RESPONSE OF COLOURED CAPSICUM (*Capsicum annuum* var. *grossum* L.) VARIETIES FOR DIFFERENT IRRIGATION LEVELS UNDER SHADE NET

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B.Sc. (Ag.)

MASTER OF SCIENCE IN AGRICULTURE

(AGRONOMY (WATER MANAGEMENT))

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BY

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B.Sc. (Ag.)

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2019

CERTIFICATE

Ms. B. KIRUTHIGA has satisfactorily prosecuted the course of research and that the thesis entitled **"RESPONSE OF COLOURED CAPSICUM *(Capsicum annuum* var. *grossum* L.*)* VARIETIES FOR DIFFERENT IRRIGATION LEVELS UNDER SHADENET"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that neither the thesis nor its part thereof has been previously submitted by her for a degree of any University.

Date: 19-06-2019 **(K. AVIL KUMAR)**

Chairperson

CERTIFICATE

This is to certify that the thesis entitled **"RESPONSE OF COLOURED CAPSICUM *(Capsicum annuum* var. *grossum* L.*)* VARIETIES FOR DIFFERENT IRRIGATION LEVELS UNDER SHADE NET"** submitted in partial fulfillment of the requirements for the degree of **'Master of Science in Agriculture'** of the Professor Jayashankar Telangana State Agricultural University, Hyderabad is a record of the bonafide original research work carried out by **Ms. B. KIRUTHIGA** under our guidance and supervision.

No part of the thesis has been submitted by the student for any other degree or diploma. The published part and all assistance received during the course of the investigations have been duly acknowledged by the author of the thesis.

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Date of final viva-voce: 11-07-2019

DECLARATION

I, **B. KIRUTHIGA**, hereby declare that the thesis entitled **“RESPONSE OF COLOURED CAPSICUM (*Capsicum annuum* var. *grossum* L.) VARIETIES FOR DIFFERENT IRRIGATION LEVELS UNDER SHADE NET”** submitted to the **Professor Jayashankar Telangana State Agricultural University** for the degree of **Master of Science in Agriculture** is the result of the original research work done by me. I also declare that no material contained in the thesis has been published earlier in any manner.

Place: Hyderabad **(B. KIRUTHIGA)**

Date: 19 -06- 2019 **ID. No. RAM/2017-96**

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LIST OF ABBREVIATIONS

µg	: Microgram
%	: Per cent
&	: And
@	: At the rate of
^{o}C	: Degree Celsius
AOAC	: Association of Official Analytical Chemists
ARI	: Agriculture Research Institute
ASTA	: American Spice Trade Association
B:C ratio	: Benefit cost ratio
branches plant^{-1}	: Number of branches per plant
C.D	: Critical difference
cc	: Cubic centimeter
cm	: Centi meter
CPE	: Cumulative pan evaporation
CV	: Coefficient of Variation
cv.	: Cultivar
DAS	: Days of sowing
DAT	: Days after transplanting
DMP	: Dry matter production
dS m^{-1}	: Decisiemen per meter
EC	**:** Electrical Conductivity
EOA	: Essential Oil Association of America
ET	: Evapotranspiration
e*t al.*	: And others
ETc	: Crop evapotranspiration
ETo	: Refrence evapotranspiration
FAO	: Food and Agriculture Organization
FC	: Field capacity
Fig.	: Figure
FYM	: Farm Yard Manure
g plant^{-1}	: Grams per plant
ha^{-1}	: Per hectare
i.e.	: That is

IWUE	: Irrigation water use efficiency
K	: Potassium
K pan	: Pan coefficient
Kg ha^{-1}	: Kilo gram per hectare
Kg m^{-3}	: Kilo gram per cubic meter
L h^{-1}	: Liter per hour
LAI	: Leaf Area Index
me L^{-1}	: Millieqvalents per liter
mg L^{-1}	: Milligrams per liter
ml	: Milliliter
mm day^{-1}	: Millimeter per day
N	: Nitrogen
NS	: Non significant
OC	: Organic carbon
P	: Phosphorus
PE	: Pan evaporation
PET	: Potential evapotranspiration
pH	: Soil reaction (negative algorithm of hydrogen ions concentration)
$plant^{-1}$	: Number of fruits per plant
PWP	: Permanent Wilting Point
RDF	: Recommended Dose of fertilizer
RH	: Relative Humidity
RSC	: Residual sodium carbonate
SAR	: Sodium absorption ratio
SCMR	: SPAD Chlorophyll Meter Readings
SD	: Standard deviation
SEM	: Standard error of mean
SSP	: Single super phosphate
t ha^{-1}	: tonnes per hectare
T.S.S.	: Total soluble solids
USWB	: United State Weather Bureau
viz.,	: Namely
WP	: Water Productivity
WUE	: Water use efficiency

Author : **B. KIRUTHIGA**

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ABSTRACT

A field experiment was conducted at Horticulture farm, College of Agriculture, Rajendranagar, Hyderabad during *rabi* 2018-19 to study the "Response of coloured capsicum *(Capsicum annuum* var. *grossum* L.*)* varieties for different irrigation levels under shade net". The experiment was laid out in split plot design and the treatment comprises of four irrigation levels *viz.*, drip irrigation at 0.4 Epan (I_1), 0.6 Epan (I_2), 0.8 Epan (I_3) and 1.0 Epan (I_4) as main treatments and three varieties *viz.*, Indra (green), Orobelle (yellow) and Bomby (red) as sub treatments and replicated thrice. The recommended dose (RD) of nutrients were 100:80:60 N, P_2O_5 and K_2O kg ha^{-1} and entire dose of 80 kg P_2O_5 ha^{-1} was applied as basal, N and K_2O applied as fertigation in three days interval. The crop was transplanted at 45cm x 40 cm spacing in September. The experimental soil was sandy loam in texture, slightly alkaline in reaction, non-saline, low in available nitrogen, available potassium and organic carbon content. Irrigation scheduling was done based on daily evaporation data recorded from USWB class 'A' pan evaporimeter. The cumulative daily evaporation during crop growth period was 737.5 mm. Effective rainfall during the crop growth period estimated was 58.6, 64.2, 74.6, 82.6 mm for 100, 80, 60 and 40 per cent irrigation treatments respectively out of 127.4 mm of rainfall as per water balance method. The water source for irrigation was from a bore well. The irrigation water used to the experiment was neutral and categorized under Class II (C_2S_1). Bed size was 7.6 m × 0.9 m and plants were transplanted in zig-zig manner. The data generated in this study were analyzed through standard statistical methods.

There was no significant difference in plant height, number of branches and LAI among the treatments at 30, 150 and 178 days after transplanting (DAT) due to drip irrigation levels. The interaction effect between drip irrigation levels and varieties was not significant on growth parameters, yield and yield attributes, quality parameters, N, P & K uptakes and economics of capsicum. Though the plant height, number of branches, number of leaves, SCMR and LAI were higher with drip irrigation at 1.0 Epan, there was no significant difference among the treatments of drip irrigation at 1.0 and 0.8 Epan and were significantly higher than drip irrigation at 0.6 and 0.4 Epan. The growth parameters and DMP were significantly lower with drip irrigation at 0.4 Epan throughout the crop growth over other drip irrigation levels. Significantly higher yield

(47.50 t ha^{-1}) and yield attributes *i.e.* fruit length and diameter, fruits $plant^{-1}$ and fruit yield $plant^{-1}$ were recorded with drip irrigation at 1.0 Epan. Significantly higher capsanthin and capsaicin were recorded with drip irrigation at 0.8 and 1.0 Epan and were on par with each other and total soluble solids, ascorbic acid and oleoresin were not significantly influenced by drip irrigation levels. Drip irrigation at 1.0 Epan recorded significantly higher water productivity (8.4 kg m^{-3}) than rest of the drip irrigation levels. Total water applied with 0.4, 0.6, 0.8 and 1.0 Epan were 327.9, 466.6, 610.7 and 757.1 mm. Significantly higher N and K were observed at all growth stages with drip irrigation at 1.0 Epan than 0.6 and 0.4 Epan and was on par with 0.8 Epan except N at 90 and 120 DAT. P uptake was significantly higher with drip irrigation at 1.0 Epan than 0.4 and 0.6 Epan except 30 and 178 DAT and was on par with 0.8 Epan. Gross, net returns and B:C ratio (₹1254352, 910313 ha^{-1} and 3.64) were significantly higher with drip irrigation at 1.0 Epan than rest of the drip irrigation treatments.

Among hybrids, Indra recorded significantly higher growth parameters, DMP, yield and yield parameters than other two varieties. Bomby recorded significantly higher fruit length and diameter, pericarp thickness and average fruit weight than Orobelle and Indra. Bomby recorded significantly higher TSS, oleoresin and capsanthin than rest of the treatments. Orobelle recorded significantly higher ascorbic acid than Bomby and Indra. Significantly higher capsaicin was observed with Bomby than Indra and Orobelle. Indra recorded significantly higher water productivity than other two varieties. Significantly higher gross returns, net returns and B:C ratio were recorded by Orobelle than Bomby and Indra.

Based on the above results it can be concluded that drip irrigation at 1.0 Epan recorded higher yield and economics of capsicum than 0.8, 0.6 and 0.4 Epan and the hybrid bell pepper Orobelle was economical than hybrids of Bomby and Indra, though higher fresh fruit yield than other two hybrids.

Chapter I

INTRODUCTION

Capsicum is also known as bell pepper or sweet pepper and *shimla* mirch which is a cool season tropical crop belongs to the family Solanaceae, and is native of South and Central America. Fruits of *Shimla* mirch are large (usually bell shaped; hence called bell pepper) and non-pungent (hence also called sweet pepper). The term *Shimla* mirch originated because probably it was first cultivated in *Shimla* region (temperate climate), which was suitable for its cultivation. It attained a status of high value crop in India in recent years, occupying an area of 46 thousand hectares, producing 327 thousand metric tons. The major capsicum producing states in India are Himachal Pradesh, Karnataka, Madhya Pradesh, Haryana, Jharkhand, Uttarkhand and Orissa. In Telangana it occupies an area of 0.52 thousand hectares, producing 6.63 thousand tonnes (MoA&FW, 2017).

