GROWTH AND YIELD OF TOMATO AS INFLUENCED BY SEEDLING AGE & MULCHING

A THESIS
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CERTIFICATE

This is to certify that the thesis entitled, "Growth and Yield of Tomato as influenced by Seedling age & Mulching" submitted to the Dept. of Horticulture & Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE in HORTICULTURE, embodies the result of a piece of bona fide research work carried out by Sayeeda Sultana Shampa. Registration No. 00988 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 of during the course of this investigation has been duly acknowledged by her.

Dated: June, 2008
Dhaka, Bangladesh

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Sayeeda Sultana Shampa

ABSTRACT

The field experiment was conducted in the experimental farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka -1207 during November 2006 to April 2007 to find out the effect of seedling age and different mulches on the growth and yield of tomato. The experiment consisted of two factors Factor A: age of seedling such as S_1: 30 days, S_2: 35 days and S_3: 40 days, Factor B: different mulching such as M_0: No mulch; M_1: Water hyacinth; M_2: Black polythene and M_3: Straw. The trial was laid out in Randomized complete Block Design (RCBD) with three replications. In case of seedling age S_2 produced the maximum number of fruits per plant (37.94), weight of individual fruit (77.85 g) and yield (71.69 t/ha). In case of mulching M_2 produced the maximum number of fruits per plant (41.37), weight of individual fruit (84.91 g) and yield (79.17 t/ha). In case of combined effect S_2M_2 produced maximum number of fruits per plant (42.78), weight of individual fruit (98.10 g) and yield (88.29 t/ha). It may therefore be concluded that the 35 days age of seedling along with application of black polythene mulching is suitable combination for better growth and yield of tomato.


Dedicated to
My
Beloved
Parents

LIST OF CONTENTS

CONTENTS (cont'd)

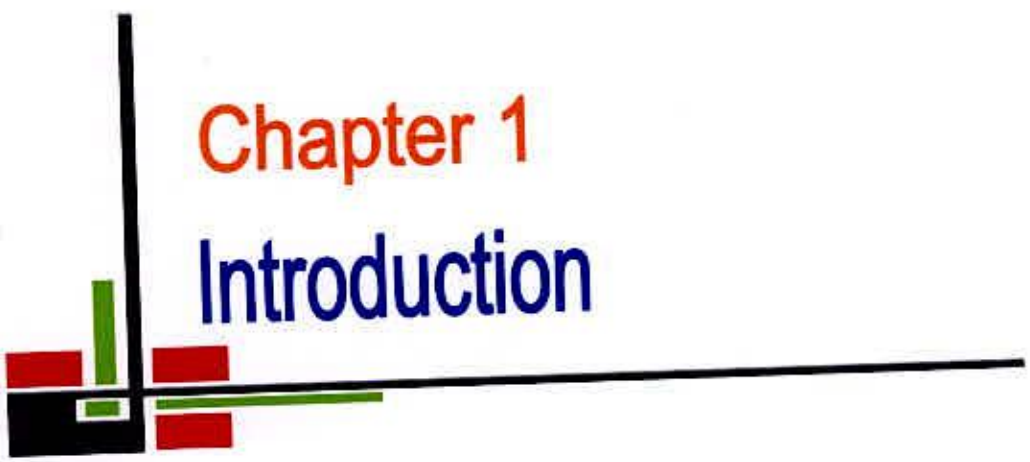
LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBRIVIATIONS

ABBREVIATION	FULL WORD
AEZ	Agro-Ecological Zone
ANOVA	Analysis of variance
BARI	Bangladesh Agricultural Research Instite
BT	BARI Tomato
@	At the rate
cm	Centimeter
cv.	Cultivar(s)
CV%	Percentage of Coefficient of Variance
DAT	Days after transplanting
DMRT	Duncan's Multiple Range Test
e.g.	example
et al.	and others
g	Gram
gl^{-1}	Gram per litre
i.e	that is
K	Potassium
kg	Kilogram
kg ha^{-1}	Kg per hectare
LSD	Least Significant Difference
m	Meter
ml	Milliliter
mm	Millimeter
MP	Muriate of Potash
N	Nitrogen
NS	Not Significant
RAT	Recovery after transplanting
RCBD	Randomized Complete Block Design
SAU	Sher-e-Bangla Agricultural University
SRTI	Sugarcane Research and Training Institute
t ha^{-1}	Ton per hectare
TSP	Triple super phosphate
^0C	Degree Celsius
%	Percent



Chapter 1

Introduction

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) belonging to the family Solanaceae is one of the most popular, nutritious and profitable vegetable crops grown in Bangladesh during rabi season. It has originated in tropical America (Salunkhe *et al.*, 1987), particularly in peru, Ecuador and Bolivia of the Andes (Kalloo, 1986). The leading tomato production countries of the world are China, United States of America, India, Turkey, Iran, Italy, Mexico, Brazil and Indonesia (FAO, 1999). It is cultivated in almost all home gardens and also in the field due to its adaptability to wide ranges of soil and climate (Ahmed, 1976). It ranks next to potato and sweet potato in the world vegetable production (Rashid, 1983). Tomato ranks third in terms of world vegetable production (FAO, 2000) and tops the list of canned vegetables (Chaudhury, 1979). However, the yield of the crop in this country is very low compared to those of some advanced countries (Sharfuddin and Siddique, 1985).

The popularity of tomato and its products is increasing. It is a nutritious and delicious vegetable used in salads, soups and processed into stable products like ketchup, sauce, puree, marmalade, chutney and juice. Tomato adds variety of colour and flavour to the foods. It contains high quantity of vitamins A, B, C, calcium and carotene (Bose and Som, 1990).

In Bangladesh, the recent statistics shows that tomato was grown in 15,142 hectares of land and the total production was approximately 131,000 metric tons during the year 2005-2006 and the average yield of tomato was 8.65 t ha^{-1} (BBS, 2006), which is very low in comparison with that of other countries namely, India (15.67 t/ha), Japan (52.82 t/ha) and USA (63.66 t/ha) (FAO, 1995). The yield of tomato in our country is not satisfactory in comparison to its requirement (Aditya *et al.*, 1999). The low yield of tomato in Bangladesh, however, is not an indication of low yielding ability of this crop, but of the fact that the tomatoes grown here are not always of high yielding types and that the cultural practices commonly used by the growers are not improved

because of their ignorance about improved production technology including use of proper age of seedlings as well as mulching practices. Since the soil and climatic conditions of Bangladesh during the winter season are congenial to proper growth of tomato, it is expected that improved management practices would augment the yield considerably.

Tomato has great demand throughout the year, but is grown mainly in the winter season during the month of September to April. Successful tomato cultivation largely depends on the efficient use of soil moisture, judicious application of manure and fertilizers, improved varieties and crop protection measures. Out of these, efficient use of soil moisture is very important. Because of scanty rainfall during the rabi season in Bangladesh, growers have to depend either on natural precipitation or supplemental irrigation water for growing their tomato crop. Water is the single factor that directly effects the tomato yield. Because it contains 94% water successful crop about 285 mm water is required especially at flowering and enlargement stage (Anon, 1995). Irrigation facilities are not sufficient in all the regions of the country. Sometimes pumps can not lift water in dry season due to lower water table underneath the soil. Moreover, many farmers cannot afford to buy irrigation pump as well as water. As a result, the production of tomato is hampered to a greater extent. Under such condition mulches may be an alternative to irrigation. Artificial mulch like straw, sawdust, water hyacinth or plastic mulch and crop residues are generally used as cover mulches in the production of horticultural crops (Wilhoit *et al.*, 1990).

The age of seedlings to be transplanted is very important for proper establishment in the field and production of good quality fruits as well as high yield. Tender aged or over aged seedlings are not suitable for better yield. Medium aged seedlings results in greater leaf area, high yield and number of fruits per plant and greater average fruit weight (Hassan, 1967).

Mulching conserves soil moisture and controls the weeds and pests. Different types of mulch play an important role in conserving soil moisture than non-mulched one (Suh and Kim, 1991). Mulching is a desirable management practice which is reported to regulate soil temperature, improved soil moisture, suppress weed growth and save labour cost (Patil and Basad, 1972), and improves the soil physical conditions by enhancing the biological activity of soil fauna and thus increases soil fertility (Lal, 1986). The practice has been reported to increase yield by creating favourable temperature and moisture regimes in different parts of the world (Ma and Han, 1995). Soil temperature is an important factor affecting germination, growth and other developmental processes for crops (Larson *et al.*, 1960). Mulching has that unique character of reducing the maximum soil temperature and increasing the minimum temperature (Singh *et al.*, 1987).

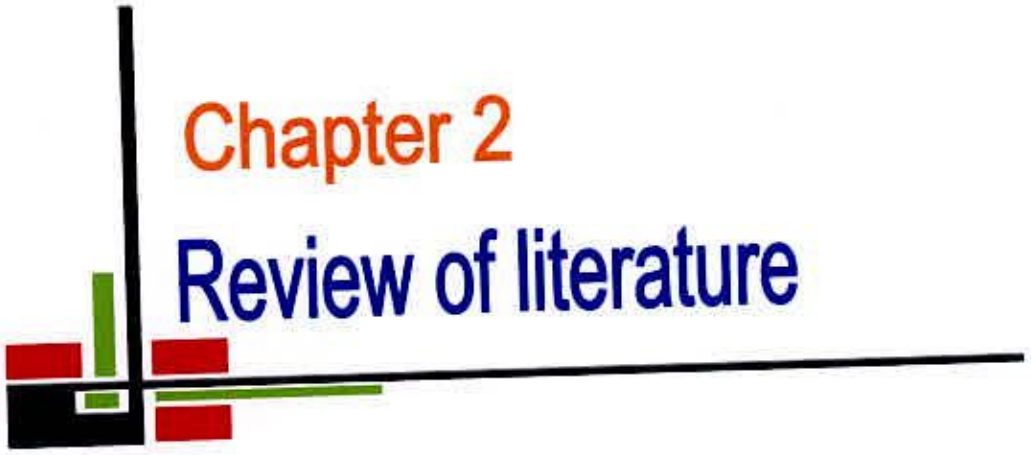
Mulching associated with proper age of seedling is an important factor for successful tomato production. The combined effect of these production practices have not been defined clearly and the information in this respect is meagre in Bangladesh. The present study was undertaken in view of the following objectives:

Objectives:

i) To determine the optimum age of tomato seedlings for transplanting in the main field in order to achieve higher yield.

ii) To find out suitable mulch material for better growth and higher yield of tomato under rainfed condition.

iii) To find out the best combination of optimum seedling age and suitable mulch material for successful tomato production.



Chapter 2

Review of literature

REVIEW OF LITERATURE

Tomato is one of the most important vegetable crops grown under field and greenhouse condition, which received much attention of the researchers throughout the world. Among various research works, investigations have been made in various parts of the world to determine the suitable seedling age and mulching practices for its successful cultivation. However, the combined effects of these production practices have not been defined clearly. In Bangladesh, there is a little studies on the influence of seedling age or mulching practices on the growth and yield of tomato. The relevant literature on tomato and some other related crops available in this connection have been reviewed here with the hope that this might contribute to the present study.

INFLUENCE OF SEEDLING AGE ON THE GROWTH AND YIELD OF TOMATO.

Establishment and growth of tomato plants largely depend on the age of seedling to be transplanted in the field. Proper age of seedling to be transplanted is very important to get good quality fruit and high yield. Tender aged or over aged seedlings are not suitable for high yield. Seedlings should be transplanted after a particular time of sowing.

Casseres (1946) reported that seedlings of seven weeks from seed sowing to field planting produced significantly higher, early and total yield than those of 11 weeks old.

Thompson and Kelly (1957) stated that the proper age of seedling to be transplanted largely depends on several factors such as the methods followed in growing the seedlings, the climatic conditions and the purpose for which the

crop was grown. They suggested that six weeks were sufficient time for seed sowing to field planting. If they were to be transplanted once before field setting, 8 to 10 weeks should be allowed; but the length of time should vary with the spacing.

The effect of age of seedlings on yield was also studied with several varieties of tomato by Mercik and Skapski (1961). They found that the youngest (4 week old) transplants of the variety Fire Ball produced the highest yield. They suggested that 4-8 week old transplant were suitable for better yield. The highest total yield was obtained from 4 week old transplants. It was clear from the study that a delay of 2 weeks in planting resulted in yield reductions in all varieties.

While investigating into the influence of age of transplants on vegetative., floral and fruit development in tomato, Hassan (1967) found an increased yield with 4 weeks old seedling instead of 7 or 9 weeks old transplants. The transplanting age had no effect upon the initiation of the first inflorescence but had marked effect on its development. He also reported that 4 weeks old transplants gave greater stem length, relative growth rate, net assimilation rate and leaf weight ratio than 7-9 week old transplants.

Bahcevanova (1970) found that sowing and planting dates of tomato affect mainly the length of the growth period, earliness and yield. Biemans (1973) also carried out an experiment with tomato and reported that earlier planting resulted in higher yield.

Histatomi and Urabe (1973) reported that high soil temperature (15°C) and the use of young tomato seedlings supported vigorous vegetative growth, resulting in longer and thicker stems, more leaves and larger leaves. The proportion of large fruits rose with the use of young seedlings and additional nitrogen. Size of fruit showed an interaction between soil temperature and moisture. From the findings, it

was possible to produce high yield of good quality fruit by controlling the nitrogen supply, plant density, high intensity, night temperature, soil temperature, soil moisture and seedling quality.

Tongova and Zhelev (1975) reported that both early sowing and early planting of tomato gave increased yield. The highest early and total yield were produced by plants sown on 20 September and transplanted at the 4-5 leaf stage. On the other hand, Zakoyan (1974) reported that the highest yield was obtained from plants transplanted on 20 April.

Adelana (1976) reported that the earliest planting of tomato seedlings resulted in greater leaf area, higher yield and number of fruits per plant and greater average fruit weight than later planting.

Souma *et al.*, (1976) while investigating into the effect of the length of the seedling age on the growth, yield and quality of tomato reported that the seedlings transplanted 40 day after sowing grow best and that abnormal fruits were produced by the plants transplanted 60 and 70 day after sowing. Dayan *et al.*, (1978) have indicated that delayed planting reduced overall yield.

On the other hand, while investigating into the effect of different methods and time of sowing on yield and quality of tomato found that the number of fruits per plant and mean yield per plant decreased with delay in sowing date. Sowing date and transplant age have tremendous effect on growth and yield of tomato. (Ravikumar and Shanmugavelu, 1983).

In trials during spring and autumn under greenhouse, tomato seedlings at the age of 2 to 6 weeks were planted out and irrigated using drip or sub surface irrigation. In spring, the older transplants produced more shoot and root up to 2 weeks after transplanting than young transplants. At 3 and 4 weeks after transplanting, there were no difference between 4, 5 and 6 weeks old transplants under either irrigation system. Total yield and early yield were similar for all transplant ages. In the autumn, shoot

growth in the older transplants was initially faster than in the younger transplants but this effect diminished after 1 week. However, this difference diminished with time and was insignificant 4 weeks later. It was concluded that using the traditional older transplants gave no yield advantages and that use of younger transplants would reduce seedling production costs (Leskovar *et al.*, 1991).

Vavrina and Orzolek (1993) conducted the research to determine the optimum age at which to transplant tomatoes. It was concluded that transplants ranging from 2 to 13 weeks old could produce similar yields, depending on many factors involved in commercial production.

Rahman *et al.*, (1994) reported that in experiments of tomato cv. Manik, seedling age at transplanting had a significant effect on the number of days until flowering commenced, the number of days until harvest, number of fruits/plant and yield. Plants grown from younger seedlings flowered and were ready to harvest earlier than those grown from older seedlings. The numbers of fruit/plant and average fruit weight were greatest when seedlings were 40 day old at transplanting.

