EFFECT OF DIFFERENT MULCH MATERIALS ON GROWTH, YIELD AND QUALITY OF STRAWBERRY IN OPEN AND POLYHOUSE CULTIVATION IN MIZORAM

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

VANLALHMUAKA NGENTE

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DEPARTMENT OF HORTICULTURE, AROMATIC AND MEDICINAL PLANTS

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EFFECT OF DIFFERENT MULCH MATERIALS ON GROWTH, YIELD AND QUALITY OF STRAWBERRY IN OPEN AND POLYHOUSE CULTIVATION IN MIZORAM.

BY
VANLALHMUAKA NGENTE
DEPARTMENT OF HORTICULTURE, AROMATIC AND MEDICINAL PLANTS

SUPERVISOR
Dr. CHHUNGPUII KHAWLHRING

Submitted
In partial pulfillment of the requirement of the Degree of Doctor of Philosophy in Horticulture, Aromatic and Medicinal Plants of Mizoram University, Aizawl

Dedicated to

My beloved father

Lalrammawia Ngente,

Who has gone first on the 19th February of 2024

Mizoram University, Aizawl

(A Central University under the Act of Parliament)

partment of Horticulture, Aromatic & Medicinal Plants

उद्यानिकी, सगन्ध एवं औषधीय पादप विभाग

Dr. Chhungpuii Khawlhring

Associate Professor

No. 9/16/Ph.D. Prog./MZU-HAMP/60 **Dated 14.5.2025**

CERTIFICATE

This is to certify that **Mr. Vanlalhmuaka Ngente** has prepared a Thesis under my Supervision on the topic "**Effect of different mulch materials on growth, yield and quality of strawberry in open and polyhouse condition in Mizoram**" in partial fulfillment for the award of the Degree of Doctor of Philosophy (Ph.D.) in the Department of Horticulture, Aromatic and Medicinal Plants, Mizoram University, Aizawl.

This thesis has been the outcome of her original work and it does not form a part of other thesis submitted for the award of any other degrees.

She is duly permitted to submit the Thesis.

Dr. Chhungpuii Khawlhring

Supervisor

DECLARATION

MIZORAM UNIVERSITY

MAY, 2024

I **VANLALHMUAKA NGENTE**, hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis did not form basis of the award of any previous degree to me or to do the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other University/Institute.

This is being submitted to the Mizoram University for the **Degree of Doctor of Philosophy** in Horticulture, Aromatic and Medicinal Plants.

(VANLALHMUAKA NGENTE)
Candidate

(PROF. RAMBIR SINGH)
Head

(Dr. CHHUNGPUII KHAWLHRING)
Supervisor

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Vanlalhmuaka Ngente

Mizoram University, Aizawl

(A Central University under the Act of Parliament)

Department of Horticulture, Aromatic & Medicinal Plants

उद्यानिकी, सगन्ध एवं औषधीय पादप विभाग

Dr. Rambir Singh
Professor & Head

Dated 30.5.2024

TO WHOM IT MAY CONCERN

This is to certify that **Mr. Vanlalhmuaka Ngente**, a Ph. D. scholar, Registration No. MZU/Ph.D./1066 of 31.5.2017 has worked on the thesis entitled **"Effect of different mulch materials in growth, yield and quality of strawberry (*Fragaria x Ananassa* Duch.) in open and poly-house condition in Mizoram''**. He has fulfilled all criteria prescribed by the UGC (Minimum Standard and Procedure governing PhD Regulation). He has fulfilled the mandatory publication (publication enclosed). It is also certified that the scholar has been admitted in the department through entrance test followed by an interview as per Clause 9(i) & (ii) of the UGC Regulation 2009.

(RAMBIR SINGH)

Mob. 947358321; 7309446589, e-mail: hod.hamp@mzu.edu.in; www.mzu.edu.in

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/	:Per
A.O.A.C	:Association of Official Analytical Chemists
%	: Percentage
ANOVA	:Analysis of variance
^0C	: Degree Centigrade
M^2	: square metre
cm	: Centimeter
RBD	: Randomized Block Design
FYM	: Farm Yard Manure
DAP	:Days after planting
gm	: gram
E	: East
ppm	:parts per million
F.A.O	:Food and Agriculture Organization
Kg	: kilogram
ha	: Hectare
hr	: Hour
ml	: milliliter
NaOH	: sodium Hydroxide
HCL	: Hydrochloric acid
KVK	: Krishi Vigyan Kendra
N	: North
W	: West
S	: South
NS	:Non-significant
RH	:Relative humidity
S.Ed	:Standard error of difference
TSS	:Total soluble solids
Viz.	: Namely
Rs	:Rupees
Var.	:Variety

CHAPTER I

Introduction

Strawberry (*Fragaria x Ananassa* Duch.) family: *Rosaceae* is one of the most important temperate fruit which can be grown in tropical and subtropical climate. It is grown all over the world mainly consumed in fresh but also used to produce different fruit product. It is an excellent source of Vitamin and beta –carotene, dietary fiber and some other nutrients for human health and nutrition (Rannu *et al*., 2018). Strawberry is amongst the few crops which give quick and very high returns per unit area on the capital investment, as the crop is ready for harvesting within six months of planting. It is an important soft fruit after grapes and being preferred by people around the world due to its attractive colour, pleasant flavor and aroma (Singh *et al*., 2023). Strawberry was introduced in India during the early sixties, but could not become choice of grower initially due to several reasons (Sharma and Sharma, 2004). However, during last decade, it has become favourite fruit among growers because of its remunerative prices and higher profitability. Further, availability of day-neutral and high yielding varieties and standardization of plasticultural techniques have resulted in phenomenal increase in its area and production particularly near towns and cities (Sharma and Sharma, 2004; Pramanick *et al*., 2005). Strawberry is non-climacteric fruit and fruit reach in full red stage within 28-30 days after anthesis. Strawberry is a very short duration temperate fruit crop but due to day neutral habit of growth and multi uses of polythene crops may be successfully cultivated in subtropical region.

University of Florida released Sweet Charlie strawberry in 1992, it is an early ripening cultivar, enabled grower to find a production niche early in the season when crop value is at its highest (Polling, 1993) and is a day neutral cultivar and can adjust well with growing periods, the fruit are firm having deep red colour. Leaves Are medium to dark green, slightly cupped and semi glossy (Das *et al*., 2015).

Botanically strawberry fruit is termed an aggregate fruit called etaerio of achenes. It requires a well-drained medium loam soil, rich in organic matter. Soil should be slightly acidic with pH of 5.7-6.5. Temperate climate is ideal for strawberry cultivation. Generally, between 10-25 °C temperature is supportive for this crop. Retentive power of flower commences at minimum of 15 °C and it is sluggish after more than 37 °C. In the winter season plant do not make growth and remains dormant, when the day becomes longer in spring with rise in temperature the plant resume growth and flowering. The last decade has witnessed the emergence of strawberries as the leading fruit in the category of soft berries. The area and production of strawberry in the world have increased logarithmically during the last two decades as much of the crop is being grown under protected structures (Singh *et al*., 2023).

In India, strawberry is cultivated on a commercial scale in the states of Haryana, Himachal Pradesh, Maharashtra, Punjab, Delhi, Jammu & Kashmir, Uttarakhand, Uttar Pradesh, West Bengal (Darjeeling hills) and Rajasthan (Rana and Chandel, 2003). Strawberry var. Sweet Charlie was grown at the southernmost part of the State and also in some pockets of the northern parts of the state. Owing to wide climatic and soil adaptation and high and quick returns, it has tremendous potential in Mizoram. The quick and high return suits the temperament of Mizoram cultivators and it gains popularity at a fast pace. Its cultivation can be extended to other suitable areas having assured irrigation and transport facilities. Successful strawberry production depends upon the use of quality of planting materials and cultivation practices for the same. Even though the cultivation is popular in Mizoram, the farmers are usually getting poor fruit quality and yield due to lack of proper agronomic management.

Strawberry plant is a shallow rooted crop and surface feeder therefore temperature and soil moisture condition of the upper layer of soil significantly influence the plant growth and fruiting characters of the plant. Mulching is an important cultural practice followed in strawberry. It has strong influence on yield, quality and duration of harvesting which is primarily due to better soil moisture conservation, change in soil temperature, improve nutrient availability, suppression in number and growth of weed, protection from frost injury and reduction in number of dirty and disease berries (Sharma, 2000). Besides conserving soil moisture, mulching also improves growth and fruit quality of strawberry (Hassan *et al*., 2000). Mulches boost water use efficiency which lowers soil evaporation and increases productivity (Singh *et al*., 2023). Mulching reduces soil temperature in summer and raises it in winter. It prevents the extremes of temperatures. During summer, mulching conserves the soil moisture due to reduced evaporation (Semwal *et al*., 2022). Different types of organic and inorganic mulches are used. Organic mulches are derived from plant and animal materials. The most frequently used organic mulches include plant residues such as straw, cut grass, hay, peanut hulls, leaf mold compost, wood products such as sawdust, wood chips and shavings, and animal manures. Organic mulches such as straw vetch providing environmental benefits such as increased nitrogen, recycling of nutrients, weed emergence, reduced soil erosion, addition of organic matter to the soil, reducing soil temperature during hot summer days and acting as a slow-released fertilizer (Baki and Teasdale, 1993). At present used of black plastic films is common. The black polyethylene mulch checks all types of weeds in addition to soil moisture conservation therefore; black plastic mulch is more beneficial (Mc Cann *et al*., 2007). Polythene mulch with black side facing upward is the most effective for improving plant growth, fruit yield and quality (Lalruatsangi and Hazarika, 2018). Under plastic mulch, the soil is still friable, loose, and thoroughly aerated. Roots have access to enough oxygen, which enhances microbial activity (Singh *et al*., 2023). The greatest benefit from plastic mulch is that the soil temperature in the planting bed is raised, promoting faster crop development and earlier harvest. Black plastic mulch can give a harvest earlier by some 7-14 days. Plant growth can be doubled due to mulching under specific conditions (Pandey *et al*., 2016) however; the negative consequence of polythene mulch is disposal of waste and the associated environmental impact (Lament, 1993).

The growth and yield of strawberry is significantly influence by the growing condition, the bulk of the production under open condition is usually harvested during March – May when the average market price is low, high market price can be realized if the winter production is enhanced, this can be achieved through polyhouse cultivation along with micro irrigation system (Shylla and Sharma, 2010). Protected cultivation has been used for straw berry cultivation in order to protect plants from harsh weather, earlier harvest and for a better control of diseases. However, the adoption of protected systems for strawberry production in subtropical areas must be carefully evaluated and implemented, since a number of reports mention the occurrence of higher temperatures under protected environments in relation to field conditions, especially with regard to maximum temperatures, this condition could be adverse for strawberry production requiring an adaptation of cultural practices (Pires *et al*., 2006).

Conversely, irrigation is an essential technique for strawberry cultivation in Mizoram due to crop sensitivity to water deficits (Hanson and Bendixen, 2004). Crop sensitivity to water stress at different stages of development has strong interference on plant growth and yield (Kruger *et al*., 1999). As it is a shallow rooted plant and susceptible to water stress condition may effect photo synthetic activity and reduce the potential growth of the plant (Firoz, 2018) and Kirnak *et al*., (2001) found that it caused reduction of fruit yield, fruit size, leaf nutrient compositions, and normal plant growth parameters in strawberry except water-soluble dry matter concentrations in fruits. Limited soil moisture affects growth, development, yield, and existence of the strawberry plant in the winter season (Krugger *et al*., 2000). Irrigation plays an important role on the total yield, berry weight, runner production, and leaf area of strawberry (Taparauskiene and Miseckaite, 2014). So, frequent irrigation is necessary at different stages of strawberry plants. Water unavailability can affect all physiological processes of plant ultimately that has effect on mortality of plant (Sarkar *et al*., 2005). Yield losses up to 60 to 100% are reported due to long spell of drought stress in different crop species (Singh *et al*., 2002). Some fertilizers and pesticides may be applied through the irrigation system, thus reducing the need and cost to enter the field with equipment.

In hills, surface irrigation is not possible due to undulating topography, shallow and light texture soil with low water holding capacity and meager water resources. On the other hand, Drip irrigation is very popular in water scarcity areas as this system provides more frequent, precise and direct application of water in small quantities at the root zone. 51% irrigation water was saved under drip irrigation and about 19% higher fruit yield was obtained as compared with surface irrigation treatment (Kumar and Dey, 2011). Childer *et al*., 1995 reported that 15-20% increase in yield, 30% or more saving in water and energy, better water supply and less rotting of strawberry under drip irrigation. Kumar and Dey, 2012 reported that Drip and surface irrigation methods, as well as mulching, were found to be effective for enhancing the growth, irrigation water use efficiency (IWUE), fruit yield and quality of strawberry plants. However, the number of crowns per plant, the percentage berry set, root length density (RLD), and fruit yield were highest under treatment black polyethylene mulch plus drip irrigation.

Although, Mizoram has a high potential for the cultivation of Strawberry but there is no systematic research on strawberry cultivation till now especially in connection to efficacy of different mulching materials. Moreover, farmers are also completely unaware about the scientific cultivation of this high valued crop. It is the need of the hour to pursue an investigation on different types of mulches on strawberry in Mizoram to get maximum production. This investigation is expected to streamline the best practice for Mizoram farmers who are growing Strawberry at small and marginal scale. It will help them to adapt the best practice conducive for the local area. It is expected to result in higher production and better quality with reduced cost of cultivation as there will be specific scientific practice that could be recommended for their use.

The following objectives have therefore been formulated in the present investigation for strawberry cultivation:

1. To study the effect of different mulch materials on growth of strawberry plant in open and poly-house cultivation.

2. To study the effect of mulches on yield and economics of strawberry plant in open and poly-house condition.

3. To study the effect of different mulching on fruit quality and shelf life of strawberry in open and poly-house condition.

4. To study the effect of different mulches on soil health in open and poly-house condition.

5. To compare efficacy of surface irrigation and sub – surface-irrigation (drip irrigation) in strawberry cultivation.

CHAPTER II

Review of Literature

The literatures pertaining to the research works that were conducted in India and abroad on the effect of different mulching materials (Organic and Inorganic mulching) on growths, yields, economics and soil heath in open and poly-house cultivation were reviewed in this chapter.

2.1 Effect of mulching on plant growth characters.

Ramakrishna *et al.* (2006) conducted an experiment 'Effect of mulch on soil temperature, moisture, weed infestation and yield of groundnut in northern Vietnam' the result showed that Polythene and straw mulch were effective in suppressing the weed infestation and Polythene mulch increased the soil temperature by about 6- 8 ^{0}C at 5 cm depth and by 4-8 ^{0}C at 10 cm depth.

Parmer *et al*. (2013) conducted field experiment on watermelon (*Citrullus lanatus* Thunb) cv. Kiran to study the effect of different mulching material on growth, yield and quality of water melon they observed that all the plant growth, yield and quality characters were superior with silver-polyethylene mulch while, plants without mulch (control) resulted poor growth and yield.

Bakshi *et al.* (2014) states in their investigation on the effect of mulch that strawberry is very responsive to the different mulching materials but black polythene mulch gave the best results in terms of reducing weed population, increasing plant height, plant spread, number of leaves per plant, number of flowers per plant, number of fruits per plant, fruit weight, fruit length, fruit breadth and yield.

A study carried out by Deb *et al.* (2014) about the effect of different mulches on vegetative growth of strawberry in six different treatments. The findings revealed that the highest plant height, the largest canopy diameter, maximum number of number of leaves and leaf breadth were observed under polythene mulch and lowest results were observed in no mulch condition.

Gunasekaran and Shakila. (2014) studied the effect of mulching in weed control in medicinal coleus (*Coleus forskholli* Briq.) they observed that weed density (number/m^2) and weed biomass (g/m^2) were lowest in the treatment black polythene mulch. The weed control index and fresh tuber weight were also the highest in the black polythene mulch treatment.

Deb *et al.* (2014) in their studies in strawberry mulching found that transparent polythene was regarded as a best mulch material and black polythene mulch is a better option for farmers to increase vegetative growth of Straw berry.

Patil *et al.* (2016) conducted an investigation on Effect of mulching on soil properties, growth and yield of strawberry cv. Chandler they observed that mulching treatments encouraged plant growth, yield, and effectively checked the weed growth.

Mann *et al.* (2017) reported in strawberry that mulching with red plastic gave significant higher plant height (20.99 cm), plant spread (30.86 cm), number of leaves (20.75/plant), leaf area (101.13 cm^2), fruit weight (13.56 g), fruit length (38.82 mm), fruit breadth (26.85 mm), number of fruits (10.89), yield (148g/plant).

Punetha (2020) found in their investigation on Broccoli that maximum number of leaves, leaf length, leaf breadth, numbers of spears, average spear weight, head polar diameter, head equatorial diameter, head weight, yield and TSS and minimum days to head harvest were observed in Black poly-mulch.

Singh *et al*. (2023) proved that black polythene mulch was the most effective to increase the plant height, number of leaves, plant spread, early flowering and maximum number of fruits and also stated that Black polythene with FYM 100% in strawberry enhances all growth and yield attributing parameters

2.2 Effect of mulching on yield and yield attributing character.

Moor *et al*. (2004) were studied the influence of mulching in the quality of strawberry and reported that mulching is an effective and inexpensive way to increase the quality and yield of strawberry.

Kher *et al*. (2010) conducted an experiment on 'Influence of planting time and mulching material on growth and fruit yield of strawberry cv. Chandler' the result shoed that plant height, plant spread, leaf area, fruit weight and fruit yield were significantly higher in plants mulched with black polyethylene than those either mulched with transparent polyethylene or paddy straw.

Younis *et al*. (2012) carried out a study in Pakistan in the effect of different mulching materials Viz. transparent plastic sheet, rice straw and black plastic sheet on growth and flowering of Freesia cv. Aurora and they observed that black plastic mulch triggers plant growth and development (vegetative growth) while straw mulch encourages flower production both qualitatively and quantitatively in freesia plants.

Ali and Gaur (2013) revealed in their studies that all the organic mulches significantly increased runner production of strawberry. Maximum number of runner per plant, runner platelets per runner and runner plantlets per plant was recorded with paddy straw followed sugarcane trash.

Pandey *et al.* (2016) reported that maximum fruit length, fruit width, fruit weight, fruit number and maximum yield/ plant were observed under black polythene mulch in strawberry cultivation.

Adnan *et al*. (2017) studied the performance of growth and yield of strawberry var. Rabi 1 and Rabi 3 under different mulch condition in Bangladesh. They found that the maximum number of flowers, fruit and the biggest fruit size and the highest yield was observed under black poly-mulch.

Helaly *et al*. (2017) in their studies in Effect of Polyethylene Mulching on *Physalis Pubescens* that maximum value of number of fruit/ plant, total yield and early yield per plot were obtained from silver poly mulch treatment followed by black poly mulch treatment.

Sharma and Goel (2017) reported that plants mulched with black Polyethylene have significantly better growth and yield attributes than either with Eupatorium or paddy straw or no mulch, fruit yield of strawberry was significantly higher in plants mulched with black polyethylene (26.2 q/ha) which was 39.4, 29.7 and 83.2 percent higher as compared to Eupatorium, paddy straw and no mulch.

Semwal *et al*. (2022) conducted an investigation on the effect of mulching on growth,

yield and economics of strawberry and reported that black polythene mulching results in maximum number of leaves per plant (26.95), number of flower per plant (24.08), leaf area (955.99 cm^2), number of runners per plant (16.00), number of fruits per plant (15.5).

Singh *et al*. (2023) conducted an investigation "Effect of various mulching material on yield and yield attributes of strawberry (*Fragaria x Ananassa* Duch.) cv. Winter Dawn" the result revealed that black polythene mulch showed the best performance viz. earliest flowering along with maximum number of flowers per plant, maximum number of fruits per plant, longest fruit length and fruit width, the highest number of runners, maximum fruit weight and fruit yield per plant.

2.3 Effect of mulching on Fruit quality character.

Moor et al. (2005) showed that significant increase in anthocyanin content with plastic mulch with pre-planting fertilization, 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 in strawberry

An investigation was carried out in 2015 by Shokouhian and Asghari on four mulching methods, including straw, black plastic, light plastic and without mulch in various cultivars, including Pazhero, Paros and Queeneliza. They reported that the effect of cultivar and mulching methods were significant for more of traits such as final yield, soil moisture, fruit quality and weed control and they found that black plastic mulch was best cover for strawberry in Ardabil district of Iran.

Pandey *et al*. (2016) carried out a study in Rajasthan using different kinds of mulch materials to observe their effect on the soil physicochemical changes and on growth, production and quality of strawberry. The highest content of total sugar, reducing sugar, vitamin C, anthocyanin and minimum titrable acidity was observed in black polythene mulch.

. Sujatha *et al*. (2018) studied the effect of mulching materials on fruit quality of strawberry (*Fragaria ananassa*. Duch.). The result showed that paddy straw recorded maximum TSS, juice percentage, specific gravity, vitamin-C content, total sugars and minimum physiological loss in weight, titrable acidity and very less Albinism disorder as compared to other mulching treatments and control and also states that the physiological loss in weight was minimum under black poly-mulch.

Abdalla *et al*. (2019) reported that plastic mulching (whether clear or black) was beneficial in improving the fruits anthocyanin content compared to the un-mulched plants. Black plastic mulch was helpful in improving fruits contents of vitamin C and anthocyanin compared to the un-mulched plants. Moreover, black plastic mulching for strawberry production in was more profitable than the un-mulched farm.

Singh *et al.* (2023b) in their studies on strawberry mulching revealed that the maximum TSS, total sugar and minimum titrable acidity was observed under black polythene mulch.

2.4 Effect of mulching on physico- chemical characters of soil.

Awodoyin *et al*. (2007) reported that mulches are effective in weed control and conservation of soil moisture, and the plant-based mulches are most effective in reducing soil temperature.

Inkevičienė *et al*. (2009) carried out a field experiment in the Pomological Garden of Lithuanian University of Agriculture in 2005–2008 with treatments: 1) without mulching; 2) chopped wheat straw; 3) peat; 4) sawdust; 5) grass. The results revealed that all organic mulches significantly decreased soil temperature in hot days and Mulched plots also had higher soil moisture content throughout the experimental period with the highest soil moisture content in sawdust.

Shylla and Sharma in 2010 reported from Solan, Himachal Pradesh that Yellow plastic mulch significantly increased number of fruits, effected early and higher total yield compared to black or silver-over-purple plastic mulches while un-mulched bed produced lowest yield and fruit quality. They also observed that yellow plastic mulch raised soil temperature by 2 ^{0}C compared to the un-mulched bed. Under poly-house conditions, maximum and earliest yields were observed under yellow polythene mulch, while better quality fruits.

Kumar *et al*. (2014) studied effect of plant spacing and organic mulch on growth,yield and quality of natural sweetener plant Stevia and soil fertility in western Himalayas and they observed that all the mulched plots significantly increased organic carbon (OC), available nitrogen (N), phosphorus (P) and potassium (K), bacterial and fungal population compared to un-mulched plots were obtained under black polythene mulch.

Pandey *et al.* (2016) studied the soil physico - chemical characteristic in strawberry states that maximum increase in soil temperature and maximum soil moisture retention was observed under black polythene mulch and also states that rice husk mulch were effective in increasing soil organic matter, available nitrogen and water holding capacity.

Patil *et al*. (2016) observed that mulching with organic materials was quite effective in improving the chemical properties of soil, i.e., pH, electrical conductivity, organic carbon content, available nitrogen, phosphorus, potassium and viable bacterial count and their values increased as compared to control and inorganic mulches.

2.5 Economics of cultivation and cost benefit ratio.

Parmer *et al*. (2013) conducted field experiment on watermelon (*Citrullus lanatus* Thunb) cv. Kiran and found that polythene mulch resulted in the highest net return and found to be more economical with highest cost: benefit ratio.

Kumar *et al*. (2021) in their studies in tomato found that highest benefit cost ratio was recorded in black polythene mulch whereas lowest was recorded in unweeded plot. The maximum growth and yield along with the minimum weed density was observed in black poly mulch.

Semwal *et al*. (2022) studied the effect of mulch on growth, yield and economic of strawberry and reported that maximum total yield per plot, total yield per hectare, and B: C ratio was obtained in black polythene mulching.

2.6. Influence of polyhouse cultivation

Pires *et al.* (2006) reported that the poly-house cultivation favours vegetative growth and the marketable fruit yield and its component (fruit number, weight of fruit per plant) than open cultivation.

Shylla and Sharma (2010) conducted an investigation on mulch colour for enhancing winter-strawberry production under polyhouse in mid-hills of Himachal Pradesh, they reported that under polyhouse condition, maximum and earliest yield was observed under yellow polythene mulch while better fruits quality were observed under black polythene mulch.

Kumar *et al*. (2011) stated that the maximum number of flower trusses, maximum number of fruit, fruit weight and best fruit quality was observed under plastic tunnel in strawberry cultivation.

Kumar and Ahad (2012) stated that eight varieties of strawberry evaluated perform well under poly house condition in terms of growth, yields and fruit quality.

Sharma *et al*. (2013) studied effect of plastic mulch colour on growth, fruiting and fruit quality of strawberry under polyhouse cultivation and found that all three coloured plastic mulches (black, red and yellow) significantly increased the growth of strawberry plants as compared to control but did not differ significantly among themselves with respect to plant growth.

Pandey *et al.* (2015) revealed that strawberry grown under naturally ventilated polyhouse had higher crown height, plant spread and produced higher fruit yield with maximum number of fruits/plant and total anthocyanin content in the fruits.

Homez and Arouie (2016) studied on Evaluation of Soil Temperature under Mulches and Garlic Extract on Yield of Cucumber (*Cucumis sativus* L.) in Greenhouse Conditions that soil temperature under polythene mulch was significantly increases over no mulch.

Kumar *et al*. (2018) reported that strawberry is very responsive to the mulching materials, Fruit length, fruit width, fruit weight, fruit volume, ascorbic acid content and anthocyanin content were significantly higher in fruits harvested from plants mulched with black polyethylene under poly--house.

Islam *et al*. (2021) reported that the most suitable growing condition for yield and yield parameters of strawberries is under the net house. In contrast, poly house conditions are favourable for producing better quality fruit under Bangladesh condition.

2.7 Efficacy of drip irrigation

Kumar *et al*. (2005) in their studies revealed that Drip irrigation at 1.0 'V' volume of water (100% crop ET) gave significantly higher fruit yield compared with the surface irrigation black polyethylene mulch plus drip irrigation further can raised the yield.

Singh *et al.* (2009b) conducted a field study on sandy loam soil to investigate the effect of drip irrigation and black polyethylene mulch compared with surface irrigation on growth, yield, water-use efficiency and economics of tomato

(*Lycopersicon esculentum* Miller). They revealed that drip irrigation at 80% evapo-transpiration (ET) crop based on pan evaporation applied gave significantly higher fruit yield compared with the surface irrigation. Use of black polyethylene mulch plus drip irrigation further raised the fruit yield. Plant height, leaf area index, dry matter production, fruit weight and yield increased significantly with the use of drip irrigation alone and in conjunction with polyethylene mulch compared to surface irrigation alone or with mulch, maximum net returns and benefit cost ratio was found with drip irrigation at 80% ET coupled with polyethylene mulch compared to other treatments.

Kumar and Dey (2012) carried out an experiment entitled ‘Influence of soil hydrothermal environment, irrigation regime, and different mulches on the growth and fruit quality of strawberry (*Fragaria x ananassa* L.) plants in a sub-temperate climate’ to investigate the effects of irrigation and mulch material on the growth, flowering, fruiting behaviour, yield, and quality of strawberry (*Fragaria x ananassa* L. ‘Chandler’) the result revealed that drip and surface irrigation methods, as well as mulching, were found to be effective for enhancing the growth, irrigation water use efficiency (IWUE), fruit yield and quality of strawberry plants. However, the number of crowns per plant, the percentage berry set, the RLWC, root length density (RLD), and fruit yield were highest under treatment black polyethylene mulch plus drip irrigation compared to the no mulch plus rain-fed control. The drip and surface irrigation treatments raised the minimum soil temperature by 3.0º – 5.4ºC, and lowered the maximum temperature by 2.2º – 5.8ºC compared to the rain-fed control. Hay mulch was more effective in raising the minimum temperature and lowering the maximum soil temperature than black polyethylene mulch. Moisture conservation increased by 2.8 – 12.8% under the black polyethylene mulch compared to the no-mulch treatment.

Paul *et al*. (2013) studied on effect of drip and surface irrigation on yield, water-use efficiency and economics of capsicum (*Capsicum annum* l.) The study indicated better plant growth, more number of fruits per plant and enhancement in the yield under drip irrigation system with LLDPE mulch. The highest yield was recorded under 100% net irrigation volume with drip irrigation (VD) and plastic mulching as compared to other treatments. This system increased the yield and net seasonal income by 57 % and 54 %, respectively as compared to conventional surface irrigation without mulch with a benefit cost ratio of 2.01. The benefit cost ratio was found to be the highest (2.44) for the treatment VD without mulch. Drip irrigation system could increase the yield by 28 % over surface irrigation even in the absence of mulch.

Kachwaya and Chandel (2015) conducted a field experiment during 2011-12 to study the performance of different levels of fertigation and soil fertilization on growth, yield, fruit quality and leaf nutrients content of strawberry (*Fragaria* × *ananassa* Duch.). The results revealed that fertigation with recommended dose of NPK gave significantly higher plant height, leaf area, fruit yield as compared to fertigation with ½ and 1/3 of recommended dose of NPK and soil fertilization, the maximum fruit length, fruit breadth and fruit weight was also recorded in fertigation with full recommended dose of NPK. The values of TSS, total sugar, anthocyanin and ascorbic acid was significantly higher in fertigation with recommended dose of NPK treatment as compared to lower levels of fertigation and soil fertilization.

Rannu *et al*. (2018) studied effect of irrigation and mulch on the yield and water use of Strawberry in Bangladesh that mulching with black polythene mulch along with 5 days irrigation interval through drip system attained the maximum fruit size, fruit weight and yield.

Singh *et al*. (2020) conducted an experiment in Punjab to explore the effect of drip irrigation, fertigation and mulching on fruit quality of strawberry (*Fragaria* × *ananassa* Duch.) cultivar Chandler. Fruit production and quality related attributes, viz. fruit yield/ha, juice acid, TSS, total sugars, reducing sugars, ascorbic acid and fruit juice improved significantly with irrigation at 80% level, fertigation at 80% of SDF and plant mulched with Silver-black mulch as compared to other treatments.

Islam *et al*. (2022) studied effects of irrigation and soil mulching in different growing environments on strawberry yield and quality in Bangladesh and they revealed that gross fruit yield and water use efficiency of strawberries significantly increased in a covered field environment using black polyethylene mulching and drip irrigation system, the yield and other physical parameters (fruit length, width, average fruit weight) of strawberry were higher in covered field with drip irrigation than fruit grown in open field.

CHAPTER III

MATERIALS AND METHODS

The present investigation entitled "**EFFECT OF DIFFERENT MULCH MATERIALS ON GROWTH, YIELD AND QUALITY OF STRAWBERRY IN OPEN AND POLYHOUSE CULTIVATION IN MIZORAM**" was carried out at N. Vanlaiphai, Serchhip District, Mizoram, for two consecutive years viz. 2017-2018 and 2018-2019. Two experiments were conducted viz., (a) Effect of different mulch materials on performance of strawberry under open and poly- house cultivation. (b) Efficacy of drip irrigation and manual irrigation for strawberry cultivation with different mulch treatment. The details about the materials and the methodology adopted during the course of investigation are given below.

3.1 Geographical location of the Experimental site:

The research was carried out in the Demonstration Farm, KVK, N. Vanlaiphai, Serchhip District, Mizoram for two seasons during the year 2017-18 and 2018-19. The area is located at an altitude of 1270m above mean sea level at $23^0$7'40.22" N and $93^0$3'33.63" E

3.2 Climatic and Weather Condition:

The prevailing climatic condition of the site was characterized as sub-tropical hill climate with temperature ranging from 5 ^{0}C – 28 ^{0}C with average annual rainfall of 2500 mm per year. Mild summer is experienced from May- September while mild to severe winter is experience from October–February. The monsoon usually starts from end of May and remains up to end of September. (Meteorological data for 2017 and 2018 and 2019 in particular to the study area is shown in annexure I).

3.3 Soil characteristics of the experimental field:

In order to determine the fertility status of the soil, the representative soil samples were collected from the experimental plot at random from a depth of 0-15 cm before starting the experiments and composited for analysis. The soil under polyhouse contain 295 kg/ha of available nitrogen, 22.55 kg/ha of available phosphorus, 265 kg/ha of available potassium with pH 6.35. The results of the soil samples under drip irrigation plot contain 295 kg/ha of available Nitrogen, 21.23 kg/ha of available phosphorus, 270 kg/ha of available potassium with pH 6.15, the soil samples under manual irrigation plot contain 285 kg/ha of available nitrogen, 21.21 kg/ha of available phosphorus, 270 kg/ha of available potassium with pH 5.95.

3.4 Land preparation and bed formation:

The experimental field was ploughed thoroughly for planting of strawberry. Ploughing was done first with soil turning plough and another two ploughing was done with harrow. The recommended dose of fertilizer (100:80:100) kg/hectare (anonymous, 2021) in the form of urea (N), single super phosphate (P), and muriate of potash (P) were applied, half dose of nitrogen (N) and the full dose of phosphorus (P) and potassium (K) were applied at the time of final ploughing along with 10 tons of FYM/ha while the remaining half dose of nitrogen was applied at 25 days after planting. Thorough leveling was done after ploughing. The beds were formed at the size of 0.75m width and 1.5 m length at a distance of 45 cm and raised to a height of 25 cm high to facilitate drainage and to increases the soil temperature during winter period which enhances plant growth. Every plot will accommodate 10 plants each.

3.5 Selection of plant:

Healthy and disease free poly-potted runners of strawberry variety ‘Sweet Charlie' were planted at a distance of 30cms x 45cms; five plants were selected from each plot for observation and investigation and are marked with tag for observation

3.6 Details of Experiment:

Two sets of experiments were conducted, one being the effect of mulching under open and poly-house cultivation and the other being the comparison on efficacy of surface and drip irrigation in strawberry cultivation

3.6.1. Experiment 1: Effect of different mulch materials on performance of strawberry under open and poly- house cultivation.

3.6.1.1. Experimental design and layout

The experiments were laid out in Factorial Randomized Block Design under two conditions i.e., poly-house and open cultivation with 10 treatments each and 3 replications, the details of the treatments were viz:

T_1 - Paddy straw.	**T_2** - Saw dust.
T_3 - Wood shaving.	**T_4** - Leaf litter.
T_5 - Pine needle.	**T_6** - Cut grass.
T_7 - Rice husk.	**T_8** - Black polythene mulch 30 micron.

T_9 - Silver on Black polythene mulch 30 micron.

T_{10} -No mulch (Control)

Design	: Factorial RBD
No of treatments	: 10
No of replication	: 3
Spacing	: 30 cm x 45 cm
No of plant/ bed	: 10

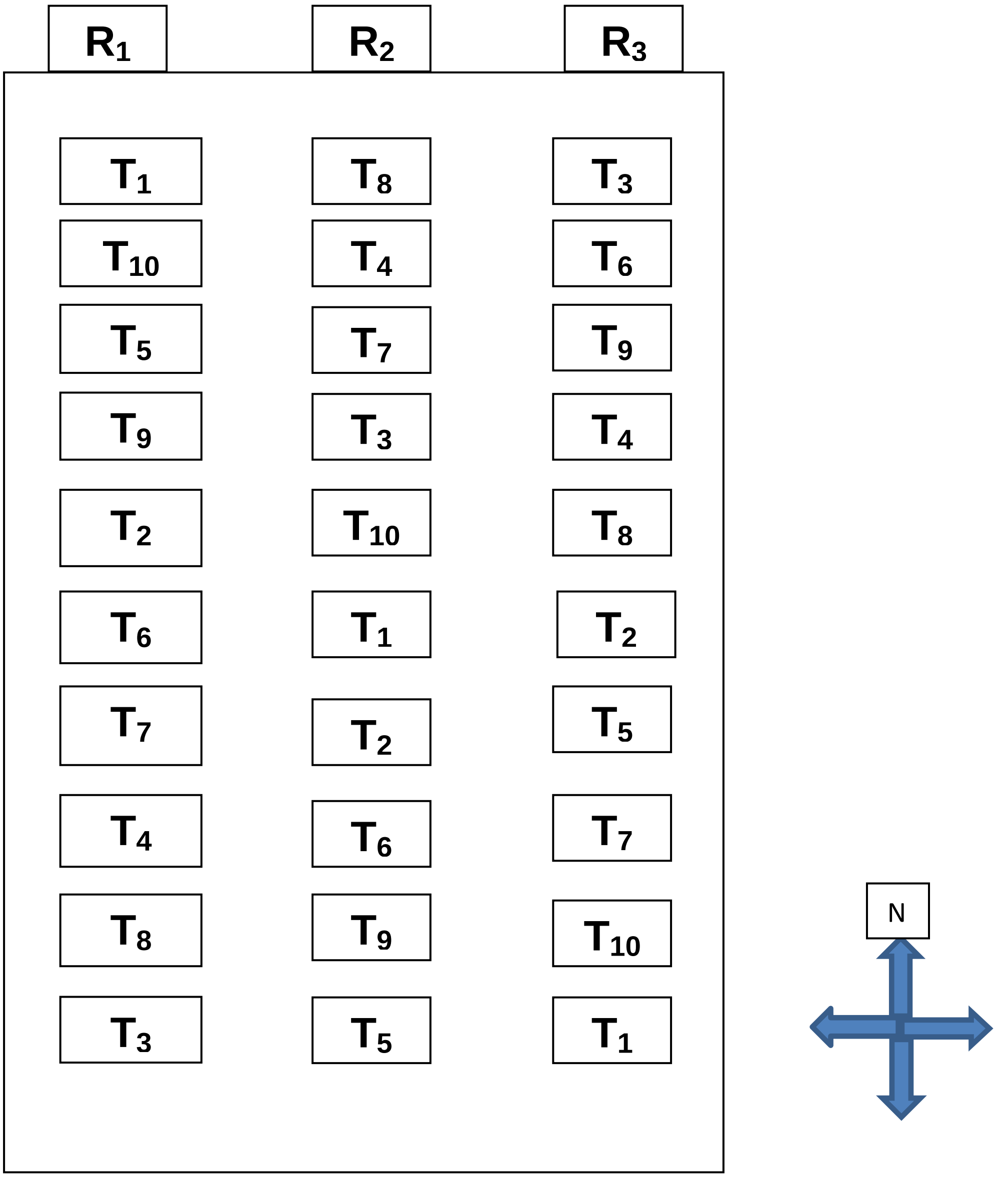

Fig.3.1 Layout of experimental plot 1 for strawberry cultivation.

3.6.1.2. Time of planting and irrigation system.

Well-developed poly-potted strawberries variety Sweet Charlie' were planted in the month of December on the prepared beds which was installed with drip irrigation with 4lph (litre per hour) dropper using gravity. The strawberry plants were irrigated at two days interval.

3.6.1.3. Mulching

The different mulching materials were installed after 3 days of planting, 30 microns of black plastic films and silver films were used while in the organic mulching, mulch materials like straw, cut grass, leaf litter, pine needle, saw dust, wood shaving and rice husk were applied uniformly at a thickness of 5cm.

3.6.1.4. Polyhouse structure:

Pre-fabricated steel structure with the roof covered by UV stabilized poly-film of 200 microns with insect net for the wall were used for planting of strawberry under poly-house cultivation.

3.6.1.5. Parameters Recorded:

3.6.1.5.1. Plant height

The average heights of the plant were measured with a measuring scale from the crown level to the apex of the primary leaves at 30, 60 and 90 days after planting and expressed in Centimeters.

3.6.1.5.2. Plant spread:

The plant spread was measured with measuring scale in two directions, i.e. East -west and North - South directions, five plant per plot were selected for the observation at 30, 60 and 90 days after planting. The mean of five plants was taken as actual plant spread and the values are expressed in centimetre.

3.6.1.5.3. Number of leaves per plant:

The total numbers of leaves were recorded at 30, 60 and 90 days after planting from five plants of each bed and the results were expressed as number of leaves per plant.

3.6.1.5.4. Number of flowers per plant:

The numbers of flowers were recorded carefully from five plants per bed at an interval of every 4-5 days and consolidated at the end of the season (90 DAP). The result was expressed as number of flowers per plant.

3.6.1.5.5. Number of fruits per plant:

The numbers of fruits were counted at the time of fruit formation from five plants of each bed at an interval of every 4-5 days and consolidated at end of the season. The result was expressed as number of fruits per plant.

3.6.1.5.6 Number of runners per plant:

The numbers of runners were counted at 90 days after planting from five plants of each bed and the results were expressed as number of runners per plant.

3.6.1.5.7 Total Number of Weed:

A permanent 30 x 30 cm quadrant ($0.9m^2$) were fixed in each plot before emergence of weeds, the numbers of weeds were counted at 30, 60,90 days and the results were expressed as number of weeds.

3.6.1.5.8. Berry setting percentage:

The berry setting percentages were taken against the total number of flower set upon the total number of fruit set

3.6.1.5.9 Fruit weight:

To ascertain the berry weight, ten berries from each treatment were randomly selected and average weight of the berry were recorded and expressed as mean fruit weight in grams.

3.6.1.5.10 Fruit length:

The length of ten randomly selected fruits from each plots were measured from the calyx plug to the pointed end or apex of the fruit and expressed in centimeter.

3.6.1.5.11 Fruit width:

The width of ten randomly selected fruit from each plot are measured horizontally at the widest point with the help of Vernier calipers and expressed in centimeter.

3.6.1.5.12 Total yield per plant:

The total fruit productions in each treatment were recorded from five plants per plot and yields per plants were calculated and expressed in grams.

3.6.1.5.13 Shelf life of fruits:

The harvested fruits were observed for determining their shelf life ie. loss in moisture content after storage in ambient conditions. The loss in moisture content of the fruits were recorded in every 24, 48 and 72 hr. and expressed in percentage

3.6.1.5.14 Total Soluble Solid (TSS):

Total soluble solids (TSS) of the fresh fruits were taken with a hand refractometer and expressed in ^{0} Brix (AOAC, 2016).

3.6.1.5.15 Titrable Acidity (%):

It was determined by adopting the standard methods of AOAC, 2016. For estimation of titratable acidity, 10 g of pulp was grounded in mortar with pestle and 100 ml of distilled water was added followed by filtration. Ten ml of filtrate was titrated against 0.1 N NaOH using phenolphthalein as indicator. Titratable acidity was expressed in percentage in terms of anhydrous citric acid by using the following formula:

$$\text{Titrable acidity} = \frac{\text{Titre value X Normality of alkali X Volume made up X Eq. weight of citric acid}}{\text{Weight of sample X Aliquot X 1000}} \text{ X } 100$$

3.6.1.5.16 Total sugar (%)

The total sugar percentages of the fruits were determined by the methods suggested in AOAC (2016). 10 ml of freshly extracted Juice was added with 2-4 drops of conc. HCL and kept it overnight. The solution was then neutralized with 10% NaOH and volume was made up to 100 ml with distilled water and titrated against 2ml boiling Fehling's solution mixture using methylene blue as indicator. From the titre value, percentage of total sugar was calculated as follows:

$$\text{\% Total sugar} = \frac{\text{Amount of invert sugar x Volume of stock solution}}{\text{Titre value X volume of the sample (Aliquot)}} \text{ x } 100$$

3.6.1.5.17 Ascorbic acid (mg/100g):

The ascorbic acid content was determined by the method described by Jagota and Dani (1982). 2gm of sample was taken in a mortar and small amount of neutral glass powder was added to it. Mixture was exposed to grinding with equal volume of 6% metaphosphoric acid the above mixture was centrifuged at 5000rpm for 10 mins and then filterd through Whatman. no 1 filter Paper and collected in volumetric flask. The aloqout of the sample extract (0.1 ml) was diluted to 1.2ml with 3% metaphosphoric acid and final volume was made upto 4ml with distilled water. To each tube 0.4 ml of Folin-ciocalteau was added and mix well. The tubes were incubated for 10 mins at room temperature and centrifuge at 3000rpm for 10 mins. After centrifugation, supernatant was read against the blank solution in a UV-visible spectrophotometer at 760nm. The concentration of ascorbic acid in the sample was calculated from the slope of the ascorbic acid standard curve. The ascorbic acid content (Mg/100gm) was calculated by using the formula

$$\text{Ascorbic acid (mg/100 gm)} = \frac{\text{Total volume of the sample x conc. of the vit. C x 100 x 1}}{\text{Weight of the sample x amount of sample x 1000}}$$

3.6.1.5.18 Anthocyanin content of fruit (mg/100gm):

The Anthocyanin contents were determined by the method suggested by Fuleki and Francis (1968). 1 ml of the freshly extracted juice was taken and mixed with 9ml ethanolic HCL, the mixture is kept overnight in the refrigerator at 4^0C, after which the mixture is filter through filter paper, OD was recorded at 535nm, the ethanolic HCL was used as blank.

$$\text{Total OD/100 g} = \frac{\text{OD x Volume made up}}{\text{Volume of sample}} \text{ x 100}$$

$$\text{Total anthocyanin (mg/100g)} = \frac{\text{Total OD/ 100g}}{98.2}$$

3.6.1.5.19 Preparation of soil samples

Soil samples from each experimental plot were collected at 0-15 cm depth with the help of a soil auger. The samples were then dried in shade and thoroughly mixed and pulverized to pass through 0.2mm sieve and kept in polythene bag for further analysis.

3.6.1.5.20 Soil pH:

Soil pH was determined by glass electrode with calomel as standard (Jackson, 1973). 20 g of soil samples were weighed and 50 ml of distilled water was added in a 100 ml beaker. The contents were stirred with glass rod for 30 minutes and used for determining pH. The pH meter was calibrated using buffer solutions.

3.6.1.5.21 Determination of available nitrogen (N) of soil (kg/ha):

The available nitrogen (N) of the soil sample was determined by Kjeldahl's method (Jackson, 1973). A known weight (5 g) of the soil sample was put into a distillation flask and 25 ml of 0.32 % potassium permanganate solution and 25 ml of 2.5 % sodium hydroxide solution was added into it. Then, 3 to 4 drops of methyl red indicator was added in a conical flask along with 25 ml of 2.5 % boric acid. The digestion process automatically started by the analyser machine and completes within 9-12 minutes. The distilled from the digestion was collected in a conical flask containing boric acid and titrated against 0.02 N HCl solutions till the colour changes to pink colour.

$$\text{Available nitrogen in soil (ppm)} = V \times \left[\frac{14}{1000} \times 0.02 \times \frac{1000000}{5}\right]$$

$$\text{Available nitrogen in soil (kg/ha)} = V \times \left[\frac{14}{1000} \times 0.02 \times \frac{1000000}{5}\right] \times 2.24$$

Where, V = Volume of 0.02 N HCl solution used for titration

3.6.1.5.22 Determination of available phosphorus (P) of soil (kg/ha).

The available phosphorous (P) of the soil sample was determined using procedure of Bray and Kurtz (Jackson, 1973). A known weight (5 g) of the soil sample was taken in a 100 ml conical flask and 50 ml of extracting solution was added into it. The content was stirred for 5 minutes and filtered through Whatman no. 42 filter paper, the extracts were collected for estimation. Then, 5 ml of extracting solution was added into each 25 ml volumetric flask (test and P standards) followed by addition of 5 ml of Dickman and Bray's reagent. One ml of working (dilute) stannous chloride solution was added; the intensity of the blue colour was measured in photoelectric calorimeter at 660 nm after 10 minutes.

Available P in soil (kg/ha) = A × 50 (Dilution factor) × 2.24

Where, A = Concentration of P as read from the standard curve.

3.6.1.5.23 Determination of available potassium (K) in soil (kg/Ha):

The available potassium (K) of the soil sample was estimated by flame photometric method as described by Jackson (1973). A known weight (5 g) of the soil sample was taken in a 150 ml conical flask and 25 ml of neutral normal ammonium acetate was added into it. The content was shake for 5 minutes and then, filtered using Whatman no. 41 filter paper. The filtrate collected was feed into atomizer of the flame photometer, 100 of which has been set with 40 ppm K solution and the reading noted were located on the standard curve which will give the K concentration in the extract. Thus, the amount of potassium in the sample can be calculated from the concentration measurement.

Available K in soil (ppm) = C × 5

Available K in soil (kg/ha) = C × 5 × 2.24

Where, C = Concentration (ppm) as read from the standard curve

3.6.1.5.24 Soil moisture content (%):

The soil moisture content was determined by drying a known weight of the sample in hot air oven at 105 ^{o}C for 24 hours or till the weight become constant. The loss in weight was reported to be the moisture content of the sample.

$$\text{Moisture content (\%)} = \frac{\text{Initial weight of soil - weight of oven dried soil}}{\text{Weight of oven dried soil}} \times 100$$

3.6.1.5.25 Soil temperature (^{0}C):

Soil temperature was measured by using thermometer at a depth of 5cm at 30, 60, 90 days after planting.

3.6.2. Experiment 2: Efficacy of drip irrigation and manual irrigation for strawberry cultivation with different of mulch treatment.

3.6.2.1. Experimental design and layout

The second experiment was laid out in Factorial Randomized Block Design under two irrigation conditions i.e., manual irrigation and drip- irrigation with 10 treatments and 3 replications, viz:

T_1 - Paddy straw.
T_2 - Saw dust.
T_3 - Wood shaving.
T_4 - Leaf litter.
T_5 - Pine needle.
T_6 - Cut grass.
T_7 - Rice husk.
T_8 - Black polythene mulch 30micron.
T_9 - Silver on Black polythene mulch 30 micron.
T_{10} - No mulch. (Control)

Design	: Factorial RBD
No of treatments	: 10
No of replication	: 3
Spacing	: 30 cm x 45 cm
No of plant/ bed	: 10

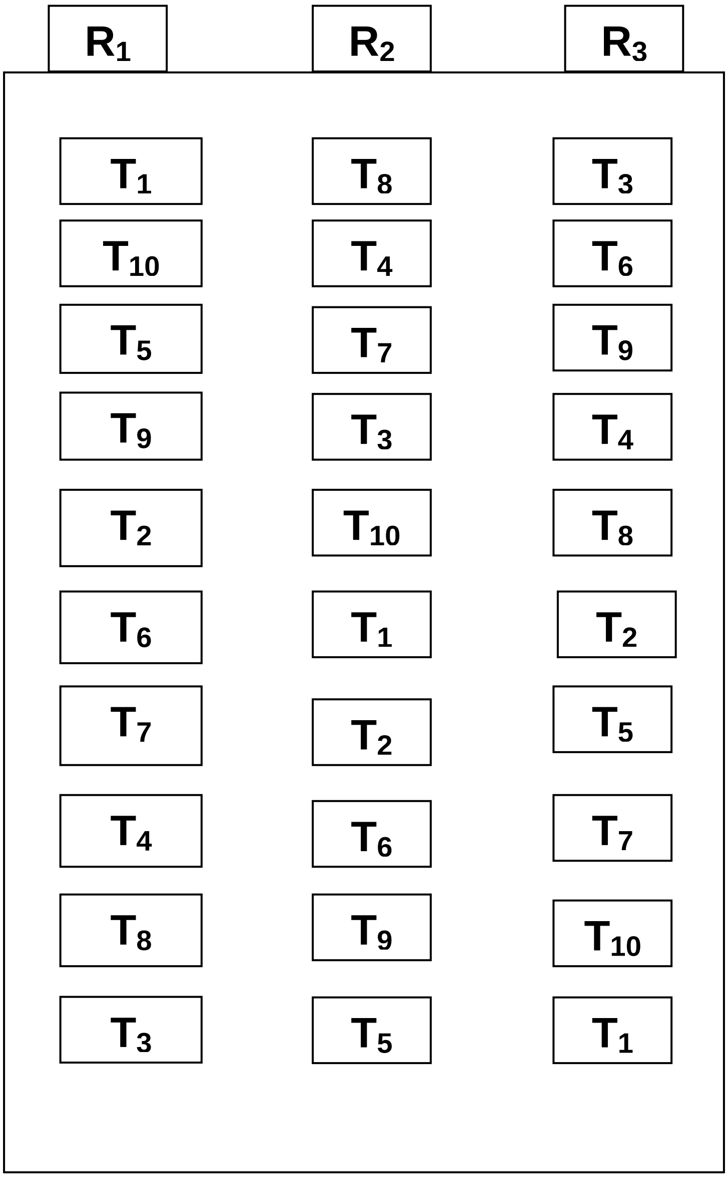

Fig3.2. Layout of experimental plot 2 for strawberry cultivation

3.6.1.2. Time of planting and irrigation system.

Well-developed poly-potted strawberries variety Sweet Charlie were planted in the month of December on the prepared beds which was equipped with drip irrigation with 4lph dropper using gravity under drip-irrigation plot. Under surface irrigation plot, no drip irrigation systems were installed, watering was done manually using watering-can. The frequency of watering was same for all the plots which were two days interval.

3.6.1.3. Mulching

The different mulching materials were installed after 3 days of planting, 30 microns of black plastic films and silver films were used while in the organic mulching mulch materials like straw, cut grass, leaf litter, pine needle, saw dust, wood shaving and rice husk were applied uniformly with 5 cm thick.

3.6.2.4 Parameters recorded:

The plant growth parameters viz. plant height, plant spread, number of leaves per plant, number of flowers per plant, number of fruits per plant, fruit setting percentage and the number of runners per plant were recorded at very 4-5 days and consolidated at 90 days after planting and The number of weed emergence were recorded at 30, 60 and 90 days after planting and measurement were taken as describe earlier in experiment-1.

Parameters on the fruit quality viz, fruit weight, TSS, titrable acidity, total sugar, anthocyanin and ascorbic acid and yield were taken as experiment-1.

3.7 Economics of the crops.

The economics of all the treatment were work out and expressed in terms on per hectare basis

3.7.1. Cost of Land preparation.

Cost of land preparation includes clearing/cleaning of plots, ploughing and harrowing with tilling machine at the rate of Rs. 1300.00 per hour, bed/ plot formation with labour at the rate of Rs. 400.00 which was the current local rates.

3.7.2. Labour wages:

Labour wages means the wages for all agronomic practices at Rs 400.00 per day (current local rates) that was carried out throughout the cropping period, the cropping period was considered to be the month of December to March. Labours were engaged for application of different mulching materials at different plots and also engaged in planting of the well maintained poly-potted runners and other intercultural operations like weeding of the foot path and the surroundings area, erection of scare-crow, earthing up, top dressing of fertilizers, watering with watering-can in case of surface irrigation, management of drip irrigation system, crop inspection and harvesting was done every 3-5 days interval. Fungicidal spray was done at 7, 14 and 21 days after planting in order to prevent the crops from leafspot disease, powdery mildew and anthracnose. The mature and ripen fruits were harvested and recorded in every 3-5 days; it was then packed and transported to local market and nearby cities.

3.7.3. Cost of Material inputs:

This includes all the cost of materials utilized for the crop cultivation including planting materials (poly-potted runner @ Rs 15), fertilizers that were applied at recommended dose ie 100:80:100 in the forms of urea 220 kg/ ha, single super phosphate 500kg/ha and muriate of Potash 170kg/ha., other chemicals like fungicides, FYM, mulching materials, packing materials like plastic boxes, drip irrigation. In case of poly- house cultivation, cost of poly house for the cropping period (3 months) was included, the steel structure poly-house are expected to last for more than 7 years and the cost of pre-fabricated steel structure poly-house was Rs. 750/m^2 the cost for 1ha. will be Rs. 75,00,000/-, if steel structure poly house last for 10 years, the cost of 1 year will be Rs. 7,50,000/-, the cost of poly-house for 1 month will be Rs. 62,500/- if the cropping period was 3 months, the cost of cultivation of strawberry under poly-house for 3 months will be Rs.1,87,500/- per ha. Water tank of at least 5000L capacity was required for fertigation/ irrigation per ha. Tools and implements like khurpi, spade, shovel, secateurs and sprayer were utilized for different agronomical practices.

3.7.4. Cost of Cultivation:

The cost of cultivation refers that the sum of all cost of land preparation, labour wages and material inputs expressed in per hectare basis

3.7.5. Gross Returns:

This means the sale price of the fruit at current market rates of each plot and converted in per hectare basis.

3.7.6. Net Returns.

The net returns were calculated by subtracting the cultivation cost from the gross returns and expressed in rupees per hectare.

3.7.7. Benefit Cost Ratio.

Cost benefit ratio was calculated based on the benefit obtained per rupees invested on different treatment**.**

$$\text{B: C ratio} = \frac{\text{Net returns (Rs/ha)}}{\text{Gross expenditure (Rs/ha)}}$$

3.8. Statistical analysis:

Data was analyzed for statistical interference following statistical method for Factorial Randomized Block design described by Gomez and Gomez (1983).

Chapter IV

Results and Discussions

The present investigation entitled "**EFFECT OF DIFFERENT MULCH MATERIALS ON GROWTH, YIELD AND QUALITY OF STRAWBERRY IN OPEN AND POLYHOUSE CULTIVATION IN MIZORAM**" was carried out in Krishi Vigyan Kendra, N. Vanlaiphai, Serchhip district, Mizoram during 2017-18 and 2018-19. The observations and discussion on various growth, flowering, yield, fruit quality, soil temperature, soil moisture and soil nutrient content of strawberry var. Sweet Charlie are presented in this chapter under the following headings. Each characters of strawberry are described with the help of tables.

4.1. Experiment 1: Effect of different mulch materials on performance of strawberry under open and polyhouse cultivation.

4.1.1 Plant growth parameters.

Growing conditions have significant effect in the plant growth where taller plant height, wider plant spread, more number of leaves and lower number of weeds were observed under polyhouse cultivation when compared to open cultivation.

4.1.1.1 Plant height (cm).

It is apparent that plant heights recorded at 30, 60 and 90 days after planting (DAP) were significantly influenced by different types of mulching, growing conditions and their interaction during two years as well as pool analysis (tables 4.1.1.1.1 to 4.1.1.1.3).

The performance of plant height of strawberry at 30 DAP was significantly influenced by the growing conditions, table 4.1.1.1.1 showed higher plant height was observed under poly house cultivation ie. 12.43 cm, 12.16 cm and 12.29 cm against 9.99 cm, 9.98 cm and 9.99 cm in open cultivation in the first year, second year and pooled data respectively. Significant effect of different mulch materials on plant height of strawberry at 30 DAP, among the different mulch materials black poly-mulch (M_8) were found to have the highest value (12.07cm, 11.89cm, 11.9cm) followed by M_9 whereas lowest value 9.78 cm, 9.58 cm and 9.68 cm were noted in no mulch (M_{10}) in the first year, second year and pool data respectively. Taller plant heights were observed under poly-house cultivation as compared to open cultivation at 30, 60 and 90 days after planting. No significant effect of mulching and their interaction with the growing condition was observed at 30 DAP.

Table-4.1.1.1.1: Effect of mulching treatments and growing condition on plant height (cm) of strawberry at 30 days after planting.

Plant height (cm) at 30 DAP									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	10.42	12.45	11.43	10.30	12.37	11.34	10.36	12.41	11.38
M_2	10.29	12.09	11.19	10.03	12.38	11.20	10.16	12.23	11.20
M_3	9.74	12.99	11.37	10.29	12.20	11.25	10.02	12.60	11.31
M_4	10.10	12.62	11.36	9.90	12.24	11.07	10.00	12.43	11.21
M_5	10.21	12.24	11.23	9.89	11.83	10.86	10.05	12.03	11.04
M_6	9.71	11.91	10.81	9.73	11.35	10.54	9.72	11.63	10.68
M_7	9.93	12.42	11.18	10.03	12.38	11.20	9.98	12.40	11.19
M_8	10.49	13.65	**12.07**	10.53	13.25	**11.89**	10.51	13.45	**11.98**
M_9	10.42	13.01	11.72	10.39	13.13	11.76	10.41	13.07	11.74
M_{10}	8.62	10.93	**9.78**	8.74	10.42	**9.58**	8.68	10.68	**9.68**
Mean	9.99	**12.43**		9.98	**12.16**		9.99	**12.29**	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM (±)	0.38	0.17	0.54	0.36	0.16	0.52	0.26	0.12	0.37
$CD_{0.05}$	1.08	0.48	NS	1.04	0.47	NS	0.74	0.33	NS
CV%	8.27			8.07			8.13		

1st Year Mean	11.21	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	11.07	S. EM(±)	0.52	0.37	0.17	0.12
Pool Mean	11.14	$CD_{0.05}$	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation.

