EFFECT OF DIFFERENT SHADING INTENSITIES AND MULCHING ON GROWTH AND YIELD OF CAULIFLOWER

By

Mr. BICHKULE CHANDAN VASANT

(Reg. No. 013/324)

A thesis submitted to the

Mahatma Phule Krishi Vidyapeeth, Rahuri- 413722

Dist. Ahmednagar, Maharashtra State, India

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE (HORTICULTURE)

in

VEGETABLE SCIENCE

HORTICULTURE SECTION

COLLEGE OF AGRICULTURE, KOLHAPUR

MAHATMA PHULE KRISHI VIDYAPEETH

RAHURI- MAHARASHTRA (INDIA)

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2015

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I hereby declare that this thesis or part there of has not been submitted by me or any other person to any other University or Institute for Degree or Diploma

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C E R T I F I C A T E

This is to certify that the thesis entitled, **"EFFECT OF DIFFERENT SHADING INTENSITIES AND MULCHING ON GROWTH AND YIELD OF CAULIFLOWER"** submitted to the Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra State, India in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **VEGETABLE SCIENCE**, embodies the results of a piece of *bonafide* research work carried out by **Mr. BICHKULE CHANDAN VASANT** under my guidance and supervision and that no part of this thesis has been submitted for any other degree or diploma.

Place : KOLHAPUR
Date : / /2015

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Place : Kolhapur **(G. G. Khot)**

Date : / /2015 Associate Dean

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***Place**: Kolhapur*

***Date**: / / 2015* *(Bichkule Chandan Vasant)*

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LIST OF ABBREVIATIONS

APAR	:	Absorbed Photosynthetically Active Radiation
@	:	At the rate of
CD	:	Critical Difference
CF	:	Chemical Fertilizer
cm	:	Centimeter (s)
Cv.	:	Cultivar
DAT	:	Days After Transplanting
^{o}C	:	Degree Celsius
et al.	:	Et alli (and others)
etc.	:	Et cetra
e.g.	:	For example
FCRD	:	Factorial completely Randomized Design
Fig.	:	Figure (s)
FYM	:	Farm Yard Manure
g	:	Gram (s)
ha^{-1}	:	Per hectare

i.e.	:	Id est (That is)
Kg	:	Kilogram (s)
LSP	:	Light Saturation Point
mg	:	Milligram (s)
m	:	Meter
MT	:	Metric Tons
N.S.	:	Non-significant
/	:	Per
%	:	*Per cent*
PAR	:	Photosynthetically Active Radiation
q	:	Quintal
S.E.	:	Standard Error
S	:	Shade net
M	:	Mulching
viz.,	:	Vide licet (Namely)

ABSTRACT

Effect of different shading intensities and mulching on growth and yield of cauliflower

By

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Research Guide	**:** Dr. S. V. Sawant
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An experiment entitled "Effect of different shading intensities and mulching on growth and yield of cauliflower" was conducted in a specially designed shade net having four different shading intensities *viz.* 0 (Open), 35, 50 and 75 *per cent* intensity with and without mulching in month of March, 2015. The experiment was laid out in factorial completely randomized design with eight treatments and three replications.

The results indicated that, among the different shading intensities 35 *per cent* shading intensity had maximum number of leaves (25.70). Among the mulching and without mulching treatments, mulching recorded the highest number of leaves (24.02).

The highest length of leaves, plant spread and plant height was observed in 35 *per cent* shading intensities (32.20, 72.33 and 18.65 cm) and in mulching was (29.90, 67.03 and 16.47 cm, respectively). While lowest length of leaves, plant spread and plant height observed in 0 (Open) *per cent* shading intensity (23.93, 56.40 and 13.30 cm) and without mulching (27.27, 62.92 and 15.26 cm, respectively).

The minimum days were required for curd initiation, first harvesting and last harvesting under 35 *per cent* shading intensity (49.67, 61.83 and 65.33 days) as compared to other shading intensities. While in mulching were (52.83, 65.25 and 68.03 days, respectively) as compared to without mulching.

The maximum diameter of curd (20.17 cm), highest weight of curd (606.50 g), yield $plot^{-1}$ (9.70 kg) and yield ha^{-1} (22.44 t/ha) of cauliflower crop was recorded in 35 *per cent* shading intensity as compared to other shading intensities. While in mulching was (18.32 cm, 482.57 g, 7.72 kg and 17.86 t/ha) compared to without mulching.

Abstract contd..... ***Bichkule C. V.***

The highest per cent of pest incidence (34.80 *per cent*) was observed in 0 (Open) *per cent* shading intensity as compared to 35, 50 and 75 *percent* shading intensities (23.89, 17.81, 13.43 *per cent*), respectively.

Thus, it is concluded that, 35 *per cent* shading intensity and mulching found sustainable for improving growth and yield of cauliflower during summer season.

Total pages : 1 to 67

1. INTRODUCTION

Cauliflower is one of several vegetables in the species *Brassica oleracea* belonging to family Cruciferae. It is an annual vegetable that reproduces by seed. Typically, only the white curd is consumed. The cauliflower curd is composed of a white inflorescence meristem. Cauliflower curd resemble those in broccoli, which differs in having flower buds. Its name is derived from Latin word *caulis* (Cauliflower) and flower. *Brassica oleracea* also includes cabbage, brussel's sprout, kale, broccoli and collard greens, though they are of different cultivar groups.

In India, important cauliflower producing states are West Bengal, Bihar, Madhya Pradesh, Odisha, Gujrat and Maharashtra. The area under cauliflower crop in India in the year 2012-2013 was 4.022 lakh ha with production of 78.87 lakh MT, whereas area under cauliflower in Maharashtra was 11,000 ha with production of 2.38 lakh MTwith an average productivity of 21.6 MT/ha (Anonymous, 2013).

Cauliflower was first introduced to India, from England in 1822. Its popularity and cultivation increased tremendously with the development of Indian tropical cultivars. Original cauliflower is a biennial, requiring temperate climate. Indian cauliflower is an early maturing annual type, tolerate to high temperature and humid climatic conditions.

Cauliflower can be used in both raw and cooked preparations. It can be boiled, steamed, roasted, fried and pickled. It can be used as a substitute in recipes wherever

traditional cauliflower is called for. Steamed cauliflower can be pureed to make sauces and soups. Cauliflower contains several anti-cancer phyto-chemicals like sulforaphane.

Fresh cauliflower is an excellent source of vitamin C; 100 g edible portion provides about 48.2 mg or 80% of daily recommended value. Vitamin-C is a proven anti-oxidant which helps to fight against harmful free radicals, boosts immunity and prevent infections and cancers. It contains good amounts of many vital B-complex groups of vitamins such as folates, pantothenic acid (vitamin B_5), pyridoxine (vitamin B_6), thiamin (vitamin B_1)and niacin (B_3) as well as vitamin K. These vitamins are essential in the sense that body requires them from external sources to replenish and required for fat, protein and carbohydrate metabolism. Further, it is also good source of minerals such as manganese, copper, iron, calcium and potassium.

Growing plants under cover improves the quality of the produce. This in turn is helpful in fetching higher price that becomes remunerative to the grower. It is also possible to make the produce available in the market, when it is in great demand, provided the grower takes advantage of protected cultivation. The growers can cultivate a crop in any season under protected environment, as he can provide the temperature, humidity and light, as required by the plant species.

Shade net can be utilized to protect sensitive plants from adverse environmental conditions. There are many significances of protected cultivation over the field cultivation

such as; environment control allows raising plants anywhere in the world at any time of the year i.e. crops could be grown under the inclement climatic conditions when it would not be otherwise possible to grow crops under the open field conditions. The crop yields are at the maximum level per unit area, per unit volume and per unit input basis. The control of the micro-climate allows the production of higher quality products which are free from insect attack, pathogens and chemical residue. Prado *et al.* (2008) found that more than one layer of Shade net used in growing broccoli produced taller plants, bigger heads and reduced the occurrence of insect pests, thus reducing mortality rate and resulting in higher yield. Due to control of micro-climate; high value and high quality crops could be grown for export markets.

Black and silver mulch film is a protection cover over the soil, primarily to modify the effect of local climate. The most powerful feature of plastic mulch is the impact it has on light. The soil temperature in the planting bed is raised, promoting faster crop development and earlier harvest. Soil water loss is reduced under plastic mulch, as a result, irrigation frequency can be reduced. Since mulch film blocks the photosynthesis light, the weeds can not survive under these conditions. Hence, it is evident that, mulching is an important factor for the production of cauliflower.