Capsicum varieties may occur in many shapes and colours. Capsaicin is the main chemical content in sweet pepper. It is rich in carbohydrates, Vitamin A (8493 IU), Vitamin C (283 mg) and minerals like Calcium (13.4 mg), Magnesium (14.9 mg) Phosphorus (28.3 mg) and Potassium, (263.7 mg) per 100 g fresh weight. The mature fruits (green, red and yellow) of sweet pepper are eaten raw or widely used in stuffings, bakings, pizza, burger preparations, spices and as external medicine. Red bell pepper contain 1.5 times more vitamin C, 8 times more vitamin A and 11 times more beta carotene than green bell peppers. Yellow bell peppers have more vitamin C than green ones, but less vitamin A and beta carotene (Jessy, 2012). The high market price it fetches is attributed to the heavy demand from the urban consumers and for export which needs fruits with longer shelf life, medium size tetra lobed fruits with attractive colour, mild pungency with good taste. However, the supply is inadequate due to the low productivity of the crop (Muthukrishnan *et al*., 1986). The target can be achieved by bringing additional area under capsicum crop using hybrid seeds, improved agro techniques, perfection and promotion of protected cultivation of vegetables.

Water is the vital source for crop production and is the most limiting factor in Indian agricultural scenario. Though India has the largest irrigation network, the irrigation efficiency achieved is not more than 40 per cent. Rational use of irrigation water is important for increasing productivity and to save irrigation water, which is costly and a scarce resource. This can be achieved by advanced method of irrigation like micro irrigation systems particularly, drip method which is most efficient coupled with other improved water management practices.

Among the production factors, irrigation and fertilizer management are undoubtedly important for successful production. Irrigation scheduling helps in increasing yield through better utilization of all resources. Telangana state principally falls under semiarid tropical climate. The soils are predominantly red loamy, mostly suitable for the production of horticultural crops. With prevailing semiarid tropical climate, there is a potential scope for shade net cultivation, especially for remunerative vegetables and export oriented crops using drip irrigation.

Antony and Singandhupe (2004) claimed that capsicum under drip irrigation with higher level of irrigation provides excellent results in term of growth and yield. The drip irrigation adoption increases water use efficiency (60-200%), saves water (20-60%), reduces fertilization requirement (20-33%) through fertigation, produces better quality crop and increases yield (7-25%) as compared with conventional irrigation (Kaushal *et al.* 2012). Veeranna *et al*. (2001) reported increase in yield, water and fertilizer use efficiency and better quality in capsicum under drip irrigation.

Sweet pepper consumption in India is increasing now-a-days due to increasing demand among urban consumers as lot of farmers are also showing interest in the cultivation of this crop under protected condition, as it is having definite qualitative and quantitative advantage over the traditional cultivation (Sreedhara *et al.* 2013). To obtain good quality produce, shade nets can be commercially exploited for successful year round cultivation of high value thermo sensitive crops like sweet pepper. Shade nets are perforated plastic materials used to cut down the solar radiation and prevent scorching or wilting of leaves caused by marked temperature increase with in leaf tissue from strong sunlight. Earlier studies on capsicum under shade net conditions revealed that different levels of fertigation and irrigation had significant effect on plant parameters, yield, water use efficiency, fertilizer use efficiency and quality parameters. A study revealed that under shade net the crop yield was increased by 80 % over open field cultivation along with water saving of about 40 % in covered cultivation (Ramana rao *et al.*, 2013).

Optimization and minimization of water to be applied to crops is essential in irrigation system. Yields of crops are adversely affected with excess or inadequate water supply. Yields can be considerably increased by adopting proper irrigation management. For proper irrigation management scheduling of water is essential. Irrigation scheduling is the process by which an irrigator/farmer determines the timing and quantity of water to be applied to the crops. For proper irrigation management, the challenge is to estimate crops water requirement in the context of growth. There are only few studies on irrigation requirement and economic aspects of capsicum production. Keeping all this in view, the present study was initiated to increase the yield potential of capsicum and also to assess the effect of drip irrigation levels on growth and yield of coloured capsicum varieties under shade net with the following objectives.

Objectives of Investigation:

1. To study the effects of different drip irrigation levels on growth, yield and N, P, K nutrient uptake of capsicum varieties under shade net.

2. To study the variations in weather parameters under shade net compared to outside environment.

3. To workout the economics of capsicum varieties in different irrigation levels under shade net.

Chapter II

REVIEW OF LITERATURE

The research on drip irrigation and its effect on growth characters, yield attributes and yield of capsicum is briefly reviewed in this chapter under appropriate headings. In this section an attempt has been made to review the work done earlier on **"Response of coloured capsicum *(Capsicum annuum* var. *grossum* L.*)* varieties for different irrigation levels under shade net".** As the literature pertaining to the subject has been found few in number, hence, the review of literature also covers the other vegetables.

The relevant available literature has been reviewed under following subheads:

2.1 Effect of drip irrigation on plant growth characters

2.1.1 Plant height

2.1.2 Number of leaves plant^{-1}

2.1.3 Number of branches plant^{-1}

2.1.4 LAI

2.1.5 Days to 50% flowering

2.2 Effect of drip irrigation on yield and yield characters

2.2.1 Fruit length

2.2.2 Fruit diameter

2.2.3 Pericarp thickness

2.2.4 Fruits plant^{-1}

2.2.5 Average fruit weight

2.2.6 Total dry matter production

2.2.7 Fruit yield

2.3 Effect of drip irrigation on quality parameters

2.4 Effect of microclimate on crop environment and yield

2.5 Effect of drip irrigation on water use studies

2.6 Effect of drip irrigation on nutrient uptakes

2.7 Effect of drip irrigation on economics

2.1 Effect of drip irrigation on plant growth characters

2.1.1 Plant height

Antony and Singhdhupe (2004) conducted an experiment to study the impact of drip and surface irrigation on growth of bell pepper during winter in loamy soil at Bhuvaneshwar with treatments of four levels each of surface irrigation *i.e.* 1.2, 1.0, 0.8 and 0.6 of IW/CPE and drip irrigation *viz.,* at 100, 80, 60, 40 per cent of cumulative pan evaporation. Maximum plant height (51 cm) was recorded when irrigation was supplied at 100 per cent of CPE through drip as compared to other drip irrigation levels and surface irrigation.

Dagdelen (2004) concluded that 100 per cent irrigation at different critical growth stages recorded highest plant height (74.5 cm) in bell pepper in Turkey under loamy soil

A field experiment on sandy loam soils at Himachal Pradesh during *kharif* to evaluate the performance of capsicum under different drip irrigation levels (irrigating crop at 100 per cent, 80 per cent and 60 per cent crop evapotranspiration) along with black polyethylene mulch and compared with surface irrigation, indicated that maximum plant height (68.83 cm) was observed in the drip irrigation receiving 100 per cent crop evapotranspiration with plastic mulch (Spehia *et al.,* 2007).

Studies on the timing of drip irrigation initiation affects on plant height of bell pepper under plastic mulch in loamy fine sand at Michigan region during *kharif* season with irrigation treatments of initiated at pepper transplanting (S0), after transplant establishment (S1), at first flower (S2), at first fruit (S3) and at fruit ripening (S4) shown that maximum plant height was observed at S3 treatment (51.8 cm) compared to other treatments (Ngouajio *et al.,* 2008).

Choudhary *et al.* (2012) conducted an experiment at Precision Farming Development Centre, Horticulture Farm, Indira Gandhi Agricultural University, Raipur, Chhattisgarh, India to evaluate the influence of different levels of drip irrigation (1.0 Epan, 0.8 Epan, 0.6 Epan through drip and 1.0 Epan with flood irrigation) on plant height of bell pepper and recorded maximum plant height (63.18 cm) with drip irrigation at 1.0 Epan followed by drip irrigation at 0.8 Epan in silty clay loam soil.

At Bhubaneswar, Paul *et al.* (2013) conducted two years study to evaluate the growth performance of *rabi* capsicum under drip and surface irrigation in loamy sand soil and mulched with black plastic film and the results revealed that plant height (78.6

cm) was significantly better in 100 per cent irrigation through drip irrigation compared to the rest of the treatment combination.

Khalkho *et al.* (2013) studied the irrigation scheduling and effect of different soil moisture regime over the yield and growth parameters of *rabi* chilli crop at Bastar in Chattisgarh on sandy loam soil with eight treatments of seven different available soil moisture (ASM) levels at 70, 60, 50, 40, 30, 20 and 10 per cent along with one treatment of furrow irrigation of chilli crop and showed that the irrigation at 70 per cent ASM level gave the highest plant height (52.93 cm) and 10 per cent gave lowest height (30.67 cm).

Studies on the performance of coloured sweet pepper (*Capsicum annuum L. var. grossum*) under naturally ventilated greenhouse to determine the effect of different fertigation levels NPK (120 , 100 , 80 per cent) and irrigation levels (100, 80, 60 per cent replenishment of ET_C) with varieties of Syngenta Yellow and Syngenta Red under sandy loam soil at Ludhiana during *rabi* season revealed that fertigation with 120 % dose of NPK and 100 per cent replenishment of ET_C with Syngenta Yellow variety produced maximum plant height (191.77 cm) (Biwalkar *et al.*, 2015).

Reddy *et al.* (2015) conducted study on sandy loam soil at Visakhapatnam district to investigate the effect of different types of irrigation (surface irrigation, furrow irrigation, furrow irrigation + mulch and furrow irrigation + mulch + trellising) on plant height and reported that the maximum plant heights were 91.22 cm and 83.32 cm in drip + polythene mulch + trellising and surface irrigation respectively.

In a study conducted by Salunkhe *et al.* (2017) revealed that maximum plant height at all the stages of growth such as 30 (54.30 cm), 60 (88.36 cm) and 90 DAT (129.53cm) was obtained with drip irrigation at 60 per cent ETc under polyhouse and lowest obtained with 60 per cent ETc under open field at 30 (28.44), 60 (56.50) and 90 DAT (95.67) among the combination treatments of 100, 80, 60 ET_C in polyhouse, shade and open field in *rabi* capsicum at Bhopal in Madhya Pradesh.

2.1.2 Number of leaves plant^{-1}

Paul *et al.* (2013) recorded maximum number of leaves plant^{-1} (99.7) in *rabi* capsicum which was significantly better in 100 per cent irrigation through drip irrigation compared to 80 and 60 per cent treatment combination in loamy sand soil at Bhuvaneshwar.