At 60 DAP, the different mulch materials have significant effect on the height of the plant in both the growing conditions, the highest plant height (21.71 cm, 21.09 cm, 21.4 cm) was observed on Black poly mulch (M_8) which was followed by silver poly-mulch (M_9) (21.52 cm,

Table-4.1.1.1.2: Effect of mulching treatments and growing condition on plant height (cm) of strawberry at 60 days after planting

Plant height (cm) at 60 DAP									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	13.95	19.61	16.78	14.82	19.23	17.03	14.39	19.42	16.90
M_2	13.06	18.29	15.68	13.52	17.81	15.66	13.29	18.05	15.67
M_3	13.70	19.42	16.56	14.72	18.97	16.85	14.21	19.20	16.70
M_4	12.87	17.52	15.19	14.43	17.36	15.89	13.65	17.44	15.54
M_5	13.08	18.53	15.81	14.30	18.53	16.42	13.69	18.53	16.11
M_6	12.63	18.14	15.39	12.99	17.67	15.33	12.81	17.91	15.36
M_7	12.34	18.68	15.51	12.17	18.77	15.47	12.25	18.72	15.49
M_8	15.16	21.71	**18.44**	15.55	21.09	**18.32**	15.36	21.40	**18.38**
M_9	14.49	21.52	18.01	14.93	21.01	17.97	14.71	21.27	17.99
M_{10}	10.67	15.58	**13.12**	11.19	15.74	**13.46**	10.93	15.66	**13.29**
Mean	13.19	**18.90**		13.86	**18.62**		13.53	**18.76**	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM (±)	0.57	0.25	0.80	0.58	0.26	0.82	0.40	0.18	0.56
$CD_{0.05}$	1.62	0.72	NS	1.65	0.74	NS	1.12	0.50	NS
CV%	8.64			8.69			8.57		

1st Year Mean	16.05	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	16.24	S. EM(±)	0.80	0.56	0.25	0.18
Pool Mean	16.14	$CD_{0.05}$	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation

21.01 cm, 21.27 cm) in the first year, second year and pool analysis respectively while the lowest plant height (13.12 cm, 13.46 cm and 13.29 cm) was noted under no mulch (M_{10}). Significant effect in the growing conditions had been observed in the height of the plant where the higher plant (18.90 cm, 18.62 cm and 18.76 cm) was observed under poly-house cultivation in the first year, second year and pool analysis respectively. No significant effect of mulching and their interaction with the growing condition was observed at 60 DAP. Strawberry plant mulch with black poly mulch (M_8) has shown maximum plant height (25.99 cm, 27.63 cm and 26.81 cm) whereas the minimum plant height (14.91 cm, 15.87 cm and15.39 cm) was noticed

Table-4.1.1.1.3: Effect of mulching treatments and growing condition on plant height (cm) of strawberry at 90 days after planting

Plant height (cm) at 90 DAP									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	18.70	22.35	20.53	18.92	23.64	21.28	18.81	23.00	20.90
M_2	17.27	19.14	18.21	17.55	19.95	18.75	17.41	19.54	18.48
M_3	18.56	20.23	19.40	18.85	21.74	20.30	18.71	20.99	19.85
M_4	18.29	18.93	18.61	18.00	19.14	18.57	18.15	19.03	18.59
M_5	18.05	19.34	18.70	17.97	20.51	19.24	18.01	19.93	18.97
M_6	17.37	18.82	18.09	17.80	18.79	18.29	17.58	18.80	18.19
M_7	17.61	21.49	19.55	17.70	23.26	20.48	17.65	22.38	20.02
M_8	21.06	25.99	**23.52**	21.08	27.63	**24.36**	21.07	26.81	**23.94**
M_9	20.00	25.33	22.67	20.55	25.79	23.17	20.27	25.56	22.92
M_{10}	14.91	17.51	**16.21**	15.87	17.08	**16.47**	15.39	17.29	**16.34**
Mean	18.18	**20.91**		18.43	**21.75**		18.31	**21.33**	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.53	0.24	0.75	0.67	0.30	0.95	0.43	0.19	0.61
CD 0.05	1.52	0.68	2.15	1.93	0.86	2.72	1.22	0.54	1.72
CV%	6.65			8.21			7.56		

1st Year Mean	19.55	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	20.09	S. EM(±)	0.87	0.61	0.27	0.19
Pool Mean	19.82	CD 0.05	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation

under no mulch (M_{10}) during the experimental years as well as in the pool analysis respectively at 90 DAP. The growing conditions had the significant effect on the performance of plant height where higher values (20.9 cm, 21.75 cm and 21.33 cm) were observed under poly-house cultivation while the lower values (18.18 cm, 18.43 cm and 18.31 cm) were found in open cultivation in the first year, second year and pool data at 90 days after planting. Significant effect of mulching and their interaction with the growing condition was observed at 90 DAP, the treatment combination of black plastic mulching with poly-house cultivation (C_2M_8) resulted the maximum plant height (25.99, 27.63 and 26.81) cm was observed which was found at par with silver poly-mulch in poly-house cultivation (C_2M_9) while the minimum plant height (14.91, 15.87 and 15.39) cm was observed with no much in open cultivation (C_1M_{10}) in the individual years and pool analysis. at par with silver poly-mulch in poly-house cultivation (C_2M_9) while the minimum plant height (14.91, 15.87 and 15.39) cm was observed with No much in open cultivation (C_1M_{10}) in the individual years and pool analysis.

Table-4.1.1.2.1.1: Effect of mulching treatments and growing condition on plant spread (N-S direction) (cm) of strawberry at 30 days after planting

Plant spread (N-S direction) (cm) at 30 DAP									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	11.75	16.07	13.91	11.29	16.17	13.73	11.52	16.12	13.82
M_2	10.53	13.54	12.04	10.79	13.64	12.22	10.66	13.59	12.13
M_3	11.65	15.50	13.58	11.56	15.72	13.64	11.61	15.61	13.61
M_4	10.88	14.49	12.69	10.91	14.59	12.75	10.90	14.54	12.72
M_5	10.90	14.34	12.62	11.00	14.18	12.59	10.95	14.26	12.61
M_6	10.02	13.35	11.69	9.97	13.66	11.82	10.00	13.51	11.75
M_7	10.90	15.26	13.08	10.83	15.17	13.00	10.86	15.22	13.04
M_8	12.60	16.46	**14.53**	12.58	16.95	**14.77**	12.59	16.71	**14.65**
M_9	12.17	16.25	14.21	12.02	16.81	14.42	12.10	16.53	14.31
M_{10}	9.10	12.27	**10.68**	9.47	12.63	**11.05**	9.28	12.45	**10.87**
Mean	11.05	**14.75**		11.04	**14.95**		11.05	**14.85**	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.56	0.25	0.79	0.56	0.25	0.79	0.39	0.17	0.55
CD $_{0.05}$	1.59	0.71	NS	1.60	0.71	NS	1.10	0.49	NS
CV%	10.58			10.52			10.44		
1st Year Mean		12.90		Pooled analysis		M x C x Y	M x Y	C x Y	Y
2nd year Mean		12.99		S. EM(±)		0.78	0.55	0.25	0.17
Pool Mean		12.95		CD $_{0.05}$		NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation

4.1.1.2 Plant spread (cm).

Higher values of plant spread (N-S direction and E-W direction) were observed with polyhouse cultivation compared to open cultivation at 30, 60 and 90 days after planting of strawberry.

4.1.1.2.1 Plant spread (N-S direction)

The different mulching materials have significant effect on the plant spread (N- S direction) at 30 days after planting (table 4.1.1.2.1.1), highest spread was observed (14.53 cm, 14.77 cm and 14.65 cm) under black poly-mulch (M_8) in the first year, second year and pool data whereas the lowest plant (N-S) spread (10.68 cm, 11.05 cm and 10.87 cm) was observed in no mulch (M_{10}) in the first year, second year and pool data. Significant effect in the growing

Table-4.1.1.2.1.2: Effect of mulching treatments and growing condition on plant spread (North-South direction) (cm) of strawberry at 60 days after planting

Plant spread (N-S direction) (cm) at 60 DAP									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	22.85	24.20	23.53	22.89	23.97	23.43	22.87	24.08	23.48
M_2	19.29	21.33	20.31	20.20	21.23	20.72	19.75	21.28	20.51
M_3	21.98	23.70	22.84	22.79	23.72	23.25	22.39	23.71	23.05
M_4	19.50	21.95	20.73	19.61	21.83	20.72	19.55	21.89	20.72
M_5	20.13	23.62	21.88	21.00	23.51	22.26	20.57	23.56	22.07
M_6	19.11	20.87	19.99	19.47	20.97	20.22	19.29	20.92	20.10
M_7	20.44	23.43	21.93	20.71	23.27	21.99	20.57	23.35	21.96
M_8	24.14	26.94	**25.54**	24.59	26.97	**25.78**	24.37	26.95	**25.66**
M_9	23.31	25.87	24.59	24.38	25.21	24.80	23.85	25.54	24.70
M_{10}	16.55	18.60	**17.58**	16.96	18.72	**17.84**	16.76	18.66	**17.71**
Mean	20.73	**23.05**		21.26	**22.94**		21.00	**23.00**	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM (±)	0.77	0.34	1.09	0.74	0.33	1.05	0.54	0.24	0.76
CD $_{0.05\%}$	2.20	0.99	NS	2.13	0.95	NS	1.51	0.67	NS
CV%	8.61			8.25			8.44		
1st Year Mean	21.89			Pooled analysis	M x C x Y		M x Y	C x Y	Y
2nd year Mean	22.09			S. EM(±)	1.07		0.76	0.34	0.24
Pool Mean	21.99			CD $_{0.05\%}$	NS		NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation.

conditions have been observed in the spread of the plant (N-S direction) where higher values of 14.75cm, 14.95cm and 14.85 cm were observed under polyhouse cultivation while the lower values (11.05 cm, 11.04 cm and 11.05 cm) were cited in open cultivation in the first year, second year and pool analysis respectively.

It is evident from the table 4.1.1.2.1.2 that mulching has significant effect in the plant spread (N-S direction) at 60 days after planting, the maximum plant spread was observed under black poly mulch (25.54 cm, 25.78 cm and 25.66 cm) in the first year, second year and pool analysis respectively whereas the minimum values were cited under no mulch (17.58 cm, 17.84 cm and 17.71 cm) in the first year, second year and pool analysis respectively. Significant effects in the growing conditions have been observed in the spread of the plant (N-S direction) where higher values of 23.05 cm, 22.94 cm and 23.00 cm were observed with polyhouse cultivation first year, second year and pool analysis respectively.

Table-4.1.1.2.1.3: Effect of mulching treatments and growing condition on plant spread (North-South) (cm) at 90 days after planting of strawberry cultivation.

Plant spread (N-S direction) (cm) at 90 DAP									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	26.26	26.77	26.51	26.87	27.39	27.13	26.57	27.08	26.82
M_2	21.59	25.44	23.51	22.09	26.02	24.06	21.84	25.73	23.79
M_3	26.07	26.01	26.04	26.68	26.62	26.65	26.37	26.31	26.34
M_4	26.25	26.85	26.55	26.87	27.48	27.18	26.56	27.17	26.86
M_5	26.90	27.27	27.09	27.53	27.90	27.72	27.21	27.59	27.40
M_6	20.80	24.93	22.87	21.28	25.52	23.40	21.04	25.23	23.14
M_7	27.91	26.93	27.42	28.57	27.56	28.06	28.24	27.24	27.74
M_8	30.35	32.67	**31.51**	31.06	33.43	**32.25**	30.70	33.05	**31.88**
M_9	29.69	32.62	31.16	30.37	33.39	31.88	30.03	33.00	31.52
M_{10}	17.73	22.82	**20.27**	17.95	23.35	**20.65**	17.84	23.09	**20.46**
Mean	25.35	**27.23**		25.93	**27.87**		25.64	**27.55**	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.71	0.32	1.00	0.73	0.33	1.03	0.53	0.24	0.75
CD 0.05	2.02	0.90	2.86	2.08	0.93	2.94	1.49	0.67	2.11
CV%	6.57			6.62			6.90		
1st Year Mean		26.29		Pooled analysis		M x C x Y	M x Y	C x Y	Y
2nd year Mean		26.89		S. EM(±)		1.06	0.75	0.34	0.24
Pool Mean		26.59		CD 0.05		NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation

At 90 days of planting as depicted in table 4.1.1 2.1.3, significant effects were observed with mulching, growing condition and their interaction effect on the plant spread (N-S direction), Maximum plant spread was observed under black poly mulch (31.51 cm, 32.25 cm and 31.88 cm) and the minimum values was observed under no mulch (20.27 cm, 20.65 cm and 20.46 cm) in the first year, second year and pool analysis respectively. Significant effects in the growing conditions have been observed in the spread of the plant (N-S direction) higher values of 27.23 cm, 27.87 cm and 27.55 cm were observed under polyhouse cultivation in first year, second year and pool analysis respectively. Significant effect of mulching and their interaction with the growing condition was observed at 90DAP, the treatment combination of black plastic mulching with poly-house cultivation (C_2M_8) resulted the maximum plant spread (32.67, 33.43 and 33.05) cm in N-S direction was observed which was found at par with silver poly-mulch in poly-house cultivation (C_2M_9) while the minimum (17.73, 17.95 and 17.84) cm was observed with No mulch in open cultivation (C_1M_{10}) in the individual years and pool analysis.

Table-4.1.1.2.2.1: Effect of mulching treatments and growing condition on plant Spread (East-West) (cm) of strawberry at 30 days after planting.

Plant spread (E-W direction) (cm) at 30 DAP									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	13.62	16.93	15.28	13.13	16.97	15.05	13.38	16.95	15.16
M_2	12.52	15.70	14.11	12.39	15.97	14.18	12.46	15.83	14.14
M_3	13.55	16.74	15.15	13.00	16.61	14.80	13.28	16.67	14.97
M_4	12.85	16.21	14.53	12.81	16.18	14.50	12.83	16.20	14.51
M_5	12.28	16.40	14.34	12.09	16.47	14.28	12.19	16.44	14.31
M_6	11.98	15.82	13.90	11.89	15.85	13.87	11.94	15.84	13.89
M_7	12.55	16.27	14.41	12.56	16.05	14.30	12.56	16.16	14.36
M_8	13.43	18.19	**15.81**	13.75	18.33	**16.04**	13.59	18.26	**15.92**
M_9	13.28	18.03	15.66	13.19	18.11	15.65	13.24	18.07	15.66
M_{10}	10.17	14.27	**12.22**	11.07	14.55	**12.81**	10.62	14.41	**12.52**
Mean	12.62	**16.46**		12.59	**16.51**		12.61	**16.48**	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.48	0.22	0.68	0.48	0.22	0.68	0.35	0.15	0.49
CD $_{0.05}$	1.38	0.62	NS	1.38	0.62	NS	0.97	0.44	NS
CV%	8.15			8.14			8.23		
1st Year Mean		14.54		Pool analysis		M x C x Y	M x Y	C x Y	Y
2nd year Mean		14.54		S.EM(±)		0.69	0.49	0.22	0.15
Pool Mean		14.54		CD $_{0.05}$		NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation

Table-4.1.1.2.2.2: Effect of mulching treatments and growing condition on plant spread (East-West direction) (cm) of strawberry at 60 days after planting

Plant spread (E-W direction) (cm) at 60 DAP									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	23.05	26.13	24.59	23.41	25.74	24.58	23.23	25.93	24.58
M_2	20.80	23.75	22.28	20.49	23.19	21.84	20.65	23.47	22.06
M_3	22.79	25.27	24.03	23.02	25.16	24.09	22.91	25.22	24.06
M_4	20.40	24.72	22.56	20.71	24.88	22.79	20.55	24.80	22.68
M_5	21.81	25.29	23.55	21.21	25.19	23.20	21.51	25.24	23.38
M_6	18.02	22.35	20.19	18.60	22.15	20.37	18.31	22.25	20.28
M_7	22.02	23.99	23.01	22.71	23.49	23.10	22.37	23.74	23.05
M_8	24.40	28.45	**26.42**	24.33	28.15	**26.24**	24.36	28.30	**26.33**
M_9	23.25	27.96	25.60	24.02	27.70	25.86	23.64	27.83	25.73
M_{10}	16.41	20.12	**18.27**	16.34	20.39	**18.37**	16.38	20.25	**18.32**
Mean	21.30	**24.80**		21.48	**24.60**		21.39	**24.70**	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM (±)	0.77	0.34	1.09	0.76	0.34	1.08	0.54	0.24	0.76
CD $_{0.05}$	2.21	0.99	NS	2.18	0.98	NS	1.51	0.67	NS
CV%	8.19			8.10			8.05		

1st Year Mean	23.05	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	23.04	S.EM (±)	1.07	0.76	0.34	0.24
Pool Mean	23.05	CD $_{0.05}$	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation

4.1.1.2.2 Plant spread (E-W direction)

Table 4.1.1.2.2.1 showed significant effect of different mulch materials on plant spread (E-W direction) of strawberry at 30 days after planting, among the different mulch materials black poly-mulch (M_8) resulted in highest value (15.81 cm, 16.04 cm, 15.92 cm) whereas lowest value 12.22 cm, 12.81 cm and 12.52 cm were cited in no mulch (M_{10}) in the first year, second year and pool data respectively. The performance of plant spread (E-W direction) of strawberry at 30 days after planting was significantly higher under poly house cultivation ie. 16.46 cm, 16.51 cm and 16.48 cm in the first year, second year and pooled analysis respectively. It is clear from the table 4.1.1.2.2.2 that mulching has significant effect in the plant spread (E-W direction) at 60 days after planting, the maximum plant spread was observed under black poly mulch (26.42 cm, 26.24 cm and 26.33 cm) whereas the minimum values were cited under no mulch (18.27 cm, 18.37 cm and18.32 cm) in the first year, second year and pool data respectively. Significant effect in the growing conditions have been observed in the spread of the plant (E-W direction) where higher values of 24.80 cm, 24.60 cm and 24.70 cm were observed under polyhouse cultivation in first year, second year and pool analysis respectively.

Table-4.1.1.2.2.3: Effect of mulching treatments and growing condition on plant spread (East-West) (cm) of strawberry at 90 days after planting.

Plant spread (E-W direction (cm) at 90 DAP									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	26.62	30.63	28.63	26.81	30.32	28.56	26.71	30.48	28.59
M_2	21.91	27.35	24.63	21.88	28.67	25.28	21.90	28.01	24.96
M_3	26.52	29.28	27.90	26.69	29.46	28.08	26.61	29.37	27.99
M_4	24.27	28.37	26.32	24.17	28.89	26.53	24.22	28.63	26.42
M_5	25.85	29.05	27.45	26.03	29.72	27.88	25.94	29.38	27.66
M_6	21.75	26.19	23.97	21.73	27.52	24.63	21.74	26.85	24.30
M_7	24.49	28.49	26.49	24.57	28.08	26.33	24.53	28.28	26.41
M_8	28.36	34.09	**31.23**	28.72	33.29	**31.01**	28.54	33.69	**31.12**
M_9	27.83	33.42	30.63	28.37	32.91	30.64	28.10	33.17	30.64
M_{10}	19.25	23.99	**21.62**	19.87	23.60	**21.74**	19.56	23.79	**21.68**
Mean	24.68	**29.09**		24.89	**29.25**		24.79	**29.17**	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.96	0.43	1.35	0.92	0.41	1.30	0.66	0.29	0.93
CD 0.05	2.74	1.23	NS	2.63	1.18	NS	1.85	0.83	NS
CV%	8.73			8.31			8.43		

1st Year Mean	26.88	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	27.06	S.EM(±)	1.31	0.93	0.42	0.29
Pool Mean	26.97	CD 0.05	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation.

At 90 days of planting as depicted in the table4.1.1. 2.2.3, mulching has significant effect in the plant spread (E-W direction), the maximum plant spread was observed under black poly mulch (31.23 cm, 31.01 cm and 31.12 cm) whereas the minimum values were noted under no mulch (21.62 cm, 21.74 cm and 21.68 cm) in the first year, second year and pool analysis respectively. Significant effect in the growing conditions has been observed in the spread of the plant (N-S direction) where higher values of 29.09 cm, 29.25 cm and 29.17 cm were observed with poly-house cultivation in first year, second year and pool analysis respectively.

Table-4.1.1.3.1: Effect of mulching treatments and growing condition on number of leaves of strawberry at 30 days after planting.

Number of leaves at 30 DAP									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C1	**C2**	**Mean**	**C1**	**C2**	**Mean**	**C1**	**C2**	**Mean**
M_1	9.20	11.73	10.47	9.60	10.93	10.27	9.40	11.33	10.37
M_2	6.47	10.20	8.33	6.07	9.93	8.00	6.27	10.07	8.17
M_3	9.07	11.60	10.33	9.07	10.27	9.67	9.07	10.93	10.00
M_4	6.93	10.07	8.50	7.60	9.87	8.73	7.27	9.97	8.62
M_5	8.13	10.00	9.07	8.40	9.80	9.10	8.27	9.90	9.08
M_6	7.13	9.93	8.53	7.20	9.27	8.23	7.17	9.60	8.38
M_7	8.27	11.00	9.63	8.33	10.33	9.33	8.30	10.67	9.48
M_8	9.73	12.07	**10.90**	10.07	11.80	**10.93**	9.90	11.93	**10.92**
M_9	9.53	11.93	10.73	9.80	11.40	10.60	9.67	11.67	10.67
M_{10}	5.60	9.40	**7.50**	5.07	9.13	**7.10**	5.33	9.27	**7.30**
Mean	8.01	**10.79**		8.12	**10.27**		8.06	**10.53**	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.40	0.18	0.56	0.35	0.16	0.50	0.26	0.12	0.37
CD $_{0.05}$	1.14	0.51	NS	1.01	0.45	NS	0.74	0.33	1.05
CV%	10.39			9.38			9.82		

1st Year Mean	9.40	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	9.19	S. EM(±)	0.53	0.37	0.17	0.12
Pool Mean	9.29	CD $_{0.05}$	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation.

Table-4.1.1.3.2: Effect of mulching treatments and growing condition on number of leaves of strawberry at 60 days after planting.

Number of leaves at 60 DAP									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C1	**C2**	**Mean**	**C1**	**C2**	**Mean**	**C1**	**C2**	**Mean**
M_1	18.27	20.34	19.31	18.40	20.56	19.48	18.33	20.45	19.39
M_2	14.58	18.11	16.35	14.32	18.45	16.39	14.45	18.28	16.37
M_3	16.72	19.14	17.93	18.38	19.91	19.15	17.55	19.53	18.54
M_4	18.13	18.80	18.47	18.33	18.80	18.57	18.23	18.80	18.52
M_5	18.87	19.20	19.03	18.93	19.71	19.32	18.90	19.45	19.18
M_6	12.80	18.74	15.77	13.76	19.96	16.86	13.28	19.35	16.32
M_7	18.47	20.95	19.71	19.87	21.21	20.54	19.17	21.08	20.12
M_8	22.33	26.52	**24.43**	22.40	25.00	**23.70**	22.37	25.76	**24.06**
M_9	21.67	25.44	23.55	21.73	24.60	23.17	21.70	25.02	23.36
M_{10}	9.73	14.54	**12.14**	10.37	14.87	**12.62**	10.05	14.71	**12.38**
Mean	17.16	**20.18**		17.65	**20.31**		17.40	**20.24**	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.45	0.20	0.64	0.60	0.27	0.85	0.38	0.17	0.54
$CD_{0.05}$	1.30	0.58	1.84	1.72	0.77	2.43	1.08	0.48	1.53
CV%	5.97			7.76			7.08		

1st Year Mean	18.67	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	18.98	S. EM(±)	0.96	0.68	0.30	0.21
Pool Mean	18.82	$CD_{0.05}$	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation

4.1.1.3 Number of leaves

The Mean data pertaining to the number of leaves recorded at 30, 60 and 90 days after planting were significantly influenced by different types of mulching materials, growing conditions and their interaction and the growing conditions are presented in the table 4.1.1.3.1 to 4.1.1.3.3. In all cases, more number of leaves were observed in polyhouse cultivation.

An evaluated data in the number of leaves at 30 days after planting (Table 4.1.1 3.1) was significantly influenced by different mulch materials. The maximum number of leaves (10.90, 10.93 and 10.92) was observed in black poly-mulch (M_8) followed by silver poly- mulch (10.73, 10.60 and10.67) whereas minimum number of leaves

(7.50, 7.10 and 7.30) was noted in no mulch (M10) in the first year, second year and pool data respectively. The number of leaves of strawberry at 30 DAP was significantly influenced by the growing condition where more number of leaves (10.79, 10.27 and 10.53) were found under poly house cultivation while the fewer number of leaves (8.01, 8.12 and 8.06) were noted in open cultivation in the first year, seconds year and pool data respectively.

It is clear from table 4.1.1.3.2 that mulching significantly affect the number of leaves at 60 days of planting, the maximum number of leaves was observed under black poly mulch (24.43, 23.70 and 24.06) in the first year, second year and pool data whereas the minimum number was cited under no mulch (12.14, 12.62 and 12.38) in the first year, second year and pool data respectively. Significant effect in the growing conditions has been observed in the numbers of leaves where the higher number of leaves (20.18, 20.31 and 20.24) were observed under poly-house cultivation and the lower number of leaves (17.16, 17.65 and 17.40) was observed under open cultivation in the first year, second year and pool data respectively.

Significant effect of mulching and their interaction with the growing condition was observed in number of leaves at 60 DAP, the treatment combination of black plastic mulching with poly-house cultivation (C_2M_8) resulted the maximum number of leaves (26.52, 25.00 and 25.76) was observed which was followed by silver poly-mulch in poly-house cultivation (C_2M_9) while the minimum number of leaves (9.73, 10.37 and 10.05) was observed with No mulch in open cultivation (C_1M_{10}) in the individual years and pool analysis.

Table-4.1.1.3.3: Effect of mulching treatments and growing condition on number of leaves of strawberry at 90 days after planting.

Number of leaves at 90 DAP									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C1	**C2**	**Mean**	**C1**	**C2**	**Mean**	**C1**	**C2**	**Mean**
M_1	23.47	24.93	24.20	23.73	26.27	25.00	23.60	25.60	24.60
M_2	19.53	22.13	20.83	21.53	23.93	22.73	20.53	23.03	21.78
M_3	23.20	23.73	23.47	23.60	25.80	24.70	23.40	24.77	24.08
M_4	21.87	22.93	22.40	22.07	23.13	22.60	21.97	23.03	22.50
M_5	22.47	23.00	22.73	21.93	24.53	23.23	22.20	23.77	22.98
M_6	17.60	21.80	19.70	17.73	22.80	20.27	17.67	22.30	19.98
M_7	23.20	23.67	23.43	21.80	26.27	24.03	22.50	24.97	23.73
M_8	26.73	29.40	**28.07**	25.07	31.60	**28.33**	25.90	30.50	**28.20**
M_9	26.47	29.33	27.90	24.53	29.80	27.17	25.50	29.57	27.53
M_{10}	13.60	20.60	**17.10**	13.00	20.80	**16.90**	13.30	20.70	**17.00**
Mean	21.81	**24.15**		21.50	**25.49**		21.66	**24.82**	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.70	0.31	0.99	0.74	0.33	1.04	0.51	0.58	0.73
$CD_{0.05}$	2.01	0.90	2.85	2.11	0.94	2.99	1.45	NS	2.05
CV%	7.49			7.69			7.66		
1st Year Mean		22.98		Pooled analysis		M x C x Y	M x Y	C x Y	Y
2nd year Mean		23.49		S. EM(±)		1.03	0.73	0.33	0.23
Pool Mean		23.24		$CD_{0.05}$		NS	NS	0.92	NS

*C_1= open cultivation, C_2= polyhouse cultivation.

Table-4.1.1.4.1: Effect of mulching treatments and growing condition on number of weeds (m^2) in strawberry cultivation at 30 days after planting.

Number of weeds at 90 DAP									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C1	**C2**	**Mean**	**C1**	**C2**	**Mean**	**C1**	**C2**	**Mean**
M_1	0.67	0.73	0.70	0.67	0.67	0.67	0.67	0.70	0.68
M_2	0.73	0.60	0.67	0.80	0.93	0.87	0.77	0.77	0.77
M_3	0.60	0.60	0.60	0.87	0.60	0.73	0.73	0.60	0.67
M_4	0.80	0.80	0.80	0.80	0.53	0.67	0.80	0.67	0.73
M_5	0.67	0.87	0.77	0.87	0.73	0.80	0.77	0.80	0.78
M_6	0.93	1.07	1.00	1.20	1.13	1.17	1.07	1.10	1.08
M_7	0.73	0.60	0.67	0.60	0.80	0.70	0.67	0.70	0.68
M_8	0.20	0.07	0.13	0.13	0.13	0.13	0.17	0.11	0.13
M_9	0.13	0.07	**0.10**	0.13	0.13	**0.13**	0.13	0.10	**0.12**
M_{10}	5.67	2.80	**4.23**	5.07	2.67	**3.87**	5.37	2.73	**4.05**
Mean	1.11	**0.82**		1.11	**0.83**		1.11	**0.83**	

Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.16	0.07	0.23	0.15	0.07	0.21	0.11	0.05	0.16
CD $_{0.05}$	0.46	0.21	0.66	0.43	0.19	0.60	0.31	0.14	0.44
CV%	41.07			37.58			39.44		

1st Year Mean	0.97	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	0.97	S. EM(±)	0.22	0.16	0.07	0.05
Pool Mean	0.97	CD $_{0.05}$	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation

At 90 days of planting as depicted in the table 4.1.1.3.3, mulching has significant effect in the number of leaves, the maximum number was observed under black poly mulch (28.07, 28.33 and 28.20) followed by silver poly mulch (27.90, 27.17 and 27.53) whereas the minimum number (17.10, 16.90, and 17.00) was noted under no mulch in the first year, second year and pool data. The number of leaves of strawberry at 90 days after planting was significantly influenced by the growing condition where more number of leaves (24.15, 25.49 and 24.82) was found under poly house cultivation in the first year, seconds year and pool data respectively.

Significant effect of mulching and their interaction with the growing condition was observed in number of leaves at 90DAP, the treatment combination of black plastic mulching with poly-house cultivation (C_2M_8) resulted the maximum number of leaves (29.40, 31.60 and 30.50) was observed which was followed by silver poly-mulch in polyhouse cultivation (C_2M_9) while the minimum number of leaves (13.60, 13.00 and 13.30) was observed with No mulch in open cultivation (C_1M_{10}) in the individual years and pool analysis.

Table-4.1.1.4.2: Effect of mulching treatments and growing condition on number of weeds per m^2 of strawberry cultivation at 60 days after planting.

Number of weeds at 60 DAP									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C1	**C2**	**Mean**	**C1**	**C2**	**Mean**	**C1**	**C2**	**Mean**
M_1	2.07	2.00	2.03	2.20	2.27	2.23	2.13	2.13	2.13
M_2	3.07	2.27	2.67	3.27	2.53	2.90	3.17	2.40	2.78
M_3	2.00	1.93	1.97	2.13	1.87	2.00	2.07	1.90	1.98
M_4	5.80	6.80	6.30	5.27	5.93	5.60	5.53	6.37	5.95
M_5	2.13	2.00	2.07	2.00	1.80	1.90	2.07	1.90	1.98
M_6	3.53	2.93	3.23	4.40	3.80	4.10	3.97	3.37	3.67
M_7	1.80	1.80	1.80	2.00	2.33	2.17	1.90	2.07	1.98
M_8	0.27	0.33	**0.30**	0.33	0.40	**0.37**	0.30	0.37	**0.33**
M_9	0.33	0.40	0.37	0.27	0.47	0.37	0.30	0.43	0.37
M_{10}	14.80	9.17	**11.98**	15.07	11.00	**13.03**	14.93	10.08	**12.51**
Mean	3.58	**2.96**		3.69	**3.24**		3.64	**3.10**	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.21	0.10	0.30	0.31	0.14	0.44	0.19	0.08	0.27
CD $_{0.05}$	0.61	0.27	0.87	0.89	0.40	1.26	0.53	0.24	0.75
CV%	16.08			21.93			19.29		

1st Year Mean	3.27	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	3.47	S. EM(±)	0.38	0.27	0.12	0.08
Pool Mean	3.37	CD $_{0.05}$	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation.

4.1.1. Number of weeds:

It is obvious that the number of weeds per m^2 recorded at 30, 60 and 90 days after planting (DAP) were significantly influenced by different types of mulching, growing conditions and their interaction have been presented in the table 4.1.1.4.1 to 4.1.1.4.3. The number of weed emergence per m^2 was lesser in the polyhouse cultivation than open cultivation.

Table 4.1.1.4.1 showed significant effect of different mulch materials on the number of weeds at 30 DAP, among the different mulch materials M_9, silver poly-mulch (0.10, 0.13 and 0.12) were found to have the lowest number of weeds followed by M_8 black poly-mulch (0.13, 00.13 and 0.13) whereas highest number of weeds (4.23, 3.87 and 4.05) was cited in no mulch (M_{10}) in the first year, second year and pool data respectively. The number of weeds at 30 DAPS was significantly influenced by the growing conditions, lower number of weeds (0.82, 0.83 and 0.83) were observed under Poly-house condition in the first year, second year and pooled data respectively.

Significant effect of mulching and their interaction with the growing condition was observed in number of weeds at 30DAP, the treatment combination of silver poly- mulching with poly-house cultivation (C_2M_9) resulted the minimum number of weeds (0.07, 0.13 and 0.10) was observed which was followed by black poly-mulch in poly-house cultivation (C_2M_8) while the maximum number of weeds (5.67, 5.07 and 5.37) was observed with No mulch in open cultivation (C_1M_{10}) in the individual years and pool analysis.

At 60 days of planting (table 4.1.1.4.2), the minimum numbers of weed population (0.30, 0.37 and 0.33) was cited under black poly-mulch (M_8) which is statistically at par with silver poly- mulch (M_9) in the first year, second year and in pool data respectively The maximum number (11.98, 13.03 and 12.51) of weeds were found under no mulch (M_{10}). The number of weeds at 60 DAP was significantly influenced by the growing conditions, lower number of weeds (3.58, 3.24 and 3.10) were observed under Polyhouse condition in the first year, second year and pooled data respectively.

Significant effect of mulching and their interaction with the growing condition was observed in number of weeds at 60 DAP, the treatment combination of black poly-mulching with poly-house cultivation (C_2M_8) resulted the minimum number of weeds (0.33, 0.40 and 0.37) was observed which was followed by silver poly-mulch in polyhouse cultivation (C_2M_9) while the maximum number of weeds (14.80, 15.07 and 14.93) was observed with No mulch in open cultivation (C_1M_{10}) in the individual years and pool analysis. At 90 DAP (table 4.1.3), the minimum numbers of weed population (0.53, 0.65 and 0.59) were observed under black poly-mulch (M_8) whereas the maximum numbers (17.36, 17.88 and 17.62) of weeds were cited under no mulch (M_{10}) in the first year, second year and pool analysis.

Table-4.1.1.4.3: Effect of mulching treatments and growing condition on number of weeds per m^2 at 90 days after planting in strawberry cultivation

No of weed per m^2 at 90 DAP									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	3.27	2.94	3.11	3.17	2.89	3.03	3.22	2.92	3.07
M_2	3.78	3.03	3.41	4.12	3.10	3.61	3.95	3.07	3.51
M_3	3.10	2.93	3.02	3.22	3.02	3.12	3.16	2.98	3.07
M_4	6.16	5.20	5.68	5.30	4.65	4.97	5.73	4.92	5.33
M_5	3.07	2.79	2.93	3.01	3.27	3.14	3.04	3.03	3.03
M_6	4.15	3.28	3.72	4.28	3.36	3.82	4.22	3.32	3.77
M_7	3.41	2.82	3.11	3.52	2.98	3.25	3.46	2.90	3.18
M_8	0.60	0.47	**0.53**	0.73	0.56	**0.65**	0.67	0.52	**0.59**
M_9	0.80	0.50	0.65	0.80	0.63	0.72	0.80	0.57	0.68
M_{10}	22.37	12.36	**17.36**	23.00	12.77	**17.88**	22.68	12.56	**17.62**
Mean	**5.07**	3.63		**5.11**	3.72		**5.09**	3.68	

Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.27	0.12	0.38	0.21	0.09	0.30	0.17	0.08	0.25
CD $_{0.05}$	0.76	0.34	1.08	0.60	0.27	0.85	0.49	0.22	0.70
CV%	15.00			11.64			13.81		

1st Year Mean	4.35	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	4.42	S. EM(±)	0.35	0.25	0.11	0.08
Pool Mean	4.39	CD $_{0.05}$	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation.

The number of weeds at 90 DAP was significantly influenced by the growing conditions, lower number of weeds (5.07, 5.11 and 5.09) were observed under Poly-house condition in the first year, second year and pooled data respectively.

Significant effect of mulching and their interaction with the growing condition was observed in number of weeds at 90 DAP, the treatment combination of black poly- mulching with poly-house cultivation (C_2M_8) resulted the minimum number of weeds (0.47, 0.56 and 0.52) was observed which was followed by silver poly-mulch in poly-house cultivation (C_2M_9) while the maximum number of weeds (22.37, 23.00 and 22.68) was observed with No much in open cultivation (C_1M_{10}) in the individual years and pool analysis.

Discussion

The performance on plant growth parameters were significantly influenced by different types of mulches. The highest plant height was observed under Black poly mulch (M_8) which was followed by silver poly-mulch (M_9). The increased in number of leaves under polythene mulch might be due to the reason that black polythene have conserved higher soil moisture and maintain higher temperature as well as reduced the nutrient losses by suppressing the weed population (Semwal *et al*., 2022). The extended retention of moisture and availability of moisture near the root zone leading to higher uptake of nutrient for proper growth and development of plants which result in higher growth of plant as compared to control. Singh *et al*. (2010) also reported higher number of leaves in aonla under black polythene mulch. Ali and Gaur (2007) found the plant height under black plastic mulch significantly increases in strawberry, similar finding also cited in watermelon by Parmer *et al.* (2013) where maximum number of branches per vine, main vine length and number of nods per vine over control were observed under polythene mulch. Sharma and Agrawal Narendra (2004) also showed that plant height was significantly increased in coloured plastic mulches in Tomato.

The increased in plant spread under polythene mulch may be due to better soil hydrothermal regime and minimum weed infestation (Sharma and Sharma. 2003). Kher *et al.* (2010) also observed an increase in plant spread, plant height and number of leaves in strawberry under plastic mulch. Pandey *et al*. (2016) recorded in their studies of strawberry that the maximum plant spread (N-S and E-W direction) was observed under black poly-mulch.

The increase in number of leaves with black poly-mulch may be attributed to favourable modification of soil hydrothermal regime and physico- chemical properties, better moisture conservation and weed suppression which improves nutrient uptake by the plant. Sekhawat *et al*. (2023) found that the number of leaves increased significantly in strawberry with black plastic mulch. Semwal *et al*. (2022) also observed significant increase in number of leaves under black poly mulch.

Pandey *et al*. (2015) reported that the number of leaves in strawberry increased significantly in plastic mulches.

Different kind of mulches applied in the present investigation had the significant effect in controlling weeds emergence over control. Among them, Black polythene mulch showed significant superiority in reducing weed population over rest of the treatments. Among the organic mulches, rice husk (M_7), pine needle (M_5) and wood shaving (M_3) performs well in controlling weeds emergence as it forms the continuous and compact layer in the soil whereas leaf litter (M_4) has porous and non-compacted forms especially in dry weather has higher chance of weed emergence. Maximum reduction of weed emergence under black poly-mulch may be due to smothering effect and causing physical barrier to photosynthetic activity imparted by polythene mulches (Semwal *et al*., 2022). Bakshi *et al*. (2014) found that black polythene mulch also showed significant superiority in reducing weed population over other mulching treatments. Patil *et al*. (2016) observed that black polythene mulch was the best mulch for complete elimination of weeds. Shokouhian and Asghari (2015) reported that application of black polythene mulch significantly suppressed weed growth in strawberry as compare to straw mulch and clear polythene mulch.

4.1.2 Yield attributing parameters.

Yield and yield attributing parameters of strawberry were affected by growing conditions, the higher yield and its attributing parameters were observed in polyhouse cultivation when compared to open cultivation.

4.1.2.1 Total numbers of flowers per plant:

The Mean data pertaining to the total numbers of flowers per plant were significantly influenced by different types of mulching materials and their growing conditions (table 4.1.2.1). The maximum number of flowers (41.03, 41.39 and 41.21) per plant was observed in black poly-mulch (M_8) whereas minimum number of flowers (24.08, 24.27 and 24.18) was noted in no mulch (M_{10}) in the first year, second year and pool data respectively. The total number of fruits per plant of strawberry was significantly influenced by the growing condition, where the number of flowers (33.15, 33.48 and 33.80) was found higher under open cultivation. No significant effect of interaction with mulching and growing condition was observed in total number of flowers per plant.

Table-4.1.2.1: Effect of mulching treatments and growing condition on the total number of flowers per plant of strawberry

Total numbers of flowers / plant									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C1	**C2**	**Mean**	**C1**	**C2**	**Mean**	**C1**	**C2**	**Mean**
M_1	37.02	33.08	35.05	36.28	33.59	34.94	36.65	33.34	34.99
M_2	28.85	26.16	27.50	28.48	25.90	27.19	28.66	26.03	27.35
M_3	34.47	30.92	32.70	33.21	30.65	31.93	33.84	30.79	32.31
M_4	29.30	27.53	28.42	29.41	27.36	28.39	29.36	27.45	28.40
M_5	33.78	30.62	32.20	33.35	31.23	32.29	33.57	30.93	32.25
M_6	28.25	25.76	27.00	27.85	26.15	27.00	28.05	25.96	27.00
M_7	37.02	31.62	34.32	33.15	30.43	31.79	35.09	31.03	33.06
M_8	42.75	39.32	**41.03**	42.84	39.94	**41.39**	42.80	39.63	**41.21**
M_9	41.66	39.75	40.71	41.73	39.64	40.69	41.70	39.70	40.70
M_{10}	24.89	23.28	**24.08**	25.20	23.34	**24.27**	25.05	23.31	**24.18**
Mean	**33.80**	30.80		**33.15**	30.82		**33.48**	30.81	

Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.66	0.30	0.94	0.65	0.29	0.93	0.49	0.22	0.69
CD $_{0.05}$	1.90	0.85	NS	1.87	0.84	NS	1.38	0.62	NS
CV%	5.03			5.01			5.27		

1st Year Mean	32.30	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	31.99	S. Em(±)	0.98	0.69	0.31	0.22
Pool Mean	32.14	CD $_{0.05}$	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation

4.1.2.2 Total number of fruits per plant:

The Mean data pertaining to the total number of fruits per plant were significantly influenced by different types of mulching materials and their growing conditions. Minimum number of fruits (21.39, 21.54 and 21.47) was noted under no mulch (M_{10}) in the first year, second year and pool data respectively. The number of fruits of strawberry was significantly influenced by the growing condition where the number of fruits (32.38, 31.55 and 31.96) was found higher under open cultivation.

Table-4.1.2.2: Effect of mulching treatments and growing condition on total number of fruits per plant of strawberry.

Total number of fruits per plant									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C1	**C2**	**Mean**	**C1**	**C2**	**Mean**	**C1**	**C2**	**Mean**
M_1	35.21	30.98	33.10	35.20	31.57	33.38	35.21	31.28	33.24
M_2	27.91	24.86	26.39	27.11	23.54	25.33	27.51	24.20	25.86
M_3	33.65	29.14	31.39	31.30	28.98	30.14	32.48	29.06	30.77
M_4	27.68	25.48	26.58	27.62	24.85	26.23	27.65	25.17	26.41
M_5	33.01	28.18	30.60	31.78	29.92	30.85	32.40	29.05	30.72
M_6	26.74	23.54	25.14	25.97	24.24	25.10	26.36	23.89	25.12
M_7	34.72	29.45	32.09	31.49	27.89	29.69	33.10	28.67	30.89
M_8	42.13	38.52	**40.32**	41.73	38.22	**39.98**	41.93	38.37	**40.15**
M_9	40.89	37.88	39.38	40.60	37.80	39.20	40.74	37.84	39.29
M_{10}	21.84	20.94	**21.39**	22.71	20.38	**21.54**	22.28	20.66	**21.47**
Mean	**32.38**	28.90		**31.55**	28.74		**31.96**	28.82	

Interaction effect

Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S. EM(±)	0.72	0.32	1.02	0.71	0.32	1.00	0.52	0.23	0.74
$CD_{0.05}$	2.07	0.93	NS	2.02	0.91	NS	1.47	0.66	NS
CV%	5.78			5.75			5.97		

1st Year Mean	30.64	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	30.14	S. EM(±)	1.05	0.74	0.33	0.23
Pool Mean	30.39	$CD_{0.05}$	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation

4.1.2.3 Fruit setting percentage:

The data depicted in the table 4.1.2.3 clearly indicates significant effect of mulching and their growing conditions on the total fruit setting percentage. The maximum fruit setting percentage (98.25, 96.53 and 97.39) was observed under black poly-mulch (M_8) followed by M_9 silver poly-mulch (96.70, 96.36 and 96.53) whereas the minimum fruit setting percentage was found under (M_{10}) no mulch (88.68, 88.70 and 88.69) in the individual years and pool analysis. Significant effect in the growing conditions also observed where higher fruit setting percentage (95.43, 94.86

and 95.14) was observed under open cultivation in the first year, second year and pool analysis.

Table-4.1.2.3: Effect of mulching treatments and growing condition on fruit setting percentage of strawberry.

Fruit setting percentage									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	95.20	93.66	94.43	97.00	94.05	95.52	96.10	93.85	94.98
M_2	96.75	95.07	95.91	95.20	91.08	93.14	95.97	93.08	94.52
M_3	97.55	94.27	95.91	94.34	94.54	94.44	95.94	94.40	95.17
M_4	94.43	92.55	93.49	93.84	90.97	92.41	94.14	91.76	92.95
M_5	97.72	91.98	94.85	95.33	95.76	95.55	96.52	93.87	95.20
M_6	94.64	91.38	93.01	93.30	92.72	93.01	93.97	92.05	93.01
M_7	93.85	93.35	93.60	94.94	91.57	93.25	94.39	92.46	93.43
M_8	98.54	97.95	**98.25**	97.40	95.66	**96.53**	97.97	96.81	**97.39**
M_9	98.10	95.30	96.70	97.36	95.35	96.36	97.73	95.33	96.53
M_{10}	87.49	89.87	**88.68**	89.92	87.48	**88.70**	88.70	88.67	**88.69**
Mean	**95.43**	93.54		**94.86**	92.92		**95.14**	93.23	

Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	1.14	0.51	1.61	1.45	0.65	2.05	0.94	0.42	1.33
CD 0.05	3.27	1.46	NS	4.14	1.85	NS	2.65	1.18	NS
CV%	2.96			3.78			3.46		

1st Year Mean	94.48	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	93.89	S. EM(±)	1.88	1.33	0.59	0.42
Pool Mean	94.19	CD 0.05	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation

4.1.2.4 Numbers of runners:

The formations of strawberry runners were significantly influenced by the growing condition where the higher numbers of runners (4.73, 4.51 and 4.62) were found under poly house cultivation than open cultivation in the first year, seconds year and pool data respectively (Table 4.1.2.4). The formation of runners was significantly influenced by different types of mulching materials, maximum number of runners (5.77, 5.90 and 5.83) was observed in black poly-mulch (M_8) whereas minimum number of runners (2.6, 2.77 and 2.68) was noted under no mulch (M_{10}) in the individual years as well as pool data.

Table-4.1.2.4: Effect of mulching treatments and growing condition on number of runners per plant of strawberry.

Number of runners per plant									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C1	C2	Mean	C1	C2	Mean	C_1	C_2	Mean
M1	3.67	5.60	4.63	3.93	5.20	4.57	3.80	5.40	4.60
M2	2.93	3.73	3.33	2.80	3.27	3.03	2.87	3.50	3.18
M3	3.60	5.27	4.43	3.27	5.13	4.20	3.43	5.20	4.32
M4	3.00	4.27	3.63	3.07	3.13	3.10	3.03	3.70	3.37
M5	3.07	5.00	4.03	3.40	4.93	4.17	3.23	4.97	4.10
M6	2.53	3.67	3.10	2.87	3.53	3.20	2.70	3.60	3.15
M7	3.20	4.53	3.87	3.00	3.67	3.33	3.10	4.10	3.60
M8	5.33	6.20	**5.77**	5.13	6.67	**5.90**	5.23	6.43	**5.83**
M9	4.80	6.07	5.43	4.67	6.40	5.53	4.73	6.23	5.48
M10	2.27	2.93	**2.60**	2.40	3.13	**2.77**	2.33	3.03	**2.68**
Mean	3.44	**4.73**		3.45	**4.51**		3.45	**4.62**	
Interaction effect									
Source	**Mulching (M)**	**Growing condition (C)**	**M x C**	**Mulching (M)**	**Growing condition (C)**	**M x C**	**Mulching (M)**	**Growing condition (C)**	**M x C**
S.EM(±)	0.22	0.10	0.31	0.26	0.12	0.37	0.18	0.08	0.25
CD 0.05	0.64	0.28	NS	0.76	0.34	NS	0.50	0.22	NS
CV%	13.31			16.29			15.18		
1st Year Mean		4.08		Pooled analysis		M x C x Y	M x Y	C x Y	Y
2nd year Mean		3.98		S. EM(±)		0.35	0.25	0.11	0.08
Pool Mean		4.03		CD 0.05		NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation.

Discussion

The pragmatic improvement on the number of flowers on polythene mulching may be attributed to the benefit which led to decrease water loss and higher soil temperature reduced soil erosion and supressed weed growth which in turn promoted vegetative growth which positively reflected on increased in number of flowers (Singh *et al.*, 2023). Among the organic mulches, paddy straw mulch (35.05, 34.94 and 34.99) has the highest number of flowers in individual years and pool analysis followed by rice husk and pine needle mulch. Taparauskienė and Miseckaitė (2014), Johnson and Fennimore (2005) also reported increase in the number of fruits, flowers and yield in strawberry under coloured inorganic mulch. Bakshi *et al*. (2014) also reported significant increase in the number of flowers under black poly mulch. The significant increase in the number of flowers in the growing condition also observed where higher number of flowers (33.80, 33.15 and 33.48) was found under open cultivation. Kumar *et al.* (2011) observed that more number of flower trusses from strawberry grown under open condition as compared to poly house cultivation, flower formation favours lower temperature than the high temperature as it is a temperate crop. Soliman *et al.* (2015) reported the total no of flowers was higher under low tunnel as compare to poly house cultivation under black poly- mulch. Shokouhian and Asghari (2015) reported that application of black polythene mulch significantly increase the number of fruit per plant in strawberry as compare to straw mulch and clear polythene mulch. Singh *et al*. (2010), Kher *et al*. (2010) and Bakshi *et al.* (2014) also reported that increased in number of fruits in strawberry under black poly mulch. Mulching improves the micro climates around the plant leading to early growth and development, flowering and ultimately leads to increased number of fruit per plant and it may also be attributed to the black polythene enhance the number of flowers due to decreased water loss and soil temperature which in turns increase the number of fruits respectively, (Singh *et al*., 2023).

The present investigation shows that all the mulch treatment has significant effect in the formation of runners. The maximum and the longest runner formation were observed under black poly-mulch (M_8) however care should be taken that runner didn’t have soil substrate to support and nurture the young runner upon the plastic sheet there was a high chance of mortality. Among the organic mulches, paddy straw mulch (M_1) has maximum capacity in runner formation, Increase in number of runners per plant under black poly mulch might be due to the reason that increases in growth of plant in the form of height, number of leaves and leaf area which accumulated more photosynthates and thereby increased runners per plant (Subraya *et al*., 2017). Maximum runner formation under black plastic mulch was observed by Patil *et al*. (2023). Semwal *et al.* (2022) also stated that black poly mulch produces the highest number of runners among the different mulches. Ali and Gaur, (2013), Kaur and Kaur, (2017) found that the production of strawberry runners were higher under mulch conditions.

4.1.3 Fruit quality parameters:

From observation of different fruit quality parameters, better fruit qualities were observed under polyhouse cultivation than from open cultivation.

4.1.3.1 Fruit size

4.1.3.1.1 Fruit length: The data regarding the fruit length in effect to various mulching materials and interaction with the growing conditions presented in table 4.1.3.1.1 states that the maximum fruit length (4.00 cm, 4.07 cm and 4.04 cm) was noted in black poly-mulch (M_8) which was found at par with M_9 silver poly-mulch (3.90 cm, 3.95 cm and 3.92 cm) whereas the minimum value was recorded in M_{10} no mulch (2.96 cm, 2.95 cm and 2.96 cm) in the individual years and pool analysis respectively. The fruit length was influenced by growing conditions where fruit length increased significantly under polyhouse cultivation (3.78 cm, 3.72 cm and 3.75 cm) than open cultivation.

Table-4.1.3.1.1: Effect of mulching treatments and growing condition on fruit length (cm) of strawberry.

Fruit length (cm)									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	3.67	3.89	3.78	3.72	3.97	3.85	3.70	3.93	3.81
M_2	2.94	3.64	3.29	3.08	3.57	3.33	3.01	3.60	3.31
M_3	3.51	3.81	3.66	3.56	3.77	3.67	3.54	3.79	3.67
M_4	3.15	3.70	3.43	3.21	3.50	3.36	3.18	3.60	3.39
M_5	3.40	3.78	3.59	3.57	3.69	3.63	3.49	3.73	3.61
M_6	2.83	3.55	3.19	2.90	3.32	3.11	2.86	3.43	3.15
M_7	3.58	3.87	3.72	3.51	3.84	3.68	3.55	3.85	3.70
M_8	3.86	4.15	**4.00**	3.90	4.24	**4.07**	3.88	4.20	**4.04**
M_9	3.77	4.02	3.90	3.84	4.06	3.95	3.81	4.04	3.92
M_{10}	2.56	3.37	**2.96**	2.68	3.23	**2.95**	2.62	3.30	**2.96**
Mean	3.33	**3.78**		3.40	**3.72**		3.36	**3.75**	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.12	0.05	0.17	0.12	0.05	0.16	0.08	0.04	0.12
CD $_{0.05}$	0.34	0.15	NS	0.33	0.15	NS	0.23	0.10	NS
CV%	8.16			8.02			8.00		
1st Year Mean		3.55		Pooled analysis		M x C x Y	M x Y	C x Y	Y
2nd year Mean		3.56		S. EM(±)		0.16	0.12	0.05	0.04
Pool Mean		3.55		CD $_{0.05}$		NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation

4.1.3.1.2 Fruit breadth: The perusal of the data in table 4.1.2.6.2 clearly indicates significance of mulching materials and interaction with the growing conditions. The maximum fruit width (3.65 cm, 3.67 cm and 3.66 cm) was observed in black poly-mulch (M_8)followed by M_9 silver poly-mulch (3.52 cm, 3.49 cm and 3.50 cm) whereas the minimum value was recorded in M_{10} no mulch (2.52 cm, 2.68 cm and 2.60 cm) in the first year, second year and pool analysis respectively. The fruit breadth was influenced by the growing conditions where fruit breadth increased significantly under poly-house cultivation (3.23 cm, 3.22 cm and 3.23 cm) than open cultivation.

Table-4.1.3.1.2: Effect of mulching treatments and growing condition on fruit breadth (cm) of strawberry.

Fruit breadth (cm)									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	3.28	3.48	3.38	3.27	3.47	3.37	3.28	3.47	3.38
M_2	2.75	2.98	2.87	3.15	3.07	3.11	2.95	3.03	2.99
M_3	3.06	3.32	3.19	3.22	3.25	3.23	3.14	3.28	3.21
M_4	2.72	3.04	2.88	2.86	2.97	2.92	2.79	3.01	2.90
M_5	2.96	3.21	3.08	3.03	3.13	3.08	3.00	3.17	3.08
M_6	2.56	2.92	2.74	2.71	2.91	2.81	2.64	2.92	2.78
M_7	3.11	3.18	3.15	3.03	3.20	3.11	3.07	3.19	3.13
M_8	3.43	3.87	**3.65**	3.50	3.83	**3.67**	3.47	3.85	**3.66**
M_9	3.35	3.68	3.52	3.41	3.56	3.49	3.38	3.62	3.50
M_{10}	2.42	2.63	**2.52**	2.51	2.85	**2.68**	2.46	2.74	**2.60**
Mean	2.96	**3.23**		3.07	**3.22**		3.02	**3.23**	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.10	0.05	0.15	0.11	0.05	0.15	0.07	0.03	0.10
CD $_{0.05}$	0.29	0.13	NS	0.30	0.13	NS	0.21	0.09	NS
CV%	8.14			8.19			8.19		

1st Year Mean	3.09	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	3.14	S. EM(±)	0.15	0.10	0.05	0.03
Pool Mean	3.12	CD $_{0.05}$	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation

4.1.3.2 Fruit weight:

The data presented in table 4.1.2.7 showed significant effect in the single fruit weight (gm) by different types of mulching materials and their growing conditions. Black poly-mulch (M_8) recorded the maximum fruit weight (19.83 gm, 19.92 gm and 19.87 gm) followed by M_9, silver poly- mulch (19.54, 19.76 and 19.65) gm whereas the minimum fruit weight (12.42 gm, 12.18 gm and 12.30 gm) was noted in no mulch (M_{10}). The fruit weight was influenced by growing conditions where fruit weight increased significantly under polyhouse cultivation (17.44 gm, 17.53 gm and 17.49 gm) than open cultivation.

Table-4.1.3.2: Effect of mulching treatments and growing condition on fruit weight (gm.) of strawberry.

Fruit weight (gm)									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	15.88	18.07	16.97	15.88	18.25	17.06	15.88	18.16	17.02
M_2	14.13	15.54	14.84	14.13	15.72	14.93	14.13	15.63	14.88
M_3	15.88	17.50	16.69	15.88	17.68	16.78	15.88	17.59	16.73
M_4	12.88	15.49	14.19	12.88	15.67	14.28	12.88	15.58	14.23
M_5	15.46	16.34	15.90	15.46	16.52	15.99	15.46	16.43	15.94
M_6	13.42	14.69	14.06	13.52	14.87	14.19	13.47	14.78	14.13
M_7	14.74	17.26	16.00	14.74	17.44	16.09	14.74	17.35	16.04
M_8	16.68	22.97	**19.83**	16.68	23.16	**19.92**	16.68	23.07	**19.87**
M_9	16.19	22.89	19.54	16.60	22.93	19.76	16.39	22.91	19.65
M_{10}	11.23	13.60	**12.42**	11.23	13.12	**12.18**	11.23	13.36	**12.30**
Mean	14.65	**17.44**		14.70	**17.53**		14.67	**17.49**	

Interaction effect

Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.54	0.24	0.76	0.54	0.24	0.77	0.38	0.17	0.54
$CD_{0.05}$	1.54	0.69	2.18	1.56	0.70	2.20	1.08	0.48	1.53
CV%	8.21			8.26			8.28		

1st Year Mean	16.04	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	16.12	S. EM(±)	0.77	0.54	0.24	0.17
Pool Mean	16.08	$CD_{0.05}$	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation.

4.1.3.3 TSS:

It is apparent from the data presented in the Table 4.1.3.3 that effect of different types of mulches and their growing conditions were observed in terms of quality parameter. The maximum total soluble solids (TSS) was found in (M_8) Black poly-mulch (8.16, 8.21 and 8.19 ^{0} Brix) while the minimum TSS (7.62, 7.55 and 7.59 ^{0} Brix) was observed under (M_2) saw dust in the individual years as well as pool data. TSS was significantly influenced by the growing condition where the higher values (7.98, 7.97 and 7.97 ^{0} Brix) were found under poly house cultivation than the open cultivation in the first year, second year and pool data respectively.

Table-4.1.3.3: Effect of mulching treatments and growing condition on TSS (^{0} Brix) of Strawberry.

TSS (^{0} Brix)									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	7.76	8.03	7.90	7.98	8.05	8.02	7.87	8.04	7.96
M_2	7.45	7.79	**7.62**	7.46	7.64	**7.55**	7.46	7.72	**7.59**
M_3	7.69	7.95	7.82	7.84	7.89	7.87	7.77	7.92	7.84
M_4	7.77	7.87	7.82	7.80	7.92	7.86	7.78	7.89	7.84
M_5	7.89	8.05	7.97	8.02	7.99	8.01	7.96	8.02	7.99
M_6	7.46	8.07	7.76	7.70	7.94	7.82	7.58	8.01	7.79
M_7	8.01	8.06	8.03	8.12	8.12	8.12	8.06	8.09	8.07
M_8	8.16	8.16	**8.16**	8.19	8.23	**8.21**	8.18	8.20	**8.19**
M_9	8.14	8.12	8.13	8.15	8.23	8.19	8.15	8.17	8.16
M_{10}	7.64	7.65	7.65	7.50	7.69	7.60	7.57	7.67	7.62
Mean	7.80	7.98		7.88	7.97		7.84	7.97	

Interaction effect

Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.09	0.04	0.12	0.08	0.04	0.12	0.06	0.03	0.09
CD $_{0.05}$	0.25	0.11	NS	0.24	NS	NS	0.17	0.08	NS
CV%	2.71			2.61			2.70		

1st Year Mean	7.89	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	7.92	S. EM(±)	0.12	0.09	0.04	0.03
Pool Mean	7.90	CD $_{0.05}$	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation.

4.1.3.4 Acidity:

The data in table 4.1.3.4 clearly shows the significant effect of different mulching materials on titratable acidity (%) content of strawberry and their interaction with the growing conditions. The lowest value (0.43 %, 0.43 % and 0.44 %) of acidity was obtained in black poly- mulch (M_8) followed by M_9 silver poly-mulch (0.48 %, 0.47 % and 0.48 %) whereas the maximum acidity (0.71 %, 0.71 % and 0.71 %) was obtained in no mulch (M_{10}) in the individual years as well as pool analysis. Lower acidity (0.50 %, 0.50 % and 0.50 %) was observed in open cultivation under the influenced of growing condition in the individual years and pool analysis.

Table-4.1.3.4: Effect of mulching treatments and growing condition on titratable acidity (%) of strawberry.

