 25 DAT) treatment combination. In comparison, the lowest number of heads per plant of cabbage (1.0) was measured in M_0P_0 (no mulch with no pinching) treatment combination.

4.11 Weight of unfolded leaves per plant (g)

Mulch materials of different types showed significant effect on weight of unfolded leaves per plant of cabbage (Table 7). The highest weight of unfolded leaves per plant (997.70 g) was recorded from M_1 (black polythene) treatment. In comparison, the lowest weight of unfolded leaves per plant (839.70 g) was measured in M_0 (no mulch) treatment.

Pinching operation at different times showed significant effect on weight of unfolded leaves per plant of cabbage (Table 8). The maximum weight of unfolded leaves per plant (962.60 g) was recorded from P_1 (pinching at 25 DAT) treatment. In comparison, the minimum weight of unfolded leaves per plant (849.30 g) was measured in P_0 (no pinching) treatment.

Combined effect of mulch materials and pinching was significantly influenced by the weight of unfolded leaves per plant of cabbage (Table 9). The highest weight of unfolded leaves per plant of cabbage (1051.00 g) was recorded from M_1P_1 (black polythene with pinching at 25 DAT) treatment combination. In comparison, the lowest weight of unfolded leaves per plant of cabbage (769.80 g) was measured in M_0P_0 (no mulch with no pinching) treatment combination.

Table 7. Effect of mulch materials on number of head per plant, weight of unfolded leaves per plant (g), length of largest leaves (cm), length of stem (cm), diameter of stem (cm) and length of root (cm) of cabbage

Treatments	Number of heads per plant	Weight of unfolded leaves per plant (g)	Length of largest leaves (cm)	Length of stem (cm)	Diameter of stem (cm)	Length of root (cm)
M_0	1.89c	839.70 d	18.12 d	7.92 d	1.37 d	21.11 d
M_1	2.3a	997.70 a	22.56 a	9.57 a	2.64 a	35.11 a
M_2	2.1b	865.70 c	20.65 b	8.79 b	2.44 b	30.61 b
M_3	1.9b	907.70 b	20.17 c	8.20 c	2.14 c	28.89 c
$LSD_{(0.05)}$	0.07	8.70	0.28	0.26	0.05	0.34
CV (%)	2.59	4.87	6.82	5.75	4.37	4.70

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
Note: M_0 – No mulch, M_1 – Black polythene, M_2 – Water hyacinth and M_3 – Rice straw

Table 8. Effect of pinching on number of head per plant, weight of unfolded leaves per plant (g), length of largest leaves (cm), length of stem (cm), diameter of stem (cm) and length of root (cm) of cabbage

Treatments	Number of head per plant	Weight of unfolded leaves per plant (g)	Length of largest leaves (cm)	Length of stem (cm)	Diameter of stem (cm)	Length of root (cm)
P_0	1.0c	849.30 c	18.58 c	7.77 c	2.39 a	25.75 c
P_1	2.2b	962.60 a	19.89 b	8.80 b	2.17 b	28.96 b
P_2	2.6a	896.20 b	22.66 a	9.28 a	1.88 c	32.08 a
$LSD_{(0.05)}$	0.08	7.53	0.25	0.22	0.04	0.30
CV (%)	2.59	4.87	6.82	5.75	4.37	4.70

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
Note: P_0 – No pinching, P_1 – Pinching at 25 DAT and P_2 – Pinching at 35 DAT

4.12 Length of largest leaves (cm)

Mulch materials of different types showed significant effect on length of largest leaves per plant of cabbage (Table 7). The highest length of largest leaves per plant (22.56 cm) was recorded from M_1 (black polythene) treatment. In comparison, the lowest length of largest leaves per plant (18.12 cm) was measured in M_0 (no mulch) treatment.

Pinching operation at different times had significant effect on length of largest leaves of cabbage (Table 8). The maximum length of largest leaves (22.66 cm) was recorded from P_2 (pinching at 35 DAT) treatment. In comparison, the minimum length of largest leaves (18.58 cm) was measured in P_0 (no pinching) treatment.

Combined effect of mulch materials and pinching significantly was influenced by the length of largest leaves of cabbage (Table 9). The longest length of largest leaves (24.43 cm) was recorded from M_1P_2 (black polythene with pinching at 35 DAT) treatment combination. In comparison, the smallest length of largest leaves (16.33 cm) was measured in M_0P_0 (no mulch with no pinching) treatment combination.

4.13 Length of stem (cm)

Mulch materials of different types showed significant effect on length of stem per plant of cabbage (Table 7). The maximum length of stem (9.57 cm) was recorded from M_1 (black polythene) treatment. In comparison, the minimum length of stem (7.92 cm) was measured in M_0 (no mulch) treatment.

Pinching operation at different times showed significant effect on length of stem of cabbage (Table 8). The longest stem (9.28 cm) was reported from P_2 (pinching at 35 DAT) treatment. In comparison, the shortest stem (7.77 cm) was measured in P_0 (no pinching) treatment.