In Shirol tahsil of Kolhapur district of Maharashtra; cauliflower is grown on near about 400 ha area under open field conditions during summer season. But, farmers envisage the problems of high light intensity and temperature with high

attack of diamond back moth. Due to these situations, quality and quantity of curd is hampered and small curds are developed. Shading and mulching is an important way to create the suitable environment for exuberant growth and yield of cauliflower.

The yield potential of cauliflower is more in *rabi* and *kharif* season. However, to fetch better market prices to the cauliflower, especially by growing this crop during off season is of prime importance and needs investigation in this direction.Keeping in view all these facts, the present investigation on “Effect of different shading intensities and mulching on growth and yield of cauliflower” was conducted with following objectives:

1) To study the effect of different shading intensities and mulching on growth characteristics of cauliflower.
2) To study the effect of different shading intensities and mulching on yield of cauliflower.
3) To study the effect of different shading intensities and mulching on pest and disease incidence in cauliflower.

2. REVIEW OF LITERATURE

Literature pertaining to the effect of shade net intensities and mulching on growth and yield aspects of cauliflower and other cole crops is reviewed and presented under the appropriate headings as below:

2.1. Effect of shade net intensities on growth and yield of cauliflower

Sajjapongse and Raon (1983) observed poor head formation, leaf twisting, early bolting and reduced yields when temperate leafy vegetables were grown under hot, high-sunlight conditions.

Smith *et al.* (1984) observed that under shading nets, the air temperature was lower than that of the ambient air, depending on the shading intensity. Shade netting not only decreases light quantity but also alters light quality to a varying extent and might also change other environmental conditions.

Chen and Jiang (1998) studied the effect of shade (0, 30, 65 %) on photosynthesis and growth of different cultivars of capsicum. They found that the plant height, leaf area, chlorophyll and carotenoid content was increased and leaf thickness and specific leaf weight increased with increased shade.

Swagatika *et al.* (2006) observed that cauliflower sown in the month of September and grown under shade net recorded the highest values for plant height, number of leaves, girth and curd yield.

Khattak *et al.* (2007) studied the response of exotic tomato lines under 0, 55 and 75 *per cent* shading densities. Shading intensity of 75 *per cent* shading intensity recorded the maximum plant height, number of leaves, days to flowering and fruiting, yield plot^{-1}. While minimum plant height, leaf number, days to flowering and fruiting, yield plot^{-1} were recorded in control.

Rahman *et al.* (2007) conducted an experiment to study the response of cauliflower cv. "Nautilus F_1" to different radiation integralsafter curd initiation by covering the plants with different levels (0, 38, 50 and 68%) of neutral shading materials. Further, they reported that the cauliflower growth and development declined with increasing shade levels after curd initiation. Curd growth also increased linearly with increasing accumulated incident radiation integral with greater mean relative curd dry matter increase per MJ under lower incident radiation conditions than higher incident radiation levels.

Prado *et al.* (2008) found that broccoli plants raised in two and three layered shading nets were least attacked by insect pests and hence had the least mortality rate than rest of the treatments. Broccoli raised under two or three layers of shade net, flowered and matured earlier, had more leaves with taller plants at heading and harvesting, had bigger and heavier heads and higher yield per treatment.

Vethamoni and Natarajan (2008) studied the effect of three different shade levels (open field condition, 35 and 50 %) on growth and yield of sweet pepper cultivars *viz.*, Indra and Kohinoor during two seasons *viz.*, September, 2004 to March,

2005 (Season-I) and June to December, 2005 (Season-II) and concluded that 35 *per cent* shade is most suitable for year round cultivation of sweet pepper under tropical conditions.

Dhatt and Kaler (2009) studied the effect of shade net and growing media on nursery raising of cauliflower in sub-tropical area. Among the three shade treatments, agro shade net (green colour 6 mesh size, 25 % reduction of sunlight), monofilament insect net (white colour 26 mesh size, 10 % reduction of sunlight) and open field, the monofilament insect net showed the best results for cauliflower germination, seedling length, number of true leaves, dry matter, field establishment of transplant, plant height, days to harvesting and yield.

Haque *et al.* (2009) studied the morpho-physiological changes and yield performance of bottle gourd under four different levels of light (100, 75, 50 and 25 % PAR). It was observed that some of the morphological characters like main stem length, internode length and individual leaf area was increased, whereas main stem diameter and number of leaves plant^{-1} were decreased due to the reduced light levels. However, considering total dry matter and fruit yield, bottle gourd was found suitable for reduced light condition (up to 50 % PAR).

Kittas *et al.* (2009) conducted an experiment using four different shading nets with different colours and shading intensities and found that the shading increased the leaf area index and total marketable yield production, whereas reduced

the appearance of tomato cracking to about 50 *per cent* than under non shading conditions.

Moniruzzaman *et al.* (2009) reported that 50 *per cent* shade and application of 161 kg N ha^{-1}, independently as well as in combination, gave maximum fresh yield of Bangladhonia. Further, it was concluded that Bangladhonia performed better in terms of fresh yield and quality under 25-50 *per cent* shade condition.

Xu *et al.* (2009) observed that the non-heading Chinese Cauliflower plants grew better under the stronger illumination (100 % and 60 %) with 80 % water holding capacity of substrate, or 60 % substrate moisture under lower light intensity (30 %).

Fu *et al.* (2010) reported that the low light intensity resulted in lower total biomass, root/shoot ratio and leaf thickness, whereas the specific leaf area and leaf pigments were found to increase under lower light availability.

Suseela and Rangaswami (2011) recorded that the curd initiation during summer season in all the greenhouses was earlier than winter season. The formation of curd in the 4.5 m greenhouse, where temperature was comparatively low, was earlier and plants showed a delayed the curd formation with decrease in the height of the greenhouse.

Srivastava *et al.* (2011) conducted an experiment to study the performance of early cauliflower (*Brassica oleracea* var. *botrytis*) under naturally ventilated polyhouse and found that, the plant height was maximum (66.05 cm) in the variety

Pant Composite, while the variety Pusa Meghna produced dwarfest plant (54.5 cm) with widest leaf lamina (25.4 cm). Maximum number of leaves plant^{-1} (23.45) and the longest leaf (50.50 cm) were produced by the variety Pant Gobhi-3. Curd weight was maximum (472.5 g) in Early Himlata followed by Pusa Deepali (439.0 g) and Pusa Meghna (426.5 g). The former also yielded highest (16.25 t ha^{-1}) followed by Early Kunwari (15.8 t ha^{-1}). The maturity was earliest (78.15 days) in Pusa Meghna followed by Early Kunwari (83.10 days). Considering all characters like vegetative growth, curd size, yield and the crop duration, the varieties Early Himlata, Early Kunwari and Pusa Meghna were found to be most suitable for protected rainy season cultivation in a naturally ventilated polyhouse.

Kotadia *et al.* (2012) showed that leafy vegetables grown in shade net situation favoured plant growth attributes and gave higher yield as compared to open field situation during summer season. Amaranthus and spinach grown in 30 *per cent* shade net produced vigorous growth in terms of plant height, root length, number of leaves and leaf area.

Chatterjee and Mahanta (2013) showed that planting of off -season cauliflower during summer season under 50 *per cent* shade intensities on different dates have significant effect on vegetative and yield attributes of cauliflower. Among the different planting dates, 14th May planting recorded the highest plant height (37.28cm), maximum number of leaves (17.31/plant), curd weight (314.53 g), curd yield (1.55 kg/m^2) and vitamin C content of curd (35.59 mg/100 g).

Juan Carlos and Diaz-Perez (2013) reported that with increased shade level, the total plant leaf area, individual leaf area and individual leaf weight were increased, whereas leaf number per plant and specific leaf weight were decreased and morphological changes such as taller plants and thinner and larger leaves, likely enhanced light capture under shaded conditions compared with unshaded plants.

Rajasekar *et al.* (2013) reported that mean weekly temperatures during summer and winter were higher under open field conditions than in the shade net house. Lower temperature causesplant height, number of branches, internodal length, average fruit weight and yield per plant to be higher in the shade net house than in the open field. Hence, the growing of tomato, eggplant, chilli, cucumber, radish, amaranthus and coriander under shade house conditions will be more profitable irrespective of the seasons.

Thapa *et al.* (2013) conducted study to assess the production of quality sprouting broccoli (*Brassica oleracea* var. *italica*) under cover and open condition situation and reported that plants grown in poly house gave the highest production in all the four varieties as compared to the plants grown in open field. Marketable curd yield of 'Early you' was highest in poly house condition.

