MULCHING AND MICRO IRRIGATION PRACTICES FOR YIELD OPTIMIZATION OF CHILLI IN RAIN SHELTER

by

SHILPA E.N

(2017-11-050)

THESIS

Submitted in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF AGRONOMY
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM – 695 522
KERALA, INDIA

2019

DECLARATION

I, hereby declare that this thesis entitled **"MULCHING AND MICRO IRRIGATION PRACTICES FOR YIELD OPTIMIZATION OF CHILLI IN RAIN SHELTER"** is a bonafide record of research done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled **"MULCHING AND MICRO IRRIGATION PRACTICES FOR YIELD OPTIMIZATION OF CHILLI IN RAIN SHELTER"** is a record of research work done independently by Ms. Shilpa E. N (2017-11-050) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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ACKNOWLEDGEMENTS

With great respect, I express my heartfelt gratitude to my guide and chairman of Advisory Committee, ***Dr. T. Sajitha Rani,*** *Professor and Head, Instructional Farm for giving me the opportunity to do this work. The thesis appears in its current form due to her valuable guidance, constant supervision and advices. I solemnly submit my honest and humble thanks to her for bringing my dreams into reality.*

I am extremely thankful to the members of the advisory committee, ***Dr. O. Kumari Swadija*** *Professor and Head, Department of Agronomy,* ***Sri. V Jayakrishnakumar*** *Associate professor, Department of Agronomy and* ***Dr. B. Rani*** *Professor, Department of Soil Science & Agricultural Chemistry for their valuable suggestions, moral support, timely correction of thesis and encouragement.*

I express my gratitude to ***Dr. Sheela, Dr. Sansamma George*** *and* ***Dr. Elizabeth K. Syriac*** *(Retired Professors) for their valuable suggestion and deep insights, scholarly advice, generous support and timely help in all possible ways during the entire period of my study and research work.*

I am thankful to ***Dr. A. S Anilkumar,*** *Professor, Department of Agronomy, for his encouragement, inspiration and support during my study.*

I wish to place on record my thanks to each and every teaching and non-teaching staff of Agronomy Department and Instructional Farm especially ***Deepu chettan, Girija chechi, Bijith Chettan, Shivaprsad chettan*** *and* ***Asha chechi*** *for their sincere and wholehearted co-operation throughout the research work.*

Words are inadequate to express my heartfelt gratitude to my colleagues, ***Namitha, Amal, Amala, Greeshma, Reni, Yamini, Abhuji, Anju, Reshma, Liz, Dhanu, Gopan, Golmei, Bindya*** *for their friendship, affection, encouragement, and suggestions during the difficult times of my study.*

I avail this opportunity to express my sincere regards to my dear friends, especially ***Navi, Lakshmi, Neethu, Safna and Ankitha*** *and my seniors* ***Dhanalakshmi***

***chechi, Lekshmi chechi, Gritta chechi, Ammu chechi, Anju chichi, Anjana chechi, Ishratha, Pooja chechi, Akhilettan**, **Nihalatha, Greeshma chechi, Kari chechi, Pinky chechi, Chinju chechi and Amrithechi** for their unreserved help during the course of my study and for their inspiration.*

*I would express my heartful thanks to my dear **13 batch** of **Padannakkad** family especially **Ayshu, Akhil, Thadiyan, Sethu, Jeba, Suhu**, and **Rohit** for their lovely support and care.*

*At this moment, I recall with love and gratitude, the constant encouragement and inspiration given to me by my **family members.***

*Words can't express the deep gratitude to my dear father **E. Narayanan Nair,** mother **P. Sharada** and brother, **Dr. Sreeveen. E. N.** for their affection, encouragement, mental support, caring and sacrifices for educating and preparing me for my future. I would not be where I am today without my family.*

Shilpa E. N

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LIST OF ABBREVIATIONS

et al.	And others
@	At the rate of
Cm	Centimeter
CD	Critical difference
DAT	Days after transplanting
°C	Degree Celsius
DMP	Dry matter production
FYM	Farmyard manure
Fig.	Figure
G	Gram
K. lux	Kilo lux
kg ha^{-1}	Kilogram per hectare
LAI	Leaf area index
L	Litre
Max.	Maximum
M	Metre
Mg	Milligram
Mm	Milli metre
Mt	Million tonnes
Min.	Minimum
MOP	Muriate of potash
viz.	Namely

N	Nitrogen
NS	Not-significant
No.	Number
POP	Package of practices
%	Per cent
m^{-2}	Per metre square
ha^{-1}	Per hectare
P	Phosphorus
K	Potassium
RH	Relative humidity
₹ ha^{-1}	Rupees per hectare
SE	Standard error
i.e.	That is
t ha^{-1}	Tonnes per hectare

INTRODUCTION

1. INTRODUCTION

Chilli (*Capsicum annum* L.) is considered as one of the commercial spice crops and cultivated extensively in India for its fruits which are used in green as well as ripe dried form for its pungency. The green chilli fruits are used in salad as well as in curries. They have biting pungency attributed to the alkaloid capsaicin and captivating red colour due to the pigment capsanthin. The fruits also contain fixed oil (red colouring matter) which is non-pungent and yield 20 to 25 per cent alcoholic extract called oleoresin The oleoresins of chilli are used by food industries in the preparation of processed products and also for incorporation into number of pharmaceutical formulations (Kumar and Rai, 2005).

The largest producer of chilli in the world is India, accounting for 13.76 mt of production annually. Indian share in global chilli production ranges between 50 to 60 per cent (Geetha and Selvarani, 2017).

Indian chilli is considered to be world famous owing to its colour and pungency levels. However, the availability of chilli per capita per day is very low. In the present scenario, there is an urgent need to increase the production of chilli by manipulating the production technology. The main reasons for low productivity are water stress, unbalanced nutrient management and weed problem during the critical stages of growth and development. Under such situation, the targeted yield can be achieved by providing optimum nutrition and maintaining adequate soil moisture and proper weed management. For efficient water and weed management, fertigation along with mulching is the best option (Banjara, 2014).

Any material used at the surface of the soil primarily to prevent loss of water by evaporation, to keep down weeds, to dampen temperature fluctuations or to promote soil productivity generally may be designated as mulch (Jacks *et al.*, 1955). Mulching is usually done with the organic materials like green leaves, dry leaves, straw, rice husk, sugarcane trash etc. During the last 60 years, the advent of synthetic materials have altered the method and benefits of mulching. When compared to other mulches, plastic mulches are completely impermeable to water and therefore prevent direct evaporation of moisture from the soil, thus limiting water loss and soil erosion from the surface. Plastic mulch can offer a barrier against weeds, moisture loss, nutrient loss, erosion and insect and disease injury. It encourages plant establishment and an earlier crop of potentially higher quality. The combined effect of soil temperature, soil moisture and weed suppression not only work to improve crop growth but also facilitate hand picking and lead to higher yield and increased fruit size. Different mulches regulate soil moisture and temperature, suppress weeds and improve germination and emergence. Increase in soil temperature by application of plastic mulch causes a significant reduction in pathogen levels. The effect of plastic mulch and its colour improves soil structure, crop growth and development (Abdul-Baki *et al.,* 1992). Higher yield and better quality, less infestation of insects diseases, earliness, prolonged growing season, higher nutritive value of the produce and improved storability are the advantages of mulching.

Drip irrigation is very popular in areas of water scarcity as this system provides more frequent, precise and direct application of water in small quantities in the root zone. Drip irrigation has also proved to produce more crop per unit of applied water. In surface drip irrigation (DI), water and nutrients are introduced to soil surface near roots through emitters. Sub surface drip irrigation (SDI) laterals are buried underground, supplying water and nutrients directly to root zone (Phene and Beale, 1976).

Surface drip irrigation system usually is being adopted by the farmers in most parts of the country. Such a system can be made more applicable for irrigating a wide range of fruit crops by installing laterals below soil surface as a sub surface drip. Sub surface drip has the same range of discharge rates as surface drip (ASAE Standards, 2003). The system has a higher capability for minimizing the loss of water by evaporation, runoff and deep percolation in comparison with other irrigation methods which supply water to the soil surface.

Hence the present study was conducted with following objectives:

- To assess the effect of different types of mulching material and drip irrigation on the growth and yield of chilli in rain shelter.
- To work out the economics.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Chilli (*Capsicum annuum* L.) is an important spice cum vegetable crop cultivated extensively in India. It belongs to the family Solanaceae. Chilli is cultivated all over India and is mainly used in salads, chutney, sauces, pickles and also main ingredient of Indian diet. However, the availability of chilli per capita per day is very low. Looking to present scenario, there is an urgent need to increase the production of chilli by modifying the production technology. The main reasons for low productivity are water stress, unbalanced nutrient management and weed problem during the critical stages of growth and development. The literature pertaining to the use of mulching, sub surface irrigation and surface irrigation have been reviewed and presented in this chapter.

2.1 EFFECT OF BLACK POLYETHENE MULCH

2.1.1 Effect on Growth and Growth Attributes

In a study conducted by Anisuzzaman *et al.* (2009) on the effect of different mulches in onion, use of black polythene mulch resulted in increased plant height, higher number of tillers per plant, higher number of leaves per plant and maximum number of umbels per plant compared to white polythene mulch, water hyacinth mulch and control.

Growth attributes like plant spread, plant height and number of leaves per plant were significantly higher for muskmelon under black polythene mulch compared to organic mulches and control (Bhatt *et al.,* 2011).

Belel (2012) compared the effect of grassed and synthetic mulching materials on growth and yield of sweet pepper (*Capsicum annuum*) and found that plant height was higher with black polythene mulch compared to control.

Banjara (2014) studied the response to fertigation and black plastic mulch on the growth and yield of chilli (*Capsicum frutescens* L.). The highest plant height, stem girth and number of leaves were recorded for black polythene mulch compared to control.

According to Hanumant (2014), in bitter gourd and summer squash, the growth parameters like height of plant, number of leaves per plant and number of branches per plant were significantly higher with black plastic mulch than control.

Mulching with black polythene sheet recorded earliness in germination and flowering and higher fresh and dry biomass in squash and okra compared to bare soil. Number of branches per plant and length of okra per plant were also higher under black polythene mulch (Mahadeen, 2014).

Muhammed (2015) conducted a study on efficacy of mulches for weed management in okra and reported a significantly higher plant height at 30 days after sowing with black polyethene mulch compared to unweeded control.

A study conducted by Pinder *et al*. (2016) revealed that mulching with black polyethene sheet in tomato increased the plant height which was significantly higher compared to control.

Selvaperumal and Muthuchamy (2017) noticed a significantly higher plant height in chilli with black plastic mulch of 25 micron thickness than control.

Jaysawal *et al.* (2018) studied the effect of different mulches on growth and yield of carrot (*Daucus carota* L.) and reported that plant height, leaf length, number of leaves per plant, fresh weight and dry weight of leaves, fresh weight and dry weight of roots, fresh weight and dry weight of carrot plant, root length and root diameter were higher for plants grown under black polyethene mulch compared to control.

Kumar and Sharma (2018) conducted an experiment to study the effect of mulching on growth, yield and quality in different varieties of summer squash (*Cucurbita pepo* L.) and observed taller plants and higher number of leaves per plant with black polythene mulch than control.

2.1.2 Effect on Yield Attributes and Yield

Asiegbu (1991) observed significantly increased yield (52.8 t ha^{-1}) in tomato with black polythene mulch over control (32.8 t ha^{-1}).

Abdul-Baki *et al.* (1992) studied the effect of black polyethylene mulch on yield of tomato and reported that significantly higher yield with black polythene mulch (87.4 t ha^{-1}) compared to control (43.1 t ha^{-1}).

Mukherjee *et al.* (2010) pointed out that in tomato, significantly higher fruit yield was recorded under black polythene mulch (43 Mg ha^{-1}) compared to white polythene mulch (23.5 Mg ha^{-1}), rice straw mulch (19.8 Mg ha^{-1}) and no mulch (36.4 per cent) treatments.

Ashrafuzzaman *et al.* (2011) conducted an experiment to study the effect of plastic mulch on growth and yield of chilli and recorded the maximum number of fruits per plant (472) and the highest fruit weight per plant with black polyethene mulch compared to blue mulch and transparent mulch.

Bhatt *et al.* (2011) studied the effect of mulch materials on vegetative characters, yield and economics of summer squash (*Cucurbita pepo*) under rainfed mid -hill condition of Uttarakhand and revealed that higher fruit yield was recorded under black polythene mulch compared to control.

Belel (2012) studied the effects of grassed and synthetic mulching materials on growth and yield of sweet pepper (*Capsicum annuum*) and reported the highest fruit weight per plant (23.75 g), fruit length and fruit yield per plant with black polythene mulch over control (11.7 g).

Choudhary *et al.* (2012) observed a significantly higher fruit yield (31.24 t ha^{-1}) in capsicum with black polythene mulch compared to no mulching treatment (22.56 t ha^{-1}).

From a trial conducted in tomato, Singh and Kamal (2012) observed higher plant height with black polyethene mulch compared to those grown under bare soil conditions. There was a yield increase from 21.7 to 29.8 per cent in black polyethene mulch over control.

Banjara (2014) conducted a trial on chilli with black plastic mulch, paddy straw mulch and control. Black polythene mulch gave significantly higher fruit yield, fruit weight and fruit length compared to other treatments.

Mahadeen (2014) noticed a significantly higher yield in summer vegetable crops like squash and okra with black polythene mulch. The study revealed that with black polythene mulch, okra yield was increased by 140 per cent and squash yield about 60 per cent compared to bare soil.

Black polythene mulch increased the number of fruits per plant, fruit weight and total fruit yield per plant in bitter gourd and summer squash compared to control (Hanumant, 2014).

In green bean, black polythene mulch showed higher pod yield compared to clear polythene mulch, grass mulch and control treatments (Kwambe *et al.*, 2015).

Mulching with black polyethene sheet in okra recorded significantly higher number of fruits and total fruit yield compared to control (Muhammed, 2015).

Pinder *et al.* (2016) conducted a study to evaluate the effect of different mulching materials on tomato production and observed higher number of fruits per plant (10.46), fruit weight (23.34 g) and fruit yield for black polyethene mulch compared to control (6.58 and 14.74 g, respectively).

Selvaperumal and Muthuchamy (2017) observed maximum number of fruits per plant and maximum fruit length of chilli under black polythene mulch with 25 micron thickness.

Jaysawal *et al.* (2018) reported that the maximum fruit yield in chilli was recorded under black polyethene mulch compared to blue and white polyethene mulches and organic mulches.

The experiment conducted in summer squash by Kumar and Sharma (2018) revealed that the number of fruits per plants, average fruit weight, yield per plant, yield per hectare and number of harvest obtained with black polythene mulch were higher compared to control.

2.1.3 Effect on Weed Biomass

Asiegbu (1991) studied the response of tomato and eggplant to mulching and N fertilization under tropical conditions and noticed that black polyethene mulch had reduced the weed biomass significantly compared to other organic mulches.

Choudhary *et al.* (2012) noticed a reduction in weed biomass and weed dry weight with black polyethene mulch compared to control.

Jamkar (2014) reported that black polyethene mulch resulted in a reduction of weed biomass of *Cyperus rotundus, Cynodon dactylon,* and *Convolvulus arvensis* population in chilli.

Kwambe *et al.* (2015) noticed that in green beans weed infestation was less at eight weeks after planting under black polythene mulch treatment compared to grass, rice left over and control treatments.

Muhammed (2015) observed that black mulches can effectively minimize weed infestation and nutrient loss in okra.

Bobby *et al.* (2017) reported that total weed count and weed dry weight decreased significantly with black polyethene mulch in cucumber.

2.1.4 Effect on Soil Properties

2.1.4.1 *Soil Temperature*

According to Romic *et al.* (2003) black polythene mulch increased the soil temperature in watermelon compared to paper mulch, clear film mulch and control.

Treatment with black polythene mulch produced a significantly higher soil temperature in green beans (33.5 °C) at eight weeks after planting compared to other organic and inorganic mulch treatments. The lowest temperature was recorded under grass mulched soil (26.8 °C) (Kwambe *et al.* 2015).

Muhammad (2015) conducted a study on efficacy of mulches for weed management in okra and observed that soil temperature can be higher up to 35.43°C under black plastic mulch compared to organic mulches.

Canul-Tuna *et al.* (2017) conducted a study on influence of coloured plastic mulch on soil temperature, growth, nutrimental status and yield of bell pepper under shade house conditions and observed that maximum soil temperature of 25.9 ° C was recorded under black polyethene mulch compared to control (22.6 °C).

In a study conducted in tomato, Singh and Kamal (2012) reported that the highest soil temperature was recorded under black polyethene mulch (34.1°C) over control (31.4°C).

2.1.4.2 *Soil Moisture*

Maurya and Lal (1981) reported that in maize and cowpea, black polythene mulch recorded a higher soil moisture content than control.

According to Mahadeen (2014) black polythene mulch increased the soil moisture content in summer vegetable crops like squash and okra at 30, 60, 90 days after planting compared to bare soil.

Kwambe *et al.* (2015) conducted a study on the effects of organic and inorganic mulches on growth and yield of green bean (*Phaseolus vulgaris* L.) in a semi-arid environment and revealed that higher soil moisture content was observed under black polythene mulch treatment (64.33 %) at eight weeks after planting than control (45.77 %).

2.2 EFFECT OF ORGANIC MULCH

2.2.1 Effect on Growth and Growth Attributes

A study conducted by Maurya and Lal (1981) on the effects of different mulch materials on soil properties and on root growth and yield of maize (*Zea mays*) and cowpea (*Vigna unguiculata*) and revealed that organic mulch recorded higher root growth and development compared to other mulching materials.

In ginger mulching with organic mulches significantly increased rhizome sprouting, reduced weed infestation, increased the number of tillers, leaves per clump and size of leaf over control (Chandra and Govind, 2001).

Dukare *et al.* (2017) found that in cowpea, organic mulches recorded a higher root length of 33.50 cm compared to black mulch (19.75 cm).

The experiment conducted in hot pepper (*Capsicum annuum* L.) by Zerga *et al.* (2017) revealed that higher plant height, number of branches and higher number of leaves per plant were recorded by organic mulches compared to other mulches.

2.2.2 Effect on Yield Attributes and Yield

A study conducted by Chandra and Govind (2001) reported that treatment with organic mulches significantly increased the rhizome yield of ginger compared to no mulch. Among organic mulches paddy straw mulch showed a significantly higher rhizome yield (43.6 per cent) compared to other mulches.