Combined effect of mulch materials and pinching was significantly influenced by the length of stem of cabbage (Table 9). The longest stem (10.13 cm) was recorded from M_1P_2 (black polythene with pinching at 35 DAT) treatment combination. In comparison, the shortest stem (7.23 cm) was measured in M_2P_0 (water hyacinth with no pinching) treatment combination.

4.14 Diameter of stem (cm)

Mulch materials of different types showed significant effect on diameter of stem of cabbage (Table 7). The longest diameter of stem (2.64 cm) was recorded from

M_1 (black polythene) treatment. In comparison, the shortest diameter of stem (1.37 cm) was measured in M_0 (no mulch) treatment.

Pinching operation at different times showed significant influence on diameter of stem of cabbage (Table 8). The largest diameter of stem (2.39 cm) was recorded from P_0 (no pinching) treatment. In comparison, the smallest diameter of stem (1.88 cm) was measured in P_2 (pinching at 35 DAT) treatment.

Combined effect of mulch materials and pinching was significantly influenced by the diameter of stem of cabbage (Table 9). The longest diameter of stem (2.93 cm) was recorded from M_1P_0 (black polythene with no pinching) treatment combination. In comparison, the shortest diameter of stem (1.23 cm) was measured in M_0P_2 (no mulch with pinching at 35 DAT) treatment combination.

4.15 Length of root (cm)

Mulch materials of different types showed significant effect on length of root per plant of cabbage (Table 7). The longest root (35.11 cm) was recorded from M_1 (black polythene) treatment. In comparison, the shortest root (21.11 cm) was measured in M_0 (no mulch) treatment.

Pinching operation at different times showed significant effect on length of root of cabbage (Table 8). The longest root (32.08 cm) was recorded from P_2 (pinching at 35 DAT) treatment. In comparison, the shortest root (25.75 cm) was measured in P_0 (no pinching) treatment.

Combined effect of mulch materials and pinching significantly was influenced by the length of root of cabbage (Table 9). The maximum length of root (39.00 cm) was recorded from M_1P_2 (black polythene with pinching at 35 DAT) treatment combination. On the other hand, the minimum length of root (18.00 cm) was measured in M_0P_0 (no mulch with no pinching) treatment combination.

Table 9. Combined effect of mulch materials and pinching on number of heads per plant, weight of unfolded leaves per plant (g), length of largest leaves (cm), length of stem (cm), diameter of stem (cm) and length of root (cm) of cabbage

Treatments	Number of heads per plant	Weight of unfolded leaves per plant (g)	Length of largest leaves (cm)	Length of stem (cm)	Diameter of stem (cm)	Length of root (cm)
M_0P_0	1.00e	769.80 i	16.33 j	7.50 g	1.50 i	18.00 k
M_0P_1	1.40d	908.60 d	17.70 i	7.97 f	1.40 j	21.00 j
M_0P_2	2.20b	840.60 g	20.33 f	8.30 e	1.23 k	24.33 i
M_1P_0	1.60d	967.80 c	21.17 e	8.87 d	2.93 a	31.33 d
M_1P_1	2.40a	1051.00 a	22.07 d	9.70 b	2.57 c	35.00 b
M_1P_2	2.00a	974.80 bc	24.43 a	10.13 a	2.43 e	39.00 a
M_2P_0	1.60d	815.30 h	19.17 h	7.23 h	2.73 b	28.00 g
M_2P_1	1.8cd	909.50 d	20.30 f	9.27 c	2.50 d	30.50 e
M_2P_2	2.0bc	872.40 f	22.47 c	9.87 b	2.10 g	33.33 c
M_3P_0	1.00d	844.20 g	17.63 i	7.50 g	2.43 e	25.67 h
M_3P_1	1.8bc	981.90 b	19.47 g	8.27 e	2.23 f	29.33 f
M_3P_2	2.1bc	897.10 e	23.40 b	8.83 d	1.77 h	31.67 d
$LSD_{(0.05)}$	0.18	8.70	0.28	0.26	0.05	0.34
CV (%)	2.59	4.87	6.82	5.75	4.37	4.70

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

Note: M_0 – No mulch, M_1 – Black polythene, M_2 – Water hyacinth, M_3 – Rice straw and P_0 – No pinching, P_1 – Pinching at 25 DAT, P_2 – Pinching at 35 DAT

4.17 Gross yield per plot (kg)

Mulch materials of different types showed significant effect on gross yield per plot of cabbage (Table 10). The maximum gross yield per plot (23.40 kg) was recorded from M_1 (black polythene) treatment. In comparison, the minimum gross yield per plot (15.60 kg) was measured in M_0 (no mulch) treatment.

Pinching operation at different times showed significant effect on gross yield per plot of cabbage (Table 11). The highest gross yield per plot (21.39 kg) was recorded from P_2 (pinching at 35 DAT) treatment. In comparison, the lowest gross yield per plot (17.40 kg) was measured in P_0 (no pinching) treatment.