Andhale *et al.* (2014) reported that micro-meteorological parameters *viz.,* absorbed photosynthetically active radiation (APAR) and light use efficiency were significantly increased fewer in the 35 *per cent* shading intensity which resulted into higher photosynthetic rate and ultimately the yield of

capsicum, suggesting suitability of 35 *per cent* shading intensity for capsicum cultivation under protected cultivation. The 35 *per cent* shading intensity in combination with green + white coloured shade net recorded higher yield of capsicum.

Nangare *et al.* (2015) studied the effect of three green shade nets (35, 50 and 75%) on yield and quality of tomatoes and reported that there was no significant difference found in average monthly temperature and humidity inside shade net house and open field (control). Significant difference was recorded in yield. Highest average plant yield of (3.49 kg/plant) was found in 35 % shading net followed by open field (2.27 kg/plant) with lowest yield observed (1.07 kg/plant) in 75 % shading net.

2.2 Effect of mulching on growth and yield of cauliflower

Baten *et al.* (1995) studied the effect of different mulches on growth and yield of late planted garlic and reported that plant treated with any of the mulches showed significant increase in plant height, number of leaves per plant, length of leaf and length of pseudostem.

Nagalaxmi *et al.* (2002) obtained the maximum number of fruits per plant (97.67), length of fresh fruit (6.93 cm), circumference of fruit (3.57 cm) and yield of chilli (8602 Kg/ha) with application of black LLDPE mulch compared to organic mulch and no mulch.

Christopher (2003) found that mulching chillies with black linear low density polyethylene (LLDPE) film of 25 micron thickness significantly influenced plant height (47.5

cm), number of fruits per plant (97.7), fruit girth (3.6 cm), fruit length (6.9 cm) and fresh fruit yield per ha (8.602 t) over organic mulch of maize stalk and control treatment. The net returns were also favourably influenced by plastic mulching compared to unmulched control.

Moniruzzaman *et al.* (2007) found that mulching with black polythene independently as well as in combination produced maximum values for yield attributes and marketable yield of cauliflower. The highest curd yields of 30.38 and 29.40 t ha^{-1} were obtained from 7 days irrigation interval with black polythene mulch in 2000-01and 2001-02, respectively.

Salim *et al.* (2008) studied the growth and yield of cauliflower as influenced by polyethylene mulching.The treatments were polyethylene mulch (with or without) and the three varieties (Poushali, Snow crown and IPSA-1). There was a positive impact of mulch on yield and yield attributes of the crops. The highest marketable yield (31.32 t/ha) was obtained from hybrid variety Snow crown with mulch, which was 35.16 *per cent* higher than without mulch.

Akhter *et al.* (2009) reported that the increase in plant height, internodal distance and node numbers with reduction of PAR from 100 up to 25 *per cent* but the pod yield per plant, dry seed yield of grains of garden pea was found reduced with the reduction in the light intensities under the protected shade conditions of mosquito nets of different colours and mesh numbers.

Easmin *et al.* (2009) reported that highest Chinese cabbage plant spread (44.50 cm, 58.28 cm) during harvest period was recorded in black polythene mulch and the shortest plant spread of plant (37.60 cm and 49.58 cm) was recorded in no mulch i.e. control. The highest number of days to start head formation of Chinese cabbage (45.37) was recorded in no mulch and the least number of days (41.17) were recorded in black polythene mulch. The highest marketable yield per hectare of Chinese cabbage (123.27 ton) was recorded in black polythene mulch and the lowest yield (76.51 ton) was recorded in no mulch.

Gordon *et al.* (2010) reported that the use of black colored plastic mulch increased early and total yield of okra compared with bare soil with and without row cover.

Rajablariani *et al.* (2012) reported that tomato plants grown on silver/black mulch produced maximum marketable yield and fruit weight. The silver/black and black plastic mulches resulted in a 95-98 % reduction in weed biomass. In an attempt to reduce chemical input for weed control and increase in yield of tomato, black and silver/black plastic mulch may be a good alternative for conventional clear plastic mulches.

Mustapha (2012) observed that black polythene mulch recorded the highest mean fresh fruit yield of 23.75 g per plant with 0.95 tons ha^{-1} total yield of sweet pepper. Black polythene mulch also recorded the highest mean values for all the growth parameters. In the investigation black polythene

mulch showed a better result to other synthetic and grass mulch.

Parmar *et al.* (2013) reported that the plant growth, yield and quality characters were superior with silver /black polyethylene mulch while, plants without mulch (control) resulted poor growth and yield.

2.3 Effect of shade net intensities and mulching on pest and disease incidence

Bextine *et al.* (2001) reported that the row covers prevented the transmission of yellow vine disease (a phloem limited bacterium) in squash plants. The disease is transmitted by spotted cucumber beetles (*Diabrotica undecimpunctata howardi*), striped cucumber beetles (*Acalymma vitatum*), and squash bugs (*Anasa tristis*). The disease did not occur in squash with row covers because the row covers prevented the access of harmful insects that act as vectors for the disease to plants.

Elad *et al.* (2007) reported that green nets were associated with lower levels of disease in the field experiments of pepper crop.

Prado *et al.* (2008) revealed that broccoli plants raised in two and three layered shading nets were least attacked by insect pest and hence had the least mortality rate than the rest of the treatments.

3. MATERIAL AND METHODS

The present experiment entitled “Effect of different shading intensities and mulching on growth and yield of cauliflower” was carried out in a specially designed shade net house at Horticulture Sectional farm, College of Agriculture, Kolhapur during summer, 2015.

The material used and methodology adopted in conducting the research programme are furnished in this chapter.

3.1 Experimental site

3.1.1 Location

The present investigation on “Effect of different shading intensities and mulching on growth and yield of cauliflower” was carried out in a specially designed shade net house at Horticulture Sectional farm, College of Agriculture, Kolhapur during summer, 2015.

3.1.2 Geography and climate

The experimental farm, College of Agriculture, Kolhapur, Dist. Kolhapur is situated in tropical region at 16^0 42’ North latitude and 74^0 14’ East longitudes. Ecologically this area comes under the Sub-montane Zone with annual rainfall ranging from 700 to 2500 mm. The average annual rainfall is 1057 mm out of which 80 *per cent* receives from south west monsoon in June to September while rest of rainfall receives in the month of October and November from North - West monsoon.

3.1.3 Nature of season during experimental period

The weather data during the period of experimentation (March, 2015 to May, 2015) was obtained from Meteorological Observatory located at Agronomy farm, college of Agriculture, Kolhapur revealed that the mean maximum temperature ranged from 33.4 to 37.7 ^{0}C while minimum temperature from 20.3 to 22.2 ^{0}C. The maximum temperature (37.7 ^{0}C) was observed during 17th meteorological week, whereas minimum temperature (20.3^{0}C) was noticed during 12th meteorological week whereas in controlled condition the temperature was observed maximum during 17th and minimum during 22th meteorological week.

The mean relative humidity ranged from 66 to 90 *per cent* at morning and 27 to 57 *per cent* at evening. The maximum relative humidity (90 %) was observed during 19th meteorological week at morning hours and minimum relative humidity was observed in 14th meteorological week (27 %) during evening hours.

3.2 Methodology

3.2.1 Shade net house

The three shade net houses 35, 50 and 75 *per cent* shading intensities are made having 12 m × 9 m length and width. The two lateral drip lines were arranged on each bed along the crop row and drippers were placed to each plant at the spacing of 45 cm. The shade net was provided with the foggers to protect the crop from excessive heat and to control the humidity.

3.2.2 Mulching of beds

Silver Black Polyethylene film (30 μ) is used as mulch material.

3.3 Details of experiment

A. Experiment Details:

1) Crop	:	Cauliflower
2) Variety	:	Sungrow-110
3) Design	:	Factorial Completely Randomized Design
4) No. of Treatments	:	
a. Main Treatments	:	04
b. Sub treatments	:	02
5) No. of Replications	:	03
6) Season	:	Summer, 2015
7) Seed rate	:	600 g/ha
8) Spacing	:	60 X 45 cm
9) Fertilizer dose	:	20 t FYM + 150: 75: 75 (NPK kg/ha)
10) Plot size (m)	:	Gross plot : 2.7 X 2.4 m
	:	Net plot : 1.8 X 2.4 m
11) Planting layout	:	B.B.F. (Broad Base Furrow)
12) Location	:	Horticulture sectional farm, College of Agriculture, Kolhapur

B. Treatment Details:

a. Shading intensities:

S_1 : 0 % (Open)

S_2 : 35 %

S_3 : 50 %

S_4 : 75 %

b. Mulching:

M_1 : Mulching (silver black polyethylene mulch)

M_2 : Without mulching

C. Observations to be recorded:

I. Growth observations:

1) Number of leaves
2) Length of leaves (cm)
3) Plant spread (cm)
4) Plant height (cm)
5) Number of days required for curd initiation
6) Days required for first harvesting
7) Days required for last harvesting

II. Yield observations:

1) Diameter of curd (cm)
2) Weight of curd (g)
3) Yield per plot (Kg)
4) Yield per hectare (t/ha)

III. Pest and disease incidence

3.4 Cultural operations

3.4.1 Preparation of land in shade net house and fumigation

The weeds and stubbles were removed completely and soil was brought to a fine tilth. Two days later, farm yard manure and fine sand were incorporated into the soil in proportion of 40 *per cent* red soil + 20 *per cent* sand + 40 *per cent* FYM and mixed uniformly. This homogenous mixture of media was disinfected with 2 *per cent* Formalin (20 ml L^{-1}) by saturating the media with application of diluted Formalin (meq L^{-1}) @ 4 litres of solution m^{-3}. Immediately after treating the soil, the entire area was covered with black polythene sheet for 4 days and thereafter irrigated twice to remove chemical residue if any.