Ghosh *et al.* (2006) found out that in summer ground nut, an increased pod yield was observed under paddy straw mulch compared to control and black polyethene mulch. The increased yield was about 20 per cent and 9 per cent respectively.

Kar and Kumar (2007) reported that rice straw mulch with different irrigation levels increased the tuber yield of potato compared to non-mulched condition. An increased yield of 24 to 42 per cent was reported under rice straw mulch compared to control.

According to Komla (2013) organic mulch recorded significantly higher yield in sweet pepper during dry season (*Capsicum annum* L.) compared to control at 50 per cent flowering stage.

Sathiyamurthy *et al.* (2017) conducted a study on the effect of different mulching materials on weed intensity, yield and economics in chilli and reported that among the different mulching materials, organic mulch recorded higher yield compared to control.

2.2.3 Effect on Weed Biomass

Komla (2013) reported that in sweet pepper (*Capsicum annuum* L.), organic mulches especially cocoa pod husk significantly minimized weed growth than control.

2.2.4 Effect on Soil Properties

2.2.4.1 *Soil Moisture*

Chakraborty *et al.* (2008) conducted a study on the effect of mulching on soil plant water status, and the growth and yield of wheat. Study revealed that rice husk mulch maintained a higher moisture content at deeper layers of soil compared to transparent mulch and black polyethene mulch.

According to Komla (2013), soil moisture maintained a significantly higher level in sweet pepper (*Capsicum annuum* L.) under organic mulched area compared to control in the dry season.

According to Muhammad (2015) coconut frond mulch increased the soil organic carbon content significantly (1.85) compared to unweeded control (1.56).

2.3 EFFECT OF SILVER BLACK POLYETHENE MULCH

2.3.1 Effect on Growth and Growth Attributes

In an experiment conducted by Parmar *et al.* (2013) for studying the effect of mulching materials on growth, yield and quality of watermelon (*Citrullus lanatus*) using materials like wheat straw, silver black polyethylene mulch and dry leaves. It was reported that silver black polyethene mulch recoded significantly higher growth rate compared to others.

Dattatraya (2014) reported that silver black mulching produced maximum number of branches per plant, minimum days to first flowering and higher plant height at 45 and 90 DAT compared to control.

Rao *et al.* (2017) found that in watermelon higher number of branches per vine and increased main vine length were reported with silver black polythene mulch compared to other coloured mulches and organic mulches.

2.3.2 Effect on Yield Attributes and Yield

Parmar *et al.* (2013) conducted a study on effect of mulching material on growth, yield and quality of watermelon (*Citrullus lanatus*) and found that significantly higher fruit yield, average fruit weight, and fruit length were recorded under silver black polyethene mulch.

Dattatraya (2014) obtained the highest yield of 23.97 t ha^{-1} in chilli when mulched with silver black polyethene mulch sheet compared to control (16.47 t ha^{-1}).

A study conducted by Rao *et al*. (2017) on the effect of mulching on growth, yield and economics of watermelon (*Citrullus lanatus*) revealed that the highest fruit weight and fruit yield (35.57 t ha^{-1}) were recorded under silver black polythene mulch compared to control (15.31 t ha^{-1}).

2.3.3 Effect on Soil Properties

2.3.3.1 *Soil Moisture*

According to Dattatraya (2014) silver black polyethene mulch improved moisture status of the soil compared to other polyethene mulches and organic mulches.

2.3.4 Effect on Pest and Disease Incidence

Population density of thrips and aphids and the incidence of leaf curl disease was lower in plots mulched with silver black polyethene (Dattatraya, 2014).

2.4 EFFECT OF NEWSPAPER MULCH

2.4.1 Effect on Yield Attributes and Yield

Munn (1992) compared the effect of shredded newspaper and crop straw mulch on different crops and observed an increased fruit yield of soybean, corn and tomatoes with shredded newspaper compared to straw mulch and control.

2.4.2 Effect on Weed Biomass

Pellet and Heleba (1995) studied the effect of chopped newspaper for weed control in nursery crops and reported that weed growth was lower with chopped newspaper (< 5 weeds m^{-2}) compared to control (200 weeds m^{-2}).

According to Monks *et al.* (1997), chopped newspaper 2.5 cm deep controlled annual grass weeds in tomato effectively (89%) compared to shredded newspaper 2.5 cm deep (40%). It was reported that rain can convert chopped newspaper into solid mulch, which effectively reduces the weed growth.

Brault *et al.* (2002) opined that paper mulch had reduced the weed density in iceberg lettuce than control, with black/black paper mulch shows higher weed control efficiency. There were no monocot weeds with black/black paper mulch.

Sanchez *et al.* (2008) conducted a study on newspaper mulches for suppressing weeds for organic high-tunnel cucumber production and found that newspaper mulches had reduced the growth of predominant weeds such as *Amaranthus spp*, *Galinsoga ciliata*, *Setaria spp, Panicum dichotomiflorum* and *Digitaira spp* compared to straw mulch and no mulch treatment.

Gawronski (2012) reported that in silver beet chard there was a significant reduction ($p<0.0001$) in weed density with newspaper mulch than clover mulch, coffee mulch and control.

2.5 ECONOMICS OF MULCHING

In summer squash, higher net returns (₹ 232629 ha^{-1}) and benefit cost ratio (2.61) were obtained with black polythene mulch compared to control (₹ 94020 ha^{-1} and 1.79 respectively) (Bhatt *et al.*, 2011).

In a study on organic mulch on sweet pepper Komla (2013) observed that the organic mulch (rice husk) recorded least cost of production, highest economic yield and highest revenue.

As per the study conducted by Dattatraya (2014) in chilli with different mulching materials, the high net returns and benefit: cost ratio (₹ 2, 49,029 ha^{-1} and 3.25) were obtained with silver black polyethene mulch compared to control (₹ 161339 ha^{-1} and 2.88, respectively).

Muhammad (2015) reported that the treatment receiving black polyethene mulch recorded significantly higher benefit: cost ratio of 2.77 compared to unweeded control (0.30) in okra.

The economic analysis of an experiment conducted by Rao *et al.* (2017) in watermelon revealed that silver black polythene mulch produced the highest net returns (₹ 357050 ha^{-1}) and highest benefit cost ratio (3.02) whereas no mulch recorded the lowest benefit cost ratio of 1.47.

Selvaperumal and Muthuchamy (2017) observed the highest benefit cost ratio with 25 micron thickness plastic mulch at 100 per cent recommended dose of fertilizer for chilli (*Capsicum annuum* L.).

2.6 EFFECT OF SURFACE DRIP IRRIGATION ON GROWTH AND YIELD OF CROPS

Singandhupe *et al.* (2003) conducted fertigation studies and irrigation schedules in drip irrigation system in tomato crop (*Lycopersicon esculentum* L.) and found out that tomato under drip irrigation showed an increased yield of 12. 5 per cent compared to furrow irrigated crop. Significantly higher shoot yield was also recorded for drip irrigated crop.

Antony and Singandhupe (2004) studied the impact of drip and surface irrigation on growth, yield and water use efficiency of capsicum (*Capsicum annuum* L.) and observed a higher plant height, number of branches and higher yield under 100 per cent drip irrigated treatment compared to surface irrigation.

Manjunatha *et al.* (2004) compared the effect of drip and surface irrigation on yield and water-production efficiency of brinjal (*Solanum melongena*) and observed that highest plant height (62.8 cm) and brinjal yield (26.2 t ha^{-1}) were obtained under drip irrigation compared to surface irrigation (50.2 cm and 15.7 t ha^{-1} respectively).

As per the study conducted by Ashoka (2005) in chilli, significantly higher plant height (79.21 cm), number of branches and higher fruit yield (2097 kg ha^{-1}) were recorded under drip irrigation with split application of nutrients compared to other methods of irrigation.

Panigrahi *et al.* (2010) studied the water usage and yield responses of tomato as influenced by drip and furrow irrigation and found that a significantly higher yield under drip irrigation at 100 per cent crop evapotranspiration than control.

According to Choudhary *et al.* (2012), in capsicum a significantly higher fruit yield (32.02 t ha^{-1}) was noticed under drip irrigation compared to flood irrigation system (20.52 t ha^{-1}).

Tagar *et al.* (2012) performed a comparative study of drip and furrow irrigation methods at farmer's field in Umarkot and observed that in tomato, yield was significantly higher under drip irrigation system (11440 kg ha^{-1}) than furrow irrigation system (8945 kg ha^{-1}).

Singh *et al.* (2017) observed higher fruit yield per ha and fruit weight per ha in chilli under drip irrigation at 80 per cent pan evaporation compared to control.

2.7 EFFECT OF SUB SURFACE DRIP IRRIGATION ON GROWTH AND YIELD OF CROPS

According Subbarao *et al.* (1997), the highest number of harvestable heads was found in lettuce with sub surface drip irrigation than furrow irrigation. In a study conducted by Ayars *et al.* (1998), with the application of sub surface drip irrigation based on open pan evaporation rate, maximum marketable fruit, non-marketable fruit, total soluble solids and total solids were obtained. All sub surface treatments showed significantly higher yield compared to furrow irrigation. He also observed that in tomato sub surface drip irrigation showed a higher yield compared to high frequency surface drip and low frequency surface drip irrigation.

Hanson and May (2004) conducted a study on the effect of sub surface drip irrigation on processing yield of tomato, water table depth, soil salinity and profitability and observed that in processing tomato sub surface drip irrigation recorded higher yield of 93.63 Mg ha^{-1} compared to sprinkler irrigation (74.82 Mg ha^{-1}).

El-Gindy *et al.* (2009) studied the effect of fertilization and irrigation water levels on summer squash yield under drip irrigation and observed that highest fruit yield per plant, fruit diameter, fruit length and plant height were obtained under sub surface drip irrigation at 80 per cent evapo transpiration over surface drip irrigation.

2.8 COMPARATIVE EFFECT OF SURFACE AND SUB SURFACE DRIP IRRIGATION ON GROWTH OF CROPS

2.8.1 Effect on Growth and Growth Attributes

Singh and Rajput (2007) studied the response of lateral placement depths of sub surface drip irrigation for okra (*Abelmoschus esculentus*) and reported an increase in plant height in sub surface drip irrigation seven weeks after sowing than surface drip irrigation. They also observed that laterals placed at 0.1 m depth showed a significantly higher plant height compared to all other sub surface lateral depths.

Douh and Boujelben (2011) studied the effects of surface and sub surface drip irrigation on agronomic parameters of maize (*Zea mays* L.) under Tunisian climatic condition and it was revealed that sub surface drip irrigation at 0.35 cm depth significantly improved the morphological characters like plant growth and leaf area compared to drip buried at 0 m, 0.05 m, 0.2m depths.

Bidondo *et al.* (2012) conducted a study on comparison of the effect of surface and sub surface drip irrigation on water use, growth and production of a greenhouse tomato crop and found that the sub surface drip irrigation showed higher stem length and stem diameter. This treatment was on par with surface drip irrigation.

In an experiment conducted by Khodke and Patil (2012) to study the response of cauliflower under sub surface drip irrigation system and observed that significantly higher root length and root density was observed under sub surface drip irrigation system than surface drip irrigation system.

Kong *et al.* (2012) reported a higher root growth and deeper root development in bell pepper under sub surface drip irrigation system (2.81 per cent) compared to surface drip irrigation system (1.25 per cent).

Colaka *et al.* (2018) noticed a significantly higher plant height (128 cm) and leaf area in egg plant under surface drip irrigation with an irrigation intervals of three days compared to sub surface drip irrigation. Sub surface drip irrigation exhibited slightly less water consumption over surface drip due to reduced evaporation rate from soil surface.

2.8.2 Effect on Yield Attributes and Yield

Kalfountzos *et al.* (2007) reported that the total seed cotton yield per plant was increased by 21 per cent in sub surface drip irrigation with irrigation levels of 80 per cent and 60 per cent compared to that of surface drip irrigation system.

A significant increase in yield (13.48 per cent) was noticed in okra in sub surface drip irrigation with a lateral placement of 0.10 m than sub surface drip placed at 0, 0.05 and 0.15m (Singh and Rajput, 2007).

As per the study conducted by Douh and Boujelben (2011) in maize, sub surface drip irrigation at a depth of 0.35 m resulted in higher grain yield compared to depth of irrigation at 0 m, 0. 05 m, 0.20 m.

Khodke and Patil (2012) studied the effect of sub surface drip irrigation on moisture distribution, root growth and production of cauliflower and found that the highest curd yield was produced under sub surface drip irrigation with 80 per cent cumulative pan evaporation compared to control.

In an experiment conducted by Kong *et al.* (2012) to compare the response of surface and sub surface drip irrigation under different fertigation levels in bell pepper, it was found that sub surface drip irrigation produced a higher fruit yield of 4 per cent and 13 per cent in 2007 and 2008, respectively over surface drip irrigation.

Colaka *et al.* (2018) studied the yield and quality response of surface and sub surface drip-irrigated egg plant and compared the net returns. There was a significant difference in yield from 40.9 t ha^{-1} in sub surface drip irrigation to 78.70 t ha^{-1} in the surface drip irrigation.

2.9 COMBINED EFFECT OF DRIP IRRIGATION AND MULCHING ON CROP GROWTH AND YIELD

Tiwari *et al*. (1998) observed that the fruit weight and fruit length of tomato were significantly influenced by different types of mulching and drip irrigation. Application of 100 per cent irrigation water through drip irrigation along with black plastic mulching showed significantly higher fruit weight and fruit length compared to control.

Romic *et al.* (2003) opined that in watermelon, combined effect of black polythene mulch and drip irrigation recorded a higher yield of 85% compared to control.

Tiwari *et al.* (2003) studied the effect of drip irrigation on yield of cabbage under mulch and no mulch condition and noticed a significantly higher yield of cabbage through drip irrigation with plastic mulch treatment compared to control.

Paul *et al*. (2013) observed that in capsicum 100 per cent irrigation requirement through drip irrigation with linear low density polyethene mulch produced higher number of fruits per plant and total fruit yield. Higher plant growth was also observed under this treatment.

Brown and Channell-Butcher (2014) reported a higher marketable fruit yield and higher plant height in bell pepper under the combined effect of black plastic mulch and drip irrigation compared to control.

Thakur (2014) studied the effect of fertigation with black polyethylene mulch on growth and yield attributes of tomato (*Solanum lycopersicum* L.) and observed significantly higher plant height and number of fruits per plant under the combined effect of 100 per cent recommended dose of fertilizer through fertigation and black plastic mulch than control.

Biswas *et al.* (2015) compared the effect of drip irrigation and mulching on yield, water use efficiency and economics of tomato and found that the combined effect of drip irrigation at 50 per cent evapo transpiration and mulching shows an increased yield compared to drip irrigation alone at 75 per cent and 100 per cent evapo transpiration.

Sreedevi *et al.* (2017) recorded that growth and growth attributes like number of branches and leaf area index of brinjal (*Solanum melongena* L.) were higher under drip irrigation at 80 per cent evapo transpiration with silver black mulch compared to control. Similarly yield and yield attributes like fruit length and fruit size were also higher under this treatment.

In an experiment conducted by Shivaraj *et al.* (2018) to study the combined effect of coloured plastic mulch and drip irrigation in okra, they noticed that drip irrigation at 80 per cent evapotranspiration with white on black plastic colour mulch produced taller plants. Similarly minimum days to fifty per cent flowering was recorded under drip irrigation at 80 per cent evapotranspiration with white on black plastic mulch.

3. ECONOMICS OF DRIP IRRIGATION

Tiwari *et al.* (1998) studied the response of okra to drip irrigation under mulch and non-mulch condition and revealed that the highest net seasonal income was recorded under drip irrigation with black plastic mulch compared to control.

Study conducted by Singh *et al.* (2007) in chilli revealed significantly higher net return (₹ 230291 ha^{-1}) and benefit cost ratio (2.12) with the application of drip irrigation at 80 per cent pan evaporation. Study also showed that with the increased level of drip irrigation, benefit cost ratio and net return increased significantly.

A study conducted by El-Wahed and Ali (2012) on the effect of irrigation systems, amounts of irrigation water and mulching on corn yield, water use efficiency and net profit found that total returns and net profit was higher under drip irrigation system when compared to sprinkler irrigation system.

Paul *et al.* (2013) studied the effect of drip and surface irrigation on yield, water use- efficiency and economics of capsicum (*capsicum annum* L.) grown under mulch and non-mulch conditions in eastern coastal India and observed that providing 100 per cent irrigation requirement through drip irrigation with black linear low density polyethene mulch produced higher net profit and benefit cost ratio compared to control.

Thakur (2014) recorded higher net return and benefit cost ratio in tomato with the combined effect of 100 per cent recommended dose of fertilizers through drip irrigation and black plastic mulch compared to control.

Biswas *et al.* (2015) studied the effect of drip irrigation and mulching on yield, water-use efficiency and economics of tomato and recorded higher net return under drip irrigation at 50 per cent irrigation level with straw mulch compared to control.

Colaka *et al.* (2018) stated that in egg plant sub surface drip irrigation (fifty percentage of partial root zone drying irrigation at six days interval) had reduced the profit margin when compared to surface drip irrigation (full irrigation at three days interval).

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The experiment entitled "Mulching and micro irrigation practices for yield optimization of chilli in rain shelter" has been carried out at the Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala, during March to September, 2018. The objectives of the field experiment were to assess the effect of different types of mulching materials and drip irrigation systems on the growth and yield of chilli in rain shelter and to work out the economics.

3.1 EXPERIMENTAL SITE

The experiment was conducted in the garden land of the Instructional Farm attached to the College of Agriculture, Vellayani, Kerala. The farm is situated at 8.5° North latitude and 76.9° East longitude, at an altitude of 29 m above mean sea level.

3.1.1 Soil

The soil of the experimental site was sandy clay loam texture with slightly an acidic fraction.

Prior to the investigation, composite soil samples were drawn from 0-30 cm layer from the soil surface and analysed for its mechanical composition and chemical properties. The data on mechanical composition and chemical nature of the soil of the experimental site are presented in Table 1a and 1b respectively.

3.1.2 Cropping History of the Field

The experimental area was under amaranthus cultivation during the year preceding the experiment.

3.1.3 Season

The experiment was conducted during March to September, 2018.

3.1.4 Weather

The data on maximum and minimum temperature, relative humidity, soil temperature and light intensity inside the rain shelter are given in Appendix I and illustrated in Fig. 1 a.