Combined effect of mulch materials and pinching was significantly influenced by the gross yield per plot of cabbage (Table 12). The highest gross yield per plot (26.76 kg) was recorded from M_1P_2 (black polythene with pinching at 35 DAT) treatment combination. On the other hand, the lowest gross yield per plot (13.20 kg) was measured in M_0P_0 (no mulch with no pinching) treatment combination.

4.18 Gross yield per hectare

Mulch materials of different types showed significant effect on gross yield per hectare of cabbage (Table 10). The maximum gross yield per hectare (83.57 ton) was recorded from M_1 (black polythene) treatment. In comparison, the minimum gross yield per hectare (55.72 ton) was measured in M_0 (no mulch) treatment.

Pinching operation at different times showed significant effect on gross yield per hectare of cabbage (Table 11). The highest gross yield per hectare (76.40 ton) was recorded from P_2 (pinching at 35 DAT) treatment. In comparison, the lowest gross yield per hectare (62.14 ton) was measured in P_0 (no pinching) treatment.

Combined effect of mulch materials and pinching significantly was influenced by gross yield per hectare of cabbage (Table 12). The highest gross yield per hectare (95.57 ton) was recorded from M_1P_2 (black polythene with pinching at 35 DAT) treatment combination. On the other hand, the lowest gross yield per hectare (47.14 ton) was measured in M_0P_0 (no mulch with no pinching) treatment combination.

Table 10. Effect of mulch materials on gross yield and marketable yield on of cabbage

Treatments	Gross yield		Marketable yield	
	plot (kg)	hectare (ton)	plot (kg)	hectare (ton)
M_0	15.60 d	55.72 d	13.03 d	46.55 d
M_1	23.40 a	83.57 a	20.97 a	74.88 a
M_2	20.32 b	72.57 b	17.89 b	63.88 b
M_3	17.96 c	64.14 c	15.56 c	55.57 c
$LSD_{(0.05)}$	0.85	3.03	0.87	3.05
CV (%)	5.29	5.78	4.97	6.36

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
Note: M_0 – No mulch, M_1 – Black polythene, M_2 – Water hyacinth and M_3 – Rice straw

Table 11. Effect of pinching on gross yield and marketable yield of cabbage

Treatments	Gross yield		Marketable yield	
	plot (kg)	hectare (ton)	plot (kg)	hectare (ton)
P_0	17.40 c	62.14 c	14.80 c	52.86 c
P_1	19.17 b	68.47 b	16.74 b	59.80 b
P_2	21.39 a	76.40 a	19.04 a	68.00 a
$LSD_{(0.05)}$	0.74	2.62	0.72	2.65
CV (%)	5.29	5.78	4.97	6.36

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
Note: P_0 – No pinching, P_1 – Pinching at 25 DAT and P_2 – Pinching at 35 DAT

4.19 Marketable yield per plot (kg)

Mulch materials of different types showed significant effect on marketable yield per plot of cabbage (Table 10). The maximum marketable yield per plot (20.97 kg) was recorded from M_1 (black polythene) treatment. In comparison, the minimum marketable yield per plot (13.03 kg) was measured in M_0 (no mulch) treatment.

Pinching operation at different times showed significant effect on marketable yield per plot of cabbage (Table 11). The highest marketable yield per plot (19.04 kg) was recorded from P_2 (pinching at 35 DAT) treatment. In comparison, the lowest marketable yield per plot (14.80 kg) was measured in P_0 (no pinching) treatment.

Combined effect of mulch materials and pinching was significantly influenced by the marketable yield per plot of cabbage (Table 12). The highest marketable yield per plot (24.46 kg) was recorded from M_1P_2 (black polythene with pinching at 35 DAT) treatment combination. On the other hand, the lowest marketable yield per plot (10.50 kg) was measured in M_0P_0 (no mulch with no pinching) treatment combination.

4.20 Marketable yield per hectare (ton)

Mulch materials of different types showed significant effect on marketable yield per hectare of cabbage (Table 10). The maximum marketable yield per hectare (74.88 ton) was recorded from M_1 (black polythene) treatment. In comparison, the minimum marketable yield per hectare (46.55 ton) was measured in M_0 (no mulch) treatment.

Pinching operation at different times showed significant effect on marketable yield per hectare of cabbage (Table 11). The highest marketable yield per hectare (68.00 ton) was recorded from P_2 (pinching at 35 DAT) treatment. In comparison, the lowest marketable yield per hectare (52.86 ton) was measured in P_0 (no pinching) treatment.

Combined effect of mulch materials and pinching was significantly influenced by the marketable yield per hectare of cabbage (Table 12). The highest marketable yield per hectare (87.36 ton) was recorded from M_1P_2 (black polythene with pinching at 35 DAT) treatment combination. On the other hand, the lowest marketable yield per hectare (37.50 ton) was measured in M_0P_0 (no mulch with no pinching) treatment combination.