Formalin treatment to growing media was done to sterilize the media and to overcome the soil borne diseases. The media was then perfectly leveled and the raised beds of 45 cm height, 2.4 m width and 2.7 m length were prepared.

3.4.2 Seedling

The required quantity of seedlings of Cauliflower variety Sungrow 110 was procured from the Kachare Nursery, Tamdalage, Tal. Shirol, Dist. Kolhapur (M.S.) for present investigation.

3.4.3 Transplanting

The beds were soaked with water and brought to wapsa condition. The healthy seedlings were transplanted in 20 March (2015) at the spacing of 60 x 45 cm on the raised beds under shade net. A five cm hole was made with the help of

stick at an interval of 45 cm near each emitter for transplanting the seedling in each hole. The roots of seedling alone with coco peat were placed in soil and slightly pressed for easy establishment of seedling. In each treatment 24 seedlings were transplanted.

3.4.4 Fertilizer dose

The recommended fertilizer dose @ 150:75:75 N, P_2O_5 and K_2O kg ha^{-1} was applied on the bed at the time of transplanting of Cauliflower seedlings.

3.4.5 Gap filling

To maintain the optimum plant population gap filling was carried out after 5 days of transplanting.

3.4.6 Irrigation

Plants were irrigated on every alternate day through drip irrigation system laid on bed.

3.4.7 Weeding

Three hand weedings were carried out during the experimental period.

3.4.8 Shade net management

The dried leaves were removed regularly. Sanitation was maintained within the shade net and the structure was kept clean by removing plant debris or weeds. Allowing visitors inside the protected structure was discouraged as it may allow insect pests and vectors to enter into the shade net.

3.4.9 Harvesting

Cauliflower curds were harvested separately when they were firm, compact and attained horticultural maturity.

3.5 Biometric observations

Five plants were randomly selected and tagged from each treatment from all the three replications to record the periodical observations at an interval of 15 days during experimentation.

3.5.1 Number of leaves plant^{-1}

The total number of leaves of five randomly selected plants were counted and average number of leaves per plant was recorded at an interval of 15 days.

3.5.2 Length of leaves (cm)

It was counted at 15, 30, 45 days after transplanting at an interval of 15 days till harvest. It was measured from the distance between tip of leaves to pedicel with the help of meter scale. The mean length of leaveswas calculated and expressed in centimeter.

3.5.3 Plant spread (cm)

The maximum growth of the plant in either directions (North-South or East-West) was measured in centimeter and the average was worked out.

3.5.4 Plant height (cm)

Five plants were tagged at random in each treatment for recording the height from 15 days after transplanting at an interval of 15 days till the end of the crop. It was measured from the ground level to the growing tip of the main stem with

the help of meter scale. The mean plant height was calculated and expressed in centimeter.

3.5.5 Number of days required for curd initiation

Number of days required to curd initiation from transplanting were counted and the average was worked out.

3.5.6 Days required for first harvesting

Number of days required for first harvesting from transplanting were counted and the average was worked out.

3.5.7 Days required for last harvesting

Number of days required for last harvesting from transplanting were counted and the average was worked out.

Table 1.Details of observations recorded during experimentation

Sr. No.	Particulars	Frequency	Size of sample	Days after transplanting
A.	**Growth observations**			
1.	Number of leaves plant^{-1}	4	5	15, 30, 45 DAT and at harvest
2.	Length of leaves	4	5	15,30,45DAT and at harvest
3.	Plant spread (cm)	4	5	15,30,45 and at harvest
4.	Plant height (cm)	4	5	15,30,45 DAT and at harvest
5.	Number of days required for curd initiation	1	-	-
6.	Days required for first Harvesting	1	-	-

7.	Days required for last Harvesting	1	-	-
B.	**Yield observations**			
1.	Curd diameter(cm)	1	5	At Harvest
2.	Weight of curd (g)	1	5	At Harvest
3.	Yield plot^{-1} (Kg)	1		
4.	Yield (t ha^{-1})	1		At harvest
C.	**Pest and disease incidence**		-	On per plot basis

3.6 Yield observations

3.6.1 Diameter of curd (cm)

The diameter of curd of cauliflower was recorded by measuring of each curd with measuring tape expressed in centimeter during harvesting of five selected plants from the net plot area and mean diameter of curd plant^{-1} (cm) was worked out.

3.6.2 Weight of curd (g)

Curd weight was recorded on the same curds which were used for recording the curd diameter by measuring the weight of each curd on weighing balance and expressed in grams.

3.6.3 Yield plot^{-1}

The fresh curd from net plot area at harvesting was recorded. The sum of curd yield of net plot was calculated after harvesting of cauliflower.

3.6.4 Yield ha^{-1}

The sum of curd yield of net plot was calculated after harvesting of Cauliflower. This yield of net plot was then converted on hectare basis and presented as tones ha^{-1}.

3.7 Pest and disease incidence

The pest and disease incidence was counted on per plot basis.

Pest incidence was calculated by formula: (Philip and Qadri (2009)

$$\text{Pest incidence} = \frac{\text{Affected plants}}{\text{Total number of plants}} \times 100$$

3.9 Statistical analysis

The data recorded were statistically analyzed by using technique of analysis of variance and significance was determined for Factorial completely randomized block design (Panse and Sukhatme, 1967). The standard error of mean (S.E.$\pm$) was worked out. Whenever, the results were significant, the critical difference (CD) at 5 *per cent* level of significance was worked out and presented. The suitable graphical illustrations of the data have been given at appropriate places.

4. EXPERIMENTAL RESULTS

An experiment entitled "Effect of different shading intensities and mulching on growth and yield of cauliflower" was conducted in a specially designed shade net having three different shading intensities and open condition *viz.* 0 (Open), 35, 50 and 75 *per cent* and mulching under each intensity.The cauliflower Cv Sungrow-110 variety was transplanted in March, 2015 for experimentation.

The present investigation dealt with different aspects *viz.*, effect of different shading intensities and mulching on growth, yield and pest and disease incidence in cauliflower. Results of the experiment are presented in this chapter.

4.1 Growth Parameters

The various growth parameters *viz.* number of leaves, length of leaves, plant spread, plant height were recorded at 15 days interval upto 45 days after transplanting and at harvesting, starting from 15 days after transplanting. Moreover, number of days required for curd initiation, for first harvesting and for last harvesting were also recorded.

4.1.1 Number of leaves

The data on mean number of leaves of cauliflower as influenced by different treatments are presented in Table 2 and graphically depicted in Fig.1.

Table 2. Number of leaves plant^{-1} as influenced by different shading intensities and mulching

Treatment	Number of leaves plant^{-1}			
	15 DAT	**30 DAT**	**45 DAT**	**At Harvest**
Shading intensities (S)				
S_1- 0 % (Open)	5.73	8.73	16.33	20.47
S_2- 35 %	9.40	14.63	24.80	25.70
S_3- 50 %	8.27	13.57	23.03	24.13
S_4-75 %	7.17	11.73	21.00	22.30
SEm±	0.18	0.25	0.49	0.47
CD at 5 %	0.56	0.75	1.48	1.43
Mulching (M)				
M_1- Mulching	8.33	12.98	22.20	24.02
M_2-Without mulching	6.95	11.35	20.38	22.18
SEm(±)	0.13	0.17	0.35	0.33
CD at 5%	0.39	0.53	1.05	1.01
Interaction (S x M)				
SEm±	0.26	0.35	0.70	0.67
CD at 5 %	NS	NS	NS	NS
General mean	**7.64**	**12.17**	**21.29**	**23.10**

4.1.1.1 Effect of shading intensities

The number of leaves plant^{-1} of cauliflower was significantly influenced due to different shading intensities during all the crop growth stages. Significantly more number of leaves were recorded at 15, 30, 45 DAT and at harvest in 35 *per cent* shading intensity which were to the tune of 9.40, 14.63, 24.80 and 25.70, respectively as compared to that of 0, 50 and 75 *per cent* shading intensities.