Table 1a. Mechanical composition of the soil of the experimental site

Sl. No.	Fractions	Content in soil (%)	Method used
1	Coarse sand	47.01	Bouyoucos hydrometer method (Bouyoucos, 1962)
2	Find sand	16.64	
3	Silt	4.34	
4	Clay	29.41	
	Texture	Sandy clay loam	

Table 1b. Chemical properties of the soil of the experimental site

Sl. No.	Parameter	Content in soil	Method used
1	Soil reaction (pH)	6.4	Soil : water ratio of 1:1.25 using pH meter (Jackson, 1973)
2	Organic carbon (%)	1.00	Walkley and black rapid titration method (Jackson, 1973)
3	Available N (kg ha^{-1})	112.90	Alkaline permanganate method (Subbiah and Asija, 1956)
4	Available P (kg ha^{-1})	38.01	Bray colorimetric method (Jackson, 1973)
5	Available K (kg ha^{-1})	100.8	Ammonium acetate method (Jackson, 1973)

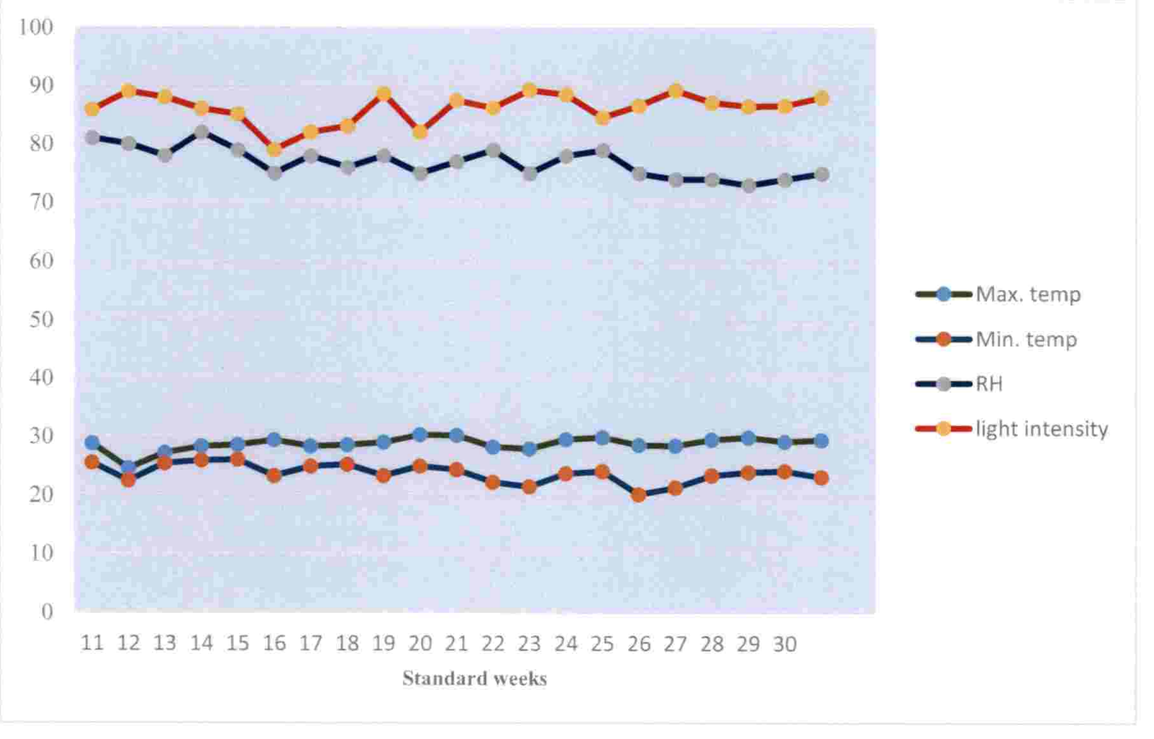

Fig. 1. Weather parameters during the cropping period (inside rain shelter) (March 13- September 13, 2018)

3.2 MATERIALS

3.2.1 Cultivar Used

Chilli variety Vellayani Athulya was used for the experiment. The variety was released from College of Agriculture, Vellayani and is a selection from Aryanadu local. Plants are short statured with good spread, tolerant to shade and highly branching. Fruits have an attractive light green colour with medium pungency. Mature fruits are 8 to 10 cm long.

3.2.2 Source of Seed Material

The seeds for the study were obtained from the Department of Olericulture, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala.

3.2.3 Manures and Fertilizers

Farm yard manure with 0.5 % N, 0.2 % P_2O_5, and 0.5 % K_2O was used as the organic source. Urea (46% N), Rajphos (20 % P_2O_5) and MOP (60 % K_2O) were used as the inorganic sources for the experiment.

3.3 METHODS

3.3.1 Design and Layout

The experiment was laid out in split plot design (Fig.2) with mulching materials as main plot treatment and types of drip irrigation as sub plot treatment.

3.3.2 Treatments

Treatments	: 10
Replication	: 4
Variety	: Vellayani Athulya
Spacing	: 45 cm x 45 cm
Season	: March to September, 2018
Plot size	: 2.7 m × 1.8 m
Main plot treatments	: Mulching materials (M)

m_1: Paper mulch

m_2: Organic mulch (Crop residues)

m_3: Black polythene mulch

m_4: Silver-black polythene mulch

m_5: No mulch

Sub plot treatments: Types of drip irrigation (D)

d_1: Surface drip irrigation
d_2: Sub surface drip irrigation

3.4 CULTURAL OPERATIONS

The details of cultural operations carried out during the course of experiment are detailed below

3.4.1 Land Preparation

The land was ploughed to bring the soil to fine tilth. Plots were laid out as per the layout plan with a plot size of 2.7 m × 1.8 m. Since the soil pH was in acidic range, lime was applied @ 600 kg ha^{-1}. Farm yard manure @ 25 t ha^{-1} was applied one week after lime application. Healthy seedlings of 30 days old were transplanted at a spacing of 45 cm × 45 cm.

3.4.2 Manure and Fertilizer Application

As per Package of Practices recommendation of KAU, FYM @ 25 t ha^{-1} was applied as basal at the time of land preparation and fertilizers were applied @ 75:40:25 kg NPK ha $^{-1}$. Phosphorus was applied as basal by direct soil application whereas N and K applied through fertigation at three days intervals.

3.4.3 Drip Irrigation

The daily requirement of water for chilli calculated as 1.41 L day^{-1} was applied through drip irrigation. Sub surface drip was laid out at a depth of 20 cm.

m_4d_2	m_2d_1	m_1d_2	m_4d_1
m_1d_2	m_4d_2	m_2d_2	m_5d_1
m_4d_1	m_1d_1	m_5d_2	m_4d_2
m_2d_2	m_5d_1	m_3d_1	m_2d_1
m_5d_1	m_2d_2	m_4d_2	m_1d_1
m_3d_2	m_1d_2	m_3d_2	m_5d_2
m_1d_1	m_5d_2	m_4d_1	m_3d_2
m_2d_2	m_3d_2	m_1d_1	m_1d_2
m_5d_2	m_4d_1	m_5d_1	m_3d_1
m_3d_2	m_3d_1	m_2d_1	m_2d_2

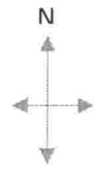

Fig. 2. Layout plan of the experiment

Plate 1. General view of experimental plot

Plate 2. Different mulching materials

Plate 3(a). Surface drip irrigation

Plate 3(b). Sub surface drip irrigation

Plate 4. Initial stage of crop growth

3.4.4 Other Management Practices

Two hand weeding were done at 25 and 45 DAT to keep the experimental area weed free.

3.4.5 Harvest

The crop was ready for first harvest at 45 DAT and subsequent harvests were made at 10 days interval (8 pickings from one plant). The fruits were picked when a slight yellowish green colour appeared.

3.5 OBSERVATIONS

For analysing the growth pattern of the crops, five plants were selected randomly from the net plot area from each replication, tagged as observational plants for reading various observations. The parameters and procedure followed are given below.

3.5.1 Growth Characters

3.5.1.1 *Plant Height*

Height of the observational plants was taken from the base to the growing tip at 30 days intervals. The mean of the plant height of five plants were worked out and expressed in cm.

3.5.1.2 *Number of Branches per Plant*

Number of branches per plant at 50 per cent flowering and final harvest from observational plants were recorded and the mean value was calculated.

3.5.1.3 *Leaf Area Index*

The LAI was calculated at 50% flowering by the following formula developed by Watson (1947).

$$\text{LAI} = \frac{\text{Leaf area plant}^{-1}\ (\text{cm}^2)}{\text{Land area occupied by the plant}\ (\text{cm}^2)}$$

3.5.1.4 *Length of Tap Root*

Length of tap root was recorded at final harvest and expressed in cm.

3.5.1.5 *Root Spread*

The length of the largest lateral root on both sides of the taproot was measured, the mean worked out and expressed in cm.

3.5.1.6 *Root Shoot Ratio*

The plants were pulled out at harvest and the dry weights of shoots and roots were recorded. From this, root: shoot ratio was calculated.

3.5.1.7 *Dry Matter Production*

Total dry matter production was calculated after final harvest. Dry weight of fruits as well as vegetative parts were taken. The samples were dried to a constant weight in hot air oven at 60±5°C and the dry weights were recorded and expressed in kg ha^{-1}.

3.5.1.8 *Days to First Flowering*

Days to first flowering was recorded.

3.5.2 Yield and Yield Attributes

3.5.2.1 *Number of Fruits per Plant*

Number of fruits of observational plants were recorded and the mean was worked out.

3.5.2.2 *Length of Fruit*

Length of randomly selected fruits from observational plants were measured and the mean was calculated and expressed in cm.

3.5.2.3 ***Fruit Yield per Plant***

Total fruit yield from observational plants was recorded and mean yield was calculated in kg.

3.5.2.4 ***Total Fruit Yield per m²***

Fruit yield in the net plot area was converted to yield per m^2.

3.5.3 Quality Aspects of Fruit

3.5.3.1 ***Shelf Life***

Sample fruits were taken treatment wise separately and the number of days taken from the harvest of fruits to the stage at which fruits become shrunken and lost firmness was recorded. The shelf life was represented in days.

3.5.3.2 ***Ascorbic Acid***

Ascorbic acid content of green fruits was estimated by 2, 6- dichlorophenol indophenol dye method (Sadasivam and Manickam, 1992). Ascorbic acid content of the sample was calculated using the formula:

$$\text{Ascorbic acid content (mg 100 g}^{-1}\text{ fresh fruit)} = \frac{\text{Titre value} \times \text{dye factor} \times \text{volume made up to} \times 100}{\text{Aliquot of extract taken} \times \text{weight of sample taken}}$$

3.5.3.3 ***Capsaicin***

Capsaicin content was determined by Folin- Dennis method. The pungent principle react with Folin- Dennis reagent to give a bluish complex which was estimated calorimetrically (Mathew *et al.,* 1971). The capsaicin values were represented in percentage.

3.5.4 Plant Analysis

The nutrients N, P and K were estimated by plant analysis using standard procedure. For this purpose, fruits and other plant parts from each plot were dried in an electrical hot air oven to constant weights at a temperature of 70 °C, ground and passed through a 0.5 mm sieve. The required quantity of samples were weighed out accurately in an electronic balance and were subjected to acid extraction before conducting the chemical analysis.

3.5.4.1 ***Uptake of Nitrogen***

Plant available N was estimated by micro kjeldhal method (Jackson, 1973) and the uptake of N was calculated by multiplying the N content of fruits and other plant parts separately with dry weight of plants and total values were calculated. The uptake values were expressed in kg ha^{-1}.

3.5.4.2 ***Uptake of Phosphorus***

The plant samples were subjected to nitric – perchloric (9:4) digestion and available P contents were determined using Vanadomolybdo phosphoric yellow colour method (Jackson, 1973). The uptake of P was calculated by multiplying the P content of the fruits and other plant parts separately with total dry weight of plants and total values were calculated. The uptake values were expressed in kg ha^{-1}.

3.5.4.3 ***Uptake of Potassium***

Plant samples were subjected to nitric – perchloric (9:4) digestion and available K content in plant samples were determined by flame photometer method (Jackson, 1973). The uptake of K was calculated by multiplying the K content of the fruits and other plant parts separately with total dry weight of plants and total values were calculated. The uptake values were expressed in kg ha^{-1}.

3.5.5 Soil Analysis

Composite soil samples were collected from the experimental area before the experiment and plot wise after the experiment. The air dried samples passed through 2 mm sieve were used for the determination of physico- chemical properties as mentioned in Table 1b adopting standard procedures.

3.5.5.1 *Soil Temperature (15 and 30 cm depth)*

Soil temperatures at 15 and 30 cm depth were observed at weekly interval by using soil thermometer.

3.5.5.2 *Soil Moisture (15 and 30 cm depth)*

Soil moisture contents at 15 and 30 cm depth were calculated at fortnightly interval by gravimetric method.

3.5.6 Incidence of Pest and Disease

No incidence of disease was found to infect crop beyond the economic threshold level demanding control measures and hence no scoring was done. Leaf curl caused by thrips and mites were scored. The following scale (0-4) was adopted for cataloguing the damage (Niles, 1980).

Score	Per cent infestation
0	0
1	1-25
2	26-50
3	51-75
4	>76

3.5.7 Meteorological Parameters

Meteorological parameters like maximum and minimum temperature, relative humidity and light intensity inside the rain shelter were recorded.

3.5.7.1 *Temperature*

The observation on maximum and minimum air temperatures in °C were recorded inside the rain shelter by using a mercury thermometer (0-50° C) at canopy height and averages were computed.

3.5.7.2 *Relative Humidity*

The relative humidity inside the rain shelter was recorded by using wet bulb and dry bulb thermometer (0 to 100 %) expressed in per cent.

3.5.7.3 *Light Intensity*

Light intensity inside the rain shelter was recorded with lux meter at crop canopy level and recorded in K. lux.

3.5.8 Economic Analysis

Economics of cultivation was worked out for the field experiment after taking into account the cost of cultivation and prevailing market price of chilli. The net income and B: C ratio were calculated as follows:

Net income (Rs ha^{-1}) = Gross income – total expenditure

$$\text{Benefit: Cost ratio} = \frac{\text{Gross income}}{\text{Total expenditure}}$$

3.5.9 Statistical Analysis

Data generated from the experiment were subjected to statistical analysis applying Analysis of Variance technique and significance tested by 'F' test (Snedecor and Cochran, 1975). In cases where the effects were found to be significant, CD was calculated using standard techniques.

RESULTS

4. RESULTS

A field experiment to study the effect of mulching and micro irrigation practices for yield optimization of chilli in rain shelter was conducted at the Instructional Farm, College of Agriculture, Vellayani, during the period March to September, 2018. The experimental data collected were statistically analysed and the results obtained are presented in this chapter.

4.1 GROWTH CHARACTERS

4.1.1 **Height of the Plant (cm)**

Different mulching materials significantly influenced the plant height at 30, 60, 90, 120 and 150 days after transplanting (DAT) (Table 2).

Among the different mulching materials, organic mulch recorded maximum plant height at all growth stages viz. 52.31 cm, 69.19 cm and 84.60 cm, 99.40 cm and 106.55 cm at 30, 60, 90, 120 and 150 DAT respectively. Organic mulch was on par with paper mulch and silver black mulch at 30 and 60 DAT and with paper mulch alone at 90 and 150 DAT.

No significant variation was observed among the types of drip irrigation and the interaction of different mulching materials and types of drip irrigation.

4.1.2. **Number of Branches per Plant**

Number of branches per plant recorded at 50 per cent flowering and final harvest is presented in Table 3.

Different mulching materials caused a significant variation in number of branches per plant. At 50 per cent flowering, organic mulch produced the highest number of branches (2.41) and the lowest number of branches was recorded by no mulch (2). Similarly higher number of branches (7.11) at final harvest stage was also recorded by organic mulch.

Types of drip irrigation and the interaction effect had no significant influence on number of branches per plant at 50 per cent flowering and final harvest stage.

Table 2. Effect of mulching materials and types of drip irrigation on plant height, cm

Treatments	Plant height (cm)				
	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT
Mulching materials (M)					
m_1 (Paper mulch)	51.86	66.41	82.11	95.37	105.56
m_2 (Organic mulch)	52.31	69.19	84.60	99.40	106.55
m_3 (Black mulch)	39.45	55.45	70.41	92.08	97.97
m_4 (Silver black mulch)	50.78	67.53	75.74	90.88	98.67
m_5 (No mulch)	37.91	56.27	72.94	88.82	95.13
SE m±	1.26	1.87	1.249	1.22	1.81
CD (0.05)	3.930	5.816	3.890	3.790	5.644
Drip irrigation (D)					
d_1(Surface drip)	48.12	64.81	78.92	94.89	102.76
d_2(Sub surface drip)	44.80	61.12	75.40	91.74	98.80
SE m±	1.18	1.31	1.40	1.05	1.40
CD (0.05)	NS	NS	NS	NS	NS
m×d Interaction					
m_1d_1	50.45	67.32	83.82	100.41	112.25
m_1d_2	53.26	65.51	80.40	90.32	98.88
m_2d_1	56.44	67.77	85.53	99.65	109.12
m_2d_2	48.17	70.60	83.68	99.15	103.98
m_3d_1	38.25	57.13	72.03	90.31	95.64
m_3d_2	40.64	53.78	68.79	93.86	100.31
m_4d_1	53.80	70.53	80.33	93.29	102.09
m_4d_2	47.75	64.52	71.16	88.48	95.25
m_5d_1	41.63	61.33	72.88	90.77	94.69
m_5d_2	34.19	51.22	73.00	86.88	95.57
SE m±	2.26	2.79	2.55	2.06	2.86
CD (0.05)	NS	NS	NS	NS	NS

Table 3. Effect of mulching materials and types of drip irrigation on number of branches per plant

Treatments	Number of branches per plant	
	50 per cent flowering	final harvest
Mulching materials (M)		
m_1 (Paper mulch)	2.24	6.65
m_2 (Organic mulch)	2.41	7.11
m_3 (Black mulch)	2.11	6.27
m_4 (Silver black mulch)	2.05	6.75
m_5 (No mulch)	2.00	6.05
SE m±	0.04	0.10
CD (0.05)	0.125	0.302
Drip irrigation (D)		
d_1(Surface drip)	2.20	6.64
d_2(Sub surface drip)	2.13	6.49
SE m±	0.03	0.06
CD (0.05)	NS	NS
m×d Interaction		
m_1d_1	2.30	6.80
m_1d_2	2.18	6.50
m_2d_1	2.45	7.20
m_2d_2	2.38	7.03
m_3d_1	2.23	6.40
m_3d_2	2.00	6.13
m_4d_1	2.00	6.80
m_4d_2	2.10	6.70
m_5d_1	2.00	6.00
m_5d_2	2.00	6.10
SE m±	0.06	0.13
CD (0.05)	NS	NS

4.1.3. **Leaf Area Index**

Leaf area index recorded at 50 per cent flowering is presented in Table 4. The data revealed that different mulching materials caused significant variation in LAI.