Table 12. Combined effect of mulch materials and pinching on gross yield and marketable yield of cabbage

Treatments	Gross yield		Marketable yield	
	plot (kg)	hectare (ton)	plot (kg)	hectare (ton)
M_0P_0	13.20 i	47.14 i	10.50 j	37.50 j
M_0P_1	15.60 h	55.71 h	13.10 i	46.79 i
M_0P_2	18.00 f	64.29 f	15.50 g	55.36 g
M_1P_0	20.40 d	72.86 d	17.80 de	63.57 de
M_1P_1	23.04 b	82.29 b	20.64 b	73.71 b
M_1P_2	26.76 a	95.57 a	24.46 a	87.36 a
M_2P_0	19.20 e	68.57 e	16.60 f	59.29 f
M_2P_1	20.40 d	72.86 d	18.00 d	64.29 d
M_2P_2	21.36 c	76.29 c	19.06 c	68.07 c
M_3P_0	16.80 g	60.00 g	14.30 h	51.07 h
M_3P_1	17.64 fg	63.00 fg	15.24 g	54.43 g
M_3P_2	19.44 e	69.43 e	17.14 ef	61.21 ef
$LSD_{(0.05)}$	0.85	3.03	0.87	3.05
CV (%)	5.29	5.78	4.97	6.36

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
Note: M_0 – No mulch, M_1 – Black polythene, M_2 – Water hyacinth, M_3 – Rice straw and P_0 – No pinching, P_1 – Pinching at 25 DAT, P_2 – Pinching at 35 DAT

4.13 Economic analysis

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

4.13.1 Gross return

The combination of mulches and pinching of cabbage showed different value in terms of gross return under the trial (Table 13). The highest gross return (Tk. 6,98,880.00) was obtained from M_1P_2 treatment The lowest gross return (Tk. 3,00,000.00) was obtained from M_0P_0 treatment.

4.13.2 Net return

In case of net return, mulches and pinching of cabbage showed different levels of net return under the present trial (Table 13). The highest net return (Tk. 5,22,732.00) was found from M_1P_2 treatment. The lowest (Tk. 1,40,652.00) net return was obtained M_0P_0 treatment.

4.13.3 Benefit cost ratio

In the mulches and pinching of cabbage, the highest benefit cost ratio (3.97) was noted from M_1P_2 treatment and the second highest benefit cost ratio (3.35) was estimated from M_1P_1. The lowest benefit cost ratio (1.88) was obtained from M_0P_0 treatment (Table 13). From economic point of view, it is apparent from the above results that M_1P_2 (Black polythene and pinching at 35 DAT) treatment was better than rest of the combination.

Table 13. Cost and return of cabbage cultivation as influenced by mulch materials and pinching

Treatments	Cost of production (Tk./ha)	Yield of cabbage (t/ha)	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio
M_0P_0	1,59,348.00	37.50	3,00,000.00	1,40,652.00	1.88
M_0P_1	1,64,948.00	46.79	3,74,320.00	2,09,372.00	2.27
M_0P_2	1,64,948.00	55.36	4,42,880.00	2,77,932.00	2.68
M_1P_0	1,70,548.00	63.57	5,08,560.00	3,38,012.00	2.98
M_1P_1	1,76,148.00	73.71	5,89,680.00	413,532.00	3.35
M_1P_2	1,76,148.00	87.36	6,98,880.00	5,22,732.00	3.97
M_2P_0	1,66,068.00	59.29	4,74,320.00	3,08,252.00	2.86
M_2P_1	1,71,668.00	64.29	5,14,320.00	3,42,652.00	3.00
M_2P_2	1,71,668.00	68.07	5,44,560.00	3,72,892.00	3.17
M_3P_0	1,68,308.00	51.07	4,08,560.00	2,40,252.00	2.43
M_3P_1	1,73,908.00	54.43	4,35,440.00	2,61,532.00	2.50
M_3P_2	1,73,908.00	61.21	4,89,680.00	3,15,772.00	2.82

Price of Cabbage @ Tk. 8000/ton

Note: M_0 – No mulch, M_1 – Black polythene, M_2 – Water hyacinth, M_3 – Rice straw and P_0 – No pinching, P_1 – Pinching at 25 DAT, P_2 – Pinching at 35 DAT

CHAPTER V

SUMMARY AND CONCLUSION

The field experiment was conducted in the Horticultural farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from October 2014 to January 2015 to find out the effect of mulching and pinching on the growth, yield and economic point of view of cabbage. The experiment consisted of two factors viz., factor A: it included of four mulch materials denote as M viz., M_0 – No mulch, M_1–Black polythene, M_2 – Water hyacinth, M_3 – Rice straw and factor B: it consisted of three pinching denote as P viz., P_0 – No pinching, P_1 – Pinching at 25 DAT, P_2 – Pinching at 35 DAT. Data on different growth and yield contributing characters were recorded.