Salunkhe *et al.* (2017) observed that drip irrigation at 60 per cent ETc under polyhouse in *rabi* capsicum recorded maximum leaves plant^{-1} at 30 (49.23), 60 (65.25) and 90 (83.31) DAT than 80 and 100 per cent ET_C at Bhopal under clay loam soil.

2.1.3 Number of branches plant^{-1}

Antony and Singhdhupe (2004) conducted an experiment to study the impact of drip and surface irrigation on growth of bell pepper during winter in loamy soil at Bhuvaneshwar and recorded maximum number of branches (9) in bell pepper when irrigation was supplied at 100 per cent of CPE than 80, 60 and 40 CPE through drip and surface irrigation.

The field experiment on chilli conducted during rabi season by Vijayakumar *et al.* (2010) and revealed that the maximum number of branches of 5.17, 9.67, 13.93 and 15.83 at 30, 60, 90 and 120 DAP with drip irrigation at 75 per cent of PE than 100 and 50 per cent of PE levels of irrigation on sandy loam soils at Tamil Nadu.

Choudhary *et al.* (2012) recorded that drip irrigation at 1.0 Epan produced maximum number of primary (9.30) and secondary branches plant^{-1} (14.13) in bell pepper with drip irrigation at 1.0 Epan followed by drip irrigation at 0.8 Epan at Chhattisgarh under silty clay loam soil.

Nesthad *et al.* (2013) studied the effect of different irrigation levels and drip system layout under plastic mulch on the performance of *rabi* chilli *(Capsicum annum)* at Tavanur in Kerala on sandy loam soil. Maximum number of branches (7) was observed for the treatment with 85 per cent than 75 and 65 per cent of daily irrigation requirement.

Khalkho *et al.* (2013) recorded that the irrigation at 70 per cent ASM level gave the highest number of branches (7.4) in *rabi* chilli at chattisgarh on sandy loam soil.

2.1.4 Leaf area

Choudhary *et al.* (2012) revealed that maximum leaf area index (3.04) in bell pepper with drip irrigation at 1.0 Epan followed by drip irrigation at 0.8 Epan (2.98), 0.6 Epan (2.89) and lowest leaf area observed with furrow irrigation (2.73) in silty clay loam soil at Chhattisgarh.

Kara and Yildirim (2015) concluded that *kharif* pepper plants produced maximum leaf area index (1.23) in $I_{1.0}$ compared to different irrigation levels (0.2, 0.8, 1.0 and 1.2 ETc) in clay loam soil of Turkey.

Fertigation with 120 per cent dose of NPK and drip irrigation at 100 per cent replenishment of ET_C with Syngenta Yellow variety produced maximum leaf area index (4.34) compared to Sygenta Red variety (4.29) under sandy loam soil at Ludhiana during *rabi* season (Biwalkar *et al.*, 2015).

2.1.5 Days to early flowering

Paul *et al.* (2013) recorded that higher days taken for flowering (64.7) by *rabi* capsicum in 100 per cent irrigation through drip irrigation compared to 80 (57.8) and 60 per cent (53.6) treatment combination in loamy sand soil at Bhuvaneshwar.

Salunkhe *et al.* (2017) observed that drip irrigation at 60 per cent ETc under polyhouse recorded minimum period *i.e* .33.39 and 47.10 days was required for flower initiation and fruit set compared to 80 per cent ET_C *i.e* .35.59 and 49.66 days and 100 per cent ETc *i.e* .36.34 and 51.27 days of *rabi* capsicum at Bhopal under clay loam soil.

2.2 Effect of drip irrigation on yield and yield characters

2.2.1 Fruit length

Choudhary *et al.* (2012) observed maximum fruit length (12.90 cm) in bell pepper with drip irrigation at 1.0 Epan followed by drip irrigation at 0.8 Epan (12.43 cm), 0.6 Epan (11.35 cm) and furrow irrigation (10.06 cm) at Chhattisgarh under silty clay loam soil.

Khalkho *et al.* (2013) recorded that the irrigation at 60 percent ASM level gave the highest fruit length (8.265 cm) in *rabi* chilli at chhattisgarh on sandy loam soil.

Studies on the effects of supplemental irrigation was conducted during *spring-summer* season in capsicum crop under shade mesh and in open-field in Brazil in summer season on loam soil with irrigation treatments of 0.25, 0.50, 0.75 and 1.0 rate of crop evapotranspiration indicated that the fruit length in open-field (15.0 cm) and under shade mesh (18.0 cm) showed better performance with 0.75 and 0.50 of ETc, respectively (Padron *et al.* 2015).

Biwalkar *et al.* (2015) concluded that the fertigation with 120 per cent dose of NPK and 100 per cent replenishment of ET_C with Syngenta red variety produced maximum fruit length (10.37 cm) than Syngenta Yellow variety (9.33 cm) under sandy loam soil at Ludhiana during *rabi* season.

Sahin *et al.* (2015) evaluated the effects of different irrigation quantities (T1: 1.0, T2: 0.85 and T3: 0.70) of cumulative evaporation from a Class A pan on drip-irrigated cucumber in open field conditions under medium textured soil in Turkey during *kharif* season. Different irrigation levels were and found that the maximum fruit length was determined from T1 irrigation level (15.95 cm) than T2 (15.36) and T3 (15.0 cm) irrigation levels.

Kumar *et al.* (2016) investigated the irrigation scheduling under polyhouse during *spring-summer* seasons at Solan in Himachal Pradesh on sandy loam soil and shown that the treatment with 0.75 cm of irrigation daily resulted in maximum fruit length (8.57 cm) than 0.5 cm (8.52 cm) and 0.25 cm (8.28 cm) of irrigation alternate day.

2.2.2 Fruit diameter

Maximum fruit diameter in capsicum was recorded with moderate irrigation level (80% of pan evapo-transpiration) as compared to 100 per cent of pan evapo-transpiration through drip irrigation and 100 per cent surface irrigation (Gupta *et al.,* 2010).

Padron *et al.* (2015) observed maximum fruit diameter of bell pepper in open-field (6.6 cm) and under shade mesh (6.7 cm) with irrigation scheduled at 0.25 and 0.50 of ETc, respectively during *spring-summer* season under loamy soil of Brazil.

Biwalkar *et al.* (2015) concluded that the fertigation with 120 per cent dose of NPK and drip irrigation with 100 per cent replenishment of ETc with Syngenta red variety produced maximum fruit diameter (9.20 cm) than Syngenta yellow variety (8.92 cm) under sandy loam soil at Ludhiana during *rabi* season.

Fruit diameter (6.5 cm) was observed maximum when 0.50 cm irrigation given at alternate day and minimum (5.9 cm) when 0.25 cm irrigation given at daily during *spring-summer* seasons at Himachal Pradesh on sandy loam soil (Kumar *et al.,* 2016).

2.2.3 Pericarp thickness

Dagdelen (2004) noticed that 100 per cent irrigation at different critical growth stages was recorded maximum pericarp thickness (4.31 mm) in bell pepper at turkey under loamy soil.

Biwalkar *et al.* (2015) observed that the fertigation with 120 per cent dose of NPK and drip irrigation with 100 per cent replenishment of ET_C with Syngenta red variety produced maximum pericarp thickness (0.84 cm) than Syngenta yellow variety (0.78 cm) under sandy loam soil at Ludhiana during *rabi* season.

2.2.4 Fruits plant^{-1}

A field experiment was conducted by Spehia *et al.* (2007) on sandy loam soils at Himachal Pradesh during *kharif* and observed the maximum fruits plant^{-1} (22.93) in the drip irrigation receiving 100 per cent crop evapotranspiration with plastic mulch in capsicum and minimum fruits plant^{-1} (16.88) observed with surface irrigation + mulch .

Choudhary *et al.* (2012) observed maximum fruits plant^{-1} (32.35) in bell pepper with drip irrigation at 1.0 Epan followed by drip irrigation at 0.8 Epan (30), 0.6 Epan (23.4) and furrow irrigation (18.38) at Chhattisgarh under silty clay loam soil.

Significantly higher fruits plant^{-1} (9.9) in *rabi* capsicum was recorded with 100 per cent irrigation through drip and lower fruits plant^{-1} was obtained with 100 per cent surface irrigation in loamy sand soil at Bhuvaneshwar (Paul *et al.,* 2013).

Sahin *et al.* (2015) evaluated the effects of different irrigation quantities (T1: 1.0, T2: 0.85 and T3: 0.70) of cumulative evaporation from a Class A pan on drip-irrigated cucumber in open field conditions under medium textured soil in Turkey during *kharif* season and observed the maximum number of fruits plant^{-1} was from T1 irrigation level (19.94) followed by T2 (17.64) and T3 (13.69).

Kumar *et al.* (2016) found that the treatment with 0.5 cm of irrigation at alternate day resulted in maximum number of fruit plant^{-1} (18.26) in bell pepper followed by the treatment with 0.5 cm of irrigation at daily (17.9) and minimum number of fruits observed from 0.25 cm of irrigation at alternate day from during *spring-summer* seasons at Himachal Pradesh on sandy loam soil.

Drip irrigation at 60 per cent ETc under polyhouse recorded maximum number of fruit plant^{-1} (11.77) in *rabi* capsicum followed by 80 per cent ETc under polyhouse (10.83) and 100 per cent ETc under polyhouse (10.26) at Bhopal under clay loam soil (Salunkhe *et al.*, 2017)

2.2.5 Average fruit weight

Irrigation at 100 per cent level during different critical growth stages recorded maximum fruit weight (37.53 g fruit^{-1}) in bell pepper in turkey under loamy soil (Dagdelen, 2004).

Spehia *et al.* (2007) conducted a field experiment on sandy loam soils at Himachal Pradesh during *kharif* and observed that the highest fruit weight (31.86 g fruit^{-1}) was observed in the drip irrigation receiving 100 per cent ETc with plastic mulch in capsicum than 80 per cent ETc (30.45 g) and 60 per cent ETc (28.99 g).