Among the different mulching materials, organic mulch recorded maximum leaf area index (0.60) and it was on par with paper mulch (0.53) and silver black mulch (0.47).

Different types of drip irrigation and the interaction effects did not cause significant variation in LAI at 50 per cent flowering.

4.1.4. **Length of Tap Root (cm)**

Average length of tap root recorded at harvest is presented in Table 5. Different mulching materials, types of drip irrigation and their interaction had no significant influence on length of tap root.

4.1.5. **Root Spread (cm)**

Root spread at final harvest stage is presented in Table 5. Different mulching materials and the interaction between different mulching materials and types of drip irrigation were not found significant.

Different types of drip irrigation significantly influenced root spread at final harvest stage. Root spread was higher for surface drip irrigation.

4.1.6. **Root Shoot Ratio**

Root shoot ratio at final harvest is presented in Table 5. Different types of drip irrigation caused a significant variation in root shoot ratio.

Plant grown with surface drip irrigation produced higher root shoot ratio.

The different mulching materials and interaction effect had no significant influence on root shoot ratio at harvest.

4.1.7. **Dry Matter Production (kg ha^{-1})**

Dry matter production (DMP) at final harvest is presented in the Table 6.

Different mulching materials had significant influence on DMP of crop. Among the different mulching materials the highest DMP was obtained from organic mulch (6,437 kg ha^{-1}) and the lowest dry matter production was recorded by no mulch (5,352 kg).

Table 4. Effect of mulching materials and types of drip irrigation on leaf area index at 50 per cent flowering

Treatments	LAI
	50 per cent flowering
Mulching materials (M)	
m_1 (Paper mulch)	0.53
m_2 (Organic mulch)	0.60
m_3 (Black mulch)	0.39
m_4 (Silver black mulch)	0.47
m_5 (No mulch)	0.27
SE m±	0.06
CD (0.05)	0.171
Drip irrigation (D)	
d_1(Surface drip)	0.50
d_2(Sub surface drip)	0.41
SE m±	0.03
CD (0.05)	NS
m×d Interaction	
m_1d_1	0.48
m_1d_2	0.59
m_2d_1	0.62
m_2d_2	0.59
m_3d_1	0.45
m_3d_2	0.33
m_4d_1	0.55
m_4d_2	0.39
m_5d_1	0.40
m_5d_2	0.14
SE m±	0.08
CD (0.05)	NS

Table 5. Effect of mulching materials and types of drip irrigation on root characters

Treatments	Root characters		
	Length of tap root (cm)	Root spread (cm)	Root - shoot ratio
Mulching materials (M)			
m_1 (Paper mulch)	12.02	18.13	0.07
m_2 (Organic mulch)	8.56	18.45	0.17
m_3 (Black mulch)	8.97	20.72	0.13
m_4 (Silver black mulch)	9.96	21.30	0.06
m_5 (No mulch)	9.88	18.55	0.05
SE m±	0.82	1.20	0.03
CD (0.05)	NS	NS	NS
Drip irrigation (D)			
d_1(Surface drip)	10.20	20.46	0.124
d_2(Sub surface drip)	9.56	18.40	0.052
SE m±	0.42	0.68	0.024
CD (0.05)	NS	2.057	0.0721
m×d Interaction			
m_1d_1	12.16	17.99	0.09
m_1d_2	11.88	18.26	0.04
m_2d_1	7.89	18.13	0.28
m_2d_2	9.24	18.78	0.05
m_3d_1	8.49	24.26	0.19
m_3d_2	9.45	17.18	0.07
m_4d_1	11.41	22.08	0.02
m_4d_2	8.50	20.53	0.05
m_5d_1	11.03	19.83	0.04
m_5d_2	8.73	17.28	0.05
SE m±	0.42	1.61	0.05
CD (0.05)	NS	NS	NS

Table 6. Effect of mulching materials and types of drip irrigation on days to 50 per cent flowering and dry matter production

Treatments	Days to 50 per cent flowering	Dry matter production (kg ha^{-1})
Mulching materials (M)		
m_1 (Paper mulch)	42.38	6104
m_2 (Organic mulch)	42.75	6437
m_3 (Black mulch)	44.63	5818
m_4 (Silver black mulch)	43.25	6081
m_5 (No mulch)	42.63	5352
SE m±	0.08	90.15
CD (0.05)	NS	280.861
Drip irrigation (D)		
d_1(Surface drip)	42.9	6112
d_2(Sub surface drip)	43.35	5804
SE m±	0.09	40.02
CD (0.05)	NS	NS
m×d Interaction		
m_1d_1	43.00	6113
m_1d_2	41.75	6096
m_2d_1	42.50	6697
m_2d_2	43.00	6177
m_3d_1	42.25	6140
m_3d_2	44.00	5496
m_4d_1	43.00	6361
m_4d_2	43.50	5801
m_5d_1	40.75	5250
m_5d_2	44.50	5453
SE m±	0.16	110.15
CD (0.05)	NS	340.476

Types of drip irrigation could not produce significant influence on DMP.

The DMP varied significantly due to the interaction of types of drip irrigation and different mulching materials. Organic mulch with surface drip irrigation produced significantly higher dry matter (6697 kg ha^{-1}) and it was on par with silver black mulch with surface drip irrigation (6361 kg ha^{-1}).

4.1.8 **Days to First Flowering**

Neither the treatments nor their interaction had significant influence on days to flowering.

4.2.2. **Length of Fruit (cm)**

The effect of different mulching materials and types of drip irrigation on length of fruit is presented in table 7.

Main plot treatments significantly influenced the length of fruit. Higher fruit length of 8.74 cm was recorded by organic mulch.

Drip irrigation and its interaction with different mulching materials did not cause significant variation in length of fruit.

4.2.3. **Fruit Yield per Plant (g)**

Different mulching materials significantly influenced the total fruit yield per plant (Table 7).

Among different mulching materials, organic mulch recorded significantly higher fruit yield per plant (736.19 g). The lowest fruit yield per plant was recorded by no mulch (576.43 g) and it was on par with paper mulch (601.25 g).

The types of drip irrigation had no significant influence on fruit yield per plant.

The combination of surface drip with organic mulch recorded maximum fruit yield per plant (762.02 g) and it was on par with silver black mulch combined with surface drip irrigation (721.85 g).

4.2.4. **Fruit Yield per m^2 (kg)**

The effect of different mulching materials and types of drip irrigation on fruit yield per m^2 is presented in Table 7.

The data revealed that different mulching materials influenced on the fruit yield per m^2. The maximum fruit yield per m^2 was recorded by organic mulch (3.56

kg). The lowest fruits per m^2 was observed with no mulch (2.78 kg) and it was on par with paper mulch (2.90 kg).

The types of drip irrigation had no significant influence on total fruit yield per m^2.

Fruit yield per m^2 showed significant variation due to the interaction between different mulching materials and types of drip irrigation. Organic mulch with surface drip irrigation recorded higher fruit yield per m^2 (3.69 kg) and it was on par with silver black mulch with surface drip irrigation (3.48 kg).

Table 7. Effect of mulching materials and types of drip irrigation on yield attributes and yield

Treatments	Yield attributes and yield			
	Number of fruits per plant	Length of fruit (cm)	Fruit yield per plant (g)	Fruit yield per m^2 (kg)
Mulching materials (M)				
m_1 (Paper mulch)	70.39	8.10	601.25	2.90
m_2 (Organic mulch)	86.58	8.74	736.19	3.56
m_3 (Black mulch)	76.73	8.03	654.19	3.16
m_4 (Silver black mulch)	78.71	8.20	678.54	3.28
m_5 (No mulch)	67.84	8.14	576.43	2.788
SE m±	1.37	0.09	12.03	0.06
CD (0.05)	4.280	8.10	37.561	0.183
Drip irrigation (D)				
d_1(Surface drip)	76.90	8.32	657.86	3.18
d_2(Sub surface drip)	75.21	8.17	640.78	3.09
SE m±	0.80	0.08	6.86	0.003
CD (0.05)	NS	NS	NS	NS
m×d Interaction				
m_1d_1	69.24	8.08	594.98	2.87
m_1d_2	71.53	8.13	607.53	2.93
m_2d_1	89.64	9.08	762.02	3.69
m_2d_2	83.52	8.40	710.36	3.43
m_3d_1	81.27	8.03	692.79	3.34
m_3d_2	72.19	8.03	615.58	2.97
m_4d_1	83.43	8.38	721.85	3.48
m_4d_2	73.98	8.03	635.23	3.07
m_5d_1	67.01	8.03	569.33	2.75
m_5d_2	68.67	8.25	583.53	2.82
SE m±	1.86	0.15	16.22	0.08
CD (0.05)	NS	NS	49.989	0.242

4.3. QUALITY ASPECTS OF FRUITS

4.3.1. **Shelf Life**

The effect of different mulching materials and types of drip irrigation on shelf life of fruit is presented in Table 8.

Shelf life of chilli showed significant variation due to different mulching materials. Fruits obtained from plots laid with black mulch recorded maximum shelf life (11.88 days). Chilli fruit obtained from paper mulch and no mulch showed minimum shelf life (9.38 days).

Different types of irrigation and the interaction effect of mulching materials and types of drip irrigation had no significant influence on shelf life of fruit.

4.3.2. **Ascorbic Acid Content (mg 100 g^{-1})**

Ascorbic acid content of fruits is presented in Table 8.

The results revealed that different mulching materials significantly influenced the ascorbic acid content.

Among different mulching materials, maximum ascorbic acid content was recorded by black mulch (118.17 mg 100 g^{-1}) and the lowest was recorded with no mulch (76.13 mg 100 g^{-1}).

Types of drip irrigation did not cause any significant effect on ascorbic acid content of fruits.

Black mulch with sub surface drip irrigation (119.23 mg 100 g^{-1}) recorded maximum ascorbic acid content and it was on par with black mulch with surface drip irrigation (117.11 mg 100 g^{-1}), paper mulch with surface drip irrigation (111.95 mg 100 g^{-1}) and silver black mulch with subsurface drip irrigation (114.99 mg 100 g^{-1}).

4.3.3. **Capsaicin Content (per cent)**

Capsaicin content of chilli fruit is presented in Table 8.

Different mulching materials, types of drip irrigation and their interaction could not produce any significant influence on capsaicin content of fruit.

Table 8. Effect of mulching materials and types of drip irrigation on quality aspects of fruits

Treatments	Quality aspects of fruits		
	Shelf life	Ascorbic acid content (mg $100g^{-1}$)	Capsaicin content (%)
Mulching materials (M)			
m_1 (Paper mulch)	9.38	106.35	1.04
m_2 (Organic mulch)	10.50	96.42	1.02
m_3 (Black mulch)	11.88	118.17	1.19
m_4 (Silver black mulch)	9.75	104.94	1.07
m_5 (No mulch)	9.38	76.13	1.05
SE m±	0.26	3.52	0.08
CD (0.05)	0.814	10.977	NS
Drip irrigation (D)			
d_1(Surface drip)	10.20	108.44	1.06
d_2(Sub surface drip)	10.15	102.37	1.08
SE m±	0.15	2.30	0.09
CD (0.05)	NS	NS	NS
m×d Interaction			
m_1d_1	9.25	111.95	1.00
m_1d_2	9.50	100.74	1.08
m_2d_1	10.75	102.09	1.01
m_2d_2	10.25	90.74	1.02
m_3d_1	12.00	117.11	1.18
m_3d_2	11.75	119.23	1.20
m_4d_1	10.00	94.90	1.08
m_4d_2	9.50	114.99	1.05
m_5d_1	9.00	76.13	1.05
m_5d_2	9.75	76.13	1.05
SE m±	0.04	4.07	0.16
CD (0.05)	NS	14.598	NS

4.4 NUTRIENT UPTAKE

4.4.1 **Nitrogen Uptake (kg ha^{-1})**

Nitrogen uptake by the crop is presented in Table 9.

Different mulching materials had significant influence on N uptake. Maximum N uptake was recorded by plants grown with organic mulch (87.50 kg ha^{-1}) and it was on par with black polyethene mulch (72.20 kg ha^{-1}) and paper mulch (67.65 kg ha^{-1}).

Types of drip irrigation and their interaction with mulching materials did not cause any significant influence on N uptake.

4.4.2 **Phosphorus Uptake (kg ha^{-1})**

Phosphorus uptake by chilli crop as influenced by the treatments presented in Table 9.

Uptake of P varied significantly due to the effect of different mulching materials. Plants grown with organic mulch recorded the highest P uptake (14.61 kg ha^{-1}) and it was significantly superior to all other treatments.

The different types of drip irrigation and interaction of different mulching materials and types of drip irrigation did not cause significant influence on P uptake.

4.4.3 **Potassium Uptake (kg ha^{-1})**

Potassium uptake by the crop presented in Table 9.

The potassium uptake was observed to vary significantly with different mulching materials. Among the different mulching materials, organic mulch (68.10 kg ha^{-1}) recorded higher K uptake and it was on par with paper mulch (62.49 kg ha^{-1}) and black polyethene mulch (52.23 kg ha^{-1}). The lowest K uptake was recorded by no mulch (34.41 kg ha^{-1}).

The different types of drip irrigation and their interaction with different mulching materials failed to produce any significant effect on K uptake at harvest of the crop.

4.5. SOIL ANALYSIS

4.5.1 **Organic Carbon (%)**

Available organic carbon content of the soil is presented in Table 10.

Higher organic carbon content in soil after the experiment was recorded by organic mulch (1.28 %) and it was on par with paper mulch (1.25 %). All other mulching materials recorded significantly lower organic carbon content.

4.5.2 **Available N (kg ha^{-1})**

Available N content of the soil after the experiment is presented in Table 10.

Different mulching materials caused significant influence on available N content of soil after the experiment. Among the different mulching materials, organic mulch (228.42 kg ha^{-1}) recorded higher available N followed by paper mulch (189.75 kg ha^{-1}). The lowest available N was recorded with no mulch (124.05 kg ha^{-1}).

Types of drip irrigation and its interaction with mulching materials had no significant influence on available N content of soil.

4.5.3 **Available P (kg ha^{-1})**

Available P content of the soil after the experiment is presented in Table 10.

There was no significant difference in available P content of soil with different mulching materials, different types of irrigation and their interaction.

4.5.4 **Available K (kg ha^{-1})**

Available K content in the soil after the experiment has influenced by the treatments presented in Table 10.

Organic mulch showed higher available K content (68.31 kg ha^{-1}) and it was on par with black polyethene mulch (60.31 kg ha^{-1}). The lower soil K content was reported by no mulch (39.85 kg ha^{-1}) and it was on par with silver black mulch (46.15 kg ha^{-1}) and paper mulch (41.41 kg ha^{-1}).

Types of drip irrigation had no significant influence on available K content of soil.

The interaction between organic mulch with surface drip irrigation recorded significantly higher available K content (75.70 kg ha^{-1}).

4.5.5 **Soil Temperature (°C)**

Soil temperature is presented in the Table 11.

At 15 cm depth Black polyethene mulch recorded higher soil temperature among different mulching materials (28.20 °C) and it was found to be on par with silver black mulch. The lowest soil temperature was recorded with no mulch (24.78 °C) and it was comparable with organic mulch (24.84 °C).

At 30 cm depth no mulch recorded the lowest soil temperature (20.34 °C) followed by organic mulch (23.91 °C). Maximum temperature was recorded by black polyethene mulch (25.89 °C) and it was on par with silver black mulch (25.81 °C) and paper mulch (25 °C).

Types of drip irrigation and the interaction between different mulching materials and types of drip irrigation had no significant effect on soil temperature.

4.5.6 **Soil Moisture Content (%)**

Soil moisture content is presented in the Table 11.

Different mulching materials caused significant influence on soil moisture content both at 15 cm and 30 cm depth. Organic mulch recorded significantly higher soil moisture content at 15 cm depth (13.43 %) and it was found to be on par with paper mulch (12.41 %). The soil moisture content recorded by paper mulch was on par with black polyethene mulch and silver black polyethene mulch. The lowest soil moisture was recorded by no mulch (9.65%).

At 30 cm depth the higher soil moisture content was recorded by organic mulch (13.69 %) and the lowest by no mulch (9.47 %). All other mulches recorded more or less same moisture content.

Types of drip irrigation and the interaction between different mulching materials and types of drip irrigation had no significant effect on soil moisture.

