INFLUENCE OF MULCH ON GROWTH, YIELD AND FRUIT QUALITY OF STRAWBERRY

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CERTIFICATE

This is to certify that the thesis entitled ***"INFLUENCE OF MULCH ON GROWTH, YIELD AND FRUIT QUALITY OF STRAWBERRY"*** *submitted to the* ***DEPARTMENT OF AGRICULTURAL BOTANY****, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE IN AGRICULTURAL BOTANY****, embodies the results of a piece of bonafide research work carried out by* ***MD. HASNAT RAHMAN****, Registration number:* ***05-01680*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

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DEDICATED
TO MY
PARENTS

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ABSTRACT

The experiment was carried out at the horticulture farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to study the influence of mulches on growth, yield and quality contributing characters of strawberry. Strawberry genotypes RABI-3, Camarosa and Nohime were subjected with four mulching treatments, namely control (no mulch), straw mulch, styrofoam mulch and black polythene mulch. The two-factor experiment was conducted following RCBD with four replications. Results revealed that the best vegetative growth was found in Camarosa, which also required less duration for floral bud initiation, flowering, fruit setting and fruit ripening. Total fruit weight and average fruit weight were also the highest in Camarosa. Number of flower bud, flower, fruit and percentage of fruit set were found highest in RABI-3. Nohime had higher fruit pH which was significantly different from the others. The fruit soluble solid content (SSC) and ascorbic acid percentage were higher in Camarosa. All mulch treatments influenced plant growth, yield and fruit quality. Among them black polythene and straw mulch had no significant difference on vegetative growth. Percentage of fruit set and total fruit weight were the highest in Camarosa treated with black polythene. The value of pH was the maximum when Nohime treated with no mulch. SSC was higher in Camarosa treated with styrofoam and no mulch. Ascorbic acid percentage was the greatest in Camarosa treated with black polythene mulch. In almost all the parameter tested, Camarosa performed better among the three genotypes. Among the mulching application, black polythene mulch gave the best performance for growth, yield and quality attributes.

CHAPTER I

INTRODUCTION

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Strawberry (*Fragaria x ananassa* Dutch.) is one of the most delicious and fragrantly sweet flavored fruit which is very popular in many countries. The fruit is widely appreciated for its characteristic aroma, bright red color, juicy texture and sweetness. *Fragaria* is a genus of flowering plants in the Rosaceae family. The most common strawberries grown commercially are cultivars of the garden strawberry, a hybrid known as *Fragaria x ananassa* Duch. Strawberries are often grouped according to their flowering habit. There are basically three types of strawberry plants grown from temperate countries- June bearing, ever bearing and day neutral. June bearers are the traditionally grown plants producing a single flush of flowers and many runners. They are classified into early, mid-season and late varieties. The largest fruits are generally produced from June bearing varieties. Ever bearing strawberries produce two to three harvests of fruit intermittently during the spring, summer and fall. They do not send out many runners. Day-neutral strawberries will produce fruit throughout the growing season.

The strawberry plant is a herbaceous perennial. The cultivated strawberry is an octoploid ($2n = 56$) and thought to be an autopolyploid. The plant comprises a short stem or crown from which arises leaves, runners, roots, auxiliary crowns and inflorescences. The leaves typically have three leaflets. Flowering in strawberry is greatly influenced by environmental condition particularly temperature and day length. Flowers and fruits are produced on a stalk that emerges from an axillary bud. Each flower is subtended by bracts and has five or more green sepals, five separate white petals, numerous stamens and a domed receptacle (called a torus) that bears an indefinite number of pistils. The pistil (ovary plus style and stigma) develops into a one-seeded, dry fruit, called an achene. It is an aggregate accessory fruit, meaning that the fleshy part is derived not from the plant's ovaries but from the "receptacle" that holds the ovaries. Each apparent "seed" (achene) on the outside of the fruit is actually one of the ovaries of the flower with a seed inside it. In both culinary and botanical terms, the entire structure is considered a fruit. Strawberry fruit ripens rapidly. Fruit develop a fully red (ripe) stage within 30 to 40 days after anthesis, depending on cultivar and environment (Perkins-Veazie, 1995). Many physiological changes occur in the ripening fruit that determine consumer perception of fruit quality. During ripening, fruits continue to increase in size, accumulate soluble solid content (SSC) and show distinct changes in pigmentation and softening (Morris, 1981). Strawberries have a taste that varies by cultivar and ranges from quite sweet to rather tart. It is usually eaten raw or used in making ice creams, jams, jellies, pickles, chocolates, biscuits, cakes and milk shakes. It is a rich source of high quality carbohydrates, low fats and proteins, vitamins and minerals important flavinoids and antioxidant which have anticancerous activity. It is used in pharmaceuticals for its medicinal value. It is also used in cosmetic industries.

Strawberries are widely grown in all temperate regions of the world. It has been introduced in Bangladesh recently and getting popularity but the crop is cultivated in small scale. Different regions of Bangladesh are potentially suitable to cultivate strawberry in terms of photoperiod, temperature and humidity. It is the time to research for improving strawberry varieties which are cultivated in our environment. The growing period is relatively short and the income per unit area is high in strawberry cultivation. On the other hand, its market demand is very high. Due to these advantages in production and marketing, strawberry cultivated area is gradually increasing in Bangladesh. To meet the increasing demand in our local market, traders import large amount of strawberry from different foreign countries.

In Bangladesh it can be grown everywhere during the month of October to April. Strawberry cultivation is successful in Rajshahi, Rangamati and Khagrachari. Strawberry farming is already in motion in 30 districts in the country mainly in Panchagarh, Dinajpur, Tangail, Rangpur, Kurigram, Mymensingh, Noakhali, Laxmipur, Jessore, Magura, Faridpur, Madaripur and many areas around Dhaka. However, our farmers are new in the field of successful commercial strawberry production. In addition, due to lack of suitable variety and knowledge of intercultural operations which are sustainable in our environments farmers are facing some sorts of problem.

Strawberry cultivation requires high labor inputs, but still enjoys great popularity. Fruit quality is affected by agro-technical treatments, i.e. mulching, irrigation, chemical protection, fertilization, crop rotation, intercropping, proper preparation of the field, planting date, the health status and type of seedlings. There are two main functions of the mulch used in the cultivation of strawberry: (1) to provide a barrier between the ground and the plants so that the berries will be kept from getting dirty and (2) to isolate them as much as possible from becoming infected with pathogenic fungi that cause the berries to rot. The addition of organic mulch can increase enzyme activity, but can also decrease microbial biomass (Niemi et al., 2008). Straw is the most popular mulch used in for strawberry production, but synthetic mulches e.g. polyethylene films are also used (Lamont, 1993). Lots of research work have been carried out in many countries with the use of natural mulches (Yavari et al., 2008), synthetic films (Haynes, 1987) and also biodegradable films of organic origin (Scarascia-Mugnozza et al., 2006). Plenty of research work showed that mulching with organic material has a beneficial effect on weed control and conservation of soil moisture (Skroch et al., 1992; Osterkamp, 1993). Plastic mulches over trickle irrigation systems are widely used in raised-bed culture of strawberry to conserve water and keep fruit clean. Black is the most widely used color of plastic mulch (Bhella, 1988; Blackhurst, 1962). There exist some other benefits of using mulches. The mulch can contribute to a considerable reduction in the evaporation of water from the soil surface. This means better water utilization by the plants. Mulch can also be used to alleviate the negative effects of a long-term draught. A study showed that black polyethylene increased the yield of strawberry by 56 per cent over the unmulched control and produced fruits of bigger size with higher total soluble sugar (TSS), higher sugar and lower acidity as compared to the remaining mulched treatments (Gupta and Acharya, 1993).

Considering the above mentioned facts, this study was undertaken to find out the effect of mulch on strawberry yield and quality and to find out a proper mulching material in strawberry production in Bangladesh. The aim of the study is also to know how the quality can be increased by using mulches such as sweetness, yield, fruit size, ascorbic acid percentage etc.

OBJECTIVES

The present study was under taken with the following objectives:

1. To determine the influences of different mulches on growth and development of strawberry;
2. To measure the influences of different mulches on yield and yield contributing characters of strawberry and
3. To investigate the influences of mulches on fruit quality of strawberry.

CHAPTER II

REVIEW OF LITERATURE

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REVIEW OF LITERATURE

Strawberry (*Fragaria x ananassa* Dutch.) is an important fruit crop and its commercial production is possible in Bangladesh. The country's weather is suitable for strawberry farming. Although this delicious fruit is normally produced in countries having cold weather but with the increasing demand, its production area is increasing day by day. There is a lacking of information regarding its production under climatic conditions of Bangladesh. Nonetheless, some of the important and informative works done abroad in these aspects have been presented below-

2.1 Influence of mulches

Plastic mulches over trickle irrigation systems are widely used in raised-bed culture of strawberry to conserve water, control weeds with less herbicide and keep fruit clean. Black is the most widely used color of plastic mulch (Bhella, 1988; Blackhurst, 1962; Lamont, 1993)

According to Rebandel (1988), there are two main functions of the mulch used in the cultivation of strawberry. Firstly to provide a barrier between the ground and the plants so that the berries will be kept from getting dirty and secondly to isolate them as much as possible from becoming infected with pathogenic fungi that cause the berries to rot.

Straw is the most popular mulch used in Poland for strawberry production, but synthetic mulches e.g. polyethylene films are also used (Ochmian et al., 2007). Similar studies have also been carried out in other countries with the use of natural mulches (Yavari et al., 2008; Vestberg et al., 2009) synthetic films (Haynes, 1987) and also biodegradable films of organic origin (Scarascia-Mugnozza et al., 2006; Kapanen et al., 2008; Immirzia et al., 2009).

Niemi et al., 2008 reported that the addition of organic mulch can increase enzyme activity, but can also decrease microbial biomass.

2.2 Influence of mulches on growth of strawberry

Himelrick (1982) showed that plants grown on black plastic mulch produced more runners than plants grown on clear or white plastic mulches.

Gupta & Acharya (1993) studied the effect of five different mulching materials, *viz.* transparent polyethylene, black polyethylene, pine needles, grass and *Eupatorium* and an unmulched control. Result shows that black polyethylene induced higher root growth followed by pine needles, transparent polyethylene, grass *Eupatorium* and unmulched control.

Himelrick et al., (1993) observed that annual planting of strawberries using raised beds, trickle irrigation, and black or clear plastic mulches has been practiced for a number of years in production areas such as California and Florida and results showed that vegetative strawberry plant responses can be modified by the type of organic or synthetic mulch used in the production system.

Shiow et al., (1998) conducted an experiment to study the influence of mulch types (black polythene, red poly ethylene and straw-vetch in raised bed hill culture) on the chemical composition of Northeaster and Primetime strawberry (*Fragaria × ananassa* Duch.) fruit and plant parts was evaluated. Results showed that strawberry plants grown on straw-vetch mulch had the largest leaf area and the highest chlorophyll content, while plants grown on red polyethylene mulch had the smallest leaf area and lowest chlorophyll content. There were significant mulch cultivar interactions in leaf area, chlorophyll contents and soluble carbohydrate and starch contents in leaves petioles, crowns, crown-roots and roots.

Pirjo et al., (2002) conducted two years organic strawberry field experiment in Finland to study the influence of mulching materials on the growth, yield, microbiological fruit quality and strawberry mite. Organically produced plants of *cv.* Jonsok were planted in first year in double rows, 10 plants/plot 45 cm apart in four replicates. Mulching materials are black plastic, flax fibre mat, green mass, barley straw, and buckwheat husk as well as pine and birch woodchips. In the first experimental year, mulches had a significant effect on the vegetative growth as measured by the numbers of runners. Strawberry plants grew most vigorously in buckwheat husk and in black plastic mulch. The vegetative growth remained low in woodchips mulches.

Plekhanova and Petrova (2002) studied the influence of black plastic soil mulching on the yield, on the dates of maturity, on berry quality, and on plants' resistance to fungal diseases in 36 cultivars of Russian and foreign breeding. It was established that mulching accelerates the beginning of flowering and ripening for 1 to 7 days, increases yield for 20% on the average at the expense of the larger number of peduncles and berries. Losses from gray mold reduce for 15%. A disadvantage of mulching is in stronger spring frost damage of flowers in early cultivars. The best ones for cultivation in the Northwest of Russia are 'Junia Smaids', 'Divnaya', 'Surpriz Olympiade', 'Onega', 'Borovitskaya', 'Senga Sengana'.

Birkeland et al., (2002) reported that in North Atlantic coastal climate plastic mulch promoted fruit ripening and straw mulch delayed ripening, but the differences were small.