Maximum fruit weight in capsicum was found with moderate irrigation level (80% of pan evapo-transpiration) through drip irrigation as compared to 100% surface irrigation (Gupta *et al.*, 2010)

Singh *et al.* (2011) conducted a field experiment in split plot design keeping three fertigation treatments (100 (F1), 80 (F2) and 60 (F3) per cent of recommended fertilizers) in main plots and three irrigation treatments (drip irrigation with 1.0 (I1), 0.8 (I2) and 0.6 Potential evapotranspiration (PET) (I3) in sub plots) to study the effect of different levels of irrigation and fertigation on drip irrigated *rabi* bell pepper (*Capsicum annuum* L. var. *grossum*) in sandy loam soil at Ludhiana and the result showed that the average fruit weight (49.34 g fruit^{-1}) was found to be maximum with 0.8 PET water application with 80 per cent recommended dose of fertilizers.

Choudhary *et al.* (2012) observed maximum green fruit weight (24.54 g fruit^{-1}) in bell pepper with drip irrigation at 1.0 Epan followed by drip irrigation at 0.8 Epan at Chhattisgarh under silty clay loam soil.

Paul *et al.* (2013) recorded maximum fruit weight (112.7 g fruit^{-1}) in *rabi* capsicum which was significantly higher in 100 per cent irrigation through drip irrigation compared to the rest of the treatment combination in loamy sand soil at Bhuvaneshwar.

Padron *et al.* (2015) observed maximum fruit weight of bell pepper in open-field (144.70 g fruit^{-1}) and under shade mesh (198.9 g fruit^{-1}) with 1.0 of ETc, followed by 0.75 ETc with open field (153.2 g) and shade mesh (188.6 g) during *spring-summer* season at Brazil under loamy soil.

Kumar *et al.* (2016) found that the treatment with 0.50 cm of irrigation at alternate day resulted in maximum fruit weight (95.20 g fruit^{-1}) in bell pepper than 0.75 cm of irrigation at daily (93.66 g fruit^{-1}) during *spring-summer* seasons at Himachal Pradesh on sandy loam soil.

2.2.6 Total dry matter production

An experiment conducted to study the impact of drip (100, 80, 60 and 40 per cent) surface irrigation (1.2, 1.0, 0.8, 0.6 IW/CPE) on DMP of bell pepper during winter in loamy soil at Bhuvaneshwar and showed that maximum total DMP (33.99 g plant^{-1}) in bell pepper was observed when irrigation was supplied at 100 per cent of crop water requirement through drip as compared to other drip irrigation levels and surface irrigation (Antony and Singhdhupe, 2004)

Results of Gupta *et al.* (2010) indicated that the highest dry matter content in capsicum was noticed with replenishment of 80% evapo-transpiration through drip irrigation as compared to 60% and 100% evapo- transpiration.

Choudhary *et al.* (2012) recorded maximum total dry matter production (45.92 g plant^{-1}) in bell pepper with drip irrigation at 1.0 Epan followed by drip irrigation at 0.8 Epan (43.72 g plant^{-1}) than 0.6 Epan (38.54 g plant^{-1}) in silty clay loam soil at Chhattisgarh.

Kara and Yildirim (2015) reported that *kharif* pepper plants produced maximum total dry matter (1.54 Mg ha^{-1}) in 1.0 Etc compared to different irrigation levels (0.2, 0.8, 1.0 and 1.2 ETc) in clay loam soil of Turkey.

Study conducted on sandy loam soil at Visakhapatnam district to investigate the effect of different types of irrigation and growing methods and indicated that the maximum DMP plant^{-1} was 49.32 g and 41.32 g in drip + polythene mulch + trellising and surface irrigation respectively comparing to drip alone and drip + polythene mulch treatments (Reddy *et al.*, 2015).

A field experiment was conducted at Himachal Pradesh during *spring-summer* seasons on sandy loam soil by Kumar *et al.* (2016) and pursued that total DMP of bell pepper was significantly higher (165.38 g plant^{-1}) with 0.50 cm of irrigation at alternate day under polyhouse than 0.75 cm of irrigation at daily (162.89 g plant-1).

2.2.7 Fruit yield

Hegde (1988) noticed that fruit yield goes on increasing when capsicum was subjected to -25 to -65 kPa irrigation regime and reduced when imposed to either high or low water stress.

Dalla Costa and Gianquinto (2002) reported that the highest yield was obtained for 120 per cent ETc and the lowest was at 40 per cent ETc in bell pepper grown in lysimeter under loamy soil in Mediterranean region of Turkey.

Antony and Singhdhupe (2004) conducted an experiment to study the impact of drip and surface irrigation on growth of bell pepper during winter in loamy soil at Bhuvaneshwar and recorded maximum fruit yield (39.84 t ha^{-1}) in bell pepper when irrigation was supplied at 100 per cent of crop water requirement through drip as compared to other drip irrigation levels (100, 80, 60 and 40 per cent) and surface irrigation (1.2, 1.0, 0.8 and 0.6 IW/CPE).

A field experiment conducted on sandy loam soils at Himachal Pradesh during *kharif* shown that the drip irrigation at 0.8 ETc of water gave significantly higher yield (116.69 q ha^{-1}) as compared to surface irrigation (95.67 q ha^{-1}) in capsicum and drip irrigation with polyethylene mulch raised the yield further to 131.47 q ha^{-1} which was 37 per cent higher yield as compared to surface irrigation (Spehia *et al.*, 2007).

Singh and Kumar (2007) concluded that drip irrigation at 80 per cent ET based on PE resulted in significantly higher fruit yield (45.57 t ha^{-1}) compared with the surface irrigation (29.43 t ha^{-1}) in tomato at Abohar region during winter season.

Sekhon *et al.* (2008) showed that rice straw mulching @ 6Mg/ha saved 120 mm irrigation water because the optimum irrigation schedule with mulching was IW/Pan-E =0.4 (9 irrigations) compared to IW/Pan-E = 0.6 (12 irrigations) when no mulch was applied besides 16 per cent improvement in yield.

An experiment conducted by Demirtas and Ayas (2009) to determine the effect of deficit irrigation on yield for pepper grown under unheated greenhouse condition at the Agricultural Research Station Bursa, Turkey with irrigation water applied to pepper as 100, 75, 50, 25 and 0 per cent (as control) of evaporation from a Class A pan (K1cp

1.00, K2cp 0.75, K3cp 0.50, K4cp 0.25, K5cp 0.00- control) corresponding to 2-day irrigation frequency and found that irrigation water applied to crops ranged from 65 to 724 mm and highest yields were 24 and 19 t ha^{-1} for the K1cp and K2cp treatments respectively.

Vijayakumar *et al.* (2010) recorded the highest chilli yield (11.56 t ha^{-1} in 2007 and 10.25 t ha^{-1} in 2008) with drip irrigation at 75 per cent of PE than 100 and 50 per cent of PE levels of irrigation during *rabi* at Bhavanisagar in Tamil Nadu on sandy loam soil.

Panigrahi *et al.* (2010) studied the impact of different levels of drip irrigation on yield response in tomato during winter in orissa in sandy loam soil and the study revealed that drip irrigation at 100 per cent ET replenishment in tomato increases the yield (180.97 q ha^{-1}) by 15.4 per cent, besides saving 17.9 per cent more costly irrigation water than the conventional furrow irrigation 36.6 per cent which most commonly practiced by the farmers.

Sezen *et al.* (2011) studied the effects of different irrigation regimes on yield of pepper irrigated by a drip system under field conditions at the Soil and Water Resources Research Institute in Tarsus, Turkey which consisted of three irrigation intervals (20±2, 40±2 and 60±2 mm of CPE) evaluated by three irrigation levels (DI_1=0.50, DI_2=0.75 and DI_3=1.00) in silty clay loam soil. The results indicated that irrigation intervals varied from 3-6 days in I_1, 6-11 days in I_2 and 9-15 days in I_3 treatments and the maximum yield of 33.14 t ha^{-1} in the year 2002 and 35.3 t ha^{-1} in the year 2003 growing season was obtained from irrigation interval of 3-6 days and plant-pan coefficient of 1.0 (I_1DI_3).

Capsicum fruit yield (189.27 q ha^{-1}) was maximum with 0.8 PET water application than 1.0 and 0.6 PET at Ludhiana under sandy loam soil.

A field experiment was conducted by Edossa and Emana (2011) to investigate the effects of three irrigation levels (50, 75 and 100 % of crop ETc) and two planting methods (normal and paired-row planting) on water use efficiency of drip-irrigated green pepper (*Capsicum annuum* L.) in Bako, Ethiopia and the results indicated that the maximum fruit yield (17,590 kg ha^{-1}) was recorded with treatment of 100 per cent ETc, while the minimum yield (4510 kg ha^{-1}) in treatment 50 per cent ETc.

Choudhary *et al.* (2012) observed that significantly higher capsicum yield (32.02 t ha^{-1}) of bell pepper was with drip irrigation at 1.0 Epan followed by drip irrigation at 0.8 Epan (29.89 t ha^{-1}) than 0.6 Epan (25.54 t ha^{-1}) at Chhattisgarh under silty clay loam soil.

The effect of irrigation levels (25, 75, 125, 175 and 225 % of PE replenishment) on marketable yield of cabbage was evaluated by Himanshu *et al.* (2012) under drip irrigation system under clay loam during *rabi* at Allahabad and found that the highest mean marketable yield of cabbage (90.51 t ha^{-1}) was recorded with 175 per cent of PE evaporation replenishment with 1.0 m lateral spacing compared to rest of the treatments.

Nagaz *et al.* (2012) carried out a study to assess the effects of different irrigation scheduling regimes on yield of pepper under actual commercial-farming conditions in the arid region of Tunisia with irrigation treatments consisted of water replacements of accumulated ETc at levels of 100 per cent (FI, full irrigation), 80 per cent (DI-80), 60 per cent (DI-60) and highest yields for both years (2008 and 2009) were obtained under FI (22.3 and 24.4 t ha^{-1}) compared to other treatments.

Field experiment conducted to study the response of chilli to irrigation levels of 0.3, 0.5 and 0.7 IW/CPE ratios under *Vertisols* at Water Management Research Centre, Karnataka during *kharif* and observed that higher chilli yield was observed with irrigation at 0.5 IW/CPE (1794.2 kg ha^{-1}) ratio than other treatments (Ullegaddi, 2012).

Yildirim *et al.* (2012) studied the effect of different irrigation treatments (0.0, 0.2, 0.5, 0.8, 1.0, 1.2 of ETc) in bell pepper to determine stress with a fixed interval of 7 days throughout the whole drought season and reported yields of 3.25, 8.64, 16.93, 20.08, 27.67 and 24.61 t ha^{-1}, respectively under clay loam soil at Turkey.