Titratable acidity (%)									
Treatments	1st year			2nd year			Pooled		
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean
M_1	0.52	0.59	0.55	0.51	0.59	0.55	0.51	0.59	0.55
M_2	0.49	0.47	0.48	0.49	0.49	0.49	0.49	0.48	0.48
M_3	0.49	0.55	0.52	0.49	0.57	0.53	0.49	0.56	0.52
M_4	0.51	0.52	0.52	0.49	0.49	0.49	0.50	0.51	0.51
M_5	0.51	0.55	0.53	0.53	0.53	0.53	0.52	0.54	0.53
M_6	0.51	0.57	0.54	0.50	0.61	0.56	0.50	0.59	0.55
M_7	0.49	0.55	0.52	0.45	0.54	0.50	0.47	0.54	0.51
M_8	0.41	0.46	**0.44**	0.41	0.45	**0.43**	0.41	0.45	**0.43**
M_9	0.44	0.51	0.48	0.46	0.49	0.47	0.45	0.50	0.48
M_{10}	0.66	0.75	**0.71**	0.68	0.74	**0.71**	0.67	0.75	**0.71**
Mean	0.50	0.55		0.50	0.55		0.50	0.55	

Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.02	0.01	0.03	0.02	0.01	0.02	0.01	0.01	0.02
$CD_{0.05}$	0.06	0.03	NS	0.04	0.02	NS	0.04	0.02	NS
CV%	9.75			7.18			8.63		

1st Year Mean	0.53	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	0.53	S. EM(±)	0.03	0.02	0.01	0.01
Pool Mean	0.53	$CD_{0.05}$	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation.

4.1.3.5: Total sugar:

The data presented in table 4.1.3.5 indicates significant effect on total sugar content (%) of strawberry with different mulch materials and growing conditions. The maximum value of total sugar was observed under M_8 black poly-mulch (6.82 %, 6.79 % and 6.81 %) followed by M_9 silver poly-mulch (6.67 %, 6.78 % and 6.73 %) the minimum value was obtained under M_{10} no mulch (5.38 %, 5.58 % and 5.48 %) in the first year, second year and pool analysis respectively. The total sugar content of strawberry was influenced by the growing conditions where higher values were obtained under poly-house cultivation (6.18 %, 6.35 % and 6.26 %) in the first year, second year and pool analysis.

Table-4.1.3.5: Effect of mulching treatments and growing condition on total sugar (%) of strawberry.

Total sugar (%)									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	5.90	6.02	5.96	6.06	6.39	6.22	5.98	6.20	6.09
M_2	5.83	6.13	5.98	5.67	6.15	5.91	5.75	6.14	5.94
M_3	5.74	6.18	5.96	5.81	6.58	6.20	5.78	6.38	6.08
M_4	5.31	5.99	5.65	5.72	6.09	5.91	5.52	6.04	5.78
M_5	5.35	6.09	5.72	5.78	6.14	5.96	5.57	6.12	5.84
M_6	5.53	6.05	5.79	5.68	6.12	5.90	5.61	6.09	5.85
M_7	5.99	6.01	6.00	5.83	6.27	6.05	5.91	6.14	6.03
M_8	6.68	6.95	**6.82**	6.53	7.05	**6.79**	6.61	7.00	**6.81**
M_9	6.48	6.86	6.67	6.64	6.92	6.78	6.56	6.89	6.73
M_{10}	5.22	5.53	**5.38**	5.42	5.74	**5.58**	5.32	5.64	**5.48**
Mean	5.80	**6.18**		5.91	**6.35**		5.86	**6.26**	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.11	0.05	0.16	0.10	0.05	0.14	0.08	0.03	0.11
$CD_{0.05}$	0.32	0.14	NS	0.29	0.13	NS	0.21	0.10	NS
CV%	4.51			4.06			4.35		

1st Year Mean	5.99	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	6.13	S. EM(±)	0.15	0.11	0.05	0.03
Pool Mean	6.06	$CD_{0.05}$	NS	NS	NS	0.10

*C_1= open cultivation, C_2= polyhouse cultivation.

4.1.3.6: Ascorbic acid content:

The data presented in table 4.1.3.6 clearly indicates significant effect of ascorbic acid content (mg/100 gm) of strawberry. The maximum content of ascorbic acid was observed under M_8 black poly-mulch (52.78, 52.36 and 52.57 mg/100 gm) followed by M_9 silver poly- mulch (51.61, 51.58 and 51.60 mg/100 gm) the minimum value was obtained under M_{10} no mulch (46.58, 7.17 and 46.88 mg/100gm) in the first year, second year and pool analysis. The ascorbic acid content of strawberry was influenced by the growing conditions where ascorbic acid content was increased significantly under polyhouse cultivation (49.89, 50.02 and 49.96 mg/100 gm).

Table-4.1.3.6: Effect of mulching treatments and growing condition on ascorbic acid (mg/100 gm) of strawberry

Ascorbic acid (mg/100 gm)									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	49.52	49.16	49.34	49.52	50.37	49.95	49.52	49.77	49.64
M_2	47.86	49.45	48.66	48.29	49.75	49.02	48.07	49.60	48.84
M_3	48.08	49.48	48.78	48.33	48.77	48.55	48.21	49.13	48.67
M_4	49.49	48.90	49.19	49.58	49.12	49.35	49.53	49.01	49.27
M_5	47.23	48.89	48.06	47.47	49.75	48.61	47.35	49.32	48.34
M_6	46.53	48.27	47.40	46.28	48.78	47.53	46.41	48.53	47.47
M_7	47.53	50.88	49.20	47.73	50.34	49.03	47.63	50.61	49.12
M_8	51.87	53.69	**52.78**	51.24	53.49	**52.36**	51.56	53.59	**52.57**
M_9	50.24	52.98	51.61	51.14	52.02	51.58	50.69	52.50	51.60
M_{10}	45.94	47.23	**46.58**	46.52	47.82	**47.17**	46.23	47.52	**46.88**
Mean	48.43	49.89		48.61	50.02		48.52	49.96	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.61	0.27	0.86	0.68	0.30	0.96	0.46	0.21	0.66
CD $_{0.05}$	1.75	0.78	NS	1.94	0.87	NS	1.31	0.58	NS
CV%	3.04			3.36			3.26		

1st Year Mean	49.16	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	49.31	S. EM(±)	0.93	0.66	0.29	0.21
Pool Mean	49.24	CD $_{0.05}$	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation

4.1.3.7: Anthocyanin content of fruit:

`The data in table 4.1.3.7 clearly shows the significant effect of different mulching materials on anthocyanin content (mg/100 gm) of strawberry and their interaction with the growing conditions. The maximum value (48.21, 48.13 and 48.17 mg/100 gm) of anthocyanin was obtained in black poly-mulch (M_8) followed by M_9 silver poly-mulch (47.52, 47.47 and 47.50 mg/100 gm) whereas the minimum value (38.20, 36.55and 37.38 mg/100 gm) was obtained in no mulch (M_{10}) in the individual years as well as pool analysis.

Table-4.1.3.7: Effect of mulching treatments and growing condition on anthocyanin content (mg/100 gm) of Strawberry.

Anthocyanin content (mg/100 gm)									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	43.31	46.64	44.97	41.95	47.51	44.73	42.63	47.07	44.85
M_2	38.13	41.67	39.90	36.42	43.38	39.90	37.28	42.53	39.90
M_3	41.95	45.87	43.91	44.40	46.21	45.30	43.17	46.04	44.61
M_4	40.35	41.67	41.01	39.22	40.04	39.63	39.79	40.86	40.32
M_5	45.37	46.35	45.86	46.75	46.30	46.53	46.06	46.33	46.19
M_6	44.77	41.78	43.27	45.69	42.03	43.86	45.23	41.91	43.57
M_7	45.85	47.01	46.43	45.54	47.07	46.31	45.70	47.04	46.37
M_8	46.71	49.72	**48.21**	46.91	49.34	**48.13**	46.81	49.53	**48.17**
M_9	46.56	48.49	47.52	46.69	48.25	47.47	46.63	48.37	47.50
M_{10}	37.24	39.17	**38.20**	36.05	37.04	**36.55**	36.65	38.11	**37.38**
Mean	43.02	**44.84**		42.96	**44.72**		42.99	**44.78**	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM (±)	0.94	0.42	1.32	1.04	0.46	1.47	0.71	0.32	1.00
CD $_{0.005}$	2.68	1.20	NS	2.97	1.33	NS	1.99	0.89	2.81
CV%	8.06			8.12			8.28		
1st Year Mean	43.93			Pooled analysis	M x C x Y		M x Y	C x Y	Y
2nd year Mean	43.84			S. EM(±)	1.41		1.00	0.45	0.32
Pool Mean	43.89			CD $_{0.005}$	NS		NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation.

4.1.3.8 Shelf life of strawberry

In the present study, shelf life of strawberry is expressed in physiological loss in weight (%) which was calculated and recorded at 24, 48 and 72 hours after harvest, the higher loss percentage indicated faster fruit deterioration and lesser physiological weight loss (%) indicated better keeping quality of strawberry. The harvested fruits after removing the field heat were taken as the initial weights and the final weights were taken 24 hrs. later. The percentages in weight loss were calculated as physiological loss in weight.

4.1.3.8.1: Physiological loss in weight within 24hours:

The data depicted in the table 4.1.3.8.1 depicted significant effects of different types of mulching and their growing conditions on the physiological loss in weight (%) 24 hrs. after harvest. The lowest loss in moisture content of fruits (6.07 %, 5.97 % and 6.02 %) were observed under black poly-mulch (M_8) followed by M_9 silver poly-mulch (6.08 %, 6.00 % and 6.04 %) in the first year, second year and pool data whereas the maximum record (6.90 %, 6.89 % and 6.89 %) was found under no mulch (M_{10}) in the first year, second year and in pool analysis. Significant effect of loss in weight in the growing conditions was observed where lower moisture loss percentage (5.98 %, 5.97 % and 5.98 %) was observed under open cultivation in the first year, second year and pool analysis mulching and their growing conditions as well as their interaction effect on the physiological loss in weight (%) at 48 hrs. after harvest. The lowest loss in moisture content of fruits (9.50%, 9.53 % and 9.51 %) were observed under paddy straw mulch (M_1) followed by $M_{3,}$ wood shaving (9.53 %, 9.76 % and 9.64 %) in the first year, second year and pool data whereas the maximum record (11.06 %, 11.05 % and 11.05 %) was found under no mulch (M_{10}) in the first year, second year and in pool analysis.

Significant effect of loss in weight in the growing conditions was observed where lower moisture loss percentage (9.71 %, 9.89 % and 9.80 %) was observed under open cultivation in the first year, second year and pool analysis.

Table-4.1.3.8.1: Effect of mulching treatments and growing condition on physiological loss in weight (%) within 24 hrs. after harvest of strawberry.

Physiological loss in weight (%) within 24 hrs									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	5.80	6.43	6.11	5.86	6.14	6.00	5.83	6.29	6.06
M_2	6.06	6.62	6.34	6.09	6.49	6.29	6.07	6.56	6.31
M_3	5.92	6.43	6.18	5.98	6.54	6.26	5.95	6.48	6.22
M_4	6.15	6.49	6.32	6.11	6.37	6.24	6.13	6.43	6.28
M_5	5.92	6.33	6.12	5.89	6.52	6.21	5.91	6.42	6.17
M_6	6.07	6.78	6.43	6.11	6.71	6.41	6.09	6.75	6.42
M_7	5.93	6.41	6.17	5.91	6.33	6.12	5.92	6.37	6.14
M_8	5.65	6.50	**6.07**	5.46	6.47	**5.97**	5.56	6.48	**6.02**
M_9	5.58	6.57	6.08	5.54	6.47	6.00	5.56	6.52	6.04
M_{10}	6.76	7.05	**6.90**	6.74	7.03	**6.89**	6.75	7.04	**6.89**
Mean	**5.98**	6.56		**5.97**	6.51		**5.98**	6.53	

Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.14	0.06	0.20	0.13	0.06	0.19	0.10	0.04	0.14
$CD_{0.05}$	0.40	0.18	NS	0.38	0.17	NS	0.27	0.12	NS
CV%	5.45			5.25			5.32		

1st Year Mean	6.27	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	6.24	S. EM(±)	0.19	0.14	0.06	0.04
Pool Mean	6.25	$CD_{0.05}$	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation.

Table-4.1.3.8.2: Effect of mulching treatments and growing condition on physiological loss in weight (%) within 48 hrs. after harvest of strawberry.

Physiological loss in weight (%) within 48 hrs.									
Treatments	1st year			2nd year			Pooled		
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean
M_1	9.43	9.57	**9.50**	9.47	9.59	**9.53**	9.45	9.58	**9.51**
M_2	9.63	9.85	9.74	9.97	9.87	9.92	9.80	9.86	9.83
M_3	9.32	9.73	9.53	9.78	9.74	9.76	9.55	9.74	9.64
M_4	9.80	9.99	9.90	9.90	9.97	9.93	9.85	9.98	9.92
M_5	9.45	9.90	9.68	9.74	9.91	9.83	9.60	9.91	9.75
M_6	9.97	10.05	10.01	9.93	10.09	10.01	9.95	10.07	10.01
M_7	9.61	9.99	9.80	9.98	9.91	9.94	9.80	9.95	9.87
M_8	9.47	10.48	9.98	9.50	10.44	9.97	9.49	10.46	9.97
M_9	9.57	10.53	10.05	9.88	10.56	10.22	9.73	10.54	10.14
M_{10}	10.81	11.31	**11.06**	10.72	11.37	**11.05**	10.77	11.34	**11.05**
Mean	**9.71**	10.14		**9.89**	10.15		**9.80**	10.14	

Interaction effect

Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.17	0.08	0.24	0.08	0.04	0.11	0.09	0.04	0.13
CD $_{0.05}$	0.48	0.22	NS	0.23	0.10	0.33	0.27	0.12	0.38
CV%	4.17			1.98			3.27		

1st Year Mean	9.92	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	10.02	S. EM(±)	0.19	0.13	0.06	0.04
Pool Mean	9.97	CD $_{0.05}$	NS	NS	NS	NS

*C1= open cultivation, C2= polyhouse cultivation

4.1.3.8.3: Physiological loss in weight within 72 hours:

The data on table 4.1.3.8.3 depicted significant effects of different types of mulching and their growing conditions on the physiological loss in weight (%) at 72 hrs. after harvest. The lowest loss in moisture content of fruits (11.97 % and 12.96 %) was observed under wood shaving (M_3) in the first year and pool analysis whereas in the second year, M_1, paddy straw mulch (13.26%**)** was found lowest. The maximum record (15.70 %, 15.65 % and 15.67 %) was found under no mulch (M_{10}) in the first year, second year and in pool analysis. Significant effect of loss in weight in the growing conditions was observed where lower moisture loss percentage (13.95 %, 13.80 % and 13.87 %) was observed under open cultivation in the first year, second year and pool analysis.

Table-4.1.3.8.3: Effect of mulching treatments and growing condition on physiological loss in weight (%) within 72 hrs. after harvest of strawberry.

Physiological loss in weight (%) within 72 hrs.									
Treatments	1st year			2nd year			Pooled		
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean
M_1	13.44	14.55	13.99	12.56	13.95	**13.26**	13.00	14.25	13.62
M_2	14.18	14.18	14.18	14.11	14.29	14.20	14.15	14.23	14.19
M_3	12.87	11.06	**11.97**	13.21	14.71	13.96	13.04	12.89	**12.96**
M_4	14.43	15.00	14.72	13.29	14.93	14.11	13.86	14.97	14.41
M_5	13.58	14.52	14.05	13.42	14.50	13.96	13.50	14.51	14.00
M_6	14.12	15.29	14.70	14.63	15.18	14.91	14.37	15.24	14.80
M_7	14.07	14.52	14.30	13.89	15.07	14.48	13.98	14.80	14.39
M_8	13.62	15.58	14.60	14.02	15.78	14.90	13.82	15.68	14.75
M_9	14.14	15.46	14.80	14.03	15.47	14.75	14.08	15.46	14.77
M_{10}	15.03	16.37	**15.70**	14.84	16.46	**15.65**	14.93	16.41	**15.67**
Mean	13.95	14.65		13.80	15.03		13.87	14.84	

Interaction effect

Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.52	0.23	0.73	0.18	0.08	0.25	0.28	0.13	0.40
$CD_{0.05}$	1.48	0.66	NS	0.51	0.23	NS	0.79	0.35	NS
CV%	8.86			3.01			6.78		

		Pooled analysis	M x C x Y	M x Y	C x Y	Y
1st Year Mean	14.30					
2nd year Mean	14.42	S. Em±	0.56	0.40	0.18	0.13
Pool Mean	14.36	$CD_{0.05}$	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation.

Discussion

Significant effect of mulching and their interaction with the growing condition was observed in single fruit weight , the treatment combination of black poly- mulching with poly- house cultivation (C_2M_8) resulted the maximum single fruit weight (22.97 gm, 23.16 gm and 23.07 gm) was observed which was followed by silver poly-mulch in poly-house cultivation (C_2M_9) while the minimum fruit weight (11.23 gm, 11.23 gm and 11.23 gm) was observed with No much in open cultivation (C_1M_{10}) in the individual years and pool analysis.

The present investigation reveals that different type of mulching improves the fruit size and yield of strawberry as compared to control. The black polythene might have induced favourable condition conducive for the attainment of berries with higher fruit size. The increase in fruit length and breadth under black poly mulch may be attributed to congenial soil moisture resulting in higher uptake of nutrition for better growth of fruit and the decline in evaporation losses of soil moisture caused by plastic mulches (Singh *et al*., 2023). Pandey *et al*. (2016) also reported that fruit length and breadth was significantly increased under black poly- mulch.

Among different treatments, the plant grown under plastic mulch produced larger number of fruits, fruit weight, and finally contributed to yield. Plants under black poly-mulch produced higher yield per plant, as fruits are larger due to better plant growth due to favourable hydrothermal regime of soil and complete weed free environment (Semwal *et al*., 2022). Singh *et al*. (2023) reported that black poly-mulch induces the favourable condition conducive for the attainment of heavier fruits. Pandey *et al*. (2016) also reported maximum fruit yield under black poly mulch in strawberry. Saeid and Mohammed, (2015) also found the same results in summer squash because of better plant growth due to favourable hydrothermal regime and complete weed free environment. Strawberry plants, when mulched with black polythene film, produced more number of fruits which ultimately resulted in highest strawberry production compared to other types of mulches found by Castaneda *et al*., 2008. Parmar *et al*. (2013) observed heavier fruits under black poly mulch in water melon, Sharma and Agrawal Narendra (2004) found heavier fruit in tomato, Ali and Gaur (2007) also reported maximum fruit weight in strawberry under black poly mulch. Kher *et al*. (2010), Kumar and Dey, (2011) and Bakshi *et al*. (2014) also reported higher vegetative growth and yield of strawberry under black polythene mulch.

Singh *et al*. (2023) observed that lower acidity but higher TSS, Sugar, ascorbic acid and anthocyanin content in black poly mulch. Singh et al. (2007) also observed fruit harvested from plants mulched with black polyethylene have higher TSS, ascorbic acid and lower acidity than those harvested from plant mulch either with clear polyethylene or paddy straw. Pandey et al., (2016) found that maximum value of TSS, total sugar, ascorbic acid and anthocyanin content of strawberry when mulch with black polyethylene. Hassan *et al*. (2000), Sharma *et al*. (2004) and Gupta and Acharya, (1993) also observed similar result in strawberry. The higher fruit quality under black poly-mulch may be explained in terms of higher moisture and nutrient availability, higher root activity including higher uptake of water and nutrient, high photosynthesis and other enzymatic activities (Pandey *et al*., 2016) and weed free environment (Singh *et al*., 2007). Sharma and Sharma, 2003; Wang *et al*., 1998 reported that paddy straw mulches recorded high titratable acidity content as compared to other mulches in various strawberry varieties.

The anthocyanin content of strawberry was influenced by the growing conditions where higher values of anthocyanin were obtained under poly-house cultivation (44.84, 44.72 and 44.78 mg/100 gm). Pandey *et al*. (2015) observed the higher anthocyanin content under naturally ventilated polyhouse than open condition.

The physiological loss in weight is governed by substrate present in the fruit and its storage environment. It is important criteria for deciding the shelf life of fruits and vegetables (Sorensen *et al*., 1994)). Low temperature during flowering and fruit development greatly favours starch, carbohydrates and dry matter accumulation (Wang and Camp, 2000). Sujatha *et al*. (2018) states that variation in the physiological loss in weight of fruits harvested from the plant applied with various mulches could be attributed to variation in respiration and transpiration rates. The lowest loss in moisture was found in black poly mulch which might be due to the good response in terms of growth, flowering and quality traits in black poly mulch (Bakshi *et al.,* 2014). Sujatha *et al*. (2018) also reported the significant variation in moisture loss.

4.1.4: Physico – chemical properties of soil.

Higher reading of soil temperature and soil moisture content with lower soil pH were recorded from strawberry in polyhouse cultivation, while available nitrogen, phosphorus and potassium were not significantly affected by growing conditions in the present investigation.

4.1.4.1 Soil temperature

4.1.4.1.1 Soil temperature at 30 days after planting (DAP):

The data depicted in the table 4.1.4.1.1 clearly indicates significant effect of different types of mulching and their growing conditions on the soil temperature at 30 days after planting (DAP). The highest record (23.37, 23.10 and 23.23 ^{0} C) was observed under black poly-mulch (M_8) followed by M_9 silver poly-mulch (23.09, 22.89 and 22.99 ^{0} C) in the first year, second year and pool data whereas the minimum temperature record (20.68 ^{0}C) was found under leaf litter (M_4) in the first year, 21.13 ^{0} C in the second year under saw dust (M_2), 21.13 ^{0} C under leaf litter in pool analysis. Significant effect in the growing conditions was observed where higher soil temperature (22.28, 22.14 and 22.21 ^{0} C) was observed under polyhouse cultivation in the first year, second year and pool analysis.

4.1.4.1.2 Soil temperature at 60 DAP:

The data depicted in the table 4.1.4.1.2 clearly indicates significant effect of different types of mulching and their growing conditions on the soil temperature at 60 days after planting. The soil temperature at a depth of 5 cm was higher under plastic mulch than most of the organic mulch. The highest temperature record (25.48, 25.40 and 25.44 ^{0} C) was observed under black poly-mulch (M_8) followed by M_9 silver poly- mulch (25.15, 25.40 and 25. 28 ^{0} C) in the first year, second year and pool data whereas the minimum temperature record (22.08 ^{0}C) was found under pine needle mulch (M_5) in the first year, 22.18 ^{0}C and 22.27 ^{0} C under straw mulch (M_1) in the second year and in pool analysis. Significant effect in the growing conditions was observed where higher soil temperature (23.46, 23.35 and 23.41 ^{0} C) was observed under polyhouse cultivation in the first year, second year and pool analysis.

Table-4.1.4.1.1: Effect of mulching treatments and growing condition on soil temperature (^{0} C) of strawberry cultivation at 30 days after planting.

Soil temperature (^{0} C) at 30 DAP									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	21.47	21.94	21.70	21.10	22.03	21.57	21.29	21.99	21.64
M_2	20.98	22.10	21.54	20.97	21.29	**21.13**	20.98	21.69	21.34
M_3	21.08	21.44	21.26	21.13	21.51	21.32	21.11	21.47	21.29
M_4	20.70	20.66	**20.68**	21.30	21.86	21.58	21.00	21.26	**21.13**
M_5	20.69	21.60	21.15	21.28	21.33	21.30	20.98	21.47	21.22
M_6	21.02	22.05	21.53	21.09	21.93	21.51	21.06	21.99	21.52
M_7	21.29	22.35	21.82	21.13	21.88	21.51	21.21	22.12	21.66
M_8	22.49	24.25	**23.37**	22.79	23.41	**23.10**	22.64	23.83	**23.23**
M_9	22.46	23.72	23.09	22.63	23.14	22.89	22.55	23.43	22.99
M_{10}	21.80	22.65	22.23	23.02	22.97	23.00	22.41	22.81	22.61
Mean	21.40	**22.28**		21.64	**22.14**		21.52	**22.21**	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.26	0.12	0.37	0.22	0.10	0.32	0.19	0.08	0.26
CD $_{0.05}$	0.75	0.34	NS	0.64	0.29	NS	0.52	0.23	NS
CV%	2.95			2.51			2.95		

1st Year Mean	21.84	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	21.89	S. EM(±)	0.37	0.26	0.12	0.08
Pool Mean	21.86	CD $_{0.05}$	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation

Table-4.1.4.1.2: Effect of mulching treatments and growing condition on soil temperature (^{0}C) of strawberry cultivation at 60 days of planting.

Soil temperature (^{0}C) at 60 DAP									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	21.91	22.80	22.36	21.99	22.38	**22.18**	21.95	22.59	**22.27**
M_2	22.07	22.76	22.42	22.12	22.67	22.39	22.09	22.72	22.40
M_3	22.16	22.66	22.41	22.27	22.30	22.29	22.22	22.48	22.35
M_4	22.25	22.32	22.29	22.06	22.69	22.38	22.15	22.51	22.33
M_5	21.89	22.27	**22.08**	22.71	22.51	22.61	22.30	22.39	22.34
M_6	22.37	23.04	22.71	21.94	22.71	22.32	22.16	22.88	22.52
M_7	23.32	23.43	23.38	23.18	22.69	22.94	23.25	23.06	23.16
M_8	24.58	26.37	**25.48**	24.50	26.30	**25.40**	24.54	26.34	**25.44**
M_9	24.13	26.17	25.15	24.72	26.09	25.40	24.43	26.13	25.28
M_{10}	24.11	22.80	23.45	24.26	23.18	23.72	24.19	22.99	23.59
Mean	22.88	23.46		22.97	23.35		22.93	23.41	

Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.25	0.11	0.36	0.26	0.12	0.37	0.18	0.08	0.26
CD $_{0.05}$	0.73	0.33	1.03	0.75	0.34	1.07	0.52	0.23	0.74
CV%	3.38			4.24			3.81		

1st Year Mean	23.17	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	23.16	S. EM(±)	0.37	0.26	0.12	0.08
Pool Mean	23.16	CD $_{0.05}$	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation.

4.1.4.1.3 Soil temperature at 90 DAP: The data depicted in the table 4.1.4.1.3 clearly indicates significant effect of different types of mulching and their growing conditions on the soil temperature at 90 days after planting. The highest temperature record (29.46, 29.40 and 29.43 ^{0}C) was observed under black poly-mulch (M_8) followed by M_9 silver poly-mulch (29.24, 28.51 and 28.88 ^{0}C) in the first year, second year and pool data whereas the minimum temperature record (25.68, 25.46 and 25.57 ^{0}C) was found under pine needle (M_5) in the first year, second year, in pool analysis. Significant effect in the growing conditions was observed where higher soil temperature (27.30, 27.00 and 27.15 ^{0}C) was observed under polyhouse cultivation in the first year, second year and pool analysis.

Table-4.1.4.1.3: Effect of mulching treatments on soil temperature (^{0} C) of strawberry cultivation at 90 days after planting.

Soil temperature (^{0} C) at 90 DAP									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	25.92	26.89	26.40	26.39	26.27	26.33	26.15	26.58	26.37
M_2	26.33	26.34	26.34	26.32	26.33	26.33	26.33	26.34	26.33
M_3	25.98	26.00	25.99	25.88	26.18	26.03	25.93	26.09	26.01
M_4	25.86	26.51	26.18	25.91	26.12	26.02	25.89	26.31	26.10
M_5	25.55	25.80	**25.68**	25.49	25.43	**25.46**	25.52	25.62	**25.57**
M_6	25.84	26.30	26.07	26.27	26.11	26.19	26.05	26.20	26.13
M_7	25.47	26.20	25.83	25.97	26.48	26.23	25.72	26.34	26.03
M_8	27.60	31.32	**29.46**	27.90	30.90	**29.40**	27.75	31.11	**29.43**
M_9	27.58	30.90	29.24	27.74	29.28	28.51	27.66	30.09	28.88
M_{10}	25.85	26.78	26.32	25.88	26.87	26.38	25.87	26.83	26.35
Mean	26.20	**27.30**		26.41	**27.00**		26.30	**27.15**	

Interaction effect

Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
SEM(±)	1.39	0.62	1.97	0.31	0.14	0.44	0.73	0.32	1.03
CD $_{0.05}$	3.99	1.78	NS	0.90	0.40	1.27	2.05	0.91	NS
CV%	12.75			2.88			9.42		

1st Year Mean	26.32	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	26.70	S. EM(±)	1.45	1.03	0.46	0.32
Pool Mean	26.51	CD $_{0.05}$	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation.

4.1.4.2 Soil moisture content

4.1.4.2.1 Soil moisture content at 30 DAP: The data depicted in the table 4.1.4. 2.1 shows significant effect of different types of mulching and their growing conditions on the soil moisture content at 30 days after planting. The soil moisture taken at a depth of 15 cm was higher under plastic mulch than most of the organic mulch. The highest record (48.24, 47.95 and 48.10 %) was observed under black poly-mulch (M_8) followed by M_9 silver poly-mulch (46.22, 46.48 and 46.35) percentage in the first year, second year and pool data whereas the minimum moisture record (25.23, 25. 31 and 25. 27 %) was found under no mulch (M_{10}) in the first year, second year and in pool analysis. Significant effect in the growing conditions was observed where higher soil moisture percentage (42.88, 43.87 and 43.37) was observed under polyhouse cultivation in the first year, second year and pool analysis.

Table-4.1.4.2.1: Effect of mulching treatments and growing condition on soil moisture content (%) of strawberry cultivation at 30 days after planting.

Soil moisture content (%) at 30 DAP									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	40.70	48.13	44.42	40.23	47.77	44.00	40.47	47.95	44.21
M_2	39.15	42.83	40.99	39.76	44.79	42.27	39.46	43.81	41.63
M_3	38.43	42.32	40.37	38.54	45.31	41.92	38.48	43.81	41.15
M_4	38.06	40.55	39.31	38.28	41.42	39.85	38.17	40.99	39.58
M_5	40.18	45.58	42.88	40.43	45.18	42.80	40.31	45.38	42.84
M_6	34.75	39.23	36.99	34.69	40.80	37.75	34.72	40.02	37.37
M_7	39.28	42.80	41.04	38.54	45.52	42.03	38.91	44.16	41.54
M_8	45.20	51.29	**48.24**	44.69	51.22	**47.95**	44.94	51.25	**48.10**
M_9	43.21	49.22	46.22	43.03	49.93	46.48	43.12	49.58	46.35
M_{10}	23.62	26.85	**25.23**	23.89	26.74	**25.31**	23.75	26.79	**25.27**
Mean	38.26	**42.88**		38.21	**43.87**		38.23	**43.37**	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	1.44	0.64	2.04	3.08	1.38	4.36	1.68	0.75	2.38
CD $_{0.05}$	4.13	1.85	NS	8.83	3.95	NS	4.74	2.12	NS
CV%	8.71			18.49			14.32		
1st Year Mean	40.57			Pooled analysis	M x C x Y		M x Y	C x Y	Y
2nd year Mean	40.18			S. EM(±)	3.37		2.38	1.06	0.75
Pool Mean	40.38			CD $_{0.05}$	NS		NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation.

4.1.4.2.2 Soil moisture content at 60 DAP:

The data depicted in the table 4.1.4.2.2 clearly indicates significant effect of different types of mulching and their growing conditions on the soil moisture content at 60 days after planting. The soil moisture at a depth of 15 cm was higher under plastic mulch than most of the organic mulch. The highest moisture percentage (46.80 %) was observed under M_8 in the first year, 45.94 and 45.27 % under M_9 in the second year and pool analysis whereas the minimum soil moisture content (25.26, 25.89 and 25.58 %) was found under no mulch (M_{10}) in the first year, second year and in pool analysis. Significant effect in the growing conditions was observed where higher soil moisture percentage (40.54, 40.81 and 40.67 %) was observed under polyhouse cultivation in the first year, second year and pool analysis.

Table-4.1.4.2.2: Effect of mulch treatments and growing condition on soil moisture content (%) of strawberry cultivation at 60 days after planting.

Soil moisture content (%) at 60 DAP									
Treatments	1st year			2nd year			Pooled		
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean
M_1	39.91	41.06	40.49	39.89	44.53	42.21	39.90	42.80	41.35
M_2	38.65	39.94	39.30	39.68	40.55	40.12	39.17	40.25	39.71
M_3	38.23	40.66	39.45	38.36	39.95	39.15	38.30	40.30	39.30
M_4	37.85	39.59	38.72	37.58	39.92	38.75	37.71	39.75	38.73
M_5	37.58	41.87	39.73	37.48	41.26	39.37	37.53	41.56	39.55
M_6	35.70	39.87	37.79	38.58	41.19	39.88	37.14	40.53	38.83
M_7	38.36	39.94	39.15	37.14	39.55	38.34	37.75	39.74	38.75
M_8	44.56	49.04	**46.80**	40.76	44.51	42.64	42.66	46.78	44.72
M_9	42.01	47.20	44.61	42.30	49.57	**45.94**	42.16	48.39	**45.27**
M_{10}	24.31	26.21	**25.26**	24.72	27.06	**25.89**	24.52	26.64	**25.58**
Mean	37.72	**40.54**		37.65	**40.81**		37.68	**40.67**	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.95	0.43	1.35	0.99	0.44	1.40	0.71	0.32	1.01
$CD_{0.05}$	2.73	1.22	NS	2.84	1.27	NS	2.01	0.90	NS
CV%	5.97			6.20			6.31		
1st Year Mean		39.13		Pooled analysis		M x C x Y	M x Y	C x Y	Y
2nd year Mean		39.23		S. EM(±)		1.43	1.01	0.45	0.32
Pool Mean		39.18		$CD_{0.05}$		NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation

4.1.4.2.3 Soil moisture content at 90 DAP:

The data depicted in the table 4.1.4.2.3 clearly indicates significant effect of different types of mulching and their growing conditions on the soil moisture content at 90 days after planting. The soil moisture at a depth of 15 cm was higher under plastic mulch than most of the organic mulch. The highest moisture content (40.80, 40.35 and 40.57 %) was observed under M_8 in the first year, second year and pool analysis whereas the minimum soil moisture

Table-4.1.4.2.3: Effect of mulching treatments on soil moisture content (%) of strawberry cultivation at 90 days after planting.

Soil moisture content (%) at 90 DAP									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	37.69	40.46	39.08	38.86	40.74	39.80	38.27	40.60	39.44
M_2	35.25	38.14	36.69	34.42	39.48	36.95	34.83	38.81	36.82
M_3	36.87	40.39	38.63	36.63	39.82	38.22	36.75	40.10	38.43
M_4	36.72	37.40	37.06	36.13	37.26	36.70	36.43	37.33	36.88
M_5	38.37	40.76	39.57	39.67	41.39	40.53	39.02	41.08	40.05
M_6	34.79	38.39	36.59	34.70	39.62	37.16	34.75	39.01	36.88
M_7	36.92	39.15	38.04	37.09	40.39	38.74	37.00	39.77	38.39
M_8	39.76	41.84	**40.80**	39.45	41.24	**40.35**	39.61	41.54	**40.57**
M_9	39.09	41.64	40.37	39.19	40.37	39.78	39.14	41.01	40.07
M_{10}	20.58	23.66	**22.12**	20.40	23.62	**22.01**	20.49	23.64	**22.06**
Mean	35.60	**38.18**		35.65	**38.39**		35.63	**38.29**	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.84	0.38	1.19	0.62	0.28	0.87	0.52	0.23	0.73
CD $_{0.05}$	2.41	1.08	NS	1.77	0.79	NS	1.46	0.65	NS
CV%	5.58			4.08			4.87		

1st Year Mean	36.89	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	37.02	S. Em±	1.04	0.73	0.33	0.23
Pool Mean	36.96	CD $_{0.05}$	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation.

percentage (22.12, 22.01 and 22.06) was found under no mulch (M_{10}) in the first year, second year and in pool analysis. Significant effect in the growing conditions was also observed where higher soil moisture percentage (38.18, 38.39 and 38.29) was observed under polyhouse cultivation in the first year, second year and pool analysis.

4.1.4.3: Soil pH:

The data presented in the table 4.1.4.3 shows there was no significant difference on soil pH of strawberry cultivation as affected by mulching treatments and growing conditions. Among the treatments, lowest pH (5.77, 5.73 and 5.75) was recorded under black poly-mulch (M_8) whereas the maximum pH (6.0, 5.95 and 6.02) was found under rice husk ($M_{7)}$ and lower pH (5.84, 5.83 and 5.83) recorded under polyhouse cultivation in the first year, second year and pool analysis respectively.

Table-4.1.4.3: Effect of mulching treatments and growing conditions on soil pH of strawberry cultivation.

Soil pH									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	5.75	5.87	5.81	5.82	5.83	5.83	5.79	5.85	5.82
M_2	5.93	5.81	5.87	5.87	5.87	5.87	5.90	5.84	5.87
M_3	5.82	5.90	5.86	5.97	5.82	5.89	5.89	5.86	5.88
M_4	5.88	5.60	5.74	5.74	5.80	5.77	5.81	5.70	5.76
M_5	5.85	5.68	5.77	5.94	5.82	5.88	5.89	5.75	5.82
M_6	5.95	6.05	6.00	5.95	5.83	5.89	5.95	5.94	5.94
M_7	6.04	6.14	**6.09**	5.97	5.92	**5.95**	6.01	6.03	**6.02**
M_8	5.81	5.73	**5.77**	5.72	5.74	**5.73**	5.76	5.74	**5.75**
M_9	5.99	5.72	5.86	5.78	5.83	5.81	5.88	5.78	5.83
M_{10}	5.74	5.87	5.81	5.87	5.86	5.87	5.81	5.87	5.84
Mean	5.88	**5.84**		5.86	**5.83**		5.87	**5.83**	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.08	0.04	0.12	0.09	0.04	0.13	0.06	0.03	0.09
CD $_{0.05}$	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV%	3.42			3.96			3.70		
1st Year Mean		5.86		Pooled analysis		M x C x Y	M x Y	C x Y	Y
2nd year Mean		5.85		S. EM(±)		0.09	0.09	0.04	0.03
Pool Mean		5.86		CD $_{0.05}$		NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation

4.1.4.4: Available nitrogen content of soil:

The data depicted in the table 4.1.4.4 shows significant effect of different types as of mulching on available nitrogen content in the soil. The available soil nutrients were analysed at the end of the growing season. All the treatments were found to increase the available soil nitrogen content, the highest available soil nitrogen content (292.50, 281.67 and 287.08 kg/ha) was found in M_1 (paddy straw mulch) followed by (M_7) rice husk mulch (276.67, 277.50 and 277.08 kg/ha) in the first year, second year and pool analysis. The minimum soil nitrogen content was noted in (M_{10}) no mulch (212.50, 215.00 and 213.75 kg/h) a in the first year, second year and pool analysis. No Significant effect in the growing conditions was observed.

Table-4.1.4.4: Effect of mulching treatments and growing condition on available soil nitrogen content (kg/ha) of strawberry cultivation.

Available soil nitrogen content (kg/ha)									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	286.67	298.33	**292.50**	283.33	280.00	**281.67**	285.00	289.17	**287.08**
M_2	260.00	261.67	260.83	250.00	258.33	254.17	255.00	260.00	257.50
M_3	283.33	253.33	268.33	275.00	255.00	265.00	279.17	254.17	266.67
M_4	255.00	253.33	254.17	253.33	260.00	256.67	254.17	256.67	255.42
M_5	240.00	260.00	250.00	236.67	266.67	251.67	238.33	263.33	250.83
M_6	246.67	251.67	249.17	250.00	270.00	260.00	248.33	260.83	254.58
M_7	280.00	273.33	276.67	285.00	270.00	277.50	282.50	271.67	277.08
M_8	260.00	255.00	257.50	236.67	251.67	244.17	248.33	253.33	250.83
M_9	250.00	260.00	255.00	246.67	256.67	251.67	248.33	258.33	253.33
M_{10}	208.33	216.67	**212.50**	210.00	220.00	**215.00**	209.17	218.33	**213.75**
Mean	257.00	258.33		252.67		255.75	254.83		256.71

Interaction effect

Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	8.07	3.61	11.41	7.22	3.23	10.21	5.64	2.52	7.97
$CD_{0.05}$	23.09	NS	NS	20.67	NS	NS	15.87	NS	NS
CV%	8.96			10.18			7.67		

		Pooled analysis	M x C x Y	M x Y	C x Y	Y
1st Year Mean	257.67					
2nd year Mean	255.75	S. EM(±)	11.27	7.97	3.56	2.52
Pool Mean	256.71	$CD_{0.05}$	NS	NS	NS	NS

***C1= open cultivation, C2= polyhouse cultivation**

4.1.4.5: Available phosphorus content of soil:

The data depicted in table 4.1.4.5 showed significant effects of different types as of mulching on available phosphorus content in the soil. The highest available soil Phosphorus content (24.01, 24.21 and 24.11 kg /ha) was found in M_7 (rice husk mulch) followed by (M_1) paddy straw mulch (23.28, 23.86 and 23.57 kg /ha). The minimum soil phosphorus content was noted in (M_{10}) no mulch (18.47, 19.60 and 19.03 kg /ha) in the first year, second year and pool analysis. No Significant effect in the growing conditions was observed.

Table-4.1.4.5: Effect of mulch treatments and growing condition on available soil Phosphorus content (kg/ha) in strawberry cultivation.

Available soil phosphorus content (kg/ha)									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	23.02	23.55	23.28	23.42	24.30	23.86	23.22	23.93	23.57
M_2	21.65	21.93	21.79	21.58	21.90	21.74	21.62	21.92	21.77
M_3	22.10	23.46	22.78	22.12	22.37	22.24	22.11	22.91	22.51
M_4	20.97	22.15	21.56	20.80	21.97	21.38	20.88	22.06	21.47
M_5	20.20	22.30	21.25	21.53	22.83	22.18	20.87	22.57	21.72
M_6	21.79	21.00	21.40	23.86	22.17	23.01	22.83	21.58	22.20
M_7	23.63	24.38	**24.01**	24.24	24.18	**24.21**	23.94	24.28	**24.11**
M_8	20.29	20.82	20.56	20.12	20.41	20.26	20.20	20.62	20.41
M_9	20.32	21.27	20.80	21.47	21.04	21.26	20.89	21.16	21.03
M_{10}	18.87	18.07	**18.47**	20.02	19.18	**19.60**	19.44	18.63	**19.03**
Mean	21.28	21.89		21.92	22.04		21.60	21.96	
Interaction content									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.56	0.25	0.79	0.78	0.35	1.11	0.51	0.23	0.72
CD $_{0.05}$	1.60	NS	NS	2.24	NS	NS	1.43	NS	NS
CV%	6.34			8.74			8.06		
1st Year Mean	21.59			Pooled analysis	M x C x Y		M x Y	C x Y	Y
2nd year Mean	21.98			S. EM(±)	1.01		0.72	0.32	0.23
Pool Mean	21.78			CD $_{0.05}$	NS		NS	NS	NS

***C1= open cultivation, C2= polyhouse cultivation**

4.1.4.6: Available potassium content of soil:

The data depicted in the table 4.1.4.6 depicted significant effects of different types as of mulching on available Potassium content in the soil. There was an increase in available potassium content of soil in all the mulch treatment over control however the highest content (278.00, 279.17 and 278.58 kg/ha) was found in M_1 (paddy straw mulch) followed by (M_5) pine needle mulch (277.05, 276.67 and 277.08 kg/ha). The minimum soil potassium content was noted in (M_{10}) no mulch (243.83, 240.83 and 242.33 kg/ha) in the first year, second year and pool analysis. No Significant effect in the growing conditions was observed.

Table-4.1.4.6: Effect of mulch treatments and growing condition on available soil potassium content (kg/ha) in strawberry cultivation.

Available soil potassium content (kg/ha)									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	281.00	275.00	**278.00**	281.67	276.67	**279.17**	281.33	275.83	**278.58**
M_2	269.00	260.00	264.50	257.33	264.67	261.00	263.17	262.33	262.75
M_3	261.33	266.67	264.00	270.67	273.33	272.00	266.00	270.00	268.00
M_4	256.00	256.67	256.33	261.00	255.00	258.00	258.50	255.83	257.17
M_5	273.33	281.67	277.50	280.00	273.33	276.67	276.67	277.50	277.08
M_6	250.00	255.33	252.67	248.33	249.33	248.83	249.17	252.33	250.75
M_7	280.00	273.33	276.67	276.67	275.00	275.83	278.33	274.17	276.25
M_8	271.67	278.33	275.00	271.33	261.67	266.50	271.50	270.00	270.75
M_9	271.67	266.67	269.17	261.67	268.00	264.83	266.67	267.33	267.00
M_{10}	237.67	250.00	**243.83**	243.33	238.33	**240.83**	240.50	244.17	**242.33**
Mean	265.17	266.37		265.20	263.53		265.18	264.95	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	5.05	2.26	7.14	4.22	1.89	5.96	3.31	1.48	4.68
CD $_{0.05}$	14.45	NS	NS	12.07	NS	NS	9.32	NS	NS
CV%	3.79			3.96			4.68		
1st Year Mean		265.77		Pooled analysis	M x C x Y		M x Y	C x Y	Y
2nd year Mean		264.37		S. EM(±)	6.62		4.68	2.09	1.48
Pool Mean		265.07		CD $_{0.05}$	NS		NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation

Discussion

Soil temperature (thermal regime) is one of the most important factors that control soil microbiological transformations and various other processes involved in the nutrition, growth and development of plants (Mauromicale *et al*., 2005). The soil temperature at a depth of 5 cm was higher under plastic mulch than most of the organic mulch in the observation taken at 30. 60 and 90 DAP. The higher temperature under black poly mulch is attributed to entrapment of long wave radiation from soil, reduction in conduction loss and cut off of convection loss under plastic mulch (Pandey *et al*., 2016). All the Organic mulches had the temperature lower than the plastic mulch however the temperature under organic mulches were higher than the air temperature; it may be the reason that organic mulches have the capacity to reduce the incoming solar energy and reduction in heat loss.

Kumar and Dey, (2011) also found black polythene mulch increased the minimum soil temperature by 0.4-2.5 ^{0} C and also states that hay mulch has low thermal conductivity and thus reduce the heat flux into and out of the soil resulting in lowering the maximum and increasing the minimum soil temperature. Different kind of mulches have been reported to increase the yield of several crops through their modification of hydrothermal regimes (Bhella, 1988, Ramakrishna *et al.*, 2006,)

All other organic mulches have the soil moisture content in between the poly much and control, among them straw mulch (M_1) and wood shaving (M_3) had the higher soil moisture content. This may be due to the evaporation losses through the porous mulch materials and also the absorption of moisture by the mulch itself (Pandey *et al*., 2016) while the higher moisture content in the black poly-mulch might be the fact that black polythene mulch acts as an insulating substance that condenses the evaporating soil moisture inside the mulch and again drops it down to the soil surface (Tariq *et al*., 2016). Swenson *et al*. (2004) and Headu and Kumar, (2002) also reported improvement of water infiltration and higher water retention capacity under black poly mulch. Bakshi *et al*. (2014) also reported that high soil moisture content under polythene mulch in strawberry. Ali and Radwan, (2008), Kumar and Dey, (2011) and Singh *et al.* (2010) also recorded the maximum soil moisture content under poly-mulch.

The minimum value of pH under black poly mulch may be attributed to the high rate of mineralization, generation of organic acid due to increased temperature and entrapment of released CO2 under mulched conditions (Pandey *et al*., 2016). More intensive mineralization and generation of large amount of organic acid and CO2 led formation of carbonic acid was explained as reason by Cabilovoski *et al*. (2014) which perhaps resulted in lowering the soil pH. Patil *et al*. (2016) reported no significant in pH of soil under different type of mulching in strawberry cultivation.

The increment in the nitrogen content may be due to decomposition of the organic mulches in the soil increasing the soil organic content which in turns increase the nutrient content (Pandey *et al*., 2016). Patil *et al*. (2016) found significantly superior level of nitrogen content in soil with paddy straw mulch compared to all other mulches studied and minimum available nitrogen content was recorded in control, the reason in minimum content may be the lower microbial activity that leads to slow rate of mineralization of nitrogen and also due to lower content of moisture in soil.

Higher content of P and K in the organic mulches may be due to their decomposition which added nutrient to the soil (Patil *et al*., 2016) however in the case of pine needle and poly-mulch which has slow and non-decomposable properties in the soil had higher P and K content over control which may be attributed to reduction in nutrient loss by controlling weed population (Patil *et al*., 2016) and better conservation of moisture. Patil *et al*. (2016) found that paddy straw mulch recorded highest available soil phosphorus followed by pine needles. Lowest available phosphorus was recorded under control followed by paper cutting waste and transparent polythene.

Patil *et al*. (2016) observed that paddy straw mulch recorded highest available soil potassium followed by pine needles and black poly-mulch whereas lowest available potassium was recorded under control followed by paper cutting waste and transparent polythene.

4.1.5: Yield

4.1.5.1 Yield per plant: Table 4.1.5.1 showed significant effect of different mulch materials on fruit production per plant. Among the different mulch materials, black poly-mulch (M_8) was found to have maximum fruit production (572.06, 579.57and 575.81 gm) followed by M_9 silver poly mulch (557.15, 557.82 and 557.48 gm) whereas minimum fruit production (254.48, 258.79 and 256.64 gm) was observed in no mulch (M_{10}) in the first year, second year and pool data respectively. The fruit production was also significantly influenced by growing conditions, higher yield (473.99, 475.36 and 474.68 gm) was observed under poly house cultivation in the first year, second year and pooled data respectively.

Table-4.1.5.1: Effect of mulching treatments and growing condition on yield per plant (gm) of strawberry.

Yield per plant (gm.)									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	407.76	509.54	458.65	413.47	505.30	459.39	410.62	507.42	459.02
M_2	308.40	400.63	354.51	311.25	403.10	357.18	309.83	401.86	355.85
M_3	438.69	489.40	464.05	437.54	498.98	468.26	438.12	494.19	466.15
M_4	307.32	419.12	363.22	309.46	412.54	361.00	308.39	415.83	362.11
M_5	399.40	481.47	440.43	412.85	486.69	449.77	406.12	484.08	445.10
M_6	285.03	364.93	324.98	272.74	378.85	325.79	278.88	371.89	325.39
M_7	407.99	483.03	445.51	432.23	446.25	439.24	420.11	464.64	442.37
M_8	493.66	650.45	**572.06**	489.74	669.39	**579.57**	491.70	659.92	**575.81**
M_9	489.10	625.19	557.15	470.86	644.77	557.82	479.98	634.98	557.48
M_{10}	192.79	316.17	**254.48**	209.83	307.75	**258.79**	201.31	311.96	**256.64**
Mean	373.01	**473.99**		376.00	**475.36**		374.51	**474.6**8	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	12.09	5.41	17.10	11.49	5.14	16.24	8.46	3.78	11.97
CD $_{0.05}$	34.61	15.48	46.62	32.89	14.71	46.51	23.83	10.66	33.70
CV%	6.99			6.61			6.90		
1st Year Mean		423.50		Pooled analysis		M x C x Y	M x Y	C x Y	Y
2nd year Mean		425.68		S. EM(±)		16.93	11.97	5.35	3.78
Pool Mean		424.59		CD $_{0.05}$		NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation

4.1.5.2 Yield per plot:

The data presented in table 4.1.5.2 clearly shows various type of mulch materials have significant effect on the fruit production per plot of strawberry, the highest fruit production per plot (4.55, 4.49and 4.52 kg) was obtained under black poly-mulch (M_8) which was followed by M_9 silver poly-mulch (4.33, 4.32 and 4.33 kg) while the lowest fruit production (1.45, 1.44 and 1.45 kg) was noted under no mulch (M_{10}) in the first year, second year and pool analysis respectively. Significant effect in fruit production per plot has been observed where the higher yield (3.21, 3.24 and 3.23 kg) was observed under poly-house cultivation in the first year, second year and pool analysis respectively.

Table-4.1.5.2: Effect of mulching treatments and growing condition on yield per plot (kg) of strawberry

Yield per plot (kg)									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	2.79	3.36	3.08	2.84	3.42	3.13	2.82	3.39	3.10
M_2	1.85	2.41	2.13	1.92	2.42	2.17	1.89	2.41	2.15
M_3	2.62	3.09	2.85	2.64	3.14	2.89	2.63	3.11	2.87
M_4	1.68	2.51	2.10	1.86	2.51	2.19	1.77	2.51	2.14
M_5	2.32	2.89	2.61	2.58	2.92	2.75	2.45	2.90	2.68
M_6	1.64	2.19	1.91	1.52	2.27	1.90	1.58	2.23	1.91
M_7	2.44	2.90	2.67	2.59	3.17	2.88	2.52	3.03	2.78
M_8	3.51	5.59	**4.55**	3.54	5.44	**4.49**	3.52	5.51	**4.52**
M_9	3.35	5.31	4.33	3.41	5.24	4.32	3.38	5.27	4.33
M_{10}	1.01	1.90	**1.45**	1.04	1.85	**1.44**	1.02	1.87	1.**45**
Mean	2.32	3.21		2.39	3.24		2.36	3.23	

Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.06	0.03	0.09	0.07	0.03	0.10	0.05	0.02	0.07
CD $_{0.05}$	0.18	0.08	0.26	0.20	0.09	0.28	0.14	0.06	0.20
CV%	6.24			6.81			7.02		

1st Year Mean	2.53	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	2.51	S. EM(±)	0.10	0.07	0.03	0.02
Pool Mean	2.52	CD at 5%	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation

4.1.5.3 Yield per hectare: The data presented in table 4.1.5.3 shows various type of mulch materials have significant effect on the fruit yield per hectare of strawberry, the highest fruit yield per hectare (21.22, 20.51and 20.87 ton) was obtained under Black poly-mulch (M_8) which was followed by M_9 silver poly-mulch (21.07, 20.12 and 20.59 ton) while the lowest yield (8.40, 8.17 and 8.28 ton) was noted under no mulch (M_{10}) in the first year, second year and pool analysis respectively. Significant effect in fruit yield per hectare has been observed where the higher yield (17.80, 16.92 and17.36 ton) were observed under poly-house cultivation in the first year, second year and pool analysis respectively.

Table-4.1.5.3: Effect of mulching treatments and growing condition on yield per ha (ton) of strawberry.

Yield per ha (ton)									
Treatments	**1st year**			**2nd year**			**Pooled**		
	C_1	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
M_1	15.02	18.67	16.85	15.25	17.21	16.23	15.14	17.94	16.54
M_2	12.25	16.03	14.14	12.34	16.12	14.23	12.29	16.08	14.19
M_3	15.08	18.57	16.82	15.82	16.90	16.36	15.45	17.73	16.59
M_4	12.46	15.84	14.15	11.70	15.77	13.73	12.08	15.81	13.94
M_5	14.92	17.81	16.36	14.38	16.55	15.47	14.65	17.18	15.91
M_6	10.93	14.10	12.51	11.63	14.15	12.89	11.28	14.12	12.70
M_7	15.24	17.64	16.44	15.53	16.48	16.00	15.38	17.06	16.22
M_8	17.79	24.66	**21.22**	18.00	23.01	**20.51**	17.90	23.83	**20.87**
M_9	17.89	24.25	21.07	17.63	22.61	20.12	17.76	23.43	20.59
M_{10}	6.37	10.43	**8.40**	5.99	10.35	**8.17**	6.18	10.39	**8.28**
Mean	13.79	**17.80**		13.83	**16.92**		13.81	**17.36**	
Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.63	0.28	0.89	0.61	0.27	0.86	0.44	0.20	0.62
CD $_{0.05}$	1.80	0.80	NS	1.75	0.78	NS	1.24	0.55	NS
CV%	9.23			9.25			9.32		

1st Year Mean	15.80	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	15.37	S. EM(±)	0.84	0.59	0.27	0.19
Pool Mean	15.58	CD $_{0.05}$	NS	NS	NS	NS

*C_1= open cultivation, C_2= polyhouse cultivation

Table-4.1.5.4: Economics of strawberry cultivation with mulching treatments and growing conditions cultivation under Polyhouse and open cultivation.

Treat ments	Open cultivation (C_1)				Polyhouse cultivation (C_2)			
	Gross expenditure (Rs/ ha)	Gross income (Rs/ha)	Net income (Rs/ha)	BC Ratio	Gross expenditure (Rs/ha)	Gross income (Rs/ha)	Net income (R/ha)	BC Ratio
M_1	1079231	3833954	2754722	2.55	1302101	4910829	3608727	2.77
M_2	1073111	3073662	2000550	1.86	1291799	4149743	2857944	2.21
M_3	1079231	3787564	2708333	2.51	1302101	4833423	3531321	2.71
M_4	1074131	3019152	1945020	1.81	1290371	4066506	2776134	2.15
M_5	1088411	3662228	2573816	2.36	1302101	4747646	3445544	2.65
M_6	1072601	2819956	1747355	1.63	1281191	4006243	2725051	2.13
M_7	1089431	3795307	2705876	2.48	1304141	4864341	3560200	2.73
M_8	**1159607**	**4474636**	**3315028**	**2.86**	**1364627**	**6033136**	**4668509**	**3.42**
M_9	1154507	4439097	3284590	2.85	1363607	5955703	4592096	3.37
M_{10}	**977741**	**1845065**	**867324**	**0.89**	**1183271**	**2597097**	**1413826**	**1.19**

4.1.5.4 Economics of cultivation:

The economics of cultivation of strawberry under poly house and open cultivation were carefully calculated and the following were the results; the maximum gross expenditure per hectare (Rs. 13,64,627), the maximum gross income per hectare (Rs. 60,33,136) and the maximum net income per hectare (Rs. 46,68,509) with BC ratio of 3.42:1 was recorded on black poly-mulch (M_8) under poly house cultivation whereas the highest gross expenditure (Rs. 11,59,607), the maximum gross income per hectare (Rs. 44,74,636) and the net income per hectare (Rs. 33,15,028) with the BC ratio of 3.2 :1 was observed under black poly mulch (M_8) in open cultivation. The minimum expenditure, gross income and net income per hectare (Rs. 11,83,271, Rs. 25,97,097 and Rs. 14,13,826) with BC ratio 1.19:1was observed in no mulch(M_{10}) under Poly-house cultivation whereas The minimum expenditure, gross income and net income per hectare (Rs. 9,77,741, Rs. 18,45,065and Rs. 8,67,324) with BC ratio 0.89:1 was observed in no mulch (M_{10}) under open cultivation.

The high cost of expenditures under black poly mulch in polyhouse cultivation may be the high cost of polythene mulch, high cost of poly-house structure and high cost of irrigation system whereas the minimum expenditures on control in open cultivation might be no need of mulch material and application of extra labour cost for mulch.

Discussion

The increase in yield under black poly mulch may be attributed to increase in availability of nutrients and highly suppressed weeds (Pandey *et al.,* 2016, Bakshi *et al.*, 2014). Higher yield per plant may be accounted to better plan growth owing to favourable hydrothermal regime of soil and complete weed free environment as provided by black polythene mulch (Singh *et al*., 2023). Kumar *et al*. (2012) also found that plants mulched with black polythene have significantly better growth, early flowering and fruiting, and produced larger fruit and higher yield of strawberry. Sharma and Sharma, (2003), Singh and Asrey, (2005) and Singh *et al.* (2006) also found highest yield in strawberry under black polythene mulch. Different kind of mulches have been reported to increase the yield of several crops through their modification of hydrothermal regimes (Bhella, 1988, Ramakrishna *et al.*, 2006)

4.2. Experiment 2: Efficacy of drip irrigation and manual irrigation condition in strawberry cultivation with different mulching treatment:

4.2.1 Plant growth parameters.

Significant effect of irrigation conditions was observed in strawberry cultivation in the investigation. Drip irrigation resulted in higher readings of plant height, plant spread and total numbers of leaves along with lower number of weeds per m^2 when compared with manual irrigation

4.2.1.1 Plant height (cm):

Plant height of strawberry was measured at 90 days after planting and significant effect of irrigation conditions and mulching treatments were observed (table 4.2.1.1). Taller plant height (18.18, 18.43 and 18.31 cm) was observed in strawberry cultivation with drip irrigation as compare to manual irrigation in the first year, second year and pooled data respectively. Among the different mulch materials, black poly-mulch (M_8) were found to have the tallest plant height (19.65, 19.96 and 19.81 cm) followed by M_9 silver poly-mulch (18.74, 19.36 and 19.05 cm) whereas lowest value (14.25, 14.64 and 14.45 cm) were cited in no mulch (M_{10}) in the first year, second year and pool data respectively.

4.2.1.2 Plant spread (cm):

As depicted in table 4.2.1.2 (a), significant effect was observed with mulching and irrigation condition on the plant spread (N-S direction). Significant effect of the irrigation conditions had been observed in the spread of the plant (N-S direction) where higher values (25.35, 25. 93 and 25. 64 cm) was observed under drip irrigation. Maximum plant spread was observed under M_8 black poly mulch (28.45, 28.38 and 28.41 cm) and the minimum values were observed under no mulch (16.83, 16.98 and 16.90 cm) in the first year, second year and pool analysis respectively.

Table 4.2.1.2 (b) shows that mulching has significant effect in the plant spread (East - West direction), the maximum plant spread was observed under M_8

black poly mulch (26.56, 27.06 and 26.81 cm) whereas the minimum values was noted under no mulch (18.00, 18.27 and 18.14 cm) in the first year, second year and pool analysis respectively. Significant effect of irrigation conditions had been observed in the spread of the plant (East - West direction) where higher values (24.68, 24.89 and 24.79 cm) were observed under drip irrigation in first year, second year and pool analysis respectively.

Table-4.2.1.1: Effect of mulching treatments and irrigation condition on plant height (cm) of strawberry.