Sharma et al., (2004) conducted an experiment with five cultivars (Sweet Charlie, Chandler, Douglas, Fern and Etna) cultivated with three types of mulch materials (black polyethylene, white polyethylene and paddy straw). No mulch was used as a control. Observations were recorded on plant growth parameters and fruit quality parameters of five cultivars under different mulch materials. All growth parameters were better with mulching than with control. Among the different types of mulch materials, plants had the best growth with black polyethylene, but the fruits were more affected by albinism as compared with those cultivated with paddy straw mulch. Thus, paddy straw is the best option for use as mulch for strawberry in warmer localities.

The influence of organic mulches on crop yield is unequal. Mulching improves plant growth and yield (Singh et al., 2007).

Sharma et al., (2004) conducted an experiment with three mulches viz. black polyethylene, white polyethylene, and paddy straw in 10 cultivars to observe that crown height; leaf number and leaf area were influenced by different mulch materials.

Rajbir (2005) reported that plants mulched with black polyethylene had the best growth compared with those mulched with clear polyethylene or paddy straw mulch.

Laugale et al., (2006) observed three organic mulch types, straw, shavings and living grass mulch, were compared with the standard system of no mulch using two cultivars, 'Induka' and 'Festivalnaya Romascha'. Results showed that flowering and production period did not differ significantly between treatments. Better runnering, flowering higher productivity was observed in the production system without mulch, followed by living grass mulch.

Atkinson et al., (2006) reported that mulches with different polythene have reflective capacities impacted on strawberry production. Highly reflective mulches significantly increased growth.

Regina et al., (2006) conducted an experiment on different mulch treatment and found that with different mulch leaves from plants grown in straw- vetch mulch had the largest leaf area and the highest chlorophyll content while red polyethylene had the smallest amount and leaf area.

Ali and Gaur (2007) observed the effect of different mulches on growth, flowering of strawberry (*Fragaria × ananassa* Duch.) cv. Sweet Charlie at Kanpur (India). The mulching types adopted were black polyethylene, sugarcane trash, paddy straw, saw dust, dry grasses and un-mulched control. The results revealed that mulching increased the vegetative growth and flowering of plants. Plants mulched with black polyethylene mulch showed maximum plant height, plant spread, number of leaves and flowers per plant. Best result was obtained with paddy straw closely followed by sugarcane trash.

Ravneet and Sarabjeet (2009) carried out a study to evaluate the effect of different mulching treatments on growth, yield and quality of strawberry (*Fragaria × ananassa* Duch.) cv. Chandler. The six mulching treatments employed were black polythene, transparent polythene, paddy straw, saw dust, dry grasses and unmulched control. The maximum number of leaves and flowers were observed with black polythene followed by transparent polythene and paddy straw.

Katiyar et al., (2009) studied the effect of mulching on plant growth of strawberry under agro-climatic conditions of Kanpur and found that black polythene has established its superiority with regard to maximum crown height crown spread, leaf number, leaf area and quality parameters followed by white polythene and paddy straw. The minimum values on all the above parameters of growth, yield and quality were recorded under no mulch (control).

2.3 Influence of mulches on yield of strawberry

Himelrick (1982) showed that plants grown on black plastic mulch produced more fruit than the plants grown on clear or white plastic mulches and that total fruit mass was greater with black and clear plastic mulches than the bare soil.

Gupta & Acharya (1993) studied the effect of five different mulching materials and found that black polyethylene increased the yield of strawberry by 56 per cent over the unmulched control and produced fruits of bigger size.

In florida 2 years field experiment was done and found that strawberry plants grown over red painted plastic give larger berries than over polyetylene (Albregts and Chandler, 1993).

Himelrick et al., (1993) observed that annual planting of strawberries using raised beds, trickle irrigation, and black or clear plastic mulches has been practiced for a number of years in production areas such as California and Florida and results showed that reproductive strawberry plant responses can be modified by the type of organic or synthetic mulch used in the production system.

Baumann et al., (1995) reported no yield differeces between green and black plastic mulch but plants on black mulch produced larger berries than did those on green or no plastic mulch.

It is well documented that black polythene mulched strawberry produced higher yields of high quality fruit than unmulched controls (Wittwer and Castilla, 1995).

Cortez (1995) conducted a field trial in Jaboticabal, Sao Paulo, Brazil, strawberries cv. Campinas (IAC 2712) were covered with black polyethylene film or polypropylene film with a grey upper and black lower surface or were not covered. Yield of marketable fruit and average fruit weight were not affected by mulching, while yield of non-marketable fruit was decreased by mulching.

Kasperbauer (2000) found that plastic mulches are frequently used in raised-bed culture of strawberry (*Fragaria×ananassa* Duch.) to conserve water, control weeds with less herbicides and keep fruit clean. The most commonly used plastic mulch color is black. It was hypothesized that specially formulated red plastic mulch that reflects a higher far-red photon ratio could regulate photosynthate allocation enough to increase yield of strawberry. Yields over the red plastic were compared with those over standard black plastic in field experiments at a research center and on a commercial strawberry farm. Yield per plant and size per berry were greater over the red than over the black plastic at both locations. The yield advantage of red mulch relative to black occurred whether the red plastic was placed directly over the soil or over a layer of black plastic.

Mohamed (2002) observed that in Egypt to study the effect of transplant defoliation and mulch color on the performance of three strawberry cultivars was investigated during two successive seasons. Silver on Purple plastic mulch significantly increased early and total yield compared to clear or black mulch. Unmulched bed produced the lowest yield. The highest yield and growth were those of 'Camarosa' plants grown with their foliage intact on Silver on Purple plastic mulch.

Pirjo et al., (2002) conducted two years organic strawberry field Finland to study the influence of mulching materials on the growth, yield, microbiological fruit quality and strawberry mite. Organically produced plants of *cv.* Jonsok were planted in first year in double rows, 10 plants/plot 45 cm apart in four replicates. Mulching materials are black plastic, flax fibre mat, green mass, barley straw, and buckwheat husk as well as pine and birch woodchips. In the first yielding, plastic mulch gave the highest total and marketable yield. Birch mulch gave the lowest total and marketable yield. Berries from woodchips mulches had the longest shelf-life under the storage conditions studied. Buckwheat husk mulch seems to reduce the shelf-life of berries.

Birkeland et al., (2002) conducted a four-year strawberry field trial under organic production in a North Atlantic coastal climate. Three mulching materials, viz. black plastic film, barley straw and fresh spruce bark, were compared in the cultivars 'Korona', 'Nora' and 'Jonsok'. Runner plants were planted in single rows on elevated beds. Plastic mulch gave the highest total and marketable yields in the first three years, while bark mulching gave the highest yield in the fourth year. Of the two organic mulches, bark gave the highest yields and fewest diseased fruits. Straw mulch performed well in the first year of harvest, with higher yields than bark mulch and the lowest number of fruits infected by *Botrytis cinerea.*

Kikas and Luik (2002) observed the influence of different mulches (black plastic, bed carpet, wooden chips, straw, and unmulched control) and cultivars ('Jonsok', 'Bounty' and 'Senga Sengana') on strawberry yield. The average production of berries per plant in the variants of black plastic and bed carpet in all three cultivars was significantly higher ($p<0.001$) than that in the control variant. The use of black plastic mulch caused the best result in 'Senga Sengana'. The highest total yield over the period of 4 years was collected from the plots of 'Jonsok'. The black plastic and the bed carpet are recommended for mulching of strawberry plants because these materials promote strawberry yield.

The influence of organic mulches on crops is unequal. Mulching improves plant growth (Sharma & Sharma, 2003; Singh et al., 2007).

Mathad and Jholgiker (2005) found that mulching is an essential cultural practice in strawberry cultivation. Investigation on use of different synthetic and organic mulches revealed that the plants covered with polythene mulches performed better than the organic mulches. White over black (W/B) laminated polythene mulched plants produced higher yields with berries of high mean fruit weight (10.37 g). The marketable berry yield was 10-13 per cent more in synthetic mulches when compared to organic mulches.

Rajbir (2005) reported that plants mulched with black polyethylene had the best fruit weight, yield and quality compared with those mulched with clear polyethylene or paddy straw mulch.

Laugale et al., (2006) observed that three organic mulch types, straw, shavings and living grass mulch, were compared with the standard system of no mulch using two cultivars, 'Induka' and 'Festivalnaya Romascha'. Results showed that higher productivity was observed in the production system without mulch, followed by living grass mulch. Living grass mulch facilitated higher number of misshapen berries and reduced fruit size.

Atkinson et al., (2006) reported that mulches with different polythene have reflective capacities impacted on strawberry production; highly reflective mulches significantly increased and yield, the latter due to increases in fruit size and number.

Ali and Gaur (2007) observed the effect of different mulches on yield of strawberry (*Fragaria* × *ananassa* Duch.) cv. Sweet Charlie at Kanpur (India). The mulching types adopted were black polyethylene, sugarcane trash, paddy straw, saw dust, dry grasses and un-mulched control. The results revealed that number of fruits per plant, average weight and size (length and width) and fruit yield were also maximum with black polyethylene mulch. However, the effect of black polyethylene mulch was statistically at par with paddy straw and sugarcane trash far most of the parameters. Best result was obtained with paddy straw closely followed by sugarcane trash.

Mateusz et al., (2009) conducted an experiment which involved three strawberry cultivars: 'Senga Sengana', 'Kent' and 'Elsanta' in Poland. The strawberry plants were mulched with a peat substrate, or sawdust, or pine bark, or compost or rye straw, and inoculated with a mycorrhizal preparation Mycosat. The experiments confirmed the cultivar-specific differences in yield between the strawberries cultivars studied. At comparable yields, they differed significantly in terms of the number and mean weight of the fruits collected.

Ravneet and Sarabjeet (2009) carried out a study to evaluate the effect of different mulching treatments on growth, yield and quality of strawberry (*Fragaria × ananassa* Duch.) cv. Chandler. The six mulching treatments employed were black polythene, transparent polythene, paddy straw, saw dust, dry grasses and unmulched control. The maximum number of fruits and fruit yield were observed with black polythene followed by transparent polythene and paddy straw.

Medina et al., (2011) conducted an experiment under high tunnels and open fields to determine the effects of various plastic mulches on microclimate conditions, growth, yields and fruit quality of day-neutral strawberry. Four plastic mulches (green, grey on grey, white on black and black) were compared. All mulch treatments under the high tunnels produced higher yield than the outdoor control. Black mulch caused excessive soil and air temperatures in tunnels, but was found adequate for the open field.

Laugale et al., (2012) conducted an experimetnt to carry out in Latvia. Cold stored strawberry plants of cultivars 'Polka', 'Elsanta' and 'Honeoye' were planted on two row beds and mulched by white plastic with black lower side (white on black) or unmulched. Plants were evaluated for two growing seasons.

Using of white plastic with black lower side mulch increased the yield and fruit size in both planting densities compared with the unmulched variant.

2.4 Influence of mulches on fruit quality of strawberry

Ascorbic acid present in high concentrations provides an essential nutrient with numerous associated health benefits (Block, 1991; Kalt, 2001; Olsson, 2004).

Gupta & Acharya (1993) studied the effect of five different mulching materials and found that black polyethylene had higher TSS, higher sugar and lower acidity as compared with the remaining mulched treatments

Shiow et al., (1998) conducted an experiment to study the influence of mulch types (black polythene, red poly ethylene and straw-vetch in raised bed hill culture) on the chemical composition of Northeaster and Primetime strawberry (*Fragaria×ananassa* Duch.) fruit and plant parts was evaluated. Ascorbic acid (AA), malic acid, citric acid, and ellagic acid levels were higher in Primetime than in Northeaster fruits, while Northeaster had higher soluble solids content (SSC). Fruit grown on straw-vetch had lower SSC than did those grown on the polythene mulches. The AA content in the fruit of either cultivar was not affected by the mulch treatment. Fruit grown on the straw-vetch mulch had less red surface and flesh color but higher pigment intensity than fruit grown on the polyethylene mulches. There were significant mulch×cultivar interactions in fruit titratable acid (TA) and AA levels, sugars, citric and ellagic acid. TA was highest in Northeaster fruit when grown on red polyethylene, whereas TA was highest in Primetime fruit when grown on straw-vetch.

Fruit quality is also affected by agro technical treatments, i.e. mulching, irrigation, chemical protection, fertilization, and before establishing a plantation: crop rotation and intercropping, proper preparation of the field, planting date, or the health status and type of seedlings (LaMondia et al., 2002; Pawłowska et al., 2004).