Chui *et al.*, (1997) conducted a greenhouse and field experiment with three tomato cultivars to study the influence of seedling age (4, 6, 8 or 10 weeks) on growth and early yield of fresh market tomatoes. Seedlings more than 6 weeks old showed slower growth and recovery after transplanting (RAT) and took longer time to flower in all 3 cultivars. Although older seedlings (>8 weeks) had restricted roots, they produced higher early yields than younger seedlings.

Three tomato cultivars were grown using the plug system or traditionally from seedlings sown in the field. They were then planted when 2 to 8 weeks old. There were no differences in performance of seedlings from the 2 different nursery systems when seedlings were less than 4 weeks old at planting. After 4 weeks, the growth rate of the field sown seedlings was greater than those raised as plugs.

Sanjoi Saha (1999) studied the impact of seedling age (15 or 30 days old) and planting time (early: 16 November or late: 16 December) on the fruit yield performance of tomato (*Lycopersicon lycopersicum*) cultivars BT 18, BT 12, BT 10, BT 2 and MIX ENT in upland rice (cv. Annada)-based cropping system. All cultivars performed well when planted early (with 15-day-old seedlings) and showed a declining trend in fruit yield and other yield-attributing characters when planted late with 30 days old seedlings. Among the tomato cultivars, remarkably good fruit yields of 60.7 and 47.0 t/ha were recorded from BT 18 during 1994-95 and 1995-96, respectively, when planted early with 15 days old seedlings. BT 12 gave fruit yields of 59.7 and 41.9 t/ha during 1994-95 and 1995-96, respectively. The economics of different tomato cultivars also showed the same trend. The gross return, net return and net return per rupee were highest in BT 18, followed by BT 12, irrespective of seedling age and planting time.

Lee and Kim (1999) observed the effects of seedling age (45, 60 or 75 days) and transplanting depth (rootball, or up to cotyledon or first true leaf). Tomatoes plant height and stem diameter were not influenced by seedling age or planting depth. The cluster-emerged node number was not affected by planting depth. The second cluster-emerged node number was lower in 45-day-old seedlings compared with older seedlings. Average fruit weight was lowest in first cluster regardless of seedling age. The number of marketable fruits was not influenced by planting depth, but was highest in 60-day-old seedlings. The highest marketable yields (1699-1849 g/plant) were obtained from 60-day-old seedlings.

Tomato Seedlings were higher than that of field-sown transplants especially for those too young (2-4 weeks old) or too old (7-8 weeks old). After transplanting, the first flowers appeared on field sown seedlings 3-6 days earlier (depending on cultivar) than on plug seedlings. Early fruit yields were higher from field sown seedlings but total season fruit yields were higher from plug seedlings (Huang *et al.*, 1998).

Weon *et al.*, (1999) reported that plant height and stem diameter were not influenced by seedling age or planting depth of tomato. The cluster-emerged node number was not affected by planting depth. The second cluster emerged node number was lower in 45 day old seedlings compared with older seedlings. Average fruit weight was lowest in first cluster regardless of seedling age. The number of marketable fruit was not influenced by planting depth, but was highest in 60 days old seedlings. The highest marketable yield (1849 g/plant) was obtained from 60 days old seedlings.

Zhao-Rui *et al.*, (2000) noted that old seedlings of tomato (60-days-old) had the worst quality, but produced the highest early yield and lowest total yield. Young seedlings (30 days old) produced the highest total yield, but a lower early yield. The best quality seedlings were 45 days old seedlings.

Benedictos *et al.*, (2000) reported that young (5 weeks old) transplants of tomato had highest fruit setting rate (81.69%), followed by medium-aged (7 weeks old) transplants (76.94%) and old (9 week old) transplants (76.04%).

Okano *et al.*, (2000) reported the effects of seedling age at planting on the quality of nursery plants, on plant from after planting and on growth rate and fruit yield. The younger the seedling at planting, the faster the plant grew after planting. When seedlings were raised for >35 days, growth was considerably retarted. Dry weight of roots and stems at harvest were higher when tomatoes were planted at a younger age. However, leaf dry weight, total leaf area and fruit yield were highest in the 25 and 35 days old seedling plots. Total leaf area per plant was positively correlated with fruit yield.

Okano Kunio *et al.*, (2000) observed the effect of seedling age at planting on plant form and fruit productivity in single-truss tomato (*Lycopersicon esculentum* Mill.) grown hydroponically. Light interception and photosynthetic activity of the leaves were also examined in plants with different plant forms. Growth after planting was

retarded in proportion to the duration of raising of seedlings. 25-day to 35-day(4 to 7 leaf stages) plug seedlings were considered to be most suitable for single-truss cultivation of tomato. Fruit yield was positively correlated with total leaf area. Frequent emergence of lateral shoots could not be inhibited by the use of over mature seedlings. Interception of solar radiation which was highest for the uppermost leaf decreased for the leaves toward the lower part of the plant. Radiation interception by individual leaves varied depending on the plant form, which influenced the rate of field photosynthesis. Only upper three leaves contributed to photosynthesis in a shorter plant, while many more leaves in a taller plant.

Choi-YoungHah *et al.,* (2002) reported that the effects of seedling containers and seedling ages on the growth and yield of tomato plants were examined to establish the criteria for appropriate seedling production methods in the summer season. The quality of seedlings were better when seedlings were grown in polyethylene pots (phi9 cm) than in 72-cell plug trays. Seedling quality was better with increasing the growth duration in black polyethylene pots, whereas growth durations did not affect seedling quality in plug trays. Fruits matured earlier with pot-grown seedlings for a long duration than with plug tray-grown seedlings for a short duration. The yields of tomato during the first two months were significantly higher in pot-nursed seedlings than the plug tray-nursed seedlings. Also, the total yield of tomato during the four-month period was highest in pot-nursed seedlings. In pot-grown seedlings, there were no yield differences between 35 and 45 days old seedlings during the first two months of harvest, while the yields of 25 days old seedlings were much lower than the older seedlings (35 and 45 days old). Seedling ages had no effect on the cumulative yield for 3 months after the first harvest. With plug tray-grown transplants, the cumulative yield for the initial 3 months was highest in plants grown for 35 days in the nursery, followed by 25 days and 45 days. However, there were no significant differences among seedling ages in the total yield.

Aparajita Borah (2002) reported that the age (3, 4, 5 and 6-week-old) of the seedlings of tomato cv. Pusa Ruby and aubergines cv. Pusa Purple had significant effect on the development of *M. incognita*. The damage caused by *M. incognita* was more to plants of tender age (3 to 4 weeks old) than that of older age (5 to 6 weeks old).

Zhao Rui and Chen (2004) conducted to determine the effect of nutritive area on the growth of tomato seedlings grown in plug trays. They recommended to transplant middle-aged seedlings by evaluating the effects of seedling age and plug tray nursery area on yield.

A field experiment was conducted by Rajbir Singh *et al.*, (2005) to see the effects of transplanting time (10 and 30 December, and 20 January) on the growth and yield of tomato cv. Rupali. Early planting (10 December) resulted in the highest vegetative growth, yield attributes, early and total fruit yield, whereas the lowest values for the parameters measured were lowest with 20 January transplanting. The highest net returns (Rs. 52 700/ha) was recorded with transplanting on 10 December.

INFLUENCE OF MULCHING ON THE GROWTH AND YIELD OF TOMATO:

Mulches have various effects on plant growth and yield. Many researchers noted that plants were greatly influenced by mulching.

Use of various types of mulches viz., straw, sawdust, water hyacinth, white and coloured polythene sheets is reported to conserve soil moisture efficiently. It helps better utilization of all the nutrients in the soil. Mulching also stimulates microbial activity in soil (Aldefer, 1946) through improvement of soil agro-physical properties (Goebal, 1972; Lee and Yoon, 1975) so that organic matter content is increased (Strizaker *et al.*, 1989).

Calvert (1957) found that high temperature and low light intensity accelerate the number of leaves per plant in tomato. The highest number of leaves per plant

produced in mulch treatments was possibly due to greater plant height and favourable temperature, P^H and moisture condition in the soil. Polythene mulch is responsible to higher temperature resulting higher number of leaf.

Waggoner *et al.*, (1960) noticed that the maximum percentage of tomato seedlings were established in water hyacinth and the minimum in black polythene mulching. It was possible that the black polythene mulch encouraged absorption of solar radiation which also increased soil temperature underneath and ultimately affected seedling establishment.

Mulch has positive effect on the yields of other vegetables. Clear polythene mulch increased the yield of corn and beans (Harris, 1965). Cucumber production was 15.17% higher when grown under rice straw mulch over the control (Surlekov, 1965).

The effect of tomato mulching on fresh weight of roots per plant was highly significant. Mulching influenced increasing the fresh weight of roots. Knavel and Mohr (1967) recorded a greater root growth when the soil was covered with either black paper or black polythene.

Bieloral (1970) reported that polythene sheets showed 2% increase in the moisture content of the top 30 cm of the soil. Similarly, Patil and Basad (1972) found that black polythene, saw-dust and dried grass mulch in tomato production improved soil moisture retention but black polythene had the best performance.

Chaudhary and Prihar (1974) reported significant increase in plant height of maize plants in plots covered with water hyacinth or straw mulch than those in the soil-mulched plot or control at the Regional Agricultural Research Station, Jamalpur. Similar results were also obtained by Quayyum and Ahmed (1993) and Jones *et al.*, (1969).

Mulch application also produced taller plant in tobacco (Murty and Rao, 1969), cotton (Villamayor, 1976), Sorghum (Mane and Umrani 1981), Wheat (Kapur *et al.*, 1978 ; Sharma and Chakor, 1989), moong (Kumar *et al.*, 1995), garlic (Baten *et al.*, 1995) and potato (Rashid *et al.*, 1981).

Polythene mulch has positive effect on plant growth. Black polythene mulch in cauliflower induced maximum growth (Singh and Mishra, 1975).

Petrov and Al-Amiri (1976) noticed that, temperature at 10 cm depth was the highest in May and June in soil covered with black polythene, followed by transparent film. In the straw mulched soil it was lower than the control. Black and transparent films for mulching led to higher early and overall yields of tomato.

Collins (1977) reported that transparent black polythene and polythene coated black paper mulches increased soil temperature and advanced emergence of potato.

Amador and Vives (1978) carried out an experiment on different mulch and reported that transparent plastic mulch was inferior owing to abundant weed growth compared to black polythene, rice-husks and saw-dust mulch. Kiss (1976) observed that mulching with plastic sheet reduced weed growth and improved soil and air temperature, soil moisture relations and yield and earliness in straw-berries, melons, tomatoes and grape vines.

Working on nutritional variation of mulched soils, Chen and Katan (1980) focused that nitrate, ammonium, potassium, calcium, magnesium, chlorine, sodium-bi-carbonate ions and extractable P were found by mulch application. In case of soil P^{H}, Famosa Bautista (1983) reported that mulching had no significant affect on soil P^{H}.

An experiment was conducted by Gonzalez and Vives (1980) with tomato and mulches (black polythene, blue polythene, red polythene, rice husk and saw dust). They found mat black, blue and red polythene mulches increased tomato yield and quality more than rice or sawdust mulches. While conducting an

experiment on tomato using black clear plastic and grass clipping mulches, Geneve (1981) reported that the plastic mulches yielded the highest whereas, grass clipping reduced it.

Gupta and Gupta (1981) showed that light and frequent irrigation (30 mm water at E_0 = 30 mm) to a sandy loam soil, together with straw mulching (6 t/ha), reduced soil temperature by 2 to 7°C and increased water and N availability, thereby increasing the yields of tomato and okra by 100 and 400%, respectively.

A 2-year field study with tomato cv. Sunny was conducted on a fine sandy loam soil near Vincennes, India (Bhella, 1988). Use of trickle irrigation with mulching increased Mg concentration in soils mulched with polythene than in soils without mulch. The use of trickle irrigation increased plant height, whereas polythene mulch increased plant spread and dry matter production. Early, late and total yields were improved with all trickle irrigation and polythene mulch treatments. Total yields were 66, 70 and 123% greater for plants grown with polythene mulch, trickle irrigation and polythene mulch plus trickle irrigation, respectively, than in the control plants.

Famoso and Bautista (1983) conducted an experiment on tomato production as influenced by mulching with sugarcane truss and straw. They stated that, mulching with rice straw increased the number of flowers and the chlorophyll content of the leaves in tomato, resulting enhanced yield of tomato. On the other hand, Petrov and Al-Amiri (1976) reported that black or transparent films for mulching led to higher early and over all yields of tomato. In case of soil P^H, they also reported that mulching had no significant affect on soil P^H.

An experiment was performed by Perrella *et al.,* (1983) on mulching with photodegradable plastic films. They used photodegradable plastic mulches including 0.05 mm Alkatene (brick coloured) and Fertene (black, ranging in thickness from 0.03 to 1.0 mm). These were compared with crops mulched with

black, brown and colourless polythene films and with un-mulched controls. The tomatoes ripened earlier and yielded best (452 q/ha) with black Fertene.

Manrique and Meyer (1984) in their experiment at Manila Agricultural Experiment Station, Lima, Peru, reported that in summer, plastic mulches significantly increased day soil temperature to above 30°C, whereas rice straw mulch reduced the maximum daily soil temperature and increased the soil microbial population.

Mulches reduced the soil temperature at daytime because they reflected a considerable part of incidental solar radiation except polythene mulch. Moreover, their lower thermal conductivity prevented and decreased the amount of downward transmission of heat (Giri and Singh, 1985).

Perry and Sanders (1986) reported that black polythene mulch increased early and total yield of large and marketable fruits of tomato. Sutator (1987) stated that shading and mulching increased the potato yield.

In general, mulching conserved the soil moisture (Prihar, 1986; Devaun and Haverkort, 1987 and Ifnekwe *et al.*, 1987). Polythene mulch conserves more moisture in soil than the control (Harris, 1965). Straw mulch also improves soil water retention (Surlekov, 1965 and Taja and Vander-Zaag, 1991)

Rudich and Luchinsky (1987) clearly demonstrated that the water requirement of tomatoes is affected by the cultivar used, and they showed that the crop production function (yield as a function of evapotranspiration) varied widely. In the weekly irrigation treatments, yield of fruit increased with increasing water rates from 53 liters/m of row to 374 liters/m of row. Yields were lower in the weekly application treatments than in the daily irrigation treatments. For example, at an irrigation rate of 267 liters/m of row, tomato yielded 80% higher in the daily irrigatin treatment than in the weekly irrigation treatment (Phene *et al.*, 1985).

Al-jebori *et al.,* (1987) studied the effectiveness of black polythene, silver polythene, newspaper, straw and no mulch or control, mulching treatments under two nitrogen fertilizer sources (amonium sulphate and urea) at 100 kg N/ha on tomato plants (cv. Super Marmando). The results indicated that black and silver polythene mulches significantly increased early production and total yield.

Siddique and Rabbani (1987) conducted an experiment with two newly released varieties of sweet potato (Kamala Sundari and Tripti) in furrow and ridge methods of planting and with or without mulch. The experiment was conducted under rain-fed condition. Mulching was found beneficial in all cases for the development of vegetative parts and tuberous roots. Kamala Sundari gave the highest yield of tuberous roots in furrow method in combination with mulch and tripti gave the highest yield in ridge method in combination with mulch.

Baldev *et al.,* (1988) mentioned that mulching with 6 ton rice-straw per hectare decreased soil temperature at 10 cm depth by 1-6^{0}C, conserved soil water, suppressed weed growth and increased water use efficiency.

Gunadi and Suwanti (1988) observed that 25 days old seedlings were transplanted and not mulched or mulched with rice straw at 6 t/ha. The plants were spaced at 60 X 40 or 60 X 50 cm in single rows, or at 50 X 40 or 50 X 50 cm in double rows. The highest yield increase (16.3%) over the non-mulched control was obtained with mulched plants spaced at 60 X 50 cm in single rows.

Ammonification and nitrification were increased by mulching as deliberated by Boyajieva and Rankov (1989) who also observed enhanced CO_2 levels and reduced redox potential in mulched soil.