The highest fruit yield (28.7 t ha^{-1}) of *rabi* capsicum was recorded under 100 per cent net irrigation volume through drip irrigation in plastic mulching plots compared to other treatments (80 and 60 % net irrigation volume) in loamy sand soil at Bhuvaneshwar (Paul *et al.*, 2013).

Nesthad *et al.* (2013) observed maximum chilli yield (18.32 t ha^{-1}) from the treatment with 85 per cent of the irrigation requirement with one lateral for each row of crop than 85 per cent of the irrigation requirement with one lateral between two row of crop (14.28 t ha^{-1}) at Tavanur in Kerala on sandy loam soil during *rabi* season.

A field experiment was conducted by Pandey *et al.* (2013) to investigate the effect of drip irrigation on yield of *rabi* chilli (*Capsicum annuum*L.) in sandy loam soil at Bihar and found that the drip irrigation had significantly increased yield (10.50 kg m^{-2}) as compared to flood irrigation (6.55 kg m^{-2}).

Yaghi *et al.* (2013) studied the effect of two types of plastic mulch (transparent and black) and drip irrigation on yield potential of cucumber under vertisol in Syria during *kharif* season and the results of the study indicated that (transparent mulched and drip irrigation) treatment excelled all other treatments with maximum yield of 63.9 t ha^{-}

^{1} while, (black mulched with drip irrigation) treatment, (drip irrigation without mulching) treatment and (surface irrigation) treatment produced 57.9 t ha^{-1}, 44.1 t ha^{-1}, 37.7 t ha^{-1}, respectively.

An experiment conducted by Abdul and Sunil (2014) at Patna with irrigation water equivalent to 100, 80 and 60 per cent ET in main plots and water as per daily, alternate days and once in three days schedule in sub-plots indicated that yield of tomato ha^{-1} was maximum at irrigation 80 per cent ET (838.5, 967.72, 895.52 q ha^{-1}, respectively in three consecutive years) and was significantly higher than 100 per cent ET treatment.

Biwalkar *et al.* (2015) concluded that the fertigation with 120 % dose of NPK and 100 % replenishment of ET_C with Syngenta Yellow variety produced maximum fruit yield (168.74 ton ha^{-1}) than Syngenta red variety (121.60 t ha^{-1}) under sandy loam soil at Ludhiana during *rabi* season.

Kara and Yildirim (2015) reported from a study on water and radiation use efficiencies of pepper (*Capsicum annuum* L.cv. Carliston) during *kharif* in clay loam soil in Turkey with different irrigation levels (0.2, 0.5, 0.8, 1.0 and 1.2 ETc) that yields were 18.78, 20.60, 21.57, 18.90 and 15.16 Mg ha^{-1}, respectively, with maximum yield with 0.8 ETc.

A field experiment on impact of irrigation regimes on yield of sweet pepper in sandy loam soil conducted at Ludhiana by Lodhi *et al.* (2014) during summer season indicated that the best drip irrigated treatment (0.75 IW/CPE) gave maximum fruit yield with increase of 30.67% over furrow irrigation with paired row planting treatment and an increase of 33.74% over furrow irrigation with single row planting treatment.

Reddy *et al.* (2015) conducted study on sandy loam soil at Visakhapatnam district to investigate the effect of different types of irrigation and growing methods on fruit yield and resulted shown that the maximum yields were 62.21 t ha^{-1} and 43.82 t ha^{-1} in drip + polythene mulch + trellising and surface irrigation respectively compared to drip + polythene mulch treatment.

Sahin *et al.* (2015) evaluated the effects of different irrigation levels of 1.0, T_2: 0.85 and T_3: 0.70 CPE from Class A pan on the fruit yield of drip-irrigated cucumber in open field conditions under medium textured soil in Turkey during *kharif* season. Different irrigation levels were (T_1: and found that the maximum fruit yield was determined from 1.0 CPE irrigation level (64.13 Mg ha^{-1}).

An experiment conducted to study the effect of three drip irrigation levels (I_1-100 per cent, I_2-80 per cent and I_3-60 per cent of ETc) on yield of brinjal during *rabi* season at Ratnagiri under clay loam soil showed that I_1 - 100 per cent ETcrop noticed maximum fruit yield (40.17 t ha^{-1}) than other irrigation levels.

Kumar *et al.* (2016) found that the treatment with 0.50 cm of irrigation at alternate day resulted maximum and significantly higher yield (36.17 kg $plot^{-1}$) in bell pepper during *spring-summer* seasons at Himachal Pradesh on sandy loam soil than 0.50 cm of irrigation daily (35.37 kg $plot^{-1}$).

Salunkhe *et al.* (2017) reported that drip irrigation at 60 per cent ETc than 80 per cent and 100 per cent under polyhouse shown superior yield (1163.7 q ha^{-1}) in *rabi* capsicum over rest combination at Bhopal under clay loam soil.

2.3 Effect of drip irrigation on quality parameters

Veeranna (2000) conducted experiment on *rabi* chilli at Bangalore under sandy loam soil and concluded that quality parameters were significantly influenced by irrigation levels. Ascorbic acid (122.97 mg 100^{-1} g) and capsanthin (0.43%) contents were higher with irrigation at 0.8 CPE. capsaicin content was higher under moisture stress situations as compared to well watered conditions. Irrigation given at 0.4 CPE recorded significantly higher (0.61%) capsaicin content over 0.6 (0.49 %) and 0.8 (0.48 %) CPE.

Drip irrigation + 100% RDF recorded significantly higher oleoresin percentage (13.04%) than furrow irrigation + 100% RDF (11.67%) in red chilli at Dharwad under clay loam soil during *kharif* season and drip irrigation + 100% RDF recorded significantly lower discoloured fruits percentage (6.24%) than the furrow irrigation + 100% RDF with 9.99% (Ashoka, 2005).

Gupta et *al.* (2010) reported that the highest TSS content was recorded with moderate irrigation level *i.e.,* 80% evapo-transpiration through drip irrigation as compared to 60% and 100% evapo-transpiration in capsicum.

Birhanu and Tilahun (2010) observed that total soluble solids content in tomato increases with the increase in stress level, while moisture content of fruits decrease in Ethiopia.

Gupta *et al.* (2010) noticed that the maximum ascorbic acid content was observed in 100% ET as compared to 80% and 60% through drip irrigation in capsicum.

Singh *et al.* (2010) observed higher ascorbic acid content with 0.75 pan evaporation compared to 0.5 and 1.0 pan evaporation under sandy loam soil in Ludhiana and stated that higher irrigation rates are not recommended in capsicum, because they result in reduced water use efficiency, decrease in yield and increased incidence of soil borne diseases.

Fertigation with 120 % dose of NPK and 100 % replenishment of ET_C with Syngenta Yellow variety produced maximum ascorbic acid content (167.40 mg $100g^{-1}$) than Syngenta Red variety (151.77 mg $100g^{-1}$) under sandy loam soil at Ludhiana during *rabi* season (Biwalkar *et al.,* 2015).

Kumar *et al.* (2016) reported that the treatment with 0.25 cm of irrigation at alternate day recorded maximum total soluble solids (5.30%) and treatment with 0.75 cm of irrigation at alternate day recorded maximum ascorbic content (126.19 mg 100 g^{-1}) in bell pepper under sandy loam soil during *spring-summer* season at Himachal Pradesh.

2.5 Effect of microclimate on crop environment and yield

Ibrahim Al-Arifi (1998) studied the effects of shading rates as solar interceptors and air velocity on the greenhouse crop environment. The 50% shade nets reduced evapotranspiration (ET) rates by 22% while solar energy loads were reduced by 45%. For the 0% Shaded greenhouse, top leaf temperatures were approximately 1°C higher than air temperatures. The results inferred that with 50 % shade, both leaf temperatures at the top and within the plant canopy were consistently lower than air temperatures.

Andhale *et al.* (2014) conducted an experiment at Ahmednagar, Maharashtra in a specially designed shade net of three shading intensities *viz*., 35, 50 and 75 per cent and six different shade net colours *viz*., black, red, green plus white, green, blue and white. The micrometeorological studies indicated that absorbed photosynthetically active radiation (APAR) and light use efficiency were significantly increased in the 35 per cent shading intensity and it was suitable for capsicum cultivation under protected cultivation. The micro-meteorological parameters *viz*., APAR, light use efficiency, photosynthetic rate and yield of capsicum were significantly improved under green plus white and green shade net colors than other shade net colours in combination with 35 per cent shading intensity recorded higher values in respect of micrometeorological traits *viz*., absorbed photosynthetically active radiation, light use efficiency and yield of capsicum.

Satasiya *et al.* (2014) developed a poly-cum-shade net house of 9.2 m x 5 m x 3.6 m covered with 50 % green shade net on periphery and roof covered with 200 UV PE sheets for capsicum cultivation. In this design temperature decreases around 1-2 ^{0}C and 4-5^{o}C while RH increased from 5.5-2.1% and 3.7-3.0% during winter and summer season, respectively as compared to ambient condition. Whereas the light intensity during winter, summer season varied from 1520 to 41,590 lux inside the structure and

2450 to 73,560 lux in open field and 4720 to 22,090 lux and 10,110 to 91,170 lux for inside and open field respectively.

Vethamoni and Natarajan (2008) studied on two sweet pepper cultivars viz., Indra and Kohinoor under three levels of shade (open field condition, 35 per cent and 50 per cent). The prevailing weather parameters inside the shade net significantly influence the yield parameters and more number of fruits per plant was observed under 35 percent shade (22.35, 18.15) than open (5.70, 3.20) and 50 percent shade (16.05, 12.98) in sweet pepper cultivar Indra.