Plant height (cm)									
Treatments	**1st year**			**2nd year**			**Pooled**		
	I_1	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**
M_1	18.70	16.33	17.52	18.92	16.73	17.83	18.81	16.53	17.67
M_2	17.27	14.48	15.88	17.55	14.69	16.12	17.41	14.58	16.00
M_3	18.56	16.30	17.43	18.85	16.18	17.52	18.71	16.24	17.47
M_4	18.29	15.38	16.84	18.00	16.01	17.01	18.15	15.70	16.92
M_5	18.05	16.05	17.05	17.97	16.57	17.27	18.01	16.31	17.16
M_6	17.37	15.44	16.40	17.80	15.59	16.69	17.58	15.51	16.55
M_7	17.61	15.19	16.40	17.70	15.63	16.66	17.65	15.41	16.53
M_8	21.06	18.23	**19.65**	21.08	18.85	**19.96**	21.07	18.54	**19.81**
M_9	20.00	17.48	18.74	20.55	18.18	19.36	20.27	17.83	19.05
M_{10}	14.91	13.59	**14.25**	15.87	13.41	**14.64**	15.39	13.50	**14.45**
Mean	**18.18**	15.85		**18.43**	16.18		**18.31**	16.02	

Interaction effect

Source	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I
S.EM(±)	0.40	0.18	0.57	0.47	0.21	0.67	0.31	0.14	0.44
CD $_{0.05}$	1.15	0.51	NS	1.35	0.60	NS	0.87	0.39	NS
CV%	5.78			6.68			6.23		

1st Year Mean	17.01	Pooled analysis	M x I x Y	M x Y	I x Y	Y
2nd year Mean	17.31	S. EM(±)	0.62	0.44	0.20	0.14
Pool Mean	17.16	CD $_{0.05}$	NS	NS	NS	NS

*I_1= Drip irrigation, I_2= manual watering.

Table-4.2.1.2 (a): Effect of mulching treatments and irrigation on plant spread (cm) (North - South direction) of strawberry cultivation.

Plant spread (cm) (N- S direction)									
Treat ments	**1st year**			**2nd year**			**Pooled**		
	I_1	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**
M_1	26.26	23.68	24.97	26.87	22.72	24.80	26.57	23.20	24.88
M_2	21.59	18.74	20.17	22.09	19.21	20.65	21.84	18.98	20.41
M_3	26.07	22.66	24.37	26.68	22.79	24.73	26.37	22.73	24.55
M_4	26.25	23.00	24.63	26.87	22.73	24.80	26.56	22.87	24.71
M_5	26.90	24.34	25.62	27.53	23.76	25.64	27.21	24.05	25.63
M_6	20.80	18.79	19.80	21.28	18.28	19.78	21.04	18.53	19.79
M_7	27.91	24.04	25.98	28.57	24.98	26.77	28.24	24.51	26.37
M_8	30.35	26.54	**28.45**	31.06	25.70	**28**.38	30.70	26.12	**28.41**
M_9	29.69	25.91	27.80	30.37	25.09	27.73	30.03	25.50	27.77
M_{10}	17.73	15.93	**16.83**	17.95	16.01	**16.98**	17.84	15.97	**16.90**
Mean	**25.35**	22.37		**25.93**	22.13		**25.64**	22.25	

Interaction effect

Source	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I
S.EM(±)	0.61	0.27	0.86	0.63	0.28	0.89	0.45	0.20	0.63
CD $_{0.05}$	1.75	0.78	NS	1.79	0.80	NS	1.25	0.56	NS
CV%	6.27			6.38			6.45		

1st Year Mean	23.86	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	24.03	S.EM(±)	0.89	0.63	0.28	0.20
Pool Mean	23.94	CD $_{0.05}$	NS	NS	NS	NS

*I_1= Drip irrigation, I_2= manual watering.

4.2.1.3 Total number of leaves:

As depicted in the table 4.2.1.3 mulching has significant effect in the number of leaves per plant, the maximum number was observed under M_8 black poly mulch (25.16, 24.37 and 24.76) followed by M_9 silver poly mulch (24.78, 23.90 and 24.34) whereas the minimum number (13.25, 12.88 and 13.07) was noted under no mulch M_{10} in the first year, second year and pool data. The number of leaves of strawberry was significantly influenced by the irrigation condition where higher number of leaves (21.81, 21.50 and 21.66) was found with drip irrigation in the first year, seconds year and pool data respectively.

Table-4.2.1.2(b): Effect of mulching treatments and irrigation on plant spread (cm) (East- West direction) of strawberry cultivation.

Plant spread (cm) (E- W direction)									
Treatments	**1st year**			**2nd year**			**Pooled**		
	I_1	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**
M_1	26.62	23.45	25.04	26.81	23.98	25.39	26.71	23.72	25.21
M_2	21.91	18.68	20.30	21.88	19.05	20.47	21.90	18.87	20.38
M_3	26.52	23.19	24.85	26.69	23.14	24.92	26.61	23.16	24.89
M_4	24.27	20.40	22.33	24.17	21.24	22.70	24.22	20.82	22.52
M_5	25.85	23.08	24.47	26.03	24.72	25.38	25.94	23.90	24.92
M_6	21.75	19.50	20.63	21.73	19.24	20.49	21.74	19.37	20.56
M_7	24.49	21.84	23.17	24.57	22.01	23.29	24.53	21.92	23.23
M_8	28.36	24.77	26.56	28.72	25.40	27.06	28.54	25.08	26.81
M_9	27.83	24.29	26.06	28.37	25.12	26.75	28.10	24.70	26.40
M_{10}	19.25	16.75	18.00	19.87	16.67	18.27	19.56	16.71	18.14
Mean	24.68	21.60		24.89	22.06		24.79	21.83	

Interaction effect									
Source	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I
SEM(±)	0.79	0.35	1.12	0.65	0.29	0.92	0.51	0.23	0.73
$CD_{0.05}$	2.26	1.01	NS	1.85	0.83	NS	1.45	0.65	NS
CV%	8.36			6.76			7.64		

1st Year Mean	23.14	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	23.47	S. EM(±)	1.03	0.73	0.33	0.23
Pool Mean	23.31	$CD_{0.05}$	NS	NS	NS	NS

*I_1= Drip irrigation, I_2= manual watering.

4.2.1.4 Total number of weeds:

Table 4.2.1.4 showed the total number of weeds per m^2 was significantly affected by mulching treatment, irrigation condition and their interaction effect. Among the different mulch materials, M_9 silver poly-mulch were found to have the lowest (0.90, 0.78 and 0.84 per m^2) number of weeds followed by M_8 black poly-mulch (0.93, 0.83 and 0.88per m^2) whereas highest number of weeds (27.32, 27.08 and 27.20 per m^2) were cited in no mulch (M_{10}) in the first year, second year and pool data respectively. The number of weeds was lower (5.42, 5.38 and 5.40 per m^2) in drip irrigation than manual irrigation in the first year, second year and pooled data respectively.

Table-4.2.1.3: Effect of mulching treatments and irrigation condition on total number of leaves (per plant) of strawberry.

Total number of leaves (per plant)									
Treatments	**1st year**			**2nd year**			**Pooled**		
	I_1	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**
M_1	23.47	20.74	22.10	23.73	21.67	22.70	23.60	21.20	22.40
M_2	19.53	18.03	18.78	21.53	19.39	20.46	20.53	18.71	19.62
M_3	23.20	20.25	21.73	23.60	21.22	22.41	23.40	20.74	22.07
M_4	21.87	19.19	20.53	22.07	19.79	20.93	21.97	19.49	20.73
M_5	22.47	19.33	20.90	21.93	19.85	20.89	22.20	19.59	20.90
M_6	17.60	15.81	16.70	17.73	15.44	16.59	17.67	15.63	16.65
M_7	23.20	21.23	22.21	21.80	20.12	20.96	22.50	20.67	21.59
M_8	26.73	23.58	**25.16**	25.07	23.67	**24.37**	25.90	23.63	**24.76**
M_9	26.47	23.10	24.78	24.53	23.27	23.90	25.50	23.18	24.34
M_{10}	13.60	12.91	**13.25**	13.00	12.76	**12.88**	13.30	12.84	**13.07**
Mean	**21.81**	19.42		**21.50**	19.72		**21.66**	19.57	

Interaction effect									
Source	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I
S.EM(±)	0.49	0.22	0.69	0.54	0.24	0.77	0.37	0.17	0.53
CD $_{0.05}$	1.40	0.63	NS	1.55	0.69	NS	1.06	0.47	NS
CV%	8.36			6.76			7.64		

1st Year Mean	20.62	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	20.61	S. EM(±)	0.75	0.53	0.24	0.17
Pool Mean	20.61	CD $_{0.05}$	NS	NS	NS	NS

*I_1= Drip irrigation, I_2= manual watering.

Table-4.2.1.4: Effect of mulching treatments and growing condition on total number of weed per m^2 of strawberry.

Total number of weed per m^2									
Treat ments	1st year			2nd year			Pooled		
	I_1	I_2	Mean	I_1	I_2	Mean	I_1	I_2	Mean
M_1	3.38	4.75	4.07	3.40	4.73	4.07	3.39	4.74	4.07
M_2	4.02	5.44	4.73	4.40	5.38	4.89	4.21	5.41	4.81
M_3	3.28	3.93	3.61	3.26	3.73	3.50	3.27	3.83	3.55
M_4	7.27	6.63	6.95	6.80	7.06	6.93	7.03	6.85	6.94
M_5	3.35	4.47	3.91	3.07	4.07	3.57	3.21	4.27	3.74
M_6	4.67	6.18	5.42	4.57	6.48	5.53	4.62	6.33	5.47
M_7	3.60	4.20	3.90	3.67	4.27	3.97	3.63	4.23	3.93
M_8	0.53	1.32	0.93	0.67	1.00	0.83	0.60	1.16	0.88
M_9	0.67	1.14	**0.90**	0.55	1.01	**0.78**	0.61	1.07	**0.84**
M_{10}	23.44	31.19	**27.32**	23.45	30.72	**27.08**	23.44	30.96	**27.20**
Mean	**5.42**	6.92		**5.38**	6.85		**5.40**	6.89	
Interaction effect									
Source	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I
S.EM(±)	0.24	0.11	0.33	0.18	0.08	0.26	0.15	0.07	0.22
CD $_{0.05}$	0.68	0.30	0.96	0.52	0.23	0.74	0.43	0.19	0.61
CV%	9.39			7.34			8.67		
1st Year Mean	6.17			Pooled analysis	M x C x Y	M x Y	C x Y	Y	
2nd year Mean	6.11			S.EM(±)	0.31	0.22	0.10	0.07	
Pool Mean	6.14			CD $_{0.05}$	NS	NS	NS	NS	

*I_1= Drip irrigation, I_2= manual watering.

<u>Discussion</u>

The present investigation revealed that drip irrigation along with mulching had significant effect on plant growth characters. The maximum plant height was observed under drip irrigation with back poly-mulch, Islam *et al*., (2022) found that plant height, was significantly higher under drip irrigation with black poly-mulch. Kachwaya and Chandel, (2015) also reported significant increase in plant height and numbers of leaves when fertilizer was supplied through drip irrigation. Karki *et al*. (2020) observed that plant height and number of leaves were significantly increased under drip irrigation with poly mulch as compare to manual irritation with poly-mulch treatment in cucumber. Paul *et al*. (2013) noted the significant increase in plant height, number of leaves, number of flowers, number of fruits and fruits weight in drip irrigation when compared with surface irrigation in capsicum. Rannu *et al*. (2018) observed that combined effect of irrigation and mulch showed that black polythene mulch with 5 days irrigation interval performed better than rice straw mulch with 5 days irrigation interval in case of plant height, number of leaves per plant, and leaf length for the two consecutive years. Islam *et al*. (2022) also found that plant height, plant spread and the no of fruits were significantly higher under drip irrigation with black poly-mulch. The increased in plant spread may be due to better soil hydrothermal regime and minimum weed infestation. The presence of adequate moisture in the soil is vital for plant growth not only because plant needs water for their physiological processes but also for nutrient solubility and their availability in soil solution (Bakshi *et al*., 2014) which can be achieved through drip irrigation. Sharma and Sharma, (2003) and Kher *et al. (*2010) also observed an increase in plant spread, plant height and number of leaves in strawberry under plastic mulch. Pandey *et al*. (2016) recorded in their studies of strawberry that the maximum plant spread (N-S and E-W direction) was observed under black poly-mulch. The increase in plant growth parameters under drip irrigation may be attributed to the fact that the more moisturized condition due to frequent irrigation helps in enhancing the vegetative growth (Rannu *et al*., 2018).

Semwal *et al*. (2023) reported that the maximum number of leaves might be due to the reason that the black polythene mulch had conserved higher soil moisture and temperature as well as reduced the nutrient losses by suppressing the weed population. Bakshi *et al.* (2014) observed significant increase in plant height of strawberry under polythene mulch. Sekhawat *et al*. (2023) found that the number of leaves increased significantly in strawberry with black plastic mulch. Pandey *et al*. (2015) and Bakshi *et al*. (2014) reported that the number of leaves in strawberry increased significantly in plastic mulches. Tariq *et al*. (2016) also found black polythene mulch performed better in the case of vegetative growth and yield followed by rice straw mulch for strawberry cultivation.

Drip irrigation can supply limited quantities of water to an area surrounding the crop root zone, limited wetting pattern and low volume of water used for drip irrigation reduces the chances of weed germination, drip systems are often designed for frequent, low-volume irrigations, which keep the soils around plants may remain moist. Therefore, the weed control benefits of drip irrigation are due to the ability to precisely manage and locate water where it will most benefit crops while reducing availability for weed growth. Arpita *et al*. (2021) found that lowest weed dry weight was registered in drip irrigation system when compared to rain hose and surface irrigation which is attributed to reduced weed number due to restricting the excess moisture which favours the weed emergence and unavailability of sufficient moisture which creates least opportunity for weed growth while surface irrigation produced highest weed dry weight. Mohanpuria *et al*. (2022) states drip irrigation produces higher marketable yield and reduces costs by reducing foliar pathogen and weed populations while Sprinkler irrigation may increase weed germination and weed seedling survival by wetting the entire upper soil surface, instead of the narrower, within-row band that is watered in drip irrigation.

4.2.2 Yield attributing parameters

Irrigation conditions have significant effect on the yield and its attributing parameters where higher number of flowers, fruits, fruit setting percentage, runners and yield were observed from drip irrigation condition than those from manual irrigation.

4.2.2.1 Total number of flowers:

The Mean data pertaining to the total numbers of flowers per plant were significantly influenced by different types of mulching materials and their irrigation conditions as well as interaction effect (table 4.2.2.1). The maximum number of flowers (33.90, 32.62 and 33.26) was observed in black poly-mulch (M_8) whereas minimum number of flowers (20.13, 17.57 and 18.85) was noted in no mulch (M_{10}) in the first year, second year and pool data respectively. Significant effects of irrigation condition have been observed, higher numbers of flowers (26.65, 25.06 and 25.85) were found under drip irrigation than manual irrigation.

Table-4.2.2.1: Effect of mulching treatments and irrigation condition on total number of flowers per plant of strawberry.

Total number of flowers per plant									
Treatments	**1st year**			**2nd year**			**Pooled**		
	I_1	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**
M1	27.97	26.75	27.36	26.72	24.83	25.78	27.35	25.79	26.57
M2	24.62	23.54	24.08	22.15	22.33	22.24	23.38	22.93	23.16
M3	27.68	25.79	26.74	26.98	24.46	25.72	27.33	25.13	26.23
M4	23.61	23.79	23.70	22.06	21.75	21.91	22.84	22.77	22.80
M5	25.81	25.29	25.55	23.71	23.29	23.50	24.76	24.29	24.52
M6	19.34	18.68	19.01	17.94	17.70	17.82	18.64	18.19	18.42
M7	26.31	27.37	26.84	25.01	25.87	25.44	25.66	26.62	26.14
M8	35.56	32.23	**33.90**	34.23	31.00	**32.62**	34.90	31.62	**33.26**
M9	34.14	31.86	33.00	32.96	31.24	32.10	33.55	31.55	32.55
M10	21.41	18.85	**20.13**	18.88	16.26	**17.57**	20.15	17.55	**18.85**
Mean	**26.65**	25.41		**25.06**	23.87		**25.85**	24.64	
Interaction effect									
Source	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I
S.EM(±)	0.57	0.25	0.80	0.44	0.20	0.63	0.38	0.17	0.53
CD 0.05	1.62	0.72	NS	1.27	0.57	1.79	1.06	0.47	1.50
CV%	5.32			4.43			5.15		

1st Year Mean	26.03	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	24.47	S.EM(±)	0.75	0.53	0.24	0.17
Pool Mean	25.25	CD 0.05	NS	NS	NS	0.47

*I_1= Drip irrigation, I_2= manual watering.

4.2.2.2: Total number of fruit:

The Mean data pertaining to the total number of fruits were significantly influenced by different types of mulching materials and their interaction with irrigation (table 4.2.2.2). The maximum number of fruits (32.32, 31.80 and 32.06) was observed in black poly-mulch (M_8) followed by M_9 silver poly mulch (32.22, 31.56 and 31.89) whereas minimum number of fruits (17.57, 16.92 and 17.25) was noted under no mulch (M_{10}) in the first year, second year and pool data respectively. Higher number of fruits (25.24, 25.06 and 25.15) was found under drip irrigation compare to manual irrigation.

Table-4.2.2.2: Effect of mulching treatments and irrigation condition on total number of fruits per plant in strawberry.

Total number of fruits per plant									
Treatments	**1st year**			**2nd year**			**Pooled**		
	I_1	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**
M_1	26.38	24.83	25.61	25.99	24.81	25.40	26.19	24.82	25.50
M_2	22.15	22.33	22.24	22.39	21.36	21.88	22.27	21.85	22.06
M_3	26.32	24.46	25.39	25.52	23.82	24.67	25.92	24.14	25.03
M_4	22.06	21.75	21.91	22.77	21.73	22.25	22.42	21.74	22.08
M_5	23.71	23.29	23.50	23.28	22.50	22.89	23.49	22.90	23.19
M_6	20.78	17.70	19.24	20.72	17.36	19.04	20.75	17.53	19.14
M_7	25.01	25.07	25.04	25.73	25.03	25.38	25.37	25.05	25.21
M_8	33.63	31.00	**32.32**	33.40	30.21	**31.80**	33.52	30.60	**32.06**
M_9	33.52	30.91	32.22	33.19	29.93	31.56	33.36	30.42	31.89
M_{10}	18.88	16.26	**17.57**	17.64	16.21	**16.92**	18.26	16.23	**17.25**
Mean	**25.24**	23.76		**25.06**	23.30		**25.15**	23.53	

Interaction effect

Source	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I
S.EM(±)	0.43	0.19	0.61	1.62	0.73	2.29	0.85	0.38	1.20
CD $_{0.05}$	1.24	0.55	NS	4.64	2.08	NS	2.38	1.07	NS
CV%	4.33			16.49			12.06		

1st Year Mean	24.50	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	23.68	S.EM(±)	1.69	1.20	0.54	0.38
Pool Mean	24.09	CD $_{0.05}$	NS	NS	NS	NS

*I_1= Drip irrigation, I_2= manual watering.

4.2.2.3: Total fruit setting percentage:

The data depicted in the table 4.2.2.3 clearly indicates significant effect of mulching and their growing conditions on the total fruit setting percentage. The maximum fruit setting percentage (97.36 and 96.54 %) was observed under black poly-mulch (M_8) in the first year and pool data, 96.74 percent in M_8 in the second year while the minimum fruit set percentage was found under (M_{10}) no mulch (85.51, 86.49 and 86.00 %) in the individual years and pool analysis. Significant effect in the growing conditions also observed where higher fruit setting percentage (87.36, 89.92 and 88.64 %) was observed under drip irrigation in the first year, second year and pool analysis.

Table-4.2.2.3: Effect of mulching treatments and growing condition on total fruit setting percentage of strawberry.

Total fruit setting percentage									
Treatments	**1st year**			**2nd year**			**Pooled**		
	I_1	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**
M_1	95.53	93.11	94.32	93.39	95.07	94.23	94.46	94.09	94.28
M_2	90.02	94.97	92.50	90.35	92.19	91.27	90.18	93.58	91.88
M_3	97.43	94.85	96.14	95.87	96.23	96.05	96.65	95.54	96.09
M_4	93.39	91.38	92.39	91.37	92.26	91.81	92.38	91.82	92.10
M_5	92.79	92.12	92.45	95.28	91.37	93.32	94.03	91.74	92.89
M_6	92.75	95.04	93.90	92.26	90.18	91.22	92.51	92.61	92.56
M_7	95.12	94.62	94.87	95.17	95.44	95.30	95.14	95.03	95.09
M_8	96.30	96.17	96.24	96.58	96.91	**96.74**	96.44	96.54	96.49
M_9	96.68	98.05	**97.36**	97.10	94.34	95.72	96.89	96.19	**96.54**
M_{10}	88.20	86.53	**87.36**	90.51	89.33	**89.92**	89.36	87.93	**88.64**
Mean	93.82	93.68		93.79	93.33		93.80	93.51	
Interaction effect									
Source	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I
S.EM(±)	1.76	0.79	2.49	1.42	0.63	2.01	1.19	0.53	1.69
$CD_{0.05}$	5.03	NS	NS	4.06	NS	NS	3.36	NS	NS
CV%	3.65			3.71			4.33		
1st Year Mean	93.75	Pooled analysis	M x C x Y	M x Y	C x Y	Y			
2nd year Mean	93.56	S.EM(±)	2.39	1.69	0.75	0.53			
Pool Mean	93.66	$CD_{0.05}$	NS	NS	NS	NS			

*I_1= Drip irrigation, I_2= manual watering.

4.2.2.4: Total number of runners:

It is apparent from the data presented in the Table 4.2. 2.4, the formations of runners were significantly influenced by different types of mulching materials and their irrigation conditions. The maximum number of runners per plant (4.97, 4.83 and 4.90) was observed in black poly-mulch (M_8) whereas minimum number of runners (2.40, 2.33 and 2.37) was noted under no mulch (M_{10}) in the individual years as well as pool data. The formation of strawberry runners were significantly influenced by irrigation condition where the higher numbers of runners per plant (3.46, 3.45 and 3.45) were found under drip irrigation compare to manual irrigation.

Table-4.2.2.4: Effect of mulching treatments and irrigation condition on total number of runners per plant of strawberry.

Total number of runners per plant									
Treat ments	**1st year**			**2nd year**			**Pooled**		
	I_1	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**
M_1	3.82	3.28	3.55	3.93	3.27	3.60	3.88	3.27	3.57
M_2	2.93	2.66	2.80	2.80	2.60	2.70	2.87	2.63	2.75
M_3	3.60	3.03	3.32	3.27	2.95	3.11	3.43	2.99	3.21
M_4	3.00	2.87	2.93	3.07	2.53	2.80	3.03	2.70	2.87
M_5	3.07	2.98	3.03	3.40	3.18	3.29	3.23	3.08	3.16
M_6	2.53	2.49	2.51	2.87	2.80	2.83	2.70	2.64	2.67
M_7	3.20	2.80	3.00	3.00	2.77	2.88	3.10	2.78	2.94
M_8	5.33	4.60	**4.97**	5.13	4.52	**4.83**	5.23	4.56	**4.90**
M_9	4.80	4.43	4.62	4.67	4.37	4.52	4.73	4.40	4.57
M_{10}	2.27	2.53	**2.40**	2.40	2.27	**2.33**	2.33	2.40	**2.37**
Mean	**3.46**	3.17		**3.45**	3.13		**3.45**	3.15	
Interaction effect									
Source	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I
S.EM(±)	0.19	0.08	0.27	0.18	0.08	0.25	0.13	0.06	0.18
CD $_{0.05}$	0.54	0.24	NS	0.50	0.23	NS	0.37	0.16	NS
CV%	13.98			13.10			13.73		
1st Year Mean		3.31		Pooled analysis	M x C x Y		M x Y	C x Y	Y
2nd year Mean		3.29		S. EM(±)	0.26		0.18	0.08	0.06
Pool Mean		3.30		CD $_{0.05}$	NS		NS	NS	NS

*I_1= Drip irrigation, I_2= manual watering.

Discussion

The significant improvement on yield attributing parameters were observed in various type of mulches mulch under drip irrigation condition, the increment in flower and fruits formation under polythene mulching might be improved micro climate around the plant which leads to increased number of flowers and fruit per plant (Singh *et al*., 2023). Ali and Radwan (2008), Kaur and Singh, (2009) reported in strawberry that the number of flowers increased significantly under poly-mulch. The findings of Singh *et al*. (2023), Soliman *et al.* (2015) in various strawberry cultivars and also Bakshi *et al*. (2014) in strawberry cv. Chandler reported significant increase in number of flowers under black poly mulch. Significant increase in (2008), Kaur and Singh (2009) reported in strawberry that the number of flowers increased significantly under poly-mulch. The findings of Singh *et al.* (2023), Soliman *et al.* (2015) in various strawberry cultivars and also Bakshi *et al*. (2014) in strawberry cv. Chandler reported significant increase in number of flowers under black poly mulch. Significant increase in number of fruits grown under drip irrigation compared to surface irrigation was also reported in capsicum (Paul *et al*., 2013). Bakshi *et al*., 2014 and Singh *et al*., 2010 also reported that significant increase in number of fruits per plant under black polythene mulch. This increase in fruit number might be attributed to the fact that the black polyethylene enhanced the number of flowers due to the decreased water loss and soil temperature, which in turn increased the number of fruits respectively (Pandey *et al*., 2016), Kumar and Dey, (2012) observed maximum flowering, fruiting and the maximum fruit set percentage of strawberry under drip irrigation. Kumar and Dey, (2012) observed maximum flowering, fruiting and the maximum fruit set percentage of strawberry under drip irrigation. The increased number of runners under poly mulch may be due to optimum soil moisture, sparse weed population and availability of nutrients which might have formed increased number of runners and their better growth (Ali and Gaur, 2013). Semwal *et al.* (2022) stated that black poly mulch produces the highest number of runners among the different mulches.

4.2.3 Fruit quality parameters:

Irrigation condition have significant effect on the fruit size and quality of strawberry where drip irrigation resulted in larger fruit size and heavier fruit weight, lower acidity, higher values of TSS, total sugar, anthocyanin and ascorbic acid content as compared to manual irrigation.

4.2.3.1 Fruit weight:

The data presented in table 4.2.3.1 showed significant effect in the fruit weight (gm.) by different types of mulching materials and irrigation conditionsBlack poly mulch (M_8) recorded the maximum fruit weight (15.56, 15.21 and 15.38 gm) whereas the minimum fruit weight (10.55, 10.83 and 10.69 gm) was noted in no mulch (M_{10}). Singh *et al.* (2023) reported higher fruit yield of strawberry in black poly- mulch. Heavier fruit weight (14.55, 14.48 and 14.52 gm) was observed with drip irrigation.

Table-4.2.3.1: Effect of mulching treatments and irrigation condition on average fruit weight (gm) of strawberry.

Average fruit weight (gm)									
Treatments	**1st year**			**2nd year**			**Pooled**		
	I_1	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**
M_1	14.79	14.32	14.56	15.01	14.73	14.87	14.90	14.53	14.71
M_2	14.06	13.07	13.57	13.97	13.13	13.55	14.02	13.10	13.56
M_3	14.98	14.40	14.69	15.21	14.57	14.89	15.10	14.48	14.79
M_4	13.77	12.84	13.31	13.61	12.97	13.29	13.69	12.91	13.30
M_5	15.42	14.06	14.74	15.08	14.41	14.75	15.25	14.24	14.74
M_6	13.51	12.98	13.25	13.21	13.00	13.10	13.36	12.99	13.17
M_7	15.66	14.71	15.18	15.37	14.18	14.78	15.52	14.44	14.98
M_8	16.30	14.81	**15.56**	15.68	14.74	**15.21**	15.99	14.78	**15.38**
M_9	15.89	14.71	15.30	15.86	14.77	15.19	15.88	14.74	15.31
M_{10}	11.16	9.93	**10.55**	11.79	9.87	**10.83**	11.48	9.90	**10.69**
Mean	**14.55**	13.58		**14.48**	13.64		**14.52**	13.61	

Interaction effect

Source	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I
S.EM(±)	0.28	0.12	0.39	0.28	0.13	0.40	0.20	0.09	0.29
CD $_{0.05}$	0.80	0.36	NS	0.80	0.36	NS	0.57	0.26	NS
CV%	4.76			4.80			4.93		

		Pooled analysis	M x C x Y	M x Y	C x Y	Y
1st Year Mean	14.33					
2nd year Mean	14.34	S.EM(±)	0.41	0.29	0.13	0.09
Pool Mean	14.33	CD $_{0.05}$	NS	NS	NS	NS

*I_1= Drip irrigation, I_2= manual watering.

4.2.3.2:- Total Soluble Solid:

The data presented in the Table 4.2.3.2 showed significant effect of different types of mulches, their growing conditions and interaction effect on total soluble solid (TSS) of strawberry fruit. The maximum TSS was found in (M_9) silver poly-mulch (8.52 ^{0} Brix) in the first year, 8.47 ^{0} Brix under M_1 straw mulch in the second year while in the pool analysis, the maximum TSS (8.44) was found under M_8 black poly mulch. The minimum TSS (7.45, 7.58 and 7.52 ^{0} Brix) was observed under (M_6) cut grass in the individual years as well as pool data. TSS was significantly influenced by the growing condition where the higher values (8.19, 8.18 and 8.19 ^{0} Brix) were found under drip irrigation in the first year, second year and pool data respectively.

Table-4.2.3.2: Effect of mulching treatments and irrigation condition on TSS (^{0} Brix) of strawberry fruit.

TSS (^{0} Brix)									
Treatments	**1st year**			**2nd year**			**Pooled**		
	I_1	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**
M_1	8.39	8.21	8.30	8.38	8.56	**8.47**	8.39	8.38	8.38
M_2	7.81	7.67	7.74	7.83	7.51	7.67	7.82	7.59	7.70
M_3	8.01	7.38	7.70	7.97	7.65	7.81	7.99	7.52	7.75
M_4	7.87	7.32	7.60	7.87	7.41	7.64	7.87	7.37	7.62
M_5	7.75	7.50	7.63	7.77	7.76	7.76	7.76	7.63	7.69
M_6	7.46	7.45	**7.45**	7.49	7.67	**7.58**	7.48	7.56	**7.52**
M_7	8.01	7.10	7.55	8.05	7.33	7.69	8.03	7.21	7.62
M_8	9.01	7.97	8.49	8.99	7.79	8.39	9.00	7.88	**8.44**
M_9	9.16	7.89	**8.52**	9.16	7.46	8.31	9.16	7.68	8.42
M_{10}	8.44	7.11	7.77	8.31	7.03	7.67	8.38	7.07	7.72
Mean	**8.19**	7.56		**8.18**	7.62		**8.19**	7.59	
Interaction effect									
Source	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I
S.EM(±)	0.14	0.06	0.20	0.16	0.07	0.23	0.11	0.05	0.16
$CD_{0.05}$	0.41	0.19	0.59	0.47	0.21	0.66	0.31	0.14	0.44
CV%	9.18			7.50			8.78		

1st Year Mean	7.87	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	7.90	S.EM(±)	0.22	0.16	0.07	0.05
Pool Mean	7.89	$CD_{0.05}$	NS	NS	NS	NS

*I_1= Drip irrigation, I_2= manual watering

4.2.3.3:- Acidity

The data in table 4.2.3.3 shows significant effect on acidity of strawberry with different mulching materials. The lowest percentage of acidity (0.44, 0.43 and 0.43 %) was obtained in black poly-mulch (M_8) followed by M_9 silver poly-mulch (0.48, 0.47 and 0.48 %) whereas the maximum acidity (0.71, 0.71 and 0.71%) was obtained in no mulch (M_{10}) in the individual years as well as pool analysis. Acidity was influenced by growing condition where the lower values (0.50, 0.50 and 0.50 %) were found under drip irrigation as compared to manual irrigation.

Table-4.2.3.3: Effect of mulching treatments and irrigation condition on acidity (%) of strawberry.

Acidity (%)									
Treatments	**1st year**			**2nd year**			**Pooled**		
	I_1	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**
M_1	0.52	0.59	0.55	0.51	0.59	0.55	0.51	0.59	0.55
M_2	0.49	0.47	0.48	0.49	0.49	0.49	0.49	0.48	0.48
M_3	0.49	0.55	0.52	0.49	0.57	0.53	0.49	0.56	0.52
M_4	0.51	0.52	0.52	0.49	0.49	0.49	0.50	0.51	0.51
M_5	0.51	0.55	0.53	0.53	0.53	0.53	0.52	0.54	0.53
M_6	0.51	0.57	0.54	0.50	0.61	0.56	0.50	0.59	0.55
M_7	0.49	0.55	0.52	0.45	0.54	0.50	0.47	0.54	0.51
M_8	0.41	0.46	**0.44**	0.41	0.45	**0.43**	0.41	0.45	**0.43**
M_9	0.44	0.51	0.48	0.46	0.49	0.47	0.45	0.50	0.48
M_{10}	0.66	0.75	**0.71**	0.68	0.74	**0.71**	0.67	0.75	**0.71**
Mean	**0.50**	0.55		**0.50**	0.55		**0.50**	0.55	
Interaction effect									
Source	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I
S.EM(±)	0.02	0.01	0.03	0.02	0.01	0.02	0.01	0.01	0.02
CD $_{0.05}$	0.06	0.03	NS	0.04	0.02	NS	0.04	0.02	NS
CV%	9.75			7.18			8.63		

1st Year Mean	0.53	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	0.53	S.EM(±)	0.03	0.02	0.01	0.01
Pool Mean	0.53	CD $_{0.05}$	NS	NS	NS	NS

*I_1= Drip irrigation, I_2= manual watering.

4.2.3.4:- Total sugar content:

The data presented in table 4.2.3.4 indicates significant effect on total sugar content (%) of strawberry with different mulch materials and growing conditions. The maximum value of total sugar was observed under M_8 black poly-mulch (6.31, 6.21 and 6.26 %) followed by M_9 silver poly- mulch (6.04, 6.30 and 6.17 %) the minimum value was obtained under M_{10} no mulch (4.88, 5.10 and 4.99 %) in the first year, second year and pool data respectively. The total sugar content of strawberry was influenced by the irrigation conditions where higher values (5.83, 5.91 and 5.87 %) were obtained under drip irrigation in the first year, second year and pool analysis.

Table-4.2.3.4: Effect of mulching treatments and irrigation condition on total sugar content (%) of strawberry.

Total sugar content (%)									
Treatments	**1st year**			**2nd year**			**Pooled**		
	I_1	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**
M_1	5.90	5.18	5.54	6.06	5.35	5.70	5.98	5.26	5.62
M_2	5.83	5.11	5.47	5.67	5.00	5.34	5.75	5.06	5.40
M_3	5.74	5.08	5.41	5.81	5.17	5.49	5.78	5.12	5.45
M_4	5.54	5.15	5.35	5.72	4.84	5.28	5.63	4.99	5.31
M_5	5.35	5.05	5.20	5.78	5.14	5.46	5.57	5.10	5.33
M_6	5.53	4.94	5.24	5.68	5.92	5.80	5.61	5.43	5.52
M_7	5.99	5.15	5.57	5.83	5.04	5.43	5.91	5.10	5.50
M_8	6.68	5.95	**6.31**	6.53	5.88	**6.21**	6.61	5.91	**6.26**
M_9	6.48	5.59	6.04	6.64	5.96	6.30	6.56	5.78	6.17
M_{10}	5.22	4.54	**4.88**	5.42	4.78	**5.10**	5.32	4.66	**4.99**
Mean	5.83	5.17		5.91	5.31		5.87	5.24	

Interaction effect									
Source	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C	Mulching (M)	Growing condition (C)	M x C
S.EM(±)	0.15	0.07	0.21	0.19	0.08	0.26	0.12	0.05	0.17
CD $_{0.05}$	0.43	0.19	NS	0.53	0.24	NS	0.34	0.15	NS
CV%	6.69			8.13			7.55		

1st Year Mean	5.50	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	5.61	S.EM(±)	0.24	0.17	0.08	0.05
Pool Mean	5.56	CD $_{0.05}$	NS	NS	NS	NS

*I_1= Drip irrigation, I_2= manual watering.

4.2.3.5:- Anthocyanin content:

The data in table 4.2.3.5 depicted significant effect of different mulching materials and their interaction effect on anthocyanin content (mg/100 gm) of strawberry. The maximum value (44.34, 43.88 and 44.11 mg/100 gm) of anthocyanin was obtained in black poly-mulch (M_8) followed by M_9 silver poly-mulch (44.19, 43.68 and 43.94 mg/100 gm) whereas the minimum value (26.95, 27.98 and 27.47 mg/100 gm) was obtained in no mulch (M_{10}) in the individual years as well as pool analysis. The anthocyanin content of strawberry was influenced by the irrigation conditions where higher values (37.98, 38.11and 38.05 mg/100 gm) of anthocyanin were obtained under drip irrigation in the individual years as well as pool analysis.

Table-4.2.3.5: Effect of mulching treatments and irrigation condition on anthocyanin content (mg/100 gm) of strawberry.

Anthocyanin content (Mg/100gm)									
Treatments	**1st year**			**2nd year**			**Pooled**		
	I_1	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**
M_1	39.91	38.76	39.33	41.31	39.27	40.29	40.61	39.01	39.81
M_2	36.92	32.31	34.61	36.85	33.22	35.03	36.88	32.77	34.82
M_3	34.99	34.84	34.91	36.26	36.14	36.20	35.63	35.49	35.56
M_4	37.25	34.83	36.04	38.51	35.19	36.85	37.88	35.01	36.45
M_5	37.27	39.15	38.21	37.55	38.21	37.88	37.41	38.68	38.05
M_6	36.51	33.25	34.88	35.61	36.46	36.03	36.06	34.85	35.46
M_7	37.87	36.70	37.29	37.27	37.32	37.29	37.57	37.01	37.29
M_8	46.19	42.48	**44.34**	45.27	42.49	**43.88**	45.73	42.49	**44.11**
M_9	46.03	42.35	44.19	45.08	42.29	43.68	45.56	42.32	43.94
M_{10}	26.86	27.05	**26.95**	27.44	28.53	**27.98**	27.15	27.79	**27.47**
Mean	37.98	36.17		38.11	36.91		38.05	36.54	
Interaction effect									
Source	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I
S.EM(±)	1.26	0.56	1.78	0.80	0.36	1.14	0.79	0.35	1.11
$CD_{0.05}$	3.61	1.61	NS	2.30	1.03	NS	2.21	0.99	NS
CV%	13.10			9.17			11.68		

1st Year Mean	37.08	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	37.51	S.EM(±)	1.57	1.11	0.50	0.35
Pool Mean	37.29	$CD_{0.05}$	NS	NS	NS	NS

*I_1= Drip irrigation, I_2= manual watering.

4.2.3.6:- Ascorbic acid content

The data presented in table 4.2.3.6 indicates significant effect of ascorbic acid content of strawberry with mulching treatments, irrigation condition and their interaction effect. The maximum content of ascorbic acid was observed under M_9 silver poly mulch (55.54, 56.43 and 55.99 mg/100 gm) followed by M_8 black poly-mulch (54.99, 56.04 and 55.52 mg/100 gm), the minimum value was obtained under M_{10} no mulch (40.05, 39.13 and 39.59 mg/100 gm) in the first year, second year and pool analysis. The ascorbic acid content of strawberry was influenced by the growing conditions where ascorbic acid content was increased significantly under drip irrigation (49.40, 50.55 and 49.97 mg/100 gm).

Table-4.2.3.6: Effect of mulching treatments and irrigation condition on ascorbic acid content (mg/100 gm) of strawberry.

Ascorbic acid content (mg/100 gm)									
Treatments	**1st year**			**2nd year**			**Pooled**		
	I_1	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**
M_1	53.44	47.44	50.44	55.07	46.40	50.74	54.25	46.92	50.59
M_2	46.50	38.08	42.29	47.38	39.55	43.47	46.94	38.82	42.88
M_3	54.68	41.72	48.20	54.57	42.85	48.71	54.63	42.28	48.46
M_4	47.22	45.87	46.55	43.96	45.39	44.68	45.59	45.63	45.61
M_5	46.72	43.91	45.32	45.18	43.70	44.44	45.95	43.81	44.88
M_6	44.56	45.77	45.17	43.07	45.06	44.07	43.82	45.42	44.62
M_7	46.92	46.58	46.75	59.89	47.58	53.73	53.40	47.08	50.24
M_8	57.13	52.85	54.99	58.14	53.95	56.04	57.64	53.40	55.52
M_9	57.01	54.07	**55.54**	58.52	54.34	**56.43**	57.77	54.20	**55.99**
M_{10}	39.78	40.32	**40.05**	39.74	38.51	**39.13**	39.76	39.42	**39.59**
Mean	49.40	45.66		50.55	45.73		49.97	45.70	

Interaction effect									
Source	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I
S.EM(±)	1.12	0.50	1.59	1.20	0.54	1.69	0.83	0.37	1.17
CD $_{0.05}$	3.21	1.44	4.54	3.43	1.53	4.85	2.32	1.04	3.29
CV%	5.78			6.16			6.01		

1st Year Mean	47.53	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	47.60	S.EM(±)	1.65	1.17	0.52	0.37
Pool Mean	47.56	CD $_{0.05}$	NS	NS	NS	NS

*I_1= Drip irrigation, I_2= manual watering.

Discussion

Reddy *et al*. (2015) reported significant increase in fruit weight in tomato which is grown under drip irrigation with polythene mulch. Paul *et al*. (2013) states that the increase in fruit weight under drip irrigation may be explained that water is applied at a low rate for a longer period at frequent intervals near the plant root zone through lower pressure delivery system, which increases the availability of nutrients near the root zone with a reduction in leaching losses. More nutrient availability, especially near the root zone might have increased the translocation of photosynthetes to storage organ of plant resulting in an increased weight of crops (Sankar *et al*., 2008) Whereas low yield in surface irrigation may be due to water stress during the critical growth period, coupled with aeration problem in first few days immediately after irrigation and may also be less availability of nutrients for crop growth due to leaching with high weed infestation between the crops (Pattanaik *et al*., 2003).

The higher fruit weight is attributed to vigorous growth of plants under black polythene mulches. Mathad and Jholgiker, (2005) also reported maximum fruit weight and yield under black poly mulch in strawberry. Parmar *et al.* (2013) observed heavier fruits under black poly mulch in water melon.

Singh *et al*. (2020) observed TSS, total sugar and ascorbic acid were significantly increased when NPK was applied through drip irrigation as compare with surface irrigation method. Singh *et al*. (2009) explained the effect of moderation in hydrothermal regime substantially facilitated to increase the uptake of water and nutrients and appreciably improved fruit quality and also observed that growing of strawberries by covering the soil of raised beds with polythene mulch significantly increased fruit quality parameters. Singh *et al*.. (2019) revealed that strawberry plant growth parameters were influenced by microclimate altering techniques with plastic mulches, fertigation and drip irrigation which resulted in the improvement of fruit quality attribute. Kachwaya and Chandel, (2015) found that application of recommended dose of NPK through drip irrigation significantly increased total soluble solids, total and reducing sugars, anthocyanin and ascorbic acid content as compared to soil fertilization during both the years. Thakur and Singh (2004), who recorded highest TSS and reducing sugar with 100% of recommended dose of NPK applied through drip irrigation in mango. Moor *et al*. (2005) also observed the significant increase in anthocyanin and vitamin anthocyanin content when fertilized through drip irrigation. Singh *et al*. (2023) observed lower acidity but higher TSS, sugar, ascorbic acid and anthocyanin content in black poly mulch in strawberry. Singh *et al*. (2007) also observed fruit harvested from plants mulched with black polyethylene have higher TSS, ascorbic acid and lower acidity than those harvested from plant mulch either with clear polyethylene or paddy straw. Pandey *et al*. (2016) found that maximum value of TSS, total sugar, ascorbic acid and anthocyanin content of strawberry when mulched with black polyethylene. The higher fruit quality under black poly-mulch may be explained in terms of higher moisture and nutrient availability, higher root activity including higher uptake of water and nutrient, high photosynthesis and other enzymatic activities (Pandey *et al*. 2016) and weed free environment (Singh *et al*., 2007).

4.2.4 Yield and economics of cultivation

Drip irrigation gave better yield per plant, per plot and per hectare as compared to manual irrigation.

4.2.4.1 Yield per plant

Table 4.2.4.1 showed significant effect of different mulch materials on fruit production per plant. Among the different mulch materials, black poly-mulch (M_8) was found to have maximum fruit production (503.52, 445.33 and 493.25 gm) per plant in the first year, second year and in pool analysis while minimum fruit production (185.79, 160.03 and 184.82 gm) was observed in no mulch (M_{10}) in the first year, second year and pool data respectively. The fruit production was also significantly influenced by irrigation conditions, higher yield (373.78, 365.72 and 369.75 gm) was observed under drip irrigation in the first year, second year and pooled data respectively.

Table-4.2.4.1: Effect of mulching treatments and irrigation condition on fruit yield per plant (gm) of strawberry.

Fruit yield per plant (gm)									
Treatments	**1^{st} year**			**2^{nd} year**			**Pooled**		
	I_1	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**
M_1	390.40	355.54	372.97	389.79	365.23	377.51	390.10	360.38	375.24
M_2	311.01	292.37	301.69	312.79	280.46	296.62	311.90	286.42	299.16
M_3	394.84	352.15	373.49	387.94	347.12	367.53	391.39	349.63	370.51
M_4	304.61	279.14	291.88	310.07	281.55	295.81	307.34	280.35	293.84
M_5	365.41	327.53	346.47	351.09	324.46	337.78	358.25	326.00	342.12
M_6	280.45	229.51	254.98	273.82	225.79	249.81	277.14	227.65	252.39
M_7	391.73	368.64	380.18	395.53	354.88	375.21	393.63	361.76	377.70
M_8	548.38	458.66	**503.52**	520.64	**445.33**	482.99	534.51	451.99	**493.25**
M_9	540.33	453.13	496.73	507.81	443.70	475.75	524.07	448.41	486.24
M_{10}	210.63	160.94	**185.79**	207.67	**160.03**	183.85	209.15	160.49	**184.82**
Mean	**373.78**	327.76		**365.72**	322.86		**369.75**	325.31	

Interaction effect

Source	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I
S.EM(±)	8.74	3.91	12.36	7.84	3.50	11.08	5.96	2.67	8.43
CD $_{0.05}$	29.79	13.32	NS	49.34	22.06	NS	28.27	12.64	NS
CV%	6.10			5.58			5.94		

1^{st} Year Mean	350.77	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2^{nd} year Mean	344.29	S.EM(±)	11.92	8.43	3.77	2.67
Pool Mean	347.53	CD $_{0.05}$	NS	NS	NS	NS

*I_1= Drip irrigation, I_2= manual watering.

4.2.4.2 Yield per plot

The data presented in table 4.2.4.2 shows various type of mulch materials have significant effect on the fruit production per plot of strawberry, the highest fruit production per plot (3.02, 2.91 and 2.96 kg) per plot was obtained under black poly-mulch (M_8) which was followed by M_9 silver poly-mulch (3.00, 2.90 and 2.96 kg) per plot while the lowest fruit production (1.11, 1.10 and 1.11 kg) per plot was noted under no mulch (M_{10}) in the first year, second year and pool analysis respectively. Significant effect in fruit production per plot in the irrigation condition has been observed where the higher yield (2.24, 2.21and 2.22 kg) per plot was observed under drip irrigation in the first year, second year and pool analysis respectively.

Table-4.2.4.2: Effect of mulching treatments and irrigation condition on fruit yield per plot (kg) of strawberry cultivation.

Fruit yield per plot (kg)									
Treatments	**1st year**			**2nd year**			**Pooled**		
	I_1	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**
M_1	2.34	2.13	2.24	2.34	2.19	2.27	2.34	2.16	2.25
M_2	1.87	1.75	1.81	1.88	1.68	1.78	1.87	1.72	1.79
M_3	2.37	2.11	2.24	2.33	2.08	2.21	2.35	2.10	2.22
M_4	1.83	1.67	1.75	1.86	1.69	1.77	1.84	1.68	1.76
M_5	2.19	1.97	2.08	2.11	1.95	2.03	2.15	1.96	2.05
M_6	1.68	1.38	1.53	1.64	1.35	1.50	1.66	1.37	1.51
M_7	2.35	2.21	2.28	2.37	2.13	2.25	2.36	2.17	2.27
M_8	3.29	2.75	**3.02**	3.12	2.67	**2.91**	3.21	2.71	**2.96**
M_9	3.24	2.76	3.00	3.16	2.66	2.90	3.20	2.71	2.96
M_{10}	1.26	0.97	**1.11**	1.25	0.96	**1.10**	1.25	0.96	**1.11**
Mean	**2.24**	1.97		**2.21**	1.94		**2.22**	1.95	

Interaction effect									
Source	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I
S.EM(±)	0.05	0.02	0.07	0.05	0.02	0.07	0.04	0.02	0.05
CD $_{0.05}$	0.15	0.07	NS	0.15	0.07	NS	0.11	0.05	0.15
CV%	5.97			6.24			6.20		

1st Year Mean	2.11	Pooled analysis	M x C x Y	M x Y	C x Y	Y
2nd year Mean	2.07	S.EM(±)	0.07	0.05	0.02	0.02
Pool Mean	2.09	CD $_{0.05}$	NS	NS	NS	NS

*I_1= Drip irrigation, I_2= manual watering.

4.2.4.3 Yield per hectare

The data presented in table 4.2.4.3 depicted various type of mulch materials have significant effect on the fruit yield per hectare of strawberry, the highest fruit yield per hectare (20.14, 19.32 and 19.73 ton) per hectare was obtained under Black poly-mulch (M_8) which was followed by M_9 silver poly-mulch (18.36, 18.76 and 18.56 ton) per hectare while the lowest yield (7.43, 7.35 and 7.39 ton) per hectare was noted under no mulch (M_{10}) in the first year, second year and pool analysis respectively. Drip irrigation had significantly higher fruit yield per hectare (14.95, 14.70 and 14.83 ton) as compared to manual irrigation.

Table-4.2.4.3: Effect of mulching treatments and irrigation condition on fruit yield per hectare (ton) of strawberry cultivation.

Fruit yield per hectare (ton)									
Treatments	**1st year**			**2nd year**			**Pooled**		
	I_1	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**
M_1	15.62	14.22	14.92	15.59	14.61	15.10	15.60	14.42	15.01
M_2	12.44	11.69	12.07	12.51	11.22	11.86	12.48	11.46	11.97
M_3	15.79	14.09	14.94	15.52	13.88	14.70	15.66	13.99	14.82
M_4	12.18	11.17	11.68	12.40	11.26	11.83	12.29	11.21	11.75
M_5	14.62	13.10	13.86	14.04	12.98	13.51	14.33	13.04	13.68
M_6	11.22	9.18	10.20	10.95	9.03	9.99	11.09	9.11	10.10
M_7	15.67	14.75	15.21	15.82	14.20	15.01	15.75	14.47	15.11
M_8	21.94	18.35	**20.14**	20.83	17.81	**19.32**	21.38	18.08	**19.73**
M_9	21.61	18.39	20.00	21.07	17.75	19.41	21.34	18.07	19.71
M_{10}	8.43	6.44	**7.43**	8.31	6.40	**7.35**	8.37	6.42	**7.39**
Mean	**14.95**	13.14		**14.70**	12.91		**14.83**	13.03	
Interaction effect									
Source	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I	Mulching (M)	Irrigation (I)	M x I
S.EM(±)	0.34	0.15	0.48	0.35	0.16	0.50	0.25	0.11	0.35
CD $_{0.05}$	0.98	0.44	NS	1.01	0.45	NS	0.70	0.31	0.99
CV%	5.97			6.24			6.20		
1st Year Mean		14.04		Pooled analysis	M x C x Y		M x Y	C x Y	Y
2nd year Mean		13.81		S.EM(±)	0.80		0.57	0.25	0.18
Pool Mean		13.93		CD $_{0.05}$	NS		NS	NS	NS

*I_1= Drip irrigation, I_2= manual watering.

4.2.4.4 Economics of cultivation

The present investigation reveals that all the mulching under drip irrigation condition significantly increase the economics and benefit cost ratio of the crops (Table 4.2.4.4). The economics of strawberry cultivation under drip irrigation and manual irrigation in open cultivation were carefully calculated and the following were the results; the maximum gross expenditure per hectare (Rs 11,59,607), the maximum gross income per hectare (Rs 44,74,636) and the maximum net income per hectare (Rs 33,15,028) with BC ratio of 2.86:1was recorded on black poly-mulch (M_8) under drip irrigation of strawberry cultivation whereas the highest gross expenditure (Rs 10,52,711), the maximum gross income per hectare (Rs 38,97,500) and the net income per hectare (Rs 28,44,789) with the BC ratio of 2.70:1 was observed under black poly mulch (M_8) in manual irrigation. The minimum expenditure, gross income and net income per hectare (Rs 9,77,741, Rs 18,45,065 and Rs 8,67,324) with BC ratio 0.89:1 was observed in no mulch (M_{10}) under drip irrigation whereas The minimum expenditure, gross income and net income per hectare (Rs 9,37,553, Rs 17,57,500 and Rs 8,19,947) with BC ratio 0.87:1 was observed in no mulch M_{10} under manual irrigation. The benefit-cost ratio was higher in drip irrigation compared to manual irrigation in all mulching treatments.

Table-4.2.4.4: Economics of strawberry cultivation with mulching treatments and irrigation conditions.

Economics of cultivation								
Treat ments	**Drip irrigation (I_1)**				**Manual irrigation (I_2)**			
	Gross expenditure (Rs / ha)	**Gross income (Rs /ha)**	**Net income (Rs /ha)**	**BC Ratio**	**Gross expenditure (Rs /ha)**	**Gross income (Rs /ha)**	**Net income (Rs /ha)**	**BC Ratio**
M_1	1079231	3808954	2729722	2.53	1003649	3402500	2398851	2.39
M_2	1073111	3073662	2000550	1.86	998243	2745000	1746757	1.75
M_3	1079231	3777564	2698333	2.50	1007117	3225000	2217883	2.20
M_4	1074131	3019152	1945020	1.81	998447	2727500	1729053	1.73
M_5	1078211	3662228	2584016	2.40	1003649	3362500	2358851	2.35
M_6	1072601	2944956	1872355	1.75	999467	2697500	1698033	1.70
M_7	1089431	3830307	2740876	2.52	999059	3377500	2378441	2.38
M_8	**1159607**	**4474636**	**3315028**	**2.86**	**1052711**	**3922500**	**2869789**	**2.73**
M_9	1154507	4439097	3284590	2.85	1052507	3907500	2854993	2.71
M_{10}	**977741**	**1845065**	**867324**	**0.89**	**937553**	**1757500**	**819947**	**0.87**

Discussion

The significant increase in yield under drip irrigation over the surface irrigation with black poly-mulch increased in yield under drip irrigation may be ascribed to better water utilization, minimum percolation and evaporation losses, and excellent soil-water-air relationship with higher oxygen concentration in the root zone, coupled with higher uptake of nutrients (Kumar *et al*., 2004). On the other hand surface irrigation might not have provided such favourable soil environment for plant growth (Kumar *et al*., 2005). Rolbiecki *et al*. (1997) also observed higher strawberry yield under drip irrigation as compared to surface irrigation. Reddy *et al*. (2015) reported significant increase in fruit weight and yield in tomato which is grown under drip irrigation with polythene mulch. Kumar and Dey, (2012) also found maximum yield of strawberry under drip irrigation. Among different treatments, the plant grown under plastic mulch produced larger number of fruits, fruit weight, and finally contributed to yield. Saeid and Mohammed, (2015) also found higher plant yield which may be attributed to better plant growth due to favorable hydrothermal regime and complete weed free environment. Castaneda *et al*., (2008) also observed strawberry plants, when mulched with black polythene film, produced more number of fruits which ultimately resulted in highest strawberry production compared to other types of mulches.

Paul *et al*. (2013) found significant increase in cost benefit ratio of capsicum which was grown under drip irrigation as compared to surface irrigation. Increase in availability of nutrients and highly suppressed weeds (Semwal *et al*., 2022) as a reason for improved yield has been reported by Moor *et al*. (2004), Sharma and Khokhar. (2006) in strawberry and Nagalakshmi *et al*. (2002) in chilli , Pandey *et al.*, (2016), Soliman *et al.* (2015) and Bakshi *et al.* (2014) also reported significant increase of yield in mulches in strawberry.

Chapter V

Summary and Conclusions

The present investigation entitled "**EFFECT OF DIFFERENT MULCH MATERIALS ON GROWTH, YIELD AND QUALITY OF STRAWBERRY IN OPEN AND POLYHOUSE CULTIVATION IN MIZORAM**" was carried out in Demonstration Farm, Krishi Vigyan Kendra, N. Vanlaiphai, Serchhip district, Mizoram during 2017-18 and 2018-19.

The salient findings from the present investigation are summarised below:

Experiment 1**: Effect of different mulch materials on performance of strawberry under open and polyhouse cultivation.**

- The strawberry plant height was measured with a measuring scale at 30, 60 and 90 DAP and use of different mulch materials show significant effect. The tallest plant height (11.9 cm, 21.4 cm and 26.81 cm) was recorded with black poly-mulch (M_8), the lowest plant height (9.68 cm, 13.29 cm and 15.39 cm) was recorded in control (M_{10}). Plant height was influenced by growing condition where taller plant height (12.29 cm, 18.76 cm and 21.33 cm) was observed under polyhouse cultivation as compared to open cultivation.
- Plant spread was measured with a measuring tape in both N-S direction and E- W direction at 30, 60 and 90 DAP, the maximum plant spread (14.65 cm, 25.66 cm and 31.88 cm) in N-S direction was observed under M_8, Black poly-mulch while the maximum plant spread (15.92 cm, 26.33 cm and 31.12 cm) in E-W direction also recorded with Black poly-mulch (M_8). The minimum plant spread in both N-S and E-W direction was recorded with no mulch (M_{10}) at 30, 60 and 90 DAP. Plant spread (N-S and E-W direction) were also influenced significantly by their growing conditions, higher values of plant spread N-S direction as well as E-W direction were observed under Black poly mulch at 30, 60 and 90 DAP.

- Maximum number of leaves (10.92, 24.06 and 28.20) was recorded under M_8, black poly-mulch and minimum number of leaves (7.30, 12.38 and 17.00) was recorded under no mulch at 30, 60 and 90 DAP. Significant influenced by growing condition was observed in number of leaves where more number of leaves was obtained from poly-house cultivation compared to open cultivation.
- Weed emergence was measured by counting the number of weed inside the quadrant and recorded at 30, 60 and 90 DAP. Minimum weeds emergence (0.12 per m^2) at 30 DAP was observed under M_9, silver poly-mulch, 0.33 per m^2 and 0.59 per m^2 at 60 and 90 DAP were recorded under black poly mulch (M_8) whereas the maximum weeds emergence (4.05, 12.51 and 17.62) was recorded with M_{10}, no mulch at 30, 60 and 90 DAP. Poly-house cultivation showed lower weed emergence than open cultivation.
- Yield attributing characters were influenced significantly by various types of mulches. Maximum number of flowers per plant (41.21), maximum number of fruits per plant (40.15), the highest fruit set percentage (97.39 %) and maximum number of runners per plant (5.83) were observed under M_8 black poly-much on the other hand minimum number of flowers per plant (24.18), the minimum number of fruit per plant (21.47), the minimum number of fruit set percentage (88.69 %) and minimum number of runners per plant (2.68) were found under M_{10} no mulch. Significant influenced in yield attributing characters were also observed with growing condition where higher number of flowers per plant (33.80), fruit per plant (31.96), fruit setting percentage (95.14 %) and higher number of runners per plant (4.62) were observed in poly-house cultivation than in open cultivation.
- Fruit size was also influenced by different mulch materials as well as growing condition. The maximum fruit length (4.04 cm), fruit breadth (3.66 cm) and fruit weight (19.87 gm) were observed under M_8, black poly mulch followed by M_9, silver poly-mulch while, the minimum fruit length (2.96 cm), fruit breadth (2.60 cm) and fruit weight (12.30 gm) were cited under M_{10}, no mulch also higher values of fruit length (3.75 cm), fruit breadth

(3.23 cm) and fruit weight (17.49 gm) were observed with poly-house cultivation compared to open cultivation.

- Strawberry fruit quality was affected by use of different mulch materials where the fruit quality in terms of TSS (8.19 ^{0} brix), total sugar (6.81 %), ascorbic acid content (52.57 mg/ 100gm) and anthocyanin content (48.17 mg/100gm) were highest and the titrable acidity (0.44 %) was lowest under black poly mulch (M_8). The growing condition had significant influence in the fruit quality where higher TSS (7.97 ^{0} Brix), total sugar content (6.26 %), ascorbic acid (49.96 mg/100 gm) and anthocyanin content (44.78 mg/100 gm) were observed under poly-house cultivation while lower acidity (0.50 %) was found under open cultivation.
- Shelf life in strawberry fruit was short, which lasted only for 2-3 days in ambient condition. In the present study, we expressed shelf life in terms of physiological loss in weight at 24 hr, 48 hr and 72 hr in ambient storage. The physiological loss in weight (loss in moisture %) were influenced by various types of mulching materials, the minimum loss was observed under black poly mulch (6.02 %) followed by silver poly mulch (6.04 %) within 24hr however, the minimum loss within 48 hr was observed under M_1, paddy straw mulch (9.51 %) followed by M_3, wood shaving (9.64 %), the lowest loss in moisture within 72 hr was observed under M_3, wood shaving (12.96 %) the maximum loss in weight was cited under M_{10}, no mulch (6.89 %, 11.05 %, 15.67 %) in 24 hr , 48 hr and 72 hr respectively. The growing condition had significant effect in the physiological loss in weight of strawberry fruit, where loss in weight was lower under open cultivation (5.98 %, 9.80 %, and 13.87 %) in 24 hr, 48 hr and 72 hr respectively when compared with polyhouse cultivation.
- The soil temperature was measured with thermometer at 11:00 am during the month of January (30 DAP) and the soil temperature recorded was highest at M_8, black poly-mulch (23.23 ^{0}C) followed by M_9, silver poly-mulch while the minimum temperature was recorded at M_2, saw dust mulch (21.13 ^{0}C). At 60 DAP, black poly- mulch (25.44 ^{0}C) recorded the maximum soil

temperature while the minimum was recorded under straw mulch (22.27 ^{0}C). At 90 DAP, the maximum soil temperature was noted under Black poly-mulch (29.43 ^{0} C) while the minimum was recorded under M_5, pine needle mulch (25.57 ^{0}C). Higher soil temperature was recorded under poly-house cultivation (22.21, 23.41 and 27.15 ^{0} C) in compared to open cultivation at 30, 60 and 90 DAP.