Mohamed (2002) observed that in Egypt, Silver on Purple plastic mulch significantly increased fruit quality and lowest in black plastic mulch.
The influence of organic mulches on crops is unequal. Mulching improves fruit quality (Sharma and Sharma, 2003; Singh et al., 2007).

Ulvi et al., (2004) conducted a study with the aim of gaining higher yields and the influence of mulch (plastic and straw), fertilization and the age of plants (two, three and four years) on the quality of strawberry fruits. Results showed that with plastic mulch, fertilization had a positive influence on vitamin C content. With straw mulch, fertilization decreased fruit damage. None of the experimental factors had an impact on the content of soluble solids.

According to Mathad and Jholgiker (2005), there are different synthetic and organic mulches revealed that the plants covered with polythene mulches performed better than the organic mulches. It promotes TSS, TSS/acid ratio and development of anthocyanin pigmentation.

Moor (2005) studied the influence of different mulches (plastic and straw) and additional fertilization on the content of anthocyanins and vitamin C in strawberry (*Fragaria* x *ananassa* Dutch.) 'Bounty' fruits in Estonia. The results of the experiments showed that liquid fertilizer increased vitamin C content in fruits grown with plastic mulch; and decreased the content of vitamin C in fruits grown with straw mulch. Strawberry fruits from plastic mulch variant also contained more vitamin C than those from straw mulch variant, but fertilization did not affect content of vitamin C in any variant.

Atkinson et al., (2006) reported that mulches with different polythene have reflective capacities impacted on strawberry production; highly reflective mulches significantly increased ascorbic acid.

Regina et al., (2006) reported that there are no differences in fruit color, fruit soluble solids content, titratable acidity, sugars, organic acids, ascorbic acid or ellagic acid among the plants grown in the different mulches. However, red polyethylene mulch produced the least and the black polyethylene produced the most soluble carbohydrates and starch content in strawberry plants.

Ali and Gaur (2007) observed the effect of different mulches on quality of strawberry (*Fragaria × ananassa* Duch.) cv. Sweet Charlie at Kanpur (India). The mulching types adopted were black polyethylene, sugarcane trash, paddy straw, saw dust, dry grasses and un-mulched control. The results revealed that The TSS (total sugars and ascorbic acid) increased by mulching treatments but the effect of was non-significant. Best result was obtained with paddy straw closely followed by sugarcane trash.

Ravneet and Sarabjeet (2009) carried out a study to evaluate the effect of different mulching treatments on growth, yield and quality of strawberry (*Fragaria × ananassa* Duch.) cv. Chandler. The six mulching treatments employed were black polythene, transparent polythene, paddy straw, saw dust, dry grasses and unmulched control. Highest TSS, sugar percentage and ascorbic acid percentage were also observed with black polythene but the effect was non-significant.

Katiyar et al., (2009) studied the effect of mulching on quality of strawberry under agro-climatic conditions of Kanpur and found that quality traits (TSS, sugar and vitamin 'C') of fruit were influenced by different mulch materials and minimum values on quality were recorded under no mulch (control).

Laugale et al., (2012) reported that significant differences of fruit chemical content between strawberry cultivars, planting densities and mulching were observed. Biochemical content was mostly influenced by genotype and in less importance by cultural methods.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in carrying out the experiment.

3.1 Experimental site and duration

The experiment was conducted at the Horticulture farm of Sher-e- Bangla Agricultural University, Dhaka, during the period from November 2010 to April 2011 to find out the influence of different mulches on growth, yield and quality of three strawberry genotypes.

3.2 Climate condition of the experimental site

The experimental site was situated in the subtropical Climatic zone, characterized by heavy rainfall during the months from April to September and scanty rainfall during the rest of the year (rabi season). Details of weather data in respect of maximum and minimum temperature, relative humidity and rainfall during the study period were collected from the Bangladesh Meteorological Department (climate division), Agargaon, Dhaka-1207 and presented in Appendix- I.

3.3 Experimental material

In the research work, the strawberry cultivar "RABI-3, Camarosa and Nohime" were used. Saplings were collected from different nurseries of Dhaka city.

3.4 Treatments of the experiment

This experiment was conducted to compare the influence of different mulches on strawberry production. The experiment had two factors. They are as follows:

Factor A: Three genotypes of strawberry seedling were used

i) V_1 (RABI-3)
ii) V_2 (Camarosa)
iii) V_3 (Nohime)

Factor B: There were 4 types of mulch treatments as follows :

i) M_o (No mulch) : Plants were grown without mulch
ii) M_1 (Rice straw): Surface of the pot covered with rice straw.
iii) M_2 (Styrofoam): Surface of the pot covered with styrofoam plastic.
iv) M_3 (Black polythene): Surface of the pot covered with black polythene.

Application of mulches was started from 15 days after transplanting the seedlings.

3.5 Design of the experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. A total of 48 pots were used in the experiment.

3.6 Layout

The whole experimental pots were divided into four blocks, each of which was then divided into 12 unit pots. The total number of plots was 48. The size of each unit pot was 25 cm (10 inches) in diameter and 20 cm in (8 inches) in height. The spaces between blocks and unit pots were 60 cm and 30cm, respectively

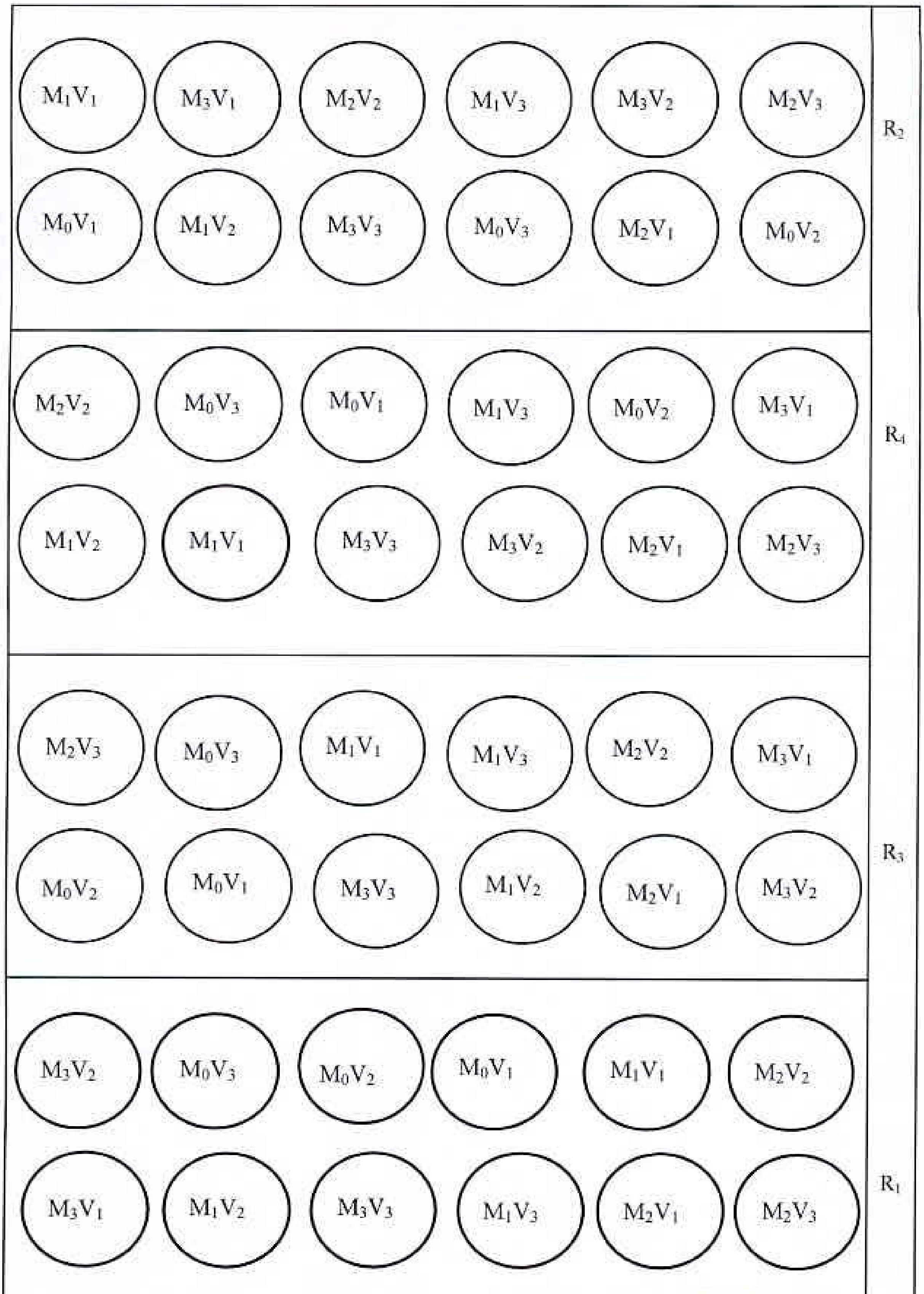

Fig 3.1 Layout of the experiment field

3.7 Pot preparation

In this experiment earthen pot were used. At first the pots were sun dried. Loamy soils were used for pot preparation. The weeds and stubbles were completely removed from the soil. Soil and cowdung were mixed and pots were filled 7 days before transplanting. Pots were filled on 4th November 2010.

3.8 Transplanting of seedlings

Runners were transplanted in such a way that the crown does not go much under the soil or did not remain in shallow. On an average runners were planted at 7 cm depth in pot on 11th November 2010. Only one seedling was planted in one pot.

3.9 Manure and fertilizers application

Cowdung @ 0.75 kg/pot and vermicompost @ 0.25 kg/pot were applied during pot preparation. Chemical fertilizers were not used in this experiment.

3.10 Intercultural operations

3.10.1 Weeding

Weeding was done whenever necessary and to pulverize the soil. Weeding was done manually by 'Khurpi'.

3.10.2 Irrigation

Frequency of watering depended upon the moisture status of the soil and water logging was avoided. Irrigation was done as and when needed.

3.10.3 Protection

During fruit ripening time the pots were covered with net to protect the fruit from bird, squirrel and rat.

3.10.4 Disease and pest control

Experimental crop was infested by grey mold during the flowering stage. It was controlled by spraying Endofil M-45 @ 1mg/L. Fungicide was sprayed two times at 15 days interval. Crop was also attacked by leaf feeder during the growing stage and flowering stage. The larvae were controlled by Pyrithrum @ 1.15 ml/L. The insecticides were sprayed 7 days after transplanting of runners.

3.10.5 Harvesting of fruits

Fruits were harvested from 26th January 2011. At harvesting, the fruits turned red in color with waxy layer on its surface.

3.11 Data collection

3.11.1 Leaf Area Index (LAI)

Leaf area was measured by using CL-202 Leaf Area Meter and expressed in cm^2. For leaf area measurement the mature leaf were collected from each plant. The leaf areas were measured by destructive method. After measuring leaf area the Leaf Area Index (LAI) was calculated by following formula:

$$LAI = \frac{\text{Total leaf area of a plant}}{\text{Ground area covered by the plant canopy}}$$

3.11.2 Days to 1st floral bud initiation, flowering, fruiting and fruit ripening

Days to floral bud initiation, flowering, fruiting and fruit ripening was counted from the date of transplanting.

3.11.3 Number of floral buds, flowers and fruits plant^{-1}

Number of leaves, flower buds, flowers and fruits per plant was recorded by counting all the leaves and flower bud, flowers and fruits from each plant of each pot and the mean was calculated.

3.11.4 Percentage of fruit set

It was determined by the formula:

$$\text{Percentage of fruit set} = \frac{\text{No. of seeded fruits per umbel}}{\text{No. of flowers per umbel}} \times 100$$

3.11.5 Fruit weight (g) plant^{-1} and Average fruit weight (g) plant^{-1}

Every fruit was weighed with the help of electrical balance. The total weight of each pot was obtained by addition the weight of total fruits. Average fruit weight was obtained from division of the total fruit weight by total number of fruit.

3.11.6 pH of the fruit

The pH content was measured by pH meter (Model-pH-208, Lutron electronic Enterprise Company Limited, Taiwan). To measure the pH content 10 gm fruits were sampled and blended with distilled water. After blending the juice was collected and made it volume 20 ml by adding distilled water. Then juice sample was analyzed with the pH meter.

3.11.7 Soluble Solid Content (SSC)

The soluble solid content (SSC) was measured by a refractometer (ERMA, Tokyo¬Japan). To measure the SSC percentage 5 gm fruits were sampled and blended. After blending the juice were collected. The SSC percentage of fruits was measured at 20^0C. When the temperature was more or less than 20 °C the reading was corrected by using the temperature correction table.