4.1.1.2 Effect of mulching

The mean number of leaves were influenced significantly due to mulching and without mulching at all stages of crop growth stages. The mulching produced significantly higher number of leaves per plant at 15, 30, 45 DAT and at harvest which were 8.33, 12.98, 22.20 and 24.02, respectively. Without mulching was found to be ineffective in ameliorating number of leaves plant^{-1}.

4.1.1.3 Effect of interaction

The interaction effect between shading intensities and mulching on number of leaves plant^{-1} of cauliflower was found non significant at 15, 30, 45 DAT and at harvest.

4.1.2 Length of leaves (cm)

The data on mean Length of leaves plant^{-1} of cauliflower as influenced by different treatments have been presented in Table 3 and graphically depicted in Fig.2.

Table 3. Length of leaves plant^{-1}as influenced by different shading intensities and mulching

Treatment	Length of leaves plant^{-1} (cm)			
	15 DAT	**30 DAT**	**45 DAT**	**At Harvest**
Shading intensities (S)				
S_1- 0 % (Open)	4.97	9.97	17.30	23.93
S_2- 35 %	8.60	15.90	26.97	32.20
S_3- 50 %	7.37	14.97	25.30	30.17
S_4-75 %	6.43	13.00	23.23	28.03
SEm±	0.19	0.26	0.51	0.63
CD at 5 %	0.57	0.79	1.54	1.90
Mulching (M)				
M_1- Mulching	7.45	14.18	24.15	29.90
M_2-Without mulching	6.23	12.73	22.25	27.27
SEm(±)	0.13	0.18	0.36	0.44
CD at 5%	0.40	0.56	1.09	1.34
Interaction (S x M)				
SEm±	0.27	0.37	0.73	0.89
CD at 5 %	NS	NS	NS	NS
General mean	**6.84**	**13.46**	**23.20**	**28.58**

4.1.2.1 Effect of shading intensities

The length of leaves plant^{-1} of cauliflower was significantly influenced due to different shading intensities during all the crop growth stages. Significantly longest leaves were observed in 35 *per cent* shading intensity at 15, 30, 45 DAT and at harvest which had length of 8.60, 15.90, 26.97 and 32.20 cm, respectively as compared to 0, 50 and 75 *per cent* shading intensities.

4.1.2.2 Effect of mulching

The mean length of leaves was influenced significantly due to mulching and without mulching at all stages of crop growth stages. The mulching produced significantly longest leaves per plant at 15, 30, 45 DAT and at harvest which had length of 7.45, 14.18, 24.15 and 29.90 cm, respectively. Short leaves were observed in the plants which were grown in without mulching.

4.1.2.3 Effect of interaction

The interaction effect between shading intensities and mulching on length of leaves was found non significant at 15, 30, 45 DAT and at harvest.

4.1.3 Plant spread (cm)

The periodical data on mean plant spread plant^{-1} of cauliflower as influenced by different treatments have been presented in Table 4 and graphically depicted in Fig. 3.

Table 4. Plant spread as influenced by different shading intensities and mulching

Treatment	Plant spread (cm)			
	15 DAT	**30 DAT**	**45 DAT**	**At Harvest**
Shading intensities (S)				
S_1- 0 % (Open)	12.10	24.67	46.77	56.40
S_2- 35 %	19.62	36.17	62.90	72.33
S_3- 50 %	18.57	34.10	58.77	67.70
S_4-75 %	16.53	32.07	54.90	63.47
SEm±	0.34	0.66	1.24	1.35
CD at 5 %	1.02	1.99	3.73	4.07
Mulching (M)				
M_1- Mulching	17.81	33.20	57.78	67.03
M_2-Without mulching	15.60	30.30	53.85	62.92
SEm(±)	0.24	0.47	0.87	0.96
CD at 5%	0.72	1.41	2.63	2.88
Interaction (S x M)				
SEm±	0.48	0.94	1.75	1.92
CD at 5 %	NS	NS	NS	NS
General mean	**16.70**	**31.75**	**55.82**	**64.98**

4.1.3.1 Effect of shading intensities

The plant spread plant^{-1} of cauliflower was significantly influenced due to different shading intensities during all the crop growth stages. Significantly more plant spread was recorded in 35 *per cent* shading intensity at 15, 30, 45 DAT and at harvest which was to the tune of 19.62, 36.17, 62.90 and 72.33 cm, respectively as compared to 0, 50 and 75 *per cent* shading intensities.

4.1.3.2 Effect of mulching

The mean plant spread of cauliflower was influenced significantly due to different mulching and without mulching at all stages of crop growth stages. The mulching had significantly more plant spread per plant at 15, 30, 45 DAT and at harvest which was 17.81, 33.20, 57.78 and 67.03 cm, respectively as compared to without mulching.

4.1.3.3 Effect of interaction

The interaction effect between shading intensities and mulching on plant spread per plant of cauliflower was found non significant at 15, 30, 45 DAT and at harvest.

4.1.4 Plant height (cm)

The periodical data on mean plant height as influenced by different shading intensities and mulching are presented in Table 5 and graphically depicted in Fig. 4.

Table 5. Plant height as influenced by different shading intensities and mulching

Treatment	Plant height (cm)			
	15 DAT	**30 DAT**	**45 DAT**	**At Harvest**
Shading intensities (S)				
S_1- 0 % (Open)	5.10	6.63	9.73	13.30
S_2- 35 %	8.43	10.93	16.57	18.65
S_3- 50 %	7.35	9.87	15.40	16.93
S_4-75 %	6.32	7.80	13.03	14.57
SEm±	0.17	0.21	0.32	0.40
CD at 5 %	0.53	0.64	0.96	1.20
Mulching (M)				
M_1- Mulching	7.23	9.27	14.25	16.47
M_2-Without mulching	6.38	8.35	13.12	15.26
SEm(±)	0.12	0.15	0.22	0.28
CD at 5%	0.38	0.45	0.67	0.85
Interaction (S x M)				
SEm±	0.25	0.30	0.45	0.57
CD at 5 %	NS	NS	NS	NS
General mean	**6.80**	**8.81**	**13.68**	**15.86**

4.1.4.1 Effect of shading intensities

The plant height of cauliflower was significantly influenced due to different shading intensities throughout the crop growth period. Significantly tallest plants were in 35 *per cent* shading intensity at 15, 30, 45 DAT and at harvest which had height of 8.43, 10.93, 16.57 and 18.65 cm, respectively as compared to 0 (Open), 50 and 75 *per cent* shading intensities.

4.1.4.2 Effect of mulching

The plant height was influenced significantly due to mulching and without mulching at all stages of growth. The mulching exhibited significantly higher plant height at all crop growth stages over the without mulching at all the days of observation. The mulching produced significantly higher plant height at 15, 30, 45 DAT and at harvest which was to the tune of 7.23, 9.27, 14.25 and 16.47cm, respectively as compared to without mulching.

4.1.4.3 Effect of interaction

The interaction effect between shading intensities and mulching on plant height was non significant at 15, 30, 45 DAT and at harvest.

4.1.5 Number of days required for curd initiation

The mean number of days required for curd initiation as influenced by different shading intensities and mulching are presented in Table 6 and graphically depicted in Fig. 5.

Table 6. Number of days required for curd initiation as influenced by different shading intensities and mulching

Treatment	**Number of days required for curd initiation**
Shading intensities (S)	
S_1- 0 % (Open)	60.50
S_2- 35 %	49.67
S_3- 50 %	51.17
S_4-75 %	55.50
SEm±	1.11
CD at 5 %	3.33
Mulching (M)	
M_1- Mulching	52.58
M_2-Without mulching	55.83
SEm(±)	0.78
CD at 5%	2.35
Interaction (S x M)	
SEm±	1.57
CD at 5 %	NS
General mean	**54.21**

4.1.5.1 Effect of shading intensities

The number of days required for curd initiation was influenced due to different shading intensities. The curd initiation was found to be earlier in 35 *per cent* shading intensity which required 49.67 days and it was at par with 50 *per cent* shading intensity. Late curd initiation was observed 0 (Open) and 75 *per cent* shade net intensity.

4.1.5.2 Effect of mulching

The number of days required for curd initiation was significantly influenced due to mulching and without mulching. The earlier curd initiation was recorded in mulching at 52.58 days compared to without mulching.