Decoteau *et al.,* (1989) reported that mulch colour affected the yield and growth of plants. Plants grown under mulch generally had the greatest early marketable yield and produced the least amount of foliage.

Firake *et al.*, (1990) stated that plastic tunnel conserved 47.08% of water and increased yield by 47.67% over the control.

Firake *et al.*, (1991) reported that sugarcane trash mulch can save 44.34% of irrigation water. Similar results were obtained by Shrivastava *et al.*, (1994). Singh *et al.*, (1987) observed that mulching by paddy straw decreased soil water depletion and increased water use efficiency under both irrigated and rainfed conditions.

Wivutvongvana *et al.*, (1991) reported that marketable yields of muskmelon, watermelon and sweet pepper were markedly increased by the use of a silvery-grey polythene plastic mulch, compared with bare soil and straw mulch.

Khalak and Kumaraswamy (1992) from their trial with potato at Bangalore, India, found that mulching with straw and polythene gave average tuber yields of 18.2 and 16.7 t/ha compared with 14.3 t/ha without mulching.

Gonzalez *et al.*, (1993) stated that plastic mulch enhances plant development, flowering and fruit numbers per plant of tomato compared with traditional or chemical weed control.

Dadomo *et al.*, (1994) carried out an experiment with tomato and obtained highest yield of 38.67 t/ha from 3 irrigations with 120 kg P_2O_5/ha, followed by the treatments under 4 irrigations with 120 kg P_2O_5/ha (38.50 t/ha), 4 irrigations with 150 kg P_2O5/ha (38.35 t/ha) and 3 irrigations with 90 kg P_2O_5/ha (35.10 t/ha). The total water use in the respective treatments were, 169.1, 194.7, 200.5 and 177.1 mm having water use efficiency of 2.29, 1.98, 1.91 and 2.98 t/ha/cm. Irrigation had an important influence on yield and processing quality.

While working with tomato plant grown on polythene mulch in New York State, Wien *et al.*, (1993) reported that the plants had more branches and higher mineral nutrient uptake and yield than the plants not mulched. They also found that

mulching increased branching, hastened flowering on basal branches and increased the concentration of major nutrients in the above ground parts. Trials with organic and white polythene mulches on tomato had very little effect on plant height (Shrivastava *et al.*, 1981), but clear plastic mulch resulted in most rapid growth (Geneve, 1981). Both polythene and straw mulches appeared to have considerable increasing effect on plant height (Gunadi and Suwanti, 1988, Olasanta, 1985).

Shaheen *et al.*, (1993) from their experiment at SRTI, Ishurdi, Pabna, reported that straw mulch played a positive role to increase the yield of both potato and sugarcane. Similarly, Imam *et al.*, (1990) reported that sugarcane and potato yield were increased by the use of rice straw mulch.

Biswas (1993) observed that all mulches increased plant height, number of branches and fruits, fruit size (by weight), enhanced earlier flowering, fruit setting and ripening and yielded more than double over the control, at the Crop Botany Field Laboratory, BAU, Mymensingh, during the rabi season.

Kaniszewski (1994) found that mulching increased marketable and total yield, but higher yield was obtained with black polythene mulch than with white and-nonwoven black polythene. Total yields were 30% and marketable 53% higher for plants grown with black polythene mulch and trickle irrigation than for control. Brown or black biodegradable paper or black plastic improved marketable yields by over 50%, compared with no mulched plants (Paterson and Earhart, 1975).

An experiment was conducted by Shrivastava *et al.*, (1994) on the fine textured heavy soils of western India from 1989-1991. They stated that black plastic mulch reduced 95% weed infestation. Black plastic mulch and drip irrigation gave 53% higher yield and 44% saving in irrigation water when compared with the surface irrigation without mulch treatment. They also stated that mulch alone could increase the yield about 30%. The net income could be increased by about 86% over the normal method by

adopting drip along with sugarcane trash as mulch. As high as 98% weed control could be achieved by the use of drip with black plastic mulch.

Elkner and Kaniszewski (1995) noticed that black polythene mulch increased total and marketable yields by about 20 and 24%, respectively. They also reported that black polythene mulch increased fruit resistance. Gunadi and Suwanti (1988) recorded that mulch increased 16.3% yield over non-mulched plant spaced at 60x50 cm in single row.

Kumar *et al.,* (1995) observed that mulching significantly improved the number of fruits per plant and fresh weight per fruit and reduced the percentage of unmarketable fruit compared with the unmulched control. Significant increases in percent early and total fruit yields were recorded due to mulching. Black polythene of 200 gauge was found to be the best mulch. The volume and specific grafity of fruits were significantly influenced by mulching, but total soluble solids and ascorbic acid content did not respond to mulching materials.

Fortnum *et al.,* (1995) conducted an experiment using different coloured polythene mulches on quantity spectra of reflected light, plant morphology and root-knot disease and reported that soil temperature was more warm under black and red mulch than white. In a similar investigation Decoteau *et al.,* (1989) also reported that mulch colour affected the yield and growth of plants. Plants grown under mulch generally had the greatest early marketable yield and produced the least amount of foliage.

In untreated green house trials in Rio Grande do Sul, Brazil in 1994 seedling of tomato cv. Marte Carlo at the 4-leaf stage were planted in loamy soil on 22 August by Streck *et al.*, (1995). They stated that the highest temperature were recorded under transparent mulch. Yields were generally higher under transparent mulch.

Hossain *et al.*, (1996) conducted an experiment on mulching and pruning on the growth and yield of tomato and they found that combined effect was insignificant. However mulching with black polythene and two time pruning (21 and 35 days after transplanting) in combination gave the highest yield (76.32 t/ha from cv. Ratan).

Padmini *et al.*, (1996) conducted trial on tomato cv. Co.3 to study the effect of different mulching materials (plastic mulch and organic mulch compared to unmulched control) and irrigation rates (IW:CPE ratios of 0.40, 0.60 and 0.80) on yield and economics. Mulching of tomato with black LLDPE mulch film (25 μm) resulted in the highest yield of 12 735 kg/ha, an increase of 28.4% compared to the unmulched control. Among the irrigation regimes, irrigating tomato at IW:CPE ratio of 0.80 produced the highest yield (12 556 kg/ha).

In West Virginia during 1993 and 1994 an experiment was conducted by Monks *et al.*, (1997) on tomato and mulches (shredded newspaper, chopped newspaper, wheat straw, black plastic and plastic landscape fabric). They observed that chopped newspaper provided higher tomato yield than shredded newspaper applied at the same rates.

An experiment was conducted by Pramanik (1997) at the Horticulture Farm, BAU, Mymensingh to study the effect of mulching on plant growth and fruit and seed yield of tomato. Black polythene mulch gave the highest yield than water hyancinth and control treatment.

Another experiment was conducted by Wen *et al.*, (1997) with plastic mulch and tomato. They reported that plastic film mulch improved soil aeration, delayed plant senescence and accelerated leaf photosynthesis and the nutrient uptake capacity of the roots resulting in high, early and total yields.

Ravinder Kumar *et al.*, (1998) observed that different mulching materials (black, blue or transparent polyethylene film, paddy straw, sugarcane trash, and poplar leaves)

significantly improved the number of fruits per plant and fresh weight per fruit and reduced the percentage of unmarketable fruit compared with the unmulched control on the growth and yield of tomato. Significant increases in percent early and total fruit yield were recorded due to mulching. Black polyethylene of 200 gauge was the best mulch. The volume and specific gravity of fruits were significantly influenced by mulching but total soluble solids and ascorbic acid content did not respond to mulching materials.

Polythene mulch had positive effect on plant growth. Black polythene mulch in cauliflower induced maximum growth (Singh and Mishra, 1975). From another trial with potato at Bangalore, India by Khalak and Kumaraswamy (1992) found that mulching with straw and polythene gave average tuber yields of 18.2 and 16.7 t/ha without mulching.

Water hyacinth and rice straw mulches had significant promotive effect on root spread and development (Awal and Khan, 1999). They also reported that mulches improved the root development of maize as compared to unmulched plot (Aina, 1981). Mulching induced increased root growth in barley (Agarwal and Rajat, 1977).

Plastic mulching with transparent polythene film mulch or linear low-density polythene also increased the soil moisture content (Mohapatra *et al.,* 1998). On the other hand Bragugnolo and Mielniczuk (1990) reported that temperature and moisture regimes of soil were greatly influenced by mulching.

A field experiment was conducted for two years (1980-81) in India by Singh *et al.,* (1987). They observed that mulching by paddy straw decreased soil water depiction and increased water use efficiency under both irrigated and rainfed conditions.

Apaydin *et al.*, (1999) carried out experiments and showed that relationship between apparent infection rate of late blight (phytophthora infestans) and yield loss of tomato. Sprinkle, furrow irrigation and black polythene mulch was used in the plots to stimulate disease development.

Mohapatra *et al.*, (1999) observed that linear black, low-density polyethylene film mulch was applied at planting or 20 days after planting. Plastic mulched plots were better than unmulched plots with respect to plant growth, yield and conservation of soil moisture. The highest yield of 180 q/ha was obtained by mulching at 20 days after planting.

Talavera and Padilla (2000) used three organic mulches: pine sawdust, sugarcane dry bagasse, and rice chaff, along with 2 coverings: black and grey plastic film, and a herbicide (trifluralin)-treated control to evaluate for the control of weeds in tomato (cv. Peto 98). Weed incidence, which affected fruit yield, was highest when organic mulches were used. The highest return was obtained with the use of plastic film.

In India, an experiment was conducted by Hundal *et al.*, (2000) during 1991-93 on tomato cv. Punjab Kesari treated with 3 types of mulches (black, transparent polythene and rice straw) and 2 mulching techniques (full plot and half meter wide strip) were applied alone or in combination with 2 herbicides (Stomp [pendimethalin] at 0.75 kg/ha and Goal [oxyfluorfen] at 0.12 kg/ha) in tomato was compared with 2 controls (weeded and nonweeded). The tallest plants were recorded under the clear polythene mulch full (TPMF) + Goal (69.23 cm) and TPMF + Stomp (69.01 cm) treatments at both the full growth and harvesting stages. The highest total and marketable yields of tomato were recorded under the treatment TPMF + Stomp (628.16 and 566.59 q/ha, respectively); those of the black polythene mulch full (BPMF) + Stomp, TPMF + Goal and BPMF + Goal treatments were on a par (622.27 and 555.60, 614.84 and 552.09, and 611.79 and 537.89 q/ha, total and marketable yields, respectively). The highest number of fruits per plant were obtained

under the TMPF + Stomp, BPMF + Stomp, and TPMF + Goal treatments. The heaviest fruits were recorded under TPMF + Stomp, BPMF + Stomp and BPMF + Goal treatments. The highest early tomato yields was recorded under TPMF + Stomp followed by TPMF + Goal treatment. Late yields, however, was higher under rice straw treatments.

Hedau *et al.,* (2001) studied the effect mulch (black, transparent or silver-black polyethylene and pea straw) on the tomato hybrid cv. Naveen-2000 investigated in Himachal Pradesh, India in 1997. The highest fruit yields of 76.42 and 75.31 t/ha were obtained with silver-black and black polyethylene mulches, respectively. Among the various interactions between N rate and mulch, the highest fruit yield (89.40 t/ha) was recorded for 125 kg N/ha combined with silver-black polyethylene.

Arin and Ankara (2001) determined the effect of mulching (black and transparent polyethylene or straw) on yield and earliness of tomato cv. Fuji F1 in unheated glasshouse. Among the mulches, plant height increase was highest with the straw mulch (679.13%). Straw and transparent polyethylene mulches recorded higher stem diameter than other mulches. The shortest time to harvest was recorded in transparent polyethylene (117.90 days), which was at par with black polyethylene (118.17 days). Early fruit yield was higher in mulched treatments than in other treatments. Among the mulch treatments, straw mulch recorded the highest yield while the control recorded the lowest. Mulching is useful for increasing the early yield.

Hedau and Mahesh Kumar (2002) studied the effect different mulches (black polyethylene, transparent polyethylene, silver black polyethylene, pea straw and no mulch) on the productivity of tomato hybrid. Fruit yield was highest with silver black polyethylene mulch (76.42 t/ha), followed by black polyethylene mulch (73.51 t/ha). The highest N uptake was recorded with silver black polyethylene mulch (90.38 kg/ha), followed by black polyethylene mulch (89.82 kg/ha). These treatments also recorded the lowest number of weeds (3.24 and 3.06/0.5 m2, respectively) and the

highest benefit:cost ratio (2.81 and 2.66, respectively). Soil moisture retention was highest in pea straw-mulched plots and lowest in unmulched plots.

Sannigrahi and Borah (2002) conducted field experiments in Assam, India to evaluate the effectiveness of different organic mulches including black polyethylene sheet on tomato production under rainfed conditions. The mulch treatments were black polyethylene sheet, rice straw, spent straw, water hyacinth (Eichhornia crassipes), thatch grass (Imperata cylindrica), and no mulch (control). Mulching increased the number of tomato fruits per plant and had higher crop yield than the control in both years. Water hyacinth mulch gave the highest increase in tomato yield (by 91%). The rate of weed emergence was lower in tomato plots, while black polyethylene mulch was the most effective treatment for weed control (83.5%).

Hudu *et al.*, (2002) observed that plant height, number of flowers per plant, fruit sets per plant, number of fruits per plant and harvested total marketable fruit yield/ha were significantly (P=0.05) higher in the mulch-treated plots than the unmulched control treatment. It was also observed that the optimum mulch thickness is at 7.5 t/ha of grass material in this area in terms of effective weed suppression, better crop growth, optimum root temperatures, and ultimate yield of tomato.

Aydin *et al.*, (2003) studied the effects of reflective and black mulches on the yield, quality and pest populations on tomato cv. DR-055 in Turkey during 2001. The total yields under reflective mulch, black mulch and no mulch treatments were 122.85, 104.99 and 95.68 t/ha, respectively. Earliness percentage was higher in the mulch treatments compared to the control. The highest colour values were obtained in the reflective much treatment. The lowest pest population was observed under the reflective mulch treatment.

Ghorbani (2004) reported that plastic mulch is an effective way to conserve water in the soil reservoir so that it can be taken up gradually by plants. The plastic mulch was used with furrow irrigation on cucumber and tomato yield, in the field, at flowering

and production stages. Using clear plastic mulch in conjunction with furrow irrigation system increased moisture retention by 75%, whereas no conservation was observed with black plastic mulch. Considerable yield increases (60 and 49%) and (66 and 47%) were achieved for tomato and cucumber crops under both clear and black plastic mulches respectively at flowering and production stages.

Radics and Bognar (2004) observed that mulching provides weed control and reduces evaporation. Eight types of mulches were examined for weed control and their effects on green bean [Phaseolus vulgaris] and tomato yields. Plastic sheet, paper mulch and straw mulch showed the best results in weed control and tomato yield. The use of plastic sheet, paper mulch and grass clippings caused the lowest weed cover. However highest yield was found in paper-mulched plots. As for green bean, weed control was higher in plastic sheet, paper mulch and straw mulch-treated plots but was not significantly different from those in control treatments.

Vetrano *et al.*, (2004) observed that the effects of transparent polyethylene (PE) mulching vs. bare soil and three different plant densities (0.74, 1.1 or 2.2 plants/m^2) on a tomato crop in the Sicilian countryside. Applying PE mulch and planting at a density of 2.2 plants/m^2 resulted in the highest yield (58.6 tonnes/ha). The lowest production (15 tonnes/ha) was obtained on bare soil and by planting at a density of 0.74 plants/m^2.