3.11.8 Ascorbic acid percentage

Ascorbic acid (%) was measured by 2, 4 dichlorophenol indophenol visual titration method. (Ranganna, 1986)

Reagents:

1. 3% Meta phosphoric acid (HPO_3): Pellets of HPO_3 was dissolved in glass distilled water.
2. Ascorbic acid standard: 100mg of l-ascorbic acid was taken and was made up to 100ml with 3% HPO_3. 10ml was diluted to 100ml with 3% HPO_3. (1 ml=0.1mg of ascorbic acid)
3. Dye solution : 50mg of sodium salt of 2,6 – dichlorophenol-indophenol was dissolved in approximately 150ml of hot glass distilled water containing 42mg of sodium bicarbonate. It was diluted and cool with glass distilled water to 200ml than it was stored in a refrigerator.

Procedure:

Standardization of dye: 5ml of standard ascorbic solution was taken and 5ml of HPO_3 was added. A micro burette was filled with the dye. Titration with the dye solution was done to a pink colour that persisted for 15seconds. Dye factor was determined, i.e. mg of ascorbic acid per ml of the dye, using the formula:

Dye factor = 0.5/titre

Preparation of sample:

10 ml of sample was taken and was made up to 100ml with 3% HPO_3. After that the solution is filtrated with filter paper.

5 ml of the HPO_3 extract of the sample was taken and titrated with the standard dye to a pink end point which should persist for at least 15 sec.

Calculation:

Calculation of ascorbic acid content of the sample from the following formula-

$$\text{Ascorbic acid (\%)} = \frac{\text{Titre} \times \text{Dye factor} \times \text{volume made up} \times 100}{\text{Extract taken for estimation} \times \text{Volume of sample taken for estimation}}$$

3.12 Statistical analysis

Data were statistically analyzed by the computer using statistical package programme MSTAT–C. The means for all the treatments were calculated and the analysis of variance was performed by F-variance test. The difference between pair of means was performed by Least Significant Difference (LSD) test (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV
RESULTS AND DISCUSSION

The research work was conducted to find out the effects of mulches on the yield and quality of strawberry. The results of this experiment have been presented and discussed in this chapter. A summary of the analysis of variance of all the parameters studied together with their sources of variation and corresponding degrees of freedom have been shown in the Appendices II to VI. Results of the different parameters studied in the experiment have been presented and discussed under the following headings.

4.1 Growth of strawberry genotypes grown with different mulches

4.1.1 Leaf area index (LAI) of strawberry genotypes grown with different mulches

Leaf Area Index (LAI) was measured at 25 and 50 days of transplanting (DAT).

Significant variation in LAI at 25 and 50 DAT were found among genotypes. Genotype V_2 (Camarosa) showed the highest LAI at 25 DAT (10.63) and (17.47) at 50 DAT. At 50 DAT V_2 was statistically similar with V_3 (Nohime). The second highest LAI at 25 DAT (8.513) were found under V_1 (RABI-3) and that was statistically similar to V_3 (Nohime) which was significantly different from that under V_2 (7.419) at 25 DAT. The lowest LAI at 50 DAT (14.48) was found in V_1 (RABI-3)

Table 4.1 Leaf area index of different strawberry genotypes under different mulches[x]

Genotype[y]	Leaf Area Index (LAI)	
	25 DAT	50 DAT
V_1	8.513	14.48
V_2	10.63	17.47
V_3	7.419	15.48
$LSD_{0.05}$	1.996	2.705
Mulch[z]		
M_0	8.006	12.08
M_1	9.258	17.82
M_2	8.670	15.13
M_3	9.481	18.21
$LSD_{0.05}$	1.704	2.310
Interaction		
$M_0 V_1$	7.867 bc	11.63 e
$M_1 V_1$	8.766 bc	17.90 bc
$M_2 V_1$	7.508 c	13.06 de
M_3V_1	9.910 ab	15.34 cd
$M_0 V_2$	11.04 a	13.05 de
$M_1 V_2$	11.66 a	20.22 ab
$M_2 V_2$	9.832 ab	15.57 cd
M_3V_2	9.992 ab	21.03 a
$M_0 V_3$	5.112 d	11.56 e
$M_1 V_3$	7.352 cd	15.34 cd
$M_2 V_3$	8.671 bc	16.77 c
M_3V_3	8.540 bc	18.25 abc
$LSD_{0.05}$	2.270	3.076
CV (%)	14.82	11.25

[x] In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance by LSD range test

[y] V_1; RABI-3, V_2; Camarosa and V_3; Nohime

[z] M_0; Control, M_1; Straw mulch, M_2 ; Styrofoam mulch, M_3; Black polythene mulch

LAI at 25 DAT under all mulching treatments were not significant but at 50 DAT significant variation were found. The highest LAI at 25 DAT (9.418) was obtained under M_3 (Black polythene mulch), which was followed by M_1, M_2 and M_0 (no mulch) had the lowest leaf area index (8.006). While in LAI at 50 DAT was found highest (18.21) under M_3 (Black polythene mulch), which was followed by M_1 and statistically similar. The lowest (12.08) LAI at 50 DAT was found under M_0 (no mulch).

A significant variation in LAI at 25 and 50 days was also observed under different interaction effects of mulching and genotypes. The highest LAI at 25 DAT (11.66) was obtained under M_1V_2 (straw mulch × Camarosa genotype), which was followed by M_0V_2, M_3V_2, M_2V_2 and statistically simillar. On the other hand the lowest LAI at 25 DAT (5.112) was found under M_0V_3 (No mulch × Nohime genotype). While in LAI at 50 DAT was found highest (21.03) under M_3V_2 (black polythene × Camarosa), which was followed by M_1V_2 and M_3V_3 treatment combination. The lowest (11.63) LAI at 50 DAT was found under M_0V_1.

Vegetative growth of strawberry plant responses can be modified by the type of organic or synthetic mulch used in the production system (Himelrick et al., 1993, Pirjo et al., 2002, Sharma et al., 2004, Atkinson et al., 2006, Ali and Gaur, 2007 and Singh et al., 2007). Gupta & Acharya (1993) observed the highest vegetative growth of strawberry plant in black polythene mulch. LAI plays a key role in vegetative growth and development of strawberry plant. Shiow et al., (1998) and Regina et al., (2006) also reported that there is a significant mulch cultivar interaction in chlorophyll contents. The rate of photosynthesis, respiration and other metabolic activities are occurred in the leaf. These all activities are fully or partially depend on LAI It is predominantly a genetic character. In this experiment genotype V2 (Camarosa) showed the highest LAI with different mulches after 25 and 50 days. There is no statistically significant variation occur at 25 DAT but at 50 DAT it showed the significant variation in application of mulch treatments and among them M3 (black polythene mulch) had the highest LAI with all genotypes. This findings was in agreement with the reports of Sharma et al., (2004) and Katiyar et al., (2009) reported that mulching have positive impact on leaf area and leaf number. Beside this findings Shiow et al., (1998) and Regina et al., (2006) found higher LAI in straw mulch. In this experiment from the interaction effect it is clearly identified that initially M_1V_2 (straw mulch × Camarosa genotype) had maximum LAI but finally after 50 DAT it is maximum in M_3V_2 (black polythene × Camarosa genotype). Shiow et al., (1998) found a significant mulch cultivar interaction in leaf area and chlorophyll contents. On the basis of above discussion it is concluded that black polythene mulch has a positive influence on LAI.

4.1.2 Days to 1st floral bud initiation

The days to 1st floral bud initiation from transplanting are presented on Figure 4.1, 4.2 and 4.3 which show there were significant variations of this character among the genotypes, mulching treatment and the mulching×genotype interactions.

Genotype V_3 (Nohime) needed the maximum days to 1st floral bud initiation (71.75 DAT), which was followed by V_2 (RABI-3). The genotype V_2 (Camarosa) required minimum days to 1st floral bud initiation (50.38 days) which was significantly different from that under V_1 and V_3.

Among all mulching treatments maximum days required to 1st floral bud initiation (69.25 DAT) was obtained under M_0 (no mulch). The second highest days to 1st floral bud initiation (61.33 DAT) was found under M_2 (styrofoam mulch), which was followed by M_1 and statistically similar. The minimum (50.67 DAT) was found under M_3 (black polythene mulch).

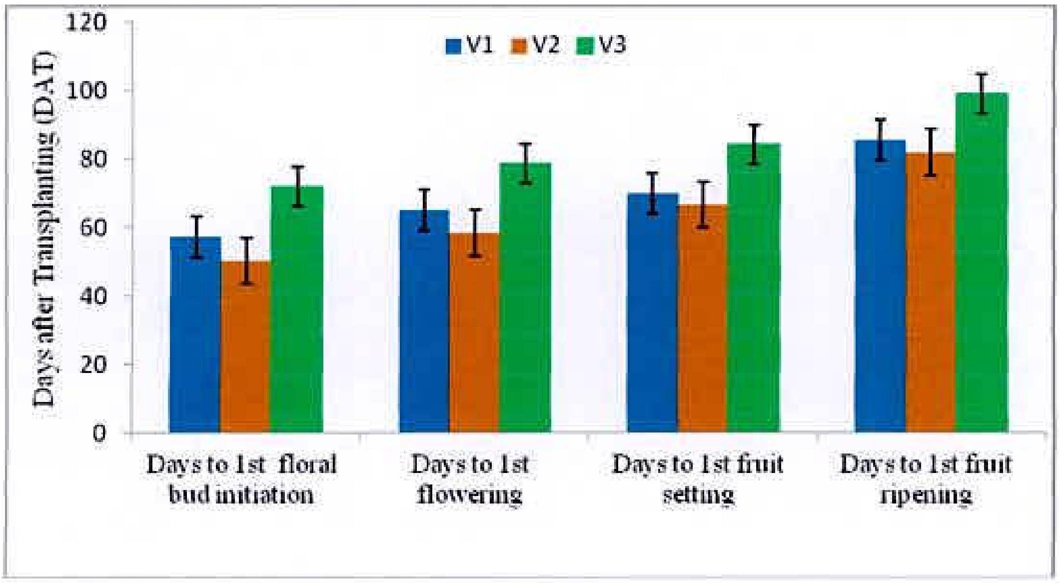

Fig. 4.1 Days to 1st floral bud initiation, flowering, fruit setting and fruit ripening (V_1: RABI-3, V_2: Camarosa and V_3: Nohime)

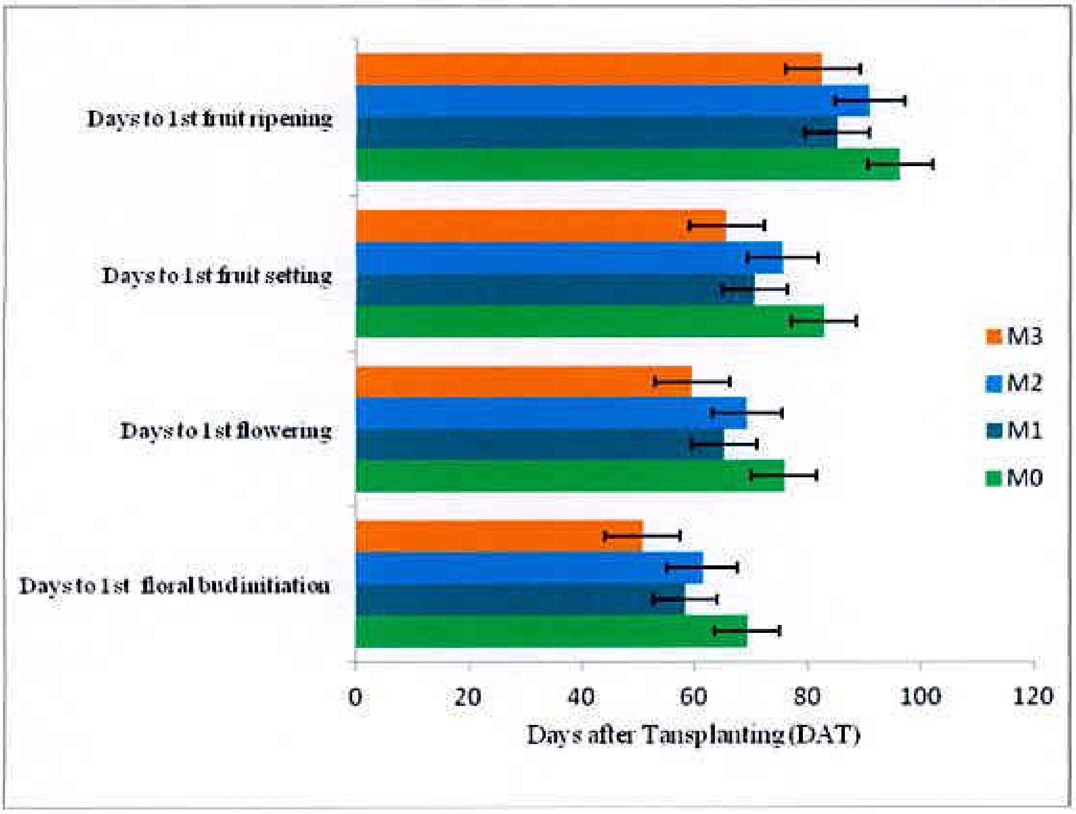

Fig. 4.2 Days to 1st floral bud initiation, flowering, fruit setting and fruit ripening (M_0: Control or no mulch, M_1: Straw mulch, M_2: Styrofoam mulch and M_3: Black polythene mulch)