An experiment was conducted by Kurubetta and Patil (2009) on Capsicum hybrids *viz.,* Orobelle, Bomby and Indra grown under naturally ventilated polyhouse, naturally ventilated shadow hall, shade house with misting and shade house without misting .The results revealed that the earliest flower initiation (33 days), least time taken for first harvesting (86 days) and highest per cent fruit set (49.81) were recorded under naturally ventilated polyhouse. The hybrid Indra recorded significantly earliest flower initiation (35 days), lower time taken for first harvesting (86 days) and higher per cent of fruit set (45.45) as compared to other two hybrids. The quality parameters like fruit weight (160 g), fruit volume (320 cc), rind thickness (0.91 cm) and shelf life (8.62 days) were also significantly maximum under naturally ventilated polyhouse than under naturally ventilated shadow hall. Among the hybrids, Bomby recorded significantly higher fruit weight (158.50 g), fruit volume (310.00 cc) and Indra recorded higher rind thickness (0.87 cm) and shelf life (8.60 days).

varieties. Average plant height ranged from 100 to 160 cm, fruit weight ranged from 205 to 280 g per fruit and number of marketable fruits per plant varied from 11 to 23. Yield and (Benefit Cost) B: C ratio for the two best hybrids i.e., Tanvi and Tanvi Plus were 140.5 and 127.3 t ha^{-1}, and 2.37 & 2.06, respectively.

Patil and Bhagat (2014) reported on the yield response of cucumber (cv. Gypsy) grown under shade net house to 35, 50, 75 per cent shading and in open field condition. Biometric characteristics *viz.,* days to 50 per cent flowering, average diameter of fruit, average length of fruit, average weight of fruit, length of vine at last harvest, number of fruits per vine and yield of fruit were observed throughout the growth period. Irrespective of nutrient sources applied, mean air temperature of 40.34 to 24.66 ^{0}C, mean relative humidity 91.80 to 30.53 per cent, mean sunshine hours 8.04 to 11.04 hrs, wind speed 1.72 to 6.55 km/hr. were found to be optimum for higher yield of cucumber 27.32 t ha^{-1} under shade net house with 75 per cent shading. The climatic condition proved adverse for cucumber cultivation under open field.

Malshe *et al.* (2016) reported on the comparative study of different capsicum genotypes conducted under two different growing environments such as poly house and open field. Under poly house conditions, Orobelle recorded maximum increase (41.85 per cent) in the fruit size compared to open conditions. The fruit yield per plant was maximum (2.426 kg plant^{-1}) by California Wonder under polyhouse which was on par with Orobelle. The incidence of thrips was significantly reduced by 41.44 per cent in protected conditions (Poly house) than open conditions.

2.5 Effect of drip irrigation on water use studies

Shashidhara (2006) reported that the Water use efficiency (WUE) increased by 24 and 11 per cent moisture regimes in 40 and 60 per cent PE as compared to 80 per cent PE under vertisol during *kharif* at Dharwad.

A field experiment conducted by Spehia *et al.* (2007) on sandy loam soil at Himachal Pradesh during *kharif* and reported that the water use efficiency at drip irrigation alone, drip irrigation with polyethylene mulch and surface irrigation were 3.73, 3.88 and 2.35 respectively. Drip irrigation with polyethylene mulch besides saving of 55.6 per cent water compared to surface irrigation in capsicum crop.

Optimum irrigation schedule IW/Pan-E =0.4 (9 irrigations) with mulching recorded highest water use efficiency (49.1 kg ha^{-1} mm^{-1}) compared to IW/Pan-E = 0.6 (12 irrigations) when no mulch was applied under sandy loam soil at Ludhiana (Sekhon *et al.*, 2008).

An experiment conducted by Demirtas and Ayas (2009) to determine the effect of deficit irrigation on yield of pepper grown under unheated greenhouse condition at the Agricultural Research Station Bursa, Turkey revealed that the highest values for water use efficiency (WUE) and irrigation water use efficiency (IWUE) were 3.13 and 3.39 kg mm^{-1}.

Karam *et al.* (2009) studied response of Bell pepper (*Capsicum annuum* L.), cv. ‘Mercury” to full and deficit irrigation at Tal Amara Research Station under the Mediterranean dry climate of the Central Bekaa Valley with Treatments of (C) wellwatered treatment receiving 100 per cent ETc, and three water stressed treatments receiving irrigation at 80, 60 and 40 per cent of ETcrop and concluded that the water use efficiency at dry yield basis (WUEy) of the control was 0.35 kg m^{-3} while 80, 60 and 40 per cent treatments had WUE higher by 22, 35 and 39 %, respectively, under the Mediterranean dry climate of the Central Bekaa Valley.

Patil and Patil (2009) determined the effect of mulch in relation to irrigation on water use and yield of capsicum in silt clay loam soil at Igatpuri in Maharashtra during the summer season for three years (2003–2005) and concluded that highest water-use-efficiency (16.9 kg ha^{-1} mm^{-1}) was recorded in treatment of drip irrigation combined with black plastic mulch which was 59.2 per cent higher than the lowest water-use-efficiency (6.9 kg ha^{-1} mm^{-1}) observed in treatment of conventional irrigation method with no mulch.

In a study conducted by Gupta *et al.* (2010) irrigating capsicum at 60 per cent of ET and application of 80 percent of RD of NPK through drip recorded highest water use efficiency of 29.40 q ha^{-1} cm^{-1}.

The investigation carried out by Singh *et al.* (2010) on the effect of irrigation (IW/CPE ratio 0.5, 0.75 and 1.0) and fertigation (100 per cent N) on sweet pepper grown in naturally ventilated polyhouse on sandy loam soil at Ludhiana revealed that the drip irrigation at 0.75×Epan irrespective of fertigation treatments gave irrigation water saving of 35.3 per cent and resulted in 38.6 per cent higher fruit yield as compared to recommended practice inside the polyhouse.

Panigrahi *et al.* (2010) reported that drip irrigation at 100 per cent ET replenishment in tomato increased the water use efficiency by 5.7, 13.9 and 27.3 per cent over the treatments of drip irrigation at 80 and 60 per cent *ETc* replenishment and furrow irrigation treatments, respectively during winter season in Orissa in sandy loam soil.

Highest water use efficiency of 20.6 kg ha^{-1} mm^{-1} was observed in *rabi* chilli with drip irrigation at 75 per cent of PE than 100 and 50 per cent of PE levels of irrigation at Bhavanisagar in Tamil Nadu on sandy loam soil (Vijayakumar *et al.*, 2010).

Maximum WUE (3.96 kg m^{-3}) was recorded in treatment 100 per cent ETc with paired-row planting, while the WUE (2.04 kg m^{-3}) was minimum in treatment 50 per cent ETc with paired-row planting (Edossa and Emana, 2011).

Nesthad *et al.* (2013) recorded maximum water use efficiency (25 kg $ha^{-1}mm^{-1}$) for the treatment with 85 per cent of the irrigation requirement with one lateral for each row of crop in *rabi* chilli which WAS on par with 65 per cent of the irrigation requirement with one lateral for each row of crop at Tavanur in Kerala on sandy loam soil.

The water use efficiency was significantly higher under 80 per cent ET (96.71 q $ha\text{-}cm^{-1}$) in tomato at Patna during *rabi* season than 100 per cent (Abdul and Sunil ,2014).

Lodhi *et al.* (2014) conducted a field experiment on impact of irrigation regimes on water use efficiency of sweet pepper under sandy loam soil at Ludhiana during summer season and reported that the percentage of water saving for drip irrigation treatments of 0.6, 0.75 and 0.9 IW/CPE was 51.01, 39.72 and 28.73 per cent respectively over the furrow irrigation treatment. The WUE was highest with 0.75 IW/CPE treatment among the all irrigation treatments.

Fertigation with 120 % dose of NPK and 100 % replenishment of ET_C with Syngenta yellow variety produced maximum water use efficiency (14.60 q ha^{-1} cm^{-1}) under sandy loam soil at Ludhiana during *rabi* season than Syngenta Red variety (12.65 q ha^{-1} cm^{-1}) (Biwalkar *et al.,* 2015).

Kara and Yildirim (2015) concluded that *kharif* pepper plants produced the highest water use efficiency in 1.0 ETc treatment (4.1 kg m^{-3}) as the amount of water applied was 324 mm compared to different irrigation levels of 0.2, 0.8, 1.0 and 1.2 ETc in clay loam soils of Turkey.

Kumar *et al.* (2016) reported that the treatment with 0.25 cm of irrigation at alternate day recorded maximum water productivity (0.43 kg m^{-2} cm^{-1}) than 0.5 cm of irrigation at alternate day (0.25 kg m^{-2} cm^{-1}) in bell pepper during *spring-summer* seasons at Himachal Pradesh on sandy loam soil.

Salunkhe *et al.* (2017) recorded the maximum water use efficiency of 30.29 q ha-cm^{-1} in drip irrigation to capsicum at 60 per cent ETc under polyhouse condition compared to 80 and 100 per cent ETc at Bhopal under clay loam soil.

2.6 Effect of drip irrigation on nutrient uptake

Fertigation with 75 per cent dose of N and K and 100 per cent Epan with California wonder variety produced maximum N, P_2O_5 and K_2O plant uptake 46.33, 7.37, 47.05 kg ha^{-1} and fruit uptakes 22.83, 3.64, 26.07 kg ha^{-1} respectively, under sandy loam soil at Assam during *rabi* season Patil and Das (2015).

Singh et al. (2017) observed that different levels of drip irrigation in chilli significantly increased N, P and K uptakes with 94.91, 20.11, 140.29 kg ha^{-1} respectively at 80 per cent PE over drip irrigation at 40 per cent under clay loam soil at Udaipur.

2.7 Effect of drip irrigation on economics

Veeranna (2000) conducted experiment on *rabi* chilli at Bangalore under sandy loam soil and showed that weekly irrigation given at 0.8 CPE was optimum irrigation level to secure higher net returns of 35,442 ha^{-1} as compared to 0.6 and 0.4 CPE. However, higher economic profit was with irrigation at 0.6 CPE was beneficial (ICBR 1:27.51) as compared to 0.8 CPE (1:16.89).

Singh and Kumar (2007) stated that drip irrigation at 80 per cent ET resulted in higher net returns (34431 Rs ha^{-1}) and benefit: cost ratio (1.76) in tomato than during *rabi* season in Abohar region.

A field experiment conducted by Spehia *et al*. (2007) sandy loam soils at Himachal Pradesh during *kharif* revealed that the benefit cost ratio of capsicum cultivation under drip irrigation, drip irrigation with polyethylene mulch and surface irrigation were 2.66, 2.77 and 2.27, respectively.

Sekhon *et al.* (2008) concluded that optimum irrigation schedule IW/Pan-E =0.4 (9 irrigations) with mulching recorded highest water use efficiency (49.1 kg ha^{-1} mm^{-1}) compared to IW/Pan-E = 0.6 (12 irrigations) when no mulch was applied under sandy loam soil at Ludhiana.