An experiment was conducted in Raipur, Madhya Pradesh, India by Sharma (2004) to study the effect of drip irrigation combined with mulches (25- micro thick) of different colours red (T_1), white (T_2) and black (T_3)) on the growth, yield and quality of tomato. Drip irrigation without mulch served as the control (T_0). The vegetative growth parameters such as plant height (68 cm), number of primary branches (7.0), number of flowers per cluster (6.92), number of fruits per cluster (6.38), stem thickness (1.78), number of locules (5.25) and diameter of fruits (6.23 cm) were highest in T_1, followed by T_2 and T_3. The days required to 50% flowering and fruiting

times of each mulched plot were found nearly the same and earlier than that in the control plot. The quality parameters such as total soluble solids (6.82%), acidity (0.93%), juice (48.72%), moisture (97.65%), pericarp thickness (0.69) and weight (51.96 g) of fruits were maximum in T_1 and minimum in T_0. The yield in T_1, T_3, T_3 and T_0, respectively, was 795.67, 730.64, 702.47 and 582.42 q/ha. The water use efficiency in T_1, T_2, T_3 and T_0, respectively, was 0.96, 0.88, 0.85 and 0.70 q/ha-mm. The net seasonal income was highest (Rs 128 261) in T_1, followed by T_2 (Rs 101 445) and T_3 (Rs 86 271), and lowest (Rs 55 165) in T_0. T_1 also recorded the highest benefit cost ratio of 1.16, followed by T_2 (0.91), T_3 (0.78) and T_0 (0.60).

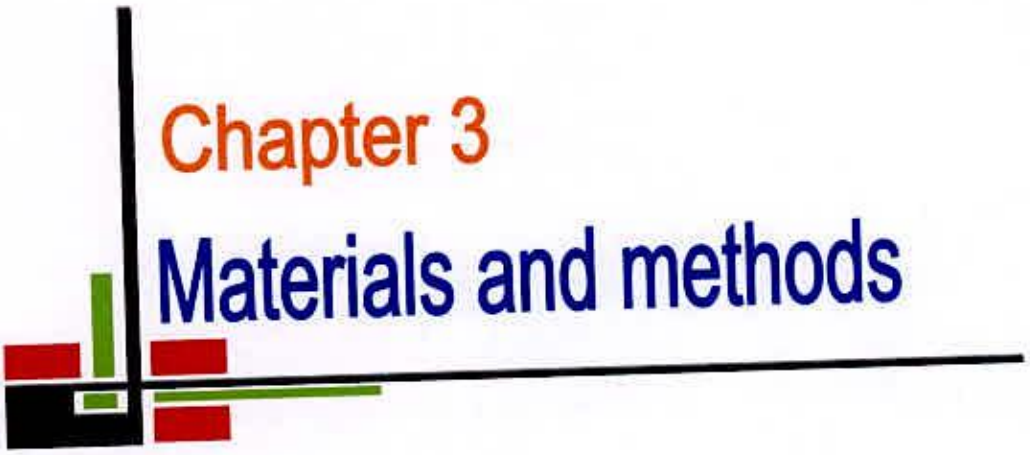
Dharmesh-Gupta *et al.,* (2005) studied the efficacy of blue, yellow, white, green and black polyethylene mulches in controlling Tomato leaf curl virus infecting tomatoes in a field experiment in Himachal Pradesh, India during 1997-98. Mulching with yellow polyethylene film resulted in the lowest disease incidence and highest crop yield.

A field experiment was conducted by Rajbir-Singh *et al.,* (2005) in Abohar, Punjab, India during the winter of 1998-2000 to study that the effect of mulching (black and clear polyethylene, sugarcane trash and rice straw) on the growth and yield of tomato cv. Rupali. The different mulching materials like black polyethylene retained higher soil moisture and temperature compared to other mulching materials and the control. Fruit yield was also highest with black polyethylene mulching. Mulching with black polyethylene treatment combination, which was significantly superior to all other treatment combinations.

Akintoye *et al.,* (2005) reported that the use of mulches in vegetable production is undergoing a radical change away from high input, nonrenewable resources, such as plastic, to the use of high-residue organic mulches from cover crops. The purpose of this study was to compare the yield of three tomato varieties when grown under different live mulches.

Ristaino *et al.,* (2006) observed that straw mulching enhanced microbial biomass, activity, and potential N availability by 42, 64, and 30%, respectively, relative to non-mulched soils via improving C and water availability for soil microbes.

Vazquez *et al.,* (2006) reported that high irrigation frequency ensured appropriate soil water content at planting, and reduced both the amount of water applied and lost by drainage to the actual needs of drip-irrigated tomato under plastic mulching conditions.



Chapter 3

Materials and methods

MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in carrying out the experiment. It includes a short description of location of the experiment, characteristics of soil, climate, materials used, land preparation, manuring and fertilizing, transplanting and gap filling, staking, after care, harvesting and collection of data.

3.1 Location of the experiment field

The field experiment was conducted in the experimental farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka -1207 during the period from November 2006 to April 2007 to find out the effect of different mulches and seedling age on the growth and yield of tomato. The location of the experimental site was at 23.75 N latitude and 90.34E longitude with an elevation of 8.45 meter from the sea level (Anon., 1989).

3.2 Climate of the experimental area

The climate of the experimental area was subtropical in nature. It is characterized by heavy rainfall, high temperature, high humidity and relatively long day during kharif season (April to September) and a scanty rainfall associated with moderately low temperature, low humidity and short day period during rabi season (October to March). Details of the meteorological data in respect of monthly maximum, minimum and average temperature, rainfall, relative humidity, average sunshine hours and soil temperature during the period of experiment are presented in Appendix I.

3.3 Soil of the experimental field

Soil of the study site was silty clay loam in texture. The area represents the Agro-Ecological Zone of Madhupur tract (AEZ-28) with P^H 5.8-6.5, ECE-25.28 (Haider *et al.*, 1991).

The analytical data of the soil sample collected from the experimental area were determined in the Soil Resources Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka and have been presented in Appendix II.

3.4 Plant materials used

The tomato variety "Ratan" was used in the experiment. It was a high yielding indeterminate type the seeds of which were collected from the Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.5 Raising of seedlings

Tomato seedlings were raised in three seedbeds situated on a relatively high land at Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka. The size of the seedbed was 3mx1m. The soil was well prepared with spade and made into loose friable and dried mass to obtain fine tilth. All weeds and stubbles were removed and 5 kg well rotten cowdung was applied during seedbed preparation. The seeds were sown on the seedbed at three different dates on 25th October, 1st November and 5th November, 2006 to get 40, 35, 30 days old seedlings, respectively. After sowing, seeds were covered with light soil to a depth of about 0.6 cm. Heptachlor 40 WP was applied @ 4 kg/ha around each seedbed as precautionary measure against ants and worm. The emergence of the seedlings took place with in 5 to 6 days after sowing. Necessary shading by banana leaves was provided over the seedbed to protect the young seedlings from scorching sun or heavy rain. Weeding, mulching and irrigation were done from time to time as and when required and no chemical fertilizer was used in the seedbed.

3.6 Treatments and layout of the experiment

The experiment consisted of two factors as follows:

Factor A : It consisted of three seedling age which are mentioned below with alphabetic symbol.

Seedling age	Alphabetic symbol
30 days	S_1
35 days	S_2
40 days	S_3

Factor B : It included four different types of mulching which are mentioned below with alphabetic symbol.

Mulching	Alphabetic symbol
No mulching	M_0
Water hyacinth	M_1
Black polythene	M_2
Straw	M_3

Total 12 treatments combination were as follows

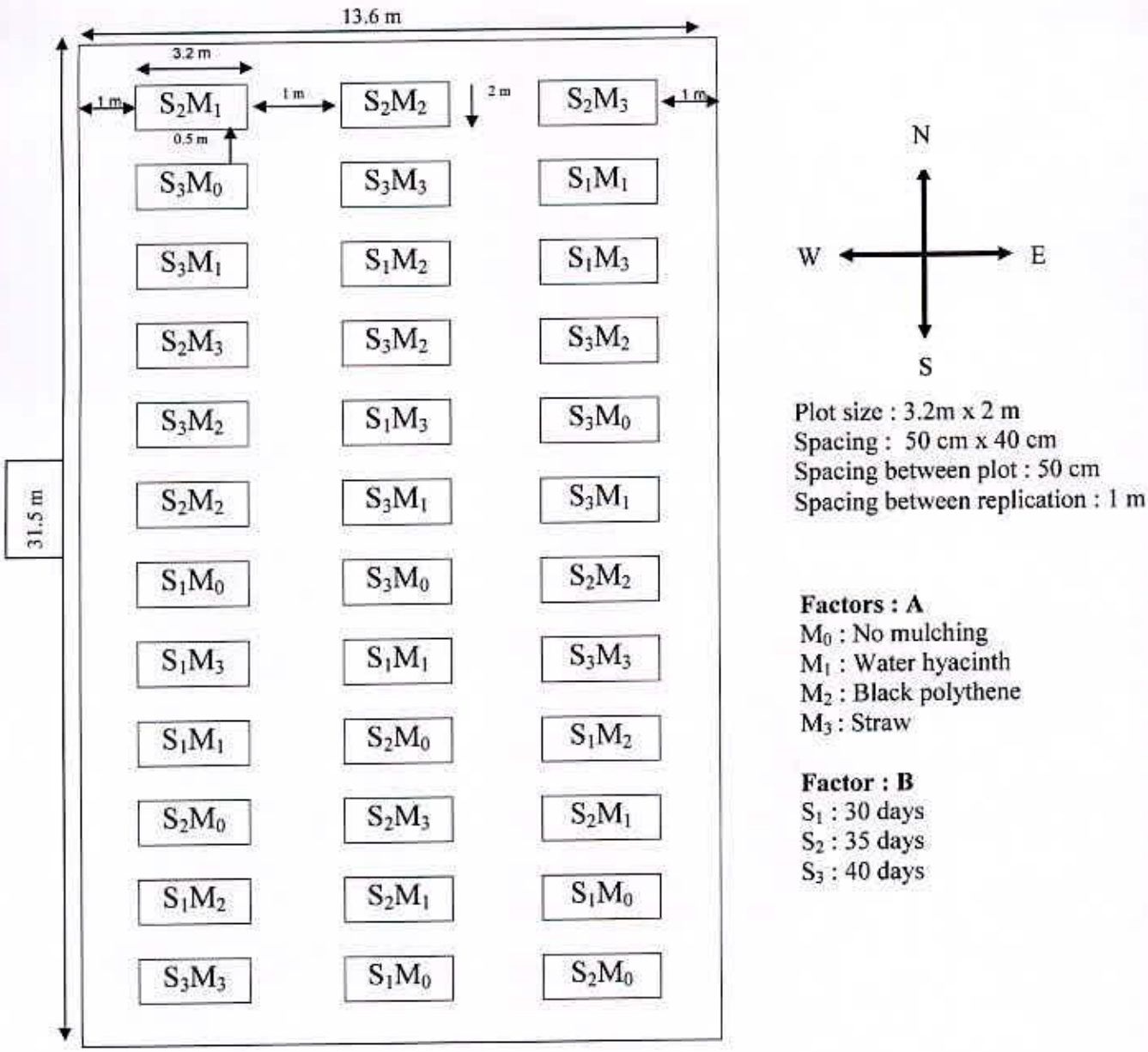
S_1M_0	S_2M_0	S_3M_0
S_1M_1	S_2M_1	S_3M_1
S_1M_2	S_2M_2	S_3M_2
S_1M_3	S_2M_3	S_3M_3

3.7 Design of the experiment

The experiment was laid out in Randomized complete Block Design (RCBD) having two factors with three replications. The treatments combinations were accommodated in the unit plots.

3.8 Layout of the experiment

An area of 31.5m x 13.6m was divided into three equal blocks. Each block consisted of 12 plots where 12 treatments were allotted randomly. There were 36 unit plots altogether in the experiment. The size of each plot was 3.2m x 2m. The distance between two blocks and two plots were 1m and 0.5m respectively. A layout of the experiment has been shown in figure 1.



Plot size : 3.2m x 2 m
Spacing : 50 cm x 40 cm
Spacing between plot : 50 cm
Spacing between replication : 1 m

Factors : A
M_0 : No mulching
M_1 : Water hyacinth
M_2 : Black polythene
M_3 : Straw

Factor : B
S_1 : 30 days
S_2 : 35 days
S_3 : 40 days

Fig 1: Field layout of the two factors experiment in the Randomized complete Block Design (RCBD)

3.9 Cultivation procedure

3.9.1 Land preparation

The soil was well prepared and good tilth was ensured for tomato crop production. The land of the experimental field was ploughed with a power tiller. Later on the land was ploughed three times followed by laddering to obtain desirable tilth. The corners of the land were spaded and larger clods were broken into smaller pieces. After ploughing and laddering, all the stubbles and uprooted weeds were removed. Finally, the unit plots were prepared as 15 cm raised beds. Thirty-two pits were made in each plot with in row-to-row and plant to plant spacing of 60cm X 40cm (BARI, 2000).

3.9.2 Manuring and Fertilizing

Manure and fertilizers such as Cowdung, Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MP) were applied in the experimental field as per recommendation of BARI (1996).

Manure/ fertilizer	Dose per hectare	Applied during land preparation	Applied in pit a week before transplanting	Applied as top dressing in rows	
				1st installment after 3 weeks of transplanting	2nd installment after 5 weeks of transplanting
Cowdung	20 ton	20 ton	-	-	-
Urea	550 kg	-	200 kg	175 kg	175 kg
TSP	450 kg	-	450 kg	-	-
MP	250 kg	-	100 kg	75 kg	75 kg

Potassium was applied as per treatment and Urea and TSP were applied at the rate of 550 kg/ha and 450 kg/ha (Razzak *et al.*, 2000). The quantity of manure, cowdung was also determined at the rate of 10 t/ha as recommended (BARC, 1997).

The entire amount of cowdung and TSP were applied as basal during land preparation. Urea and MP were used as top dressing in two equal installments. First and second installments were done 3 and 5 weeks after transplanting.

3.9.3 Transplanting of seedlings

Healthy and uniform 30, 35 and 40 days old seedlings were uprooted separately from the seed bed and were transplanted in the experimental plots in the afternoon of 05 December, 2006 maintaining a spacing of 50 cm x 40 cm between the rows and plants respectively. This allowed an accommodation of 32 plants in each plot. The seedbed was watered before uprooting the seedlings from the seedbed so as to minimize damage to the roots. The seedlings were watered after transplanting. Shading was provided using banana leaf sheath for three days to protect the seedling from the hot sun and removed after seedlings were established. Seedlings were also planted around the border area of the experimental plots for gap filling.

3.9.4 Intercultural operations

After transplanting the seedlings, various kinds of intercultural operations were accomplished for better growth and development of the plants, which are as follows.

3.9.4.1 Gap filling

When the seedlings were well established, the soil around the base of each seedling was pulverized. A few gap filling was done by healthy seedlings of the same stock where planted seedlings failed to survive.

3.9.4.2 Weeding and mulching

Weeding was done whenever it was necessary. Mulching was also done to help in soil moisture conservation.

3.9.4.3 Staking and pruning

When the plants were well established, staking was given to each plant by bamboo sticks to keep them erect. Within a few days of staking, as the plants grew up, the plants were pruned. At initial stage, the plants were pruned to keep them single-stem and thereafter only two main branches were kept before they reached flowering stage.

3.9.4.4 Irrigation

Light watering was given with watercan immediately after transplanting the seedlings and then no irrigation was done throughout the growing period upto harvest.

3.9.4.5 Plant protection

Insect pests : Melathion 57 EC was applied @ 2 ml l^{-1} of water against the insect pests like cut worm, leaf hopper, fruit borer and others. The insecticide application was made fortnightly after transplanting and stopped before second week of first harvest. Furadan 10G was also applied during final land preparation as soil insecticide.

Disease: During foggy weather precaution any measure against disease attack of tomato was taken by spraying Diathane M-45 fortnightly @ 2 g l^{-1} of water, at the early vegetative stage. Ridomil gold was also applied @ 2 g 1^{-1} of water against blight disease of tomato. Wangsoboonde *et al.*, (2002) carried out as experiment *phytophthora infestans* of tomato and pesticide.