Table 9. Effect of mulching materials and types of drip irrigation on NPK uptake by plant, kg ha^{-1}

Treatments	Nutrient uptake		
	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})
Mulching materials (M)			
m_1 (Paper mulch)	67.65	10.16	62.49
m_2 (Organic mulch)	87.50	14.61	68.10
m_3 (Black mulch)	72.20	10.17	52.23
m_4 (Silver black mulch)	57.57	10.01	46.84
m_5 (No mulch)	41.40	8.24	34.41
SE m±	7.03	0.68	5.42
CD (0.05)	21.892	2.124	16.889
Drip irrigation (D)			
d_1(Surface drip)	65.08	11.05	53.23
d_2(Sub surface drip)	65.45	10.25	52.76
SE m±	3.36	0.37	2.06
CD (0.05)	NS	NS	NS
m×d Interaction			
m_1d_1	63.72	10.86	59.54
m_1d_2	71.58	9.47	65.43
m_2d_1	83.42	14.92	68.20
m_2d_2	91.59	14.31	69.79
m_3d_1	74.48	11.23	57.85
m_3d_2	69.93	9.12	46.61
m_4d_1	59.71	11.02	44.39
m_4d_2	55.43	8.10	49.30
m_5d_1	44.07	7.24	36.17
m_5d_2	38.73	9.23	32.65
SE m±	8.81	0.90	6.32
CD (0.05)	NS	NS	NS

Table 10. Effect of mulching materials and types of drip irrigation on organic carbon content and available NPK of status of soil

Treatments	OC (%)	Available N (Kg ha^{-1})	Available P (Kg ha^{-1})	Available K (Kg ha^{-1})
Mulching materials (M)				
m_1 (Paper mulch)	1.25	189.75	72.32	41.40
m_2 (Organic mulch)	1.28	228.42	76.60	68.31
m_3 (Black mulch)	1.07	174.69	80.23	60.31
m_4 (Silver black mulch)	1.11	155.64	76.30	46.15
m_5 (No mulch)	1.04	124.05	74.69	39.85
SE m±	0.04	8.23	1.93	3.41
CD (0.05)	0.123	25.630	NS	9.739
Drip irrigation (D)				
d_1(Surface drip)	1.16	178.10	76.45	53.15
d_2(Sub surface drip)	1.14	170.92	75.61	49.26
SE m±	0.03	5.74	0.94	1.86
CD (0.05)	NS	NS	NS	NS
m×d Interaction				
m_1d_1	1.23	200.70	73.72	48.53
m_1d_2	1.27	178.80	7.92	34.27
m_2d_1	1.32	234.57	77.05	75.70
m_2d_2	1.24	222.28	76.14	60.92
m_3d_1	1.04	183.32	79.63	62.16
m_3d_2	1.10	166.05	80.83	58.46
m_4d_1	1.14	157.73	75.03	40.62
m_4d_2	1.09	153.55	77.58	51.69
m_5d_1	1.08	114.19	76.81	38.73
m_5d_2	1.00	133.91	72.57	40.97
SE m±	0.06	12.25	2.44	4.31
CD (0.05)	NS	NS	NS	13.275

Table 11. Effect of mulching materials and types of drip irrigation on soil temperature and soil moisture content

Treatments	Soil temperature at 15 cm depth (°C)	Soil temperature at 30 cm depth (°C)	Soil moisture at 15 cm depth (%)	Soil moisture at 30 cm depth (%)
Mulching materials (M)				
m_1 (Paper mulch)	26.97	25	12.41	12.11
m_2 (Organic mulch)	24.84	23.91	13.43	13.69
m_3 (Black mulch)	28.20	25.89	12.25	12.5
m_4 (Silver black mulch)	27.35	25.81	11.83	11.87
m_5 (No mulch)	24.78	20.34	9.65	9.47
SE m±	0.31	0.21	0.36	0.36
CD (0.05)	1.030	0.706	1.098	1.095
Drip irrigation (D)				
d_1(Surface drip)	26.49	24.17	12.02	11.89
d_2(Sub surface drip)	26.36	24.32	11.81	11.97
SE m±	0.17	0.228	0.08	0.07
CD (0.05)	NS	NS	NS	NS
m×d Interaction				
m_1d_1	26.93	24.72	12.67	12.04
m_1d_2	27.02	25.28	12.16	12.18
m_2d_1	24.52	23.39	13.54	13.4
m_2d_2	25.16	24.43	13.31	13.98
m_3d_1	28.50	25.79	12.45	12.63
m_3d_2	27.90	25.99	12.04	12.37
m_4d_1	27.78	25.49	11.89	11.84
m_4d_2	26.93	26.13	11.77	11.90
m_5d_1	24.75	20.34	9.55	9.52
m_5d_2	24.81	24.72	9.74	9.42
SE m±	0.49	0.419	0.38	0.38
CD (0.05)	NS	NS	NS	NS

4.6. INCIDENCE OF PEST AND DISEASE

Scoring of leaf curl complex caused by thrips and mite is presented in Table 12.

Pest infestation with different treatments was found to be not significant.

4.7 ECONOMIC ANALYSIS

4.7.1 Net Return (₹ ha^{-1})

Organic mulch recorded significantly higher net returns of ₹ 6.42 lakhs ha^{-1}.

Types of drip irrigation did not cause any significant influence on net returns.

The combination of surface drip irrigation and organic mulch recorded maximum net returns (₹ 6.80 lakhs ha^{-1}) and it was on par with silver black mulch with surface drip irrigation (₹ 6.21 lakhs ha^{-1}).

4.7.2 Benefit Cost Ratio

Maximum B: C ratio was obtained from organic mulch (2.43).

Different types of drip irrigation did not cause any significant influence on Benefit Cost ratio.

The interaction of organic mulch with surface drip irrigation recorded higher B: C ratio (2.52) and it was on par with silver black mulch with surface drip irrigation (2.38).

Table 12. Effect of mulching materials and types of drip irrigation on incidence of leaf curl disease due to mite and thrips attack

Treatments	Scoring
Mulching materials (M)	
m_1 (Paper mulch)	0.71
m_2 (Organic mulch)	0.67
m_3 (Black mulch)	0.67
m_4 (Silver black mulch)	0.64
m_5 (No mulch)	0.76
SE m±	0.037
CD (0.05)	NS
Drip irrigation (D)	
d_1(Surface drip)	0.69
d_2(Sub surface drip)	0.69
SE m±	0.037
CD (0.05)	NS
m×d Interaction	
m_1d_1	0.73
m_1d_2	0.69
m_2d_1	0.66
m_2d_2	0.68
m_3d_1	0.66
m_3d_2	0.67
m_4d_1	0.67
m_4d_2	0.60
m_5d_1	0.72
m_5d_2	0.80
SE m±	0.058
CD (0.05)	NS

Table 13. Effect of mulching materials and types of drip irrigation on economics of cultivation of chilli under rain shelter

Treatments	Net returns (₹lakhs ha^{-1})	Benefit Cost ratio
Mulching materials (M)		
m_1 (Paper mulch)	4.42	1.99
m_2 (Organic mulch)	6.42	2.43
m_3 (Black mulch)	5.20	2.16
m_4 (Silver black mulch)	5.56	2.24
m_5 (No mulch)	4.05	1.90
SE m±	0.18	0.04
CD (0.05)	0.556	0.124
Drip irrigation (D)		
d_1(Surface drip)	5.26	2.17
d_2(Sub surface drip)	5.01	2.12
SE m±	0.10	0.02
CD (0.05)	NS	NS
m×d Interaction		
m_1d_1	4.33	1.96
m_1d_2	4.51	2.01
m_2d_1	6.80	2.52
m_2d_2	6.04	2.35
m_3d_1	5.78	2.29
m_3d_2	4.63	2.03
m_4d_1	6.21	2.38
m_4d_2	4.92	2.10
m_5d_1	3.95	1.88
m_5d_2	4.16	1.93
SE m±	0.24	0.05
CD (0.05)	0.741	0.165

DISCUSSION

5. DISCUSSION

An experiment was conducted to study the effect of mulching and micro irrigation practices for yield optimization of chilli in rain shelter. The experimental findings detailed in the previous chapter have been briefly discussed here in the light of published information, fundamental theoretical knowledge and acquired information from the investigation.

5.1 EFFECT OF DIFFERENT MULCHING MATERIALS AND TYPES OF DRIP IRRIGATION ON CHILLI

5.1.1. Effect on Growth Attributes

The findings of the present study indicated that different types of mulching materials had significant influence on the vegetative growth parameters of chilli *viz.,* plant height (fig. 3), number of branches per plant (fig. 4) and LAI (fig. 5) and the highest values were registered with organic mulch. Increased plant height and higher number of branches in chilli might be due to moderate soil temperature, minimized soil erosion, reduced rate of evaporation, inhibited weed growth, promotion of growth of beneficial soil microorganism and reduced spread of soil borne pathogens. This is in corroboration with the findings of Sathiyamurthy *et al.* (2017) in chilli. Similar results of increased growth characters due to organic mulching was reported by Ann and Ankara (2001) and Bender *et al.* (2008) in tomato and Zerga *et al.* (2017) in hot pepper. Effect of organic mulch in increasing the growth attributes of summer tomato by conserving the soil moisture was also reported by Srivastava *et al.* (1984). As reported by Ranaivoson *et al.* (2017), soil water infiltration increased with an increase in soil coverage by crop residues. According to Shirish *et al.* (2013) organic mulch (straw) recorded higher soil moisture content compared to control (55 per cent more compared to control). Lower availability of moisture and high temperature experienced by no mulch might have reduced the cell size and reduced growth attributes. Similar findings of

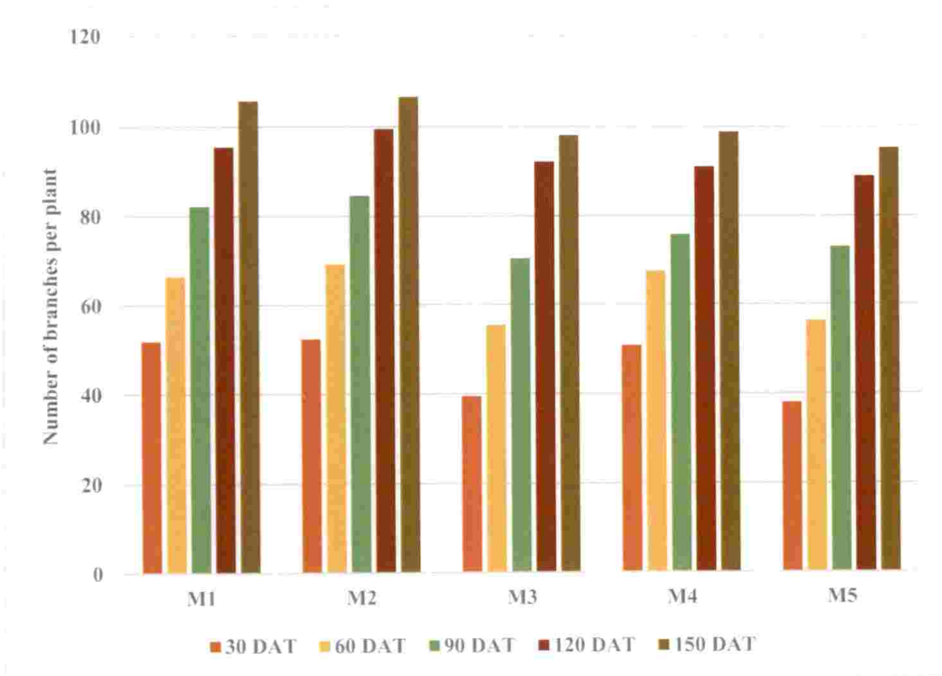

Fig. 3. Effect of different mulching materials on plant height at 30, 60, 90, 120 and 150 DAT

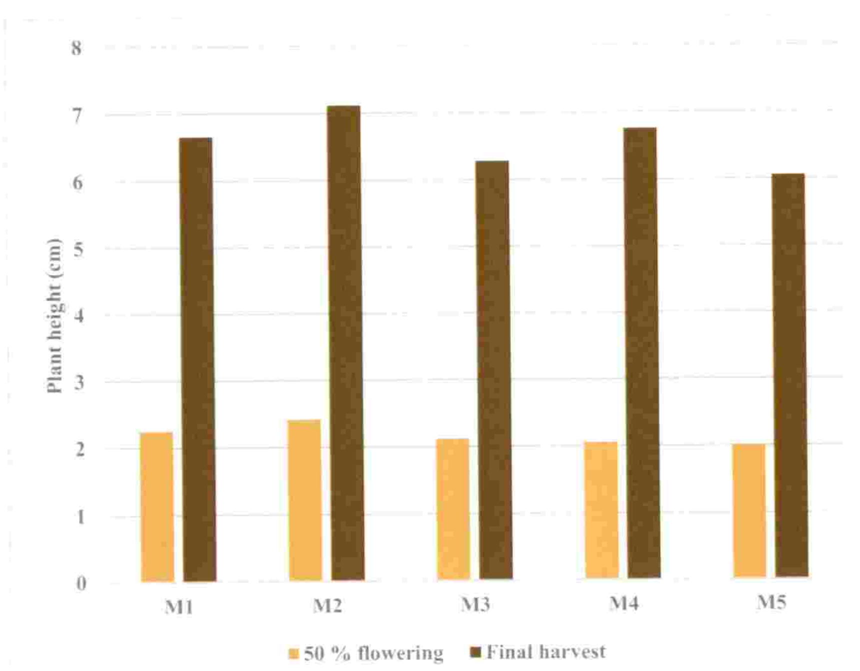

Fig. 4. Effect of different mulching materials on number of branches per plant at 50 per cent flowering and final harvest stage

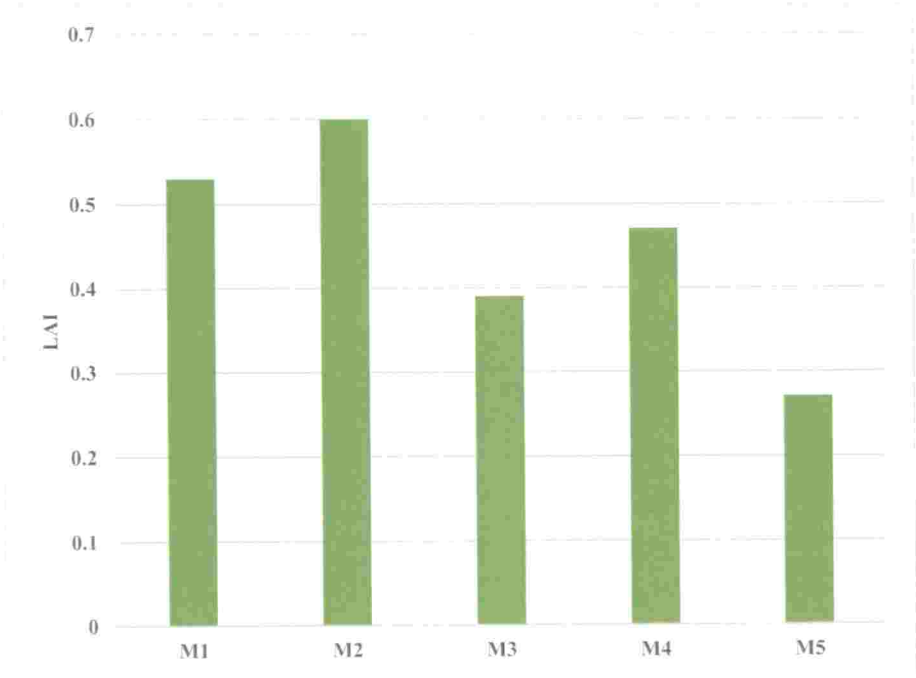

Fig. 5. Effect of different mulching materials on LAI at 50 per cent flowering of chilli under rain shelter

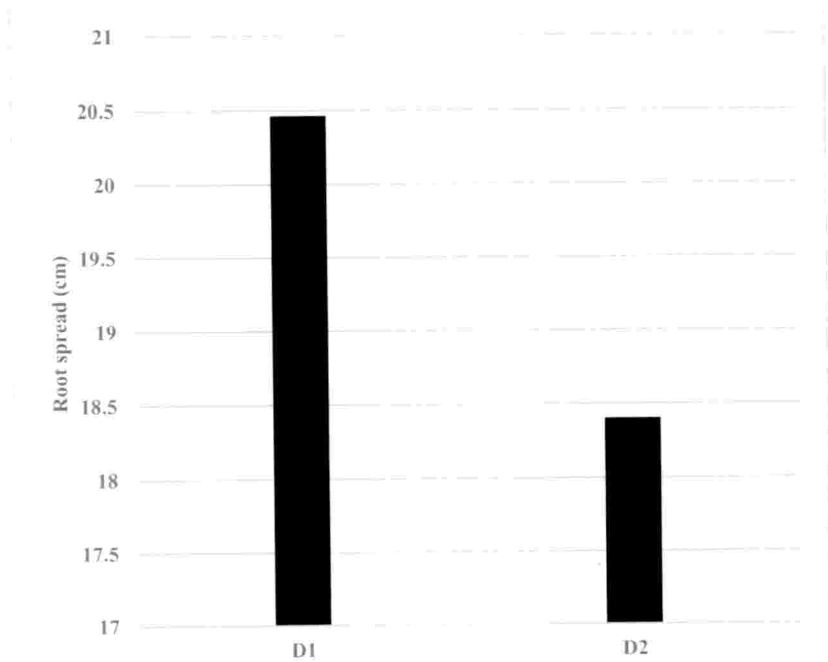

Fig. 6. Effect of types of drip irrigation on root spread at final harvest of chilli under rain shelter

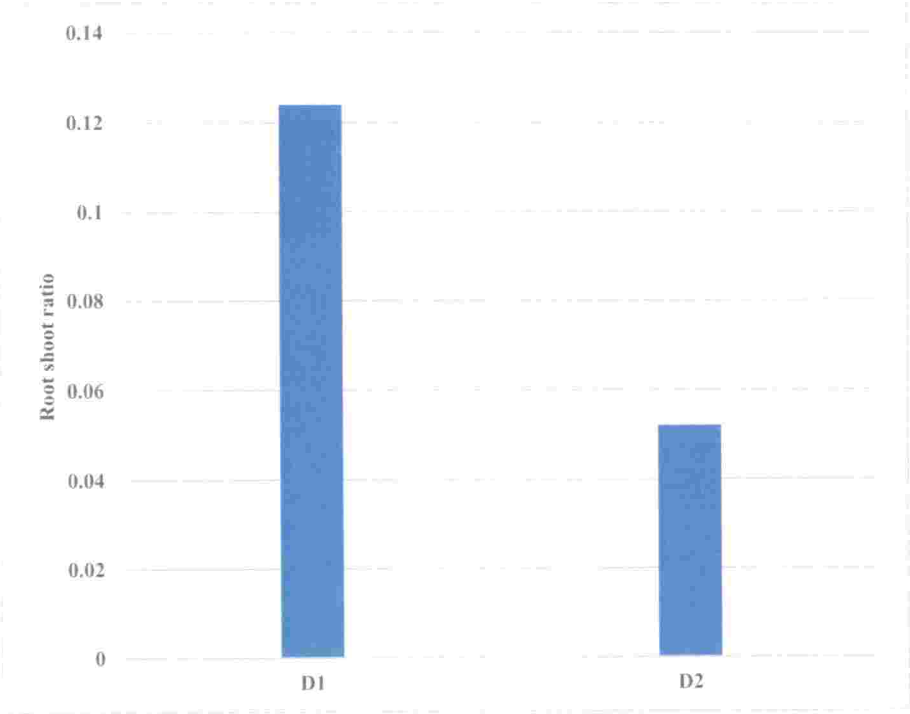

Fig. 7. Effect of types of drip irrigation on root shoot ratio at final harvest of chilli under rain shelter

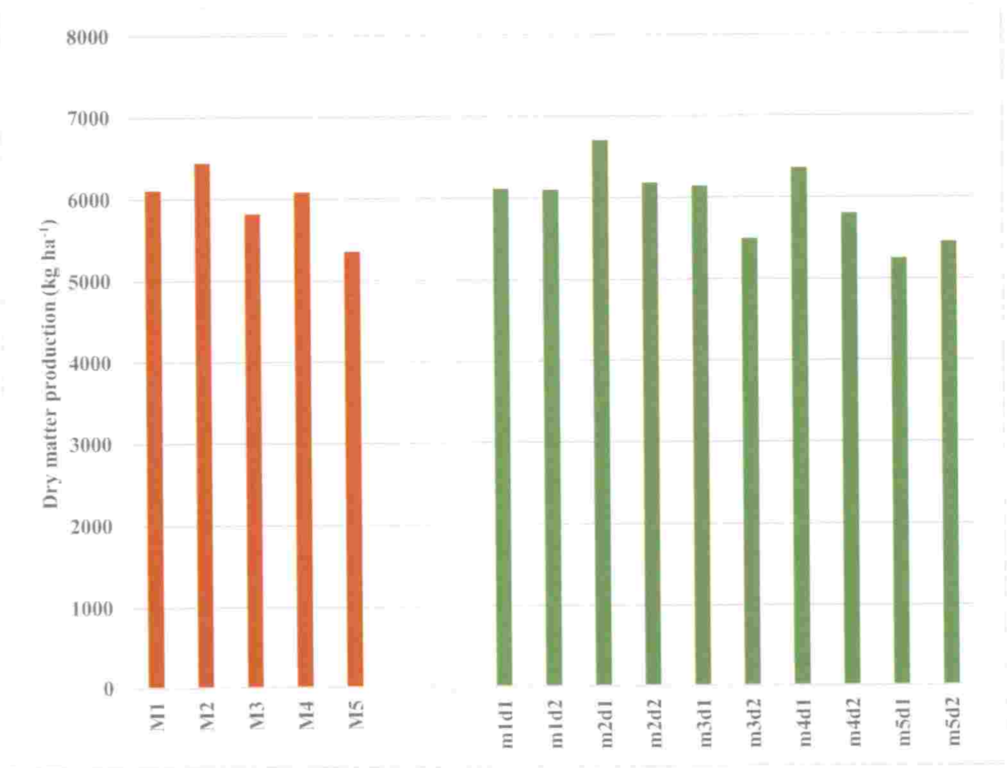

Fig. 8. Effect of different mulching materials and interaction effect of different mulching materials and types of drip irrigation on DMP

reduced plant height due to moderate soil temperature owing to reduction in cell size have been reported by Bierhuizen and Vos (1959).