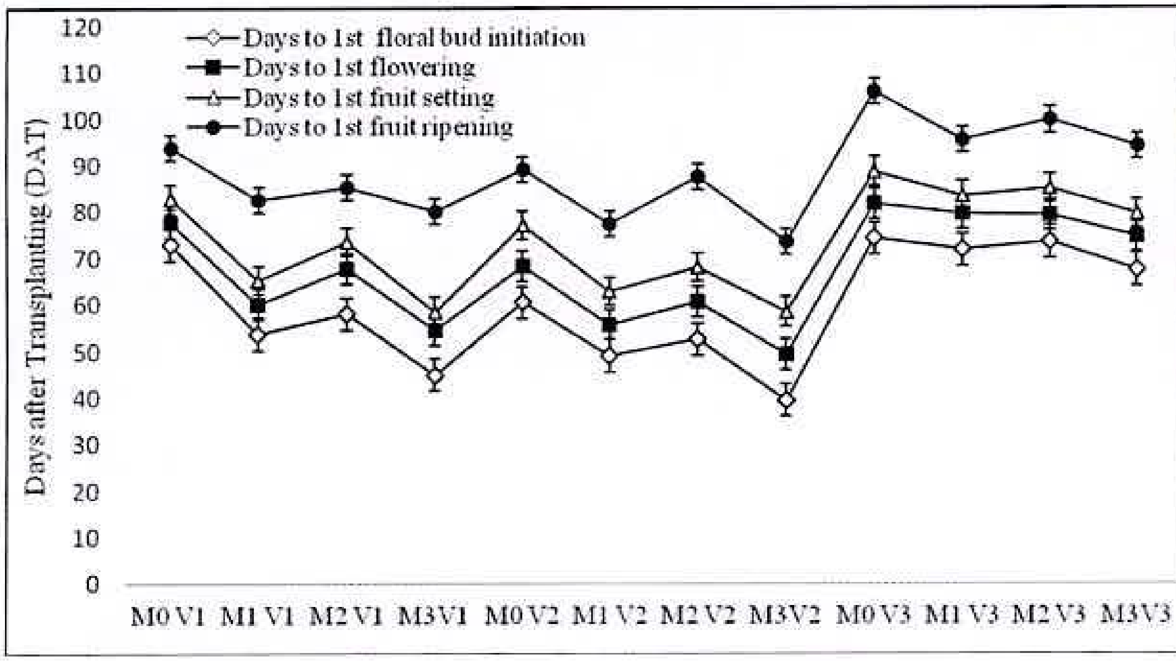

Fig 4.3 Days to 1st floral bud initiation, flowering, fruit setting and fruit ripening under mulch × genotype interactions (M0V1: Control × RABI-3, M1V1: Straw mulch × RABI-3, M2V1: Styrofoam × RABI-3, M3V1: Black polythene muclh × RABI-3, M0V2: Control × Camarosa, M1V2: Straw mulch × Camarosa, M2V2: Styrofoam × Camarosa, M3V2: Black polythene muclh × Camarosa, M0V3: Control × Nohime, M1V2: Straw mulch × Nohime, M2V2: Styrofoam × Nohime, M3V2: Black polythene muclh × Nohime)

In different interaction effects of mulching and genotypes maximum days required to 1st floral bud initiation (74.25 DAT) was obtained under M_0V_3 (no mulch × Nohime genotype), which was statistically identical with M_2V_3, M_0V_0, M_1V_3 and M_3V_3 treatment combinations. On the other hand the minimum days required to 1st floral bud initiation (39.50 DAT) was found under M_3V_2 (black polythene mulch × Camarosa genotype), which was statistically similar with M_3V_1 (black polythene mulch × RABI-3).

A number of scientists reported that mulch influence the growth (Himelrick et al., 1993, Pirjo et al., 2002, Sharma et al., 2003, Atkinson et al., 2006, Ali and Gaur 2007 and Singh et al., 2007) and among them black polythene mulch is the best (Gupta & Acharya 1993 and Ali and Gaur 2007). Days to 1st floral bud initiation is an important character in relation with early flowering. Within a short duration of winter period total flower number is depend on the days to 1st floral bud initiation. Early floral bud initiation ensures early flowering and fruiting. The yield and quality of fruit increase with early floral bud initiation. It is predominantly a genetic character but appropriate agro-technical practice slightly increase growth, yield and fruit quality (LaMondia et al., 2002). To get better performance in a short period mulching is essential. In this experiment genotype V_2 (Camarosa) required minimum time for floral bud initiation treated with different mulches. From all mulch treatments M_3 (black polythene mulch) performed the best with all genotypes and minimum time required in this treatment. From the interaction effect it is identified that black polythene mulch with Camarosa and RABI-3 genotype give the best performance. On the basis of above discussion it is clear that black polythene mulch is effective in initiating early floral bud initiation of strawberry.

4.1.3 Days to 1st flowering

The days to 1st flowering from transplanting are presented on Figure 4.1, 4.2 and 4.3 which show that there was a significant variation of this character among the genotypes, mulching treatment and the mulching×genotype interactions.

Genotype V_3 (Nohime) required maximum days to 1st flowering (78.75 DAT). The second highest days to 1st flowering (64.94 DAT) was found under V_1 (RABI-3), which was statistically similar with V_2 (Camarosa) and this (58.44 DAT) was significantly different from that under V_3.

Among all mulching treatments maximum days required to 1st flowering (75.83 DAT) was obtained under M_0 (no mulch). The second maximum days to 1st flowering (69.17 DAT) was found under M_2 (styrofoam mulch), which was statistically similar with M_1. The minimum days to 1st flowering (59.42 DAT) was found under M_3 (black polythene mulch) and which was statistically identical to M_1.

In different interaction effects of mulching and genotypes maximum days required to 1st flowering (81.75 DAT) was obtained under M_0V_3 (no mulch × Nohime genotype), which was statistically similar with M_1V_3, M_2V_3, M_0V_1 and M_3V_3 treatment combination. On the other hand the lowest days to 1st flowering (49.25 DAT) was found under M_3V_2 (black polythene × Camarosa genotype), which was statistically similar with M_3V_1 treatment combination.

With beginning of flowering, plant enters into reproductive stage. Early flowering have a significant effect on fruit setting, fruit number, size and quality of the fruit. In a short duration only early flowering can ensure better yield and fruit quality. Plekhanova and Petrova (2002), Ali and Gaur (2007) reported that black plastic mulch accelerates flowering. It also increase percentage of fruit set and fruit number and total fruit weight is also high. It is predominantly a genetic character. In this experiment genotype V_2 (Camarosa) required the lowest time for flowering treated with different mulches. From all mulch treatments M_3 (black polythene mulch) performed the best with all genotypes and minimum time required for flowering. Laugale et al., (2006) disagree with the findings of this experiment and reported that flowering is not differing significantly in mulch treatment. In this experiment from the interaction effect it is identified that M_3V_2 and M_3V_1 treatment combination give the best performance. On the basis of above discussion it is clear that black polythene mulch is effective in accelerates flowering.

4.1.4 Days to 1st fruit setting

The days to 1st fruit setting from transplanting are presented on Figure 4.1, 4.2 and 4.3 which show that were a significant variation of this character among the genotypes, mulching treatment and the mulching×genotype interactions.

Genotype V_3 (Nohime) required maximum days to 1st fruit setting (84.19 DAT). The second maximum days to 1st fruit setting (70 DAT) was found under V_1 (RABI-3), that was statistically identical with genotype V_2 (Camarosa) which required minimum days to 1st fruit setting (66.56 DAT) and significantly different from that V_3.

Among all mulching treatments maximum days required to 1st fruit setting (82.83 DAT) was obtained under M_0 (no mulch) and which was followed by M_2, M_1 and M_3 mulch treatment those are not statistically similar. The minimum days required to 1st fruit setting (65.50 DAT) was found under M_3

(black polythene mulch), which was statistically different from other mulch treatment.

In different interaction effects of mulching and genotypes maximum days required to 1st fruit setting from transplanting (88.75 DAT) was obtained under M_0V_3 (no mulch × Nohime genotype), which was statistically identical with M_2V_3 and M_1V_3, M_0V_1 treatment combinations. On the other hand the minimum days to 1st fruit setting (58.50 DAT) was found under M_3V_1 (black polythene mulch × RABI-3 genotype) and M_3V_2 (black polythene mulch × Camarosa genotype), which was statistically similar with M_1V_2 treatment combinations.

Mohamed (2002) reported that early fruit setting and yield is significantly increase by different mulches compared with unmulched control. Days to 1st fruit setting is an important character in growth stage of strawberry plant. Early fruit setting increase total fruit number, berry size and quality of the fruit. It has a great impact on yield and quality contributing characters of the fruit. It is predominantly a genietic character but mulch treatment can shorten the fruit setting period. Genotype V_2 (Camarosa) required minimum time for fruit setting treated with different mulches. From all mulch treatments M_3 (black polythene mulch) performed the best with all genotypes and minimum time required for fruit setting in this treatment. From the interaction effect it is identified that M_3V_2 and M_3V_1 treatment combination give the best performance. On the basis of above discussion it is clear that black polythene mulch is very much effective in strawberry production.

4.1.5 Days to 1st fruit ripening

The days to 1st fruit ripening from transplanting is presented on Figure 4.1, 4.2 and 4.3 which show that those were a significant variation this character among the genotypes, mulching treatment and the mulching × genotype interactions.

Genotype V_3 (Nohime) required maximum days to 1st fruit ripening (98.81 DAT). The second maximum days required to 1st fruit ripening (85.38 DAT) was found under V_1 (RABI-3), which was statistically similar with V_2 (Camarosa) and the genotype V_2 (Camarosa) required minimum (81.88 DAT) which was significantly different from that under V_3.

Among all mulching treatments maximum days required to 1st fruit ripening (96.33 DAT) was required under M_0 (no mulch). The second highest days to 1st fruit ripening (90.83 DAT) were found under M_2 (styrofoam mulch). The minimum days to 1st fruit ripening (82.50 DAT) was found under M_3 (black polythene mulch), which was statistically similar with M_1.

In different interaction effects of mulching and genotypes maximum days required to 1st fruit ripening (106 DAT) was observed under M_0V_3 (no mulch × Nohime genotype), which was statistically identical with M_2V_3 treatment combinations. The third highest days to 1st fruit ripening (95.50 DAT) was found under M_1V_3 (Straw mulch × Nohime), which was statistically identical with M_3V_3 and M_0V_1. On the other hand the minimum days to 1st fruit ripening (73.50 DAT) was found under M_3V_2 (black polythene mulch × Camarosa genotype), which was statistically identical with M_1V_2 and M_3V_1 treatment combinations.

Mohamed (2002) reported that fruiting and yield are significantly increase by mulch treatment compared with unmulched control. Days to 1st fruit ripening is an important character in relation with yield, fruit size and fruit quality. In Bangladesh the duration of winter period is very short that's why average fruit size, total fruit number, yield and fruit quality is highly depend on the time required for fruit ripening. Within a short vegetative period early fruit ripening sometime decrease the fruit size but it may be not clear. Plekhanova and Petrova (2002), Birkeland et al., (2002) reported that black plastic mulch promoted fruit ripening. It is predominantly a genetic character. In this experiment genotype V_2 (Camarosa) required minimum time for fruit ripening treated with different mulches. From all mulch treatments M_3 (black polythene mulch) performed the best with all genotypes and minimum time required for fruit setting in this treatment. From the interaction effect it is identified that black polythene mulch treated in Camarosa give the best performance. On the basis of above discussion it is clear that black polythene mulch promoted fruit ripening with different strawberry genotypes.