3.9.4.6 Harvesting

Fruits were harvested at 3-day intervals during early ripe stage when they developed slightly red color. Harvesting was started from 10 March, 2007 and was continued up to 03 April, 2007.

3.10 Parameter assessed

Ten plants were selected at random and uprooted carefully at the time of collecting data of root from each plot and mean data on the following parameters were recorded

i) Plant height (cm)
ii) Number of leaves per plant
iii) Number of flower clusters per plant
iv) Number of flowers per cluster
v) Number of flowers per plant
vi) Number of fruits per plant
vii) Fruit length (cm)
viii) Fruit diameter (cm)
ix) Dry matter of leaves per plant
x) Dry matter of fruits per plant
xi) Weight of individual fruit (Kg)
xii) Yield of fruits per plant (Kg)
xiii) Yield of fruits per plot (Kg)
xiv) Yield of fruits per hectare (ton)

3.11 Data collection

Ten plants were selected randomly from each plot for data collection in such a way that the border effect could be avoided for the highest precision. Data on the following parameters were recorded from the sample plants during the course of experiment.

i) **Plant height (cm)**

Plant height at final harvest was measured from sample plants in centimeter from the ground level to the tip of the longest stem and the mean value for each treatment was calculated. Plant height was also recorded at 15 days interval starting from 15 days of transplanting upto 90 days to observe the growth rate of plants. Lastly, the height was recorded at final harvest.

ii) **Number of leaves per plants**

The number of the sample plant was counted at the time of harvesting and the average number of leaves produced per plant was recorded.

iii) **Number of flower clusters per plant**

The number of flower clusters was counted from the sample plants and the average number of flower clusters produced per plant was recorded at the time of final harvest.

iv) **Number of flowers per cluster**

It was calculated by the following formula,

$$\text{Number of flowers per cluster} = \frac{\text{sample plant}}{\text{Total number of flower clusters from ten sample plant}}$$

v) Number of flowers per plant

Total number of flowers was counted from selected plants and their average was taken as the number of flowers per plant.

vi) Number of fruits per plant

It was recorded by the following formula:

$$\text{Number of fruits per plant} = \frac{\text{Total number of fruits from 10 sample plants upto final harvest}}{10}$$

vii) Fruit length (cm)

The length of fruit was measured with a slide caliper from the neck to the bottom of 10 selected marketable fruits from each plot and their average was taken in cm as the length of fruit.

viii) Fruit diameter (cm)

Diameter of fruit was measured at the middle portion of 10 selected marketable fruit from each plot with a slide caliper and their average was taken in cm as the diameter of fruit.

ix) Dry matter of leaves per plant

After harvesting, randomly selected 100 gram of leaf sample previously sliced into very thin pieces were put into envelop and placed in oven at 60^0c for 72 hrs. The sample was then transferred into desiccators and allowed to cool down to the room temperature. The final weight of the sample was taken. The dry matter was calculated by the following formula,

$$\text{Dry matter of leaf \%} = \frac{\text{Dry weight of leaf}}{\text{Fresh weight of leaf}} \times 100$$

x) Dry matter of fruits per plant

After harvesting, randomly slelected 100 gram of fruit sample previously sliced into very thin pieces were dried in the sun for one day and the following formula was used to find out dry matter of fruits

$$\text{Dry matter of fruit \%} = \frac{\text{Dry weight of fruit}}{\text{Fresh weight of fruit}} \times 100$$

xi) Weight of individual fruit (Kg)

Among the total number of fruits during the period from first to final harvest the fruits, except the first and final harvests, were considered for determining the individual fruit weight by the following formula:

$$\text{Weight of individual fruit (Kg)} = \frac{\text{Total weight of fruits from 10 harvest of sample plant}}{\text{Total number of fruits from 10 harvest of sample plant}}$$

xii) Yield of fruits per plant (Kg)

It was measured by the following formula:

$$\text{Weight of fruits per plant(Kg)} = \frac{\text{Total weight of fruits in 10 sample plants}}{10}$$

xiii) Yield of fruits per plot (kg)

The weight of fruits per plot was measured by totaling the fruit yield of each unit plot separately during the period from first to final harvest and was recorded in kilogram (kg).

xiv) Yield of fruits per hectare (ton)

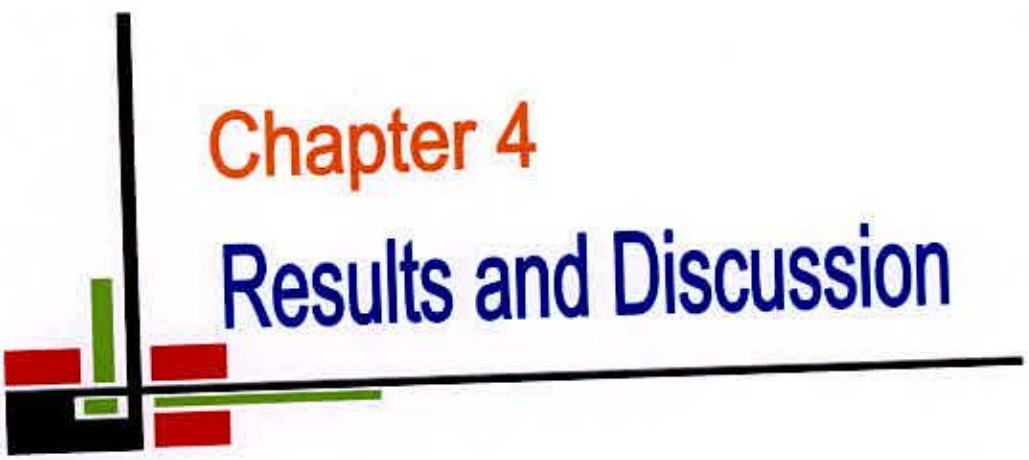
It was measured by the following formula,

$$\text{Fruit yield per hectare (ton)} = \frac{\text{Fruit yield per plot (kg) x 10000}}{\text{Area of plot in square meter x 1000}}$$

3.12 Statistical analysis

The data in respect of yield, quality and yield components were statistically analyzed to find out the significance of the experimental results. The means of all the treatments were calculated and the analysis of variance for each of the characters under study was performed by F test. The difference among the

treatment means was evaluated by Least Significant Difference (LSD) test and for interpretation of the results were determined by Duncan`s Multiple Range Test (DMRT) was used (Gomez and Gomez,1984).



Chapter 4

Results and Discussion

RESULTS AND DISCUSSION

The present study was conducted to find out the effect of seedling age and different mulches on growth and yield of tomato. Data on different yield contributing characters and yield were recorded to find out the optimum seedling age and mulches on tomato variety Ratan. The analysis of variance (ANOVA) of the data on different yield components and yield are given in Appendix III-V. The results have been presented, discussed, and possible interpretations given under the following headings

4.1 Plant height

Plant height varied significantly at different days after transplanting (DAT) for different seedling age during transplanting of tomato seedlings (Appendix III). At 20 DAT the maximum (30.62 cm) plant height was obtained from S_2 (35 days old seedling), while the minimum (26.79 cm) was recorded from S_3 (40 days old seedling) which was statistically similar (26.99 cm) to S_1 (30 days old seedling). The maximum (62.12 cm) plant height was recorded from S_2 and the minimum (57.79 cm) was found from S_3 which was statistically identical (58.22 cm) to S_1 at 40 DAT. At 60 DAT the maximum (91.26 cm) plant height was recorded from S_2 and the minimum (87.41 cm) plant height was observed in S_3 which was statistically identical (88.24 cm) to S_1. At harvest the maximum (112.02 cm) plant height was recorded from S_2 and the minimum (108.43 cm) was found from S_1 which was statistically similar (109.96 cm) to S_3 (Figure 2). The tomato seedlings of 35 days old were easily established in the field with minimum time of shocking period. Okano *et al.*, (2000) reported that the younger seedling had faster plant growth after planting and when seedlings age were more than 35 days, growth was considerably retarded. This is an agreement with the findings of Mercik and Skapski (1961).

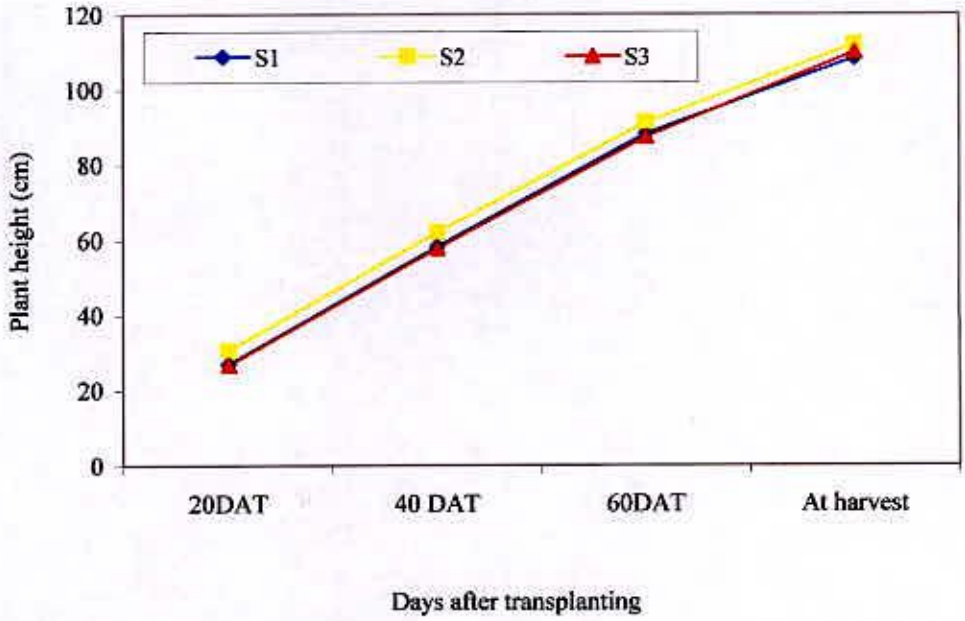


Figure 2. Effect of seedling age on plant height of tomato

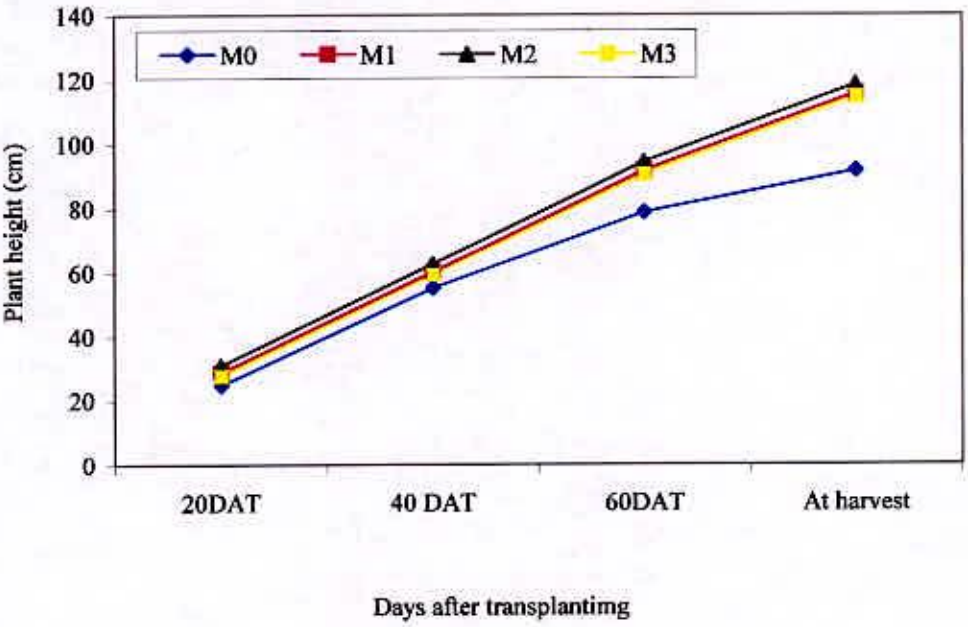


Figure 3. Effect of mulches on plant height of tomato

Different mulches showed significant variation on plant height at different days after transplanting (DAT) under the present trial (Figure 3). The maximum (30.98 cm) plant height was recorded from M_2 (Black polythene) which was closely followed (28.95 cm and 27.75 cm) by M_1 (Water hyacinth mulch) and M_3 (Straw mulch), respectively and the minimum (24.86 cm) plant height was obtained from control i.e. no mulches at 20 DAT. At 40 DAT, the maximum (62.74 cm) plant height was recorded from M_2 which was closely followed (60.27 cm and 59.37 cm) by M_1 and M_3, respectively, while the minimum (55.13 cm) plant height was obtained from control. The maximum (94.53 cm) plant height was recorded from M_2 which was closely followed (91.84 cm and 90.69 cm) by M_1 and M_3, respectively, while the minimum (78.82 cm) plant height was found from control at 60 DAT. At harvest the maximum (118.41 cm) plant height was recorded from M_2 which was statistically similar (115.77 cm and 114.63 cm) with M_1 and M_3, respectively, while the minimum (91.74 cm) plant height was obtained from control. The different mulching materials like black polyethylene retained higher soil moisture and temperature compared to other mulching materials and the control. The results of this study are comparable to the findings of Gunadi and Suwanti, (1988) and Buitellar. They also recorded maximum plant height with using mulch materials.

The variation was found due to interaction effect of seedling age and mulches for plant height at different days after transplanting (Appendix III). The maximum (35.19 cm) plant height was recorded from treatment combination S_2M_2 (35 days old seedling + Black polythene mulch), while the treatment combination S_2M_0 (35 days old seedling + no mulches) gave the minimum (24.05 cm) plant height (Table 1) at 20 DAT. At 40 DAT significant differences in terms of plant height was observed among the treatment combinations and the maximum (66.96 cm) plant height was recorded from the treatment combination S_2M_2 whereas the minimum (54.22 cm) was recorded from treatment combination S_1M_0. At 60 DAT the maximum

Table 1. Interaction effect of seedling age and different mulches on plant height and number of leaves per plant of tomato

Treatment	Plant height (cm) at				Number of leaves per plant at			
	20 DAT	40 DAT	60 DAT	At harvest	20 DAT	40 DAT	60 DAT	At harvest
S_1M_0	24.75 fg	54.22 h	80.82 e	90.84 cd	9.00 ef	17.11 e	35.89 d	49.67 d
S_1M_1	27.38 def	59.24 cdef	90.39 cd	113.52 b	11.00 cde	21.55 bcd	42.99 bc	63.28 c
S_1M_2	29.28 cd	61.17 bcd	94.14 bcd	116.62 ab	12.54 bcd	23.78 b	45.67 ab	66.22 bc
S_1M_3	26.64 defg	58.39 defg	89.49 d	112.75 b	10.62 def	21.33 cd	42.56 c	62.85 c
S_2M_0	24.05 g	55.12 gh	76.96 f	87.97 d	8.67 f	15.89 e	32.44 e	46.78 d
S_2M_1	32.72 ab	63.96 ab	95.68 ab	119.93 ab	13.99 b	23.89 b	45.56 ab	68.11 ab
S_2M_2	35.19 a	66.96 a	98.96 a	122.45 a	16.56 a	26.44 a	47.89 a	71.00 a
S_2M_3	30.53 bc	62.44 bc	93.45 bc	117.72 ab	13.01 bc	23.11 bc	44.86 bc	65.8 9 bc
S_3M_0	25.78 efg	56.27 fgh	78.67 ef	96.41 c	9.78 ef	19.33 d	33.67 de	49.11 d
S_3M_1	26.81 defg	57.71 efg	89.59 d	113.85 b	10.22 def	21.11 cd	42.44 c	64.05 c
S_3M_2	28.48 cde	60.08 cde	93.71 bcd	116.15 ab	12.89 bc	23.22 bc	45.00 abc	66.22 bc
S_3M_3	26.16 efg	57.32 efgh	89.14 d	113.41 b	10.00 def	20.67 d	42.22 c	63.00 c
$LSD_{(0.05)}$	2.762	3.062	3.414	6.355	2.047	2.183	2.677	3.242
CV(%)	5.80	8.05	9.35	6.41	8.95	6.01	7.79	9.12

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

S_1 : 30 days old seedling
S_2 : 35 days old seedling
S_3 : 40 days old seedling

M_0 : No mulching
M_1 : Water hyacinth
M_2 : Black polythene
M_3 : Straw

(98.96 cm) plant height was recorded from the treatment combination S_2M_2, while the minimum (76.96 cm) plant height was recorded from treatment combination S_2M_0. At harvest the maximum (122.45 cm) plant height was recorded from the treatment combination S_2M_2 whereas the minimum (87.97 cm) was recorded from treatment combination S_2M_0. From the results it was found that both seedling age and mulches favored plant growth which ensured maximum plant height.