No significant variation in growth characters of chilli was observed due to types of drip irrigation, except root spread (fig. 6) and root: shoot ratio (fig. 7). The results indicated that surface or sub surface drip irrigation can be adopted for improving growth characters of chilli.

Different types of mulching materials significantly influenced the dry matter production (fig. 8). The highest value of dry matter was observed in plants grown with organic mulch. This might be due to higher growth and growth attributes of chilli grown under organic mulch. Similar results of increased dry matter production by organic mulch (sawdust) was reported by Norman *et al.* (2002) in bhindi and Awal and Sultana (2011) in mustard.

Interaction effect between organic mulch and surface drip irrigation recorded higher dry matter production at harvest stage (fig. 8). Similar findings of increased dry matter production with organic mulching along with surface drip irrigation was reported by Tiwari *et al.* (1998) in okra and Sharaf-Eldin *et al.* (2017) in potato.

5.1.2. Effect on Yield Attributes and Yield

Yield and yield attributes exhibited a similar pattern as for vegetative growth characters. Number of fruits (fig .9), length of fruit (fig. 10) fruit yield per plant (fig. 11) and fruit yield per m^2 (fig. 12) increased by 27.62 per cent, 8.84 per cent, 27.71 per cent and 28.05 per cent respectively compared to no mulch. Increased number of fruits per plant in organic mulch might be due to higher soil water content and favourable soil temperature. Organic mulch provides favourable soil condition for microorganisms also. Decomposition of organic mulch increases the nutrient content of soil and it may increase the crop yield (Ghosh *et al.,* 2006). Similar results were reported by Sathiyamurthy *et al.* (2017) in chilli. Bhardwaj

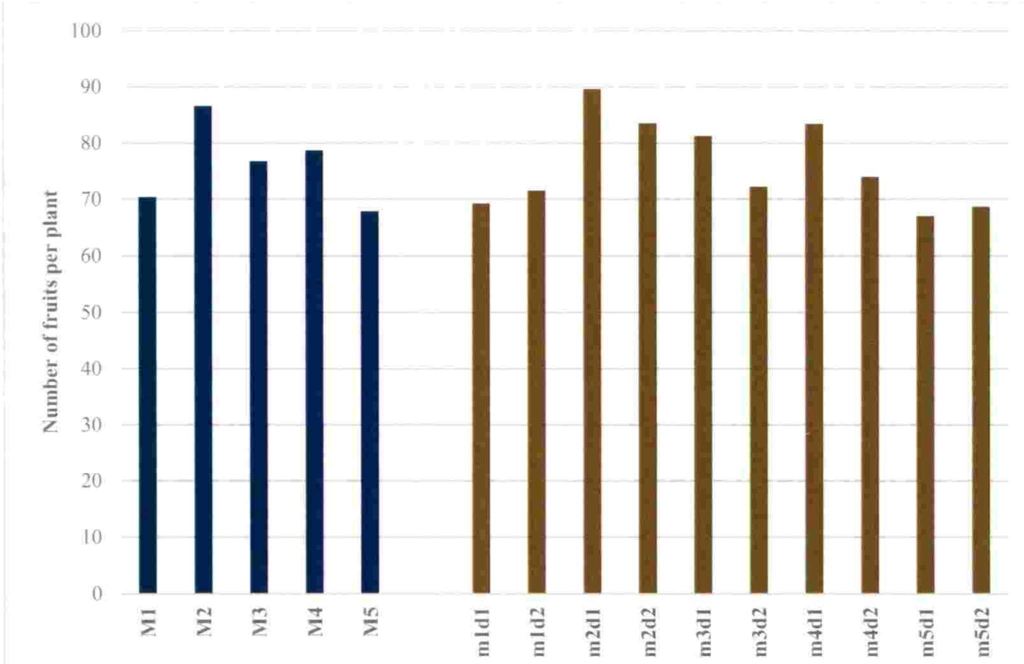

Fig. 9. Effect of different mulching materials and interaction effect of different mulching materials and types of drip irrigation on number of fruits per plant

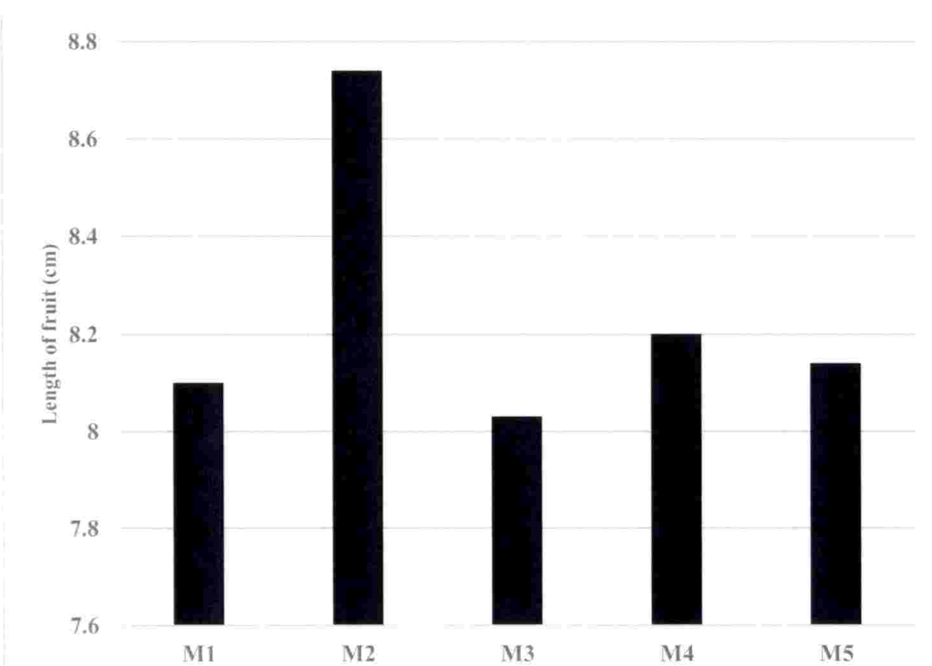

Fig. 10. Effect of different mulching materials on length of fruit of chilli under rain shelter

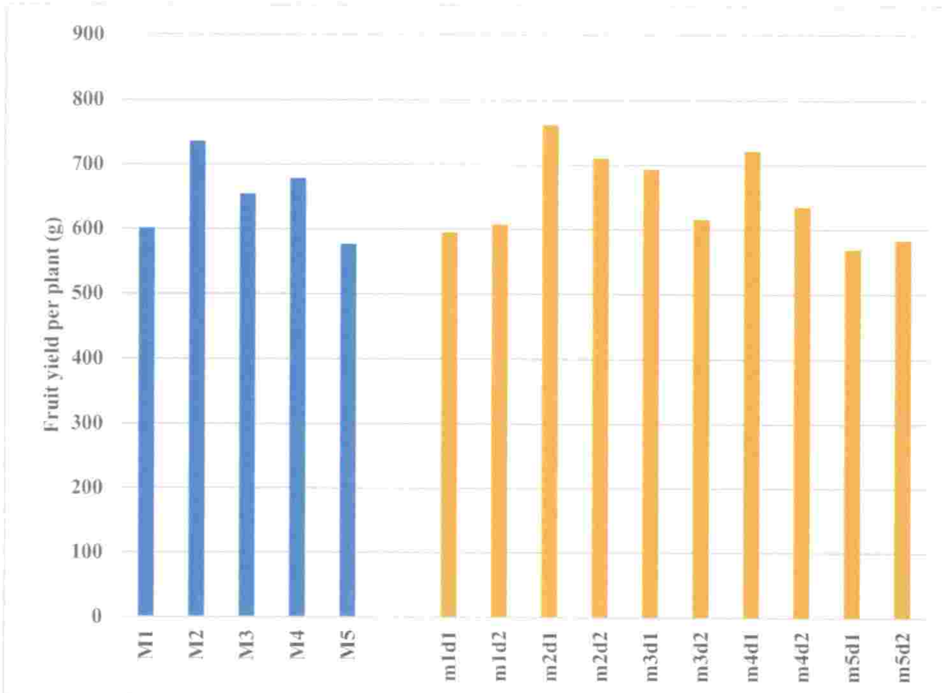

Fig. 11. Effect of different mulching materials and interaction effect of different mulching materials and types of drip irrigation on fruit yield per plant

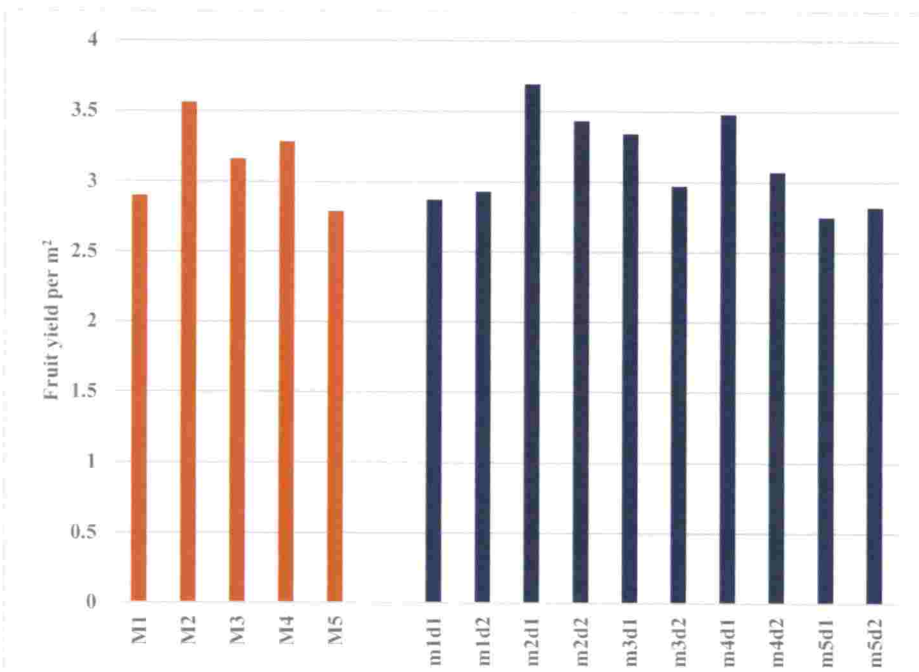

Fig. 12. Effect of different mulching materials and interaction effect of different mulching materials and types of drip irrigation on fruit yield per m^2

(2013) reported that organic mulch increased the crop yield after decomposition due to the addition of organic matter into the soil.

Increased plant height, number of branches and LAI might have increased the photosynthesis and might have contributed to the better yield attributes and yield for the organic mulch treatment.

Organic mulch could resist the effect of higher temperature to produce higher yield in red okra. This is in conformity with the findings of Godawatte and Silva (2016). Similarly the moderate soil temperature experienced by plants grown with organic mulch might have increased the soil N mineralization rate and decomposition of organic matter in the soil. Similar findings were also reported by Al-Majali and Kasarawi (1995) in musk melon, Ban *et al.* (2004) and Ansary and Roy (2005) in water melon, Ghosh *et al.* (2006) and Kaiser *et al.* (2007) in ground nut and Aruna *et al.* (2007) in tomato.

Organic mulch along with surface drip irrigation recorded the highest increase in the number of fruits (33.77%) (fig. 9), fruit yield per plant (33.84 %) (fig. 11) and fruit yield per m^2 (34.18 %) (fig. 12). Similar findings were reported by Sharaf-Eldin *et al.* (2017) in sweet potato. It was also reported that drip irrigation along with mulching recorded higher yield for unit of irrigation water applied. According to Patle *et al.* (2018) in cauliflower and broccoli, higher yield was recorded with organic mulching along with drip irrigation. This might be due to the higher uptake of nutrients, better water utilization and excellent soil water relationship in the crop root zone.

Types of drip irrigation did not show significant effect in the case of yield and yield attributes.

5.1.3 Effect on Quality Aspects of Fruits

Quality aspects of fruits like shelf life and ascorbic acid content of fruits were higher for crops mulched with black polyethene mulch. Crops grown with

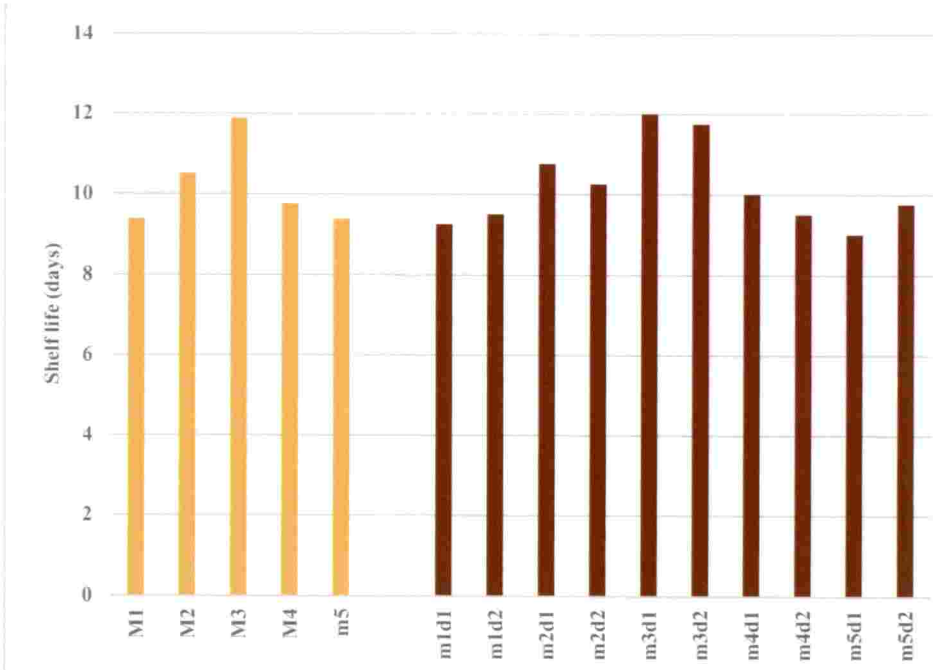

Fig. 13. Effect of different mulching materials and interaction effect of different mulching materials and types of drip irrigation on shelf life of fruit

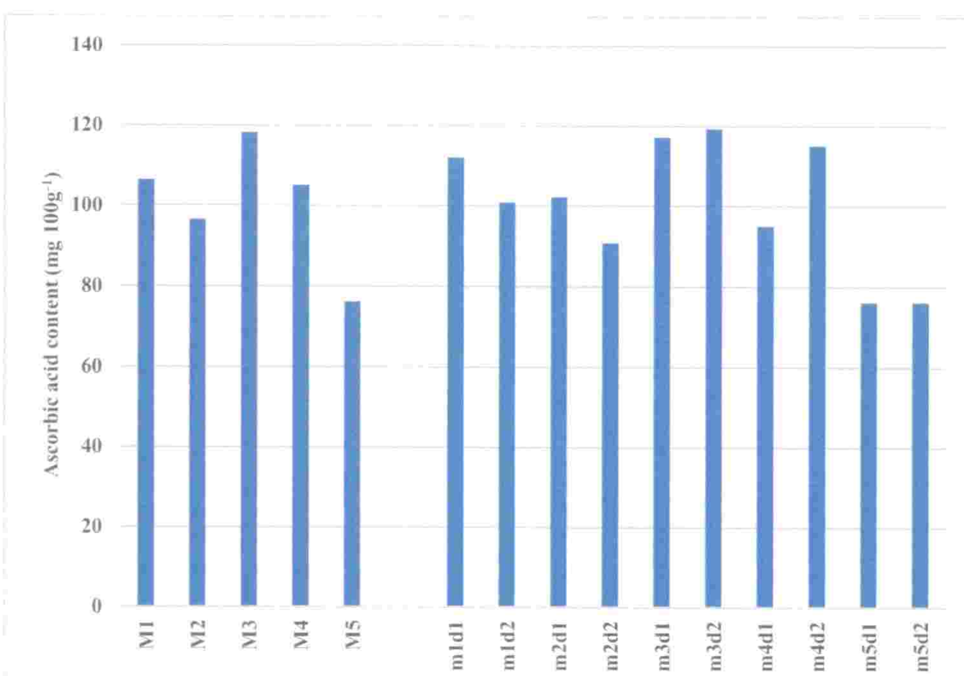

Fig. 14. Effect of different mulching materials and interaction effect of different mulching materials and types of drip irrigation on ascorbic acid content of fruit (mg $100g^{-1}$)

black polyethene mulch had 2.13 days more shelf life (fig. 13) and 55.22 per cent more ascorbic acid content (fig. 14) compared to no mulch. Black plastic mulch reflected only a lesser amount of incidental radiation irrespective of growing condition and that might be the reason for higher fruit quality of crops grown with black plastic mulch (Pandey *et al.* 2016). Mulching with black polyethene along with sub surface drip irrigation recorded higher ascorbic acid content of fruits (53.82 per cent) (fig. 14).