- Results revealed significant effect of different types of mulching and their growing conditions on the soil moisture content. At 30 DAP, highest record (48.10 %) was observed under black poly-mulch (M_8) followed by $M_{9,}$ silver poly-mulch whereas minimum moisture record (25. 27 %) was found under no mulch (M_{10}). At 60 DAP, highest moisture (45.27 %) content of the soil was recorded at M_9, silver poly-mulch while the minimum record (25.58 %) was observed under no mulch. At 90 DAP, the highest soil moisture (40.57 %) was recorded under plastic mulch while the minimum moisture (22.06 %) content was observed under no mulch, The soil moisture content was influenced significantly by the growing condition where the higher moisture content was observed under poly-house cultivation at 30, 60 and 90 DAP.
- The use of mulch improves soil nutrient content, the maximum available soil nitrogen (N) and potassium (P) content was recorded under M_1, paddy straw mulch (287.08 kg/ha and 278.58 kg/ha), the highest soil phosphorus (P) content was found in M_7, rice husk (24.11 kg/ha) and the lowest available soil N, P and K was observed under no mulch (M_{10}). No significant effect on soil pH was observed with mulching treatments and growing condition.
- The highest yield per plant (575.81gm), highest yield per plot (4.52kg) as well as per ha (20.87 ton) was found under black poly-mulch (M_8) whereas the lowest yield per plant (256.64 gm), per plot (1.45 kg) and per hectare (8.28 ton) were found under M_{10}, no mulch. Significant effect by the growing condition was observed in the fruit production where higher yield per plant (474.68 gm), per plot (3.23 kg) and per hectare (17.36 ton) was observed under poly-house cultivation as compared to open cultivation.

- Strawberry cultivation under polyhouse condition showed higher benefit: cost ratio under all mulching treatments, when compared to those cultivated in open condition.

  Again, among the different mulching treatments, use of black poly-mulch resulted in maximum gross expenditure per hectare (Rs. 13,64,627), but also maximum gross income per hectare (Rs. 60,33,136) and maximum net income per hectare (Rs. 46,68,509) with BC ratio of 3.42:1 under polyhouse condition.

Conclusions:

The present investigation showed that mulching have better influence on the plant performance of strawberry cultivation than no mulch. Among the different mulch treatments, black poly-mulch treatments was found to have best influence on plant growth and development, weed suppression, fruit size and quality as well as yield in strawberry cultivation under Mizoram condition.

Strawberry can be cultivated under both open and polyhouse condition but the present study resulted in better plant performance, better yield and more cost effective cultivation with polyhouse cultivation compared to open cultivation.

Experiment 2: **Efficacy of drip irrigation and manual irrigation condition in strawberry cultivation with different mulching treatment:**

- Irrigation condition has significant effect in the plant height of strawberry and taller plant height (18.31 cm) was observed under drip irrigation. Also various types of mulching had significant effect on plant height, the maximum plant height (19.81 cm) was observed under Black poly- mulch (M_8).
- Significant effect of drip irrigation have been observed in plant spread, the wider plant spread, 25.64 cm in N-S direction and 24.79 cm in E-W direction was observed under drip irrigation condition. Also, significant influence of mulching had been observed, the maximum plant spread (28.41cm) in N-S direction and 26.81cm in E- W direction was observed under black poly mulch (M_8).
- More number of leaves (21.66) was recorded with drip irrigation compared to manual irrigation and the maximum number of leaves (24.37) was observed under black poly-mulch (M_8) whereas the minimum number of leaves (13.07) was observed under no mulch (M_{10}).
- Irrigation condition significantly influences the number of weed / m^2, the lesser number of weeds (5.40 / m^2) was found under drip irrigation as compared to manual irrigation. Different types of mulching treatments also influences the emergence of weeds, the minimum number of weeds (0.84 / m^2) was observed under silver poly mulch, (M_9) while the maximum no of weed was found under no mulch (M_{10}).
- Significant effect of irrigation condition have been observed in yield attributing parameters where the higher number of flowers (25.85), fruits (25.15), fruit setting percentage (88.64 %) and runners (3.45) per plant were recorded under drip irrigation .

  Different types of mulching materials influences the yield attributing parameters where maximum number of flowers (33.26), maximum number of fruits (32.06) and the highest fruit set percentage (96.54 %) and maximum numbers of runners (4.90) was observed under black poly-mulch (M_8).

- Irrigation condition had significant influences on strawberry fruit quality, the heavier fruit weight (14.52), higher TSS (8.19 ^{0}Brix), higher acidity (0.50 %), the higher content of total sugar (5.87 %), higher value of anthocyanin (38.05 mg/100gm) and higher ascorbic acid content (49.97 mg/100 gm) was observed under drip irrigation compared to manual irrigation. Different kinds of mulching also had significant influence on the fruit quality parameters, the maximum individual fruit weight (15.38 gm), maximum value of total sugar (6.26 %) and the maximum value of anthocyanin with the minimum value of titrable acidity (0.43 %) was observed under black poly mulch (M_8).
- Higher yield per plant (369.75 gm), per plot (2.22 kg) and per hectare (14.83 ton) were obtained under drip irrigation. Different kinds of mulching treatment also influenced yields, the maximum yield per plant (493.25 gm), per plot (2.96 kg) and per hectare (19.73 ton) were obtained under black poly-mulch (M_8).

- The use of drip irrigation improves the economics of cultivation and cost benefit ratio of strawberry cultivation, not only the gross expenditure (Rs. 11,59,607) but also the net income (Rs. 33,15,028) was maximum with drip irrigation and also the benefit cost ratio was highest (2.86:1) in black poly mulch under drip irrigated.

Conclusions:

Strawberry cultivation requires continuous supply of water at regular interval to supplement just enough moisture needed by this shallow rooted plant. For this, manual and drip irrigation are both suitable. Finding of the present experiment revealed that drip irrigation result in better plant performance, lesser weed infestation, better fruit production and fruit quality and also a more cost effective strawberry cultivation when compared with manual irrigation.

Strawberry cultivation performs better with mulching than no mulch. Among different mulching materials used in the present investigation, use of black poly mulch (M_8) showed best result in overall plant performance, fruit production, fruit quality and yield as well as maximum weed suppression. Hence, black poly-mulch may be recommended for use as mulching material for strawberry cultivation under Mizoram condition.

PHOTO PLATES

General view of Experimental plot

Mulch with a paddy straw

Mulch with Wood Shaving

Mulch with Leaf litter

Mulch with Pine needle

Mulch with Cut grass

Mucl with Rice husk

Mulch with Black Polymulch

Mulch with Silver Polymulch

No Mulch

Field Reading

Laboratory Analysis

Harvested fruit

Laboratory Analysis

Annexure- 1			Plant height at 30 DAP		1^{st} year
Treatment	RI	R2	R3	TOTAL	MEAN
A1M1	10.76	10.80	9.70	31.26	10.42
A1M2	10.78	10.30	9.78	30.86	10.29
A1M3	9.52	10.68	9.02	29.22	9.74
A1M4	9.20	10.04	11.06	30.30	10.10
A1M5	10.40	10.30	9.94	30.64	10.21
A1M6	10.14	8.46	10.54	29.14	9.71
A1M7	10.76	9.80	9.24	29.80	9.93
A1M8	9.70	10.38	11.40	31.48	10.49
A1M9	10.26	9.60	11.41	31.27	10.42
A1M10	7.26	9.32	9.28	25.86	8.62
A2M1	11.78	12.52	13.04	37.34	12.45
A2M2	13.32	11.76	11.18	36.26	12.09
A2M3	11.88	13.64	13.46	38.98	12.99
A2M4	11.56	14.25	12.04	37.85	12.62
A2M5	13	11.56	12.16	36.72	12.24
A2M6	12.14	11.54	12.04	35.72	11.91
A2M7	13.12	13	11.13	37.25	12.42
A2M8	13.48	14.64	12.82	40.94	13.65
A2M9	13.36	12.92	12.74	39.02	13.01
A2M10	9.86	10.4	12.54	32.80	10.93

- A1- open cultivation, A2- polyhouse cultivation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -2		**Plant height at 30 DAP**			**2^{nd} year**
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	10.94	10.80	9.16	30.9	10.30
A1M2	9.54	10.20	10.34	30.08	10.03
A1M3	10.00	9.68	11.20	30.88	10.29
A1M4	9.86	9.84	10.00	29.7	9.90
A1M5	10.38	9.36	9.92	29.66	9.89
A1M6	8.40	10.84	9.96	29.2	9.73
A1M7	10.04	9.84	10.20	30.08	10.03
A1M8	11.20	10.17	10.22	31.59	10.53
A1M9	9.64	11.32	10.20	31.16	10.39
A1M10	7.58	9.80	8.84	26.22	8.74
A2M1	11.56	13.6	11.95	37.11	12.37
A2M2	12.76	11.92	12.46	37.14	12.38
A2M3	12.92	12.56	11.12	36.6	12.20
A2M4	12.8	11.32	12.6	36.72	12.24
A2M5	10.34	12.76	12.38	35.48	11.83
A2M6	12.08	11.4	10.56	34.04	11.35
A2M7	13.32	11.22	12.6	37.14	12.38
A2M8	13.12	14.26	12.38	39.76	13.25
A2M9	13.18	12.74	13.48	39.4	13.13
A2M10	9.16	10.06	12.04	31.26	10.42

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -3	Plant height at 60 DAP			1year	
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	14.30	12.24	15.30	41.84	13.95
A1M2	12.08	13.86	13.24	39.18	13.06
A1M3	14.94	14.84	11.32	41.10	13.70
A1M4	13.32	13.56	11.72	38.60	12.87
A1M5	12.86	12.74	13.64	39.24	13.08
A1M6	12.28	13.28	12.34	37.90	12.63
A1M7	13.36	10.42	13.24	37.02	12.34
A1M8	16.54	15.78	13.16	45.48	15.16
A1M9	15.02	15.26	13.20	43.48	14.49
A1M10	10.20	11.20	10.60	32.00	10.67
A2M1	20.46	20.92	17.46	58.84	19.61
A2M2	17.02	19.74	18.12	54.88	18.29
A2M3	20.1	18.16	20	58.26	19.42
A2M4	16.04	18.86	17.66	52.56	17.52
A2M5	17.92	18.42	19.26	55.60	18.53
A2M6	16.04	18.62	19.75	54.41	18.14
A2M7	17.04	18.96	20.04	56.04	18.68
A2M8	21.16	20.38	23.6	65.14	21.71
A2M9	21.48	20.96	22.12	64.56	21.52
A2M10	16.85	14.04	15.84	46.73	15.58

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10- Control(No mulch)

Annexure -4		Plant height at 60 DAP		2 year	
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	14.99	13.58	15.90	44.47	14.82
A1M2	14.42	12.02	14.12	40.56	13.52
A1M3	14.04	16.06	14.05	44.15	14.72
A1M4	14.54	15.66	13.08	43.28	14.43
A1M5	13.08	15.24	14.58	42.9	14.30
A1M6	14.04	11.30	13.64	38.98	12.99
A1M7	11.12	14.44	10.94	36.5	12.17
A1M8	16.02	16.10	14.54	46.66	15.55
A1M9	15.24	15.40	14.16	44.8	14.93
A1M10	11.02	10.04	12.50	33.56	11.19
A2M1	19.78	20.83	17.08	57.69	19.23
A2M2	16.88	18.5	18.04	53.42	17.81
A2M3	17.1	20	19.82	56.92	18.97
A2M4	15.08	18.1	18.9	52.08	17.36
A2M5	20.02	17.32	18.26	55.6	18.53
A2M6	18.04	16.16	18.82	53.02	17.67
A2M7	20.08	17.02	19.2	56.3	18.77
A2M8	20.06	20.72	22.5	63.28	21.09
A2M9	21.82	21.96	19.26	63.04	21.01
A2M10	16.02	14.92	16.28	47.22	15.74

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -5	Plant height at 90 DAP			1 year	
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	18.12	17.20	20.78	56.10	18.70
A1M2	17.86	16.70	17.26	51.82	17.27
A1M3	19.20	18.02	18.46	55.68	18.56
A1M4	18.50	17.86	18.52	54.88	18.29
A1M5	17.28	18.84	18.04	54.16	18.05
A1M6	17.96	18.10	16.04	52.10	17.37
A1M7	18.50	17.74	16.58	52.82	17.61
A1M8	21.74	21.04	20.40	63.18	21.06
A1M9	18.36	20.58	21.05	59.99	20.00
A1M10	13.40	14.26	17.08	44.74	14.91
A2M1	23.94	19.82	23.3	67.06	22.35
A2M2	19.82	19.2	18.4	57.42	19.14
A2M3	22.5	18.7	19.5	60.70	20.23
A2M4	18.98	18.54	19.26	56.78	18.93
A2M5	21.26	19.96	16.8	58.02	19.34
A2M6	19.2	20.2	17.06	56.46	18.82
A2M7	23.02	21.04	20.42	64.48	21.49
A2M8	25.68	26.16	26.12	77.96	25.99
A2M9	25.48	26	24.52	76.00	25.33
A2M10	18.04	18.24	16.25	52.53	17.51

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -6	Plant height at 90 DAP			2 year	
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	19.62	18.14	19.00	56.76	18.92
A1M2	16.90	18.72	17.04	52.66	17.55
A1M3	19.06	19.12	18.38	56.56	18.85
A1M4	18.08	19.70	16.22	54	18.00
A1M5	18.04	19.70	16.18	53.92	17.97
A1M6	17.44	16.80	19.16	53.4	17.80
A1M7	16.56	15.94	20.60	53.1	17.70
A1M8	21.46	20.68	21.10	63.24	21.08
A1M9	20.84	22.66	18.14	61.64	20.55
A1M10	16.64	14.48	16.48	47.6	15.87
A2M1	23.72	23.96	23.24	70.92	23.64
A2M2	18.18	21.04	20.62	59.84	19.95
A2M3	21.28	21.12	22.82	65.22	21.74
A2M4	16.32	20.66	20.44	57.42	19.14
A2M5	18.18	21.16	22.2	61.54	20.51
A2M6	18.1	16.2	22.06	56.36	18.79
A2M7	24.64	23.08	22.06	69.78	23.26
A2M8	27.8	28.02	27.08	82.9	27.63
A2M9	26.08	27.74	23.56	77.38	25.79
A2M10	16.44	16.25	18.54	51.23	17.08

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -7	Plant spread at 30 DAP (N-S direction)				1 year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	12.95	10.85	11.45	35.25	11.75
A1M2	11.1	10	10.5	31.60	10.53
A1M3	8.85	14	12.1	34.95	11.65
A1M4	10.35	11.45	10.85	32.65	10.88
A1M5	11.55	11.9	9.25	32.70	10.90
A1M6	10.15	12	7.9	30.05	10.02
A1M7	11.45	10.9	10.35	32.70	10.90
A1M8	11.5	13.1	13.2	37.80	12.60
A1M9	11.72	13.65	11.15	36.52	12.17
A1M10	8.8	8.7	9.8	27.30	9.10
A2M1	14.34	17.12	16.76	48.22	16.07
A2M2	14.26	12.96	13.40	40.62	13.54
A2M3	15.08	16.80	14.62	46.50	15.50
A2M4	14.44	13.86	15.18	43.48	14.49
A2M5	13.96	14.26	14.80	43.02	14.34
A2M6	14.18	14.86	11.02	40.06	13.35
A2M7	15.22	14.54	16.02	45.78	15.26
A2M8	17.12	14.96	17.30	49.38	16.46
A2M9	17.06	14.60	17.08	48.74	16.25
A2M10	13.02	9.92	13.86	36.80	12.27

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -8	Plant spread at 30 DAP (N-S direction)				2 year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	11.4	11.6	10.86	33.86	11.29
A1M2	12.46	9.2	10.72	32.38	10.79
A1M3	11.36	11.56	11.76	34.68	11.56
A1M4	12.38	9.64	10.72	32.74	10.91
A1M5	11.06	10.58	11.36	33	11.00
A1M6	12.12	8.12	9.68	29.92	9.97
A1M7	8.46	11.88	12.14	32.48	10.83
A1M8	12.24	12.56	12.94	37.74	12.58
A1M9	12.66	11.88	11.52	36.06	12.02
A1M10	10.72	9.6	8.08	28.4	9.47
A2M1	13.98	17.04	17.5	48.52	16.17
A2M2	14.86	14.04	12.03	40.93	13.64
A2M3	17.2	14.78	15.18	47.16	15.72
A2M4	15.82	13.04	14.9	43.76	14.59
A2M5	12.78	14.14	15.62	42.54	14.18
A2M6	12.56	14.4	14.02	40.98	13.66
A2M7	12.94	16.88	15.7	45.52	15.17
A2M8	18.16	17.06	15.64	50.86	16.95
A2M9	16.86	17.26	16.32	50.44	16.81
A2M10	11.3	12.5	14.08	37.88	12.63

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -9	Plant spread at 60 DAP (N-S direction)				1year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	19.74	24.46	24.36	68.56	22.85
A1M2	16.96	19.68	21.24	57.88	19.29
A1M3	19.38	22.96	23.61	65.95	21.98
A1M4	20.14	20.8	17.56	58.50	19.50
A1M5	22.44	21.98	15.97	60.39	20.13
A1M6	18.02	21.18	18.12	57.32	19.11
A1M7	20.86	21	19.46	61.32	20.44
A1M8	23.44	24.43	24.56	72.43	24.14
A1M9	23.63	23.65	22.66	69.94	23.31
A1M10	17.14	15.46	17.06	49.66	16.55
A2M1	24.52	22.78	25.3	72.60	24.20
A2M2	22.46	19.72	21.8	63.98	21.33
A2M3	22.5	23.76	24.84	71.10	23.70
A2M4	22.86	23.92	19.08	65.86	21.95
A2M5	24.16	23.96	22.74	70.86	23.62
A2M6	17.48	23.1	22.02	62.60	20.87
A2M7	23.8	23.74	22.74	70.28	23.43
A2M8	29.64	24.96	26.22	80.82	26.94
A2M9	27.18	24.22	26.22	77.62	25.87
A2M10	19.38	19.16	17.26	55.80	18.60

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -10		Plant spread at 60 DAP (N-S direction)			2 year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	21.22	23.8	23.65	68.67	22.89
A1M2	19.14	22.5	18.95	60.59	20.20
A1M3	21.5	22.96	23.9	68.36	22.79
A1M4	18.04	18.48	22.3	58.82	19.61
A1M5	20.16	19.85	23	63.01	21.00
A1M6	19.3	21.602	17.5	58.402	19.47
A1M7	22.02	19.04	21.06	62.12	20.71
A1M8	22	26.76	25	73.76	24.59
A1M9	24.01	23.736	25.4	73.146	24.38
A1M10	19.4	16.48	15	50.88	16.96
A2M1	24.5	25.7	21.7	71.9	23.97
A2M2	20.02	21.6	22.08	63.7	21.23
A2M3	21.44	25.08	24.64	71.16	23.72
A2M4	22.6	23.26	19.64	65.5	21.83
A2M5	21.7	24.78	24.04	70.52	23.51
A2M6	22.36	22.06	18.48	62.9	20.97
A2M7	24.36	22.64	22.8	69.8	23.27
A2M8	27.8	26.28	26.82	80.9	26.97
A2M9	25.84	24.22	25.58	75.64	25.21
A2M10	21.86	18.04	16.26	56.16	18.72

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -11	Plant spread at 90 DAP (N-S diretion)				1 year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	22.78	29.03	26.96	78.77	26.26
A1M2	19.88	22.50	22.38	64.76	21.59
A1M3	29.82	25.04	23.35	78.21	26.07
A1M4	25.76	26.92	26.06	78.74	26.25
A1M5	27.86	25.98	26.86	80.70	26.90
A1M6	22.31	22.82	17.28	62.41	20.80
A1M7	27.23	28.74	27.76	83.73	27.91
A1M8	29.40	30.68	30.96	91.04	30.35
A1M9	29.56	30.64	28.88	89.08	29.69
A1M10	17.30	17.52	18.36	53.18	17.73
A2M1	27.74	25.22	27.34	80.30	26.77
A2M2	24.96	25.16	26.2	76.32	25.44
A2M3	26.46	25.32	26.24	78.02	26.01
A2M4	26.84	26.94	26.78	80.56	26.85
A2M5	28.26	26.8	26.76	81.82	27.27
A2M6	24.9	26.72	23.18	74.80	24.93
A2M7	26.92	27.3	26.56	80.78	26.93
A2M8	33.22	35.86	28.92	98.00	32.67
A2M9	34.76	33.64	29.46	97.86	32.62
A2M10	23.62	22.62	22.22	68.46	22.82

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -12	Plant spread at 90 DAP (N-S direction)				2 year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	23.32	27.59	29.71	80.62	26.87
A1M2	20.34	22.90	23.03	66.27	22.09
A1M3	30.52	23.91	25.60	80.03	26.68
A1M4	26.38	26.68	27.55	80.61	26.87
A1M5	28.51	27.49	26.58	82.58	27.53
A1M6	22.82	17.67	23.36	63.85	21.28
A1M7	27.87	28.41	29.42	85.7	28.57
A1M8	30.09	31.69	31.40	93.18	31.06
A1M9	30.25	29.50	31.36	91.11	30.37
A1M10	17.02	18.90	17.93	53.85	17.95
A2M1	28.39	27.98	25.81	82.18	27.39
A2M2	25.5	26.82	25.75	78.07	26.02
A2M3	27.08	26.85	25.92	79.85	26.62
A2M4	27.47	27.4	27.57	82.44	27.48
A2M5	28.92	27.37	27.42	83.71	27.90
A2M6	25.49	23.72	27.35	76.56	25.52
A2M7	27.55	27.18	27.94	82.67	27.56
A2M8	34	29.6	36.7	100.3	33.43
A2M9	35.58	30.15	34.43	100.16	33.39
A2M10	24.17	22.74	23.15	70.06	23.35

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -13	Plant spread at 30 DAP (E-W direction)			1 year	
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	13.97	12.05	14.85	40.87	13.62
A1M2	12.85	11.2	13.5	37.55	12.52
A1M3	14.05	14.3	12.3	40.65	13.55
A1M4	13.5	12.2	12.85	38.55	12.85
A1M5	11.75	12.9	12.2	36.85	12.28
A1M6	12.15	12.9	10.9	35.95	11.98
A1M7	13.1	12.75	11.8	37.65	12.55
A1M8	12.43	13.9	13.95	40.28	13.43
A1M9	12.2	13.9	13.74	39.84	13.28
A1M10	9.97	9.05	11.5	30.52	10.17
A2M1	17.66	15.62	17.5	50.78	16.93
A2M2	15.96	14.3	16.84	47.10	15.70
A2M3	17.74	14.88	17.6	50.22	16.74
A2M4	14.12	17.58	16.92	48.62	16.21
A2M5	14.94	17.36	16.9	49.20	16.40
A2M6	16.18	15.4	15.89	47.47	15.82
A2M7	16.8	16.08	15.94	48.82	16.27
A2M8	19.84	18.18	16.54	54.56	18.19
A2M9	18.86	16.26	18.98	54.10	18.03
A2M10	15.54	12.36	14.92	42.82	14.27

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -14	Plant spread at 30 DAP (E-W direction)				2 year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	13.96	12.64	12.8	39.4	13.13
A1M2	13.5	12.56	11.12	37.18	12.39
A1M3	11.84	12.48	14.68	39	13.00
A1M4	13.14	13.12	12.18	38.44	12.81
A1M5	11.72	12.92	11.64	36.28	12.09
A1M6	13.22	12.68	9.76	35.66	11.89
A1M7	11.44	12.78	13.46	37.68	12.56
A1M8	13.6	13.44	14.2	41.24	13.75
A1M9	13.74	13.4	12.44	39.58	13.19
A1M10	12.68	9.62	10.92	33.22	11.07
A2M1	16.24	17.28	17.4	50.92	16.97
A2M2	17.04	15.4	15.46	47.9	15.97
A2M3	17.79	15.14	16.89	49.82	16.61
A2M4	17.2	15.09	16.26	48.55	16.18
A2M5	15.02	17.7	16.69	49.41	16.47
A2M6	14.58	16.64	16.32	47.54	15.85
A2M7	16.1	16.08	15.96	48.14	16.05
A2M8	18.14	19.76	17.08	54.98	18.33
A2M9	18.52	18.8	17.02	54.34	18.11
A2M10	12.09	15.84	15.72	43.65	14.55

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -15	Plant spread at 60 DAP (E-W direction)				1 year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	23.28	19.94	25.94	69.16	23.05
A1M2	18.16	20.42	23.82	62.40	20.80
A1M3	20.44	24.84	23.09	68.37	22.79
A1M4	22.02	19.88	19.298	61.20	20.40
A1M5	23.48	24.6	17.36	65.44	21.81
A1M6	17.13	17.28	19.66	54.07	18.02
A1M7	23.58	22.42	20.06	66.06	22.02
A1M8	23.12	25	25.082	73.20	24.40
A1M9	20.8	24.55	24.39	69.74	23.25
A1M10	15.1	17.04	17.1	49.24	16.41
A2M1	26.84	26.8	24.74	78.38	26.13
A2M2	24.22	23.26	23.78	71.26	23.75
A2M3	24.04	24.87	26.9	75.81	25.27
A2M4	25.4	25.74	23.02	74.16	24.72
A2M5	25.18	25.06	25.64	75.88	25.29
A2M6	24.08	22.78	20.2	67.06	22.35
A2M7	24.28	22.48	25.22	71.98	23.99
A2M8	29.5	27.32	28.52	85.34	28.45
A2M9	28.9	27.44	27.54	83.88	27.96
A2M10	20.96	21.09	18.3	60.35	20.12

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -16	Plant spread at 60 DAP (E-W direction)				2 year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	19.74	24.46	24.36	68.56	22.85
A1M2	16.96	19.68	21.24	57.88	19.29
A1M3	19.38	22.96	23.61	65.95	21.98
A1M4	20.14	20.8	17.56	58.50	19.50
A1M5	22.44	21.98	15.97	60.39	20.13
A1M6	18.02	21.18	18.12	57.32	19.11
A1M7	20.86	21	19.46	61.32	20.44
A1M8	23.44	24.43	24.56	72.43	24.14
A1M9	23.63	23.65	22.66	69.94	23.31
A1M10	17.14	15.46	17.06	49.66	16.55
A2M1	24.52	22.78	25.3	72.60	24.20
A2M2	22.46	19.72	21.8	63.98	21.33
A2M3	22.5	23.76	24.84	71.10	23.70
A2M4	22.86	23.92	19.08	65.86	21.95
A2M5	24.16	23.96	22.74	70.86	23.62
A2M6	17.48	23.1	22.02	62.60	20.87
A2M7	23.8	23.74	22.74	70.28	23.43
A2M8	29.64	24.96	26.22	80.82	26.94
A2M9	27.18	24.22	26.22	77.62	25.87
A2M10	19.38	19.16	17.26	55.80	18.60

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -17	Plant spread at 90 DAP (E-W direction)				1 year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	21.22	23.8	23.65	68.67	22.89
A1M2	19.14	22.5	18.95	60.59	20.20
A1M3	21.5	22.96	23.9	68.36	22.79
A1M4	18.04	18.48	22.3	58.82	19.61
A1M5	20.16	19.85	23	63.01	21.00
A1M6	19.3	21.602	17.5	58.402	19.47
A1M7	22.02	19.04	21.06	62.12	20.71
A1M8	22	26.76	25	73.76	24.59
A1M9	24.01	23.736	25.4	73.146	24.38
A1M10	19.4	16.48	15	50.88	16.96
A2M1	24.5	25.7	21.7	71.9	23.97
A2M2	20.02	21.6	22.08	63.7	21.23
A2M3	21.44	25.08	24.64	71.16	23.72
A2M4	22.6	23.26	19.64	65.5	21.83
A2M5	21.7	24.78	24.04	70.52	23.51
A2M6	22.36	22.06	18.48	62.9	20.97
A2M7	24.36	22.64	22.8	69.8	23.27
A2M8	27.8	26.28	26.82	80.9	26.97
A2M9	25.84	24.22	25.58	75.64	25.21
A2M10	21.86	18.04	16.26	56.16	18.72

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -18	Plant spread at 90 DAP (E-W direction)				2 year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	22.78	29.03	26.96	78.77	26.26
A1M2	19.88	22.50	22.38	64.76	21.59
A1M3	29.82	25.04	23.35	78.21	26.07
A1M4	25.76	26.92	26.06	78.74	26.25
A1M5	27.86	25.98	26.86	80.70	26.90
A1M6	22.31	22.82	17.28	62.41	20.80
A1M7	27.23	28.74	27.76	83.73	27.91
A1M8	29.40	30.68	30.96	91.04	30.35
A1M9	29.56	30.64	28.88	89.08	29.69
A1M10	17.30	17.52	18.36	53.18	17.73
A2M1	27.74	25.22	27.34	80.30	26.77
A2M2	24.96	25.16	26.2	76.32	25.44
A2M3	26.46	25.32	26.24	78.02	26.01
A2M4	26.84	26.94	26.78	80.56	26.85
A2M5	28.26	26.8	26.76	81.82	27.27
A2M6	24.9	26.72	23.18	74.80	24.93
A2M7	26.92	27.3	26.56	80.78	26.93
A2M8	33.22	35.86	28.92	98.00	32.67
A2M9	34.76	33.64	29.46	97.86	32.62
A2M10	23.62	22.62	22.22	68.46	22.82

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -19		Numbers of leaves at 30		1st year	
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	8.2	9.6	9.8	27.60	9.20
A1M2	7.4	6.8	5.2	19.40	6.47
A1M3	8.6	9.2	9.4	27.20	9.07
A1M4	6	7.2	7.6	20.80	6.93
A1M5	7.6	9	7.8	24.40	8.13
A1M6	7.4	6	8	21.40	7.13
A1M7	7.6	9.4	7.8	24.80	8.27
A1M8	10.8	9.6	8.8	29.20	9.73
A1M9	9.6	10.2	8.8	28.60	9.53
A1M10	4.8	7	5	16.80	5.60
A2M1	11.6	11.2	12.4	35.20	11.73
A2M2	8.6	10	12	30.60	10.20
A2M3	12.2	11	11.6	34.80	11.60
A2M4	11.4	9.4	9.4	30.20	10.07
A2M5	11	8.2	10.8	30.00	10.00
A2M6	11.2	8.8	9.8	29.80	9.93
A2M7	11	10.8	11.2	33.00	11.00
A2M8	11.6	12.2	12.4	36.20	12.07
A2M9	12.6	11.2	12	35.80	11.93
A2M10	9	9.4	9.8	28.20	9.40

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -20			Numbers of leaves at 30 DAP		2 year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	9.8	9	10	28.8	9.60
A1M2	7	5.4	5.8	18.2	6.07
A1M3	8	9.4	9.8	27.2	9.07
A1M4	7.6	6.8	8.4	22.8	7.60
A1M5	8.6	9	7.6	25.2	8.40
A1M6	7.6	8	6	21.6	7.20
A1M7	8	8	9	25	8.33
A1M8	9.2	10.6	10.4	30.2	10.07
A1M9	9.8	10.8	8.8	29.4	9.80
A1M10	5.8	4	5.4	15.2	5.07
A2M1	12	10.6	10.2	32.8	10.93
A2M2	9.4	10.4	10	29.8	9.93
A2M3	10.2	10.8	9.8	30.8	10.27
A2M4	9.8	10.8	9	29.6	9.87
A2M5	10	9.4	10	29.4	9.80
A2M6	8	9.8	10	27.8	9.27
A2M7	11	9.4	10.6	31	10.33
A2M8	11.4	11	13	35.4	11.80
A2M9	11.2	10.2	12.8	34.2	11.40
A2M10	8.6	9.6	9.2	27.4	9.13

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -21		Numbers of leaves at 60 DAP			1year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	17.80	18.00	19.00	54.80	18.27
A1M2	14.75	14.60	14.40	43.75	14.58
A1M3	16.35	17.60	16.20	50.15	16.72
A1M4	17.80	18.60	18.00	54.40	18.13
A1M5	19.80	17.80	19.00	56.60	18.87
A1M6	14.40	14.80	9.20	38.40	12.80
A1M7	19.00	16.80	19.60	55.40	18.47
A1M8	21.40	22.60	23.00	67.00	22.33
A1M9	21.60	22.60	20.80	65.00	21.67
A1M10	9.20	9.60	10.40	29.20	9.73
A2M1	19.80	20.11	21.12	61.03	20.34
A2M2	18.92	17.20	18.20	54.32	18.11
A2M3	19.45	19.56	18.40	57.41	19.14
A2M4	18.80	19.00	18.60	56.40	18.80
A2M5	20.20	18.80	18.60	57.60	19.20
A2M6	19.43	18.80	17.99	56.22	18.74
A2M7	21.34	19.40	22.11	62.85	20.95
A2M8	26.20	27.80	25.56	79.56	26.52
A2M9	26.60	25.60	24.11	76.31	25.44
A2M10	15.60	14.60	13.43	43.63	14.54

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -22		Numbers of leaves at 60 DAP			2year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	17.8	18	19.4	55.2	18.40
A1M2	13.77	14.8	14.4	42.97	14.32
A1M3	20.54	18	16.6	55.14	18.38
A1M4	17.8	19.2	18	55	18.33
A1M5	19.8	17.8	19.2	56.8	18.93
A1M6	14.4	15	11.89	41.29	13.76
A1M7	19.2	20.8	19.6	59.6	19.87
A1M8	21.4	22.6	23.2	67.2	22.40
A1M9	21.6	22.8	20.8	65.2	21.73
A1M10	11.11	9.6	10.4	31.11	10.37
A2M1	20	19.56	22.11	61.67	20.56
A2M2	19.56	17.4	18.4	55.36	18.45
A2M3	20.12	21.22	18.4	59.74	19.91
A2M4	18.6	19.2	18.6	56.4	18.80
A2M5	20.2	18.8	20.12	59.12	19.71
A2M6	21.34	19	19.54	59.88	19.96
A2M7	22.23	19.6	21.81	63.64	21.21
A2M8	26.4	20.8	27.8	75	25.00
A2M9	26.8	25.6	21.4	73.8	24.60
A2M10	15.8	14.6	14.2	44.6	14.87

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10 Control(No mulch)

Annexure -23		Numbers of leaves at 90 DAP			1year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	22.6	22.8	25	70.40	23.47
A1M2	20	19.4	19.2	58.60	19.53
A1M3	25.6	22.8	21.2	69.60	23.20
A1M4	22.6	20.2	22.8	65.60	21.87
A1M5	22.8	21.6	23	67.40	22.47
A1M6	19.2	19.6	14	52.80	17.60
A1M7	23.8	23.6	22.2	69.60	23.20
A1M8	26.2	27	27	80.20	26.73
A1M9	26.4	27.4	25.6	79.40	26.47
A1M10	12	13	15.8	40.80	13.60
A2M1	24.6	26	24.2	74.80	24.93
A2M2	21.4	22	23	66.40	22.13
A2M3	22.6	24.6	24	71.20	23.73
A2M4	21.6	23.8	23.4	68.80	22.93
A2M5	25	20.6	23.4	69.00	23.00
A2M6	21.8	23.8	19.8	65.40	21.80
A2M7	23.6	24.4	23	71.00	23.67
A2M8	30	32.6	25.6	88.20	29.40
A2M9	31.4	30.4	26.2	88.00	29.33
A2M10	22.4	19.4	20	61.80	20.60

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -24	Numbers of leaves at 90 DAP				2year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	23.6	22.2	25.4	71.2	23.73
A1M2	20.8	22.8	21	64.6	21.53
A1M3	25.2	23.2	22.4	70.8	23.60
A1M4	22.2	23.8	20.2	66.2	22.07
A1M5	22	23.6	20.2	65.8	21.93
A1M6	20.6	18	14.6	53.2	17.73
A1M7	21.4	20.8	23.2	65.4	21.80
A1M8	25.4	24.6	25.2	75.2	25.07
A1M9	24.8	26.6	22.2	73.6	24.53
A1M10	12.6	11.4	15	39	13.00
A2M1	27.6	24	27.2	78.8	26.27
A2M2	22.2	25	24.6	71.8	23.93
A2M3	25.4	25.2	26.8	77.4	25.80
A2M4	20.4	24.6	24.4	69.4	23.13
A2M5	22.2	25.2	26.2	73.6	24.53
A2M6	22.2	20.2	26	68.4	22.80
A2M7	25.8	27	26	78.8	26.27
A2M8	31.8	32	31	94.8	31.60
A2M9	30	31.8	27.6	89.4	29.80

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -25			Numbers of flowers at 30		1st year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	1	1	1	3.00	1.00
A1M2	1	0.8	1	2.80	0.93
A1M3	1	1	1	3.00	1.00
A1M4	0.6	1	0.6	2.20	0.73
A1M5	1	1	1	3.00	1.00
A1M6	0.8	0.6	0.6	2.00	0.67
A1M7	1	1	1	3.00	1.00
A1M8	1	1	1	3.00	1.00
A1M9	1	1	1	3.00	1.00
A1M10	0.6	0.6	0.6	1.80	0.60
A2M1	1.2	1	1	3.20	1.07
A2M2	1	1	1	3.00	1.00
A2M3	1.2	1.2	1	3.40	1.13
A2M4	1	1	1.2	3.20	1.07
A2M5	1.2	1.2	1.2	3.60	1.20
A2M6	1.2	1	1.4	3.60	1.20
A2M7	1.2	1	1.4	3.60	1.20
A2M8	1.4	1.4	1.2	4.00	1.33
A2M9	1.2	1.4	1.2	3.80	1.27
A2M10	1	1	0.8	2.80	0.93

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -26		Numbers of flowers at 30 DAP			2 year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	1	1	1	3	1.00
A1M2	1	0.6	0.8	2.4	0.80
A1M3	1	1	1	3	1.00
A1M4	0.6	0.6	0.6	1.8	0.60
A1M5	0.8	0.8	0.8	2.4	0.80
A1M6	0.6	0.6	0.6	1.8	0.60
A1M7	1	1	1	3	1.00
A1M8	1	1	1	3	1.00
A1M9	1	1	1	3	1.00
A1M10	0.4	0.8	0.6	1.8	0.60
A2M1	1.2	1	1.2	3.4	1.13
A2M2	1	1	1	3	1.00
A2M3	1.2	1	1.2	3.4	1.13
A2M4	1	1	1	3	1.00
A2M5	1.2	1	1.2	3.4	1.13
A2M6	**1**	**1**	**1**	3	1.00
A2M7	**1.2**	**1**	**1.2**	3.4	1.13
A2M8	**1.6**	**1.6**	**1.4**	4.6	1.53
A2M9	11.2	10.2	12.8	34.2	11.40
A2M10	8.6	9.6	9.2	27.4	9.13

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -27	Numbers of flowers at 60 DAP				1year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	13.2	13.8	15.2	42.20	14.07
A1M2	10.2	11	11.8	33.00	11.00
A1M3	12.3	14.6	12.8	39.70	13.23
A1M4	11.4	12	10.8	34.20	11.40
A1M5	12.2	14.4	14.6	41.20	13.73
A1M6	7	9.6	12	28.60	9.53
A1M7	13.4	14	13.2	40.60	13.53
A1M8	17.4	17.6	18.9	53.90	17.97
A1M9	17	18.6	16	51.60	17.20
A1M10	6.4	8.4	10	24.80	8.27
A2M1	14	15	15.2	44.20	14.73
A2M2	11	12.2	12.4	35.60	11.87
A2M3	13.4	14	15	42.40	14.13
A2M4	14.2	13.6	12.4	40.20	13.40
A2M5	15	14.4	13	42.40	14.13
A2M6	13	13.2	11.2	37.40	12.47
A2M7	16	15	12.6	43.60	14.53
A2M8	18.8	19	20	57.80	19.27
A2M9	19	18.2	17.6	54.80	18.27
A2M10	10	12	13.4	35.40	11.80

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -28		Numbers of flowers at 60 DAP			2year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	13.8	13.8	15.2	42.8	14.27
A1M2	10.2	13.4	12.4	36	12.00
A1M3	13	12.6	14	39.6	13.20
A1M4	11.4	11.8	12.8	36	12.00
A1M5	13.2	14.4	14.6	42.2	14.07
A1M6	9	10	11.6	30.6	10.20
A1M7	14.4	14	13.2	41.6	13.87
A1M8	17.6	17.6	19	54.2	18.07
A1M9	17.2	17	19	53.2	17.73
A1M10	9.8	10.4	6.4	26.6	8.87
A2M1	14.2	14.6	15.8	44.6	14.87
A2M2	11	12.6	12.4	36	12.00
A2M3	14	14.4	14.8	43.2	14.40
A2M4	12.2	11.6	12.8	36.6	12.20
A2M5	15	14.4	15	44.4	14.80
A2M6	13.8	13.2	11.2	38.2	12.73
A2M7	15.8	13.4	16.8	46	15.33
A2M8	20	19	19	58	19.33
A2M9	18.4	18.2	19.8	56.4	18.80
A2M10	13.4	13	10	36.4	12.13

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -29	Numbers of flowers at 90 DAP				1year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	21.8	20.4	15	57.20	19.07
A1M2	12.4	13	14	39.40	13.13
A1M3	16.4	17	17	50.40	16.80
A1M4	12	12.6	13.2	37.80	12.60
A1M5	14.6	15.2	13.8	43.60	14.53
A1M6	13.6	13.8	12.2	39.60	13.20
A1M7	15.8	14.2	15.2	45.20	15.07
A1M8	19.2	19.6	20.6	59.40	19.80
A1M9	17.8	19.8	18.6	56.20	18.73
A1M10	9.6	11.8	10.8	32.20	10.73
A2M1	18	17.6	17.8	53.40	17.80
A2M2	15	15.4	15.4	45.80	15.27
A2M3	16.6	17.8	18.6	53.00	17.67
A2M4	16.2	14.8	14.6	45.60	15.20
A2M5	18	16	16.2	50.20	16.73
A2M6	16	13	14.6	43.60	14.53
A2M7	15.4	17.8	16.8	50.00	16.67
A2M8	23	25.2	21.8	70.00	23.33
A2M9	23.6	23.8	21.4	68.80	22.93
A2M10	12	14.4	15.2	41.60	13.87

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -30	Numbers of flowers at 90 DAP				2year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	17.2	20.8	16.6	54.6	18.20
A1M2	13.4	11.2	13.6	38.2	12.73
A1M3	17.2	18.2	16	51.4	17.13
A1M4	16.4	15.2	16.4	48	16.00
A1M5	14.8	16.6	16	47.4	15.80
A1M6	13.6	12.8	11	37.4	12.47
A1M7	16.2	15.4	15.6	47.2	15.73
A1M8	19.2	19.6	19	57.8	19.27
A1M9	19.2	19.2	18.4	56.8	18.93
A1M10	10.2	9.2	8.8	28.2	9.40
A2M1	16.8	19.2	19.4	55.4	18.47
A2M2	16.4	15.6	18	50	16.67
A2M3	15.6	16.8	19	51.4	17.13
A2M4	16.2	17.6	16.6	50.4	16.80
A2M5	17	16.6	16.8	50.4	16.80
A2M6	16.6	15.6	14	46.2	15.40
A2M7	17.6	16	16.2	49.8	16.60
A2M8	24	22.6	22.4	69	23.00
A2M9	23	23.2	20.2	66.4	22.13

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -31		Numbers of fruits at 30 DAP			1st year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	0.6	0.8	0.8	2.20	0.73
A1M2	0.6	0.6	0.4	1.60	0.53
A1M3	0.8	0.6	0.6	2.00	0.67
A1M4	0.4	0.4	0.8	1.60	0.53
A1M5	0.4	0.4	0.8	1.60	0.53
A1M6	0.4	0.4	0.8	1.60	0.53
A1M7	0.8	0.8	0.6	2.20	0.73
A1M8	1	0.8	1	2.80	0.93
A1M9	0.8	0.8	0.8	2.40	0.80
A1M10	0.2	0.4	0.4	1.00	0.33
A2M1	**0.6**	**0.8**	**0.8**	2.20	0.73
A2M2	**0.8**	**0.6**	**0.8**	2.20	0.73
A2M3	**0.8**	**0.6**	**0.8**	2.20	0.73
A2M4	**0.8**	**0.6**	**0.8**	2.20	0.73
A2M5	**0.8**	**0.8**	**1**	2.60	0.87
A2M6	**0.6**	**0.8**	**0.6**	2.00	0.67
A2M7	**0.8**	**0.8**	**0.6**	2.20	0.73
A2M8	**1.2**	**1**	**1**	3.20	1.07
A2M9	**0.8**	**0.8**	**1**	2.60	0.87
A2M10	**0.6**	**0.4**	**0.6**	1.60	0.53

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -32		Numbers of fruits at 30 DAP			2 year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	0.8	0.8	0.6	2.2	0.73
A1M2	0.6	0.6	0.6	1.8	0.60
A1M3	0.8	0.6	0.6	2	0.67
A1M4	0.6	0.6	0.4	1.6	0.53
A1M5	0.8	0.8	0.8	2.4	0.80
A1M6	0.6	0.4	0.6	1.6	0.53
A1M7	0.4	0.8	0.8	2	0.67
A1M8	1	0.8	1	2.8	0.93
A1M9	1	1	0.8	2.8	0.93
A1M10	0.4	0.4	0.6	1.4	0.47
A2M1	0.8	0.6	0.6	2	0.67
A2M2	0.6	0.8	0.4	1.8	0.60
A2M3	0.8	0.8	0.8	2.4	0.80
A2M4	0.6	0.8	0.8	2.2	0.73
A2M5	1	0.8	0.6	2.4	0.80
A2M6	0.6	0.6	0.6	1.8	0.60
A2M7	0.8	1	1	2.8	0.93
A2M8	1	1.2	1.4	3.6	1.20
A2M9	1	1.4	0.8	3.2	1.07
A2M10	0.6	0.6	0.4	1.6	0.53

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -33		Numbers of fruits at 60 DAP			1year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	12.6	12.6	12.4	37.60	12.53
A1M2	9.6	9	8.8	27.40	9.13
A1M3	11.8	14	11	36.80	12.27
A1M4	9.6	9.4	9.8	28.80	9.60
A1M5	10.8	10.6	9.8	31.20	10.40
A1M6	9.6	8	6	23.60	7.87
A1M7	11.8	13.6	11.6	37.00	12.33
A1M8	16.2	15.8	15.6	47.60	15.87
A1M9	14.6	16.2	15.6	46.40	15.47
A1M10	7.8	7	4.4	19.20	6.40
A2M1	13.8	14	13.4	41.20	13.73
A2M2	11.6	11	10.4	33.00	11.00
A2M3	13.6	13	12	38.60	12.87
A2M4	11.6	11.6	12.8	36.00	12.00
A2M5	12.6	13	13.6	39.20	13.07
A2M6	10	11.8	11	32.80	10.93
A2M7	11.2	13	13	37.20	12.40
A2M8	19.2	17.6	17.4	54.20	18.07
A2M9	16.4	17.4	18	51.80	17.27
A2M10	10.8	10.4	8.6	29.80	9.93

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6- Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10- Control(No mulch)

Annexure -34		Numbers of fruits at 60 DAP			2year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	13.2	12.8	13.6	39.6	13.20
A1M2	8.8	10.4	10	29.2	9.73
A1M3	11.8	11.4	12.8	36	12.00
A1M4	9.8	10.2	10.8	30.8	10.27
A1M5	11.8	12.4	12.8	37	12.33
A1M6	6	7.6	8.2	21.8	7.27
A1M7	13.2	13.6	12.8	39.6	13.20
A1M8	17.2	16.8	16.6	50.6	16.87
A1M9	16.8	16	15.6	48.4	16.13
A1M10	7.4	4	7.8	19.2	6.40
A2M1	**13.8**	**13.8**	**14.2**	41.8	13.93
A2M2	**10**	**11.4**	**10**	31.4	10.47
A2M3	**13**	**13.4**	**13.6**	40	13.33
A2M4	**11**	**10.8**	**10**	31.8	10.60
A2M5	**12.8**	**13.4**	**13.6**	39.8	13.27
A2M6	**8.4**	**12**	**11**	31.4	10.47
A2M7	**14**	**12**	**15**	41	13.67
A2M8	**19**	**18.2**	**18**	55.2	18.40
A2M9	**18**	**17.8**	**18.8**	54.6	18.20
A2M10	**10.8**	**10**	**9.2**	30	10.00

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -35		Numbers of fruits at 90 DAP			1year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	18	17	13.4	48.40	16.13
A1M2	11.8	12.6	12	36.40	12.13
A1M3	13	14.6	16.2	43.80	14.60
A1M4	11.6	11.2	12.2	35.00	11.67
A1M5	14.2	14.8	13.4	42.40	14.13
A1M6	11.8	13	11.2	36.00	12.00
A1M7	15.4	13.4	15	43.80	14.60
A1M8	19	18	18	55.00	18.33
A1M9	17.8	18.4	18.4	54.60	18.20
A1M10	7.6	8	9	24.60	8.20
A2M1	**16.8**	**16.2**	**16.6**	49.60	16.53
A2M2	**13**	**14**	**15.2**	42.20	14.07
A2M3	**14.6**	**15.8**	**17**	47.40	15.80
A2M4	**15**	**14**	**14**	43.00	14.33
A2M5	**16.8**	**14.6**	**15.2**	46.60	15.53
A2M6	**15**	**11.8**	**13**	39.80	13.27
A2M7	**13.6**	**16**	**15**	44.60	14.87
A2M8	**20.8**	**22**	**21.4**	64.20	21.40
A2M9	**20.6**	**20.8**	**20.2**	61.60	20.53
A2M10	**11.4**	**13**	**14**	38.40	12.80

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -36	Numbers of fruits at 90 DAP				2year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	16.2	15.4	16	47.6	15.87
A1M2	12.6	11.2	13.2	37	12.33
A1M3	14	17.2	13.8	45	15.00
A1M4	13	14	12.6	39.6	13.20
A1M5	12.6	15.8	16	44.4	14.80
A1M6	12	10.6	10.2	32.8	10.93
A1M7	16	14.4	16	46.4	15.47
A1M8	17.4	16.8	18.4	52.6	17.53
A1M9	17.6	17.2	16.8	51.6	17.20
A1M10	9.2	8.8	8	26	8.67
A2M1	**15.2**	**17.4**	**17.2**	49.8	16.60
A2M2	**14.2**	**14**	**15.6**	43.8	14.60
A2M3	**14.2**	**15**	**17.4**	46.6	15.53
A2M4	**15**	**15.4**	**15.8**	46.2	15.40
A2M5	**15.2**	**16.2**	**14.8**	46.2	15.40
A2M6	**15**	**14.2**	**13.8**	43	14.33
A2M7	**16**	**15.4**	**15.6**	47	15.67
A2M8	**20.4**	**19.2**	**19**	58.6	19.53
A2M9	**19.2**	**20**	**17.4**	56.6	18.87

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -37	Fruit setting percentage at 30	DAP		1year	
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	98.33	95.75	97.85	291.93	97.31
A1M2	96.25	97.25	92.88	286.38	95.46
A1M3	92.95	98.33	96.85	288.13	96.04
A1M4	98.50	97.50	97.95	293.95	97.98
A1M5	97.50	97.50	94.75	289.75	96.58
A1M6	96.85	98.50	91.85	287.20	95.73
A1M7	94.85	98.75	97.45	291.05	97.02
A1M8	95.15	98.75	98.65	292.55	97.52
A1M9	95.35	97.75	98.88	291.98	97.33
A1M10	95.75	97.55	94.45	287.75	95.92
A2M1	94.85	98.75	95.75	289.35	96.45
A2M2	92.45	80.65	92.45	265.55	88.52
A2M3	95.75	98	80.95	274.70	91.57
A2M4	98.75	87.75	90.45	276.95	92.32
A2M5	98.5	85.95	98.8	283.25	94.42
A2M6	98	87.25	97.15	282.40	94.13
A2M7	85.85	98.75	93.65	278.25	92.75
A2M8	97.l99	97.88	98.8	196.68	98.34
A2M9	98.5	98.25	98.76	295.51	98.50
A2M10	90.5	97.5	92.75	280.75	93.58

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -38	Fruit setting percentage at 30 DAP				2 year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	95.45	98.75	96.85	291.05	97.02
A1M2	98.33	95.85	94.78	288.963	96.32
A1M3	96.85	98.33	97.65	292.833	97.61
A1M4	98.65	96.95	98.50	294.1	98.03
A1M5	94.75	99.00	97.95	291.7	97.23
A1M6	95.25	98.50	92.75	286.5	95.50
A1M7	97.50	93.85	98.75	290.1	96.70
A1M8	96.65	98.75	95.25	290.65	96.88
A1M9	95.35	97.65	98.75	291.75	97.25
A1M10	90.55	98.00	95.75	284.3	94.77
A2M1	98.5	95.25	93.85	287.6	95.87
A2M2	75.85	90.45	96.85	263.15	87.72
A2M3	85.75	98.75	95.45	279.95	93.32
A2M4	95.45	98.75	86.85	281.05	93.68
A2M5	94.85	98.75	95.45	289.05	96.35
A2M6	85.89	95.85	95.45	277.19	92.40
A2M7	98.5	87.97	97.33	283.8	94.60
A2M8	95.85	98.22	99	293.07	97.69
A2M9	98.6	95.45	98	292.05	97.35
A2M10	93.86	91.75	95.15	280.76	93.59

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -39	Fruit setting percentage at 60 DAP				1year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	96.85	98.90	96.65	292.40	97.47
A1M2	93.45	98.78	95.33	287.56	95.85
A1M3	98.96	98.96	96.45	294.36	98.12
A1M4	92.75	95.82	92.85	281.42	93.81
A1M5	98.87	98.64	94.71	292.22	97.41
A1M6	92.88	98.80	96.55	288.23	96.08
A1M7	98.86	98.97	94.76	292.59	97.53
A1M8	98.93	98.89	98.79	296.60	98.87
A1M9	98.84	98.85	98.97	296.66	98.89
A1M10	94.22	95.45	92.88	282.55	94.18
A2M1	98.98	97.22	93.78	289.99	96.66
A2M2	93.22	97.33	96.51	287.06	95.69
A2M3	96.22	96.41	93.43	286.06	95.35
A2M4	95.22	97.66	97.55	290.43	96.81
A2M5	97.22	98.89	94.67	290.78	96.93
A2M6	93.77	96.78	93.78	284.33	94.78
A2M7	96.44	97.88	93.89	288.21	96.07
A2M8	95.55	98.92	97.33	291.80	97.27
A2M9	96.65	97.34	98.56	292.55	97.52
A2M10	92.45	90.66	88.34	271.45	90.48

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -40	Fruit setting percentage at 60 DAP				2year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	97.89	98.92	96.54	293.352	97.78
A1M2	94.45	98.71	96.95	290.112	96.70
A1M3	98.90	98.89	93.98	291.773	97.26
A1M4	94.76	88.95	94.78	278.49	92.83
A1M5	96.22	98.84	97.65	292.709	97.57
A1M6	95.34	98.68	97.21	291.234	97.08
A1M7	97.66	98.97	96.45	293.081	97.69
A1M8	98.98	97.76	98.86	295.592	98.53
A1M9	98.98	97.82	98.78	295.578	98.53
A1M10	95.80	94.45	93.64	283.89	94.63
A2M1	93.88	98.94	96.77	289.592	96.53
A2M2	94.32	92.11	94.86	281.29	93.76
A2M3	96.99	91.77	97.22	285.98	95.33
A2M4	92.89	96.45	92.56	281.9	93.97
A2M5	97.55	94.67	95.95	288.17	96.06
A2M6	96.44	94.88	97.88	289.2	96.40
A2M7	96.88	96.55	95.33	288.76	96.25
A2M8	97.88	96.11	98.94	292.934	97.64
A2M9	98.41	98.97753	96.44	293.828	97.94
A2M10	90.55	89.75	93.56	273.86	91.29

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -41	Fruit setting percentage at 90 DAP				1year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	98.79	96.85	97.85	293.49	97.83
A1M2	94.56	93.74	97.56	285.86	95.29
A1M3	93.88	98.84	97.79	290.51	96.84
A1M4	95.23	96.22	92.87	284.32	94.77
A1M5	98.97	98.97	98.97	296.91	98.97
A1M6	97.56	98.94	94.22	290.72	96.91
A1M7	97.62	98.94	96.99	293.55	97.85
A1M8	98.99	98.91	98.86	296.76	98.92
A1M9	99.00	98.92	98.99	296.91	98.97
A1M10	92.21	95.34	93.95	281.50	93.83
A2M1	92.66	94.65	98.44	285.75	95.25
A2M2	96.88	93.77	97.56	288.21	96.07
A2M3	96.44	97.89	94.78	289.11	96.37
A2M4	96.45	96.87	97.45	290.77	96.92
A2M5	92.11	95.87	97.88	285.86	95.29
A2M6	94.32	98.89	94.56	287.78	95.93
A2M7	97.89	96.89	98.88	293.66	97.89
A2M8	96.89	97.45	98.45	292.79	97.60
A2M9	93.67	98.85	95.78	288.31	96.10
A2M10	93.73	94.88	90.11	278.72	92.91

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -42		Fruit setting percentage at 90 DAP			2year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	98.94	97.87	98.56	295.368	98.46
A1M2	96.67	94.52	97.88	289.07	96.36
A1M3	95.78	98.94	97.33	292.052	97.35
A1M4	95.34	96.98	91.44	283.76	94.59
A1M5	98.83	98.95	99.00	296.775	98.92
A1M6	95.62	98.79	97.51	291.922	97.31
A1M7	96.88	98.93	97.72	293.531	97.84
A1M8	98.90	98.83	98.97	296.697	98.90
A1M9	98.91	98.88	98.90	296.698	98.90
A1M10	93.21	94.73	91.44	279.38	93.13
A2M1	95.33	97.44	96.45	289.22	96.41
A2M2	97.56	95.78	93.22	286.56	95.52
A2M3	97.56	93.67	98.908046	290.138	96.71
A2M4	93.76	93.55	95.96	283.27	94.42
A2M5	98.66	97.66	96.56	292.88	97.63
A2M6	94.33	98.90141	97.45	290.681	96.89
A2M7	96.99	98.96104	97.41	293.361	97.79
A2M8	96.56	97.45	98.41	292.42	97.47
A2M9	95.67	98.84	97.19	291.7	97.23

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -43	Total numbers of flowers			1year	
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	38.92	35.2	36.95	111.07	37.02
A1M2	29.74	27.85	28.95	86.54	28.85
A1M3	34.86	32.6	35.95	103.41	34.47
A1M4	29.44	28.95	29.52	87.91	29.30
A1M5	34.74	32.74	33.86	101.34	33.78
A1M6	27.85	28.95	27.95	84.75	28.25
A1M7	38.92	33.22	38.93	111.07	37.02
A1M8	42.81	42.68	42.76	128.25	42.75
A1M9	42.62	39.4	42.96	124.98	41.66
A1M10	27.95	22.85	23.86	74.66	24.89
A2M1	33.2	33.6	32.45	99.25	33.08
A2M2	27	28.6	22.87	78.47	26.16
A2M3	31.2	32.62	28.95	92.77	30.92
A2M4	27.82	26.95	27.82	82.59	27.53
A2M5	29.85	31.6	30.4	91.85	30.62
A2M6	25.22	24.85	27.2	77.27	25.76
A2M7	33.94	30.11	30.8	94.85	31.62
A2M8	40.05	39.95	37.95	117.95	39.32
A2M9	39.21	39.84	40.2	119.25	39.75

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure - 44		Total numbers of flowers		2year	
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	36.33	35.6	36.92	108.85	36.28
A1M2	28.95	27.92	28.56	85.43	28.48
A1M3	33.21	31.8	34.63	99.64	33.21
A1M4	28.4	30.04	29.8	88.24	29.41
A1M5	34.81	33.85	31.4	100.06	33.35
A1M6	27.95	28.95	26.65	83.55	27.85
A1M7	31.6	32.52	35.32	99.44	33.15
A1M8	45.22	43.45	39.85	128.52	42.84
A1M9	43.86	42.93	38.4	125.19	41.73
A1M10	25.89	24.05	25.67	75.61	25.20
A2M1	32.2	34.8	33.76	100.76	33.59
A2M2	28.4	25.85	23.45	77.7	25.90
A2M3	30.8	32.2	28.95	91.95	30.65
A2M4	29.4	25.85	26.84	82.09	27.36
A2M5	31.75	32	29.95	93.7	31.23
A2M6	24.41	27.85	26.2	78.46	26.15
A2M7	31.05	30.4	29.85	91.3	30.43
A2M8	37.95	41.05	40.81	119.81	39.94
A2M9	39.15	40.85	38.92	118.92	39.64

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -45	Total numbers of fruits		1year		
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	35.53	33.86	36.25	105.64	35.21
A1M2	28.94	26.95	27.84	83.73	27.91
A1M3	33.85	31.25	35.84	100.94	33.65
A1M4	27.54	26.74	28.75	83.03	27.68
A1M5	34.33	31.84	32.87	99.04	33.01
A1M6	24.75	27.85	27.63	80.23	26.74
A1M7	35.64	31.65	36.87	104.16	34.72
A1M8	42.42	42.11	41.85	126.38	42.13
A1M9	42.14	37.98	42.54	122.66	40.89
A1M10	25.83	19.75	19.95	65.53	21.84
A2M1	31.85	30.52	30.57	92.94	30.98
A2M2	25.55	27.22	21.82	74.59	24.86
A2M3	30.04	29.95	27.42	87.41	29.14
A2M4	25.74	24.85	25.85	76.44	25.48
A2M5	25.84	29.76	28.94	84.54	28.18
A2M6	23.32	22.35	24.95	70.62	23.54
A2M7	29.95	29.65	28.75	88.35	29.45
A2M8	39.86	38.75	36.94	115.55	38.52
A2M9	37.85	37.84	37.95	113.64	37.88