Table 4.2 Yield contributing characters of strawberry genotypes under different mulches[x]

Genotype[y]	Flower bud plant^{-1}	Flower plant^{-1}	Fruit setting (%) plant^{-1}
V_1	47.81	43.56	88.43
V_2	44.94	38.75	87.02
V_3	21.69	17.75	75.09
$LSD_{0.05}$	5.655	4.856	10.16
Mulch[z]			
M_0	31.92	27.08	76.09
M_1	39.75	35.75	84.65
M_2	36.50	31.92	83.95
M_3	44.42	38.67	89.37
$LSD_{0.05}$	4.830	4.147	8.674
Interaction			
$M_0 V_1$	39.50 d	33.50 c	86.10 ab
$M_1 V_1$	50.50 ab	46.25 ab	90.70 a
$M_2 V_1$	46.75 bc	44.00 b	85.79 abc
M_3V_1	54.50 a	50.50 a	91.13 a
$M_0 V_2$	39.00 d	33.50 c	76.46 bcd
$M_1 V_2$	46.25 bc	41.25 b	89.92 a
$M_2 V_2$	42.00 cd	35.00 c	91.56 a
M_3V_2	52.50 ab	45.25 ab	90.13 a
$M_0 V_3$	17.25 f	14.25 e	65.71 d
$M_1 V_3$	22.50 ef	19.75 de	73.32 d
$M_2 V_3$	20.75 ef	16.75 de	74.50 cd
M_3V_3	26.25 e	20.25 d	86.84 ab
$LSD_{0.05}$	6.432	5.523	11.55
CV (%)	9.75	9.57	7.99

[x] In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance by LSD range test

[y] V_1; RABI-3, V_2; Camarosa and V_3; Nohime

[z] M_0; Control, M_1; straw mulch, M_2 ; Styrofoam mulch, M_3; Black polythene mulch

4.2 Fruit yield of strawberry genotypes under different mulches

4.2.1 Flower bud plant^{-1}

The total number of flower bud plant^{-1} are presented on Table 4.2, which shows that there were a significant variation of this character among the genotypes, mulching treatment and the mulching×genotype interactions.

Genotype V_1 (RABI-3) found the highest flower bud plant^{-1} (47.31) which was statistically identical with V_2 (Camarosa). The genotype V_3 (Nohime) produced the lowest (21.69) flower bud plant^{-1} which was significantly different from V_1 and V_2.

Among all mulching treatments the highest flower bud plant^{-1} (44.42) was obtained under M_3 (Black polythene mulch), which was statistically identical with M_1 (Straw mulch). The third highest flower bud plant^{-1} (36.50) was found under M_2, which was statistically similar to M_1 (straw mulch). The lowest (31.92) flower bud plant^{-1} was found under M_0 (no mulch).

In different interaction effects of mulching and genotypes the highest flower bud plant^{-1} (54.50) was obtained under M_3V_1 (Black polythene mulch × RABI-3 genotype), which was statistically identical with M_3V_2 and M_2V_1 treatment combination. On the other hand the lowest flower bud plant^{-1} (17.25) was found under M_0V_3 (No mulch × Nohime genotype).

Flower bud plant^{-1} is an important yield contributing character of strawberry plant. It has a very close relation with total flower and fruit number of the plant. Different types of mulch affect the flower bud number significantly. It is predominantly a genetic character. Genotype V_1 (RABI-3) have the highest flower bud when treated with different mulches. Among all mulch treatments

M_3 (black polythene mulch) performed the best with all genotypes. From the interaction effect it is identified that M_3V_1 treatment combination give the best performance. From the above discussion, it is understood that RABI-3 treated with black polythene mulch increase the total floral bud plant^{-1}.

4.2.2 Flower plant^{-1}

The total number of flower plant^{-1} is presented on Table 4.2, which shows that there were significant variations of this character among the genotypes, mulching treatment and the mulching×genotype interactions.

Genotype V_1 (RABI-3) found the highest flower plant^{-1} (43.56) which was statistically identical with V_2 (Camarosa). The genotype V_3 (Nohime) produced the lowest flower plant^{-1} (17.75) which was significantly different from that under V_1 and V_2.

Among all the mulching treatments the highest flower plant^{-1} (38.67) was obtained under M_3 (Black polythene mulch), which was statistically identical with M_1 (Straw mulch). The third highest total number of flower plant^{-1} (31.92) was found under M_2 (Styrofoam mulch). The lowest flower plant^{-1} (27.08) was found under M_0 (No mulch).

In different interaction effects of mulching and genotypes the highest flower plant^{-1} (50.50) was obtained under M_3V_1 (Black polythene mulch × RABI-3 genotype), which was statistically identical with M_3V_2 and M_1V_1 treatment combination. On the other hand, the lowest flower plant^{-1} (14.25) was found under M_0V_3 (No mulch × Nohime genotype).

Himelrick et al., (1993) reported that reproductive strawberry plant responses can be modified by the type of organic or synthetic mulch used in the production system. Total flower number plant^{-1} is one of the main yields contributing characters of strawberry plant which have major impact on total fruit number and yield. It is predominantly a genetic character. Genotype V_1 (RABI-3) have the highest flower treated with different mulches. In this experiment mulches have significant influence on total flowers are found. Among all mulch treatments M_3 (black polythene mulch) performed the best with all genotypes. From the interaction effect it is clearly identified that M_3V_1 treatment combination give the best performance. So it is clear that RABI-3 genotype treated with black polythene mulch increase the total number of flower plant^{-1}. Laugale et al., (2006) reported that flowering did not differ significantly in different mulch treatments. Beside this Ali and Gaur (2007), Ravneet and Sarabjeet (2009) reported that total number of flower is highest in black plastic mulch.

4.2.3 Percentage of fruit set

The percentage of fruit set plant^{-1} is presented on Table 4.2, which show that were a significant variation of this character among the genotypes, mulching treatment and the mulching×genotype interactions.

Genotype V_1 (RABI-3) found the highest percentage of fruit set plant^{-1}(88.43) which was statistically identical with V_2 (Camarosa). The genotype V_3 (Nohime) showed the lowest percentage of fruit set (75.09) which was significantly different from that under V_1 and V_2.

Among all mulching treatments the highest percentage of fruit set plant^{-1} (89.37) was obtained under M_3 (Black polythene mulch), which was statistically identical with M_1 (straw mulch) and M_2 (styrofoam). The lowest percentage of fruit set plant^{-1} (76.09) was found under M_0 (No mulch).

The interaction effects of mulching and genotypes the highest percentage of fruit set plant^{-1} (91.56) was obtained under M_3V_2 (Black polythene mulch × Camarosa genotype), which was statistically identical with M_3V_1, M_1V_1, M_1V_2, M_3V_3, M_0V_1 and M_2V_1 treatment combination. On the other hand the lowest percentage of fruit set plant^{-1} (65.71) was found under M_0V_3 (No mulch × Nohime genotype).

Percentage of fruit set plant^{-1} is an important yield and quality contributing character of strawberry plant. Some time high percentage of flowering occurs but fruit setting is very low this happen due to genetic erosion or influence of different environmental factors or insect or disease infestation. The total loss occur in fruit setting is generally determined by percentage of fruit set. It is generally determining that genotype V_1 (RABI-3) have the highest percent of fruit set treated with different mulches. Among all mulch treatments M_3 (black polythene mulch) performed the best with all genotypes. From the interaction effect it is identified that M_2V_2. From above discussion it is clear that both RABI-3 and Camarosa genotype treated with black polythene and straw mulch increase the percentage of fruit set.

Table 4.3 Yield contributing characters of strawberry genotypes under mulches[x]

Genotype[y]	Fruits plant^{-1}	Fruit weight plant^{-1} (gm)	Average fruit weight plant^{-1} (gm)
V_1	38.44	310.5	8.194
V_2	33.63	324.7	9.804
V_3	13.44	32.35	2.448
$LSD_{0.05}$	2.014	27.78	1.158
Mulch[z]			
M_0	20.92	183.3	7.409
M_1	31.00	230.4	6.339
M_2	27.33	225.0	7.185
M_3	34.75	251.4	6.328
$LSD_{0.05}$	1.720	23.73	0.9886
Interaction			
$M_0 V_1$	28.50 e	258.4 c	9.069 b
$M_1 V_1$	41.75 b	331.4 ab	7.960 bc
$M_2 V_1$	37.50 c	301.7 b	8.085 bc
M_3V_1	46.00 a	350.5 a	7.663 c
$M_0 V_2$	25.00 f	269.9 c	10.80 a
$M_1 V_2$	36.75 c	329.9 ab	8.986 b
$M_2 V_2$	32.00 d	337.5 a	10.55 a
M_3V_2	40.75 b	361.5 a	8.877 bc
$M_0 V_3$	9.250 i	21.50 d	2.360 d
$M_1 V_3$	14.50 h	29.75 d	2.070 d
$M_2 V_3$	12.50 h	35.90 d	2.917 d
M_3V_3	17.50 g	42.25 d	2.444 d
$LSD_{0.05}$	2.291	31.60	1.317
CV (%)	4.65%	8.21%	11.16%

[x] In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance at LSD range test

[y] V_1; RABI-3, V_2; Camarosa and V_3; Nohime

[z] M_0; Control, M_1; straw M_2 ; styrofoam, M_3; black polythene

4.2.4 Fruits plant^{-1}

The total number of fruit plant^{-1} is presented on Table 4.3, which shows that there were significant variations of this character among the genotypes, mulching treatments and the mulching×genotype interactions.

Genotype V_1 (RABI-3) found the highest total number of fruit plant^{-1} (38.44 plant^{-1}). The second highest total number of fruit plant^{-1} (33.63) was found under V_2 (Camarosa). The genotype V_3 (Nohime) produced the lowest total number of fruit plant^{-1} (13.44) which was significantly different from that under V_1 and V_2.

Among all mulching treatments the highest total number of fruit plant^{-1} (34.75) was obtained under M_3 (black polythene mulch). The second highest total number of fruit plant^{-1} (31) was found under M_1 (straw mulch) and lowest total number of fruit plant^{-1} (20.92) was found under M_0 (No mulch).

In different interaction effects of mulching and genotypes the highest total number of fruit plant^{-1} (46.00) was obtained under M_3V_1 (Black polythene mulch × RABI-3 genotype). The second highest total number of fruit plant^{-1} (41.75) was found under M_1V_1 (Straw mulch × RABI-3) which was statistically identical with M_3V_2 (Black polythene mulch × Camarosa genotype). On the other hand the lowest total number of fruit plant-1 (9.25) was found under M_0V_3 (No mulch × Nohime genotype).

Himelrick et al., (1993) reported that reproductive strawberry plant responses can be modified by the type of organic or synthetic mulch used in the production system. Total number of fruit plant^{-1} is an important yield contributing character. It is fully depending on total number of flower plant^{-1}. Atkinson et al., (2006) also reported that mulches with different polythene have reflective capacities impacted on strawberry production; highly reflective mulches significantly increased and yield the latter due to increases in fruit size and fruit number. It is predominantly a genetic character. In this experiment genotype V_1 (RABI-3) have the highest fruit treated with different mulches and statistically different from rest of two genotypes. Mateusz et al., (2009) also found cultivar specific difference in fruit number. In this experiment among all mulch treatments M_3 (black polythene mulch) performed the best with all genotypes. Himelrick (1982), Plekhanova and Petrova (2002), Birkeland et al., (2002), Ali and Gaur (2007), Ravneet and Sarabjeet (2009) support the result of present experiment and found the same effect of mulch that black plastic mulch produced more fruit than other mulch treatment. From the interaction effect it is clearly identified that black polythene mulch application with RABI-3 genotype give the best performance. From above discussion it is clear that RABI-3 genotype treated with black polythene mulch increase the total number of fruit plant^{-1}.

4.2.5 Fruit weight plant^{-1} (gm)

The total fruit weight plant^{-1} is presented on Table 4.3, which shows that there were significant variations of this character among the genotypes, mulching treatment and the mulching×genotype interactions.

Genotype V_2 (Camarosa) found the highest fruit weight plant^{-1} (324.7 gm) which was statistically identical with V_1 (RABI-3). The genotype V_3 (Nohime) produced the lowest yield (32.35 gm) which was significantly different from that under V_1 and V_2.

Among all the mulching treatments the highest fruit weight plant^{-1} (251.4 gm) was obtained under M_3 (Black polythene mulch), which was statistically identical to M_1 (straw mulch). The second highest total fruit weight plant^{-1} (230.4 gm) was found under M_1, which was statistically similar to M_2

(Styrofoam mulch). The lowest fruit weight plant^{-1} (183.3 gm) was found in M_0 (No mulch).