4.2 Number of leaves per plant

Significant variation was recorded for number of leaves per plant at different days after transplanting (DAT) for different seedling age during transplanting of tomato seedlings (Appendix III). At 20 DAT, the maximum (13.00) number of leaves per plant was recorded from S_2 (35 days old seedling), while the minimum (10.64) was obtained from S_1 (30 days old seedling) which was statistically identical (10.72) to S_3 (40 days old seedling). The maximum (22.33) number of leaves per plant was recorded from S_2 and the minimum (20.94) was found from S_1 which was statistically identical (21.08) to S_3 at 40 DAT. At 60 DAT, the maximum (42.58) number of leaves per plant was recorded from S_2 and the minimum (40.83) number of leaves per plant was obtained from S_3 which was statistically identical (41.75) to S_1. At harvest the maximum (62.94) number of leaves per plant was recorded from S_2 and the minimum (60.47) was recorded from S_1 (Figure 4).

Different mulches under the experiment showed significant differences in case of number of leaves per plant at different days after transplanting (DAT) under the present trial (Figure 5). The maximum (13.85) number of leaves per plant was recorded from M_2 (Black polythene) which was closely followed (11.74 and 11.07) by M_1 (Water hyacinth mulch) and M_3 (Straw mulch), respectively and the minimum (9.15) number of leaves per plant was obtained from control i.e. no mulch at 20 DAT. At 40 DAT, the maximum (24.48) number of leaves per plant was recorded

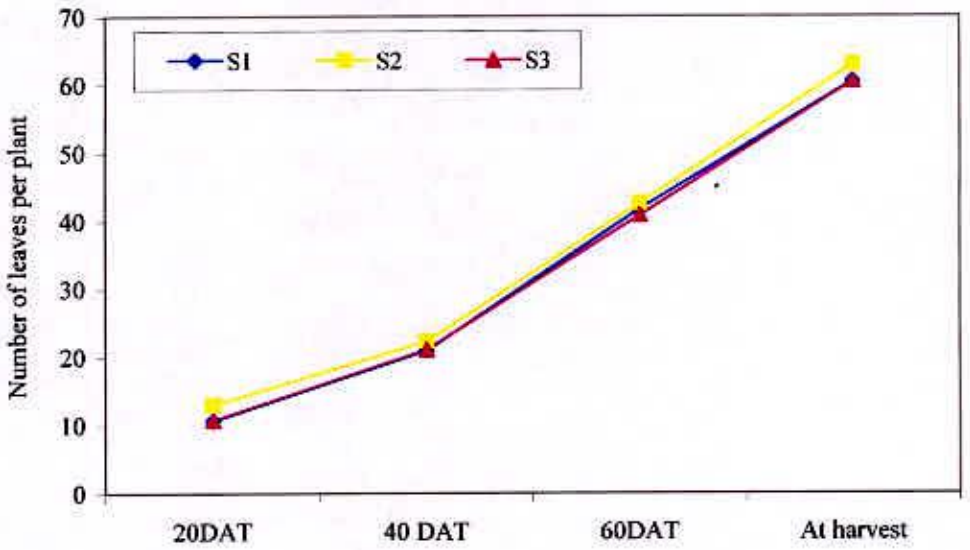


Figure 4. Effect of seedling age on number of leaves per plant of tomato

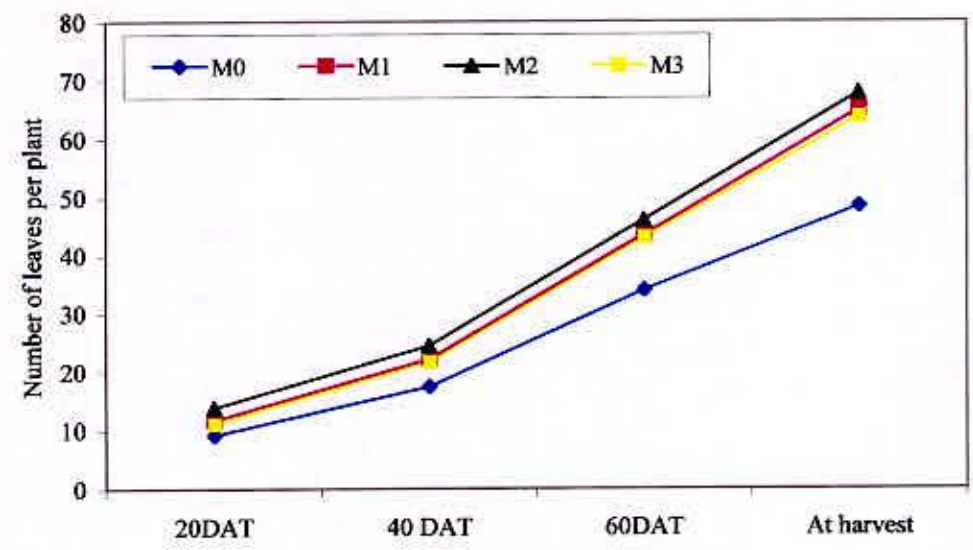


Figure 5. Effect of mulches on number of leaves per plant of tomato

from M_2 which was closely followed by M_1 (22.18) and M_3 (21.70), while the minimum (17.44) number of leaves per plant was found from control condition. The maximum (46.19) number of leaves per plant was recorded from M_2 which was closely followed by M_1 (43.63) and M_3 (43.08), while the minimum (34.00) number of leaves per plant was recorded from control at 60 DAT. At harvest the maximum (67.81) number of leaves per plant was recorded from M_2 which was closely followed by M_1 (65.00) and M_3 (63.85), while the minimum (48.52) number of leaves per plant was recorded from control.

Interaction effect of seedling age and mulches showed significant differences for number of leaves per plant at different days after transplanting (Appendix III). The maximum (16.56) number of leaves per plant was recorded from treatment combination S_2M_2 (35 days old seedling + Black polythene mulch), while the treatment combination S_2M_0 (35 days old seedling + no mulches) gave the minimum (8.67) number of leaves per plant (Table 1) at 20 DAT. At 40 DAT significant differences in terms of number of leaves per plant was observed among the treatment combinations and the maximum (26.44) number of leaves per plant was recorded from the treatment combination S_2M_2 whereas the minimum (15.89) was recorded from treatment combination S_2M_0. At 60 DAT the maximum (47.89) number of leaves per plant was recorded from the treatment combination S_2M_2, while the minimum (32.44) number of leaves per plant was recorded from treatment combination S_2M_0. At harvest the maximum (71.00) number of leaves per plant was recorded from the treatment combination S_2M_2 whereas the minimum (46.78) was recorded from treatment combination S_2M_0. From the results it was noted that both seedling age and mulches favored plant growth which ensured maximum number of leaves per plant.

4.3 Number of flower clusters per plant

Number of flower cluster per plant varied significantly for different seedling age during transplanting of tomato seedlings (Appendix IV). The maximum (12.08) number of flower clusters per plant was recorded from S_2 (35 days old seedling), while the minimum (9.53) was obtained from S_1 (30 days old seedling) which was statistically identical (9.58) with S_3 (40 days old seedling) (Table 2). Similar results were also reported by Hassan (1967) from his experiment. This finding agrees with the results obtained by Mehta and Saini (1986).

A significant variation was recorded for different mulches on number of flower clusters per plant under the present trial (Table 2). The maximum (12.59) number of flower cluster per plant was recorded from M_2 (Black polythene) and the minimum (8.04) number of flower cluster per plant was obtained from control i.e. no mulches.

The variation was found due to interaction effect of seedling age and mulches for number of flower cluster per plant (Appendix IV). The maximum (15.00) number of flower cluster per plant was recorded from treatment combination S_2M_2 (35 days old seedling + Black polythene mulch) which was statistically identical (13.67) to S_2M_1 (35 days old seedling + Water hyacinth mulch), while the treatment combination S_2M_0 (35 days old seedling + no mulches) gave the minimum (7.56) number of flower clusters per plant (Table 3).

4.4 Number of flowers per cluster

Seedling age varied significantly for number of flowers per cluster in this experiment (Appendix IV). The maximum (7.19) number of flowers per cluster was recorded from S_2 (35 days old seedling), while the minimum (6.42) was obtained from S_1 (30 days old seedling) which was statistically identical (6.39) to S_3 (40 days old seedling) (Table 2).

Different mulches showed significant variation on number of flowers per cluster under the present trial (Table 2). The maximum (7.85) number of flowers per cluster was recorded from M_2 (Black polythene) and the minimum (5.67) was found from control condition i.e. no mulch material.

The variation was found due to interaction effect of seedling age and mulches for number of flowers per cluster (Appendix IV). The maximum (8.56) number of flowers per cluster was recorded from treatment combination S_2M_2 (35 days old seedling + Black polythene mulch), while the treatment combination S_1M_0 (30 days old seedling + no mulches) gave the minimum (5.44) number of flowers per cluster (Table 3).

4.5 Number of flowers per plant

Number of flowers per plant varied significantly for different seedling age (Appendix IV). The maximum (89.50) number of flowers per plant was recorded from S_2 (35 days old seedling), while the minimum (61.89) was obtained from S_3 (40 days old seedling) which was statistically identical (62.36) to S_1 (30 days old seedling) (Table 2).

Different mulches showed significant variation with respect to number of flowers per plant under the present trial (Table 2). The maximum (99.63) number of flowers per plant was recorded from M_2 (Black polythene) and the minimum (45.56) was found from control condition i.e. no mulch. Biswas (1993) observed that all mulches increased and enhanced earlier flowering, more than double over the control.

The variation was found due to interaction effect of seedling age and mulches for number of flowers per plant (Appendix IV). The maximum (128.00) number of flowers per plant was recorded from treatment combination S_2M_2 (35 days old

Table 2. Effect of seedling age and different mulches on yield contributing characters of tomato

Treatment	Number of flower clusters per plant	Number of flowers per cluster	Number of flowers per plant	Number of fruits per plant	Dry matter content on leaves (%)	Dry matter content on fruits (%)
Seedling age						
S_1	9.53 b	6.42 b	62.36 b	34.14 b	12.59 b	13.09 b
S_2	12.08 a	7.19 a	89.50 a	37.94 a	13.06 a	13.68 a
S_3	9.58 b	6.39 b	61.89 b	34.00 b	12.38 b	13.36 ab
$LSD_{(0.05)}$	0.767	0.301	6.577	2.899	0.237	0.382
Mulching						
M_0	8.04 c	5.67 c	45.56 d	27.26 c	10.96 c	10.43 b
M_1	10.89 b	6.67 b	73.75 b	37.26 b	13.41 ab	14.39 a
M_2	12.59 a	7.85 a	99.63 a	41.37 a	13.37 a	14.45 a
M_3	10.07 b	6.48 b	66.07 c	35.56 b	13.10 b	14.23 a
$LSD_{(0.05)}$	0.886	0.347	7.595	3.347	0.273	0.441
CV(%)	8.91	5.32	10.45	9.68	7.24	8.37

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

S_1 : 30 days old seedling
S_2 : 35 days old seedling
S_3 : 40 days old seedling

M_0 : No mulching
M_1 : Water hyacinth
M_2 : Black polythene
M_3 : Straw

Table 3. Interaction effect of seedling age and different mulches on yield contributing characters of tomato

Treatment	Number of flower clusters per plant	Number of flowers per cluster	Number of flowers per plant	Number of fruits per plant	Dry matter content on leaves (%)	Dry matter content on fruits (%)
S_1M_0	7.78 de	5.44 e	42.44 f	25.67 e	11.30 d	10.21 d
S_1M_1	9.55 c	6.44 c	61.78 d	35.66 bcd	13.17 c	14.07 b
S_1M_2	12.05 b	7.56 b	87.33 bc	40.89 ab	13.19 bc	14.14 b
S_1M_3	9.22 cde	6.22 cd	57.89 de	34.33 cd	12.95 c	13.93 b
S_2M_0	7.56 e	5.78 de	43.67 ef	26.44 e	10.65 e	9.84 d
S_2M_1	13.67 a	7.33 b	102.30 b	41.56 ab	14.00 a	15.01 a
S_2M_2	15.00 a	8.56 a	128.00 a	42.78 a	14.05 a	15.09 a
S_2M_3	13.43 b	7.11 b	87.13 c	41.00 ab	13.56 ab	14.79 ab
S_3M_0	8.78 cde	5.78 de	50.56 def	29.66 de	10.94 de	11.25 c
S_3M_1	9.44 cd	6.22 cd	59.22 d	34.56 cd	12.81 c	14.10 b
S_3M_2	12.32 b	7.44 b	84.64 c	40.44 abc	12.79 c	14.13 b
S_3M_3	8.89 cde	6.11 cd	54.22 def	31.33 de	12.82 c	13.97 b
$LSD_{(0.05)}$	1.534	0.601	13.15	5.798	0.473	0.763
CV(%)	8.91	5.32	10.45	9.68	7.24	8.37

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

S_1 : 30 days old seedling
S_2 : 35 days old seedling
S_3 : 40 days old seedling

M_0 : No mulching
M_1 : Water hyacinth
M_2 : Black polythene
M_3 : Straw

seedlings + Black polythene mulch), while the treatment combination S_1M_0 (30 days old seedlings + no mulches) performed the minimum (42.44) number of flowers per plant (Table 3).

4.6 Number of fruits per plant

Number of fruits per plant differed significantly due to different seedling age under the present experiment (Appendix IV). The maximum (37.94) number of fruits per plant was recorded from S_2 (35 days old seedling), while the minimum (34.00) was recorded from S_3 (40 days old seedling) which was statistically identical (34.14) to S_1 (30 days old seedling) (Table 2). This finding agrees with the results obtained by Mehta and Saini (1986).

Different mulches showed significant variation in case of number of fruits per plant under the present trial (Table 2). The maximum (41.37) number of fruits per plant was recorded from M_2 (Black polythene) and the minimum (27.26) was observed in control condition i.e. no mulch. Ravinder (1998) observed that different mulching materials (black, blue or transparent polyethylene film, paddy straw, sugarcane trash, and poplar leaves) significantly improved the number of fruits per plant compared with the unmulched control on the growth and yield of tomato.

Interaction effect of seedling age and mulches showed significant differences for number of fruits per plant (Appendix IV). The maximum (42.78) number of fruits per plant was recorded from treatment combination S_2M_2 (35 days old seedling + Black polythene mulch) which was similar to S_1M_2, S_2M_1, S_2M_3 and S_3M_2 while the treatment combination S_1M_0 (30 days old seedling + no mulches) gave the minimum (25.67) number of fruits per plant (Table 3).

4.7 Dry matter content of leaves (%)

Dry matter content of leaves varied significantly for different seedling age (Appendix IV). The maximum (13.06%) dry matter content of leaves was found from S_2 (35 days old seedling), while the minimum (12.38%) was recorded from S_3 (40 days old seedling) which was statistically identical (12.59%) to S_1 (30 days old seedling) (Table 2).