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -46	Total numbers of fruits			2year	
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	33.86	34.89	36.84	105.59	35.20
A1M2	27.54	25.98	27.82	81.34	27.11
A1M3	30.85	31.21	31.85	93.91	31.30
A1M4	25.89	29.11	27.85	82.85	27.62
A1M5	33.35	31.55	30.45	95.35	31.78
A1M6	25.78	26.55	25.57	77.9	25.97
A1M7	28.95	31.65	33.86	94.46	31.49
A1M8	43.89	42.75	38.56	125.2	41.73
A1M9	41.84	42.01	37.95	121.8	40.60
A1M10	24.52	19.86	23.74	68.12	22.71
A2M1	30.86	31.8	32.05	94.71	31.57
A2M2	24.96	23.63	22.03	70.62	23.54
A2M3	26.95	31.95	28.05	86.95	28.98
A2M4	25.86	24.85	23.84	74.55	24.85
A2M5	29.95	31.38	28.42	89.75	29.92
A2M6	23.06	25.85	23.81	72.72	24.24
A2M7	28.99	29.63	25.04	83.66	27.89
A2M8	35.85	39.75	39.05	114.65	38.22
A2M9	38.91	38.64	35.84	113.39	37.80

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -47	Total fruit setting percentage			1year	
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	91.29	96.19	98.11	285.59	95.20
A1M2	97.31	96.77	96.17	290.24	96.75
A1M3	97.10	95.86	99.69	292.66	97.55
A1M4	93.55	92.37	97.39	283.30	94.43
A1M5	98.82	97.25	97.08	293.15	97.72
A1M6	88.87	96.20	98.86	283.92	94.64
A1M7	91.57	95.27	94.71	281.55	93.85
A1M8	99.09	98.66	97.87	295.63	98.54
A1M9	98.87	96.40	99.02	294.29	98.10
A1M10	92.42	86.43	83.61	262.46	87.49
A2M1	95.93	90.83	94.21	280.97	93.66
A2M2	94.63	95.17	95.41	285.21	95.07
A2M3	96.28	91.81	94.72	282.81	94.27
A2M4	92.52	92.21	92.92	277.65	92.55
A2M5	86.57	94.18	95.20	275.94	91.98
A2M6	92.47	89.94	91.73	274.13	91.38
A2M7	88.24	98.47	93.34	280.06	93.35
A2M8	99.53	97.00	97.34	293.86	97.95
A2M9	96.53	94.98	94.40	285.91	95.30

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -48	Total fruit setting percentage				2year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	93.20	98.01	99.78	290.99	97.00
A1M2	95.13	93.05	97.41	285.59	95.20
A1M3	92.89	98.14	91.97	283.011	94.34
A1M4	91.16	96.90	93.46	281.522	93.84
A1M5	95.81	93.21	96.97	285.986	95.33
A1M6	92.24	91.71	95.95	279.893	93.30
A1M7	91.61	97.32	95.87	284.805	94.94
A1M8	97.06	98.39	96.76	292.211	97.40
A1M9	95.39	97.86	98.83	292.08	97.36
A1M10	94.71	82.58	92.48	269.768	89.92
A2M1	**95.84**	**91.38**	**94.93**	282.153	94.05
A2M2	**87.89**	**91.41**	**93.94**	273.244	91.08
A2M3	**87.50**	**99.22**	**96.89**	283.615	94.54
A2M4	**87.96**	**96.13**	**88.82**	272.913	90.97
A2M5	**94.33**	**98.06**	**94.89**	287.285	95.76
A2M6	**94.47**	**92.82**	**90.88**	278.166	92.72
A2M7	**93.37**	**97.47**	**83.89**	274.719	91.57
A2M8	**94.47**	**96.83**	**95.69**	286.987	95.66
A2M9	**99.39**	**94.59**	**92.09**	286.063	95.35

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -49		Total numbers of weeds		1year	
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	0.80	0.60	0.60	2.00	0.67
A1M2	0.80	0.60	0.80	2.20	0.73
A1M3	0.80	0.60	0.40	1.80	0.60
A1M4	0.80	1.00	0.60	2.40	0.80
A1M5	0.60	0.80	0.60	2.00	0.67
A1M6	1.00	0.80	1.00	2.80	0.93
A1M7	0.60	0.80	0.80	2.20	0.73
A1M8	0.20	0.40	0.00	0.60	0.20
A1M9	0.00	0.20	0.20	0.40	0.13
A1M10	4.00	6.00	7.00	17.00	5.67
A2M1	0.8	0.8	0.6	2.20	0.73
A2M2	1	0.4	0.4	1.80	0.60
A2M3	0.8	0.4	0.6	1.80	0.60
A2M4	1	1	0.4	2.40	0.80
A2M5	0.8	1	0.8	2.60	0.87
A2M6	1.2	1	1	3.20	1.07
A2M7	0.6	0.6	0.6	1.80	0.60
A2M8	0.2	0	0	0.20	0.07
A2M9	0	0.2	0	0.20	0.07

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -50		Total numbers of weeds			2year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	0.80	0.60	0.60	2	0.67
A1M2	0.60	1.00	0.80	2.4	0.80
A1M3	0.80	1.00	0.80	2.6	0.87
A1M4	1.00	0.80	0.60	2.4	0.80
A1M5	0.80	0.80	1.00	2.6	0.87
A1M6	1.20	0.60	1.80	3.6	1.20
A1M7	0.80	0.40	0.60	1.8	0.60
A1M8	0.20	0.00	0.20	0.4	0.13
A1M9	0.20	0.00	0.20	0.4	0.13
A1M10	6.00	5.60	3.60	15.2	5.07
A2M1	0.8	0.8	0.4	2	0.67
A2M2	1	1	0.8	2.8	0.93
A2M3	0.8	0.6	0.4	1.8	0.60
A2M4	0.4	0.8	0.4	1.6	0.53
A2M5	0.6	0.8	0.8	2.2	0.73
A2M6	1.6	0.8	1	3.4	1.13
A2M7	1	0.6	0.8	2.4	0.80
A2M8	0.2	0	0.2	0.4	0.13
A2M9	0.2	0	0.2	0.4	0.13

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6- Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10- Control(No mulch)

Annexure -51		Number of weeds at 60 DAP			1year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	1.85	1.60	1.40	4.85	1.62
A1M2	1.60	2.25	2.20	6.05	2.02
A1M3	1.20	1.45	1.40	4.05	1.35
A1M4	2.80	2.40	2.95	8.15	2.72
A1M5	1.95	1.80	1.40	5.15	1.72
A1M6	2.35	2.15	2.40	6.90	2.30
A1M7	1.80	1.80	1.80	5.40	1.80
A1M8	0.85	0.60	1.24	2.69	0.90
A1M9	1.22	0.60	0.75	2.57	0.86
A1M10	12.75	15.35	14.22	42.32	14.11
A2M1	1.35	1.4	1.75	4.50	1.50
A2M2	2.55	1.8	2	6.35	2.12
A2M3	1	1.75	1.05	3.80	1.27
A2M4	1.8	1.4	1.64	4.84	1.61
A2M5	1.4	1.4	1.55	4.35	1.45
A2M6	1.85	1.4	1.45	4.70	1.57
A2M7	1.8	1.11	1.6	4.51	1.50
A2M8	0.6	0.8	0.95	2.35	0.78
A2M9	0.8	0.8	0.6	2.20	0.73
A2M10	11.35	14.45	11.49	37.29	12.43

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -52	Number of weeds at 60 DAP				2year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	1.45	1.95	1.22	4.62	1.54
A1M2	1.90	2.15	1.80	5.85	1.95
A1M3	1.55	1.40	1.30	4.25	1.42
A1M4	2.65	2.55	2.60	7.8	2.60
A1M5	2.00	1.40	1.85	5.25	1.75
A1M6	2.40	2.45	2.35	7.2	2.40
A1M7	1.95	1.70	2.00	5.65	1.88
A1M8	1.25	0.65	0.65	2.55	0.85
A1M9	1.25	0.85	0.55	2.65	0.88
A1M10	14.25	13.52	12.35	40.12	13.37
A2M1	1.65	2	1.35	5	1.67
A2M2	2.75	2.45	1.45	6.65	2.22
A2M3	1.55	1.25	0.95	3.75	1.25
A2M4	1.8	1.2	1.59	4.59	1.53
A2M5	1.75	1.45	1.25	4.45	1.48
A2M6	1.62	2	1.2	4.82	1.61
A2M7	1.25	1.35	1.55	4.15	1.38
A2M8	0.8	0.6	0.8	2.2	0.73
A2M9	0.6	0.75	0.75	2.1	0.70
A2M10	11.45	14.22	11.85	37.52	12.51

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -53	Number of weeds at 90 DAP				1year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	3.22	3.40	3.20	9.82	3.27
A1M2	3.60	3.65	4.10	11.35	3.78
A1M3	3.20	3.24	2.85	9.29	3.10
A1M4	4.75	6.52	7.20	18.47	6.16
A1M5	3.45	2.75	3.00	9.20	3.07
A1M6	4.60	4.60	3.25	12.45	4.15
A1M7	3.00	4.00	3.23	10.23	3.41
A1M8	0.60	0.80	0.40	1.80	0.60
A1M9	0.80	1.00	0.60	2.40	0.80
A1M10	21.55	22.80	22.75	67.10	22.37
A2M1	2.86	3.12	2.85	8.83	2.94
A2M2	3.35	2.6	3.15	9.10	3.03
A2M3	3.2	2.85	2.75	8.80	2.93
A2M4	3.79	6.6	5.21	15.60	5.20
A2M5	2.4	2.86	3.11	8.37	2.79
A2M6	3.65	3.2	3	9.85	3.28
A2M7	3.25	2.45	2.75	8.45	2.82
A2M8	0.4	0.6	0.4	1.40	0.47
A2M9	0.4	0.5	0.6	1.50	0.50
A2M10	10.4	13.85	12.82	37.07	12.36

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -54	Number of weeds at 90 DAP				2year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	3.15	3.15	3.20	9.5	3.17
A1M2	3.95	4.15	4.25	12.35	4.12
A1M3	3.55	2.80	3.30	9.65	3.22
A1M4	4.75	6.20	4.95	15.9	5.30
A1M5	3.22	2.80	3.00	9.02	3.01
A1M6	4.70	4.35	3.80	12.85	4.28
A1M7	3.60	3.40	3.55	10.55	3.52
A1M8	0.80	0.80	0.60	2.2	0.73
A1M9	0.65	0.80	0.95	2.4	0.80
A1M10	23.45	22.70	22.85	69	23.00
A2M1	2.85	3.22	2.6	8.67	2.89
A2M2	3.11	3.25	2.95	9.31	3.10
A2M3	3.55	2.72	2.79	9.06	3.02
A2M4	5.32	4.86	3.76	13.94	4.65
A2M5	3.65	2.95	3.22	9.82	3.27
A2M6	3.22	3.21	3.65	10.08	3.36
A2M7	2.8	2.8	3.35	8.95	2.98
A2M8	0.8	0.5	0.39	1.69	0.56
A2M9	0.6	0.65	0.45	1.7	0.57

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -55	Total number of runners		1year		
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	5.25	4.00	4.20	13.45	4.48
A1M2	4.19	3.55	3.20	10.94	3.65
A1M3	4.20	4.25	4.85	13.30	4.43
A1M4	3.60	3.85	4.55	12.00	4.00
A1M5	3.60	5.89	5.75	15.24	5.08
A1M6	3.65	3.20	4.25	11.10	3.70
A1M7	3.75	4.85	4.40	13.00	4.33
A1M8	6.21	6.85	5.60	18.66	6.22
A1M9	5.75	6.85	5.95	18.55	6.18
A1M10	2.80	3.35	3.85	10.00	3.33
A2M1	4.8	3.7	4.2	12.70	4.23
A2M2	2.75	3.6	2.75	9.10	3.03
A2M3	3.11	3.85	4.45	11.41	3.80
A2M4	2.85	3.85	4	10.70	3.57
A2M5	4.6	4.22	4.6	13.42	4.47
A2M6	3.4	3.55	3.6	10.55	3.52
A2M7	3.85	3.79	4.4	12.04	4.01
A2M8	5.55	4.75	6.2	16.50	5.50
A2M9	6	5.8	4.79	16.59	5.53

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -56	Total number of fruits			2year	
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	4.80	4.79	5.12	14.71	4.90
A1M2	4.75	3.45	3.40	11.6	3.87
A1M3	4.25	4.25	4.21	12.71	4.24
A1M4	3.89	3.75	3.60	11.24	3.75
A1M5	4.79	4.56	5.66	15.01	5.00
A1M6	3.20	3.65	4.21	11.06	3.69
A1M7	3.85	4.85	4.00	12.7	4.23
A1M8	6.85	6.22	6.20	19.27	6.42
A1M9	5.75	6.85	6.45	19.05	6.35
A1M10	2.80	3.74	3.78	10.32	3.44
A2M1	3.89	3.8	4.75	12.44	4.15
A2M2	2.85	2.45	3.85	9.15	3.05
A2M3	4.11	3.75	4.02	11.88	3.96
A2M4	3	3.65	3.2	9.85	3.28
A2M5	3.85	4.4	4.8	13.05	4.35
A2M6	3.59	3.2	3.4	10.19	3.40
A2M7	3.2	3.4	4.4	11	3.67
A2M8	5.22	6	4.89	16.11	5.37
A2M9	6.6	5.86	5.6	18.06	6.02

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -57		Fruit length		1year	
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	3.91	3.48	3.63	11.02	3.67
A1M2	3.04	3.35	2.43	8.82	2.94
A1M3	3.43	3.39	3.71	10.53	3.51
A1M4	3.34	2.8	3.32	9.46	3.15
A1M5	3.21	3.41	3.57	10.19	3.40
A1M6	3.03	3.02	2.45	8.50	2.83
A1M7	3.25	3.65	3.83	10.73	3.58
A1M8	3.89	3.55	4.13	11.57	3.86
A1M9	3.56	3.83	3.93	11.32	3.77
A1M10	2.37	2.26	3.04	7.67	2.56
A2M1	3.72	3.96	4	11.68	3.89
A2M2	3.68	3.81	3.42	10.91	3.64
A2M3	3.96	3.58	3.9	11.44	3.81
A2M4	3.42	3.78	3.9	11.10	3.70
A2M5	3.92	4.11	3.3	11.33	3.78
A2M6	3.57	3.93	3.14	10.64	3.55
A2M7	3.97	4	3.63	11.60	3.87
A2M8	4.29	4.05	4.11	12.45	4.15
A2M9	4.15	3.79	4.12	12.06	4.02

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -58	fruit length		2year		
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	3.97	3.71	3.49	11.17	3.72
A1M2	3.3	3.5	2.45	9.25	3.08
A1M3	3.23	3.83	3.63	10.69	3.56
A1M4	3.4	2.88	3.36	9.64	3.21
A1M5	3.56	3.28	3.88	10.72	3.57
A1M6	2.59	3.047	3.052	8.689	2.90
A1M7	3.79	3.56	3.19	10.54	3.51
A1M8	4.27	3.81	3.63	11.71	3.90
A1M9	3.93	3.75	3.83	11.51	3.84
A1M10	2.93	2.38	2.72	8.03	2.68
A2M1	3.93	3.79	4.18	11.9	3.97
A2M2	3.85	3.27	3.58	10.7	3.57
A2M3	3.88	3.64	3.8	11.32	3.77
A2M4	3.47	3.76	3.28	10.51	3.50
A2M5	3.56	3.64	3.87	11.07	3.69
A2M6	2.86	3.49	3.6	9.95	3.32
A2M7	3.66	4	3.86	11.52	3.84
A2M8	4.08	4.22	4.42	12.72	4.24
A2M9	4	3.82	4.35	12.17	4.06

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -59	Fruit breadth	1year			
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	3.35	3.26	3.24	9.85	3.28
A1M2	2.71	3.04	2.5	8.25	2.75
A1M3	2.97	3.15	3.05	9.17	3.06
A1M4	2.89	2.37	2.89	8.15	2.72
A1M5	2.79	3.00	3.09	8.88	2.96
A1M6	2.3	2.39	2.99	7.68	2.56
A1M7	3.09	3.18	3.06	9.33	3.11
A1M8	3.2	3.62	3.48	10.30	3.43
A1M9	3.59	3.41	3.06	10.06	3.35
A1M10	2.74	2.21	2.3	7.25	2.42
A2M1	3.53	3.2	3.71	10.44	3.48
A2M2	2.78	3.02	3.15	8.95	2.98
A2M3	3.4	3.05	3.51	9.96	3.32
A2M4	2.7	3.23	3.18	9.11	3.04
A2M5	3.06	3.18	3.38	9.62	3.21
A2M6	2.62	3.03	3.1	8.75	2.92
A2M7	3.25	3.04	3.26	9.55	3.18
A2M8	3.58	4.08	3.96	11.62	3.87
A2M9	3.71	3.25	4.09	11.05	3.68

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6- Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10- Control(No mulch)

Annexure -60	fruit length		2year		
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	3.35	3.26	3.24	9.85	3.28
A1M2	2.71	3.04	2.5	8.25	2.75
A1M3	2.97	3.15	3.05	9.17	3.06
A1M4	2.89	2.37	2.89	8.15	2.72
A1M5	2.79	3	3.09	8.88	2.96
A1M6	2.3	2.39	2.99	7.68	2.56
A1M7	3.09	3.18	3.06	9.33	3.11
A1M8	3.2	3.62	3.48	10.30	3.43
A1M9	3.59	3.41	3.06	10.06	3.35
A1M10	2.74	2.21	2.3	7.25	2.42
A2M1	3.53	3.2	3.71	10.44	3.48
A2M2	2.78	3.02	3.15	8.95	2.98
A2M3	3.4	3.05	3.51	9.96	3.32
A2M4	2.7	3.23	3.18	9.11	3.04
A2M5	3.06	3.18	3.38	9.62	3.21
A2M6	2.62	3.03	3.1	8.75	2.92
A2M7	3.25	3.04	3.26	9.55	3.18
A2M8	3.58	4.08	3.96	11.62	3.87
A2M9	3.71	3.25	4.09	11.05	3.68

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -61		Fruit weight	1year		
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	16.45	13.73	17.45	47.63	15.88
A1M2	13.1	15.85	13.45	42.40	14.13
A1M3	16.67	16	14.96	47.63	15.88
A1M4	12.35	13.45	12.85	38.65	12.88
A1M5	16.53	13.9	15.95	46.38	15.46
A1M6	14.11	12.22	13.94	40.27	13.42
A1M7	13.45	14.92	15.84	44.21	14.74
A1M8	15.96	17	17.08	50.04	16.68
A1M9	15.33	15.865	17.36	48.56	16.19
A1M10	10.28	12.24	11.18	33.70	11.23
A2M1	16.33	19.12	18.76	54.22	18.07
A2M2	16.26	14.96	15.4	46.62	15.54
A2M3	17.08	18.8	16.62	52.50	17.50
A2M4	16.44	15.86	14.18	46.48	15.49
A2M5	15.96	16.26	16.8	49.02	16.34
A2M6	14.184	16.86	13.02	44.06	14.69
A2M7	17.22	16.54	18.02	51.78	17.26
A2M8	23.76	20.944	24.22	68.92	22.97
A2M9	23.899	20.86	23.912	68.67	22.89

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -62			Fruit length		2year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	16.45	13.73	17.45	47.63	15.88
A1M2	13.1	15.85	13.45	42.4	14.13
A1M3	16.67	16	14.96	47.63	15.88
A1M4	12.35	13.45	12.85	38.65	12.88
A1M5	16.53	13.9	15.95	46.38	15.46
A1M6	14.41	12.22	13.94	40.57	13.52
A1M7	13.45	14.92	15.84	44.21	14.74
A1M8	15.96	17	17.08	50.04	16.68
A1M9	16.56	15.865	17.36	49.785	16.60
A1M10	10.28	12.24	11.18	33.7	11.23
A2M1	16.52	19.30	18.94	54.7515	18.25
A2M2	16.44	15.14	15.58	47.154	15.72
A2M3	17.26	18.98	16.80	53.034	17.68
A2M4	16.62	16.04	14.36	47.014	15.67
A2M5	16.14	16.44	16.98	49.554	16.52
A2M6	14.36	17.04	13.20	44.598	14.87
A2M7	17.40	16.72	18.20	52.314	17.44
A2M8	24.15	21.12	24.21	69.478	23.16
A2M9	24.08	20.62	24.09	68.785	22.93

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -63	Soil temperature at 30 DAP			1st year	
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	21.1	21.2	22.11	64.41	21.47
A1M2	21.7	20.76	20.54	62.95	20.98
A1M3	20.7	21.3	21.3	63.25	21.08
A1M4	20.3	20.6	21.2	62.10	20.70
A1M5	19.6	21.2	21.3	62.06	20.69
A1M6	20.8	21.5	20.76	63.06	21.02
A1M7	21.5	21.4	20.97	63.87	21.29
A1M8	22.4	21.8	23.25	67.48	22.49
A1M9	22.1	22.1	23.15	67.39	22.46
A1M10	18.85	18.45	19.15	56.45	18.82
A2M1	21.9	21.4	22.54	65.81	21.94
A2M2	21.6	22.87	21.87	66.29	22.10
A2M3	22.3	21.3	20.7	64.32	21.44
A2M4	19.5	20.6	21.89	61.99	20.66
A2M5	22.8	20.2	21.86	64.81	21.60
A2M6	22.0	21.4	22.76	66.14	22.05
A2M7	22.8	21.8	22.43	67.04	22.35
A2M8	24.2	23.77	24.75	72.74	24.25
A2M9	24.0	23.46	23.76	71.17	23.72
A2M10	21.35	21.85	22.85	66.05	22.02

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -64		Soil temperature at 30 DAP			2 year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	21.7	19.9	21.7	63.3	21.10
A1M2	21.1	20.32	21.5	62.92	20.97
A1M3	21.1	20.9	21.4	63.4	21.13
A1M4	21.2	21.3	21.4	63.9	21.30
A1M5	21.9	21.3	20.66	63.83	21.28
A1M6	21.5	21.12	20.65	63.27	21.09
A1M7	21.1	20.88	21.4	63.38	21.13
A1M8	23.3	22.65	22.4	68.36	22.79
A1M9	22.3	23.15	22.4	67.89	22.63
A1M10	18.8	19.05	18.75	56.64	18.88
A2M1	22.9	21.54	21.7	66.1	22.03
A2M2	21.3	20.56	21.96	63.86	21.29
A2M3	20.4	21.8	22.32	64.52	21.51
A2M4	22.9	21.3	21.43	65.59	21.86
A2M5	22.0	20.6	21.4	63.98	21.33
A2M6	22.5	21.3	21.97	65.8	21.93
A2M7	22.0	22.3	21.4	65.65	21.88
A2M8	24.1	22.85	23.25	70.22	23.41
A2M9	23.7	22.87	22.9	69.42	23.14
A2M10	21.6	21.25	22.73	65.53	21.84

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -65	Soil temperature at 60 DAP				1year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	22.32	21.66	21.75	65.73	21.91
A1M2	21.86	22.5	21.85	66.21	22.07
A1M3	22.33	21.85	22.31	66.49	22.16
A1M4	21.95	22.1	22.7	66.75	22.25
A1M5	22.43	21.56	21.68	65.67	21.89
A1M6	21.75	22.72	22.65	67.12	22.37
A1M7	23.1	24.11	22.74	69.95	23.32
A1M8	25.22	23.66	24.87	73.75	24.58
A1M9	23.22	24.75	24.43	72.40	24.13
A1M10	20.85	21.45	21.25	63.55	21.18
A2M1	22.86	21.7	23.85	68.41	22.80
A2M2	22.89	23.53	21.87	68.29	22.76
A2M3	22.75	21.7	23.54	67.99	22.66
A2M4	22.71	21.5	22.75	66.96	22.32
A2M5	22.34	21.6	22.86	66.80	22.27
A2M6	22.83	22.75	23.55	69.13	23.04
A2M7	23.68	22.4	24.22	70.30	23.43
A2M8	26.22	26.45	26.45	79.12	26.37
A2M9	26.44	26.22	25.86	78.52	26.17
A2M10	22.75	22.92	21.55	67.22	22.41

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -66		Soil temperature at 60 DAP			2year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	22.3	22.21	21.45	65.96	21.99
A1M2	21.65	21.75	22.95	66.35	22.12
A1M3	21.95	22.9	21.97	66.82	22.27
A1M4	21.65	22.21	22.31	66.17	22.06
A1M5	22.41	23.3	22.41	68.12	22.71
A1M6	21.95	22.11	21.75	65.81	21.94
A1M7	22.51	23.64	23.4	69.55	23.18
A1M8	24.45	24.4	24.65	73.5	24.50
A1M9	24.65	24.75	24.75	74.15	24.72
A1M10	21.75	22.15	21.25	65.15	21.72
A2M1	21.89	22.5	22.75	67.14	22.38
A2M2	22.55	22.5	22.95	68	22.67
A2M3	21.2	22.6	23.11	66.91	22.30
A2M4	23.28	21.9	22.9	68.08	22.69
A2M5	23.21	22.23	22.1	67.54	22.51
A2M6	22.3	22.5	23.32	68.12	22.71
A2M7	24.41	21.12	22.55	68.08	22.69
A2M8	25.78	26.58	26.53	78.89	26.30
A2M9	25.95	26.86	25.45	78.26	26.09
A2M10	22.65	21.75	22.78	67.18	22.39

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -67		Soil temperature at 90 DAP			1year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	25.1	26.4	26.25	77.75	25.92
A1M2	25.7	25.8	27.5	79.00	26.33
A1M3	25.75	26.2	26	77.95	25.98
A1M4	25.6	25.3	26.67	77.57	25.86
A1M5	26.55	25.5	24.6	76.65	25.55
A1M6	26.75	25.66	25.1	77.51	25.84
A1M7	26.7	24.1	25.6	76.40	25.47
A1M8	27.35	27.59	27.85	82.79	27.60
A1M9	27.95	26.95	27.85	82.75	27.58
A1M10	25.65	24.87	24.25	74.77	24.92
A2M1	27.22	26.54	26.9	80.66	26.89
A2M2	26.76	25.86	26.4	79.02	26.34
A2M3	26.4	26.2	25.4	78.00	26.00
A2M4	26.44	27.32	25.76	79.52	26.51
A2M5	25.75	25.2	26.45	77.40	25.80
A2M6	25.4	27.11	26.39	78.90	26.30
A2M7	26.45	25.4	26.75	78.60	26.20
A2M8	31.34	30.85	31.77	93.96	31.32
A2M9	30.85	32.65	29.2	92.70	30.90
A2M10	26.22	26.95	25.75	78.92	26.31

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure - 68		Soil temperature at 90 DAP			2 year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	26.22	26.2	26.75	79.17	26.39
A1M2	25.75	26.35	26.87	78.97	26.32
A1M3	26.2	25.85	25.6	77.65	25.88
A1M4	25.5	25.7	26.54	77.74	25.91
A1M5	24.9	26.1	25.47	76.47	25.49
A1M6	26.77	26.34	25.7	78.81	26.27
A1M7	24.5	27.3	26.1	77.9	25.97
A1M8	27.85	27.75	28.11	83.71	27.90
A1M9	27.55	27.45	28.22	83.22	27.74
A1M10	24.15	25.75	24.5	74.4	24.80
A2M1	26.1	26.4	26.3	78.8	26.27
A2M2	26.2	26.1	26.7	79	26.33
A2M3	26.7	25.4	26.45	78.55	26.18
A2M4	26.95	25.4	26	78.35	26.12
A2M5	24.5	25.4	26.4	76.3	25.43
A2M6	25.2	25.9	27.22	78.32	26.11
A2M7	25.8	26	27.65	79.45	26.48
A2M8	30.22	30.25	32.22	92.69	30.90
A2M9	30.65	28.5	28.7	87.85	29.28

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -69	Soil moisture content at 30 DAP			1st year	
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	40.44	39.74	41.93	122.11	40.70
A1M2	37.63	41.84	37.99	117.46	39.15
A1M3	38.53	37.22	39.53	115.28	38.43
A1M4	46.44	33.22	34.51	114.17	38.06
A1M5	40.31	39.88	40.36	120.55	40.18
A1M6	30.92	41.44	31.88	104.24	34.75
A1M7	40.41	40.45	36.99	117.85	39.28
A1M8	40.94	48.74	45.92	135.60	45.20
A1M9	44.81	41.99	42.82	129.62	43.21
A1M10	22.42	23.92	24.52	70.86	23.62
A2M1	46.33	55.21	42.85	144.39	48.13
A2M2	39.97	42.58	45.93	128.48	42.83
A2M3	44.27	39.75	42.93	126.95	42.32
A2M4	41.85	35.96	43.85	121.66	40.55
A2M5	46.14	41.85	48.74	136.73	45.58
A2M6	37.89	38.84	40.95	117.68	39.23
A2M7	42.93	39.74	45.74	128.41	42.80
A2M8	46.11	54.84	52.91	153.86	51.29
A2M9	50.73	47.94	49	147.67	49.22
A2M10	24.83	28.04	27.67	80.54	26.85

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -70		Soil moisture content at 30 DAP			2 year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	42.21	38.94	39.53	120.68	40.23
A1M2	41.52	38.42	39.33	119.27	39.76
A1M3	37.35	41.34	36.93	115.62	38.54
A1M4	35.99	40.22	38.63	114.84	38.28
A1M5	41.73	39.35	40.21	121.29	40.43
A1M6	38.92	32.31	32.84	104.07	34.69
A1M7	39.54	35.67	40.42	115.63	38.54
A1M8	46.91	39.94	47.21	134.06	44.69
A1M9	43.94	40.82	44.34	129.1	43.03
A1M10	24.41	25.34	21.91	71.66	23.89
A2M1	52.21	46.74	44.35	143.3	47.77
A2M2	46.89	42.52	44.96	134.37	44.79
A2M3	45.94	43.65	46.33	135.92	45.31
A2M4	42.56	46.85	34.84	124.25	41.42
A2M5	41.75	45.93	47.85	135.53	45.18
A2M6	44.32	39.68	38.41	122.41	40.80
A2M7	45.84	43.78	46.94	136.56	45.52
A2M8	53,94	49.73	52.71	102.44	51.22
A2M9	58.73	47.85	43.21	149.79	49.93
A2M10	28.45	25.95	25.81	80.21	26.74

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -71	Soil moisture content at 60 DAP				1year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	39.46	41.93	38.35	119.74	39.91
A1M2	38.49	37.72	39.74	115.95	38.65
A1M3	36.92	39.47	38.31	114.70	38.23
A1M4	36.82	39.31	37.41	113.54	37.85
A1M5	35.82	37.82	39.11	112.75	37.58
A1M6	34.82	35.35	36.93	107.10	35.70
A1M7	36.92	37.77	40.39	115.08	38.36
A1M8	41.93	48.91	42.84	133.68	44.56
A1M9	39.58	46.11	40.33	126.02	42.01
A1M10	22.84	25.37	24.73	72.94	24.31
A2M1	39.89	42.75	40.55	123.19	41.06
A2M2	37.33	40.56	41.94	119.83	39.94
A2M3	41.94	37.92	42.11	121.97	40.66
A2M4	39.33	37.94	41.49	118.76	39.59
A2M5	44.31	38.57	42.73	125.61	41.87
A2M6	44.24	39.56	35.81	119.61	39.87
A2M7	41.41	38.92	39.48	119.81	39.94
A2M8	49.45	49.85	47.83	147.13	49.04
A2M9	50.73	47.94	42.94	141.61	47.20
A2M10	25.95	25.95	26.74	78.64	26.21

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -72	Soil moisture content at 60 DAP				2year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	41.93	38.63	39.11	119.67	39.89
A1M2	40.21	38.93	39.91	119.05	39.68
A1M3	37.31	39.21	38.55	115.07	38.36
A1M4	38.41	35.42	38.91	112.74	37.58
A1M5	36.31	36.93	39.19	112.43	37.48
A1M6	38.45	39.35	37.94	115.74	38.58
A1M7	34.99	36.85	39.57	111.41	37.14
A1M8	42.91	38.93	40.45	122.29	40.76
A1M9	42.94	41.74	42.23	126.91	42.30
A1M10	24.84	24.21	25.11	74.16	24.72
A2M1	51.53	42.95	39.11	133.59	44.53
A2M2	43.84	35.95	41.85	121.64	40.55
A2M3	38.45	41.64	39.75	119.84	39.95
A2M4	41.45	39.54	38.77	119.76	39.92
A2M5	41.72	44.21	37.84	123.77	41.26
A2M6	42.74	39.45	41.37	123.56	41.19
A2M7	42.24	36.85	39.56	118.65	39.55
A2M8	49.45	44.34	39.74	133.53	44.51
A2M9	51.53	49.85	47.34	148.72	49.57
A2M10	26.31	26.43	28.45	81.19	27.06

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure -73		Soil moisture content at 90 DAP			1year
Treatment	R1	R2	R3	TOTAL	MEAN
A1M1	36.99	35.75	40.33	113.07	37.69
A1M2	34.56	35.42	35.76	105.74	35.25
A1M3	38.31	33.85	38.45	110.61	36.87
A1M4	38.47	36.93	34.75	110.15	36.72
A1M5	35.84	39.65	39.63	115.12	38.37
A1M6	36.94	33.22	34.21	104.37	34.79
A1M7	36.42	35.85	38.48	110.75	36.92
A1M8	40.22	38.75	40.31	119.28	39.76
A1M9	37.85	40.21	39.22	117.28	39.09
A1M10	21.33	19.85	20.55	61.73	20.58
A2M1	38.94	41.22	41.22	121.38	40.46
A2M2	40.53	37.11	36.77	114.41	38.14
A2M3	41.35	41.37	38.45	121.17	40.39
A2M4	33.94	36.78	41.49	112.21	37.40
A2M5	37.45	41.85	42.99	122.29	40.76
A2M6	41.97	36.75	36.45	115.17	38.39
A2M7	37.93	41.58	37.95	117.46	39.15
A2M8	41.55	42.75	41.22	125.52	41.84
A2M9	42.35	42.22	40.34	124.91	41.64
A2M10	25.75	21.67	23.55	70.97	23.66

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

• Annexure 74 soil moisture content at 90 dap 2 year					
Treatment	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	36.78	39.22	40.57	116.57	38.86
A1M2	35.75	34.75	32.75	103.25	34.42
A1M3	37.83	37.71	34.35	109.89	36.63
A1M4	36.73	32.75	38.92	108.4	36.13
A1M5	39.45	40.45	39.11	119.01	39.67
A1M6	35.99	34.85	33.27	104.11	34.70
A1M7	36.35	36.93	37.99	111.27	37.09
A1M8	39.35	38.65	40.35	118.35	39.45
A1M9	38.45	39.75	39.37	117.57	39.19
A1M10	21.43	20.21	19.56	61.2	20.40
A2M1	40.55	41.22	40.45	122.22	40.74
A2M2	38.95	37.99	41.49	118.43	39.48
A2M3	39.45	42.11	37.89	119.45	39.82
A2M4	37.45	36.85	37.48	111.78	37.26
A2M5	41.76	39.45	42.96	124.17	41.39
A2M6	38.55	39.94	40.37	118.86	39.62
A2M7	39.45	39.78	41.94	121.17	40.39
A2M8	39.45	41.84	42.44	123.73	41.24
A2M9	39.65	41.22	40.25	121.12	40.37
A2M10	24.45	21.75	24.65	70.85	23.62

A1- open cultivation, A2- polyhouse cultivation
M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 75	Fruit yield per plant (gm)				1st year
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	385.55	417.39	420.35	1223.29	407.76
A1M2	288.20	351.87	285.14	925.21	308.40
A1M3	504.52	395.67	415.89	1316.08	438.69
A1M4	346.54	282.45	292.98	921.97	307.32
A1M5	419.86	395.53	382.80	1198.19	399.40
A1M6	307.60	278.95	268.54	855.09	285.03
A1M7	432.45	414.78	376.74	1223.97	407.99
A1M8	512.65	488.65	479.67	1480.97	493.66
A1M9	492.11	467.85	507.34	1467.30	489.10
A1M10	178.56	188.50	211.32	578.38	192.79
A2M1	**509.73**	**522.34**	**496.56**	1528.63	509.54
A2M2	**412.34**	**382.98**	**406.56**	1201.88	400.63
A2M3	**495.32**	**477.61**	**495.28**	1468.21	489.40
A2M4	**450.46**	**415.53**	**391.37**	1257.36	419.12
A2M5	**481.99**	**461.78**	**500.64**	1444.42	481.47
A2M6	**363.11**	**411.38**	**320.29**	1094.79	364.93
A2M7	**440.83**	**455.54**	**473.85**	1370.22	456.74
A2M8	**663.56**	**635.98**	**651.82**	1951.36	650.45
A2M9	**655.73**	**634.51**	**585.34**	1875.58	625.19
A2M10	**296.86**	**283.70**	**367.95**	948.50	316.17

- A1- open cultivation, A2- polyhouse cultivation
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 76	Fruit yield per plant (gm)			2year	
YEAR 2	**I**	**II**	**III**	**TOTAL**	**MEAN**
A1M1	415.93	398.17	426.32	1240.42	413.47
A1M2	288.20	325.45	320.11	933.76	311.25
A1M3	443.42	446.43	422.76	1312.61	437.54
A1M4	288.99	333.56	305.83	928.38	309.46
A1M5	416.56	403.10	418.88	1238.54	412.85
A1M6	268.03	285.33	264.86	818.216	272.74
A1M7	398.12	429.70	468.86	1296.68	432.23
A1M8	522.11	489.54	457.56	1469.21	489.74
A1M9	475.34	479.58	457.67	1412.59	470.86
A1M10	174.76	216.23	238.51	629.5	209.83
A2M1	**492.16**	**536.76**	**486.97**	1515.89	505.30
A2M2	**407.66**	**396.62**	**405.03**	1209.31	403.10
A2M3	**483.22**	**479.53**	**534.18**	1496.93	498.98
A2M4	**422.67**	**433.03**	**381.92**	1237.62	412.54
A2M5	**468.00**	**499.72**	**492.36**	1460.08	486.69
A2M6	**344.69**	**456.62**	**335.23**	1136.54	378.85
A2M7	**425.56**	**474.79**	**438.39**	1338.74	446.25
A2M8	**713.32**	**645.44**	**649.42**	2008.18	669.39
A2M9	**645.63**	**635.22**	**653.45**	1934.3	644.77
A2M10	**301.01**	**274.61**	**347.63**	923.249	307.75

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 77	Fruit yield per plot (kg)			1 year	
YEAR 2	**I**	**II**	**III**	**TOTAL**	**MEAN**
A1M1	2.31	2.20	2.32	6.84	2.28
A1M2	1.73	2.11	1.71	5.55	1.85
A1M3	2.83	2.37	2.50	7.70	2.57
A1M4	2.08	1.69	1.76	5.53	1.84
A1M5	2.52	2.37	2.30	7.19	2.40
A1M6	1.85	1.67	1.61	5.13	1.71
A1M7	2.59	2.49	2.26	7.34	2.45
A1M8	3.08	2.93	2.88	8.89	2.96
A1M9	2.95	2.81	3.04	8.80	2.93
A1M10	1.57	1.13	1.27	3.97	1.32
A2M1	3.06	3.13	2.98	9.17	3.06
A2M2	2.47	2.30	2.44	7.21	2.40
A2M3	2.97	2.87	2.97	8.81	2.94
A2M4	2.70	2.49	2.35	7.54	2.51
A2M5	2.89	2.77	3.00	8.67	2.89
A2M6	2.18	2.47	1.92	6.57	2.19
A2M7	2.64	2.73	2.84	8.22	2.74
A2M8	3.98	3.82	3.91	11.71	3.90
A2M9	3.93	3.81	3.51	11.25	3.75
A2M10	1.78	1.70	2.21	5.69	1.90

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure-78	Fruit yield per plot (kg)				2 yr
YEAR 2	**I**	**II**	**III**	**TOTAL**	**MEAN**
A1M1	2.30	2.39	2.26	6.94252	2.31
A1M2	1.73	1.95	1.92	5.60256	1.87
A1M3	2.36	2.48	2.54	7.37567	2.46
A1M4	1.73	2.00	1.83	5.57028	1.86
A1M5	2.20	2.42	2.51	7.13122	2.38
A1M6	1.61	1.71	1.59	4.9093	1.64
A1M7	2.39	2.58	2.21	7.18008	2.39
A1M8	3.13	2.94	2.75	8.81526	2.94
A1M9	2.85	2.88	2.75	8.47554	2.83
A1M10	1.25	1.30	1.43	3.977	1.33
A2M1	**2.95**	**3.22**	**2.92**	9.09535	3.03
A2M2	**2.45**	**2.38**	**2.43**	7.25584	2.42
A2M3	**2.40**	**2.88**	**3.21**	8.48158	2.83
A2M4	**2.24**	**2.60**	**2.29**	7.12571	2.38
A2M5	**2.81**	**3.00**	**2.95**	8.76048	2.92
A2M6	**2.07**	**2.74**	**2.01**	6.81921	2.27
A2M7	**2.55**	**2.85**	**2.63**	8.03245	2.68
A2M8	**4.08**	**3.87**	**3.90**	11.8491	3.95
A2M9	**3.87**	**3.81**	**3.72**	11.4058	3.80
A2M10	**1.81**	**1.65**	**2.09**	5.5395	1.85

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 79	Fruit yield per hectare (ton)				1 yr
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	15.16	13.61	16.30	45.07	15.02
A1M2	12.72	12.62	11.41	36.74	12.25
A1M3	15.00	13.61	16.64	45.25	15.08
A1M4	12.38	12.73	12.26	37.37	12.46
A1M5	15.10	14.34	15.31	44.75	14.92
A1M6	12.30	10.46	10.04	32.80	10.93
A1M7	13.09	16.59	16.03	45.71	15.24
A1M8	18.35	18.94	16.09	53.38	17.79
A1M9	17.43	17.67	18.56	53.66	17.89
A1M10	6.25	6.68	6.17	19.10	6.37
A2M1	15.06	20.37	20.60	56.02	18.67
A2M2	16.52	15.32	16.26	48.10	16.03
A2M3	18.95	20.40	16.34	55.70	18.57
A2M4	16.28	16.62	14.62	47.52	15.84
A2M5	17.59	18.47	17.37	53.43	17.81
A2M6	13.02	16.46	12.81	42.29	14.10
A2M7	17.63	17.12	18.16	52.91	17.64
A2M8	24.34	26.43	23.20	73.97	24.66
A2M9	25.33	26.32	21.11	72.76	24.25
A2M10	9.67	10.69	10.92	31.28	10.43

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 80	Fruit yield per hectare (ton)				2 yr
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	16.88	12.50	16.37	45.744092	15.25
A1M2	12.88	12.19	11.95	37.0278	12.34
A1M3	15.70	15.47	16.28	47.45092	15.82
A1M4	12.87	10.52	11.69	35.08678	11.70
A1M5	14.54	14.09	14.51	43.1389	14.38
A1M6	13.00	10.42	11.45	34.877904	11.63
A1M7	13.69	17.19	15.70	46.580548	15.53
A1M8	17.78	17.19	19.05	54.014724	18.00
A1M9	17.67	17.67	17.53	52.87847	17.63
A1M10	5.90	5.97	6.10	17.97726	5.99
A2M1	16.80	16.85	17.98	51.6367066	17.21
A2M2	16.31	15.86	16.20	48.37224	16.12
A2M3	19.33	14.21	17.17	50.70336	16.90
A2M4	15.69	16.35	15.28	47.3168416	15.77
A2M5	15.50	16.73	17.42	49.653012	16.55
A2M6	13.79	15.24	13.44	42.4618712	14.15
A2M7	16.92	16.86	15.65	49.4350616	16.48
A2M8	21.11	26.75	21.17	69.0293008	23.01
A2M9	20.35	23.70	23.80	67.841724	22.61
A2M10	11.24	10.61	9.20	31.0546088	10.35

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 81	TSS (^{0} Brix)				1st year
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	7.58	7.94	7.75	23.27	7.76
A1M2	7.44	7.36	7.55	22.35	7.45
A1M3	7.59	7.54	7.94	23.07	7.69
A1M4	7.63	7.84	7.84	23.31	7.77
A1M5	7.87	7.87	7.94	23.68	7.89
A1M6	7.19	7.64	7.54	22.37	7.46
A1M7	8.44	7.94	7.64	24.02	8.01
A1M8	8.22	8.32	7.95	24.49	8.16
A1M9	7.88	8.32	8.23	24.43	8.14
A1M10	7.43	7.45	8.04	22.92	7.64
A2M1	8.04	8.12	7.94	24.10	8.03
A2M2	7.59	7.84	7.95	23.38	7.79
A2M3	8.12	7.88	7.84	23.84	7.95
A2M4	7.56	7.99	8.06	23.61	7.87
A2M5	7.87	8.33	7.94	24.14	8.05
A2M6	7.83	8.44	7.94	24.21	8.07
A2M7	8.11	8.11	7.95	24.17	8.06
A2M8	8.19	7.94	8.36	24.49	8.16
A2M9	8.19	8.22	7.95	24.36	8.12
A2M10	7.55	7.55	7.85	22.95	7.65

- A1- open cultivation, A2- polyhouse cultivation
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 82	TSS (^{0} Brix)			2^{nd} year	
YEAR 2	**I**	**II**	**III**	**TOTAL**	**MEAN**
A1M1	8.15	7.89	7.90	23.94	7.98
A1M2	7.50	7.45	7.44	22.39	7.46
A1M3	7.90	7.77	7.85	23.52	7.84
A1M4	7.82	7.98	7.59	23.39	7.80
A1M5	7.92	7.90	8.25	24.07	8.02
A1M6	7.58	7.85	7.68	23.11	7.70
A1M7	7.95	8.25	8.15	24.35	8.12
A1M8	8.32	7.95	8.31	24.58	8.19
A1M9	8.44	7.85	8.15	24.44	8.15
A1M10	7.45	7.55	7.50	22.5	7.50
A2M1	7.92	8.08	8.15	24.15	8.05
A2M2	7.59	7.45	7.87	22.91	7.64
A2M3	8.11	8.15	7.42	23.68	7.89
A2M4	7.83	8.08	7.84	23.75	7.92
A2M5	7.92	8.05	7.99	23.96	7.99
A2M6	7.82	8.05	7.95	23.82	7.94
A2M7	7.85	8.25	8.25	24.35	8.12
A2M8	8.5	8.35	7.85	24.7	8.23
A2M9	8.1	8.23	8.35	24.68	8.23
A2M10	7.35	7.98	7.75	23.08	7.69

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 83	Acidity (%)			1 year	
YEAR 2	**I**	**II**	**III**	**TOTAL**	**MEAN**
A1M1	0.51	0.61	0.57	1.69	0.56
A1M2	0.47	0.51	0.48	1.46	0.49
A1M3	0.64	0.52	0.54	1.70	0.57
A1M4	0.59	0.51	0.54	1.64	0.55
A1M5	0.56	0.54	0.48	1.58	0.53
A1M6	0.48	0.58	0.461	1.52	0.51
A1M7	0.54	0.61	0.54	1.69	0.56
A1M8	0.41	0.45	0.48	1.34	0.45
A1M9	0.45	0.49	0.52	1.46	0.49
A1M10	0.79	0.83	0.81	2.43	0.81
A2M1	0.54	0.55	0.56	1.65	0.55
A2M2	0.45	0.49	0.42	1.36	0.45
A2M3	0.56	0.55	0.54	1.65	0.55
A2M4	0.51	0.48	0.52	1.51	0.50
A2M5	0.47	0.49	0.51	1.47	0.49
A2M6	0.49	0.51	0.50	1.50	0.50
A2M7	0.53	0.56	0.52	1.61	0.54
A2M8	0.41	0.42	0.39	1.22	0.41
A2M9	0.41	0.45	0.47	1.33	0.44
A2M10	0.75	0.74	0.77	2.26	0.75

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure-84	Acidity (%)				2 yr
YEAR 2	**I**	**II**	**III**	**TOTAL**	**MEAN**
A1M1	0.56	0.53	0.55	1.64	0.55
A1M2	0.46	0.49	0.52	1.47	0.49
A1M3	0.52	0.53	0.56	1.61	0.54
A1M4	0.48	0.50	0.49	1.47	0.49
A1M5	0.54	0.49	0.57	1.6	0.53
A1M6	0.49	0.51	0.50	1.5	0.50
A1M7	0.56	0.54	0.54	1.64	0.55
A1M8	0.55	0.45	0.43	1.43	0.48
A1M9	0.52	0.43	0.42	1.37	0.46
A1M10	0.77	0.79	0.75	2.31	0.77
A2M1	0.52	0.56	0.54	1.62	0.54
A2M2	0.47	0.48	0.43	1.38	0.46
A2M3	0.54	0.54	0.50	1.58	0.53
A2M4	0.47	0.48	0.48	1.43	0.48
A2M5	0.49	0.46	0.47	1.42	0.47
A2M6	0.47	0.42	0.45	1.34	0.45
A2M7	0.52	0.48	0.54	1.54	0.51
A2M8	0.41	0.41	0.38	1.2	0.40
A2M9	0.450	0.420	0.410	1.28	0.43
A2M10	0.750	0.750	0.720	2.22	0.74

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 85	Total sugar (%)				1 yr
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	6.15	5.71	5.85	17.71	5.90
A1M2	6.2	5.55	5.73	17.48	5.83
A1M3	6.2	5.78	5.25	17.23	5.74
A1M4	5.43	5.25	5.25	15.93	5.31
A1M5	5.35	5.55	5.15	16.05	5.35
A1M6	5.2	5.65	5.75	16.60	5.53
A1M7	6.45	5.81	5.7	17.96	5.99
A1M8	6.55	6.65	6.85	20.05	6.68
A1M9	6.45	6.85	6.15	19.45	6.48
A1M10	5.45	5.05	5.15	15.65	5.22
A2M1	6.15	5.75	6.15	18.05	6.02
A2M2	6.25	6.05	6.09	18.39	6.13
A2M3	6.41	5.85	6.27	18.53	6.18
A2M4	5.85	5.97	6.15	17.97	5.99
A2M5	6.13	6.35	5.8	18.28	6.09
A2M6	5.71	6.48	5.97	18.16	6.05
A2M7	6.21	5.85	5.98	18.04	6.01
A2M8	6.75	6.85	7.25	20.85	6.95
A2M9	7.14	6.8	6.65	20.59	6.86
A2M10	5.45	5.8	5.35	16.60	5.53

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 86	Total sugar (%)				2 yr
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	6.10	5.82	6.25	18.17	6.06
A1M2	5.72	5.74	5.55	17.01	5.67
A1M3	5.83	5.65	5.95	17.43	5.81
A1M4	5.45	5.57	6.15	17.17	5.72
A1M5	5.85	5.45	6.05	17.35	5.78
A1M6	5.65	5.63	5.75	17.03	5.68
A1M7	5.98	6.08	5.43	17.49	5.83
A1M8	6.45	6.72	6.43	19.6	6.53
A1M9	6.43	6.74	6.75	19.92	6.64
A1M10	5.42	5.33	5.52	16.27	5.42
A2M1	6.57	6.30	6.30	19.17	6.39
A2M2	6.10	6.30	6.04	18.44	6.15
A2M3	7.02	6.31	6.41	19.74	6.58
A2M4	6.30	6.08	5.90	18.28	6.09
A2M5	6.23	6.11	6.09	18.43	6.14
A2M6	6.60	5.87	5.90	18.37	6.12
A2M7	6.41	6.40	6.00	18.81	6.27
A2M8	7.05	7.00	7.11	21.16	7.05
A2M9	7.02	6.87	6.86	20.75	6.92
A2M10	5.24	6.17	5.80	17.21	5.74

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 87	Anthocyanin (mg/100gm)				1st year
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	44.45	45.89	39.59	129.93	43.31
A1M2	40.66	36.88	36.85	114.39	38.13
A1M3	41.86	45.22	38.77	125.85	41.95
A1M4	40.56	36.77	43.72	121.05	40.35
A1M5	45.42	42.77	47.93	136.12	45.37
A1M6	43.87	45.22	45.21	134.30	44.77
A1M7	47.45	45.33	44.76	137.54	45.85
A1M8	46.85	48.21	45.06	140.12	46.71
A1M9	48.42	43.53	47.73	139.68	46.56
A1M10	39.88	36.31	35.53	111.72	37.24
A2M1	47.95	46.31	45.65	139.91	46.64
A2M2	40.35	46.24	38.41	125.00	41.67
A2M3	46.59	47.1	43.92	137.61	45.87
A2M4	44.35	38.03	42.64	125.02	41.67
A2M5	45.76	45.06	48.24	139.06	46.35
A2M6	40.1	43.86	41.37	125.33	41.78
A2M7	46.97	47.73	46.33	141.03	47.01
A2M8	49.96	50.25	48.95	149.16	49.72
A2M9	49.67	46.85	48.94	145.46	48.49
A2M10	37.89	39.76	39.85	117.50	39.17

- A1- open cultivation, A2- polyhouse cultivation
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 88	Anthocyanin (mg/100gm)			2nd year	
YEAR 2	**I**	**II**	**III**	**TOTAL**	**MEAN**
A1M1	44.25	41.7	39.9	125.85	41.95
A1M2	32.4	37.88	38.99	109.27	36.42
A1M3	43.11	42.87	47.21	133.19	44.40
A1M4	40.97	39.33	37.36	117.66	39.22
A1M5	46.76	48.52	44.96	140.24	46.75
A1M6	48.45	44.74	43.89	137.08	45.69
A1M7	42.55	47.31	46.77	136.63	45.54
A1M8	45.74	48.65	46.33	140.72	46.91
A1M9	45.89	46.31	47.88	140.08	46.69
A1M10	39.66	35.62	32.88	108.16	36.05
A2M1	46.89	49.81	45.83	142.53	47.51
A2M2	45.33	44.87	39.95	130.15	43.38
A2M3	49.5	44.71	44.42	138.63	46.21
A2M4	38.6	40.3	41.22	120.12	40.04
A2M5	44.87	46	48.04	138.91	46.30
A2M6	39.7	45.33	41.07	126.1	42.03
A2M7	51.3	47.3	42.6	141.2	47.07
A2M8	51.63	49.59	46.81	148.03	49.34
A2M9	45.93	48.96	49.85	144.74	48.25
A2M10	38.45	33.9	38.78	111.13	37.04

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 89	Ascorbic acid (mg/100gm)			1 year	
YEAR 2	**I**	**II**	**III**	**TOTAL**	**MEAN**
A1M1	48.62	48.95	50.98	148.55	49.52
A1M2	45.89	49.95	47.74	143.58	47.86
A1M3	45.95	49.55	48.75	144.25	48.08
A1M4	52.5	47.92	48.05	148.47	49.49
A1M5	45.79	48.95	46.94	141.68	47.23
A1M6	45.77	46.94	46.88	139.59	46.53
A1M7	48.54	48.12	45.93	142.59	47.53
A1M8	50.04	52.43	53.15	155.62	51.87
A1M9	50.08	48.44	52.21	150.73	50.24
A1M10	47.12	46.74	43.96	137.82	45.94
A2M1	50.11	48.95	48.42	147.48	49.16
A2M2	48.66	50.06	49.64	148.36	49.45
A2M3	48.95	49.73	49.77	148.45	49.48
A2M4	50.11	47.15	49.43	146.69	48.90
A2M5	49.21	47.88	49.58	146.67	48.89
A2M6	48.94	48.12	47.74	144.80	48.27
A2M7	52.85	48.67	51.11	152.63	50.88
A2M8	52.31	54.85	53.91	161.07	53.69
A2M9	53.83	52.85	52.27	158.95	52.98
A2M10	47.96	46.76	46.96	141.68	47.23

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure-90	Ascorbic acid (mg/100gm)				2 yr
YEAR 2	**I**	**II**	**III**	**TOTAL**	**MEAN**
A1M1	46.35	49.95	52.25	148.55	49.52
A1M2	45.86	51.05	47.95	144.86	48.29
A1M3	50.05	46.84	48.11	145	48.33
A1M4	47.92	49.58	51.23	148.73	49.58
A1M5	49.66	45.33	47.42	142.41	47.47
A1M6	44.88	46.21	47.75	138.84	46.28
A1M7	47.32	46.75	49.11	143.18	47.73
A1M8	52.85	48.91	51.96	153.72	51.24
A1M9	53.22	49.02	51.19	153.43	51.14
A1M10	45.21	46.12	48.22	139.55	46.52
A2M1	49.86	51.22	50.04	151.12	50.37
A2M2	48.32	51.12	49.82	149.26	49.75
A2M3	48.95	48.21	49.15	146.31	48.77
A2M4	48.93	48.21	50.21	147.35	49.12
A2M5	50.68	48.22	50.36	149.26	49.75
A2M6	50.66	47.47	48.22	146.35	48.78
A2M7	50.31	47.85	52.85	151.01	50.34
A2M8	51.95	54.54	53.97	160.46	53.49
A2M9	52.01	51.73	52.31	156.05	52.02
A2M10	47.95	48.95	46.55	143.45	47.82

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 91	Soil pH				1 yr
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	5.95	5.95	5.78	17.68	5.89
A1M2	6.21	5.82	5.75	17.78	5.93
A1M3	5.88	5.92	5.65	17.45	5.82
A1M4	5.65	6.15	5.85	17.65	5.88
A1M5	5.85	5.95	5.75	17.55	5.85
A1M6	6.25	5.75	5.85	17.85	5.95
A1M7	6.32	5.85	5.95	18.12	6.04
A1M8	5.95	5.85	5.63	17.43	5.81
A1M9	5.96	5.8	6.21	17.97	5.99
A1M10	5.77	5.66	5.8	17.23	5.74
A2M1	6.1	5.95	5.55	17.60	5.87
A2M2	5.85	5.65	5.94	17.44	5.81
A2M3	5.85	5.9	5.95	17.70	5.90
A2M4	5.65	5.55	5.59	16.79	5.60
A2M5	5.35	5.95	5.75	17.05	5.68
A2M6	5.95	6.34	5.85	18.14	6.05
A2M7	6.25	5.95	6.22	18.42	6.14
A2M8	5.75	5.82	5.63	17.20	5.73
A2M9	5.76	5.55	5.85	17.16	5.72
A2M10	5.75	5.65	6.21	17.61	5.87

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 92	Soil pH				2 yr
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	6.2	5.65	5.62	17.47	5.82
A1M2	5.65	5.85	6.12	17.62	5.87
A1M3	6.3	5.75	5.85	17.9	5.97
A1M4	5.88	5.75	5.6	17.23	5.74
A1M5	5.95	5.75	6.11	17.81	5.94
A1M6	6.3	5.75	5.8	17.85	5.95
A1M7	5.95	5.85	6.11	17.91	5.97
A1M8	5.65	5.65	5.85	17.15	5.72
A1M9	5.75	5.6	5.98	17.33	5.78
A1M10	5.75	5.65	6.22	17.62	5.87
A2M1	5.77	5.91	5.82	17.5	5.83
A2M2	5.8	5.7	6.11	17.61	5.87
A2M3	5.8	5.9	5.75	17.45	5.82
A2M4	5.87	5.95	5.57	17.39	5.80
A2M5	5.95	5.65	5.86	17.46	5.82
A2M6	5.5	6.33	5.66	17.49	5.83
A2M7	5.75	5.8	6.21	17.76	5.92
A2M8	5.66	5.86	5.7	17.22	5.74
A2M9	5.8	5.8	5.9	17.5	5.83
A2M10	5.65	6.21	5.73	17.59	5.86

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 93	Available soil Nitrogen content (kg/ha)				1st year
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	295	280	285	860.00	286.67
A1M2	250	280	250	780.00	260.00
A1M3	280	275	295	850.00	283.33
A1M4	275	265	225	765.00	255.00
A1M5	285	255	180	720.00	240.00
A1M6	240	260	240	740.00	246.67
A1M7	280	275	285	840.00	280.00
A1M8	270	290	220	780.00	260.00
A1M9	250	260	240	750.00	250.00
A1M10	185	220	220	625.00	208.33
A2M1	320	285	290	895.00	298.33
A2M2	275	250	260	785.00	261.67
A2M3	270	250	240	760.00	253.33
A2M4	250	240	270	760.00	253.33
A2M5	260	260	260	780.00	260.00
A2M6	275	230	250	755.00	251.67
A2M7	285	250	285	820.00	273.33
A2M8	250	250	265	765.00	255.00
A2M9	260	270	250	780.00	260.00
A2M10	220	210	220	650.00	216.67

- A1- open cultivation, A2- polyhouse cultivation
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 94	Available soil nitrogen content (kg/ha)				2nd year
YEAR 2	**I**	**II**	**III**	**TOTAL**	**MEAN**
A1M1	310	260	280	850	283.33
A1M2	260	240	250	750	250.00
A1M3	290	260	275	825	275.00
A1M4	250	260	250	760	253.33
A1M5	265	230	215	710	236.67
A1M6	250	240	260	750	250.00
A1M7	290	285	280	855	285.00
A1M8	260	270	180	710	236.67
A1M9	240	260	240	740	246.67
A1M10	220	190	220	630	210.00
A2M1	260	300	280	840	280.00
A2M2	260	255	260	775	258.33
A2M3	250	265	250	765	255.00
A2M4	280	260	240	780	260.00
A2M5	270	270	260	800	266.67
A2M6	280	260	270	810	270.00
A2M7	270	280	260	810	270.00
A2M8	260	255	240	755	251.67
A2M9	280	240	250	770	256.67
A2M10	200	220	240	660	220.00