Mulch materials of different types showed significant effect on plant height, spread of plant and number of leaves per plant of cabbage at 45, 60 and 75 days after transplanting (DAT). At 75 DAT, the maximum plant height (36.96 cm), spread of plant (51.38 cm) and number of leaves per plant (19.70) was recorded from M_1 (black polythene) treatment whereas, the minimum plant height (33.28 cm), spread of plant (45.68 cm) and number of leaves per plant (16.16) was observed in M_0 (no mulch) treatment. Mulch materials of different types showed significant effect on days to head formation, percentage of head formation, days required to head maturity, head thickness, diameter of head, weight of fresh head, number of unfolded leaves per plant, weight of unfolded leaves per plant, length of largest leaves per plant, length of stem, diameter of stem, root length, fresh weight of total plant, gross and marketable yield per plot and per hectare of cabbage. The maximum percentage of head formation (87.00 %), thickest head (13.19 cm), diameter of head (20.27 cm), weight of fresh head (1.95 g), number of unfolded leaves per plant (18.83), weight of unfolded leaves per plant (997.70 g), length of largest leaves per plant (22.56 cm), length of stem (9.57 cm), diameter of stem (2.64 cm), longest root (35.11 cm), fresh weight of total plant (2.94 g), gross yield per plot (23.40 kg), gross yield per hectare (83.57 ton),

marketable yield per plot (20.97 kg) and marketable yield per hectare (74.88 ton) were recorded from M_1 (black polythene) treatment. On the other hand, the minimum percentage of head formation (74.67 %), thinnest head (11.42 cm), diameter of head (17.62 cm), weight of fresh head (1.30 g), number of unfolded leaves per plant (15.84), weight of unfolded leaves per plant (839.70 g), length of largest leaves per plant (18.12 cm), length of stem (7.92 cm), diameter of stem (1.37 cm), shortest root (21.11 cm), fresh weight of total plant (2.14 g), gross yield per plot (15.60 kg), gross yield per hectare (55.72 ton), marketable yield per plot (13.03 kg) and marketable yield per hectare (46.55 ton)were observed in M_0 (no mulch) treatment.

Pinching at different times showed significant effect on plant height, spread of plant and number of leaves per plant of cabbage at 45, 60 and 75 days after transplanting (DAT). At 75 DAT, the maximum plant height (36.75 cm), spread of plant (50.23 cm) and number of leaves per plant (18.95) were recorded from P_0 (no pinching) treatment whereas, the minimum plant height (33.04 cm), spread of plant (48.09 cm) and number of leaves per plant (17.10) were observed in P_2 (pinching at 35 DAT) treatment. Pinching of different types showed significant effect on days to head formation, percentage of head formation, days required to head maturity, head thickness, diameter of head, weight of fresh head, number of unfolded leaves per plant, weight of unfolded leaves per plant, length of largest leaves per plant, length of stem, diameter of stem, root length, fresh weight of total plant, gross and marketable yield per plot and per hectare of cabbage. The highest percentage of head formation (88.67 %), thickest head (12.87 cm), diameter of head (20.49 cm), weight of fresh head (1.78 g), diameter of stem (2.39 cm) were recorded from P_0 (no pinching) treatment while, the lowest percentage of head formation (74.50 %), thinnest head (11.49 cm), diameter of head (17.00 cm), weight of fresh head (1.45 g), diameter of stem (1.88 cm) were observed in P_2 (pinching at 35 DAT) treatment. On the other hand, the longest stem (9.28 cm), longest root (32.08 cm), fresh weight of total plant (2.67 g), gross yield per plot (21.39 kg), gross yield per hectare (76.40 ton), marketable yield per plot (19.04 kg) and marketable yield per hectare (68.00 ton)

were reported from P_2 (pinching at 35 DAT) treatment whereas, the shortest stem (7.77 cm), shortest root (25.75 cm), fresh weight of total plant (2.29 g), gross yield per plot (17.40 kg), gross yield per hectare (62.14 ton), marketable yield per plot (14.80 kg) and marketable yield per hectare (52.86 ton) were observed in P_0 (no pinching) treatment.

Interaction of mulch materials and pinching significantly influenced the plant height, spread of plant and number of leaves per plant of cabbage at 45, 60 and 75 days after transplanting (DAT). At 45, 60 and 75 DAT, the maximum plant height (40.17 cm), spread of plant (52.85 cm) and number of leaves per plant (20.70) were recorded from M_1P_0 (black polythene with no pinching) treatment combination whereas, the minimum plant height (31.20 cm), spread of plant (44.87 cm) and number of leaves per plant (15.06) were observed in M_0P_2 (no mulch with pinching at 35 DAT) treatment combination. Interaction effect of mulching and pinching of different types showed significant effect on days to head formation, percentage of head formation, days required to head maturity, head thickness, diameter of head, weight of fresh head, number of unfolded leaves per plant, weight of unfolded leaves per plant, length of largest leaves per plant, length of stem, diameter of stem, root length, fresh weight of total plant, gross and marketable yield per plot and per hectare of cabbage. The maximum days required to head formation (53.06) and days required to head maturity (96.67) were recorded from M_0P_2 (no mulch with pinching at 35 DAT) treatment combination. In comparison, the least days required to head formation (30.00) and days required to head maturity (72.93) were observed in M_1P_0 (black polythene with no pinching) treatment combination. The maximum percentage of head formation (92.67 %), head of cabbage (14.33 cm), diameter of head (22.13 cm) and diameter of stem (2.93 cm) were recorded from M_1P_0 (black polythene with no pinching) treatment combination. In comparison, the minimum percentage of head formation (67.33 %), head of cabbage (10.40 cm), diameter of head (15.90 cm) and diameter of stem (1.23 cm) were observed in M_0P_2 (no mulch with pinching at 35 DAT) treatment combination. The highest number of unfolded leaves per plant (19.83), weight of unfolded leaves per plant