Different mulches showed significant differences with respect to dry matter content of leaves under the present trial (Table 2). The maximum (13.37%) dry matter content of leaves was recorded from M_2 (Black polythene) which was statistically identical (13.30%) to M_1 (Water hyacinth mulch) and the minimum (10.96%) dry matter content of leaves was recorded from control condition i.e. no mulch.

The variation was found due to interaction effect of seedling age and mulches for dry matter content of leaves (Appendix IV). The maximum (14.05%) dry matter content of leaves was recorded from treatment combination S_2M_2 (35 days old seedling + Black polythene mulch) which was statistically identical (14.00%) to S_2M_1 (35 days old seedling + Water hyacinth mulch) and S_2M_3 (13.56%). The treatment combination S_2M_0 (35 days old seedling + no mulches) gave the minimum (10.65%) dry matter content of leaves (Table 3).

4.8 Dry matter content of fruits (%)

Dry matter content of fruits varied significantly for different seedling age (Appendix IV). The maximum (13.68%) dry matter content of fruits was recorded from S_2 (35 days old seedling) which was similar (13.36%) to S_3 and the minimum (13.09%) was found from S_1 (30 days old seedling) which was statistically identical (13.36%) with S_3 (40 days old seedling) (Table 2).

Different mulches showed significant variation on dry matter content of fruits under the present trial (Table 2). The maximum (14.45%) dry matter content of fruits was

recorded from M_2 (Black polythene) which was statistically identical (14.39% and 14.23%) to M_1 (Water hyacinth mulch) and M_3 (Straw mulch), respectively and the minimum (10.43%) dry matter content of fruits was recorded from control condition.

The variation was found due to interaction effect of seedling age and mulches for dry matter content of fruits (Appendix IV). The maximum (15.09%) dry matter content of fruits was recorded from treatment combination S_2M_2 (35 days old seedling + Black polythene mulch) which was statistically identical (15.01%) to S_2M_1 (35 days old seedling + Water hyacinth mulch) and S_2M_3 (14.79%) while the treatment combination S_2M_0 (35 days old seedling + no mulches) showed the minimum (9.84%) dry matter content of fruits (Table 3).

4.9 Length of individual fruit (cm)

Length of individual fruit varied significantly for different seedling age (Appendix V). The maximum (7.99 cm) length of individual fruit was recorded from S_2 (35 days old seedling), while the minimum (7.66 cm) was recorded from S_1 (30 days old seedling) which was statistically identical (7.69 cm) to S_3 (40 days old seedling) (Table 4). This finding agrees with the results obtained by Mehta and Saini (1986).

Different mulches showed significant variation on length of individual fruit under the present trial (Table 4). The maximum (8.82 cm) length of individual fruit was recorded from M_2 (Black polythene) and the minimum (6.61 cm) was obtained from control condition.

The variation was found due to interaction effect of seedling age and mulches for length of individual fruit under the trial (Appendix V). The maximum (9.19 cm) length of individual fruit was recorded from treatment combination S_2M_2 (35 days old seedling + Black polythene mulch), while the treatment combination S_2M_0 (35 days old seedling + no mulch) had minimum (6.49 cm) length of individual fruit (Table 5).

4.10 Diameter of individual fruit (cm)

Diameter of individual fruit differed significantly for different seedling age (Appendix V). The maximum (5.90 cm) diameter of individual fruit was recorded from S_2 (35 days old seedling), while the minimum (5.60 cm) was recorded from S_3 (40 days old seedling) which was statistically identical (5.69 cm) to S_1 (30 days old seedling) (Table 4).

Different mulches showed significant variation on diameter of individual fruit under the present trial (Table 4). The maximum (6.13 cm) diameter of individual fruit was recorded from M_2 (Black polythene) and the minimum (4.93 cm) was obtained from control condition.

Interaction effect varied significantly for seedling age and mulches for diameter of individual fruit (Appendix V). The maximum (6.42 cm) diameter of individual fruit was recorded from treatment combination of S_2M_2 (35 days old seedling + Black polythene mulch), while the treatment combination of S_2M_0 (35 days old seedling + no mulches) gave the minimum (4.79 cm) diameter of individual fruit (Table 5).

4.11 Weight of individual fruit (g)

Weight of individual fruit varied significantly for different seedling age (Appendix V). The maximum (77.85 g) weight of individual fruit was recorded from S_2 (35 days old seedling), while the minimum (66.22 g) was recorded from S_3 (40 days old seedling) which was statistically identical (67.15 g) to S_1 (30 days old seedling) (Table 4).

A significant variation was recorded for mulches on weight of individual fruit under the present trial (Table 4). The maximum (84.91 g) weight of individual fruit was recorded from M_2 (Black polythene) and the minimum (51.91 g) was recorded from control condition i.e. no mulch. Baki *et al.*, (1992) reported that black polythene

Table 4. Effect of seedling age and different mulches on plant height and number of leaves per plant of tomato

Treatment	Length of individual fruit (cm)	Diameter of individual fruit (cm)	Weight of Individual fruit (g)	Yield (kg/plant)	Yield (kg/plot)	Yield (t/ha)
Seedling age						
S_1	7.66 b	5.69 b	67.15 b	2.54 b	36.29 b	56.70 b
S_2	7.99 a	5.90 a	77.85 a	2.80 a	45.88 a	71.69 a
S_3	7.69 b	5.60 b	66.22 b	2.57 b	34.38 b	53.72 b
$LSD_{(0.05)}$	0.257	0.110	7.220	0.137	4.712	7.362
Mulching						
M_0	6.61 c	4.93 c	5191 c	1.77 d	26.03 d	40.67 d
M_1	7.89 b	5.99 b	75.99 b	2.89 b	42.15 b	65.86 b
M_2	8.82 a	6.13 a	84.91 a	3.22 a	50.67 a	79.17 a
M_3	7.79 b	5.88 b	68.81 b	2.66 c	36.55 c	57.11 c
$LSD_{(0.05)}$	0.297	0.128	8.337	0.158	5.441	8.501
CV(%)	7.89	6.27	12.11	6.07	14.32	14.32

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

S_1 : 30 days old seedling
S_2 : 35 days old seedling
S_3 : 40 days old seedling

M_0 : No mulching
M_1 : Water hyacinth
M_2 : Black polythene
M_3 : Straw

Table 5. Interaction effect of seedling age and different mulches on plant height and number of leaves per plant of tomato

Treatment	Length of individual fruit (cm)	Diameter of individual fruit (cm)	Weight of Individual fruit (g)	Yield (kg/plant)	Yield (kg/plot)	Yield (t/ha)
S_1M_0	6.70 f	5.08 f	47.09 g	1.55 e	23.75 f	37.11 f
S_1M_1	7.73 de	5.86 de	72.70 bcde	2.95 b	38.54 cd	60.21 cd
S_1M_2	8.60 bc	6.05 cd	83.48 abc	3.07 b	50.30 ab	78.59 ab
S_1M_3	7.60 e	5.78 e	65.33 de	2.58 c	32.57 def	50.89 def
S_2M_0	6.49 f	4.79 g	48.66 fg	1.61 e	25.63 ef	40.05 ef
S_2M_1	8.21 bcd	6.30 ab	87.07 ab	3.18 ab	52.44 ab	81.94 ab
S_2M_2	9.19 a	6.42 a	98.10 a	3.37 a	56.50 a	88.29 a
S_2M_3	8.08 cde	6.10 bc	77.57 bcd	3.04 b	48.95 ab	76.49 ab
S_3M_0	6.65 f	4.92 fg	59.99 efg	2.14 d	28.70 def	44.85 def
S_3M_1	7.74 de	5.80 e	68.21 cde	2.56 c	35.48 cde	55.43 cde
S_3M_2	8.67 b	5.91 cde	73.15 bcde	3.21 ab	45.21 bc	70.64 bc
S_3M_3	7.69 de	5.77 e	63.52 def	2.37 cd	28.13 def	43.96 def
$LSD_{(0.05)}$	7.69	0.221	14.44	0.273	9.424	14.72
CV(%)	7.89	6.27	12.11	6.07	14.32	14.32

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

S_1 : 30 days old seedling
S_2 : 35 days old seedling
S_3 : 40 days old seedling

M_0 : No mulching
M_1 : Water hyacinth
M_2 : Black polythene
M_3 : Straw

mulch significantly increased fruit size and total yield of tomato. Ravinder (1998) observed that different mulching materials (black, blue or transparent polyethylene film, paddy straw, sugarcane trash, and poplar leaves) significantly improved the fresh weight per fruit compared with the unmulched control on the growth and yield of tomato. Biswas (1993) observed that all mulches increased fruit size (by weight), more than double over the control. Gunadi and Suwanti (1988) recorded that mulch increased 16.3% yield over non-mulched plant spaced at 60 × 50 cm in single row.

The variation was found due to interaction effect of seedling age and mulches for weight of individual fruit under the trial (Appendix V). The maximum (98.10 g) weight of individual fruit was recorded from treatment combination S_2M_2 (35 days old seedling + Black polythene mulch), while the treatment combination S_1M_0 (35 days old seedling + no mulches) performed the minimum (47.09 g) weight of individual fruit (Table 5). The weight of individual fruit was also significantly affected by variety. Varietal influence on individual fruit weight was also reported by Hossain *et al.*, (1986)and Meher *et al.*, (1994).

4.12 Yield (kg/plant)

Yield per plant varied significantly for different seedling age (Appendix V). The maximum (2.80 kg/plant) yield was recorded from S_2 (35 days old seedling), while the minimum (2.54 kg/plant) was found from S_3 (40 days old seedling) which was statistically identical (2.78 kg/plant) to S_1 (30 days old seedling) (Table 4).

Different mulches showed significant variation on yield per plant under the present trial (Table 4). The maximum (3.22 kg/plant) yield was recorded from M_2 (Black polythene) and the minimum (1.77 kg/plat) yield was obtained from control condition. Ravinder (1998) observed that different mulching materials (black, blue or transparent polyethylene film, paddy straw, sugarcane trash, and poplar leaves) significantly

reduced the percentage of unmarketable fruit compared with the unmulched control on the growth and yield of tomato.

The variation was found due to the interaction effect of seedling age and mulches for yield per plant (Appendix V). The maximum (3.37 kg/plant) yield was recorded from treatment combination S_2M_2 (35 days old seedling + Black polythene mulch) which was identical to S_1M_2 (3.07 kg/plant) and S_2M_1 (4.12 kg/plant), while the treatment combination S_1M_0 (35 days old seedling + no mulches) gave the minimum (1.55 kg/plant) yield (Table 5).

4.13 Yield (kg/plot)

Yield per plot varied significantly for different seedling age (Appendix V). The maximum (45.88 kg/plot) yield was recorded from S_2 (35 days old seedling), while the minimum (34.38 kg/plot) was recorded from S_3 (40 days old seedling) which was statistically identical (44.49 kg/plot) to S_1 (30 days old seedling) (Table 4).

Different mulches showed significant variation on yield per plot under the present trial (Table 4). The maximum (50.67 kg/plot) yield was recorded from M_2 (Black polythene) and the minimum (26.03 kg/plat) yield was recorded from control condition. Pramanik (1997) reported that Black polythene mulch gave the highest yield than water hyancinth and control treatment.

The variation was found due to interaction effect of seedling age and mulches for yield per plot (Appendix V). The maximum (56.50 kg/plot) yield was recorded from treatment combination S_2M_2 (35 days old seedling + Black polythene mulch) which was identical to S_1M_2 (50.30 kg/plot) and S_2M_1 (52.44 kg/plot), while the treatment combination S_1M_0 (35 days old seedling + no mulches) gave the minimum (23.75 kg/plot) yield (Table 5).