In different interaction effects of mulching and genotypes the highest fruit weight plant^{-1} (361.5 gm) was obtained under M_3V_2 (Black polythene mulch × Camarosa genotype), which was statistically identical with M_3V_1, M_1V_2, M_1V_1 and M_0V_2 treatment combination. On the other hand the lowest fruit weight plant^{-1} (21.50 gm) was found under M_0V_3 (No mulch × Nohime genotype).

Medina et al., (2011) reported that all mulch treatment give higher yield compared with the control and black polythene mulch is adequate for the open field cultivation. Fruit weight plant^{-1} is the measurement of yield and it is very important. The total fruit weight plant^{-1} is fully depending on different growth parameters. It is predominantly a genetic character. In this experiment genotype V_2 (Camarosa) have the highest total fruit weight treated with different mulches. Mateusz et al., (2009) also find out cultivar specific difference in yield when it is treated with different mulches. Mohamed (2002) reported that Camarosa give higher yield when treated with polythene mulch. In this experiment among all mulch treatments M_3 (black polythene mulch) performed the best with all genotypes. Himelrick (1982), Gupta and Acharya (1993), Wittwer and Castilla (1995), Cortez (1995), Pirjo et. al., (2002), Plekhanova and Petrova (2002), Kikas and Luik (2002), Sharma & Sharma, (2003), Mathad and Jholgiker (2005), Rajbir (2005), Singh et al., (2007), Ali and Gaur (2007), Ravneet and Sarabjeet (2009), Medina et al., (2011) and Laugale et al., (2012) reported that black polythene increase the yield of strawberry over the unmulched control. In this experiment from the interaction effect it is clearly identified that black polythene mulch treated in Camarosa genotype gives the best performance. From above discussion it is clear that Camarosa genotype treated with black polythene mulch give the highest total fruit weight plant^{-1}. This finding disagrees with the result founded by Baumann et al., (1995). They observe that no yiled difference between different plastic mulch. Kasperbauer, (2000) and Laugale et al., (2006) also showed that black plastic mulch have lower yield than red plastic mulch but mulching has a significant effect on yield.

4.2.6 Average fruit weight plant^{-1} (gm)

Average fruit weight is presented on Table 4.3, which shows that there were significant variations of this character among the genotypes, mulching treatment and the mulching×genotype interactions.

Genotype V_2 (Camarosa) found the highest average fruit weight (9.804 gm). The second highest average fruit weight (8.194 gm) was found under V_1 (RABI-3). The genotype V_3 (Nohime) produced the lowest average fruit weight (2.448 gm) which was significantly different from that under V_1 and V_2.

Among all the four mulching treatments the highest average fruit weight (251.4 gm) was obtained under M_0 (No mulch), which was statistically identical with M_3 (Styrofoam mulch). The second highest average fruit weight (6.339 gm) was found under M_1, which was statistically similar to that under M_3 (Black polythene mulch) and it is the lowest compared with the other.

In different interaction effects of mulching and genotypes the highest average fruit weight (10.80 gm) was obtained under M_0V_2 (No mulch × Camarosa genotype), which was statistically identical with M_2V_2 treatment combination. The second highest average fruit weight (9.069 gm) was found on M_0V_1 (No mulch × RABI-3), which was statistically identical with M_1V_2, M_3V_3, M_2V_1, M_1V_1. On the other hand the lowest average fruit weight (2.07 gm) was found under M_1V_3 (Straw mulch × Nohime genotype).

Laugale et al., (2012) reported that mulch influence the average fruit size. In another study Atkinson et al., (2006) reported that highly reflective mulches significantly increased and yield, the latter due to increases in fruit size and number. Average fruit weight is an important yield and quality contributing character of strawberry plant. The average fruit weight is depending on different growth parameters. It is predominantly a genetic character. In this experiment genotype V_2 (Camarosa) have the highest average fruit weight treated with different mulches. Similar result also finds out by Mateusz et al., (2009) and reported that there is cultivar specific difference in average fruit weight under different mulches. In this experiment among all mulch treatments M_0 (control or no mulch) performed the best with all genotypes and mulch treatment decrease the fruit size and average fruit weight. The findings of this experiment have an agreement with the findings of Gupta and Acharya, (1993), Albregts and Chanler, (1993), Kasperbauer, (2000). All of them showed that black polythene mulch treatment produce small berries. Beside these findings of this experiment has a disagreement with the findings of Baumann et al., (1995), Mathad and Jholgiker (2005), Ali and Gaur (2007) and Laugale et al., (2012). They observed that black polythene mulch produced fruits of bigger size and average fruit weight is higher. Cortez (1995) also reported that average fruit weight was not affected by mulch treatments. In this experiment from the interaction effect it is clearly identified that M_0V_2 and M_2V_2 treatment combination give the best performance. From the above discussion it is clear that Camarosa genotype treated with black polythene mulch give the highest average fruit weight and due to a short growing and reproductive period in Bangladesh the fruits get in the last harvesting stage are very small that's why percentage of fruit set is high with different mulch treatment but the average fruit weight decrease.

4.3 Fruit quality

4.3.1 pH of the fruit of strawberry grown with different mulches

The pH of the fruit presented on Table 4.4, which shows that there were a significant variation of this character among the genotypes and the mulching×genotype interactions.

Genotype V_3 (Nohime) found the highest pH of the fruit (5.444). The second highest pH of the fruit (4.81) was found under V_2 (Camarosa), which was statistically similar with V_1. The genotype V_1 (RABI-3) produced the lowest pH of the fruit (4.676) which was significantly different from that under V_3.

There was not a significant variation observed in pH of the fruit under all the four mulching treatments. The highest pH of the fruit (5.117) was obtained under M_0 (No mulch), which was followed by M_2, M_3 and M_1. The lowest pH of the fruit was found under M_1.

In interaction effects of mulching and genotypes the highest pH of the fruit (5.77) was obtained under M_0V_3 (No mulch × Nohime genotype), which was statistically identical with M_2V_3 treatment combination. On the other hand the lowest pH of the fruit (4.57) was found under M_0V_1 (black polythene mulch × RABI-3 genotype), which was statistically similar with M_3V_1, M_1V_2, M_2V_2 and M_1V_1 treatment combinations.

Table 4.4 Quality contributing characters of strawberry genotypes under different mulches[x]

Genotype[y]	pH	SSC (%)	Ascorbic acid (%)
V_1	4.676	4.188	3.98
V_2	4.813	5.000	4.40
V_3	5.444	3.563	2.47
$LSD_{0.05}$	0.3402	0.6346	0.434
Mulch[z]			
M_0	5.117	4.250	3.18
M_1	4.833	4.000	3.60
M_2	5.042	4.583	3.65
M_3	4.918	4.167	4.03
$LSD_{0.05}$	0.2905	0.542	0.37
Interaction			
$M_0 V_1$	4.575 e	4.250 cde	3.65 d
$M_1 V_1$	4.650 de	3.750 ef	4.00 cd
$M_2 V_1$	4.900 cde	4.750 abc	4.05 cd
M_3V_1	4.580 e	4.000 de	4.20 bc
$M_0 V_2$	5.000 cd	5.250 a	4.00 cd
$M_1 V_2$	4.600 e	5.000 ab	4.15 bc
$M_2 V_2$	4.650 de	5.250 a	4.55 ab
M_3V_2	5.000 cd	4.500 bcd	4.90 a
$M_0 V_3$	5.775 a	3.250 f	1.90 g
$M_1 V_3$	5.250 bc	3.250 f	2.65 ef
$M_2 V_3$	5.575 ab	3.750 ef	2.35 fg
M_3V_3	5.175 c	4.000 de	3.00 e
$LSD_{0.05}$	0.3869	0.7217	0.49
CV (%)	3.15	6.95	5.58

[x] In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance at LSD range test

[y] V_1; RABI-3, V_2; Camarosa and V_3; Nohime

[z] M_0; Control, M_1; straw M_2 ; styrofoam, M_3; black polythene

Fruit quality is affected by agro-technical treatments such as mulching (LaMondia et al., 2002; Pawłowska et al., 2004). Mohamed (2002) observed that silver on purple plastic mulch significantly increased fruit quality and lowest in black plastic mulch. Shiow et al., (1998) reported that titratable acidity (TA) is influenced by different types of mulches. Mathad and Jholgiker (2005) also reported that mulches promoted TSS/acid ratio. pH is an important quality contributing character of strawberry plant. The acidity or alkalinity of the fruit is generally determined by measuring the pH of the fruit. It is predominantly a genetic character. In this experiment genotype V_1 (RABI-3) have the lowest pH treated with different mulches that's why the acidity of RABI-3 is highest. Beside this V_3 (Nohime) has a higher pH which is mostly alkaline. Among all mulch treatments M_3 (black polythene mulch) performed the highest pH with all genotypes and lowest pH found in M_0 (no mulch) but they are not significant. Gupta and Acharya, (1993) found the similar result like this experiment that black polythene mulch reduces acidity as compared with the remaining mulch treatment. Regina et al., (2006) also reported that there are no differences in fruit color, fruit soluble solids content, titratable acidity. In this experiment from the interaction effect it is identified that Nohime genotype treated with no mulch give the best performance. From above discussion it is clear that mulching had no significant effect on fruit pH which is supported by different scientist but pH has a significant variation among the different genotypes.

4.3.2 Soluble Solid Content (SSC) of the fruit of strawberry

Soluble Solid Content (SSC) of the fruits presented on Table 4.4, which shows that there were a significant variation of this character among the genotypes, mulching treatment and the mulching×genotype interactions.

Genotype V_2 (Camarosa) found the highest Soluble Solid Content (SSC) of the fruit (5.00 %). The second highest Soluble Solid Content (SSC) of the fruit (4.188 %) was found under V_1 (RABI-3), which was statistically identical with

V_3 (Nohime) and produced the lowest Soluble Solid Content (SSC) of the fruit (3.563 %).

The highest Soluble Solid Content (SSC) of the fruit (4.583 %) was obtained under M_2 (styrofoam mulch), which was statistically identical with M_0 (no mulch) and M_3 (black polythene mulch). The lowest Soluble Solid Content (SSC) of the fruit (4.00 %) was found under M_1 (straw mulch).

Among different interaction effects of mulching and genotypes the highest Soluble Solid Content (SSC) of the fruit (5.25 %) was obtained under M_0V_2 (no mulch × Camarosa genotype) and M_2V_2 (styrofoam × Camarosa), which was statistically identical with M_1V_2 and M_2V_1 treatment combination. On the other hand, the lowest Soluble Solid Content (SSC) of the fruit (3.25 %) was found under M_0V_3 (no mulch × Nohime) and M_1V_3 (Straw mulch × Nohime genotype).

Mulching improves fruit quality (Sharma & Sharma, 2003; Mohamed, 2002; LaMondia et al., 2002; Pawłowska et al., 2004; Singh et al., 2007) and Soluble Solid Content (SSC) is an important quality contributing character of strawberry plant. The sweetness of the fruit is generally determined by the measuring the SSC. Mathad and Jholgiker (2005), Ali and Gaur (2007), Ravneet and Sarabjeet (2009) and Katiyar et al., (2009) reported that mulched increase TSS and sugar percentage. It is predominantly a genetic character. In this experiment genotype V_2 (Camarosa) have the highest SSC treated with different mulches. Similar result is carried out by Shiow et al., (1998) and showed that cultivar specific variation in SSC when treated with different types of mulches. In this experiment among all mulch treatments M_2 (styrofoam mulch) performed the highest SSC with all genotypes. Similar result also carried out by Gupta and Acharya, (1993), Shiow et al., (1998) stated that SSC is higher on black polythene mulch over unmulched control. Beside the findings of the present experiment Ulvi et al., (2004) and Regina et al., (2006) reported that there is no impact of different mulches on SSC of the fruit which disagree the present findings. In this experiment from interaction effect it is clearly identified that Camarosa genotype treated with no mulch or Styrofoam mulch increase the SSC of the fruit. From the above discussion it is concluded that styrofoam mulch increase SSC of the fruit.

4.3.3 Ascorbic acid percentage of fruit of strawberry

The ascorbic acid percentage of fruits presented on Table 4.4, which show that were a significant variation of this character among the genotypes, mulching treatment and the mulching×genotype interactions.

Genotype V_2 (Camarosa) found the highest ascorbic acid (4.4%), which was statistically identical with V_1 (RABI-3). The genotype V_3 (Nohime) had the lowest ascorbic acid (2.47 %) which was significantly different from V_1 and V_2.

Among all mulching treatments highest ascorbic acid (4.03 %) was obtained under M_3 (black polythene mulch). Second highest ascorbic acid (3.65%) was obtained under M_2 (styrofoam mulch), which was statistically identical with M_1. The lowest ascorbic acid percentage of fruit (3.18%) was found under M_0 (no mulch), which was statistically different from all other mulch treatment.