An experiment was conducted to study the comparative performance of drip irrigation and fertigation over conventional methods of irrigation and fertilizers application in Capsicum var. Nishat-1 by Gupta *et al.* (2010) and concluded that concluded that by adopting drip irrigation system, the highest income of Rs. 2,82,026/- could be generated in capsicum as against Rs. 1,69,990/- realized under conventional method. Similarly, Benefit cost ratio was also noticed maximum (3.33: 1) with the same treatment combination i.e. 80 per cent ET through drip + 80 per cent recommended NPK through fertigation.

Patil and Patil (2009) determined the effect of mulch in relation to irrigation on water use and yield of capsicum in silt clay loam soil at Igatpuri in Maharashtra during the summer season for three years (2003–2005) and concluded that net return was maximum in drip irrigation treatment with black plastic mulch of 50 μ thickness (Rs. 589001 ha^{-1}) compared to conventional irrigation method with no mulch (Rs. 30700l ha^{-1}) and resulted in an increase of Rs. 282001/- in net seasonal income.

A study on economics of drip irrigated sweet pepper was carried out by Lodhi (2009) under sandy loam soil at Ludhiana during summer season with five irrigation treatements (drip irrigation with IW/CPE ratio of 0.60, 0.75, 0.90, furrow irrigation with paired row planting and single row planting showed that highest economic returns were achieved in 75 cm low tunnel height drip irrigated with IW/CPE ratio of 0.75.

Vijayakumar *et al.* (2010) stated that the maximum benefit-cost ratio of 3.2 and 2.8 during I and II crops was observed for *rabi* chilli with drip irrigation at 75 per cent of PE than 100 and 50 per cent of PE levels of irrigation at Bhavanisagar in Tamil Nadu on sandy loam soil.

The study on the economic feasibility of drip irrigation system in bell pepper at Ludhiana under sandy loam soil indicated that better results in terms of economics were found in case of drip irrigation treatments compared to conventional irrigation. The gross income from drip irrigation system and conventional irrigation were 2,83,905 ha^{-1} and 2,30,475 ha^{-1} respectively. Besides this, drip irrigation system gave higher benefit-cost ratio of 2.55:1 as compared to control treatment (2.07:1) (Singh *et al*., 2011).

A study carried out on economics of drip irrigated pepper under Mediterranean climatic conditions under silty clay loam soil at Turkey to various water regimes by Sezen *et al.* (2011) concluded at IF1DI3 (IF1 = 20±2 mm pan evaporation values, DI3 = 1.00 irrigation level) irrigation regime is recommended for field grown pepper in order to attain higher yields with improved quality. Economic evaluation revealed that full irrigation treatment (IF1DI3) generated the highest net income. However, under water scarcity conditions, IF1DI2 (DI2 = 0.75 irrigation level) treatment can provide an acceptable net income.

Choudhary *et al.* (2012) concluded that drip irrigation at 1.0 Epan resulted in highest cost of cultivation (Rs 67,302 ha^{-1}), net return (Rs 2,52,898 ha^{-1}) and B: C (3.76) followed by drip irrigation at 0.8 Epan at Chhattisgarh.

Himanshu *et al.* (2012) evaluated the effect of irrigation levels (25, 75, 125, 175 and 225 per cent of PE replenishment) on economic return of cabbage under drip irrigation system at Allahabad during *rabi* season under clay loam soil and found that the maximum B:C ratio was 4.48 recorded with 175 per cent of pan evaporation replenishment.

Ullegaddi (2012) conducted an field experiment to study the response of chilli to irrigation under *Vertisols* at Water Management Research Centre, Belvatagi during *kharif* 2011-12 revealed that irrigation level of 0.5 IW/CPE ratio recorded higher gross income (Rs. 212320 ha^{-1}), net income (Rs. 180657 ha^{-1}) and B: C ratio of 5.45.

The benefit cost ratio for treatment with 85 per cent of the irrigation requirement with one lateral for each row of crop was 3.8 and treatment with 85 per cent of the irrigation requirement with one lateral in between two rows of crop was 3.9 in *rabi* chilli at Tavanur in Kerala on sandy loam soil. Even though the yield for the treatment T5 was high, the benefit cost ratio stands high for treatment T6. The high value of benefit cost ratio for treatment T6 was due to the reduction in the quantity of material for drip irrigation system (Nesthad *et al.*, 2013).

Pandey *et al.* (2013) concluded that the drip irrigation in *rabi* chilli recorded significantly higher net income (Rs. 60.3 m^{-2}) as compared to flood irrigation in sandy loam soil at Bihar.

Maximum net profit of Rs. 191600 ha^{-1} with B: C ratio of 2.01 recorded significantly higher in 100 percent irrigation through drip irrigation compared to the rest of the treatment of *rabi* capsicum in loamy sand soil at Bhuvaneshwar (Paul *et al.* 2013).

The study on the economics of capsicum production under protected conditions in Karnataka by Sreedhara *et al.* (2013) and resulted that the total returns and net returns from capsicum production under protected conditions was Rs. l,54,734 per unit and Rs. l,15,279 per unit, respectively and the B: C ratio of capsicum production under protected conditions was 3.92.

Reddy *et al.* (2015) conducted a study on sandy loam soil of at Visakhapatnam district to investigate the effect of different types of irrigation and growing methods on economics and revealed that the highest net returns (Rs. 102708 ha^{-1}) and benefit cost ratio (2.41) recorded was with furrow + black polythene mulch + trellising, respectively.

Kumar (2016) noticed that different levels and frequencies of irrigation produced significant differences with regards to different traits under sandy loam soil during *spring-summer* season with application of 0.5 cm of irrigation at alternate day (T4) resulted in maximum benefit: cost ratio (6.53:1) in Himachal Pradesh.

Rekha *et al.* (2017) conducted an experiment to evaluate the effect of irrigation and nutrient scheduling on the economics of bell pepper (*Capsicum annuum* L.) under protected structure in Calicut during 2014-15 and reported that in bell pepper highest cost benefit ratio of 2.2:1 was obtained from the combination of irrigation at 0.75 IW/CPE ratio and 100 per cent recommended dose of NPK.

Chapter III

MATERIAL AND METHODS

The present study on **"Response of coloured capsicum *(Capsicum annuum* var. *grossum* L.*)* varieties for different irrigation levels under shade net"** was conducted during *rabi*, 2018-19. The details of the material used and methods adopted for this study are briefly presented in this chapter.

3.1 LOCATION AND CLIMATE

The experiment was carried out at Horticultural farm, College of Agriculture, Rajendranagar, Hyderabad in a shade net during *rabi* season, 2018-2019. The farm is geographically situated in the Southern Telangana Zone at 17°19'11" N latitude and 78°24'58" E longitude at an altitude of 542.3 m above mean sea level. Satellite view of the location of the experimental site was depicted in Fig.3.1.

Figure 3.1 Satellite view of the experimental area - Shade net house (Down loaded from Google Earth).

3.2 WEATHER CONDITIONS DURING THE CROP GROWTH PERIOD

The weather parameters outside the shade net during the crop growth period was collected from the meteorological observatory, located at Agricultural Research Institute, Rajendranagar, Hyderabad and are presented in Appendix-A.

The capsicum seed was sown on 2nd August, 2018 in pluck tray nursery, 32 days old seedlings were transplanted on 2nd September, 2018 and the last date of picking was 26th February, 2019. During the capsicum crop growth period, the mean weekly maximum temperature ranged from 24.6 ºC to 34.9 ºC with an average of 30.6 ºC outside the shade net (Fig 3.2). The mean weekly minimum temperature ranged from 7.6 ºC to 20.3 ºC with an average of 14.1 ºC. The mean maximum relative humidity during the crop growing period varied from 94.7 to 78.6 per cent with an average of 88.2 per cent and the mean minimum relative humidity varied from 64.0 to 30.0 with an average of 44.8 (Fig. 3.2).

The mean weekly wind velocity ranged from 0.9 to 7.1 km h^{-1} with an average of 2.8 km h^{-1}. Likewise the mean weekly bright sunshine hours per day varied from 3.0 to 9.8 hours with an average of 7.4 hours (Fig 3.2). The pan evaporation data varied from 2.2 to 9.5 mm with a mean of 4.4 mm. The average weekly climatic parameters during the crop growth period are presented in the Figure 3.2. The data pertaining to shade net is presented in results chapter.

3.3 PREVIOUS CROP HISTORY

The cropping history of the experimental site for the previous three years was presented in Table 3.1.

Table 3.1 Previous cropping history of the experimental area.

S.No.	Year	Cropping Pattern		
		Kharif	***Rabi***	**Summer**
1	2015-2016	Fallow	Fallow	Fallow
2	2016-2017	Tomato	Capsicum	Fallow
3	2017-2018	Vegetables	Fallow	Fallow
4	2018-2019 (present investigation)	Fallow	Capsicum	-

3.4 CHARACTERISTICS OF THE EXPERIMENTAL SITE

3.4.1 Collection and preparation of soil samples

Initial soil samples were drawn at random spots from the experimental area in the shade net at 0-15 and 15-30 cm soil depth before experiment. The soil was mixed thoroughly and samples of about half a kg was obtained by quartering technique and stored in neatly labeled polythene bag for soil analysis. Similarly, after conducting the experiment, individual treatment wise, surface soil samples were also collected at final picking for laboratory analysis.

3.4.2 Physical and chemical properties of soil

The initial soil sample was analyzed for its physical, physico-chemical and chemical properties by adopting standard procedures. The results are presented in Table 3.2. The experimental soil was sandy loam in texture, slightly alkaline in reaction. The fertility status of the experimental soil was low in organic carbon, low in available Nitrogen, medium in available phosphorus and low in available potassium contents.