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 95	Available soil phosphorus content (kg/ha)				1 year
YEAR 2	**I**	**II**	**III**	**TOTAL**	**MEAN**
A1M1	24.25	23.3	21.5	69.05	23.02
A1M2	21.25	21.2	22.5	64.95	21.65
A1M3	23.44	23.7	19.15	66.29	22.10
A1M4	22	19.9	21	62.90	20.97
A1M5	21.5	20.2	18.9	60.60	20.20
A1M6	23.77	22.1	19.5	65.37	21.79
A1M7	23.65	24.75	22.5	70.90	23.63
A1M8	18.7	21.66	20.5	60.86	20.29
A1M9	21.86	20.6	18.5	60.96	20.32
A1M10	19.6	18.6	18.4	56.60	18.87
A2M1	24.75	22.65	23.25	70.65	23.55
A2M2	21.45	21.5	22.85	65.80	21.93
A2M3	22.72	24.15	23.5	70.37	23.46
A2M4	23.15	22.2	21.1	66.45	22.15
A2M5	23.2	21.3	22.4	66.90	22.30
A2M6	21.3	23.1	18.6	63.00	21.00
A2M7	26.98	22.55	23.6	73.13	24.38
A2M8	23.87	19.6	19	62.47	20.82
A2M9	21.85	19.55	22.42	63.82	21.27
A2M10	18.5	18.5	17.2	54.20	18.07

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure-96	Available soil phosphorus content (kg/ha)				2 yr
YEAR 2	**I**	**II**	**III**	**TOTAL**	**MEAN**
A1M1	24.15	23.35	22.75	70.25	23.42
A1M2	22.15	22.1	20.5	64.75	21.58
A1M3	22.66	22.5	21.2	66.36	22.12
A1M4	16.9	21.8	23.7	62.4	20.80
A1M5	21.6	20.5	22.5	64.6	21.53
A1M6	25.98	24.2	21.4	71.58	23.86
A1M7	24.4	23.1	25.21	72.71	24.24
A1M8	18.4	21.45	20.5	60.35	20.12
A1M9	21.75	22.15	20.5	64.4	21.47
A1M10	20.86	19.5	19.7	60.06	20.02
A2M1	23.8	24.95	24.15	72.9	24.30
A2M2	21.5	22.65	21.55	65.7	21.90
A2M3	23.65	21.25	22.2	67.1	22.37
A2M4	23	20.4	22.5	65.9	21.97
A2M5	22.14	24.25	22.1	68.49	22.83
A2M6	20	23	23.5	66.5	22.17
A2M7	27.75	26.2	18.6	72.55	24.18
A2M8	24.53	18.2	18.5	61.23	20.41
A2M9	20.8	20.55	21.78	63.13	21.04
A2M10	19.5	18.5	19.55	57.55	19.18

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 97	Available Soil potassium content (kg/ha)				1 yr
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	273	285	285	843.00	281.00
A1M2	268	270	269	807.00	269.00
A1M3	255	250	279	784.00	261.33
A1M4	248	255	265	768.00	256.00
A1M5	280	260	280	820.00	273.33
A1M6	260	255	235	750.00	250.00
A1M7	295	255	290	840.00	280.00
A1M8	275	270	270	815.00	271.67
A1M9	285	280	250	815.00	271.67
A1M10	225	235	253	713.00	237.67
A2M1	275	270	280	825.00	275.00
A2M2	245	260	275	780.00	260.00
A2M3	270	260	270	800.00	266.67
A2M4	265	260	245	770.00	256.67
A2M5	285	275	285	845.00	281.67
A2M6	240	270	256	766.00	255.33
A2M7	295	270	255	820.00	273.33
A2M8	290	280	265	835.00	278.33
A2M9	265	270	265	800.00	266.67
A2M10	255	250	245	750.00	250.00

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 98	Asvailable Soil potassium content				2 yr
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	280	278	287	845	281.67
A1M2	275	258	239	772	257.33
A1M3	268	270	274	812	270.67
A1M4	275	258	250	783	261.00
A1M5	275	280	285	840	280.00
A1M6	250	255	240	745	248.33
A1M7	275	280	275	830	276.67
A1M8	279	265	270	814	271.33
A1M9	270	255	260	785	261.67
A1M10	235	255	240	730	243.33
A2M1	290	270	270	830	276.67
A2M2	250	275	269	794	264.67
A2M3	280	260	280	820	273.33
A2M4	245	250	270	765	255.00
A2M5	275	280	265	820	273.33
A2M6	240	265	243	748	249.33
A2M7	285	270	270	825	275.00
A2M8	280	250	255	785	261.67
A2M9	264	275	265	804	268.00
A2M10	250	235	230	715	238.33

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 99	Physiological loss in weight within 24 hr. (%)				1st year
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	5.85	5.77	5.77	17.39	5.80
A1M2	6.22	6.02	5.93	18.17	6.06
A1M3	6.01	5.54	6.21	17.76	5.92
A1M4	6.51	5.73	6.21	18.45	6.15
A1M5	5.75	6.04	5.97	17.76	5.92
A1M6	5.97	6.22	6.03	18.22	6.07
A1M7	5.66	6.01	6.11	17.78	5.93
A1M8	5.32	5.79	5.85	16.96	5.65
A1M9	5.52	5.67	5.54	16.73	5.58
A1M10	6.63	6.43	7.21	20.27	6.76
A2M1	6.42	6.75	6.11	19.28	6.43
A2M2	6.23	6.89	6.75	19.87	6.62
A2M3	6.66	6.52	6.11	19.29	6.43
A2M4	6.87	6.25	6.36	19.48	6.49
A2M5	6.84	6.03	6.11	18.98	6.33
A2M6	7.22	6.34	6.77	20.33	6.78
A2M7	6.45	7.11	5.66	19.22	6.41
A2M8	6.52	6.52	6.45	19.49	6.50
A2M9	6.32	6.64	6.75	19.71	6.57
A2M10	6.55	7.35	7.25	21.15	7.05

- A1- open cultivation, A2- polyhouse cultivation
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 100	Physiological loss in weight within 24hr. (%)				2nd year
YEAR 2	**I**	**II**	**III**	**TOTAL**	**MEAN**
A1M1	5.82	6.02	5.75	17.59	5.86
A1M2	6.11	6.22	5.94	18.27	6.09
A1M3	5.87	5.96	6.12	17.95	5.98
A1M4	6.75	5.85	5.74	18.34	6.11
A1M5	5.51	5.53	6.64	17.68	5.89
A1M6	6.03	6.31	5.98	18.32	6.11
A1M7	6.48	5.64	5.62	17.74	5.91
A1M8	5.62	5.22	5.55	16.39	5.46
A1M9	5.55	5.85	5.21	16.61	5.54
A1M10	6.55	6.43	7.23	20.21	6.74
A2M1	6.24	6.45	5.74	18.43	6.14
A2M2	6.25	6.55	6.66	19.46	6.49
A2M3	6.75	6.59	6.27	19.61	6.54
A2M4	6.86	6.38	5.86	19.1	6.37
A2M5	6.16	6.85	6.55	19.56	6.52
A2M6	6.74	6.65	6.75	20.14	6.71
A2M7	6.52	6.21	6.25	18.98	6.33
A2M8	6.53	6.43	6.45	19.41	6.47
A2M9	6.64	6.21	6.55	19.4	6.47
A2M10	6.98	6.97	7.15	21.1	7.03

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 101	Physiological loss in weight within 48hr. (%)				1 year
YEAR 2	**I**	**II**	**III**	**TOTAL**	**MEAN**
A1M1	9.86	9.69	8.75	28.30	9.43
A1M2	8.88	9.95	10.05	28.88	9.63
A1M3	9.79	9.96	8.21	27.96	9.32
A1M4	9.48	9.95	9.98	29.41	9.80
A1M5	8.95	9.74	9.67	28.36	9.45
A1M6	10.01	9.95	9.95	29.91	9.97
A1M7	8.96	9.93	9.95	28.84	9.61
A1M8	9.95	8.92	9.55	28.42	9.47
A1M9	8.95	9.85	9.92	28.72	9.57
A1M10	10.96	10.68	10.79	32.43	10.81
A2M1	9.86	9.89	8.95	28.70	9.57
A2M2	9.76	9.75	10.03	29.54	9.85
A2M3	9.65	9.68	9.87	29.20	9.73
A2M4	10.11	10.11	9.76	29.98	9.99
A2M5	9.78	9.89	10.02	29.69	9.90
A2M6	10.18	9.98	9.98	30.14	10.05
A2M7	9.97	9.89	10.11	29.97	9.99
A2M8	10.34	10.42	10.67	31.43	10.48
A2M9	10.53	10.54	10.51	31.58	10.53
A2M10	11.44	11.46	11.04	33.94	11.31

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure-102	Physiological loss in weight within 72hr. (%)				2 yr
YEAR 2	**I**	**II**	**III**	**TOTAL**	**MEAN**
A1M1	12.82	12.35	12.51	37.68	12.56
A1M2	13.79	13.82	14.73	42.34	14.11
A1M3	13.32	13.46	12.85	39.63	13.21
A1M4	13.89	13.56	12.42	39.87	13.29
A1M5	13.42	12.89	13.95	40.26	13.42
A1M6	14.57	15.11	14.21	43.89	14.63
A1M7	13.68	13.47	14.52	41.67	13.89
A1M8	13.78	13.96	14.31	42.05	14.02
A1M9	13.82	14.32	13.95	42.09	14.03
A1M10	15.45	14.22	14.85	44.52	14.84
A2M1	13.78	13.96	14.11	41.85	13.95
A2M2	14.34	13.99	14.53	42.86	14.29
A2M3	14.46	14.89	14.79	44.14	14.71
A2M4	14.89	14.78	15.11	44.78	14.93
A2M5	14.22	14.84	14.44	43.5	14.50
A2M6	15.33	15.73	14.49	45.55	15.18
A2M7	15.15	14.67	15.39	45.21	15.07
A2M8	15.67	15.83	15.83	47.33	15.78
A2M9	14.89	15.82	15.69	46.4	15.47
A2M10	16.58	15.95	16.84	49.37	16.46

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure-103	Physiological loss in weight within 72hr. (%)				1 yr
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	13.68	13.78	12.85	40.31	13.44
A1M2	14.78	13.86	13.89	42.53	14.18
A1M3	12.89	12.73	12.99	38.61	12.87
A1M4	14.75	15.01	13.54	43.30	14.43
A1M5	13.63	13.33	13.78	40.74	13.58
A1M6	14.78	13.79	13.78	42.35	14.12
A1M7	13.78	13.9	14.54	42.22	14.07
A1M8	14.22	13.42	13.22	40.86	13.62
A1M9	14.33	14.21	13.87	42.41	14.14
A1M10	14.67	14.85	15.56	45.08	15.03
A2M1	14.78	15.21	13.65	43.64	14.55
A2M2	14.22	13.99	14.32	42.53	14.18
A2M3	14.45	13.84	4.89	33.18	11.06
A2M4	15.78	14.45	14.78	45.01	15.00
A2M5	14.78	14.82	13.95	43.55	14.52
A2M6	14.89	15.63	15.34	45.86	15.29
A2M7	14.33	14.74	14.49	43.56	14.52
A2M8	14.89	15.84	16.01	46.74	15.58
A2M9	15.33	15.21	15.84	46.38	15.46
A2M10	16.94	15.85	16.31	49.10	16.37

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure - 104	Physiological loss in weight within 72hr. (%)				2 yr
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	280	278	287	845	281.67
A1M2	275	258	239	772	257.33
A1M3	268	270	274	812	270.67
A1M4	275	258	250	783	261.00
A1M5	275	280	285	840	280.00
A1M6	250	255	240	745	248.33
A1M7	275	280	275	830	276.67
A1M8	279	265	270	814	271.33
A1M9	270	255	260	785	261.67
A1M10	235	255	240	730	243.33
A2M1	290	270	270	830	276.67
A2M2	250	275	269	794	264.67
A2M3	280	260	280	820	273.33
A2M4	245	250	270	765	255.00
A2M5	275	280	265	820	273.33
A2M6	240	265	243	748	249.33
A2M7	285	270	270	825	275.00
A2M8	280	250	255	785	261.67
A2M9	264	275	265	804	268.00
A2M10	250	235	230	715	238.33

A1- open cultivation, A2- polyhouse cultivation

- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 105	Plant height (cm) (90 DAP)				1 YEAR
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	18.12	17.20	20.78	56.10	18.70
A1M2	17.86	16.70	17.26	51.82	17.27
A1M3	19.20	18.02	18.46	55.68	18.56
A1M4	18.50	17.86	18.52	54.88	18.29
A1M5	17.28	18.84	18.04	54.16	18.05
A1M6	17.96	18.10	16.04	52.10	17.37
A1M7	18.50	17.74	16.58	52.82	17.61
A1M8	21.74	21.04	20.40	63.18	21.06
A1M9	18.36	20.58	21.05	59.99	20.00
A1M10	13.40	14.26	17.08	44.74	14.91
A2M1	15.56	15.22	18.21	48.99	16.33
A2M2	14.35	13.98	15.11	43.44	14.48
A2M3	16.96	15.38	16.56	48.90	16.30
A2M4	15.45	15.21	15.49	46.15	15.38
A2M5	15.31	16.52	16.31	48.14	16.05
A2M6	15.21	16.35	14.75	46.31	15.44
A2M7	15.78	14.95	14.85	45.58	15.19
A2M8	18.57	18.45	17.68	54.70	18.23
A2M9	17.45	17.87	17.11	52.43	17.48
A2M10	13.45	13.21	14.11	40.77	13.59

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 106	Plant height (cm) (90 DAP)				2 YEAR
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M2	16.90	18.72	17.04	52.66	17.55
A1M3	19.06	19.12	18.38	56.56	18.85
A1M4	18.08	19.70	16.22	54	18.00
A1M5	18.04	19.70	16.18	53.92	17.97
A1M6	17.44	16.80	19.16	53.4	17.80
A1M7	16.56	15.94	20.60	53.1	17.70
A1M8	21.46	20.68	21.10	63.24	21.08
A1M9	20.84	22.66	18.14	61.64	20.55
A1M10	16.64	14.48	16.48	47.6	15.87
A2M1	16.23	16.95	17.02	50.2	16.73
A2M2	14.63	14.74	14.69	44.06	14.69
A2M3	16.67	16.23	15.63	48.53	16.18
A2M4	16.32	15.75	15.97	48.04	16.01
A2M5	16.45	15.95	17.32	49.72	16.57
A2M6	14.23	16.57	15.96	46.76	15.59
A2M7	15.38	15.63	15.87	46.88	15.63
A2M8	18.64	18.45	19.45	56.54	18.85
A2M9	17.95	18.56	18.03	54.54	18.18
A2M10	13.21	13.35	13.67	40.23	13.41

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 107	Plant Spread (N-S) in cm, (90 DAP)				1 YEAR
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	22.78	29.03	26.96	78.77	26.26
A1M2	19.88	22.50	22.38	64.76	21.59
A1M3	29.82	25.04	23.35	78.21	26.07
A1M4	25.76	26.92	26.06	78.74	26.25
A1M5	27.86	25.98	26.86	80.70	26.90
A1M6	22.31	22.82	17.28	62.41	20.80
A1M7	27.23	28.74	27.76	83.73	27.91
A1M8	29.40	30.68	30.96	91.04	30.35
A1M9	29.56	30.64	28.88	89.08	29.69
A1M10	17.30	17.52	18.36	53.18	17.73
A2M1	27.74	25.22	27.34	80.30	26.77
A2M2	24.96	25.16	26.2	76.32	25.44
A2M3	26.46	25.32	26.24	78.02	26.01
A2M4	26.84	26.94	26.78	80.56	26.85
A2M5	28.26	26.8	26.76	81.82	27.27
A2M6	24.9	26.72	23.18	74.80	24.93
A2M7	26.92	27.3	26.56	80.78	26.93
A2M8	33.22	35.86	28.92	98.00	32.67
A2M9	34.76	33.64	29.46	97.86	32.62
A2M10	23.62	22.62	22.22	68.46	22.82

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 108 Plant Spread (N-S) in cm, (90 DAP) 2 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	23.32	27.59	29.71	80.62	26.87
A1M2	20.34	22.90	23.03	66.27	22.09
A1M3	30.52	23.91	25.60	80.03	26.68
A1M4	26.38	26.68	27.55	80.61	26.87
A1M5	28.51	27.49	26.58	82.58	27.53
A1M6	22.82	17.67	23.36	63.85	21.28
A1M7	27.87	28.41	29.42	85.7	28.57
A1M8	30.09	31.69	31.40	93.18	31.06
A1M9	30.25	29.50	31.36	91.11	30.37
A1M10	17.02	18.90	17.93	53.85	17.95
A2M1	28.39	27.98	25.81	82.18	27.39
A2M2	25.5	26.82	25.75	78.07	26.02
A2M3	27.08	26.85	25.92	79.85	26.62
A2M4	27.47	27.4	27.57	82.44	27.48
A2M5	28.92	27.37	27.42	83.71	27.90
A2M6	25.49	23.72	27.35	76.56	25.52
A2M7	27.55	27.18	27.94	82.67	27.56
A2M8	34	29.6	36.7	100.3	33.43
A2M9	35.58	30.15	34.43	100.16	33.39
A2M10	24.17	22.74	23.15	70.06	23.35

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 109	Plant Spread (E-W) in cm, (90 DAP)				1 YEAR
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	23.66	28.60	27.60	79.86	26.62
A1M2	22.88	23.32	19.54	65.74	21.91
A1M3	27.46	27.70	24.40	79.56	26.52
A1M4	25.42	21.58	25.80	72.80	24.27
A1M5	26.42	23.42	27.72	77.56	25.85
A1M6	23.18	21.40	20.66	65.24	21.75
A1M7	24.86	25.14	23.46	73.46	24.49
A1M8	28.44	29.22	27.42	85.08	28.36
A1M9	25.12	30.38	28.00	83.50	27.83
A1M10	25.78	15.40	16.56	57.74	19.25
A2M1	28.16	32.47	31.26	91.89	30.63
A2M2	28.7	25.76	27.6	82.06	27.35
A2M3	29.92	26.1	31.82	87.84	29.28
A2M4	28.86	28.18	28.08	85.12	28.37
A2M5	29.44	28.22	29.48	87.14	29.05
A2M6	25.78	27.84	24.94	78.56	26.19
A2M7	28.62	28.36	28.48	85.46	28.49
A2M8	32.18	34.7	35.4	102.28	34.09
A2M9	28.86	35.76	35.64	100.26	33.42
A2M10	24.52	23.64	23.8	71.96	23.99

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 110 Plant Spread (E - W) in cm, (90 dap) 2 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	27.22	25.80	27.40	80.42	26.81
A1M2	21.18	24.40	20.06	65.64	21.88
A1M3	28.44	24.22	27.42	80.08	26.69
A1M4	25.52	22.18	24.80	72.5	24.17
A1M5	26.80	27.72	23.58	78.1	26.03
A1M6	23.08	22.04	20.08	65.2	21.73
A1M7	22.32	25.40	26.00	73.72	24.57
A1M8	28.54	31.63	26.00	86.165	28.72
A1M9	29.06	26.00	30.06	85.12	28.37
A1M10	22.66	18.08	18.88	59.62	19.87
A2M1	30.1	30.28	30.58	90.96	30.32
A2M2	26.32	31.16	28.54	86.02	28.67
A2M3	29.5	29.18	29.7	88.38	29.46
A2M4	27.48	29.4	29.78	86.66	28.89
A2M5	31.08	26	32.08	89.16	29.72
A2M6	26.56	25.78	30.22	82.56	27.52
A2M7	30.62	24.26	29.36	84.24	28.08
A2M8	34	32.92	32.96	99.88	33.29
A2M9	35.06	33.66	30.02	98.74	32.91
A2M10	20.2	27.02	23.58	70.8	23.60

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 111	No. of leaves. (90 DAP)			1 YEAR	
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	22.6	22.8	25	70.40	23.47
A1M2	20	19.4	19.2	58.60	19.53
A1M3	25.6	22.8	21.2	69.60	23.20
A1M4	22.6	20.2	22.8	65.60	21.87
A1M5	22.8	21.6	23	67.40	22.47
A1M6	19.2	19.6	14	52.80	17.60
A1M7	23.8	23.6	22.2	69.60	23.20
A1M8	26.2	27	27	80.20	26.73
A1M9	26.4	27.4	25.6	79.40	26.47
A1M10	12	13	15.8	40.80	13.60
A2M1	24.6	26	24.2	74.80	24.93
A2M2	21.4	22	23	66.40	22.13
A2M3	22.6	24.6	24	71.20	23.73
A2M4	21.6	23.8	23.4	68.80	22.93
A2M5	25	20.6	23.4	69.00	23.00
A2M6	21.8	23.8	19.8	65.40	21.80
A2M7	23.6	24.4	23	71.00	23.67
A2M8	30	32.6	25.6	88.20	29.40
A2M9	31.4	30.4	26.2	88.00	29.33
A2M10	22.4	19.4	20	61.80	20.60

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 112	No of leaves (90 DAP)		2 YEAR		
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	23.6	22.2	25.4	71.2	23.73
A1M2	20.8	22.8	21	64.6	21.53
A1M3	25.2	23.2	22.4	70.8	23.60
A1M4	22.2	23.8	20.2	66.2	22.07
A1M5	22	23.6	20.2	65.8	21.93
A1M6	20.6	18	14.6	53.2	17.73
A1M7	21.4	20.8	23.2	65.4	21.80
A1M8	25.4	24.6	25.2	75.2	25.07
A1M9	24.8	26.6	22.2	73.6	24.53
A1M10	12.6	11.4	15	39	13.00
A2M1	27.6	24	27.2	78.8	26.27
A2M2	22.2	25	24.6	71.8	23.93
A2M3	25.4	25.2	26.8	77.4	25.80
A2M4	20.4	24.6	24.4	69.4	23.13
A2M5	22.2	25.2	26.2	73.6	24.53
A2M6	22.2	20.2	26	68.4	22.80
A2M7	25.8	27	26	78.8	26.27
A2M8	31.8	32	31	94.8	31.60
A2M9	30	31.8	27.6	89.4	29.80
A2M10	20.4	20.2	21.8	62.4	20.80

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 113	Total no. of flowers per plant, (90 DAP) 1YEAR				
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	38.92	35.2	36.95	111.07	37.02
A1M2	29.74	27.85	28.95	86.54	28.85
A1M3	34.86	32.6	35.95	103.41	34.47
A1M4	29.44	28.95	29.52	87.91	29.30
A1M5	34.74	32.74	33.86	101.34	33.78
A1M6	27.85	28.95	27.95	84.75	28.25
A1M7	38.92	33.22	38.93	111.07	37.02
A1M8	42.81	42.68	42.76	128.25	42.75
A1M9	42.62	39.4	42.96	124.98	41.66
A1M10	27.95	22.85	23.86	74.66	24.89
A2M1	33.2	33.6	32.45	99.25	33.08
A2M2	27	28.6	22.87	78.47	26.16
A2M3	31.2	32.62	28.95	92.77	30.92
A2M4	27.82	26.95	27.82	82.59	27.53
A2M5	29.85	31.6	30.4	91.85	30.62
A2M6	25.22	24.85	27.2	77.27	25.76
A2M7	33.94	30.11	30.8	94.85	31.62
A2M8	40.05	39.95	37.95	117.95	39.32
A2M9	39.21	39.84	40.2	119.25	39.75
A2M10	23	20.95	25.89	69.84	23.28

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 114 Total no. of flowers per plant , (90 DAP) 2 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	36.33	35.6	36.92	108.85	36.28
A1M2	28.95	27.92	28.56	85.43	28.48
A1M3	33.21	31.8	34.63	99.64	33.21
A1M4	28.4	30.04	29.8	88.24	29.41
A1M5	34.81	33.85	31.4	100.06	33.35
A1M6	27.95	28.95	26.65	83.55	27.85
A1M7	31.6	32.52	35.32	99.44	33.15
A1M8	45.22	43.45	39.85	128.52	42.84
A1M9	43.86	42.93	38.4	125.19	41.73
A1M10	25.89	24.05	25.67	75.61	25.20
A2M1	32.2	34.8	33.76	100.76	33.59
A2M2	28.4	25.85	23.45	77.7	25.90
A2M3	30.8	32.2	28.95	91.95	30.65
A2M4	29.4	25.85	26.84	82.09	27.36
A2M5	31.75	32	29.95	93.7	31.23
A2M6	24.41	27.85	26.2	78.46	26.15
A2M7	31.05	30.4	29.85	91.3	30.43
A2M8	37.95	41.05	40.81	119.81	39.94
A2M9	39.15	40.85	38.92	118.92	39.64
A2M10	25.22	22.95	21.84	70.01	23.34

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 115 Total no. of fruits per plant , (90 DAP) 1 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	35.53	33.86	36.25	105.64	35.21
A1M2	28.94	26.95	27.84	83.73	27.91
A1M3	33.85	31.25	35.84	100.94	33.65
A1M4	27.54	26.74	28.75	83.03	27.68
A1M5	34.33	31.84	32.87	99.04	33.01
A1M6	24.75	27.85	27.63	80.23	26.74
A1M7	35.64	31.65	36.87	104.16	34.72
A1M8	42.42	42.11	41.85	126.38	42.13
A1M9	42.14	37.98	42.54	122.66	40.89
A1M10	25.83	19.75	19.95	65.53	21.84
A2M1	31.85	30.52	30.57	92.94	30.98
A2M2	25.55	27.22	21.82	74.59	24.86
A2M3	30.04	29.95	27.42	87.41	29.14
A2M4	25.74	24.85	25.85	76.44	25.48
A2M5	25.84	29.76	28.94	84.54	28.18
A2M6	23.32	22.35	24.95	70.62	23.54
A2M7	29.95	29.65	28.75	88.35	29.45
A2M8	39.86	38.75	36.94	115.55	38.52
A2M9	37.85	37.84	37.95	113.64	37.88
A2M10	19.67	19.12	24.03	62.82	20.94

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 116 Total no. of fruits per plant,(90 DAP) 2 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	33.86	34.89	36.84	105.59	35.20
A1M2	27.54	25.98	27.82	81.34	27.11
A1M3	30.85	31.21	31.85	93.91	31.30
A1M4	25.89	29.11	27.85	82.85	27.62
A1M5	33.35	31.55	30.45	95.35	31.78
A1M6	25.78	26.55	25.57	77.9	25.97
A1M7	28.95	31.65	33.86	94.46	31.49
A1M8	43.89	42.75	38.56	125.2	41.73
A1M9	41.84	42.01	37.95	121.8	40.60
A1M10	24.52	19.86	23.74	68.12	22.71
A2M1	30.86	31.8	32.05	94.71	31.57
A2M2	24.96	23.63	22.03	70.62	23.54
A2M3	26.95	31.95	28.05	86.95	28.98
A2M4	25.86	24.85	23.84	74.55	24.85
A2M5	29.95	31.38	28.42	89.75	29.92
A2M6	23.06	25.85	23.81	72.72	24.24
A2M7	28.99	29.63	25.04	83.66	27.89
A2M8	35.85	39.75	39.05	114.65	38.22
A2M9	38.91	38.64	35.84	113.39	37.80
A2M10	21.04	20.52	19.57	61.13	20.38

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 117 Total no. of fruit setting percentage , (90 DAP) 1 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	91.29	96.19	98.11	285.59	95.20
A1M2	97.31	96.77	96.17	290.24	96.75
A1M3	97.10	95.86	99.69	292.66	97.55
A1M4	93.55	92.37	97.39	283.30	94.43
A1M5	98.82	97.25	97.08	293.15	97.72
A1M6	88.87	96.20	98.86	283.92	94.64
A1M7	91.57	95.27	94.71	281.55	93.85
A1M8	99.09	98.66	97.87	295.63	98.54
A1M9	98.87	96.40	99.02	294.29	98.10
A1M10	92.42	86.43	83.61	262.46	87.49
A2M1	95.93	90.83	94.21	280.97	93.66
A2M2	94.63	95.17	95.41	285.21	95.07
A2M3	96.28	91.81	94.72	282.81	94.27
A2M4	92.52	92.21	92.92	277.65	92.55
A2M5	86.57	94.18	95.20	275.94	91.98
A2M6	92.47	89.94	91.73	274.13	91.38
A2M7	88.24	98.47	93.34	280.06	93.35
A2M8	99.53	97.00	97.34	293.86	97.95
A2M9	96.53	94.98	94.40	285.91	95.30
A2M10	85.52	91.26	92.82	269.60	89.87

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 118 Total no. of fruit setting percentage , (90 DAP) 2 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	93.20	98.01	99.78	290.99	97.00
A1M2	95.13	93.05	97.41	285.59	95.20
A1M3	92.89	98.14	91.97	283.011	94.34
A1M4	91.16	96.90	93.46	281.522	93.84
A1M5	95.81	93.21	96.97	285.986	95.33
A1M6	92.24	91.71	95.95	279.893	93.30
A1M7	91.61	97.32	95.87	284.805	94.94
A1M8	97.06	98.39	96.76	292.211	97.40
A1M9	95.39	97.86	98.83	292.08	97.36
A1M10	94.71	82.58	92.48	269.768	89.92
A2M1	**95.84**	**91.38**	**94.93**	282.153	94.05
A2M2	**87.89**	**91.41**	**93.94**	273.244	91.08
A2M3	**87.50**	**99.22**	**96.89**	283.615	94.54
A2M4	**87.96**	**96.13**	**88.82**	272.913	90.97
A2M5	**94.33**	**98.06**	**94.89**	287.285	95.76
A2M6	**94.47**	**92.82**	**90.88**	278.166	92.72
A2M7	**93.37**	**97.47**	**83.89**	274.719	91.57
A2M8	**94.47**	**96.83**	**95.69**	286.987	95.66
A2M9	**99.39**	**94.59**	**92.09**	286.063	95.35
A2M10	**83.43**	**89.41**	**89.61**	262.444	87.48

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 119	Weed intensity, (90 DAP)			1 YEAR	
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	3.22	3.40	3.20	9.82	3.27
A1M2	3.60	3.65	4.10	11.35	3.78
A1M3	3.20	3.24	2.85	9.29	3.10
A1M4	4.75	6.52	7.20	18.47	6.16
A1M5	3.45	2.75	3.00	9.20	3.07
A1M6	4.60	4.60	3.25	12.45	4.15
A1M7	3.00	4.00	3.23	10.23	3.41
A1M8	0.60	0.80	0.40	1.80	0.60
A1M9	0.80	1.00	0.60	2.40	0.80
A1M10	21.55	22.80	22.75	67.10	22.37
A2M1	2.86	3.12	2.85	8.83	2.94
A2M2	3.35	2.6	3.15	9.10	3.03
A2M3	3.2	2.85	2.75	8.80	2.93
A2M4	3.79	6.6	5.21	15.60	5.20
A2M5	2.4	2.86	3.11	8.37	2.79
A2M6	3.65	3.2	3	9.85	3.28
A2M7	3.25	2.45	2.75	8.45	2.82
A2M8	0.4	0.6	0.4	1.40	0.47
A2M9	0.4	0.5	0.6	1.50	0.50
A2M10	10.4	13.85	12.82	37.07	12.36

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut flowersgrass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10- Control(No mulch)

Annexure 120 Weed intensity, (90 DAP) 2 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	3.15	3.15	3.20	9.5	3.17
A1M2	3.95	4.15	4.25	12.35	4.12
A1M3	3.55	2.80	3.30	9.65	3.22
A1M4	4.75	6.20	4.95	15.9	5.30
A1M5	3.22	2.80	3.00	9.02	3.01
A1M6	4.70	4.35	3.80	12.85	4.28
A1M7	3.60	3.40	3.55	10.55	3.52
A1M8	0.80	0.80	0.60	2.2	0.73
A1M9	0.65	0.80	0.95	2.4	0.80
A1M10	23.45	22.70	22.85	69	23.00
A2M1	2.85	3.22	2.6	8.67	2.89
A2M2	3.11	3.25	2.95	9.31	3.10
A2M3	3.55	2.72	2.79	9.06	3.02
A2M4	5.32	4.86	3.76	13.94	4.65
A2M5	3.65	2.95	3.22	9.82	3.27
A2M6	3.22	3.21	3.65	10.08	3.36
A2M7	2.8	2.8	3.35	8.95	2.98
A2M8	0.8	0.5	0.39	1.69	0.56
A2M9	0.6	0.65	0.45	1.7	0.57
A2M10	12.65	11.2	14.45	38.3	12.77

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 121 Total no. of runners, (90 DAP) 1 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	5.25	4.00	4.20	13.45	4.48
A1M2	4.19	3.55	3.20	10.94	3.65
A1M3	4.20	4.25	4.85	13.30	4.43
A1M4	3.60	3.85	4.55	12.00	4.00
A1M5	3.60	5.89	5.75	15.24	5.08
A1M6	3.65	3.20	4.25	11.10	3.70
A1M7	3.75	4.85	4.40	13.00	4.33
A1M8	6.21	6.85	5.60	18.66	6.22
A1M9	5.75	6.85	5.95	18.55	6.18
A1M10	2.80	3.35	3.85	10.00	3.33
A2M1	4.8	3.7	4.2	12.70	4.23
A2M2	2.75	3.6	2.75	9.10	3.03
A2M3	3.11	3.85	4.45	11.41	3.80
A2M4	2.85	3.85	4	10.70	3.57
A2M5	4.6	4.22	4.6	13.42	4.47
A2M6	3.4	3.55	3.6	10.55	3.52
A2M7	3.85	3.79	4.4	12.04	4.01
A2M8	5.55	4.75	6.2	16.50	5.50
A2M9	6	5.8	4.79	16.59	5.53
A2M10	3	3	2.8	8.80	2.93

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 122 Total no. of runners, (90 DAP) 2 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	4.80	4.79	5.12	14.71	4.90
A1M2	4.75	3.45	3.40	11.6	3.87
A1M3	4.25	4.25	4.21	12.71	4.24
A1M4	3.89	3.75	3.60	11.24	3.75
A1M5	4.79	4.56	5.66	15.01	5.00
A1M6	3.20	3.65	4.21	11.06	3.69
A1M7	3.85	4.85	4.00	12.7	4.23
A1M8	6.85	6.22	6.20	19.27	6.42
A1M9	5.75	6.85	6.45	19.05	6.35
A1M10	2.80	3.74	3.78	10.32	3.44
A2M1	3.89	3.8	4.75	12.44	4.15
A2M2	2.85	2.45	3.85	9.15	3.05
A2M3	4.11	3.75	4.02	11.88	3.96
A2M4	3	3.65	3.2	9.85	3.28
A2M5	3.85	4.4	4.8	13.05	4.35
A2M6	3.59	3.2	3.4	10.19	3.40
A2M7	3.2	3.4	4.4	11	3.67
A2M8	5.22	6	4.89	16.11	5.37
A2M9	6.6	5.86	5.6	18.06	6.02
A2M10	3.4	3	3	9.4	3.13

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 123 Fruit Length in cm, (90 DAP) 1 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	3.91	3.48	3.63	11.02	3.67
A1M2	3.04	3.35	2.43	8.82	2.94
A1M3	3.43	3.39	3.71	10.53	3.51
A1M4	3.34	2.8	3.32	9.46	3.15
A1M5	3.21	3.41	3.57	10.19	3.40
A1M6	3.03	3.02	2.45	8.50	2.83
A1M7	3.25	3.65	3.83	10.73	3.58
A1M8	3.89	3.55	4.13	11.57	3.86
A1M9	3.56	3.83	3.93	11.32	3.77
A1M10	2.37	2.26	3.04	7.67	2.56
A2M1	3.72	3.96	4	11.68	3.89
A2M2	3.68	3.81	3.42	10.91	3.64
A2M3	3.96	3.58	3.9	11.44	3.81
A2M4	3.42	3.78	3.9	11.10	3.70
A2M5	3.92	4.11	3.3	11.33	3.78
A2M6	3.57	3.93	3.14	10.64	3.55
A2M7	3.97	4	3.63	11.60	3.87
A2M8	4.29	4.05	4.11	12.45	4.15
A2M9	4.15	3.79	4.12	12.06	4.02
A2M10	3.08	3.39	3.64	10.11	3.37

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 124 Fruit length in cm, (90 DAP) 2 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	3.97	3.71	3.49	11.17	3.72
A1M2	3.3	3.5	2.45	9.25	3.08
A1M3	3.23	3.83	3.63	10.69	3.56
A1M4	3.4	2.88	3.36	9.64	3.21
A1M5	3.56	3.28	3.88	10.72	3.57
A1M6	2.59	3.047	3.052	8.689	2.90
A1M7	3.79	3.56	3.19	10.54	3.51
A1M8	4.27	3.81	3.63	11.71	3.90
A1M9	3.93	3.75	3.83	11.51	3.84
A1M10	2.93	2.38	2.72	8.03	2.68
A2M1	3.93	3.79	4.18	11.9	3.97
A2M2	3.85	3.27	3.58	10.7	3.57
A2M3	3.88	3.64	3.8	11.32	3.77
A2M4	3.47	3.76	3.28	10.51	3.50
A2M5	3.56	3.64	3.87	11.07	3.69
A2M6	2.86	3.49	3.6	9.95	3.32
A2M7	3.66	4	3.86	11.52	3.84
A2M8	4.08	4.22	4.42	12.72	4.24
A2M9	4	3.82	4.35	12.17	4.06
A2M10	3.2	3.46	3.02	9.68	3.23

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 125	Fruit weight in gm, (90 DAP)			1 YEAR	
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	16.45	13.73	17.45	47.63	15.88
A1M2	13.1	15.85	13.45	42.40	14.13
A1M3	16.67	16	14.96	47.63	15.88
A1M4	12.35	13.45	12.85	38.65	12.88
A1M5	16.53	13.9	15.95	46.38	15.46
A1M6	14.11	12.22	13.94	40.27	13.42
A1M7	13.45	14.92	15.84	44.21	14.74
A1M8	15.96	17	17.08	50.04	16.68
A1M9	15.33	15.865	17.36	48.56	16.19
A1M10	10.28	12.24	11.18	33.70	11.23
A2M1	16.3375	19.12	18.76	54.22	18.07
A2M2	16.26	14.96	15.4	46.62	15.54
A2M3	17.08	18.8	16.62	52.50	17.50
A2M4	16.44	15.86	14.18	46.48	15.49
A2M5	15.96	16.26	16.8	49.02	16.34
A2M6	14.184	16.86	13.02	44.06	14.69
A2M7	17.22	16.54	18.02	51.78	17.26
A2M8	23.76	20.944	24.22	68.92	22.97
A2M9	23.899	20.86	23.912	68.67	22.89
A2M10	13.02	11.92	15.86	40.80	13.60

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 126 Fruit weight in gm, (90 DAP) 2 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	16.45	13.73	17.45	47.63	15.88
A1M2	13.1	15.85	13.45	42.4	14.13
A1M3	16.67	16	14.96	47.63	15.88
A1M4	12.35	13.45	12.85	38.65	12.88
A1M5	16.53	13.9	15.95	46.38	15.46
A1M6	14.41	12.22	13.94	40.57	13.52
A1M7	13.45	14.92	15.84	44.21	14.74
A1M8	15.96	17	17.08	50.04	16.68
A1M9	16.56	15.865	17.36	49.785	16.60
A1M10	10.28	12.24	11.18	33.7	11.23
A2M1	16.52	19.30	18.94	54.7515	18.25
A2M2	16.44	15.14	15.58	47.154	15.72
A2M3	17.26	18.98	16.80	53.034	17.68
A2M4	16.62	16.04	14.36	47.014	15.67
A2M5	16.14	16.44	16.98	49.554	16.52
A2M6	14.36	17.04	13.20	44.598	14.87
A2M7	17.40	16.72	18.20	52.314	17.44
A2M8	24.15	21.12	24.21	69.478	23.16
A2M9	24.08	20.62	24.09	68.785	22.93
A2M10	12.54	11.44	15.38	39.366	13.12

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 127	Total Soluble Solid (^{0} Brix), (90 DAP)			2 YEAR	
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	7.58	7.94	7.75	23.27	7.76
A1M2	7.44	7.36	7.55	22.35	7.45
A1M3	7.59	7.54	7.94	23.07	7.69
A1M4	7.63	7.84	7.84	23.31	7.77
A1M5	7.87	7.87	7.94	23.68	7.89
A1M6	7.19	7.64	7.54	22.37	7.46
A1M7	8.44	7.94	7.64	24.02	8.01
A1M8	8.22	8.32	7.95	24.49	8.16
A1M9	7.88	8.32	8.23	24.43	8.14
A1M10	7.43	7.45	8.04	22.92	7.64
A2M1	8.04	8.12	7.94	24.10	8.03
A2M2	7.59	7.84	7.95	23.38	7.79
A2M3	8.12	7.88	7.84	23.84	7.95
A2M4	7.56	7.99	8.06	23.61	7.87
A2M5	7.87	8.33	7.94	24.14	8.05
A2M6	7.83	8.44	7.94	24.21	8.07
A2M7	8.11	8.11	7.95	24.17	8.06
A2M8	8.19	7.94	8.36	24.49	8.16
A2M9	8.19	8.22	7.95	24.36	8.12
A2M10	7.55	7.55	7.85	22.95	7.65

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 128 Total Soluble Solid (^{0} Brix), (90 DAP) 1 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	8.15	7.89	7.90	23.94	7.98
A1M2	7.50	7.45	7.44	22.39	7.46
A1M3	7.90	7.77	7.85	23.52	7.84
A1M4	7.82	7.98	7.59	23.39	7.80
A1M5	7.92	7.90	8.25	24.07	8.02
A1M6	7.58	7.85	7.68	23.11	7.70
A1M7	7.95	8.25	8.15	24.35	8.12
A1M8	8.32	7.95	8.31	24.58	8.19
A1M9	8.44	7.85	8.15	24.44	8.15
A1M10	7.45	7.55	7.50	22.5	7.50
A2M1	7.92	8.08	8.15	24.15	8.05
A2M2	7.59	7.45	7.87	22.91	7.64
A2M3	8.11	8.15	7.42	23.68	7.89
A2M4	7.83	8.08	7.84	23.75	7.92
A2M5	7.92	8.05	7.99	23.96	7.99
A2M6	7.82	8.05	7.95	23.82	7.94
A2M7	7.85	8.25	8.25	24.35	8.12
A2M8	8.5	8.35	7.85	24.7	8.23
A2M9	8.1	8.23	8.35	24.68	8.23
A2M10	7.35	7.98	7.75	23.08	7.69

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 129	Acidity, (90 DAP)		1 YEAR		
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	0.51	0.61	0.57	1.69	0.56
A1M2	0.47	0.51	0.48	1.46	0.49
A1M3	0.64	0.52	0.54	1.70	0.57
A1M4	0.59	0.51	0.54	1.64	0.55
A1M5	0.56	0.54	0.48	1.58	0.53
A1M6	0.48	0.58	0.461	1.52	0.51
A1M7	0.54	0.61	0.54	1.69	0.56
A1M8	0.41	0.45	0.48	1.34	0.45
A1M9	0.45	0.49	0.52	1.46	0.49
A1M10	0.79	0.83	0.81	2.43	0.81
A2M1	0.54	0.55	0.56	1.65	0.55
A2M2	0.45	0.49	0.42	1.36	0.45
A2M3	0.56	0.55	0.54	1.65	0.55
A2M4	0.51	0.48	0.52	1.51	0.50
A2M5	0.47	0.49	0.51	1.47	0.49
A2M6	0.49	0.51	0.50	1.50	0.50
A2M7	0.53	0.56	0.52	1.61	0.54
A2M8	0.41	0.42	0.39	1.22	0.41
A2M9	0.41	0.45	0.47	1.33	0.44
A2M10	0.75	0.74	0.77	2.26	0.75

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 130		Acidity, y (90 DAP)		2 YEAR	
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	0.56	0.53	0.55	1.64	0.55
A1M2	0.46	0.49	0.52	1.47	0.49
A1M3	0.52	0.53	0.56	1.61	0.54
A1M4	0.48	0.50	0.49	1.47	0.49
A1M5	0.54	0.49	0.57	1.6	0.53
A1M6	0.49	0.51	0.50	1.5	0.50
A1M7	0.56	0.54	0.54	1.64	0.55
A1M8	0.55	0.45	0.43	1.43	0.48
A1M9	0.52	0.43	0.42	1.37	0.46
A1M10	0.77	0.79	0.75	2.31	0.77
A2M1	0.52	0.56	0.54	1.62	0.54
A2M2	0.47	0.48	0.43	1.38	0.46
A2M3	0.54	0.54	0.50	1.58	0.53
A2M4	0.47	0.48	0.48	1.43	0.48
A2M5	0.49	0.46	0.47	1.42	0.47
A2M6	0.47	0.42	0.45	1.34	0.45
A2M7	0.52	0.48	0.54	1.54	0.51
A2M8	0.41	0.41	0.38	1.2	0.40
A2M9	0.450	0.420	0.410	1.28	0.43
A2M10	0.750	0.750	0.720	2.22	0.74

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 131	Total Sugar, (90 DAP)		1 YEAR		
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	6.15	5.71	5.85	17.71	5.90
A1M2	6.2	5.55	5.73	17.48	5.83
A1M3	6.2	5.78	5.25	17.23	5.74
A1M4	5.43	5.25	5.25	15.93	5.31
A1M5	5.35	5.55	5.15	16.05	5.35
A1M6	5.2	5.65	5.75	16.60	5.53
A1M7	6.45	5.81	5.7	17.96	5.99
A1M8	6.55	6.65	6.85	20.05	6.68
A1M9	6.45	6.85	6.15	19.45	6.48
A1M10	5.45	5.05	5.15	15.65	5.22
A2M1	6.15	5.75	6.15	18.05	6.02
A2M2	6.25	6.05	6.09	18.39	6.13
A2M3	6.41	5.85	6.27	18.53	6.18
A2M4	5.85	5.97	6.15	17.97	5.99
A2M5	6.13	6.35	5.8	18.28	6.09
A2M6	5.71	6.48	5.97	18.16	6.05
A2M7	6.21	5.85	5.98	18.04	6.01
A2M8	6.75	6.85	7.25	20.85	6.95
A2M9	7.14	6.8	6.65	20.59	6.86
A2M10	5.45	5.8	5.35	16.60	5.53

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 132	Total Sugar, (90 DAP)			2 YEAR	
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	6.10	5.82	6.25	18.17	6.06
A1M2	5.72	5.74	5.55	17.01	5.67
A1M3	5.83	5.65	5.95	17.43	5.81
A1M4	5.45	5.57	6.15	17.17	5.72
A1M5	5.85	5.45	6.05	17.35	5.78
A1M6	5.65	5.63	5.75	17.03	5.68
A1M7	5.98	6.08	5.43	17.49	5.83
A1M8	6.45	6.72	6.43	19.6	6.53
A1M9	6.43	6.74	6.75	19.92	6.64
A1M10	5.42	5.33	5.52	16.27	5.42
A2M1	**6.57**	**6.30**	**6.30**	19.17	6.39
A2M2	**6.10**	**6.30**	**6.04**	18.44	6.15
A2M3	**7.02**	**6.31**	**6.41**	19.74	6.58
A2M4	**6.30**	**6.08**	**5.90**	18.28	6.09
A2M5	**6.23**	**6.11**	**6.09**	18.43	6.14
A2M6	**6.60**	**5.87**	**5.90**	18.37	6.12
A2M7	**6.41**	**6.40**	**6.00**	18.81	6.27
A2M8	**7.05**	**7.00**	**7.11**	21.16	7.05
A2M9	**7.02**	**6.87**	**6.86**	20.75	6.92
A2M10	**5.24**	**6.17**	**5.80**	17.21	5.74

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 133	Anthocyanin (90 DAP)		1 YEAR		
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	44.45	45.89	39.59	129.93	43.31
A1M2	40.66	36.88	36.85	114.39	38.13
A1M3	41.86	45.22	38.77	125.85	41.95
A1M4	40.56	36.77	43.72	121.05	40.35
A1M5	45.42	42.77	47.93	136.12	45.37
A1M6	43.87	45.22	45.21	134.30	44.77
A1M7	47.45	45.33	44.76	137.54	45.85
A1M8	46.85	48.21	45.06	140.12	46.71
A1M9	48.42	43.53	47.73	139.68	46.56
A1M10	39.88	36.31	35.53	111.72	37.24
A2M1	47.95	46.31	45.65	139.91	46.64
A2M2	40.35	46.24	38.41	125.00	41.67
A2M3	46.59	47.1	43.92	137.61	45.87
A2M4	44.35	38.03	42.64	125.02	41.67
A2M5	45.76	45.06	48.24	139.06	46.35
A2M6	40.1	43.86	41.37	125.33	41.78
A2M7	46.97	47.73	46.33	141.03	47.01
A2M8	49.96	50.25	48.95	149.16	49.72
A2M9	49.67	46.85	48.94	145.46	48.49
A2M10	37.89	39.76	39.85	117.50	39.17

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 134	Anthocyanin, (90 DAP)			2 YEAR	
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	44.25	41.7	39.9	125.85	41.95
A1M2	32.4	37.88	38.99	109.27	36.42
A1M3	43.11	42.87	47.21	133.19	44.40
A1M4	40.97	39.33	37.36	117.66	39.22
A1M5	46.76	48.52	44.96	140.24	46.75
A1M6	48.45	44.74	43.89	137.08	45.69
A1M7	42.55	47.31	46.77	136.63	45.54
A1M8	45.74	48.65	46.33	140.72	46.91
A1M9	45.89	46.31	47.88	140.08	46.69
A1M10	39.66	35.62	32.88	108.16	36.05
A2M1	46.89	49.81	45.83	142.53	47.51
A2M2	45.33	44.87	39.95	130.15	43.38
A2M3	49.5	44.71	44.42	138.63	46.21
A2M4	38.6	40.3	41.22	120.12	40.04
A2M5	44.87	46	48.04	138.91	46.30
A2M6	39.7	45.33	41.07	126.1	42.03
A2M7	51.3	47.3	42.6	141.2	47.07
A2M8	51.63	49.59	46.81	148.03	49.34
A2M9	45.93	48.96	49.85	144.74	48.25
A2M10	38.45	33.9	38.78	111.13	37.04

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 135	Ascorbic Acid Content, (90 DAP)			1 YEAR	
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	48.62	48.95	50.98	148.55	49.52
A1M2	45.89	49.95	47.74	143.58	47.86
A1M3	45.95	49.55	48.75	144.25	48.08
A1M4	52.5	47.92	48.05	148.47	49.49
A1M5	45.79	48.95	46.94	141.68	47.23
A1M6	45.77	46.94	46.88	139.59	46.53
A1M7	48.54	48.12	45.93	142.59	47.53
A1M8	50.04	52.43	53.15	155.62	51.87
A1M9	50.08	48.44	52.21	150.73	50.24
A1M10	47.12	46.74	43.96	137.82	45.94
A2M1	50.11	48.95	48.42	147.48	49.16
A2M2	48.66	50.06	49.64	148.36	49.45
A2M3	48.95	49.73	49.77	148.45	49.48
A2M4	50.11	47.15	49.43	146.69	48.90
A2M5	49.21	47.88	49.58	146.67	48.89
A2M6	48.94	48.12	47.74	144.80	48.27
A2M7	52.85	48.67	51.11	152.63	50.88
A2M8	52.31	54.85	53.91	161.07	53.69
A2M9	53.83	52.85	52.27	158.95	52.98
A2M10	47.96	46.76	46.96	141.68	47.23

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 136	Ascorbic Acid Content, (90 DAP)			2 YEAR	
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	46.35	49.95	52.25	148.55	49.52
A1M2	45.86	51.05	47.95	144.86	48.29
A1M3	50.05	46.84	48.11	145	48.33
A1M4	47.92	49.58	51.23	148.73	49.58
A1M5	49.66	45.33	47.42	142.41	47.47
A1M6	44.88	46.21	47.75	138.84	46.28
A1M7	47.32	46.75	49.11	143.18	47.73
A1M8	52.85	48.91	51.96	153.72	51.24
A1M9	53.22	49.02	51.19	153.43	51.14
A1M10	45.21	46.12	48.22	139.55	46.52
A2M1	**49.86**	**51.22**	**50.04**	151.12	50.37
A2M2	**48.32**	**51.12**	**49.82**	149.26	49.75
A2M3	**48.95**	**48.21**	**49.15**	146.31	48.77
A2M4	**48.93**	**48.21**	**50.21**	147.35	49.12
A2M5	**50.68**	**48.22**	**50.36**	149.26	49.75
A2M6	**50.66**	**47.47**	**48.22**	146.35	48.78
A2M7	**50.31**	**47.85**	**52.85**	151.01	50.34
A2M8	**51.95**	**54.54**	**53.97**	160.46	53.49
A2M9	**52.01**	**51.73**	**52.31**	156.05	52.02
A2M10	**47.95**	**48.95**	**46.55**	143.45	47.82

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 137 Physiological loss in weight (%) within 24 hours, (90 DAP) 1 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	5.85	5.77	5.77	17.39	5.80
A1M2	6.22	6.02	5.93	18.17	6.06
A1M3	6.01	5.54	6.21	17.76	5.92
A1M4	6.51	5.73	6.21	18.45	6.15
A1M5	5.75	6.04	5.97	17.76	5.92
A1M6	5.97	6.22	6.03	18.22	6.07
A1M7	5.66	6.01	6.11	17.78	5.93
A1M8	5.32	5.79	5.85	16.96	5.65
A1M9	5.52	5.67	5.54	16.73	5.58
A1M10	6.63	6.43	7.21	20.27	6.76
A2M1	6.42	6.75	6.11	19.28	6.43
A2M2	6.23	6.89	6.75	19.87	6.62
A2M3	6.66	6.52	6.11	19.29	6.43
A2M4	6.87	6.25	6.36	19.48	6.49
A2M5	6.84	6.03	6.11	18.98	6.33
A2M6	7.22	6.34	6.77	20.33	6.78
A2M7	6.45	7.11	5.66	19.22	6.41
A2M8	6.52	6.52	6.45	19.49	6.50
A2M9	6.32	6.64	6.75	19.71	6.57
A2M10	6.55	7.35	7.25	21.15	7.05

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 138 Physiological loss in weight (%) within 24 hours, (90 DAP) 2 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	5.82	6.02	5.75	17.59	5.86
A1M2	6.11	6.22	5.94	18.27	6.09
A1M3	5.87	5.96	6.12	17.95	5.98
A1M4	6.75	5.85	5.74	18.34	6.11
A1M5	5.51	5.53	6.64	17.68	5.89
A1M6	6.03	6.31	5.98	18.32	6.11
A1M7	6.48	5.64	5.62	17.74	5.91
A1M8	5.62	5.22	5.55	16.39	5.46
A1M9	5.55	5.85	5.21	16.61	5.54
A1M10	6.55	6.43	7.23	20.21	6.74
A2M1	6.24	6.45	5.74	18.43	6.14
A2M2	6.25	6.55	6.66	19.46	6.49
A2M3	6.75	6.59	6.27	19.61	6.54
A2M4	6.86	6.38	5.86	19.1	6.37
A2M5	6.16	6.85	6.55	19.56	6.52
A2M6	6.74	6.65	6.75	20.14	6.71
A2M7	6.52	6.21	6.25	18.98	6.33
A2M8	6.53	6.43	6.45	19.41	6.47
A2M9	6.64	6.21	6.55	19.4	6.47
A2M10	6.98	6.97	7.15	21.1	7.03

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6- Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 139 Physiological loss in weight (%) within 48 hours, (90 DAP) 1 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	9.86	9.69	8.75	28.30	9.43
A1M2	8.88	9.95	10.05	28.88	9.63
A1M3	9.79	9.96	8.21	27.96	9.32
A1M4	9.48	9.95	9.98	29.41	9.80
A1M5	8.95	9.74	9.67	28.36	9.45
A1M6	10.01	9.95	9.95	29.91	9.97
A1M7	8.96	9.93	9.95	28.84	9.61
A1M8	9.95	8.92	9.55	28.42	9.47
A1M9	8.95	9.85	9.92	28.72	9.57
A1M10	10.96	10.68	10.79	32.43	10.81
A2M1	9.86	9.89	8.95	28.70	9.57
A2M2	9.76	9.75	10.03	29.54	9.85
A2M3	9.65	9.68	9.87	29.20	9.73
A2M4	10.11	10.11	9.76	29.98	9.99
A2M5	9.78	9.89	10.02	29.69	9.90
A2M6	10.18	9.98	9.98	30.14	10.05
A2M7	9.97	9.89	10.11	29.97	9.99
A2M8	10.34	10.42	10.67	31.43	10.48
A2M9	10.53	10.54	10.51	31.58	10.53
A2M10	11.44	11.46	11.04	33.94	11.31

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 140 Physiological loss in weight (%) within 48hours, (90 DAP) 2 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	8.95	9.72	9.73	28.4	9.47
A1M2	9.92	9.95	10.03	29.9	9.97
A1M3	9.85	9.83	9.65	29.33	9.78
A1M4	9.89	9.95	9.85	29.69	9.90
A1M5	9.54	9.69	9.99	29.22	9.74
A1M6	10.05	9.95	9.79	29.79	9.93
A1M7	9.95	9.97	10.02	29.94	9.98
A1M8	9.86	9.67	8.96	28.49	9.50
A1M9	9.77	10.02	9.85	29.64	9.88
A1M10	10.78	10.85	10.54	32.17	10.72
A2M1	9.76	9.47	9.54	28.77	9.59
A2M2	9.74	9.85	10.03	29.62	9.87
A2M3	9.87	9.87	9.49	29.23	9.74
A2M4	10.05	10.06	9.79	29.9	9.97
A2M5	9.89	9.78	10.07	29.74	9.91
A2M6	10.13	10.12	10.02	30.27	10.09
A2M7	10.03	9.92	9.77	29.72	9.91
A2M8	10.46	10.32	10.53	31.31	10.44
A2M9	10.31	10.76	10.61	31.68	10.56
A2M10	11.39	11.41	11.31	34.11	11.37

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 141 Physiological loss in weight (%) within 72 hours, (90 DAP) 1 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	13.68	13.78	12.85	40.31	13.44
A1M2	14.78	13.86	13.89	42.53	14.18
A1M3	12.89	12.73	12.99	38.61	12.87
A1M4	14.75	15.01	13.54	43.30	14.43
A1M5	13.63	13.33	13.78	40.74	13.58
A1M6	14.78	13.79	13.78	42.35	14.12
A1M7	13.78	13.9	14.54	42.22	14.07
A1M8	14.22	13.42	13.22	40.86	13.62
A1M9	14.33	14.21	13.87	42.41	14.14
A1M10	14.67	14.85	15.56	45.08	15.03
A2M1	14.78	15.21	13.65	43.64	14.55
A2M2	14.22	13.99	14.32	42.53	14.18
A2M3	14.45	13.84	4.89	33.18	11.06
A2M4	15.78	14.45	14.78	45.01	15.00
A2M5	14.78	14.82	13.95	43.55	14.52
A2M6	14.89	15.63	15.34	45.86	15.29
A2M7	14.33	14.74	14.49	43.56	14.52
A2M8	14.89	15.84	16.01	46.74	15.58
A2M9	15.33	15.21	15.84	46.38	15.46
A2M10	16.94	15.85	16.31	49.10	16.37

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 142 Physiological loss in weight (%) within 72 hours, (90 DAP) 2 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	12.82	12.35	12.51	37.68	12.56
A1M2	13.79	13.82	14.73	42.34	14.11
A1M3	13.32	13.46	12.85	39.63	13.21
A1M4	13.89	13.56	12.42	39.87	13.29
A1M5	13.42	12.89	13.95	40.26	13.42
A1M6	14.57	15.11	14.21	43.89	14.63
A1M7	13.68	13.47	14.52	41.67	13.89
A1M8	13.78	13.96	14.31	42.05	14.02
A1M9	13.82	14.32	13.95	42.09	14.03
A1M10	15.45	14.22	14.85	44.52	14.84
A2M1	13.78	13.96	14.11	41.85	13.95
A2M2	14.34	13.99	14.53	42.86	14.29
A2M3	14.46	14.89	14.79	44.14	14.71
A2M4	14.89	14.78	15.11	44.78	14.93
A2M5	14.22	14.84	14.44	43.5	14.50
A2M6	15.33	15.73	14.49	45.55	15.18
A2M7	15.15	14.67	15.39	45.21	15.07
A2M8	15.67	15.83	15.83	47.33	15.78
A2M9	14.89	15.82	15.69	46.4	15.47
A2M10	16.58	15.95	16.84	49.37	16.46

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 143 Soil Temperature (0C) at 30 days, (90 DAP) 1 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	21.1	21.2	22.11	64.41	21.47
A1M2	21.7	20.76	20.54	62.95	20.98
A1M3	20.7	21.3	21.3	63.25	21.08
A1M4	20.3	20.6	21.2	62.10	20.70
A1M5	19.6	21.2	21.3	62.06	20.69
A1M6	20.8	21.5	20.76	63.06	21.02
A1M7	21.5	21.4	20.97	63.87	21.29
A1M8	22.4	21.8	23.25	67.48	22.49
A1M9	22.1	22.1	23.15	67.39	22.46
A1M10	18.85	18.45	19.15	56.45	18.82
A2M1	21.9	21.4	22.54	65.81	21.94
A2M2	21.6	22.87	21.87	66.29	22.10
A2M3	22.3	21.3	20.7	64.32	21.44
A2M4	19.5	20.6	21.89	61.99	20.66
A2M5	22.8	20.2	21.86	64.81	21.60
A2M6	22.0	21.4	22.76	66.14	22.05
A2M7	22.8	21.8	22.43	67.04	22.35
A2M8	24.2	23.77	24.75	72.74	24.25
A2M9	24.0	23.46	23.76	71.17	23.72
A2M10	21.35	21.85	22.85	66.05	22.02

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 144 Soil Temperature (0C) at 30 days, (90 DAP) 2 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	21.7	19.9	21.7	63.3	21.10
A1M2	21.1	20.32	21.5	62.92	20.97
A1M3	21.1	20.9	21.4	63.4	21.13
A1M4	21.2	21.3	21.4	63.9	21.30
A1M5	21.9	21.3	20.66	63.83	21.28
A1M6	21.5	21.12	20.65	63.27	21.09
A1M7	21.1	20.88	21.4	63.38	21.13
A1M8	23.3	22.65	22.4	68.36	22.79
A1M9	22.3	23.15	22.4	67.89	22.63
A1M10	18.8	19.05	18.75	56.64	18.88
A2M1	22.9	21.54	21.7	66.1	22.03
A2M2	21.3	20.56	21.96	63.86	21.29
A2M3	20.4	21.8	22.32	64.52	21.51
A2M4	22.9	21.3	21.43	65.59	21.86
A2M5	22.0	20.6	21.4	63.98	21.33
A2M6	22.5	21.3	21.97	65.8	21.93
A2M7	22.0	22.3	21.4	65.65	21.88
A2M8	24.1	22.85	23.25	70.22	23.41
A2M9	23.7	22.87	22.9	69.42	23.14
A2M10	21.6	21.25	22.73	65.53	21.84

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 145 Soil Temperature (0C) at 60 days, (90 DAP) 1 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	22.32	21.66	21.75	65.73	21.91
A1M2	21.86	22.5	21.85	66.21	22.07
A1M3	22.33	21.85	22.31	66.49	22.16
A1M4	21.95	22.1	22.7	66.75	22.25
A1M5	22.43	21.56	21.68	65.67	21.89
A1M6	21.75	22.72	22.65	67.12	22.37
A1M7	23.1	24.11	22.74	69.95	23.32
A1M8	25.22	23.66	24.87	73.75	24.58
A1M9	23.22	24.75	24.43	72.40	24.13
A1M10	20.85	21.45	21.25	63.55	21.18
A2M1	22.86	21.7	23.85	68.41	22.80
A2M2	22.89	23.53	21.87	68.29	22.76
A2M3	22.75	21.7	23.54	67.99	22.66
A2M4	22.71	21.5	22.75	66.96	22.32
A2M5	22.34	21.6	22.86	66.80	22.27
A2M6	22.83	22.75	23.55	69.13	23.04
A2M7	23.68	22.4	24.22	70.30	23.43
A2M8	26.22	26.45	26.45	79.12	26.37
A2M9	26.44	26.22	25.86	78.52	26.17
A2M10	22.75	22.92	21.55	67.22	22.41

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 146 Soil Temperature (0C) at 60 days, (90 DAP) 2 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	22.3	22.21	21.45	65.96	21.99
A1M2	21.65	21.75	22.95	66.35	22.12
A1M3	21.95	22.9	21.97	66.82	22.27
A1M4	21.65	22.21	22.31	66.17	22.06
A1M5	22.41	23.3	22.41	68.12	22.71
A1M6	21.95	22.11	21.75	65.81	21.94
A1M7	22.51	23.64	23.4	69.55	23.18
A1M8	24.45	24.4	24.65	73.5	24.50
A1M9	24.65	24.75	24.75	74.15	24.72
A1M10	21.75	22.15	21.25	65.15	21.72
A2M1	21.89	22.5	22.75	67.14	22.38
A2M2	22.55	22.5	22.95	68	22.67
A2M3	21.2	22.6	23.11	66.91	22.30
A2M4	23.28	21.9	22.9	68.08	22.69
A2M5	23.21	22.23	22.1	67.54	22.51
A2M6	22.3	22.5	23.32	68.12	22.71
A2M7	24.41	21.12	22.55	68.08	22.69
A2M8	25.78	26.58	26.53	78.89	26.30
A2M9	25.95	26.86	25.45	78.26	26.09
A2M10	22.65	21.75	22.78	67.18	22.39

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 147 Soil Temperature (0C) at 90 days, (90 DAP) 1 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	25.1	26.4	26.25	77.75	25.92
A1M2	25.7	25.8	27.5	79.00	26.33
A1M3	25.75	26.2	26	77.95	25.98
A1M4	25.6	25.3	26.67	77.57	25.86
A1M5	26.55	25.5	24.6	76.65	25.55
A1M6	26.75	25.66	25.1	77.51	25.84
A1M7	26.7	24.1	25.6	76.40	25.47
A1M8	27.35	27.59	27.85	82.79	27.60
A1M9	27.95	26.95	27.85	82.75	27.58
A1M10	25.65	24.87	24.25	74.77	24.92
A2M1	27.22	26.54	26.9	80.66	26.89
A2M2	26.76	25.86	26.4	79.02	26.34
A2M3	26.4	26.2	25.4	78.00	26.00
A2M4	26.44	27.32	25.76	79.52	26.51
A2M5	25.75	25.2	26.45	77.40	25.80
A2M6	25.4	27.11	26.39	78.90	26.30
A2M7	26.45	25.4	26.75	78.60	26.20
A2M8	31.34	30.85	31.77	93.96	31.32
A2M9	30.85	32.65	29.2	92.70	30.90
A2M10	26.22	26.95	25.75	78.92	26.31

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 148 Soil Temperature (0C) at 90 days, (90 DAP) 2 YEAR						
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**	
A1M1	26.22	26.2	26.75	79.17	26.39	26.6
A1M2	25.75	26.35	26.87	78.97	26.32	27.4
A1M3	26.2	25.85	25.6	77.65	25.88	27.2
A1M4	25.5	25.7	26.54	77.74	25.91	26.1
A1M5	24.9	26.1	25.47	76.47	25.49	26.5
A1M6	26.77	26.34	25.7	78.81	26.27	25.3
A1M7	24.5	27.3	26.1	77.9	25.97	27.7
A1M8	27.85	27.75	28.11	83.71	27.90	32.75
A1M9	27.55	27.45	28.22	83.22	27.74	31.85
A1M10	24.15	25.75	24.5	74.4	24.80	29.75
A2M1	26.1	26.4	26.3	78.8	26.27	26.8
A2M2	26.2	26.1	26.7	79	26.33	26.5
A2M3	26.7	25.4	26.45	78.55	26.18	25.8
A2M4	26.95	25.4	26	78.35	26.12	25.8
A2M5	24.5	25.4	26.4	76.3	25.43	25.8
A2M6	25.2	25.9	27.22	78.32	26.11	26.3
A2M7	25.8	26	27.65	79.45	26.48	26.4
A2M8	30.22	30.25	32.22	92.69	30.90	30.65
A2M9	30.65	28.5	28.7	87.85	29.28	28.9
A2M10	26.7	25.64	26.6	78.94	26.31	26.65

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 149 Soil Moisture %) at 30 days, (90 DAP) 1 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	40.44	39.74	41.93	122.11	40.70
A1M2	37.63	41.84	37.99	117.46	39.15
A1M3	38.53	37.22	39.53	115.28	38.43
A1M4	46.44	33.22	34.51	114.17	38.06
A1M5	40.31	39.88	40.36	120.55	40.18
A1M6	30.92	41.44	31.88	104.24	34.75
A1M7	40.41	40.45	36.99	117.85	39.28
A1M8	40.94	48.74	45.92	135.60	45.20
A1M9	44.81	41.99	42.82	129.62	43.21
A1M10	22.42	23.92	24.52	70.86	23.62
A2M1	46.33	55.21	42.85	144.39	48.13
A2M2	39.97	42.58	45.93	128.48	42.83
A2M3	44.27	39.75	42.93	126.95	42.32
A2M4	41.85	35.96	43.85	121.66	40.55
A2M5	46.14	41.85	48.74	136.73	45.58
A2M6	37.89	38.84	40.95	117.68	39.23
A2M7	42.93	39.74	45.74	128.41	42.80
A2M8	46.11	54.84	52.91	153.86	51.29
A2M9	50.73	47.94	49	147.67	49.22
A2M10	24.83	28.04	27.67	80.54	26.85

- A1- drip irrigation, A2- manual irrigation.