In different interaction effects of mulching and genotypes highest ascorbic acid (4.90%) was obtained under M_3V_2 (black polythene mulch × Camarosa genotype), which was statistically identical with M_2V_2 treatment combination. The third highest ascorbic acid percentage of fruit (4.1%) was found on M_3V_1 (black polythene mulch × RABI-3), which was followed by M_2V_1 and M_1V_1

treatment combination and those were statistically dissimilar. On the other hand the lowest ascorbic acid percentage of fruit (19%) was found under M_0V_3 (no mulch × Nohime genotype).

Ascorbic acid present in high concentrations provides an essential nutrient with numerous associated health benefits (Block, 1991; Kalt, 2001; Olsson, 2004). Ascorbic acid percentage is an important quality contributing character of strawberry plant. The taste of the fruit is depending on ascorbic acid percentage in the fruit. It is predominantly a genetic character but mulching improves fruit quality (Sharma & Sharma, 2003; Mohamed, 2002; LaMondia et al., 2002; Pawłowska et al., 2004; Singh et al., 2007). Moor (2005) also reported that strawberry fruits from plastic mulch variant also contained more vitamin C than those from straw mulch variant. In this experiment genotype V_2 (Camarosa) have the highest ascorbic acid percentage treated with different mulches. Among all mulch treatments M_3 (black polythene mulch) performed the highest ascorbic acid percentage with all genotypes. Ali and Gaur (2007), Ravneet and Sarabjeet (2009) found the similar result and stated that ascorbic acid percentage is higher in black polythene mulch treatment. Ulvi et al., (2004) also reported that black plastic mulch with fertilization have a positive influence on vitamin C content of the fruit. Atkinson et al., (2006) reported that highly reflective mulches significantly increased ascorbic acid. Regina et al., (2006) disagrees with the present findings and reported that there are no differences in fruit color, ascorbic acid or ellagic acid among the plants grown in the different mulches. In this experiment from the interaction effect it is clear that Camarosa genotype treated with black polythene mulch increase the ascorbic acid percentage of the fruit. Similar result is also found by Shiow et al., (1998) reported that significant interaction effect between mulch × cultivar in ascorbic acid percentage but not in mulch.

CHAPTER V

SUMMARY AND CONCLUSION

CHAPTER V
SUMMARY AND CONCLUSION

The experiment was conducted at Horticulture Research Farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from November 2010 to April 2011. The objective of the study was to investigate the influence of different mulching on the growth yield and quality of strawberry. The experiment included three genotypes namely RABI-3, Camarosa, Nohime and four mulch treatments namely no mulch, straw mulch, styrofoam mulch and black polythene mulch. The experiment was laid out in randomized complete block design with four replications. Size of each pot was 25 cm × 20 cm. Runners were planted on 10^{th} November, 2010.

Among the three genotypes tested, Camarosa gave the best performance in terms of leaf area index, early floral bud initiation, flowering, fruit setting, fruit ripening and percentage of fruit set. Total fruit weight and average fruit weight also found the highest in Camarosa. Quality related parameters like soluble solid content (SSC) and ascorbic acid (%) also showed the same trend of result compared to the rest and was followed by RABI-3. The performance of the genotype Nohime was found the least comparing with other two genotypes. Mulch treatments also showed the significantly different result compared to the control treatment. Among the mulch treatments, black polythene mulch gave the best performance and which was followed by straw mulch. Leaf area index, early floral bud initiation, flowering, fruit setting and fruit ripening were found highest in black polythene mulch. This mulch also showed the best result in terms of total flower bud, flower, fruit, percentage of fruit set and total fruit weight. In relation with the qualitative parameters the best result in ascorbic acid percentage was found with this treatment. While in interaction effect the best performance was found in Camarosa genotype treated with black polythene, which showed the highest leaf area index, early floral bud initiation, flowering, fruiting and ripening. Yield and quality controlling character such as ascorbic acid percentage was found the highest in this treatment combination, which was followed by black polythene treated with RABI-3 genotype.

Camarosa genotype produced the highest leaf area index at 25 and 50 DAT. However, RABI-3 produced the highest flower bud, flower, fruit, percentage of fruit set and Nohime required the highest days to 1st floral bud initiation, flowering, fruiting and fruit ripening. On the other hand, Camarosa genotype required minimum days to 1st floral bud initiation, flowering, fruit setting and fruit ripening, which was followed by genotype RABI-3. Genotype RABI-3 had the lowest leaf area index at 50 DAT and Nohime genotype also produced lowest leaf area index at 25 DAT, total flower bud, flower, fruit and percentage of fruit set were observed. While in different types of mulches had a significant effect, black polythene mulch showed the highest leaf area index at 25 and 50 days. Flower bud, flower, fruit and percentage of fruit set were also the highest, which was followed by straw mulch treatment. In the no mulch or control treatment days to 1st floral bud initiation, flowering, fruit setting and fruit ripening period was the longest. The lowest number of days required to floral bud initiation, flowering, fruit setting and fruit ripening were observed in black polythene mulch which was followed by straw mulch. In case of interaction effect RABI-3 with black polythene mulch gave the best performance in leaf area index at 25 days, total floral bud, flower, fruit and fruit set percentage. On the other hand black polythene with Camarosa gave the highest result in leaf area index at 50 DAT. Black polythene with Nohime required the highest days to 1st floral bud initiation, flowering, fruit setting, fruit ripening compared to the other treatment combinations. Leaf area index found lowest in control with Nohime at 25 DAT and 50 DAT, the lowest number of days required to 1st floral bud initiation, flowering, fruit setting and fruit ripening was found in black polythene mulch with Camarosa. On the other hand, black polythene with RABI-3 fruit setting period was lowest. Total floral bud, flower, fruit, percentage of fruit set were found the highest in this combination.

In terms of yield Camarosa was the best followed by RABI-3 and Nohime. Fruit weight and average fruit weight plant^{-1} were the highest (324.7gm) and (9.804gm) in Camarosa genotype which was followed by RABI-3 genotype and gave (310.5gm) and (8.194gm) respectively and the lowest found in Nohime genotype. In case of mulching treatment total fruit weight was the highest (251.4gm) in black polythene but average fruit weight (7.409gm) was higher in control and which was followed by Styrofoam mulch. The lowest (183.3gm) yield was found in control or no mulch treatment. While in interaction effect yield found highest (361.5gm) in black polythene mulch with Camarosa genotype and average fruit weight found highest (10.80gm) in control or no mulch treatment with Camarosa. The lowest (21.50gm) yield observed in control or no mulch treatement and average fruit weight (2.07gm) found in straw mulch treatment both the genotype with Nohime.

In terms of quality Camarosa performed better than the other two genotypes did. The SSC (5%) and ascorbic acid percentage (4.4%) were highest in Camarosa. pH gave the highest value in Nohime. The lowest pH (4.67) was in RABI-3. SSC (3.56%) and ascorbic acid (2.47%) found lowest in Nohime. Among mulching treatments, pH value was the highest (5.11) in control or no mulch treatment but the variation was not significant. SSC is highest (4.58) in styrofoam mulch, which was followed by control or no mulch and black polythene mulch gave highest (4.03%) ascorbic acid percentage in fruit. On the other hand, pH (4.83) value and SSC (4%) was lowest in straw mulch and ascorbic acid content was lowest (3.18%) in control or no mulch treatment. While in interaction effect, pH (5.77) and SSC (5.25%) found highest in control or no mulch treatment with Nohime and Camarosa, respectively. Styrofoam mulch with Camarosa had also showed the highest (5.77%) SSC value. Ascorbic acid was higher (4.90) in black polythene when treated with Cmarosa. On the other hand, the lowest pH value (4.57) was found in control or no mulch treatment with RABI-3 genotype. SSC (3.25%) and ascorbic acid percentage (1.90%) of fruit found the lowest in control with Nohime.

CONCLUSION

The best vegetative growth was found with Camarosa genotype. Fruit weight and average fruit weight were also found maximum in Camarosa. But the maximum number of flower bud, flower and fruit and percentage of fruit set was found in RABI-3. Nohime had higher fruit pH which was significantly different from the others. The Soluble Solid Content (SSC) and ascorbic acid percentage was the maximum in the fruit of Camarosa. That means marketable yield was high in Camarosa genotype. Between the black polythene mulch and straw mulch there was no significant difference on vegetative growth and was statistical identical but it differs from other two treatments significantly. Maximum number of flower bud, flower, and fruit was recorded black polythene mulch. No significant variation observed in fruit pH among different mulching treatments but no mulch treatment gave the best result. SSC and ascorbic acid percentage of fruit was the maximum when treated with black polythene. In case of combined effect maximum number of flower bud, flower and fruit number was in RABI-3 treated with black polythene mulch. Total fruit weight was maximum in Camarosa treated with black polythene. The value of fruit pH was the greatest when Nohime treated with no mulch. Fruit SSC was higher in Camarosa treated with styrofoam and no mulch. Ascorbic acid percentage in fruit was the highest in Camarosa treated with black polythene mulch. Considering the above results, it might be concluded that Camarosa was the most suitable genotype. Among the mulching applications black polythene gave the best result for yield and quality attribute also gave better performance.

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

I. More genotypes of strawberry should be screened out for cultivation in Bangladesh condition.

II. Influence of different colors of the plastic mulches need to be studied on strawberry production in Bangladesh environment.

III. Further study is needed for determination of quality attributes of strawberry like nutritive value and antioxidant properties.

IV. Other parameters like storability, thickness, aroma and color of strawberry may be included for further study.

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APPENDICES

APPENDICES

Appendix I. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from October 2010 to March, 2011

Month	*Air temperature (°C)		*Relative humidity (%)	*Rainfall (mm) (total)
	Maximum	Minimum		
October, 2010	29.18	18.26	81	39
November, 2010	25.82	16.04	78	0
December, 2010	22.4	13.5	74	0
January, 2011	24.5	12.4	68	0
February, 2011	27.1	16.7	67	30
March, 2011	31.4	19.6	54	11

* Monthly average,

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

Appendix II. Analysis of variance of the data on leaf area index at different days after transplanting (DAT) of strawberry

Source of variation	Degrees of freedom	Mean square	
		Leaf Area Index (LAI) at	
		25 DAT	50 DAT
Factor A (Genotype)	2	42.636*	36.973*
Factor B (Mulches)	3	5.233	96.485*
Interaction (A×B)	6	6.622*	12.128*
Error	33	1.721	3.161

*: Significant at 0.05 level of probability

Appendix III. Analysis of variance of the data on days to 1st floral bud initiation, flowering, fruit setting and ripening at different days after transplanting (DAT) of strawberry

Source of variation	Degrees of freedom	Mean square			
		Days to 1st			
		Floral bud initiation	Flowering	Fruit setting	Fruit ripening
Factor A (Genotype)	2	1897.646*	1721.688*	1396.646*	1249.188*
Factor B (Mulches)	3	710.910*	573.361*	656.333*	447.354*
Interaction (A×B)	6	88.118*	59.382*	47.896*	59.021*
Error	33	17.248	19.598	14.136	17.915

*: Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on bearing habit of strawberry

Source of variation	Degrees of freedom	Mean square		
		Bearing habit at		
		Flower bud plant^{-1}	Flower plant^{-1}	Percentage of fruit set plant^{-1}
Factor A (Genotype)	2	3243.583*	3004.521*	778.984*
Factor B (Mulches)	3	329.255*	301.410*	358.048*
Interaction (A×B)	6	54.368 *	39.576*	173.2 3*
Error	33	13.819	10.188	44.575

*: Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on related to yield

Source of variation	Degrees of freedom	Mean square		
		Fruit yield at		
		Fruits plant^{-1}	Fruit weight plant^{-1} (gm)	Average fruit weight (gm)
Factor A (Genotype)	2	2815.188*	434787.984*	238.035*
Factor B (Mulches)	3	416.722*	9776.167*	3.813*
Interaction (A×B)	6	19.243*	1521.068*	2.341*
Error	33	1.753	333.571	0.579

*: Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on related to fruit quality

Source of variation	Degrees of freedom	Mean square		
		Fruit quality at		
		pH of the fruit	Soluble Solid Content (SSC) (%)	Ascorbic acid (%)
Factor A (Genotype)	2	1.341*	3.634*	809.167*
Factor B (Mulches)	3	0.096	0.791*	71.556*
Interaction (A×B)	6	0.102*	0.359*	17.389*
Error	11	0.025	0.087	4.076

*: Significant at 0.05 level of probability