4.1.5.3 Effect of interaction

The interaction effect between shade net intensities and mulching on number of days required for curd initiation was found non significant at all stages of growth.

4.1.6 Days required for first harvesting

The mean number of days required for first harvestingas influenced by different shading intensities and mulching are presented in Table 7 and graphically depicted in Fig. 6.

Table 7. Days required for first and last harvesting as influenced by different shading intensities and mulching

Treatment	Days required for first and last harvesting	
	First harvesting	**Last harvesting**
Shading intensities (S)		
S_1- 0 % (Open)	74.50	78.33
S_2- 35 %	61.83	65.33
S_3- 50 %	64.67	67.67
S_4-75 %	69.17	72.07
SEm±	1.55	1.47
CD at 5 %	4.66	4.43
Mulching (M)		
M_1- Mulching	65.25	68.03
M_2-Non mulching	69.83	73.67
SEm(±)	1.09	1.04
CD at 5%	3.29	3.13
Interaction (S x M)		
SEm±	2.19	2.09
CD at 5 %	NS	NS
General mean	**67.54**	**70.85**

4.1.6.1 Effect of shading intensities

The number of days required for first harvesting was influenced due to different shading intensities. The first harvest of curd was obtained in 35 *per cent* shading intensity. Curds in this treatment were ready for harvest at 61.83 days and this treatment was at par with 50 *per cent* shading intensity. Curds in 0 (Open) and 75 *per cent* shading intensities took more days for harvesting as compared to 35 and 50 *per cent* of shading intensities.

4.1.6.2 Effect of mulching

The number of days required for first harvesting was significantly influenced due to mulching and without mulching. The curds in mulching treatment were ready for harvest in 65.25 days. First harvesting of curd was delayed in without mulching treatment.

4.1.6.3 Effect of interaction

The interaction effect between shade net intensities and mulching on days required for first harvesting was found non significant.

4.1.7 Days required for last harvesting

The mean number of days required for last harvesting as influenced by different shading intensities and mulching are presented in Table 7.

4.1.7.1 Effect of shading intensities

The number of days required for last harvesting of curd was significantly influenced due to different shading intensities. Curds obtained in 35 *per cent* shading intensity

were ready for harvest at 65.33 days and which was at par with 50 *per cent* shading intensity. Curds formed in 0 (Open) and 75 *per cent*shading intensities took more time for harvesting.

4.1.7.2 Effect of mulching

The number of days required for last harvesting was significantly influenced due to mulching and without mulching. The last harvesting in mulching was done at 68.03 days compared to without mulching.

4.1.7.3 Effect of interaction

The interaction effect between shade net intensities and mulching on days required for last harvesting was found non significant.

4.2 Yield parameters

4.2.1 Diameter of curd

The mean curd diameter of cauliflower as influenced by different treatments are presented in Table 8.

4.2.1.1 Effect of shading intensities

The curd diameter was influenced significantly due to different shading intensities. The mean curd diameter was significantly highest in 35 *per cent* shading intensity and it was to the tune of 20.17 cm compared to 0 (Open), 50 and 75 *per cent* shading intensities.

4.2.1.2 Effect of mulching

The curd diameter was influenced significantly due to mulching and without mulching. The mean curd diameter was

significantly higher in mulching and it was 18.32 cm. The lower curd diameter was noticed in without mulching.

4.2.1.3 Effect of interaction

The interaction effect between shading intensities and mulching on diameter of curd was non significant.

4.2.2 Weight of curd

The mean weight of curd as influenced by different treatments are presented in Table 8.

4.2.2.1 Effect of shading intensities

The curd weight was influenced significantly due to different shading intensities. Significantly highest weight of curd was recorded in 35 *per cent* shading intensity which was to the tune of 606.50 g. Lowest curd weight was recorded in 0 (open), 50 and 75 *per cent* shading intensities.

4.2.2.2 Effect of mulching

The weight of curd was influenced significantly due to mulching and without mulching. The mean weight of curd was significantly higher in mulching (482.57g) compared to without mulching.

4.2.2.3 Effect of interaction

The interaction effect between shading intensities and mulching on weight of curd was non significant.

4.2.3 Yield per plot (kg)

The data on mean yield of cauliflower curd per plot of cauliflower (kg) as affected by different treatments are presented in Table 8.

4.2.3.1 Effect of shading intensities

The mean yield per plot of cauliflower curd was significantly influenced due to different shading intensities. The mean yield per plot was significantly highest in 35 *per cent* shading intensity was 9.70 kg as compared to 0 (Open), 50 and 75 *per cent* shading intensities. Significantly lowest curd yield was recorded in 0 (Open)*per cent* shading intensity.

4.2.3.2 Effect of mulching

The mean yield per plot was influenced significantly due to mulching and without mulching. The mean yield per plot was significantly higher in mulching (7.72 kg) as compared to without mulching.

4.2.3.3 Effect of interaction

The interaction effect between shading intensities and mulching on yield per plot was non significant.

Table 8. Yield observations as influenced by different shading intensities and mulching

Treatment	Yield observations			
	Diameter of curd(cm)	**Weight of curd (g)**	**Yield plot^{-1}(Kg)**	**Yield (t/ha)**
Shading intensities (S)				
S_1- 0 % (Open)	14.33	224.50	3.59	8.30
S_2- 35 %	20.17	606.50	9.70	22.44
S_3- 50 %	18.83	544.50	8.71	20.15
S_4-75 %	17.60	462.10	7.39	17.10
SEm±	0.39	9.76	0.15	0.36
CD at 5 %	1.17	29.28	0.46	1.08
Mulching (M)				
M_1- Mulching	18.32	482.57	7.72	17.86
M_2-Without mulching	17.15	436.23	6.98	16.14
SEm(±)	0.27	6.90	0.11	0.25
CD at 5%	0.83	20.70	0.33	0.76
Interaction S x M				
SEm±	0.55	13.81	0.22	0.51
CD at 5 %	NS	NS	NS	NS
General mean	**17.73**	**459.40**	**7.35**	**17.00**

4.2.4 Yield per hectare (t/ha)

The data on mean yield of cauliflower curd as influenced by different shading intensities and mulching are presented in Table 8 and graphically depicted in Fig.7.

4.2.4.1 Effect of shading intensities

The mean yield of cauliflower was influenced significantly due to different shading intensities. The yield was significantly highest in 35 *per cent* shading intensity which was to the tune of 22.44 t ha^{-1} compared to 0 (Open), 50 and 75 *per cent* shading intensities. Significantly lowest yield was observed in 0 (Open) *per cent* shading intensity.

4.2.4.2 Effect of mulching

The yield was influenced significantly due to mulching and without mulching. The mulching recorded significantly higher yield of 17.86 t ha^{-1} compared to the without mulching.

4.2.4.3 Effect of interaction

The interaction effect between shading intensities and mulching on yield of cauliflower was non significant.

4.3 Pest and disease incidence

4.3.1 Pest incidence

The pest incidence as influenced by different treatments are presented in Table 9 and fig.8.

Table 9. Pest incidence as influenced by different shading intensities and mulching

Treatment	**Incidence of diamond back moth (%)**
Shading intensities (S)	
S_1- 0 % (Open)	34.80
S_2- 35 %	23.89
S_3- 50 %	17.81
S_4-75 %	13.43
SEm±	1.33
CD at 5 %	3.99
Mulching (M)	
M_1- Mulching	22.96
M_2-Without mulching	22.00
SEm(±)	0.94
CD at 5%	NS
Interaction (S x M)	
SEm±	1.88
CD at 5 %	NS
General mean	**22.48**

4.3.1.1 Effect of shading intensities

The mean incidence of diamond back moth in cauliflower was influenced significantly due to different shading intensities. The incidence was significantly highest in 0 (open) *per cent* shading intensity (34.80 *per cent*) compared to 35, 50 and 75 *per cent* shading intensities. Significantly lowest pest incidence observed in 75 *per cent* shading intensity.

4.3.1.2 Effect of mulching

The mean pest incidence in cauliflower was non significant due to mulching and without mulching.

4.3.2 Disease incidence

Due to high temperature and low humiditydisease incidence was not observed.

5. DISCUSSION

The present investigation entitled “Effect of different shading intensities and mulching on growth and yield of cauliflower” was conducted during March, 2015 at the Horticulture Farm, College of Agriculture, Kolhapur. The result obtained have been presented in previous chapter and discussed here under the appropriate heading and subheadings.