(1051.00 g), length of largest leaves (24.43 cm), longest stem (10.13 cm), length of root (39.00 cm), fresh weight of total plant (3.20 g), gross yield per plot (26.76 kg), gross yield per hectare (95.57 ton), marketable yield per plot (24.46 kg) and marketable yield per hectare (87.36 ton) were recorded from M_1P_2 (black polythene with pinching at 35 DAT) treatment combination. On the other hand, the lowest number of unfolded leaves per plant (14.51), weight of unfolded leaves per plant (769.80 g), length of largest leaves (16.33 cm), shortest stem (7.23 cm), length of root (18.00 cm), weight of total plant (1.87 g), gross yield per plot (13.20 kg), gross yield per hectare (47.14 ton), marketable yield per plot (10.50 kg) and marketable yield per hectare (37.50 ton) were observed in M_0P_0 (no mulch with no pinching) treatment combination.

The highest benefit cost ratio (3.97) was noted from the combination of M_1P_2 and the lowest (1.88) from M_0P_0. From economic point of view, it is apparent that the combination of M_1P_2 (black polythene with pinching at 35 DAT) was suitable for cabbage cultivation.

On the basis of results of the present experiment, it may be concluded that efficient production of cabbage is increased by the judicial management of mulching and pinching. Crop yield and profit are both important for a crop production. Soil health is also very important for sustainable production. Thus, considering crop productivity, economic return and soil fertility, combined management of mulching and pinching may be helpful for sustainable production of Cabbage. So, M_1P_2 (black polythene with pinching at 35 DAT) is recommended at farmers land for profitable cabbage production. The highest benefit cost ratio (3.97) was noted from the treatment combination of M_1P_2 (black polythene with pinching at 35 DAT) and the lowest (1.88) from M_0P_0 (No mulch with No Pinching) treatment

The present research work was carried out at the Sher-e-Bangla Agriculture University, Dhaka in Robi season only. Further trail of this research work in different locations with another variety of the country is needed to justify the result for common farmers.

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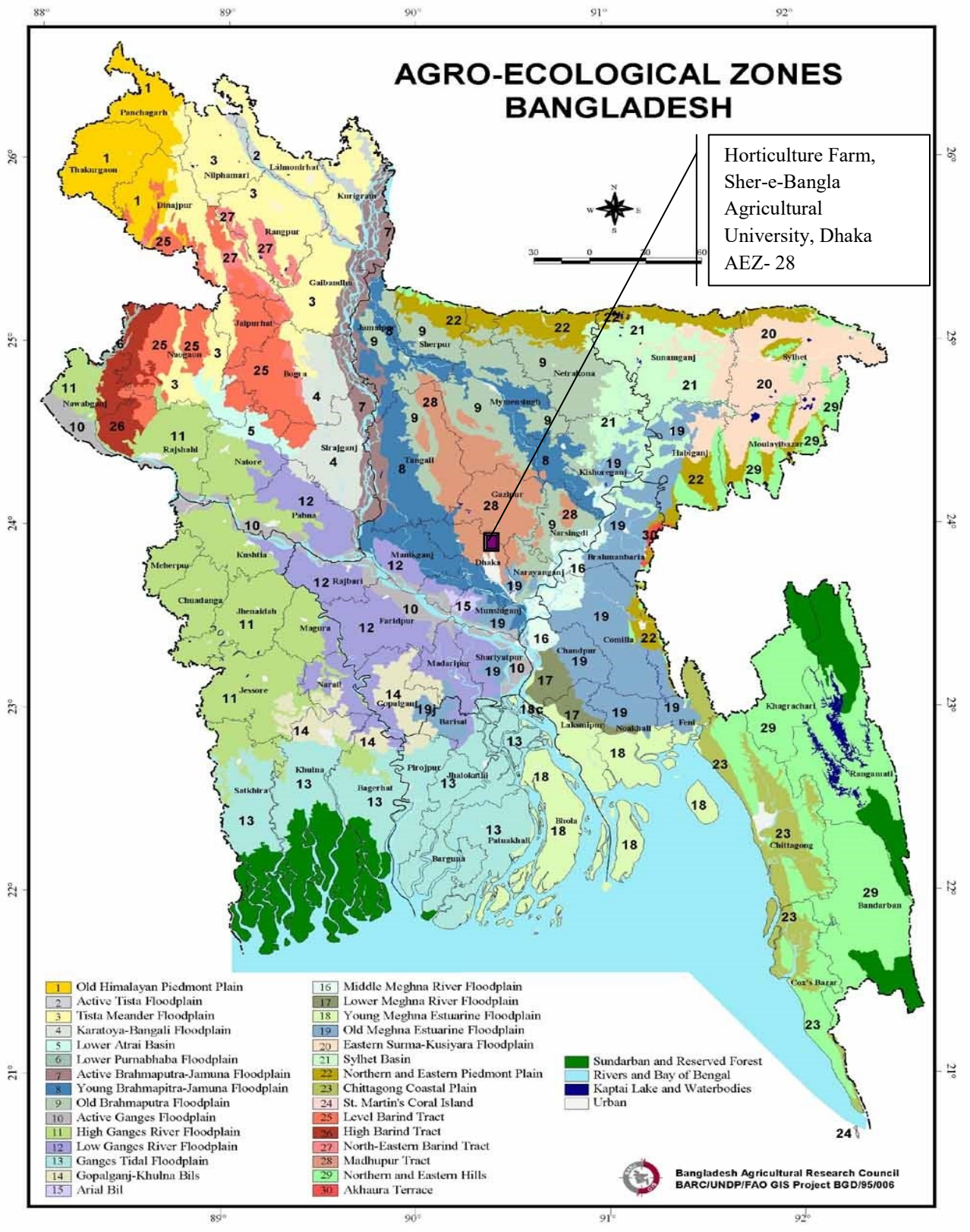
APPENDICES