M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 150 Soil Moisture %) at 30 days, (90 DAP) 2 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	42.21	38.94	39.53	120.68	40.23
A1M2	41.52	38.42	39.33	119.27	39.76
A1M3	37.35	41.34	36.93	115.62	38.54
A1M4	35.99	40.22	38.63	114.84	38.28
A1M5	41.73	39.35	40.21	121.29	40.43
A1M6	38.92	32.31	32.84	104.07	34.69
A1M7	39.54	35.67	40.42	115.63	38.54
A1M8	46.91	39.94	47.21	134.06	44.69
A1M9	43.94	40.82	44.34	129.1	43.03
A1M10	24.41	25.34	21.91	71.66	23.89
A2M1	52.21	46.74	44.35	143.3	47.77
A2M2	46.89	42.52	44.96	134.37	44.79
A2M3	45.94	43.65	46.33	135.92	45.31
A2M4	42.56	46.85	34.84	124.25	41.42
A2M5	41.75	45.93	47.85	135.53	45.18
A2M6	44.32	39.68	38.41	122.41	40.80
A2M7	45.84	43.78	46.94	136.56	45.52
A2M8	53,94	49.73	52.71	102.44	51.22
A2M9	58.73	47.85	43.21	149.79	49.93
A2M10	28.45	25.95	25.81	80.21	26.74

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 151 Soil Moisture %) at 60 days, (90 DAP) 1 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	39.46	41.93	38.35	119.74	39.91
A1M2	38.49	37.72	39.74	115.95	38.65
A1M3	36.92	39.47	38.31	114.70	38.23
A1M4	36.82	39.31	37.41	113.54	37.85
A1M5	35.82	37.82	39.11	112.75	37.58
A1M6	34.82	35.35	36.93	107.10	35.70
A1M7	36.92	37.77	40.39	115.08	38.36
A1M8	41.93	48.91	42.84	133.68	44.56
A1M9	39.58	46.11	40.33	126.02	42.01
A1M10	22.84	25.37	24.73	72.94	24.31
A2M1	39.89	42.75	40.55	123.19	41.06
A2M2	37.33	40.56	41.94	119.83	39.94
A2M3	41.94	37.92	42.11	121.97	40.66
A2M4	39.33	37.94	41.49	118.76	39.59
A2M5	44.31	38.57	42.73	125.61	41.87
A2M6	44.24	39.56	35.81	119.61	39.87
A2M7	41.41	38.92	39.48	119.81	39.94
A2M8	49.45	49.85	47.83	147.13	49.04
A2M9	50.73	47.94	42.94	141.61	47.20
A2M10	25.95	25.95	26.74	78.64	26.21

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 152 Soil Moisture %) at 60 days, (90 DAP) 2 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	41.93	38.63	39.11	119.67	39.89
A1M2	40.21	38.93	39.91	119.05	39.68
A1M3	37.31	39.21	38.55	115.07	38.36
A1M4	38.41	35.42	38.91	112.74	37.58
A1M5	36.31	36.93	39.19	112.43	37.48
A1M6	38.45	39.35	37.94	115.74	38.58
A1M7	34.99	36.85	39.57	111.41	37.14
A1M8	42.91	38.93	40.45	122.29	40.76
A1M9	42.94	41.74	42.23	126.91	42.30
A1M10	24.84	24.21	25.11	74.16	24.72
A2M1	51.53	42.95	39.11	133.59	44.53
A2M2	43.84	35.95	41.85	121.64	40.55
A2M3	38.45	41.64	39.75	119.84	39.95
A2M4	41.45	39.54	38.77	119.76	39.92
A2M5	41.72	44.21	37.84	123.77	41.26
A2M6	42.74	39.45	41.37	123.56	41.19
A2M7	42.24	36.85	39.56	118.65	39.55
A2M8	49.45	44.34	39.74	133.53	44.51
A2M9	51.53	49.85	47.34	148.72	49.57
A2M10	26.31	26.43	28.45	81.19	27.06

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 153 Soil Moisture %) at 90 days, (90 DAP) 1 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	36.99	35.75	40.33	113.07	37.69
A1M2	34.56	35.42	35.76	105.74	35.25
A1M3	38.31	33.85	38.45	110.61	36.87
A1M4	38.47	36.93	34.75	110.15	36.72
A1M5	35.84	39.65	39.63	115.12	38.37
A1M6	36.94	33.22	34.21	104.37	34.79
A1M7	36.42	35.85	38.48	110.75	36.92
A1M8	40.22	38.75	40.31	119.28	39.76
A1M9	37.85	40.21	39.22	117.28	39.09
A1M10	21.33	19.85	20.55	61.73	20.58
A2M1	38.94	41.22	41.22	121.38	40.46
A2M2	40.53	37.11	36.77	114.41	38.14
A2M3	41.35	41.37	38.45	121.17	40.39
A2M4	33.94	36.78	41.49	112.21	37.40
A2M5	37.45	41.85	42.99	122.29	40.76
A2M6	41.97	36.75	36.45	115.17	38.39
A2M7	37.93	41.58	37.95	117.46	39.15
A2M8	41.55	42.75	41.22	125.52	41.84
A2M9	42.35	42.22	40.34	124.91	41.64
A2M10	25.75	21.67	23.55	70.97	23.66

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 154 Soil Moisture %) at 90 days, (90 DAP) 2 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	36.78	39.22	40.57	116.57	38.86
A1M2	35.75	34.75	32.75	103.25	34.42
A1M3	37.83	37.71	34.35	109.89	36.63
A1M4	36.73	32.75	38.92	108.4	36.13
A1M5	39.45	40.45	39.11	119.01	39.67
A1M6	35.99	34.85	33.27	104.11	34.70
A1M7	36.35	36.93	37.99	111.27	37.09
A1M8	39.35	38.65	40.35	118.35	39.45
A1M9	38.45	39.75	39.37	117.57	39.19
A1M10	21.43	20.21	19.56	61.2	20.40
A2M1	40.55	41.22	40.45	122.22	40.74
A2M2	38.95	37.99	41.49	118.43	39.48
A2M3	39.45	42.11	37.89	119.45	39.82
A2M4	37.45	36.85	37.48	111.78	37.26
A2M5	41.76	39.45	42.96	124.17	41.39
A2M6	38.55	39.94	40.37	118.86	39.62
A2M7	39.45	39.78	41.94	121.17	40.39
A2M8	39.45	41.84	42.44	123.73	41.24
A2M9	39.65	41.22	40.25	121.12	40.37
A2M10	24.45	21.75	24.65	70.85	23.62

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 155	Soil pH, (90 DAP)			1 YEAR	
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	5.95	5.95	5.78	17.68	5.89
A1M2	6.21	5.82	5.75	17.78	5.93
A1M3	5.88	5.92	5.65	17.45	5.82
A1M4	5.65	6.15	5.85	17.65	5.88
A1M5	5.85	5.95	5.75	17.55	5.85
A1M6	6.25	5.75	5.85	17.85	5.95
A1M7	6.32	5.85	5.95	18.12	6.04
A1M8	5.95	5.85	5.63	17.43	5.81
A1M9	5.96	5.8	6.21	17.97	5.99
A1M10	5.77	5.66	5.8	17.23	5.74
A2M1	6.1	5.95	5.55	17.60	5.87
A2M2	5.85	5.65	5.94	17.44	5.81
A2M3	5.85	5.9	5.95	17.70	5.90
A2M4	5.65	5.55	5.59	16.79	5.60
A2M5	5.35	5.95	5.75	17.05	5.68
A2M6	5.95	6.34	5.85	18.14	6.05
A2M7	6.25	5.95	6.22	18.42	6.14
A2M8	5.75	5.82	5.63	17.20	5.73
A2M9	5.76	5.55	5.85	17.16	5.72
A2M10	5.75	5.65	6.21	17.61	5.87

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 156	Soil pH, (90 DAP)			2 YEAR	
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	6.2	5.65	5.62	17.47	5.82
A1M2	5.65	5.85	6.12	17.62	5.87
A1M3	6.3	5.75	5.85	17.9	5.97
A1M4	5.88	5.75	5.6	17.23	5.74
A1M5	5.95	5.75	6.11	17.81	5.94
A1M6	6.3	5.75	5.8	17.85	5.95
A1M7	5.95	5.85	6.11	17.91	5.97
A1M8	5.65	5.65	5.85	17.15	5.72
A1M9	5.75	5.6	5.98	17.33	5.78
A1M10	5.75	5.65	6.22	17.62	5.87
A2M1	5.77	5.91	5.82	17.5	5.83
A2M2	5.8	5.7	6.11	17.61	5.87
A2M3	5.8	5.9	5.75	17.45	5.82
A2M4	5.87	5.95	5.57	17.39	5.80
A2M5	5.95	5.65	5.86	17.46	5.82
A2M6	5.5	6.33	5.66	17.49	5.83
A2M7	5.75	5.8	6.21	17.76	5.92
A2M8	5.66	5.86	5.7	17.22	5.74
A2M9	5.8	5.8	5.9	17.5	5.83
A2M10	5.65	6.21	5.73	17.59	5.86

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 157 Yield per plant(in gm), (90 DAP) 1 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	385.55	417.39	420.35	1223.29	407.76
A1M2	288.20	351.87	285.14	925.21	308.40
A1M3	504.52	395.67	415.89	1316.08	438.69
A1M4	346.54	282.45	292.98	921.97	307.32
A1M5	419.86	395.53	382.80	1198.19	399.40
A1M6	307.60	278.95	268.54	855.09	285.03
A1M7	432.45	414.78	376.74	1223.97	407.99
A1M8	512.65	488.65	479.67	1480.97	493.66
A1M9	492.11	467.85	507.34	1467.30	489.10
A1M10	178.56	188.50	211.32	578.38	192.79
A2M1	**509.73**	**522.34**	**496.56**	1528.63	509.54
A2M2	**412.34**	**382.98**	**406.56**	1201.88	400.63
A2M3	**495.32**	**477.61**	**495.28**	1468.21	489.40
A2M4	**450.46**	**415.53**	**391.37**	1257.36	419.12
A2M5	**481.99**	**461.78**	**500.64**	1444.42	481.47
A2M6	**363.11**	**411.38**	**320.29**	1094.79	364.93
A2M7	**440.83**	**455.54**	**473.85**	1370.22	456.74
A2M8	**663.56**	**635.98**	**651.82**	1951.36	650.45
A2M9	**655.73**	**634.51**	**585.34**	1875.58	625.19
A2M10	**296.86**	**283.70**	**367.95**	948.50	316.17

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 158 Yield per plant(in gm), (90 DAP) 2 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	415.93	398.17	426.32	1240.42	413.47
A1M2	288.20	325.45	320.11	933.76	311.25
A1M3	443.42	446.43	422.76	1312.61	437.54
A1M4	288.99	333.56	305.83	928.38	309.46
A1M5	416.56	403.10	418.88	1238.54	412.85
A1M6	268.03	285.33	264.86	818.216	272.74
A1M7	398.12	429.70	468.86	1296.68	432.23
A1M8	522.11	489.54	457.56	1469.21	489.74
A1M9	475.34	479.58	457.67	1412.59	470.86
A1M10	174.76	216.23	238.51	629.5	209.83
A2M1	**492.16**	**536.76**	**486.97**	1515.89	505.30
A2M2	**407.66**	**396.62**	**405.03**	1209.31	403.10
A2M3	**483.22**	**479.53**	**534.18**	1496.93	498.98
A2M4	**422.67**	**433.03**	**381.92**	1237.62	412.54
A2M5	**468.00**	**499.72**	**492.36**	1460.08	486.69
A2M6	**344.69**	**456.62**	**335.23**	1136.54	378.85
A2M7	**425.56**	**474.79**	**438.39**	1338.74	446.25
A2M8	**713.32**	**645.44**	**649.42**	2008.18	669.39
A2M9	**645.63**	**635.22**	**653.45**	1934.3	644.77
A2M10	**301.01**	**274.61**	**347.63**	923.249	307.75

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 159	Yield per plot (in Kg), (90 DAP)			1 YEAR	
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	2.31	2.20	2.32	6.84	2.28
A1M2	1.73	2.11	1.71	5.55	1.85
A1M3	2.83	2.37	2.50	7.70	2.57
A1M4	2.08	1.69	1.76	5.53	1.84
A1M5	2.52	2.37	2.30	7.19	2.40
A1M6	1.85	1.67	1.61	5.13	1.71
A1M7	2.59	2.49	2.26	7.34	2.45
A1M8	3.08	2.93	2.88	8.89	2.96
A1M9	2.95	2.81	3.04	8.80	2.93
A1M10	1.57	1.13	1.27	3.97	1.32
A2M1	**3.06**	**3.13**	**2.98**	9.17	3.06
A2M2	**2.47**	**2.30**	**2.44**	7.21	2.40
A2M3	**2.97**	**2.87**	**2.97**	8.81	2.94
A2M4	**2.70**	**2.49**	**2.35**	7.54	2.51
A2M5	**2.89**	**2.77**	**3.00**	8.67	2.89
A2M6	**2.18**	**2.47**	**1.92**	6.57	2.19
A2M7	**2.64**	**2.73**	**2.84**	8.22	2.74
A2M8	**3.98**	**3.82**	**3.91**	11.71	3.90
A2M9	**3.93**	**3.81**	**3.51**	11.25	3.75
A2M10	**1.78**	**1.70**	**2.21**	5.69	1.90

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 160	Yield per plot (in Kg), (90 DAP)				2 YEAR
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	2.30	2.39	2.26	6.94252	2.31
A1M2	1.73	1.95	1.92	5.60256	1.87
A1M3	2.36	2.48	2.54	7.37567	2.46
A1M4	1.73	2.00	1.83	5.57028	1.86
A1M5	2.20	2.42	2.51	7.13122	2.38
A1M6	1.61	1.71	1.59	4.9093	1.64
A1M7	2.39	2.58	2.21	7.18008	2.39
A1M8	3.13	2.94	2.75	8.81526	2.94
A1M9	2.85	2.88	2.75	8.47554	2.83
A1M10	1.25	1.30	1.43	3.977	1.33
A2M1	**2.95**	**3.22**	**2.92**	9.09535	3.03
A2M2	**2.45**	**2.38**	**2.43**	7.25584	2.42
A2M3	**2.40**	**2.88**	**3.21**	8.48158	2.83
A2M4	**2.24**	**2.60**	**2.29**	7.12571	2.38
A2M5	**2.81**	**3.00**	**2.95**	8.76048	2.92
A2M6	**2.07**	**2.74**	**2.01**	6.81921	2.27
A2M7	**2.55**	**2.85**	**2.63**	8.03245	2.68
A2M8	**4.08**	**3.87**	**3.90**	11.8491	3.95
A2M9	**3.87**	**3.81**	**3.72**	11.4058	3.80
A2M10	**1.81**	**1.65**	**2.09**	5.5395	1.85

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 161 Yield per hectare (ton), (90 DAP) 1 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	15.16	13.61	16.30	45.07	15.02
A1M2	12.72	12.62	11.41	36.74	12.25
A1M3	15.00	13.61	16.64	45.25	15.08
A1M4	12.38	12.73	12.26	37.37	12.46
A1M5	15.10	14.34	15.31	44.75	14.92
A1M6	12.30	10.46	10.04	32.80	10.93
A1M7	13.09	16.59	16.03	45.71	15.24
A1M8	18.35	18.94	16.09	53.38	17.79
A1M9	17.43	17.67	18.56	53.66	17.89
A1M10	6.25	6.68	6.17	19.10	6.37
A2M1	15.06	20.37	20.60	56.02	18.67
A2M2	16.52	15.32	16.26	48.10	16.03
A2M3	18.95	20.40	16.34	55.70	18.57
A2M4	16.28	16.62	14.62	47.52	15.84
A2M5	17.59	18.47	17.37	53.43	17.81
A2M6	13.02	16.46	12.81	42.29	14.10
A2M7	17.63	17.12	18.16	52.91	17.64
A2M8	24.34	26.43	23.20	73.97	24.66
A2M9	25.33	26.32	21.11	72.76	24.25
A2M10	9.67	10.69	10.92	31.28	10.43

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 162 Yield per Hectare (in Ton), (90 DAP) 2 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	16.88	12.50	16.37	45.7441	15.25
A1M2	12.88	12.19	11.95	37.0278	12.34
A1M3	15.70	15.47	16.28	47.4509	15.82
A1M4	12.87	10.52	11.69	35.0868	11.70
A1M5	14.54	14.09	14.51	43.1389	14.38
A1M6	13.00	10.42	11.45	34.8779	11.63
A1M7	13.69	17.19	15.70	46.5805	15.53
A1M8	17.78	17.19	19.05	54.0147	18.00
A1M9	17.67	17.67	17.53	52.8785	17.63
A1M10	5.90	5.97	6.10	17.9773	5.99
A2M1	**16.80**	**16.85**	**17.98**	51.6367	17.21
A2M2	**16.31**	**15.86**	**16.20**	48.3722	16.12
A2M3	**19.33**	**14.21**	**17.17**	50.7034	16.90
A2M4	**15.69**	**16.35**	**15.28**	47.3168	15.77
A2M5	**15.50**	**16.73**	**17.42**	49.653	16.55
A2M6	**13.79**	**15.24**	**13.44**	42.4619	14.15
A2M7	**16.92**	**16.86**	**15.65**	49.4351	16.48
A2M8	**21.11**	**26.75**	**21.17**	69.0293	23.01
A2M9	**20.35**	**23.70**	**23.80**	67.8417	22.61
A2M10	**11.24**	**10.61**	**9.20**	31.0546	10.35

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 163 Available soil nitrogen content (kg/ha), (90 DAP) 1 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	295	280	285	860.00	286.67
A1M2	250	280	250	780.00	260.00
A1M3	280	275	295	850.00	283.33
A1M4	275	265	225	765.00	255.00
A1M5	285	255	180	720.00	240.00
A1M6	240	260	240	740.00	246.67
A1M7	280	275	285	840.00	280.00
A1M8	270	290	220	780.00	260.00
A1M9	250	260	240	750.00	250.00
A1M10	185	220	220	625.00	208.33
A2M1	320	285	290	895.00	298.33
A2M2	275	250	260	785.00	261.67
A2M3	270	250	240	760.00	253.33
A2M4	250	240	270	760.00	253.33
A2M5	260	260	260	780.00	260.00
A2M6	275	230	250	755.00	251.67
A2M7	285	250	285	820.00	273.33
A2M8	250	250	265	765.00	255.00
A2M9	260	270	250	780.00	260.00
A2M10	220	210	220	650.00	216.67

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 164 Available soil nitrogen content (kg/ha), (90 DAP) 2 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	310	260	280	850	283.33
A1M2	260	240	250	750	250.00
A1M3	290	260	275	825	275.00
A1M4	250	260	250	760	253.33
A1M5	265	230	215	710	236.67
A1M6	250	240	260	750	250.00
A1M7	290	285	280	855	285.00
A1M8	260	270	180	710	236.67
A1M9	240	260	240	740	246.67
A1M10	220	190	220	630	210.00
A2M1	260	300	280	840	280.00
A2M2	260	255	260	775	258.33
A2M3	250	265	250	765	255.00
A2M4	280	260	240	780	260.00
A2M5	270	270	260	800	266.67
A2M6	280	260	270	810	270.00
A2M7	270	280	260	810	270.00
A2M8	260	255	240	755	251.67
A2M9	280	240	250	770	256.67
A2M10	200	220	240	660	220.00

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 165 Available phosphorus content of soil (kg/ha), (90 DAP) 1 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	24.25	23.3	21.5	69.05	23.02
A1M2	21.25	21.2	22.5	64.95	21.65
A1M3	23.44	23.7	19.15	66.29	22.10
A1M4	22	19.9	21	62.90	20.97
A1M5	21.5	20.2	18.9	60.60	20.20
A1M6	23.77	22.1	19.5	65.37	21.79
A1M7	23.65	24.75	22.5	70.90	23.63
A1M8	18.7	21.66	20.5	60.86	20.29
A1M9	21.86	20.6	18.5	60.96	20.32
A1M10	19.6	18.6	18.4	56.60	18.87
A2M1	24.75	22.65	23.25	70.65	23.55
A2M2	21.45	21.5	22.85	65.80	21.93
A2M3	22.72	24.15	23.5	70.37	23.46
A2M4	23.15	22.2	21.1	66.45	22.15
A2M5	23.2	21.3	22.4	66.90	22.30
A2M6	21.3	23.1	18.6	63.00	21.00
A2M7	26.98	22.55	23.6	73.13	24.38
A2M8	23.87	19.6	19	62.47	20.82
A2M9	21.85	19.55	22.42	63.82	21.27
A2M10	18.5	18.5	17.2	54.20	18.07

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 166 Available phosphorus content of soil (kg/ha), (90 DAP) 2 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	24.15	23.35	22.75	70.25	23.42
A1M2	22.15	22.1	20.5	64.75	21.58
A1M3	22.66	22.5	21.2	66.36	22.12
A1M4	16.9	21.8	23.7	62.4	20.80
A1M5	21.6	20.5	22.5	64.6	21.53
A1M6	25.98	24.2	21.4	71.58	23.86
A1M7	24.4	23.1	25.21	72.71	24.24
A1M8	18.4	21.45	20.5	60.35	20.12
A1M9	21.75	22.15	20.5	64.4	21.47
A1M10	20.86	19.5	19.7	60.06	20.02
A2M1	23.8	24.95	24.15	72.9	24.30
A2M2	21.5	22.65	21.55	65.7	21.90
A2M3	23.65	21.25	22.2	67.1	22.37
A2M4	23	20.4	22.5	65.9	21.97
A2M5	22.14	24.25	22.1	68.49	22.83
A2M6	20	23	23.5	66.5	22.17
A2M7	27.75	26.2	18.6	72.55	24.18
A2M8	24.53	18.2	18.5	61.23	20.41
A2M9	20.8	20.55	21.78	63.13	21.04
A2M10	19.5	18.5	19.55	57.55	19.18

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6- Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10- Control(No mulch)

Annexure 167 Available pottasium content of soil (kg/ha), (90 DAP) 1 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	273	285	285	843.00	281.00
A1M2	268	270	269	807.00	269.00
A1M3	255	250	279	784.00	261.33
A1M4	248	255	265	768.00	256.00
A1M5	280	260	280	820.00	273.33
A1M6	260	255	235	750.00	250.00
A1M7	295	255	290	840.00	280.00
A1M8	275	270	270	815.00	271.67
A1M9	285	280	250	815.00	271.67
A1M10	225	235	253	713.00	237.67
A2M1	275	270	280	825.00	275.00
A2M2	245	260	275	780.00	260.00
A2M3	270	260	270	800.00	266.67
A2M4	265	260	245	770.00	256.67
A2M5	285	275	285	845.00	281.67
A2M6	240	270	256	766.00	255.33
A2M7	295	270	255	820.00	273.33
A2M8	290	280	265	835.00	278.33
A2M9	265	270	265	800.00	266.67
A2M10	255	250	245	750.00	250.00

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

Annexure 168 Available potassium content of soil (kg/ha), (90 DAP) 2 YEAR					
Treatments	**R1**	**R2**	**R3**	**TOTAL**	**MEAN**
A1M1	280	278	287	845	281.67
A1M2	275	258	239	772	257.33
A1M3	268	270	274	812	270.67
A1M4	275	258	250	783	261.00
A1M5	275	280	285	840	280.00
A1M6	250	255	240	745	248.33
A1M7	275	280	275	830	276.67
A1M8	279	265	270	814	271.33
A1M9	270	255	260	785	261.67
A1M10	235	255	240	730	243.33
A2M1	290	270	270	830	276.67
A2M2	250	275	269	794	264.67
A2M3	280	260	280	820	273.33
A2M4	245	250	270	765	255.00
A2M5	275	280	265	820	273.33
A2M6	240	265	243	748	249.33
A2M7	285	270	270	825	275.00
A2M8	280	250	255	785	261.67
A2M9	264	275	265	804	268.00
A2M10	250	235	230	715	238.33

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

- A1- drip irrigation, A2- manual irrigation.
- M1- Straw mulch, M2- Wood shaving, M3-Leaf litter, M5- Pine needle, M6-Cut grass, M7-Rice husk, M8-Black poly-mulch, M9-Silver poly-mulch, M10-Control(No mulch)

APPENDIX I

METEOROLOGICAL PARAMETERS OF N. VANLAIPHAI. 2017-2019

Month	Rainfall (mm)			Relative humidity (%)			Temperature (°C)					
							2017		2018		2019	
	2017	2018	2019	2017	2018	2019	Max.	Min.	Max.	Min.	Max.	Min.
January	0.0	3.3	0.0	36.8	45.9	49.5	24.3	4.7	23.7	5.3	22.2	8.1
February	2.0	1.2	10.6	35.5	35.5	36.7	26.4	6.2	26.6	9.1	27.7	12.3
March	78.0	11.9	12.1	39.7	32.3	39.0	25.1	6.5	28.0	12.3	26.5	13.8
April	149.0	85.0	58.6	31.5	36.4	38.0	28.0	8.6	27.6	10.0	28.0	13.1
May	79.8	189.8	53.4	36.0	42.5	35.9	28.3	11.8	28.2	10.5	28.5	11.1
June	344.0	598.6	288.8	85.3	95.6	92.8	26.4	10.2	28.0	13.0	28.5.2	14.0
July	328.0	256.0	857.2	94.2	95.1	91.2	27.1	10.8	27.0	11.0	24.4	15.8
August	559.9	342.2	360.7	95.4	92.1	90.1	26.4	10.6	27.9	11.8	25.2	13.1
September	390.6	124.8	99.9	96.3	92.4	91.3	27.9	12.1	28.4	13.3	27.5	12.9
October	270.6	123.3	61.1	92.2	92.2	83.0	27.7	13.6	27.9	14.1	23.1	13.4
November	21.0	1.2	51.0	57.0	57.4	59.3	26.8	11.9	28.5	10.7	24.2	11.2
December	22.6	11.6	7.0	47.8	48.4	47.6	23.3	9.2	21.6	11.2	23.7	10.5

Source: Meteorological Centre, Department of Science and Technology, Govt. of Mizoram

Appendix II. Details of economics of cultivation per hectare (in Rupees) for poly house (Experiment 1)										
Crops: Strawberry Var. Sweet charlie, Plant population :40,000 nos, spacing- 30x 45 cm,, wages-400/mandays										
Particulars of works	**C_1T_1**	**C1T2**	**C1T3**	**C1T4**	**C1T5**	**C1T6**	**C1T7**	**C1T8**	**C1T9**	**C1T10**
1.Cost of land preparation										
Cleaning, ploughing, harowing of plots with tilling machine @Rs 1300/hr	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000
Bed/ Plot formation & applicatin of manures & fertilizers	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000
2. Cost of materials input										
Planting materials (Poly-potted) @ Rs 15/polypot	6,00,000	6,00,000	6,00,000	6,00,000	6,00,000	6,00,000	6,00,000	6,00,000	6,00,000	6,00,000
Fertilizers (Urea220: SSP500:MOP170) kg/ha	12,570	12,570	12,570	12,570	12,570	12,570	12,570	12,570	12,570	12,570
FYM (10t/ha) @ Rs 10 /kg	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000
Mulching Materials	50,000	50,000	50,000	50,000	50,000	50,000	50,000	100,000	100,000	0
Packaging	83,500	75,400	83,500	74,000	83,500	65,000	85,500	99,800	98,800	45,000
Drip irrigation kits including installation	95,000	95,000	95,000	95,000	95,000	95,000	95,000	95,000	95,000	95,000
water reservoir (5000L)	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000
Tools & implements (LS)	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
PP chemicals (LS)	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000

3. Cost of Labour										
Application of mulch materials	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000	0
Planting & other interculture operation	20,000	20,000	20,000	20,000	20,000	20,000	20,000	12,000	12,000	24,000
Cost of Water & watering	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Havesting, Packing & transportation	32,000	30,000	32,000	30,000	32,000	30,000	32,000	35,000	35,000	16,000
4. cost of Poly-house for 3 months (@Rs750 m^2 the life span of steel stucture poly house =10 years)	1,87,500	1,87,500	1,87,500	1,87,500	1,87,500	1,87,500	1,87,500	1,87,500	1,87,500	1,87,500
Cost of cultivation	1,276,570	1,266,470	1,276,570	1,265,070	1,276,570	1,256,070	1,278,570	1,337,870	1,336,870	1,160,070
Contingency/ miscellaneous cost (2% of cultivation cost)	25,531.4	25,329.4	25,531.4	25,301.4	25531.4	25121.4	25,571.4	26,757.4	26,737.4	23,201.4
Gross expenditures	1,302,101	1,291,799	1,302,101	1,290,371	1,302,101	1,281,191	1,304,141	1,364,627	1,363,607	1,183,271
Yield (kg)	19,643	16,599	19,334	16,266	18,991	16,025	19,457	24,133	23,823	10,388
Gross Income selling price@ 250per kg	49,10,829	4,149,743	48,33,423	40,66,506	47,47,645.5	40,06,243	48,64,341	60,33,136.2	59,55,703	25,97,097
Net income	3,608,727	2,857,944	3,531,321	2,776,134	3,445,544	2,725,051	3,560,200	4,668,509	4,592,096	1,413,826
BC ratio	**2.77**	**2.21**	**2.71**	**2.15**	**2.65**	**2.13**	**2.73**	**3.42**	**3.37**	**1.19**

Appendix III. Details of economics of cultivation per hectare (in Rupees) for drip irrigation (Experiment 1)										
Crops: Strawberry Var. Sweet charlie, Plant population :40000 nos, spacing- 30x 45 cm,, wages-400/mandays										
Particulars of works	**$C2T_1$**	**C2T2**	**C2T3**	**C2T4**	**C2T5**	**C2T6**	**C2T7**	**C2T8**	**C2T9**	**C2T10**
1.cost of land preparation										
Cleaning, ploughing, harowing of plots with tilling machine @Rs 1300/hr	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000
Bed/ Plot formation & applicatin of manures & fertilizers	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000
2. Cost of materials input										
Planting materials (Poly-potted) @ Rs 15/polypot	6,00,000	6,00,000	6,00,000	6,00,000	6,00,000	6,00,000	6,00,000	6,00,000	6,00,000	6,00,000
Fertilizers (Urea220: SSP500:MOP170) kg/ha	12,570	12,570	12,570	12,570	12,570	12,570	12,570	12,570	12,570	12,570
FYM (10t/ha) @ Rs 10 /kg	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000
Mulching Materials	50,000	50,000	50,000	50,000	50,000	50,000	50,000	105,000	100,000	0
Packaging	53,500	54,500	54,500	54,500	63,500	54,500	63,500	80,800	80,800	25,000
Drip irrigation kits including installation	95,000	95,000	95,000	95,000	95,000	95,000	95,000	95,000	95,000	95,000
water reservoir (5000L)	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000
Tools & implements (LS)	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
PP chemicals (LS)	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000

3. Cost of Labour										
Application of mulch materials	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000	0
Planting & other interculture operation	20,000	20,000	20,000	20,000	20,000	20,000	20,000	12,000	12,000	28,000
Cost of Water & watering	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Havesting, Packing & transportation	31,000	24,000	30,000	25,000	30,000	23,500	31,000	35,500	35,500	18,000
4. C**ost of Poly-house for 3 months** (@Rs750 m2 the life span of steel stucture poly house =10 years)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Cost of cultivation	1,058,070	1,052,070	1,058,070	1,053,070	1,067,070	1,051,570	1,068,070	1,136,870	1,131,870	958,570
Contingency/ miscellinous cost (2% of cultivation cost)	21161	21041	21161	21061	21341	21031	21361	22737	22637	19171
Gross expenditures	1,079,231	1,073,111	1,079,231	1,074,131	1,088,411	1,072,601	1,089,431	1,159,607	1,154,507	977,741
Yield (kg)	15,335.81	12,294.65	15,150.26	12,076.61	14,648.91	11,279.82	15,181.2	17,898.5	17,756.4	7,380.3
Gross Income selling price@ 250per kg	38,33,954	30,73662	37,87564	30,19,152	36,62,228	28,19,956	37,95,307	44,74,636	44,39,097	18,45,065
Net income	2,754,722	2,000,550	2,708,333	1,945,020	2,573,816	1,747,355	2,705,876	3,315,028	3,284,590	867,324
BC ratio	**2.55**	**1.86**	**2.51**	**1.81**	**2.36**	**1.63**	**2.48**	**2.86**	**2.85**	**0.89**

Appendix IV. Details of economics of cultivation per hactare (in Rupees) for manual irrigation (Experiment 2)										
Crops: Strawberry Var. Sweet charlie, Plant population :40000 nos, spacing- 30x 45 cm,, wages-400/mandays										
Particulars of works	**I2T1**	**I2T2**	**I2T3**	**I2T4**	**I2T5**	**I2T6**	**I2T7**	**I2T8**	**I2T9**	**I2T10**
1.cost of land preparation										
Cleaning, ploughing, harowing of plots with tilling machine @Rs 1300/hr	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000
Bed/ Plot formation & applicatin of manures & fertilizers	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000
2. Cost of materials input										
Planting materials (Poly-potted) @ Rs 15/polypot	6,00,000	6,00,000	6,00,000	6,00,000	6,00,000	6,00,000	6,00,000	6,00,000	6,00,000	6,00,000
Fertilizers (Urea220: SSP500:MOP170) kg/ha	12,570	12,570	12,570	12,570	12,570	12,570	12,570	12,570	12,570	12,570
FYM (10t/ha) @ Rs 10 /kg	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000
Mulching Materials	50,000	50,000	50,000	50,000	50,000	50,000	50,000	90,000	90,000	0
Packaging	75,400	74,100	79,800	74,300	75,400	74,300	75,900	88,500	88,300	73,000
Drip irrigation kits including installation	0	0	0	0	0	0	0	0	0	0
water reservoir (5000L)	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000
Tools & implements (LS)	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
PP chemicals (LS)	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000

Appendix IV, Continue ..

3. Cost of Labour										
Application of mulch materials	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000	0
Planting & other interculture operation	20,000	20,000	20,000	20,000	20,000	20,000	20,000	12,000	12,000	29,600
Cost of Water & watering	17,000	17,000	17,000	17,000	17,000	17,000	17,000	17,000	17,000	17,000
Havesting, Packing & transportation	25,000	21,000	24,000	21,000	25,000	22,000	25,000	28,000	28,000	19,000
cost of cultivation	983,970	978,670	987,370	978,870	983,970	979,870	984,470	1,032,070	1,031,870	919,170
Contingency/ miscellinous cost (2% of cultivation cost)	19679	19573	19747	19577	19679	19597	19689	20641	20637	18383
Gross expenditures	1,003,649	998,243	1,007,117	998,447	1,003,649	999,467	1,004,159	1,052,711	1,052,507	937,553
Yield (kg)	13610	10980	12900	10910	13450	10790	13510	15690	15630	7030
Gross Income selling price@ 250per kg	3402500	2745000	3225000	2727500	3362500	2697500	3377500	3922500	3907500	1757500
Net income	2,398,851	1,746,757	2,217,883	1,729,053	2,358,851	1,698,033	2,373,341	2,869,789	2,854,993	819,947
BC ratio	**2.39**	**1.75**	**2.20**	**1.73**	**2.35**	**1.70**	**2.36**	**2.73**	**2.71**	**0.87**

Appendix V. Details of economics of cultivation per hactare (in Rupees) for drip irrigation (Experiment 2)										
Crops: Strawberry Var. Sweet charlie, Plant population :40000 nos, spacing- 30x 45 cm,, wages-400/mandays										
Particulars of works	**I1T$_1$**	**I1T2**	**I1T3**	**I1T4**	**I1T5**	**I1T6**	**I1T7**	**I1T8**	**I1T9**	**I1T10**
1.cost of land preparation										
Cleaning, ploughing, harrowing of plots with tilling machine @Rs 1300/hr	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000
Bed/ Plot formation & application of manures & fertilizers	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000
2. Cost of materials input										
Planting materials (Poly-potted) @ Rs 15/poly-pot	6,00,000	6,00,000	6,00,000	6,00,000	6,00,000	6,00,000	6,00,000	6,00,000	6,00,000	6,00,000
Fertilizers (Urea220: SSP500:MOP170) kg/ha	12,570	12,570	12,570	12,570	12,570	12,570	12,570	12,570	12,570	12,570
FYM (10t/ha) @ Rs 10 /kg	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000
Mulching Materials	50,000	50,000	50,000	50,000	50,000	50,000	50,000	105,000	100,000	0
Packaging	53,500	54,500	54,500	54,500	53,500	54,500	63,500	80,800	80,800	25,000
Drip irrigation kits including installation	95,000	95,000	95,000	95,000	95,000	95,000	95,000	95,000	95,000	95,000
water reservoir (5000L)	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000
Tools & implements (LS)	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
PP chemicals (LS)	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000

Appendix V continue..

3. Cost of Labour										
Application of mulch materials	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000	0
Planting & other intercultural operation	20,000	20,000	20,000	20,000	20,000	20,000	20,000	12,000	12,000	28,000
Cost of Water & watering	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Harvesting, Packing & transportation	31,000	24,000	30,000	25,000	30,000	23,500	31,000	35,500	35,500	18,000
Cost of cultivation	1,058,070	1,052,070	1,058,070	1,053,070	1,057,070	1,051,570	1,068,070	1,136,870	1,131,870	958,570
Contingency/ miscellaneous cost (2% of cultivation cost)	21,161	21,041	21,161	21,061	21,141	21,031	21,361	22,737	22,637	19,171
Gross expenditures	1,079,231	1,073,111	1,079,231	1,074,131	1,078,211	1,072,601	1,089,431	1,159,607	1,154,507	977,741
Yield (kg)	15,236	12,295	15,110	12,077	14,649	11,780	15,321	17,899	17,756	73,80
Gross Income selling price@ 250per kg	38,08,954	30,73,662	37,77,564	30,19,152	36,62,228	29,44,956	38,30,307	44,746,36	44,39,097	18,45,065
Net income	2,729,722	2,000,550	2,698,333	1,945,020	2,584,016	1,872,355	2,740,876	3,315,028	3,284,590	867,324
BC ratio	**2.53**	**1.86**	**2.50**	**1.81**	**2.40**	**1.75**	**2.52**	**2.86**	**2.85**	**0.89**

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BRIEF BIODATA

Name: Vanlalhmuaka Ngente

Date of Birth 23.03.1979

Gender Male

Fathers name Mr. Rammawia Ngente (L).

Mothers name Mrs. Lalrinthangi.

Permanent address H/N: ZWB/A-17, Zemabawk, Aizawl, Mizoram

Academic profiles

Qualification	Passing year	University/ Institution	Percentage/ OGPA	Division
M.Sc. Horticulture (HAMP)	2009	Mizoram University. Tanhril, Aizawl	70.50%	I^{st} Div.
B.Sc. Agriculture	2003	Central Agricultural University-Imphal	7.35 OGPA	I^{st} Div
HSSLC	1999	MBSE	50.8%	II div
HSLC	1994	MBSE	54.4%	II div

List of Publications:

1. **Vanlalhmuaka Ngente,** Olivia Lalremsangi, Jonathan Lalrinngheta, Chhungpuii Khawlhring 2023. Effect of Mulch Materials on the Plant Performance and Productivity of Strawberry (*Fragaria x ananassa* Duch.) under poly-house cultivation. *Science and technology Journal*. 11(2): 101-108.
2. **Vanlalhmuaka Ngente,** Chhungpuii Khawlhring and T. Vanlalngurzauva**.** 2021. Utilization of Different Mulch Materials on Strawberry (*Fragaria x Ananassa* Duch.) Cultivation under Open Condition in Mizoram. *J Krishi Vigyan.* **9** (2):245-250.

]

Seminar/Symposium/Training attended:

1. Paper Presentation in International Seminar on, "Effect of Different Mulch Materials on Strawberry (*Fragaria X ananassa* Duch.) Cultivation under Open Condition" in the 2nd Annual Convention of North East (India) Academy of Science and Technology (NEAST) & International Seminar on Recent Advances in Science and Technology (IRSRAST) during 16th–18th November 2020 (Virtual) organized by NEAST, Mizoram University, Aizawl-796004, Mizoram (India).
2. Paper presentation on, 'Effect of Different Mulch Materials on Strawberry (*Fragaria X ananassa* Duch.) Cultivation under poly-house Condition' in the National Conference on 'Microbes in Health, Agriculture and Environments' organised by Department of Biotechnology, School of Life Sciences, Mizoram University, Aizawl during 20^{th} &21^{st} June, 2019.
3. Participated in 2 days virtual trainers training on 'Production Technology and Post-Harvest Management of Horticulture Crops' organized by Central Institute of Horticulture, DAC & FW, GOI, Nagaland on 23-24 June, 2021.
4. Participated in distant learning school on 'Wild and Under-utilized Fruit' organized by Regional Centre, NAEB in association with Society for Advancement of Human and Nature (SADHNA), Dr. YS Parmer university of Horticulture and Forestry from May to November, 2011 securing 80% marks.
5. Attended 21 days training, 'Advance Training course on Wild and Under-utilized Fruit' organized by Regional Centre, NAEB in association with Society for of Human and Nature (SADHNA), Dr. YS Parmer university of Horticulture and Forestry from 2 to22 November, 2011 at Nauni, Solan HP.
6. Attended 4 days training programme on, 'Advances in seed production Technology for potential crops' from 15^{th} November to 18^{th} November, 2022 organised by Extention Education Institute (NE Region), MA & FW,GOI, & AAU, Khanapara, Guwahati.

PARTICULARS OF THE CANDIDATE

NAME OF CANDIDATE:	**Vanlalhmuaka Ngente**
DEGREE:	**Doctor of Philosophy**
DEPARTMENT:	**Department of Horticulture, Aromatic & Medicinal Plants**
TITLE OF THESIS:	**Effect of different mulch materials on growth, yield and quality of strawberry in open and polyhouse cultivation in Mizoram.**
DATE OF ADMISSION:	**10.08.2016**
APPROVAL OF RESEARCH PROPOSAL:	
1. BOS :	**26.04.2017**
2. SCHOOL BOARD	**31.05.2017**
MZU REGISTRATION NO. :	**3612 of 2007-08**
Ph.D. REGISTRATION NO. & DATE:	**MZU/Ph.D/1066 of 31.05.2017**
EXTENSION (IF ANY):	**No. 16-2/MZU (ACAD)/21/179-182**

HEAD

DEPARTMENT OF HORTICULTURE,

AROMATIC & MEDICINAL PLANTS

Abstract

Strawberry (*Fragaria x Ananassa* Duch) family: *Rosaceae* is one of the most important soft fruit and being preferred by people around the world due to its attractive colour, pleasant flavor and aroma. It is also amongst the few crops which give quick and very high returns per unit area on the capital investment.

An investigation entitled "**"EFFECT OF DIFFERENT MULCH MATERIALS ON GROWTH, YIELD AND QUALITY OF STRAWBERRY IN OPEN AND POLYHOUSE CULTIVATION IN MIZORAM**" was carried out at demonstration farm, Krishi Vigyan Kendra, N. Vanlaiphai, Serchhip District, Mizoram, for two consecutive year viz. 2017-2018 and 2018-2019. The experiment was laid out in Factorial Randomised Block design with nine mulching treatments viz. Straw (T1), Saw dust (T2), Wood shaving (T3), Leaf litter (T4), Pine needle (T5), Cut grass (T6), Rice husk (T7), Black poly-mulch (T8), Silver poly-mulch (T9) along with Control, No mulch (T10). The investigation consist of two sets of experiment i.e to study the 'effect of different mulch materials on growth, yield and quality of strawberry in open and polyhouse cultivation and determination of efficacy of drip irrigation and manual irrigation in strawberry cultivation with different mulch treatment. Parameters viz. plant growth parameters (plant height, plant spread, number of leaves and weed intensity), yield attributing parameters (number of flowers, number of fruits, fruit set percentage and number of runners), fruit quality parameters (fruit size, fruit weight, shelf life, TSS, acidity, total sugar, ascorbic acid content, anthocyanin content), Physico – chemical properties of soil (soil moisture content, soil temperature, pH, NPK), yield and economics of cultivation were recorded and analyzed in this investigation.

Experiment 1: Effect of different mulch materials on growth, yield and quality of strawberry in open and polyhouse cultivation:

Different kind of mulching significantly improves the plant growth yield and fruit quality of strawberry. The tallest plant height (11.9 cm, 21.4 cm and 26.81 cm) was recorded with black poly-mulch (M8), the lowest plant height (9.68 cm, 13.29 cm and 15.39 cm) was recorded in control (M10). Plant height was influenced by growing condition where taller plant height (12.29 cm, 18.76 cm and 21.33 cm) was observed under polyhouse cultivation as compared to open cultivation in the individual years as well as pool analysis.

The maximum plant spread (14.65 cm, 25.66 cm and 31.88 cm) in N-S direction was observed under M8, Black poly-mulch while the maximum plant spread (15.92 cm, 26.33 cm and 31.12 cm) in E-W direction also recorded with Black poly-mulch (M8). The minimum plant spread in both N-S and E-W direction was recorded with no mulch (M10) at 30, 60 and 90 DAP. Plant spread (N- S and E-W direction) were also influenced significantly by their growing conditions, higher values of plant spread N-S direction as well as E-W direction were observed under Black poly mulch at 30, 60 and 90 DAP.

Maximum number of leaves (10.92, 24.06 and 28.20) was recorded under M8, black poly-mulch and minimum number of leaves (7.30, 12.38 and 17.00) was recorded under no mulch at 30, 60 and 90 DAP. Significant influences by growing conditions were observed in number of leaves where more number of leaves were obtained from poly-house cultivation compared to open cultivation.

Minimum weeds emergence (0.12 per m^2) at 30 DAP was observed under M9, silver poly-mulch, 0.33 per m2 and 0.59 per m^2 at 60 and 90 DAP were recorded under black poly mulch (M8) whereas the maximum weeds emergence was recorded with M10, no mulch at 30, 60 and 90 DAP. Poly-house cultivation showed lower weed emergence than open cultivation.

Maximum number of flowers per plant (41.21), maximum number of fruits per plant (40.15), the highest fruit setting percentage (97.39 %) and maximum number of runners per plant (5.83) were observed under M8 black poly-much on the other hand minimum number of flowers per plant (24.18), the minimum number of fruit per plant (21.47), the minimum number of fruit setting percentage (88.69 %) and minimum number of runners per plant (2.68) were found under M10 no mulch. Significant influence in yield attributing characters were also observed with growing condition where higher number of flowers per plant (33.80), fruit per plant (31.96), fruit setting percentage (95.14 %) and higher number of runners per plant (4.62) were observed in poly-house cultivation than in open cultivation.

The maximum fruit length (4.04 cm), fruit breadth (3.66 cm) and fruit weight (19.87 gm) were observed under M8, black poly mulch followed by M9, silver poly-mulch while, the minimum fruit length (2.96 cm), fruit breadth (2.60 cm) and fruit weight (12.30 gm) were cited under M10 (no mulch) also higher values of fruit length (3.75 cm), fruit breadth (3.23 cm) and fruit weight (17.49 gm) were observed with poly-house cultivation compared to open cultivation.

The fruit quality in terms of TSS (8.19 ^{0} brix), total sugar (6.81 %), ascorbic acid content (52.57 mg/ 100 gm) and anthocyanin content (48.17 mg/100 gm) were highest and the titrable acidity (0.44 %) was lowest under black poly mulch (M8). The growing condition had significant influence in the fruit quality where higher TSS (7.97 ^{0} Brix), total sugar content (6.26 %), ascorbic acid (49.96 mg/100 gm) and anthocyanin content (44.78 mg/100 gm) were observed under poly-house cultivation while lower acidity (0.50 %) was found under open cultivation.

The physiological loss in weight (loss in moisture %) were influenced by various types of mulching materials, the minimum loss was observed under black poly mulch (6.02 %) followed by silver poly mulch (6.04 %) within 24hr however, the minimum loss within 48 hr was observed under M1, paddy straw mulch (9.51 %) followed by M3, wood shaving (9.64 %), the lowest loss in moisture within 72 hr was observed under M3, wood shaving (12.96 %) the maximum loss in weight was cited under M10, no mulch (6.89 %, 11.05 %, 15.67 %) in 24hr , 48hr and 72hr respectively. The growing condition had significant effect in the physiological loss in weight of strawberry fruit, where loss in weight was lower under open cultivation (5.98 %, 9.80 %, and 13.87 %) in 24hr, 48hr and 72hr respectively when compared with polyhouse cultivation.

The soil temperature recorded was highest at M8, black poly-mulch (23.23 ^{0} C) followed by M9, silver poly-mulch while the minimum temperature was recorded at M2, saw dust mulch (21.13 ^{0} C) at 30 DAP. At 60 DAP, black poly- mulch (25.44 ^{0} C) recorded the maximum soil temperature while the minimum was recorded under straw mulch (22.27 ^{0} C). At 90 DAP, the maximum soil temperature was noted under Black poly-mulch (29.43 ^{0} C) while the minimum was recorded under M5, pine needle mulch (25.57 ^{0} C). Higher soil temperature was recorded under poly-house cultivation (22.21 ^{0}C, 23.41 ^{0}C and 27.15 ^{0} C) as compared to open cultivation at 30, 60 and 90 DAP.

The maximum soil moisture content (48.10 %) was record under black poly-mulch (M8) followed by M9, silver poly-mulch whereas minimum moisture record (25. 27 %) was found under no mulch (M10). At 60 DAP, highest moisture (45.27 %) content of the soil was recorded at M9, silver poly-mulch while the minimum record (25.58 %) was observed under no mulch. At 90 DAP, the highest soil moisture (40.57 %) was recorded under plastic mulch while the minimum moisture (22.06 %) content was observed under no mulch. The soil moisture content was influenced significantly by the growing condition where the higher moisture content was observed under poly-house cultivation at 30, 60 and 90DAP.

The maximum available soil nitrogen (N) and potassium (P) content was recorded under M1, paddy straw mulch (287.08 kg/ha and 278.58 kg/ha), the highest soil phosphorus (P) content was found in M7, rice husk (24.11 kg/ha) and the lowest available soil N, P and K was observed under no mulch (M10). No significant effect on soil pH was observed with mulching treatments and growing condition.

The highest yield per plant (575.81 gm), highest yield per plot (4.52 kg) as well as per ha (20.87 ton) was found under black poly-mulch (M8) whereas the lowest yield per plant (256.64 gm), per plot (1.45 kg) and per hectare (8.28 ton) were found under M10, no mulch. Significant effect by the growing condition was observed in the fruit production where higher yield per plant (474.68 gm), per plot (3.23 kg) and per hectare (17.36 ton) was observed under poly-house cultivation as compared to open cultivation.

The maximum gross expenditure per hectare (Rs. 13,64,627), maximum income per hectare (Rs. 60,33,136) and maximum net income per hectare (Rs. 46,68,509) with BC ratio of 3.42:1 under polyhouse cultivation.

Mulching had better influence on the plant performance of strawberry cultivation than no mulch. Among the different mulch treatments, black poly-mulch treatments was the best treatment for plant growth and development, weed suppression, fruit size and quality as well as yield in strawberry cultivation under Mizoram condition. Strawberry can be cultivated under both open and polyhouse condition but the present study resulted in better plant performance, better yield and more cost effective cultivation with polyhouse cultivation compared to open cultivation.

Experiment 2: Efficacy of drip irrigation and manual irrigation in strawberry cultivation with different mulch treatment:

Irrigation condition has significant effect in the plant height of strawberry and taller plant height (18.31 cm) was observed under drip irrigation. Also various types of mulching had significant effect on plant height, the maximum plant height (19.81 cm) was observed under Black poly- mulch (M8).

Significant effect of drip irrigation have been observed in plant spread, the wider plant spread, 25.64 cm in N-S direction and 24.79 cm in E-W direction was observed under drip irrigation condition, the maximum plant spread (28.41 cm) in N-S direction and 26.81 cm in E- W direction was observed under black poly mulch (M8).

More number of leaves (21.66) was recorded with drip irrigation compared to manual irrigation and the maximum number of leaves (24.37) was observed under black poly-mulch (M8) whereas the minimum number of leaves (13.07) was observed under no mulch (M10).

The lesser number of weeds (5.40) was found under drip irrigation as compared to manual irrigation. The minimum number of weeds (0.84) was observed under silver poly mulch, (M9) while the maximum no of weed was found under no mulch (M10).

The higher number of flowers (25.85), fruits (25.15), fruit setting percentage (88.64 %) and runners (3.45) per plant were recorded under drip irrigation. The maximum number of flowers (33.26), maximum number of fruits (32.06) and the highest fruit setting percentage (96.54 %) and maximum numbers of runners (4.90) was observed under black poly-mulch (M8).

The heavier fruit weight (14.52), higher TSS (8.19 ^{0} Brix), higher acidity (0.50 %), the higher content of total sugar (5.87 %) , higher value of anthocyanin (38.05 mg/100 gm) and higher ascorbic acid content (49.97 mg/100 gm) was observed under drip irrigation compared to manual irrigation. The maximum individual fruit weight (15.38 gm), maximum value of total sugar (6.26 %) and the maximum value of anthocyanin with the minimum value of titrable acidity (0.43 %) were observed under black poly mulch (M8).

Higher yield per plant (369.75 gm), per plot (2.22 kg) and per hectare (14.83 ton) were obtained under drip irrigation. Maximum yield per plant (493.25 gm), per plot (2.96 kg) and per hectare (19.73 ton) were obtained under black poly-mulch (M8).

The use of drip irrigation improves the economics of cultivation and cost benefit ratio of strawberry cultivation, gross expenditure (Rs. 11,59,607), net income (Rs.

33,15,028) and the benefit cost ratio was highest (2.86:1) in black poly mulch under drip irrigation.

Drip irrigation result in better plant performance, lesser weed infestation, better fruit production and fruit quality and also better cost effective cultivation when compared with manual irrigation and the use of black poly mulch (M8) showed best result in overall plant performance, fruit production, fruit quality and yields as well as maximum weed suppression. Hence, black poly-mulch may be recommended for use as mulching material for strawberry cultivation under drip and manual irrigation.