Types of drip irrigation did not show significant effect in the case of yield and yield attributes

5.1.4 Effect on Nutrient Uptake by Crop

Different types of mulch had significant influence on NPK uptake of crops. Maximum increase in N uptake (87.50 kg ha^{-1}) (fig. 15) was observed with organic mulch. Similarly the highest P uptake (14.61 kg ha^{-1}) (fig. 15) and higher K uptake (68.10 kg ha^{-1}) (fig. 15) were also recorded with organic mulch. This might be due to the improved hydrothermal regime in the root zone of plant growth with organic mulch which stimulates root extension and enables exploitation of greater soil volume for uptake of nutrients. Besides, the addition of nutrients through decomposition of organic mulch may also contribute to higher nutrient uptake. This is in conformity with the findings of Sekhona *et al*. 2008.

5.1.5 Effect on Nutrient Status of the Soil after the Experiment

The experiment indicated that application of organic mulch to the soil resulted in the highest available N (228.42 kg ha^{-1}) (fig. 16) and available K (68.31 kg ha^{-1}) (fig. 16) contents of the soil. This might be due to the decomposition of organic mulch that contributes to higher nutrient content in the soil. Similar results were reported by Sekhona *et al*. (2008) and Kumar and Lal (2012). Awopegba *et al.* (2017) also reported that increased soil N content due to the release of trapped atmospheric nitrogen by organic herbaceous mulch, which also supported mineralization rate and improved the NPK status of the soil. The available NPK

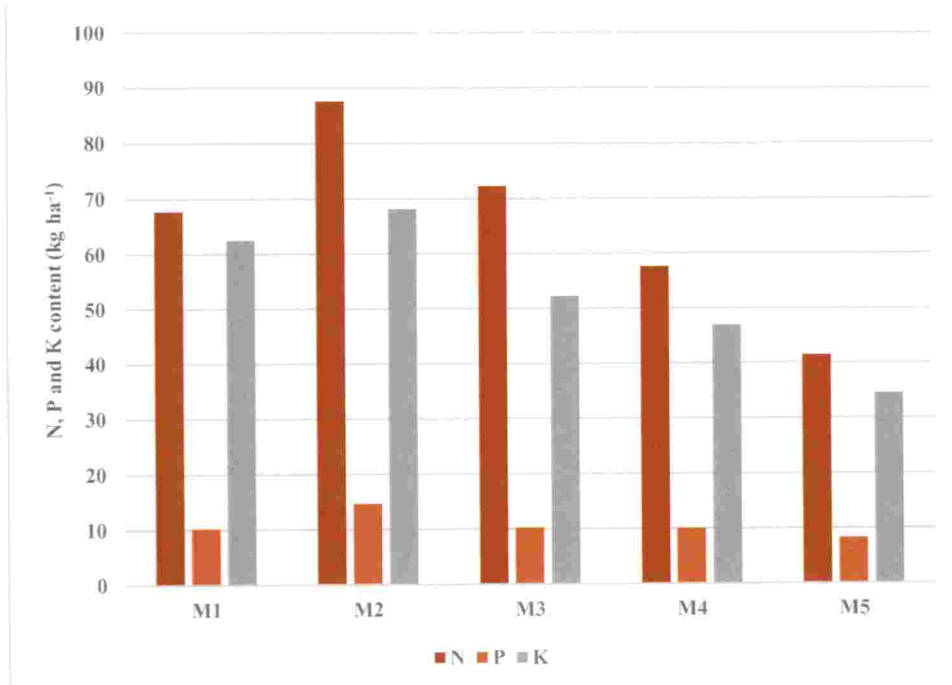

Fig. 15. Effect of different mulching materials on N, P and K uptake (kg ha^{-1}) of the crop

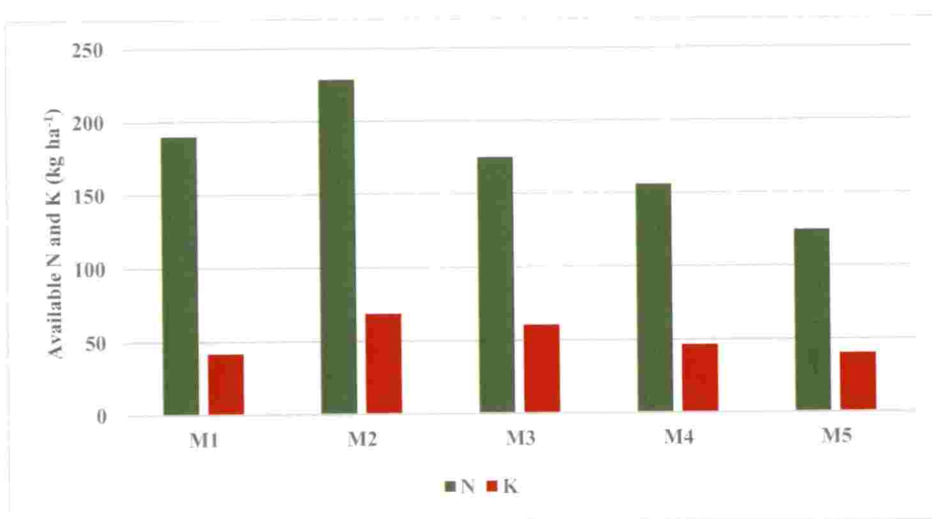

Fig. 16. Effect of different mulching materials on available N and K (kg ha^{-1})

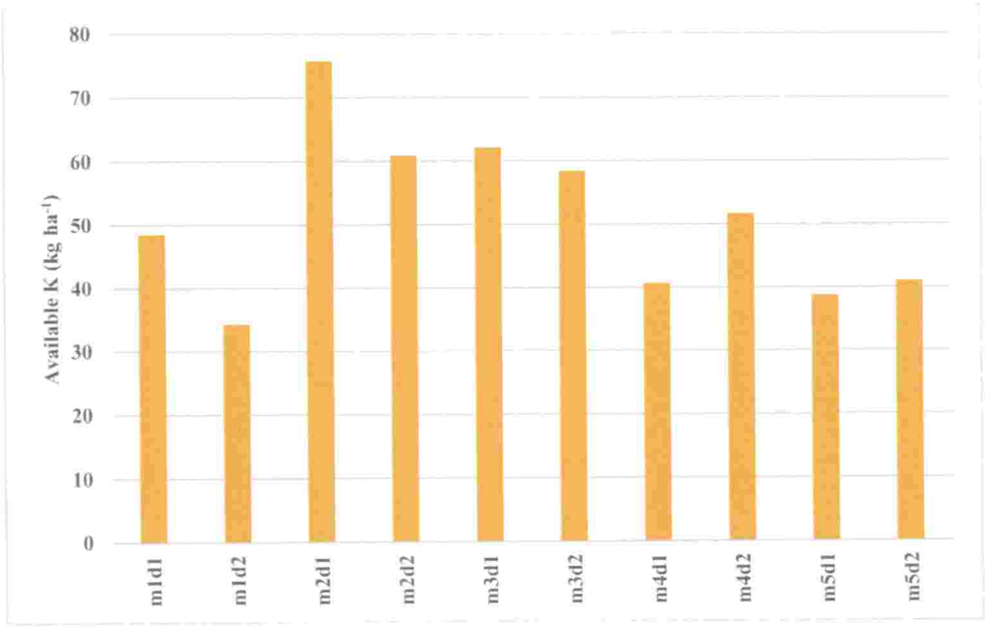

Fig. 17. Interaction effect of different mulching materials and types of drip irrigation on available K (kg ha^{-1})

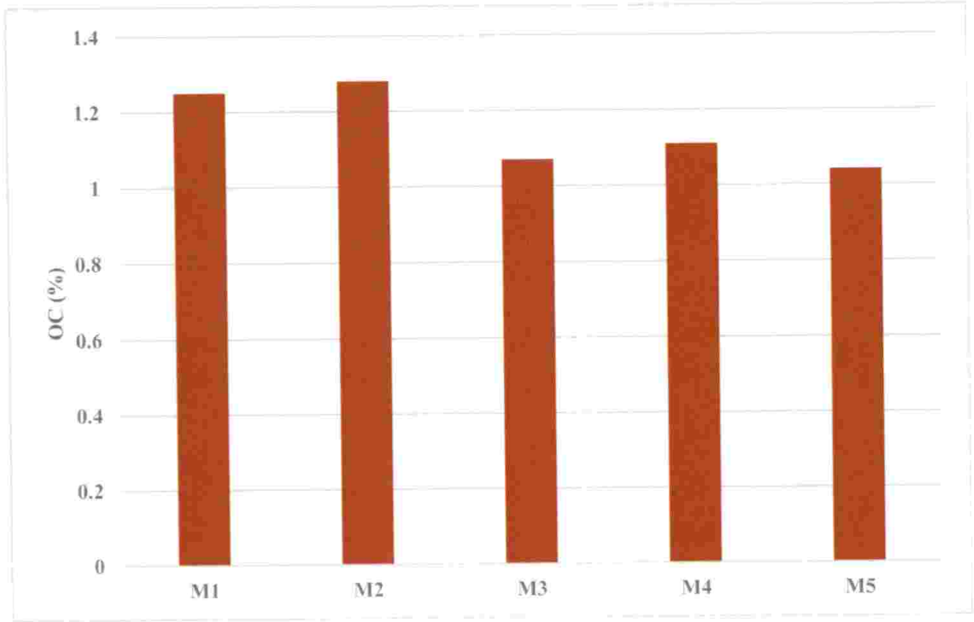

Fig. 18. Effect of different mulching materials on organic carbon (%)

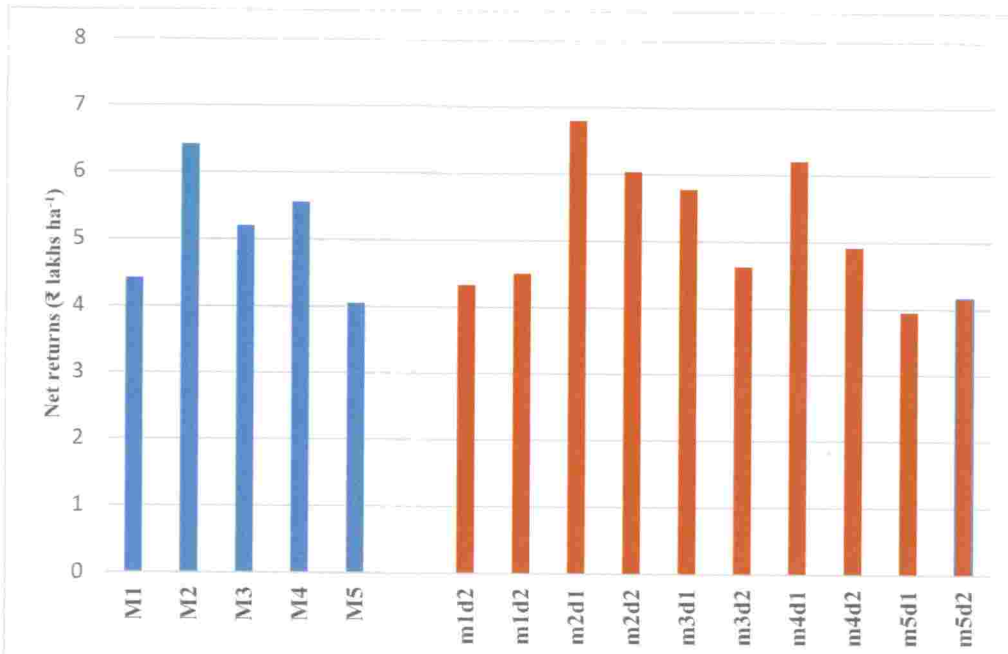

Fig. 19. Effect of different mulching materials and interaction effect of different mulching materials and types of drip irrigation on net returns (₹ ha^{-1})

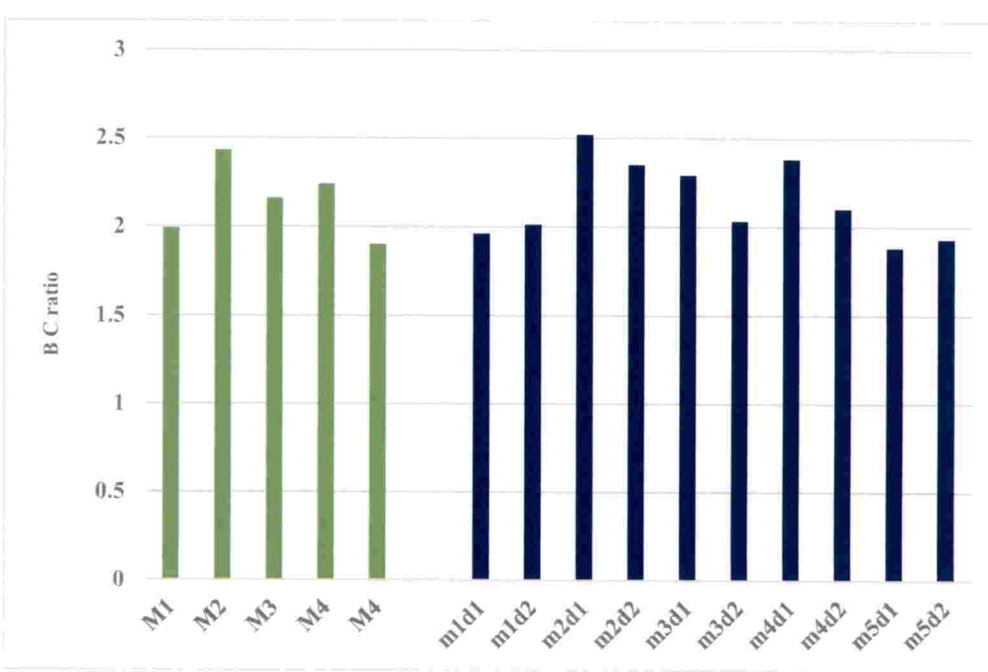

Fig. 20. Effect of different mulching materials and interaction effect of different mulching materials and types of drip irrigation on benefit cost ratio

status of the organic mulched soil after the experiment was increased by the incorporation of organic mulch materials into the soil (Wijesinghe *et al.,* 2009). The results are also in conformity with the findings of Mitra and Mandal (2015).

Significantly higher organic carbon content was recorded by organic mulch (fig. 18). The organic carbon content of the soil sample showed a slight increase after the experiment. The application of organic mulch might have increased the organic carbon content of the soil after decomposition. Bajorienė *et al.* (2013) also reported residual effect of organic mulches as the reason for increased organic carbon content of the organic mulched soil. Zhang *et al.* (2019) reported that soil respiration rate was reduced by the use of straw mulch and it might increase the organic carbon content of the soil. Higher organic carbon content with organic mulch in okra was reported by Muhammed (2015). According to Schonbeck and Evnavylo (2008), increased organic carbon content in tomato due to organic mulch application might be due to the decomposition process and addition of humus from shrubs and herbaceous mulch.

5.2 ECONOMICS OF CULTIVATION

Higher net returns and benefit cost ratio were recorded with organic mulch and it was 58.51 per cent (fig. 19) and 27.89 per cent (fig. 20) more compared to no mulch. The interaction between organic mulch with surface drip irrigation was found to be higher and it was on par with silver black mulch with surface drip irrigation for both net returns and benefit cost ratio. Similar findings of increased net returns with organic mulch has been reported by Komla (2013).

SUMMARY

6. SUMMARY

The present investigation on "Mulching and micro irrigation practices for yield optimization of chilli in rain shelter" was conducted during 2017- 2019 at College of Agriculture Vellayani to assess the effect of different types of mulching material and drip irrigation on the growth and yield of chilli in rain shelter and to work out the economics.

The field experiment was conducted at Instructional Farm College of Agriculture Vellayani. The experiment was conducted during March- September, 2018 and it was laid out in split plot design with five main plot treatment as different mulching materials (m_1: Paper mulch, m_2: Organic mulch (Crop residues), m_3: Black polythene mulch, m_4: Silver-black polythene mulch, m_5: No mulch) and two sub plot treatment were different types of drip irrigation (d_1: surface drip irrigation, d_2: sub surface drip irrigation). The variety planted was Vellayani Athulya. Paper mulch was applied at a thickness of 0.0078 inch (thickness of two standard newspapers) and organic mulch was applied @ 0.5 kg m^{-2}. Black polyethene mulch and silver black polyethene mulch with a thickness of 25 micron were used. Farmyard manure @ 25 t ha^{-1} was given as basal to all the treatments. The recommended dose of nutrients were given @ 75:40:25 kg NPK ha^{-1} through fertigation at three days intervals. All other management practices were done as per Package of Practices of Kerala Agricultural University (KAU, 2016).

The summary of salient findings is furnished below.

The results revealed that taller plants were produced by organic mulch at all growth stages (30, 60, 90, 120 and 150 DAT). It was comparable with paper mulch at all stages except 120 DAT and silver black mulch at 30 and 60 DAT. Higher number of branches at 50 per cent flowering (2.41) and final harvest (7.11) were recorded in organic mulch treatment and it was on par with all other mulches except no mulch. Higher LAI at 50 per cent flowering stage recorded in organic mulch (0.60) and it was on par with silver black mulch and paper mulch. No significant variation in the growth attributes of chilli was obtained due to different types of drip irrigation and the interaction between different mulching materials and types of drip irrigation.