5.1 Growth parameters

The various growth parameters *viz.* number of leaves, length of leaves, plant spread, plant height were recorded at 15 days interval upto 45 days after transplanting and at harvesting, starting from 15 days after transplanting. Moreover, number of days required for curd initiation, for first harvesting and for last harvesting were also recorded.

5.1.1 Number of leaves

The number of leaves plant^{-1} were influenced significantly due to different shading intensities. Significantly more number of leaves per plant were recorded in 35 *per cent* shading intensity at all crop growth stages (9.40, 14.63, 24.80 and 25.70 at 15, 30, 45 DAT and at harvest, respectively) compared to 0 (open) *per cent*, 50 *per cent* and 75 *per cent* shading intensities.Significantly the lowest number of leaves plant^{-1} were noticed under 0 (open) *per cent* shading intensity during crop growth period. The more number of leaves plant^{-1} in 35 *per cent* shading intensity may be attributed to the availability of more APAR resulting into more photosynthetic

rate and increased leaf number. Similar results were reported by Chen and Jiana (1998), Swagatika *et al.* (2006), Vethamoni and Natarajan (2008).

The mean number of leaves plant^{-1} was influenced significantly due to mulching and without mulching. Mulching produced significantly higher number of leaves plant^{-1} (8.33, 12.98, 22.20 and 24.02 at 15, 30, 45 DAT and at harvest, respectively).The microclimatic condition improved by the mulching might have provided a suitable condition for producing higher number of leaves in the cauliflower. Similar results were reported by Rajablariani et *al.* (2012).

5.1.2 Length of leaves

The mean length of leaves per plant increased progressively with advancement of crop growth.

The length of leaves plant^{-1} were influenced significantly due to different shading intensities. Significantly longest leaves plant^{-1} were recorded in 35 *per cent* shading intensity at all crop growth stages (8.60, 15.90, 26.97 and 32.20 at 15, 30, 45 DAT and at harvest, respectively) compared to 0 (open) *per cent*, 50 *per cent* and 75 *per cent* shading intensities. Significantly short length of leaves plant^{-1} was noticed under 0 (open) *per cent* shading intensity during crop growth period. The more length of leaves plant^{-1} in 35 *per cent* shading intensity may be attributed to the availability of more APAR resulting into more photosynthetic rate and increased length of leaf. These results are similar to those obtained by Moniruzzaman *et al.* (2009) and Srivastava *et al.* (2011).

The mean length of leaves plant^{-1} was influenced significantly due to mulching and without mulching. Mulching produced significantly more length of leaves plant^{-1} at all crop growth stages (7.45, 14.18, 24.15 and 29.90 cm at 15, 30, 45 DAT and at harvest, respectively).

5.1.3 Plant spread (cm)

The mean plant spread increased progressively upto harvest.

The plant spread plant^{-1} was influenced significantly due to different shading intensities. Significantly more plant spread was recorded in 35 *per cent* shading intensity at all crop growth stages (19.62, 36.17, 62.90 and 72.33 cm at 15, 30, 45 and at harvest, respectively), which was followed by 50 *per cent*, 75 *per cent* and 0 (open) *per cent* shading intensities, respectively. Significantly lowest plant spread was noticed under 0 (open) *per cent* shading. It might be due to enhanced photosynthesis due to favourable micro-climatic conditions in shade net house.

The mean plant spread was influenced significantly due to mulching and without mulching. Mulching produced significantly more plant spread plant^{-1} at all crop growth stages (17.81, 33.20, 57.78 and 67.03 cm at 15, 30, 45 DAT and at harvest, respectively).The microclimatic condition improved by the mulching might have provided a suitable condition for producing more plant spread.

5.1.4 Plant height (cm)

The plant height increased progressively with advancement of crop growth.

The plant height of cauliflower was influenced significantly due to different shading intensities throughout the crop growth period. Significantly tallest plants were observed in 35 *per cent* shading intensity at all the days of observation (8.43, 10.93, 16.57 and 18.65 cm at 15, 30, 45 DAT and at harvest, respectively) compared to 0 (open) *per cent*, 50 *per cent* and 75 *per cent* shading intensities. Significantly lowest plant height was observed in 0 (open) *per cent* shading intensity. This may be attributed to profuse vegetative growth due to higher availability of absorbed PAR under former shading intensities and enhanced photosynthesis and respiration due to favourable micro-climatic conditions in shade net house. Similar results were reported by Swagatika *et al.* (2006), Elad *et al.* (2007), Vethamoni and Natarajan (2008), Haque *et al.* (2009) and Rajasekar *et al.* (2013)

The mean plant height was influenced significantly due to mulching and without mulching. Mulching produced significantly higher plant height at all crop growth stages (7.23, 9.27, 14.25 and 16.47 cm at 15, 30, 45 DAT and at harvest, respectively).The positive response of mulches on plant height might be due to improved microclimate developed in the rhizosphere of the crop.

These findings are in conformity with the result of Christopher (2003) and Rajablariani et *al.* (2012) who reported significant increase in plant growth parameter under mulched condition.

5.1.5 Number of days required for curd initiation

The number of days to curd initiation was influenced due to different shading intensities. Earlier curd initiation was observed in 35 *per cent* shading intensity which required 49.67 days and it was at par with 50 *per cent* shading intensity. Late curd initiation was recorded in 0 (open) and 75 *per cent* shading intensities. This might be due to enhanced photosynthesis due to favourable micro-climatic conditions in shade net house which triggered early initiation of curd.

The number of days to curd initiation was influenced significantly due to mulching and without mulching. Mulching required minimum number of days to initiation of curd (52.58 days) compared to without mulch. Significantly maximum number of days to initiation of curd were observed in without mulching (55.83 days). The microclimatic condition improved by the mulching might have provided a suitable condition for initiation of curd.

5.1.6 Days required for first harvesting

The days required for first harvesting was influenced significantly due to different shading intensities. Significantly first harvesting was observed in 35 *per cent* shading intensity (61.83 days) as compared to 50 and 75 *per cent* and 0 (open) *per cent* shading intensities.

The number of days required for first harvesting was influenced significantly due to mulching and without mulching. first harvesting was observed in mulching (65.25 days) as compared to without mulch (69.83 days).

5.1.7 Days required for last harvesting

The days required for last harvesting was influenced significantly due to different shading intensities. The last harvesting was firstly completed in 35 *per cent* shading intensity at 65.33 days compared to 0 (Open), 50 and 75 *per cent* shade net intensities.

The number of days required for last harvesting was influenced significantly due to mulching and without mulching. The last harvesting was firstly completed in mulching (68.03 days) as compared to without mulch (73.67 days).

5.2 Yield parameters

5.2.1 Diameter of curd (cm)

The curd diameter was influenced significantly due to different shading intensities. The mean curd diameter was significantly highest in 35 *per cent* shading intensity is 20.17 cm compared to 0 (Open), 50 and 75 *per cent* shading intensities. Significantly lowest curd diameter was observed in 0 (Open) *per cent* shading intensities (14.33 cm). This might be due to enhanced photosynthesis due to favourable micro-climatic conditions in 35 per cent shade net house which improves vegetative growth and increase size and weight of curd. Similar results were reported by Swagatika *et al.* (2006), Vethamoni and Natarajan (2008), Haque *et al.* (2009).

The mean curd diameter was influenced significantly due to mulching and without mulching. Mulching exhibited significantly higher curd diameter (18.32 cm) as compared to

without mulching.Significantly lower curd diameter (17.15 cm) was observed in without mulching.

These findings were in conformity with the result of Christopher (2003) and Rajablariani et *al*. (2012) who reported significant increase in plant growth parameter under mulched condition.

5.2.2 Weight of curd (g)

The weight of curd was influenced significantly due to different shading intensities. Significantly highest weight of curd was recorded in 35 *per cent* shading intensity (606.50 g) compared to 50, 75 and 0 (open) percent shading intensities. This might be due to increased photosynthetic rate in 35 *per cent* shading intensity due to accumulation of heat units for longer period of time throughout crop growth period. Significantly lowest weight of curd was observed in 0 (open) *per cent* shading intensity (224.50 g). Similar results were reported by Swagatika *et al*. (2006), Vethamoni and Natarajan (2008).

The weight of curd was influenced significantly due to mulching and without mulching. Mulching exhibited higher weight of curd (482.57 g) compared to without mulching. Significantly lower weight of curd is observed in without mulching was (436.23 g). It appears that mulching might have induced favourable conditions conducive to attaintment of fruits with higher weight. Similar results were reported by Parmar *et al.* (2013).