Appendix I. Map showing the experimental sites under study



The experimental site under study

Appendix II. Physical characteristics and chemical composition of soil of the experimental plot

Soil characteristics	Analytical results
Agrological Zone	Madhupur Tract
PH	6.45
Organic matter	0.84
Total N (%)	0.46
Available phosphorous	21 ppm
Exchangeable K	0.41 meq / 100 g soil

Source: Soil Resource and Development Institute (SRDI), Dhaka

Appendix III. Monthly average record of air temperature, rainfall, relative humidity and Sunshine of the experimental site during the period from October 2014 to January 2015.

Month	Air temperature (°c)		Relative humidity (%)	Total rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
October, 2014	31.6	23.8	78	172.3	5.2
November, 2014	29.6	19.2	77	34.4	5.7
December, 2014	26.4	14.1	69	12.8	5.5
January, 2015	25.4	12.7	68	7.7	5.6

Source: Bangladesh Meteorological Department (Climate & Weather Division) Agargoan, Dhaka – 1212.

Appendix IV: Error mean square values for plant height and number of leaves per plant of cabbage at different days after transplanting

Source of variation	Degrees of freedom	Plant height			Number of leaves per plant		
		45 DAT	60 DAT	75 DAT	45 DAT	60 DAT	75 DAT
Replication	2	0.512	6.929	6.929	70.355	146.980	146.980
Mulching (A)	3	61.214*	258.021*	258.021*	262.010*	150.568*	111.634*
Pinching (B)	2	5.027*	121.587*	55.037**	79.470*	84.468*	84.468**
A × B	6	0.716**	6.669**	6.669*	3.795*	5.685**	5.685*
Error	22	1.949	15.077	15.077	36.725	11.934	11.934

*Significant at 5% level of probability
** Significant at 1% level of probability

Appendix V: Error mean square values for spread of plant of cabbage at different days after transplanting

Source of variation	Degrees of freedom	Spread of plant		
		45 DAT	60 DAT	75 DAT
Replication	2	0.008	0.612	0.401
Mulching (A)	3	3.909**	8.810*	12.801*
Pinching (B)	2	0.268*	13.934**	9.808*
A × B	6	0.087*	0.679*	0.368**
Error	22	0.185	0.350	0.481

*Significant at 5% level of probability
** Significant at 1% level of probability

Appendix VI: Error mean square values for days to head formation, percentage of head formation, days to head maturity, thickness of head (cm), diameter of head (cm) and weight of fresh head of cabbage

Source of variation	Degrees of freedom	Days to head formation	% of head formation	Days to head maturity	Thickness of head (cm)	Diameter of head (cm)
Replication	2	0.433	0.001	0.001	0.07	0.737
Mulching (A)	3	0.135*	0.082*	0.041*	0.012*	6.418**
Pinching (B)	2	0.395*	0.034*	0.026*	0.33*	7.435*
A × B	6	0.641*	0.008*	0.007*	0.103*	0.081*
Error	22	2.839	0.003	0.002	6.720	0.522

*Significant at 5% level of probability
** Significant at 1% level of probability

Appendix VII: Error mean square values for number of head per plant, weight of unfolded leaves per plant (g), length of largest leaves (cm), length of stem (cm), diameter of stem (cm) and length of root (cm) of cabbage