Root characters (root spread, root shoot ratio) were found to be higher for surface drip irrigation and it was not-significant in the case of different mulching materials and the interaction effect between different mulching materials and types of drip irrigation. Significantly higher dry matter production was recorded with organic mulch (6,437 kg ha^{-1}), interaction effect of organic mulch with surface drip irrigation resulted in higher DMP (6,697 kg ha^{-1}) and it was on par with silver black mulch with surface drip irrigation. Neither the treatments nor their interaction had significant influence on days to flowering

Higher number of fruits per plant (86.58), length of fruit (8.74 cm), fruit yield per plant (736.19 g) and fruit yield per m^2 (3.56 kg) were recorded by organic mulch. Interaction between organic mulch and surface drip also recorded higher yield attributes except length of fruit. Types of drip irrigation could not produce any significant effect in the case of yield and yield attributes.

The highest shelf life (11.88 days) and ascorbic acid content (118.17 mg 100 g^{-1}) were recorded by black mulch treatment. Interaction effect of black polyethene mulch with surface drip recorded higher ascorbic acid content and it was on par with paper mulch with surface drip and silver black mulch with sub surface drip. Types of drip irrigation could not significantly influence the quality parameters of chilli fruit.

Organic mulch significantly increased NPK uptake of the crop. It also increased the organic carbon content and available NPK status of the soil after the experiment. Types of drip irrigation and the interaction did not show any significant variation in the case of nutrient uptake except in the case of available K.

Black mulch recorded the highest soil temperature at 15 and 30 cm depth and it was on par with silver black mulch. The lowest soil temperature was recorded by no mulch. Organic mulch recorded higher soil moisture content at 15 cm and 30 cm depth compared to all other mulches and no mulch recorded lower soil moisture content.

No incidence of disease was found beyond economic threshold level. Leaf curl caused by thrips and mites were scored but found to be not significant.

Net income (₹ 6.42 lakhs ha^{-1}) and benefit: cost ratio (2.43) were higher for organic mulch. Organic mulch with surface drip irrigation produced higher net returns and benefit: cost ratio, and it was comparable with silver black mulch with surface drip irrigation. Types of drip irrigation didn't produce any significant effect on net income and benefit cost ratio.

Future line of work:

- Explore the possibility of other methods of micro irrigation.
- Explore the possibility of hydrogel

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APPENDICES

Appendix- I

Weather data in rain shelter during the cropping period

Weekly averages (13/3/2018- 13/9/2018)

Standard week	Temperature (°C)		Relative humidity	Light intensity (K. lux)
	Max. temperature	Min. temperature		
11	28.75	25.5	81	41.87
12	24.5	22.43	80	43.59
13	27.18	25.37	78	42.08
14	28.28	25.85	82	44.41
15	28.57	26	79	45.86
16	29.37	23.25	75	47.07
17	28.32	24.87	78	49.20
18	28.56	25.19	76	51.43
19	29	23.28	78	52.91
20	30.28	24.92	75	50.89
21	30.21	24.32	77	52.34
22	28.22	22.22	79	51.23
23	27.89	21.41	75	53.65
24	29.52	23.65	78	51.12
25	29.87	24.08	79	54.25
26	28.54	20.13	75	52.87
27	28.46	21.25	74	51.24
28	29.45	23.34	74	50.22
29	29.86	23.87	73	55.75
30	29.12	24.11	74	56.14
31	29.41	23.06	75	56.22

Appendix- II

Soil moisture at fortnightly intervals

Standard week	Depth (cm)	Paper mulch (%)		Organic mulch (%)		Black mulch (%)		Silver black mulch (%)		No mulch (%)	
		Surface	**Sub surface**	**Surface**	**Sub surface**	**Surface**	**Sub surface**	**Surface**	**Sub surface**	**Surface**	**Sub surface**
11	15	11.4	12.4	13.5	12.5	13	13	12	11.6	10.6	11.2
	30	12.8	12	13.2	13.6	12.6	13.2	11.3	12.1	11.6	12
13	15	13.6	11.6	13.9	14.4	14.6	13	12.5	12.4	9.4	10.7
	30	12.2	12.3	13.8	13.5	13.3	12.6	13	12.3	13	12
15	15	11.3	11.5	13.8	12.5	11.9	12	11.5	12.1	9.1	9.2
	30	12.8	12.1	13.5	11.2	13.1	12	12.3	11	7.5	9
17	15	12.5	10.5	13.8	13.5	13.7	13.5	12.5	11.8	9.7	9.6
	30	13.1	13.7	14.4	12.8	12.5	13.2	11.5	13	9.2	9
19	15	11.9	11	14	13.5	11	11	10.5	11.4	9	8.8
	30	11.5	11.2	13.4	12.6	12.6	12.4	11.5	11	7.6	8.4
21	15	10.7	11.2	13.5	12.3	11.1	11	11.5	10.6	9	9
	30	11.1	11.1	13.9	13.1	11.6	12.1	11	11.4	8	8.1
23	15	13	13.3	14	13.5	11.4	12.1	12.4	12.2	8.1	7.5
	30	11.4	11.4	14.2	13.8	12.4	12.6	12.3	12	7.6	8.3
25	15	14.9	13.2	12.7	12.9	11.5	11.8	11.4	11.6	8.2	7.5
	30	11.8	11.8	14.6	15	11.9	12.3	11.9	12	8.1	8.2
27	15	13.3	13.7	13	13.5	13	12.5	11.8	12.3	11	11.4
	30	12	12.4	14.8	13.6	12.6	12	12.4	11.7	11.4	11.2
29	15	13	12.6	13.5	13	13.5	11.5	12.5	11.9	10.4	12.6
	30	11.9	12.2	13.6	14.9	13.6	13.2	12.6	12.1	12	10.4
31	15	14.7	14.1	13.9	15.5	13.5	12.3	11.7	11.8	12.3	11.8
	30	13.8	12.8	14.9	14.8	13.4	13.8	11.5	12	9.3	8.73

Appendix- III

Soil temperature at weekly intervals

Standard week	Depth (cm)	Paper mulch (°C)		Organic mulch (°C)		Black mulch (°C)		Silver black mulch (°C)		No mulch (°C)	
		surface	Sub surface	Surface	Sub surface	surface	Sub surface	surface	Sub surface	surface	Sub surface
18	15	26.5	27	25	25	29	28	27	28	24.5	24
	30	25.5	25.5	24.5	24	28	26	25.5	26	21	20.5
19	15	27	27	25.5	24	28.5	28	28	28.5	25	25
	30	25	25	23	25.5	25.5	26	26.5	26.5	21	21
20	15	27	26.5	24.5	25	29.5	28.5	27.5	28	24.5	25.5
	30	25.5	25	23.5	24.5	28	26	25	26.5	20.5	21.5
21	15	27	27	25.5	26	28	27	28.5	28	24	25
	30	25	25	23	25.5	25	26	26	26.5	20	21
22	15	26.5	27.5	24.5	25.5	28.5	27.5	27.5	28.5	25	25.5
	30	25.5	25.5	23.5	24	25	25.5	26	26.5	21	21
23	15	27	27.5	24	25	28	28	27.5	28	24	24
	30	25.5	25	23.5	24.5	25.5	26.5	25.5	26.5	21	21.5
24	15	27	27	24.5	25.5	28	27.5	28	27	24	25.5
	30	25	25.5	23.5	24.5	25	26	25.5	25	20	21
25	15	27.5	26.5	24	26.5	29.5	28	27	28.5	24.5	25
	30	25.5	25.5	23.5	25	26	26.5	25.5	26	20	21.5
26	15	26	26	24.5	24.5	28.5	28.5	28	28	24.5	24
	30	25.5	25	23	24	25	26.5	25	26.5	21.5	20.5
27	15	27.5	27	24.5	25	28	28	28.5	28.5	25	24

	30	25	25.5	23.5	24.5	25.5	27	25	26.5	21.5	21.5.
28	15	26.5	27.5	24	25.5	29	28.5	27.5	28	25.5	24.5
	30	25	25.5	23.5	24	25.5	26	25	26.5	21.5	21
29	15	27.5	27	24.5	24.5	28	29	28.5	28.5	25	25.5
	30	25	25.5	23.5	24	26.5	25.5	25.5	25	21.5	21
30	15	26.5	27.5	24	24.5	28.5	26.5	28	28.5	24.5	25
	30	25	25	23	24	26	25	25.5	26	21	21.5
31	15	27.5	27.5	24.5	25.5	28	27.5	27.5	28	25	25
	30	25.5	25.5	23	24	25	25	25.5	26	21.5	21.5

APPENDIX IV

Cost of cultivation of chilli grown under rain shelter for one season

Particulars	Poly house with fertigation
Cost of rain shelter with drip	177777
Cost of manures	25000
Cost of fertilizers	1500
Cost of mulching sheet	10720
Cost of seed	3000
Labour cost @741/ labour	150423
Plant protection	1000
Total	369420

- Structure (including drip irrigation) ₹ 800 m^{-2} for life span of 15 years
- Mulching sheet for a life span of 5 years

MULCHING AND MICRO IRRIGATION PRACTICES FOR YIELD OPTIMIZATION OF CHILLI IN RAIN SHELTER

by

SHILPA E.N

(2017-11-050)

ABSTRACT

Submitted in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF AGRONOMY
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM – 695 522
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2019

8. ABSTRACT

The investigation entitled "Mulching and micro irrigation practices for yield optimization of chilli in rain shelter" was conducted at College of Agriculture, Vellayani from 2017- 2019, to assess the effect of different types of mulching material and drip irrigation on the growth and yield of chilli in rain shelter and to work out the economics.

The field experiment was conducted from March to September 2018 at the Instructional Farm, College of Agriculture, Vellayani. The experiment was laid out in split plot design with five main plot treatments and two sub plot treatments, with four replications. Chilli variety Vellayani Athulya was used in the experiment. The main plot treatments comprised of five different types of mulching materials (m_1 – paper mulch; m_2 –organic mulch (crop residues); m_3 –black polyethene mulch; m_4- silver black polyethene mulch and m_5- no mulch) and two sub plot treatments (d_1- surface drip irrigation and d_2- sub surface drip irrigation).

Paper mulch was applied at a thickness of 0.0078 inch (thickness of two standard newspapers) and organic mulch was applied @ 0.5 kg m^{-2}. Black polyethene mulch and silver black polyethene mulch with a thickness of 25 micron were used. Farmyard manure @ 25 t ha^{-1} was given as basal to all the treatments. The recommended dose of nutrients were given @ 75:40:25 kg NPK ha^{-1} through fertigation at three days intervals. All other management practices were done as per Package of Practices of Kerala Agricultural University (KAU, 2016)

The results indicated that organic mulch application (m_2) significantly increased the plant height at all growth stages, number of branches per plant at 50 per cent flowering (2.41) and final harvest (7.11) and leaf area index at 50 per cent flowering (0.60) compared with no mulch (m_5). Significantly higher length of fruit (8.74 cm), number of fruits per plant (86.58), fruit yield per plant (736.19 g), fruit yield per m^2 (3.56 kg) and total dry matter production (6437 kg ha^{-1}) were obtained with organic mulch. The highest uptake of N (87.50 kg ha^{-1}), P (14.61 kg ha^{-1}) and K (68.1 kg ha^{-1}) were obtained with organic mulch. The highest available N (228.42

kg ha^{-1}) and available K (68.31 kg ha^{-1}) and organic carbon (1.28%) were also recorded by organic mulch. Black mulch recorded significantly higher shelf life (11.88 days) and ascorbic acid content (118.17 mg 100 g^{-1}).

Types of drip irrigation could not produce any significant effect on growth and yield attributes of the crop. Mulches had no significant effect on root characters. Root spread and root shoot ratio were comparable in the case of surface and sub surface drip irrigation.

Organic mulch with surface drip irrigation produced higher number of fruits per plant (89.64), fruit yield per plant (762.02 g), fruit yield per m^2 (3.69 kg), total dry matter production (6697 kg ha^{-1}) and available K content of soil (75.70 kg ha^{-1}). The highest ascorbic acid content (119.23mg 100g^{-1}) was recorded with black mulch with sub surface drip irrigation.

The highest net income of ₹ 6.42 lakhs ha $^{-1}$ and the highest benefit cost ratio of 2.43 were obtained when organic mulch was applied. The interaction effect of organic mulch application with surface drip irrigation (m_2d_1) produced significantly higher net income (₹ 6.80 lakhs ha $^{-1}$) and benefit cost ratio (2.52).

The results of the study indicated that organic mulch combined with surface drip irrigation along with application of FYM @ 25 t ha^{-1} as basal and 75:40:25 kg NPK ha^{-1} through fertigation at three days interval could be recommended for getting higher yield and net return from the cultivation of chilli, under rain shelter.

സംഗ്രഹം

കൃത്യതാ കൃഷിയിൽ പുതയിടലും സൂക്ഷ്മ ജല പ്രയോഗവും മുളകിന്റെ വിള ഉത്തമീകരണത്തിനു എന്ന പരീക്ഷണം വെള്ളായണി കാർഷിക കോളേജിലെ ഇൻസ്ട്രക്ഷണൽ ഫാർമിന് കീഴിലുള്ള മഴമറയിൽ മാർച്ച് 2018 മുതൽ സെപ്തംബർ 2018 വരെയുള്ള കാലഘട്ടത്തിൽ നടത്തുകയുണ്ടായി. പുതയിടൽ, സൂക്ഷമ ജല പ്രയോഗം എന്നിവയിലൂടെ മുളകിന്റെ വളർച്ച, ഉത്പാദന ക്ഷമത, സാമ്പത്തിക വശം മനസിലാക്കുക എന്നിവയായിരുന്നു പ്രസ്തുത പഠനത്തിന്റെ ലക്ഷ്യങ്ങൾ.

പ്രസ്തുത പഠനത്തിന് സ്പ്ലിറ്റ് പ്ലോട്ട് ഡിസൈൻ എന്ന സ്റ്റാറ്റിസ്റ്റിക്സ് പഠന രീതിയാണ് അവലംബിച്ചത്, അതിൽ അഞ്ചു പ്രധാന പ്ലോട്ട് ഡിസൈനും രണ്ടു ഉപ പ്ലോട്ട് ഡിസൈനും ഉൾപ്പെടുന്നു. വെള്ളായണി അതുല്യ എന്നയിനം മുളകാണ് പഠന വിധേയമാക്കിയത്.

അഞ്ചു പ്രധാന പ്ലോട്ട് ഡിസൈനുകൾ പലതരത്തിലുള്ള പുതയിടലാണ് (1- പേപ്പർ കൊണ്ടുള്ള പുതയിടൽ, 2- ജൈവ പുതയിടൽ, 3- കറുത്ത പൊളിത്തീൻ ഷീറ്റ് കൊണ്ടുള്ള പുതയിടൽ, 4- സിൽവർ - കറുപ്പ് പൊളിത്തീൻ ഷീറ്റ് കൊണ്ടുള്ള പുതയിടൽ, 5- പുതയിടാതെയുള്ള പരിചരണ രീതി). സബ് പ്ലോട്ട് ഡിസൈനുകൾ രണ്ടു തരത്തിലുള്ള തുള്ളി നന ജലസേചനമാണ് (1- മണ്ണിനു മുകളിലൂടെയുള്ള തുള്ളിനന ജലസേചനം, 2- മണ്ണിനു താഴെയുടെയുള്ള തുള്ളി നന ജലസേചനം). പുതയിടാനുള്ള പേപ്പർ 0 .078 ഇഞ്ച് കനമുള്ളതാണ് ഉപയോഗിച്ചത് (രണ്ടു ഗുണ നിലവാരം ഉള്ള പത്ര പേപ്പറിന്റെ കനം). ജൈവിക പുത 0.5 കിലോ ഒരു സ്‌കാർ മീറ്ററിന് എന്ന തോതിൽ ഉപയോഗിച്ചു. കറുപ്പ്, സിൽവർ- കറുപ്പ് പൊളിത്തീൻ ഷീറ്റുകൾ 25 മൈക്രോൺ കനത്തിലുള്ളവ ഉപയോഗിച്ചു. കാലിവളം 25 ടൺ ഒരു ഹെക്ടറിന് എന്ന തോതിൽ അടിവളമായി നൽകി. ശുപാർശ ചെയ്ത അളവിലെ പോഷകങ്ങൾ (75 :40 :25 കിലോ നൈട്രജൻ :ഫോസ്ഫറസ് : പൊട്ടാഷ് / ഹെക്ടർ) തുള്ളി നന ജലസേചനത്തിന്റെ കൂടെ മൂന്ന് ദിവസത്തെ ഇടവേളകളിലായി നൽകപ്പെട്ടു. മറ്റുള്ള എല്ലാ പരിചരണ രീതികളും കേരള കാർഷിക സർവകലാശാലയുടെ പാക്കേജ് ഓഫ് പ്രാക്ടീസ് ശുപാർശ പ്രകാരം അവലംബിച്ചു.

പ്രധാന പ്ലോട്ട് ഡിസൈനുകളിൽ ജൈവ പുതയിടൽ മാർഗം ചെടിക്കു കൂടുതൽ വളർച്ചയും ഉത്പാദന ക്ഷമതയും നൽകി. എന്നാൽ ഗുണ മേന്മ കൂടുതൽ ഉള്ള കായ്കൾ ലഭിച്ചത് കറുപ്പ് നിറത്തിലുള്ള പോളിയെത്തീൻ ഷീറ്റ് പുതയിൽ നിന്നാണ്. കൂടുതൽ ആദായം ലഭ്യമായത് ജൈവ പുതയിടൽ നിന്നാണ്. വേരിന്റെ

പ്രസരണവും, വേരും തണ്ടും തമ്മിലുള്ള അനുപാതത്തിലും ഉപ പ്ലോട്ട് ഡിസൈനായ തുള്ളി നന ജല സേചനം സാരമായ മാറ്റങ്ങൾ കാണിച്ചു.

മഴമറയിൽ സംയോജിത ജൈവ പുതയിടലും തുള്ളി നന ജലസേചനവും ഒപ്പം മൂന്നു ദിവസത്തെ ഇടവേളകളിലായി ജല സേചനത്തിലൂടെയുള്ള വള പ്രയോഗവും (75 :40 :25 കിലോ നൈട്രജൻ :ഫോസ്ഫറസ് : പൊട്ടാഷ് / ഹെക്ടർ) മുളകിന്റെ ഉത്തമ വളർച്ചയ്ക്കും ഉത്പാദനത്തിനും അനുയോജ്യമെന്ന് ഈ പഠനം തെളിയിക്കുന്നു.