5.2.3 Yield per plot (kg)

The present study indicates that, The yield was influenced significantly due to different shading intensities. The highest yield plot^{-1} (9.70 kg) was recorded in treatment 35 *per cent* shading intensity. The lowest yield plot^{-1} (3.59 kg) was recorded in treatment 0 (Open) *per cent* shading intensity.

The mean yield plot^{-1} was influenced significantly due to mulching and without mulching. The mulching produced significantly maximum yield plot^{-1} (7.72 kg) compared to without mulching (6.98 kg plot^{-1}).

5.2.4 Yield (t ha^{-1})

In the present investigation, there was significant difference among different treatments with regard to yield ha^{-1}. However, the highest yield (22.44 t ha^{-1}) was recorded in 35 *per cent* shading intensity compared to 50, 75 and0 (open) percent shading intensity. The lowest yield (8.30 t ha^{-1}) was recorded in treatment 0 (Open) *per cent* shading intensity. The 35 *per cent* shading intensity recorded the highest length of leaves, leaf number, photosynthetic rate which might have resulted to increased yield of cauliflower. Significantly lowest yield observed in 0(open) *per cent* shading intensity. Similar results were reported by Swagatika *et al.* (2006), Vethamoni and Natarajan (2008) and Haque *et al.* (2009).

The mean yield ha^{-1} was influenced significantly due to mulching and without mulching. The mulching produced significantly maximum yield (17.86 tha^{-1})as compared to without mulching (16.14 tha^{-1}). It might be due to

conservation of moisture and improved microclimate both beneath and above the soil surface and great weed control in mulching. Similar results were reported by Salim *et al*. (2008), Rajablariani et *al*. (2012) and Parmar *et al*. (2013).

5.3 Pest incidence

Pest incidence (34.80 %) is more in 0(open) *per cent* as compared to 35, 50 and 75 percent shading intensities. It migtht be due to controlled condition in shade net as compared to 0(open) *per cent* which is responsible for low incidence of pest in shade net house.

6. SUMMARY AND CONCLUSIONS

An experiment entitled "Effect of different shading intensities and mulching on growth and yield of cauliflower" was conducted in a specially designed shade net having three different shading intensities and open condition viz. 0 (Open), 35, 50 and 75 *per cent* and mulching under each intensity. The cauliflower crop of Sungrow-110 variety was transplanted in March (2015) for experimentation.

6.1 Summary

6.1.1 Effect of shading intensities

The important findings as regards to growth characters, yield contributing characters and pest and disease incidence in cauliflower under shade net during *summer* season are summarized here.

Maximum number of leaves were observed in 35 *per cent* shading intensity (25.70). While minimum number of leaves in observed in 0 (Open) *per cent* shading intensities (20.47) at harvest.

Maximum length of leaves were observed in 35 *per cent* shading intensity (32.20 cm). While minimum length of leaves is observed in 0 (Open) *per cent* shading intensities (23.93 cm) at harvest.

Maximum plant spread was observed in 35 *per cent* shading intensity (72.33 cm).While minimum plant spread was observed in 0 (Open) *per cent* shading intensities (56.40 cm) at harvest.

Maximum growth in respect of plant height was observed in 35 *per cent* shading intensity (18.65 cm).While minimum

plant height was observed in 0 (Open) *per cent* shading intensities (13.30 cm) at harvest.

The earlier curd initiation was recorded under 35 *per cent* shading intensity (49.67 days). While late curd initiation was recorded in 0 (Open) *per cent* shading intensity (60.50 days).

The minimum days required for first harvesting was recorded under 35 *per cent* shading intensity (61.83 days) while maximum days required for first harvesting was recorded in 0 (Open) *per cent* shading intensity (74.50 days).

The minimum days required for last harvesting was recorded under 35 *per cent* shading intensity (65.33 days) while maximum days required for last harvesting was recorded in 0 (Open) *per cent* shading intensity (78.33 days).

The maximum diameter of curd (20.17 cm) was recorded in 35 *per cent* shading intensity. The minimum diameter of curd (14.33 cm) was recorded in 0 (Open) *per cent* shading intensity.

The highest weight of curd (606.50 g) was recorded in 35 *per cent* shading intensity. The lowest weight of curd (224.50 g) was recorded in 0 (Open) *per cent* shading intensity.

The highest yield plot^{-1} (9.70 kg) was recorded in 35 *per cent* shading intensity. The lowest yield per plot (3.59 kg) was recorded in 0 (Open) *per cent* shading intensity.

In respect of total yield ha^{-1}, significant differences among the various treatments were observed. The highest yield ha^{-1} was recorded in 35 *per cent* shading intensity (22.44 t/ha) while the lowest yield ha^{-1} was recorded in (8.30 t/ha) in 0 (Open) *per cent* shading intensity.

The highest *per cent* of pest incidence (34.80 %) was observed in 0 (Open) *per cent* shading intensity. The lowest *per cent* of pest incidence (13.43 %) was observed in 75 *per cent* shading intensity.

6.1.2 Effect of mulching

The important findings as regards to growth characters, yield contributing characters and pest and disease incidence in cauliflower under mulching during *summer* season are summarized here.

Maximum number of leaves were observed in mulching (24.02). While minimum number of leaves in observed in without mulching (22.18) at harvest.

Maximum length of leaves were observed in mulching (29.90 cm). While minimum length of leaves is observed in without mulching (27.27 cm) at harvest.

Maximum plant spread was observed in mulching (67.03 cm). While minimum plant spread is observed in without mulching (62.92 cm) at harvest.

Maximum growth in respect of plant height was observed in mulching (16.47 cm).While minimum plant height was observed in without mulching (15.26 cm) at harvest.

The minimum days required for curd initiation was recorded under mulching (52.58 days) while maximum days required for curd initiation was recorded in without mulching (55.83 days).

The minimum days required for first harvesting was recorded under mulching (65.25 days) while maximum days required for first harvesting was recorded in without mulching (69.83 days).

The minimum days required for last harvesting was recorded under mulching (68.03 days) while maximum days required for last harvesting was recorded in without mulching (73.67 days).

The maximum diameter of curd (18.32 cm) was recorded in mulching. The minimum diameter of curd (17.15 cm) was recorded in without mulching.

The highest weight of curd (482.57 g) was recorded in mulching. The lowest weight of curd (436.23 g) was recorded in without mulching.

The highest yield per plot (7.72 kg) was recorded in mulching. The lowest yield per plot (6.98 kg) was recorded in without mulching.

In respect of total yield ha^{-1}, significant differences among the various treatments were observed. The highest yield ha^{-1} was recorded in mulching (17.86 t/ha) while the lowest yield ha^{-1} was recorded in (16.14 t/ha) in without mulching.

6.2 Conclusions

The results obtained during the investigations are concluded as under :

1. The 35 *per cent* shading intensity of shade net significantly increased important growth attributes and yield of cauliflower.

2. The mulching registered maximum growth attributes and yield of cauliflower than without mulching.

3. The pest incidence was minimum in 75 *per cent* shade net. The disease incidence was not occurred.

Based on one year of experimentation it could be concluded that growing of cauliflower under 35 *per cent* shading intensity and mulching was found most suitable for achieving higher yield during *summer* season.

The above findings based on one year data and it seems worthwhile to continue exploration at different locations with different shading intensities and mulching in future for confirmation of the above findings.

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8. APPENDIX

Appendix-I

Meteorological data recorded during the experimental period (March, 2015 – May, 2015)

MW	Temp. (°C)		Con tr-oled Temp. (°C)	RH (%)		Wind Speed (kmph)	Sun shine hours(hrs.)	Evap. (mm)	Rain fall (mm)	No. of rainy days
	Max.	Min.		Morn.	Even.					
March, 2015										
12	35.6	20.3	31.0	83	30	1.2	5.2	4.0	00.0	-
13	37.2	21.9	34.1	73	28	1.6	5.0	3.4	06.2	1
April, 2015										
14	37.0	21.4	33.8	66	27	1.3	8.6	2.8	00.0	-
15	33.8	21.6	30.1	89	41	1.1	6.3	3.7	04.2	1
16	36.4	21.8	33.2	89	30	1.6	8.3	3.5	00.0	-
17	37.7	22.0	34.2	86	31	1.6	8.2	3.0	11.2	1
18	37.5	21.7	34.0	89	31	2.0	8.2	3.4	19.0	1
May, 2015										
19	35.8	21.5	32.1	90	38	1.4	8.2	2.7	52.1	2
20	34.6	21.1	31.3	87	48	0.8	5.0	2.9	04.0	1
21	36.0	22.2	32.2	87	43	2.5	9.9	3.1	03.2	-
22	33.4	21.6	29.8	88	57	1.9	6.4	32.1	58.4	2

9. VITA

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of

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