Source of variation	Degrees of freedom	Number of head per plant	Weight of unfolded leaves per plant (g)	Length of largest leaves (cm)	Length of stem (cm)	Diameter of stem (cm)	Length of root (cm)
Replication	2	1.863	2.164	4.224	0.302	0.264	0.136
Mulching (A)	3	3.346*	6.761**	5.643**	5.362*	2.794*	8.048**
Pinching (B)	2	4.086**	1.107**	8.127**	1.901*	3.655*	10.310*
A × B	6	3.407**	1.26**	5.03**	1.60*	3.660*	0.252**
Error	22	0.452	1.61	3.35	4.23	2.752	0.591

*Significant at 5% level of probability
** Significant at 1% level of probability

Appendix VIII: Error mean square values for gross yield and marketable yield of cabbage

Source of variation	Degrees of freedom	Gross yield		Marketable yield	
		plot (kg)	hectare (ton)	Plot (kg)	hectare (ton)
Replication	2	0.042	0.147	0.0001	0.0001
Mulching (A)	3	0.491*	0.952*	0.017**	0.054*
Pinching (B)	2	0.832*	0.892*	0.001*	0.880*
A × B	6	0.981*	0.50**	0.001*	0.515*
Error	22	5.173	5.38	0.001	3.412

*Significant at 5% level of probability

** Significant at 1% level of probability

Appendix IX: Cost of production of cabbage per hectare

A. Input cost (Tk/ha)

Treatments	Labor	Cabbage seed	Pesticides	Irrigation	Mulch	Cow dung	Fertilizer			Subtotal(A)
							Urea	TSP	MP	
M_0P_0	7,21,00	10,500	2,500	1,500	00	20,000	2,700	4,375	3,600	1,17,275
M_0P_1	7,71,00	10,500	2,500	1,500	00	20,000	2,700	4,375	3,600	1,22,275
M_0P_2	7,71,00	10,500	2,500	1,500	00	20,000	2,700	4,375	3,600	1,22,275
M_1P_0	7,21,00	10,500	2,500	1,500	10,000	20,000	2,700	4,375	3,600	1,27,275
M_1P_1	7,71,00	10,500	2,500	1,500	10,000	20,000	2,700	4,375	3,600	1,32,275
M_1P_2	7,71,00	10,500	2,500	1,500	10,000	20,000	2,700	4,375	3,600	1,32,275
M_2P_0	7,21,00	10,500	2,500	1,500	6,000	20,000	2,700	4,375	3,600	1,23,275
M_2P_1	7,71,00	10,500	2,500	1,500	6,000	20,000	2,700	4,375	3,600	1,28,275
M_2P_2	7,71,00	10,500	2,500	1,500	6,000	20,000	2,700	4,375	3,600	1,28,275
M_3P_0	7,21,00	10,500	2,500	1,500	8,000	20,000	2,700	4,375	3,600	1,25,275
M_3P_1	7,71,00	10,500	2,500	1,500	8,000	20,000	2,700	4,375	3,600	1,30,275
M_3P_2	7,71,00	10,500	2,500	1,500	8,000	20,000	2,700	4,375	3,600	1,30,275

M_0 – No mulch,
M_1 – Black polythene,
M_2 – Water hyacinth,
M_3 – Rice straw

P_0 – No pinching,
P_1 – Pinching at 25 DAT,
P_2 – Pinching at 35 DAT,

Cow dung: Tk. 2/kg
Urea: Tk. 12/kg
TSP: Tk. 24/kg
MP: Tk. 25/kg

Appendix IX: continued

B. Overhead cost (Tk/ha)

Treatments	Cost of lease of land months for 6 months (14% of value of land Tk. 4,00,000/ year)	Miscellaneous cost (Tk. 5% of the input cost)	Interest on running capital for 6 month (14% of cost /year)	Subtotal (B)	Subtotal(A)	Total cost of production (input cost +overhead cost)
M_0P_0	28,000	5,863.75	8,209.25	42,073	1,17,275	1,59,348
M_0P_1	28,000	6,113.75	8,559.25	42,673	1,22,275	1,64,948
M_0P_2	28,000	6,113.75	8,559.25	42,673	1,22,275	1,64,948
M_1P_0	28,000	6,363.75	8,909.25	43,273	1,27,275	1,70,548
M_1P_1	28,000	6,613.75	9,259.25	43,873	1,32,275	1,76,148
M_1P_2	28,000	6,613.75	9,259.25	43,873	1,32,275	1,76,148
M_2P_0	28,000	6,163.75	8,629.25	42,793	1,23,275	1,66,068
M_2P_1	28,000	6,413.75	8,979.25	43,393	1,28,275	1,71,668
M_2P_2	28,000	6,413.75	8,979.25	43,393	1,28,275	1,71,668
M_3P_0	28,000	6,263.75	8,769.25	43,033	1,25,275	1,68,308
M_3P_1	28,000	6,513.75	9,119.25	43,633	1,30,275	1,73,908
M_3P_2	28,000	6,513.75	9,119.25	43,633	1,30,275	1,73,908