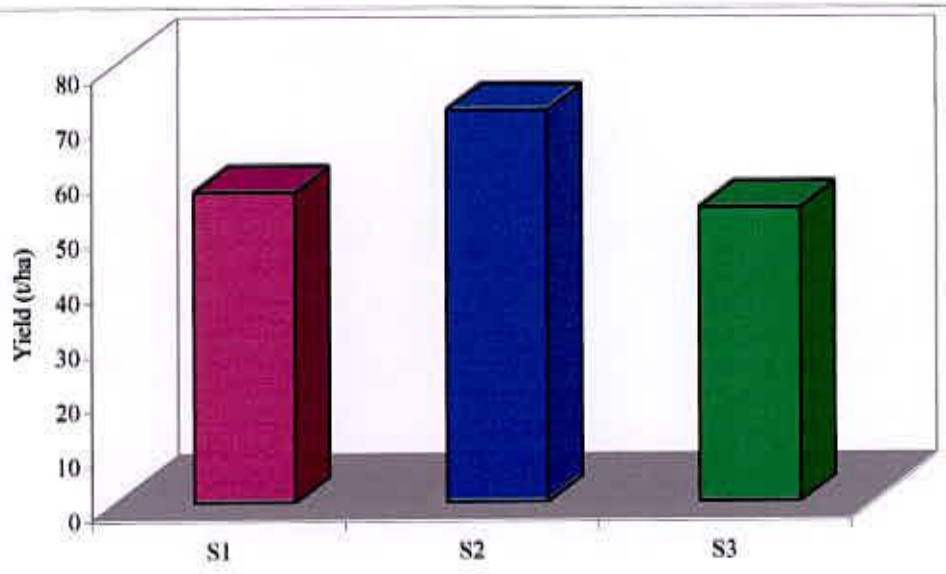


Figure 6. Effect of seedling age on yield per hectare of tomato

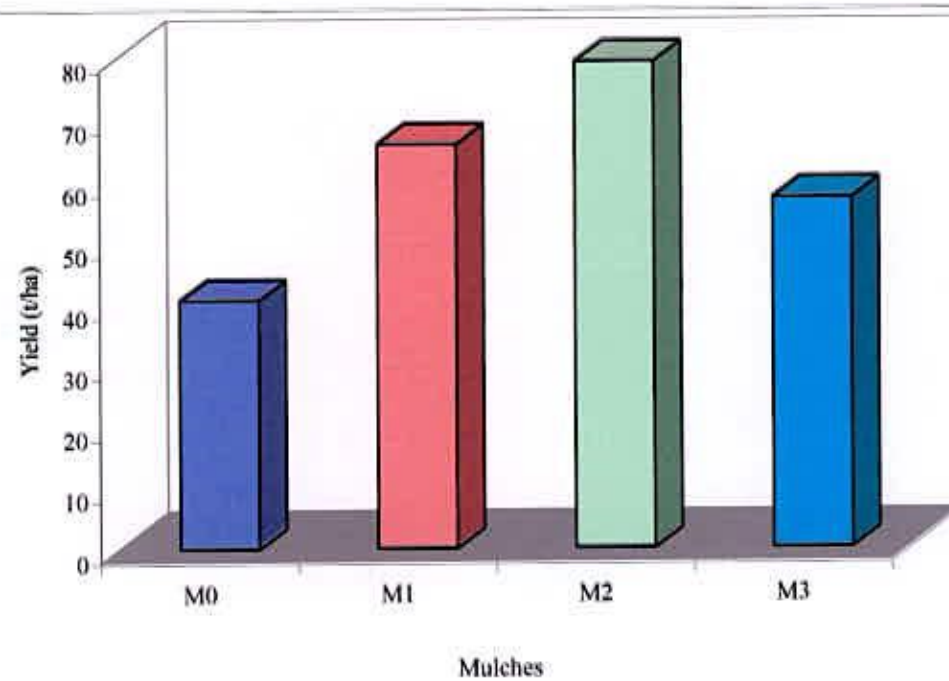


Figure 7. Effect of mulches on yield per hectare of tomato

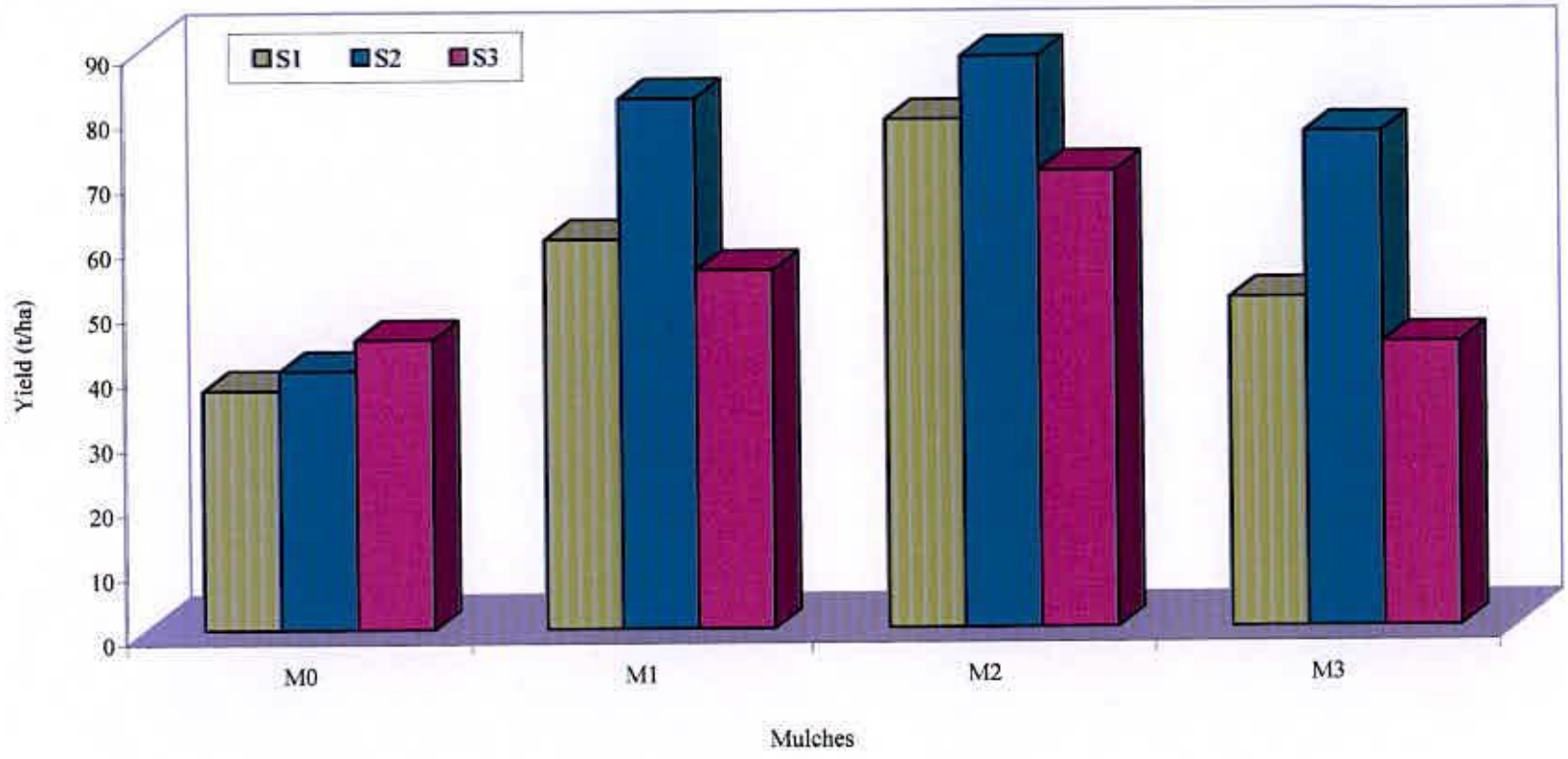


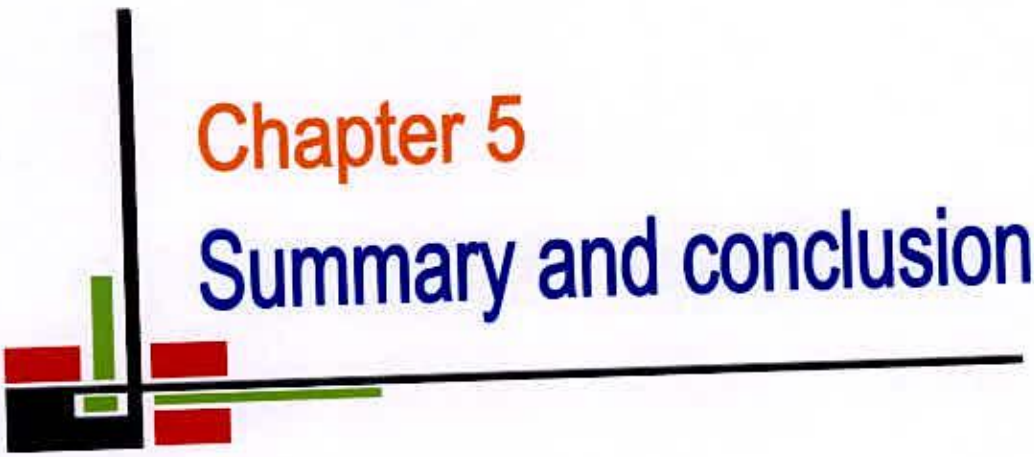
Figure 8. Interaction effect of seedling age and mulches on yield per hectare of tomato

4.14 Yield (t/ha)

Yield per hectare varied significantly for different seedling age (Appendix V). The maximum (71.69 t/ha) yield was obtained from S_2 (35 days old seedling), while the minimum (53.72 t/ha) was recorded from S_3 (40 days old seedling) which was statistically similar (56.70 t/ha) with S_1 (30 days old seedling) (Table 4).

Different mulches showed significant variation on yield per hectare under the present trial (Table 4). The maximum (79.17 t/ha) yield was recorded from M_2 (Black polythene) which was closely followed (65.86 t/ha and 57.11 t/ha) by M_1 (Water hyacinth mulch) and M_3 (Straw mulch), respectively and the minimum (40.67 t/ha) yield was recorded from control condition. Kaniszewski (1994) found that mulching increased marketable and total yield, but higher yield was obtained with Black polythene mulch than with white and non woven Black polythene. Total yields were 30% and marketable 53% higher for plants grown with Black polythene mulch and stickle irrigation than for control. Wen *et al.*, (1997) reported similar results.

Interaction effect of seedling age and mulches varied significantly for yield per hectare (Appendix V). The maximum (88.29 t/ha) yield was recorded from treatment combination S_2M_2 (35 days old seedling + Black polythene mulch) which was statistical similar to S_1M_2 (78.59 t/ha) and S_2M_1 (81.94 t/ha) while the treatment combination of S_1M_0 (35 days old seedling + no mulches) gave the minimum (37.11 t/ha) yield (Table 5).



Chapter 5

Summary and conclusion

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 November 2006 to April 2007 to find out the effect of seedling age and different mulches on the growth and yield of tomato. The experiment consisted of two factors Factor A: seedling age such as S_1: 30 days old seedling, S_2: 35 days old seedling and S_3: 40 days old seedling Factor B: M_0: No mulch; M_1: Water hyacinth; M_2: Black polythene and M_3: Straw. Data on different yield contributing characters and yield were recorded.

At harvest the maximum (112.02 cm) plant height was recorded from S_2 and the minimum (108.43 cm) was recorded from S_1. At harvest the maximum (62.94) number of leaves per plant was recorded from S_2 and the minimum (60.47) was recorded from S_1. The maximum (12.08) number of flower clusters per plant was recorded from S_2, while the minimum (9.53) was recorded from S_1. The maximum (7.19) number of flowers per cluster was recorded from S_2, while the minimum (6.42) was recorded from S_1. The maximum (89.50) number of flowers per plant was recorded from S_2, while the minimum (61.89) was recorded from S_3. The maximum (37.94) number of fruits per plant was recorded from S_2, while the minimum (34.00) was recorded from S_3. The maximum (13.06%) dry matter content of leaves was recorded from S_2, while the minimum (12.38%) was recorded from S_3. The maximum (13.68%) dry matter content of fruits was recorded from S_2 and the minimum (13.09%) was recorded from S_1. The maximum (77.85 g) weight of individual fruit was recorded from S_2, while the minimum (66.22 g) was recorded from S_3. The maximum (71.69 t/ha) yield was recorded from S_2, while the minimum (53.72 t/ha) was recorded from S_3.

At harvest the maximum (118.41 cm) plant height was recorded from M_2 (Black polythene), while the minimum (91.74 cm) plant height was recorded from control. At

harvest the maximum (67.81) number of leaves per plant was recorded from M_2 and the minimum (48.52) number of leaves per plant was recorded from control. The maximum (12.59) number of flower cluster per plant was recorded from M_2 and the minimum (8.04) was found from control. The maximum (7.85) number of flowers per cluster was recorded from M_2 and the minimum (5.67) number of flowers per cluster was recorded from control condition. The maximum (99.63) number of flowers per plant was recorded from M_2 and the minimum (45.56) number of flowers per plant was recorded from control. The maximum (41.37) number of fruits per plant was recorded from M_2 and the minimum (27.26) number of fruits per plant was recorded from control condition. The maximum (13.37%) dry matter content of leaves was recorded from M_2 and the minimum (10.96%) dry matter content of leaves was recorded from control. The maximum (14.45%) dry matter content of fruits was recorded from M_2 and the minimum (10.43%) dry matter content of fruits was recorded from control. The maximum (84.91 g) weight of individual fruit was recorded from M_2 and the minimum (51.91 g) weight of individual fruit was recorded from control treatment. The maximum (79.17 t/ha) yield was recorded from M_2 and the minimum (40.67 t/plat) yield was recorded from control.

At harvest the maximum (122.45 cm) plant height was recorded from treatment combination S_2M_2 whereas the minimum (87.97 cm) was recorded from treatment combination S_2M_0 (35 days old seedling + no mulches). At harvest the maximum (71.00) number of leaves per plant was recorded from the treatment combination S_2M_2 whereas the minimum (46.78) was recorded from treatment combination S_2M_0. The maximum (15.00) number of flower cluster per plant was recorded from treatment combination S_2M_2 and the treatment combination S_2M_0 (35 days old seedling + no mulches) gave the minimum (7.56) number of flower cluster per plant. The maximum (8.56) number of flowers per cluster was recorded from treatment combination S_2M_2, while the treatment combination S_1M_0 gave the minimum (5.44) number of flowers per cluster. The maximum (128.00) number of flowers per plant was recorded from

treatment combination S_2M_2 and the treatment combination S_1M_0 gave the minimum (42.44) number of flowers per plant. The maximum (42.78) number of fruits per plant was recorded from treatment combination S_2M_2 and the treatment combination S_1M_0 (30 days old seedling + no mulches) gave the minimum (25.67) number of fruits per plant. The maximum (14.05%) dry matter content of leaves was recorded from treatment combination S_2M_2 while the treatment combination S_2M_0 (35 days old seedling + no mulches) gave the minimum (10.65%) dry matter content of leaves. The maximum (15.09%) dry matter content of fruits was recorded from treatment combination of S_2M_2 while the treatment combination S_2M_0 gave the minimum (9.84%) dry matter content of fruits. The maximum (98.10 g) weight of individual fruit was recorded from treatment combination S_2M_2, while the treatment combination S_1M_0 gave the minimum (47.09 g) weight of individual fruit. The maximum (88.29 t/ha) yield was recorded from treatment combination S_2M_2, while the treatment combination S_1M_0 gave the minimum (37.11 t/ha) yield.

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

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performances;

2. Another seedling age may be included in the future program;

3. Another mulch materials may be included in future program.

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Appendices

APPENDICES

Appendix I: Monthly record of air temperature, rainfall, relative humidity, soil temperature and sunshine of the experimental site during the period from October 2006 to March 2007 (Site-Dhaka)

Year	Month	Air Temperature (^{0}C)			Relative humidity (%)	Rainfall (mm)	Soil temperature			Sunshine (hr)
		Maximum	Minimum	Mean			5 cm depth	10 cm depth	15 cm depth	
2006	October	30.60	24.20	27.40	75.87	204	16.07	17.1	17.20	206.9
	November	29.85	18.50	24.17	70.12	00	13.70	14.5	14.60	235.2
	December	26.76	16.72	21.74	70.63	00	12.80	13.7	14.10	290.5
2007	January	24.05	13.82	18.93	68.79	05	11.30	11.1	12.80	197.6
	February	28.90	18.03	23.46	62.04	03	12.60	12.9	13.40	220.5
	March	32.24	22.10	27.17	67.01	160	16.50	16.70	16.90	208.2

Source: Bangladesh Meteorological Department (Climatic Division), Agargaon, Dhaka-1212.

Appendix II:Characteristics of Sher-e-Bangla Agricultural University soil analysed by Soil Resources Development Institute (SRDI), Khamar Bari, Farmgate, Dhaka.

A. Morphological Characteristics of the experimental field

Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural University
AEZ	Madhupur Tract (28)
General Soil Type	Shallow Red Brown Tarrace Soil
Land Type	High land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping Pattern	Fallow-Tomato

B. Physical and Chemical properties of initial soil

Characteristics	Value
PARTIAL SIZE ANALYSIS	
% Sand	28
% Silt	42
% Clay	30
TEXTURAL CLASS	
P^H	5.6
Organic Carbon (%)	0.46
Organic matter (%)	0.80
Total N (%)	0.05
Available P (ppm)	20.00
Exchangeable K (meq/100 gm soil)	0.12
Available S (ppm)	46

Source: Soil Resources Development Institute (SRDI)

Appendix III. Analysis of variance of the data on plant height and number of leaves per plant of tomato as influenced by seedling age and different mulches

Sources of variation	Degrees of freedom	Mean square							
		Plant height (cm)				Number of leaves per plant			
		20 DAT	40 DAT	60 DAT	At harvest	20 DAT	40 DAT	60 DAT	At harvest
Replication	2	0.637	3.720	5.761	7.863	0.039	0.280	0.286	0.413
Seedling age (A)	2	55.798**	68.208**	49.333**	38.833*	21.485**	7.015*	9.201*	24.445**
Mulches (B)	3	58.880**	90.281**	435.564**	1376.057**	33.882**	77.546**	255.112**	678.081**
Interaction (A×B)	6	12.208**	9.861*	18.867**	38.102*	4.982*	7.501**	6.543*	12.222*
Error	22	2.661	3.269	4.064	14.087	1.462	1.662	2.500	3.665

** : Significant at 0.01 level of probability; * : Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on yield contributing characters of tomato as influenced by seedling age and different mulches

Sources of variation	Degrees of freedom	Mean square					
		Number of flower clusters per plant	Number of flowers per cluster	Number of flowers per plant	Number of fruits per plant	Dry matter content on leaves (%)	Dry matter content on fruits (%)
Replication	2	0.320	0.027	4.069	0.287	0.050	0.151
Seedling age (A)	2	25.588**	2.509**	2999.419**	60.115*	1.493**	1.078**
Mulches (B)	3	32.235**	7.327**	4495.620**	316.182**	11.918**	34.784**
Interaction (A×B)	6	5.204**	0.221**	459.099**	24.613*	0.526**	1.007**
Error	22	0.821	0.126	60.351	11.724	0.078	0.203

** : Significant at 0.01 level of probability; * : Significant at 0.05 level of probability

variance of the data on fruit characters and yield as influenced by seedling age and different mulches

Source of variation	Degrees of freedom	Mean square					
		Length of individual fruit (cm)	Diameter of individual fruit (cm)	Weight of Individual fruit (g)	Yield (kg/plant)	Yield (kg/plot)	Yield (t/ha)
Replication	2	0.081	0.029	58.699	0.029	2.565	6.262
Seedling age (A)	2	0.406*	0.290**	501.014**	0.245**	455.960**	1113.184**
Mulches (B)	3	7.338**	2.649**	1758.413**	3.487**	960.860**	2345.851**
Interaction (A×B)	6	0.122**	0.104**	195.076*	0.260**	88.271*	215.505*
Error	22	0.092	0.017	72.728	0.026	30.973	75.618

** : Significant at 0.01 level of probability; * : Significant at 0.05 level of probability