Table 3.2 Physical, Physico-chemical and chemical properties of soil in experimental field

S.No	Particulars	Value	Remarks	Method adopted (Reference)
I	**Physical properties**			
1	Mechanical analysis (a) Sand (%) (b) Silt (%) (c) Clay (%)	69.2 13.5 17.5		Bouyoucos hydrometer method (Piper, 1966)
2	Gravel (%)	14		
3	Textural class	Sandy loam		
4	Infiltration rate (cm h^{-1})	3.2	Moderate	Double ring infiltrometer (Singarao *et al*., 2005)
II	**Physico-chemical properties**			
1	pH (1:2.5 soil: water)	7.8	Slightly alkaline	Make-Elico, Model- LI 612 pH analyser (Jackson, 1973)
2	Electrical conductivity (dS m^{-1}) (1:2.5 soil: water)	0.31	Moderately saline	SYSTRONICS Conductivity TDS meter 308 (Jackson, 1973)

S.No	Particulars	Value	Remarks	Method adopted (Reference)
3	Organic carbon (%)	0.2	Low	Walkley and Black's modified method (Jackson, 1967)
III	**Chemical properties**			
1	Available Nitrogen (kg ha^{-1})	145.51	Low	Alkaline permanganate method using KELPLUS SUPRA LX – analyser (Subbaiah and Asija, 1956)
2	Available P_2O_5 (kg ha^{-1})	47.15	Medium	Olsen's method for extraction and Ascorbic acid method for estimation by using UV-VIS spectrophotometer (Make-systronics, Model-108) at 420 nm (Olsen *et al*., 1954)
3	Available K_2O (kg ha^{-1})	156.7	Low	Neutral normal ammonium acetate method using (Make-Elico, Model- CL361), Flame photometer (Piper, 1966)

3.4.3 Moisture holding properties

Moisture retention capacity of the experimental field was estimated at - 0.1 MPa and - 15 MPa using pressure plate apparatus (Richards, 1949) and the bulk density of the experimental soil was estimated at 0 - 30 cm depth by following the standard procedures given below (Dastane *et al.*, 1972) and the resultant data is presented in Table 3.3.

$$BD\ (Mg\ m^{-3}) = \frac{\text{Weight of oven dry soil}}{\text{Volume of soil including pore space}}$$

The total available soil moisture for plant use is the difference between -0.1 MPa and -1.5 MPa.

The available soil moisture up to 30 cm depth was computed as follows:

$$TAM = \frac{(F.C. - P.W.P.) \times B.D. \times d}{}$$

Where as

TAM = Total available moisture (mm)

F.C. = Soil moisture content at field capacity (% by dry weight)

P.W.P. = Soil moisture content at permanent wilting point (% by dry weight)

B.D. = Bulk density of soil (Mg m^{-3})

d = Depth of soil (mm)

Table 3.3 Moisture retention characteristics of the experimental soil

Soil depth (cm)	Soil moisture content w/w (%) at		Bulk density (Mg m^{-3})	Available soil moisture [mm]
	Field capacity [-0.1 MPa]	Permanent wilting point [-1.5 MPa]		
0-15	19.62	10.8	1.52	20.1
15-30	18.58	11.4	1.64	17.6

3.4. Water quality parameter

The source of water for irrigating the crop was from a bore well of Horticulture Farm, Rajendranagar. The irrigation water was analyzed to ascertain the quality by following standard methods. The resultant data was tabulated and presented in the Table 3.4.

Data presented in the Table 3.4. indicated that the irrigation water was neutral (pH=7.0) and categorized under the Class II (C_2S_1) suggesting that it is suitable for irrigating the crop. The RSC indicated that there was no carbonate hazard.

Table 3.4 Quality of irrigation water used for experiment

S.No	Parameters	Value	Remarks	Method adopted (Reference)
1	pH	7.0	Neutral	Digital pH meter – (Make - Elico, Model-LI612)
2	EC (dS m^{-1})	0.27	Slight to moderate	Digital Conductivity meter – (Systronics conductivity TDS meter 308)
3	Calcium (me L^{-1})	3.92	-	Titration with standard EDTA using EBT indicator and ammonium buffer
4	Magnesium (me L^{-1})	23.38	-	Titration with standard EDTA using EBT indicator and ammonium buffer

S.No	Parameters	Value	Remarks	Method adopted (Reference)
5	Carbonates (me L^{-1})	Nil	No hazard	Titration with 0.02 N H_2SO_4 using Phenophthalein indicator
6	Bicarbonates (me L^{-1})	7.8	Slight to moderate restriction	Titration with 0.02 N H_2SO_4 using Methyl orange indicator
7	RSC (me L^{-1})	-19.4	Safe	RSC = $(CO_3^{--} + HCO_3^{--}) - (Ca^{++} + Mg^{++})$
8	Na (me L^{-1})	2.66	Safe	Flame Photometer – CL_2 361
9	SAR	0.7	Safe	SAR=Na/[$\sqrt{(Ca^{+2} + Mg^{+2})}$ /2]
10	Cl (me L^{-1})	21.6	Unsafe	Titration with standard $AgNO_3$ using K_2CrO_4 as indicator
11	B (me L^{-1})	0.2	Low hazard	Azomethin-H method
12	NO_3	36	Slight to moderate	Ion meter

3.5 EXPERIMENTAL DETAILS

3.5.1 Design and Layout of the Experiment

The experiment was laid out in a split plot design with three replications. The treatment details are given below. It consisted of four irrigation levels and three coloured capsicum varieties.

3.5.2 Treatments:

The experiment was carried out with 12 treatments in a split plot design with three replications.

S.No.	Main treatments: Irrigation levels (4)	Sub treatments: Varieties (3)
1	0.4 Epan	Indra (Green variety)
2	0.6 Epan	Orebelle (Yellow variety)
3	0.8 Epan	Bomby (Red variety)
4	1.0 Epan	

Table 3.5 Details of different treatments imposed for capsicum varieties

S.No.	Treatments
T1	0.4 Epan + Indra (Green variety)
T2	0.4 Epan + Orobelle (Yellow variety)
T3	0.4 Epan + Bomby (Red variety)
T4	0.6 Epan + Indra (Green variety)
T5	0.6 Epan + Orobelle (Yellow variety)
T6	0.6 Epan + Bomby (Red variety)
T7	0.8 Epan + Indra (Green variety)
T8	0.8 Epan + Orobelle (Yellow variety)
T9	0.8 Epan + Bomby (Red variety)
T10	1.0 Epan + Indra (Green variety)
T11	1.0 Epan + Orobelle (Yellow variety)
T12	1.0 Epan + Bomby (Red variety)

3.5.3 Plot Size

Gross plot size : 7.6 m x 0.9 m

Lateral spacing : 0.6 m

Emitter spacing : 0.4 m

Drip discharge rate : 4 L h^{-1}

3.5.4 Shade net details:

Colour – Green

Percent shade – 50%

Tape type

3.5.5 Layout of the drip irrigation system

The drip system consisted of a head control unit (including non-return valve, air release valve, vacuum breaker, disc filter, fertigation unit, throttle valve, pressure gauge and water meter); water carrier system (including PVC main pipeline, PVC sub main pipeline, control valve, flush valve and other fittings) and water distribution system (including 16 mm dripper line with inline emitters, grommet, start connecter, nipple and end cap).

The source of water for irrigation was from bore well. Inline drip laterals of 16mm were laid at the two sides of the bed having emitting points at every 40 cm interval with discharge rate of 4 L h^{-1}. The drip system was checked at each emitting point for uniform discharge before transplanting the seedlings. Layout of the experiment is depicted in Figure 3.2.

3.5.6 Drip Irrigation scheduling

Irrigation scheduling was done based on daily evaporation data recorded from USWB class 'A' pan evaporimeter in agro-meteorological station, ARI Farm, Rajendranagar, Hyderabad (Appendix- C).

The irrigation duration was based on the number of laterals, emitter spacing and emitter discharge for a given design area. To calculate the application rate and irrigation time of the drip system following formulae were used:

$$\textbf{Application rate (mm h}^{-1}\textbf{)} = \frac{Q}{D_L \times D_E}$$

Q = Dripper discharge (L h^{-1})

D_L= Distance between laterals (m)

D_E = Distance between drippers (m)

$$\textbf{Irrigation time (minutes)} = \frac{\text{Epan (mm)} \times 60}{\text{Application rate (mm h}^{-1}\text{)}}$$

3.5.7 Fertigation Scheduling

As capsicum is energy rich crop, the nutrient requirement is very high throughout its growing period (Kohir patil and Das, 2015). Nitrogen, phosphorous and potassium had positive effect on growth and yield as it enhanced the capsicum production. Capsicum requires plenty of organic matter and ample nutrients in the form of major and minor nutrients for proper growth and production. In this experiment recommended dose of fertilizer for capsicum crop 100 kg N, 80 kg P_2O_5 and 60 kg K_2O ha^{-1} were given commonly to all the treatments. The sources of N, P and K fertilizers were Urea, Single Super Phosphate and Muriate of potash (white), respectively. These water soluble fertilizers are given through fertigation for entire crop growth period, starting from third week after transplanting. Fertigation is given every fourth day as recommended. The Single Super phosphate (80 kg P_2O_5 ha^{-1}) was applied as common basal dose in all the treatments of the study before optimizing the fertigation schedule for capsicum production in the shade net (Appendix-D).

3.6 CULTIVATION DETAILS

3.6.1 Variety:

Popularly grown commercial hybrids of capsicum in India are Indra (green), Bomby (red) and Orobelle (Yellow) were developed by Syngenta India limited company were selected for the study.

Indra

Plants are medium tall, bushy having vigorous growth with dark green leaves and dense foliage. Fruits are dark green, thick-walled and glossy with average weight 170 g, length 10-12 cm, girth 10 cm having 3 - 4 lobes. Fruit setting starts in 50-55 days after transplanting.

Bomby

Plants are strong, sturdy, tall plant which requires staking. Early hybrid with good branching. Fruits are dark green turning red at maturity, thick walled, glossy with average weight 130-150 g. length 10-11 cm, diameter 10 cm having 3-4 lobes.

Orobelle

Plants are F1 hybrid turning from green to bright yellow after maturity and early bearing hybrid. It sets well under cold conditions. Fruits are blocky, almost square (10 x 9 cm) with a medium-thick wall. Average fruit length is about 10-12 cm having 3 to 4 lobes and weight ranges between 100-200 g.

3.6.2 Nursery

Good quality seeds were selected and raised in pro-trays cell or cavities. Media (containing cocopeat, neem cake and *azospirillum*) was prepared for filling up the pro-trays and seeds were sown, one seed per cell to a depth of 5mm and covered with the same media. Then the trays were shifted to net house and watered with a rose can. Seeds germinated in about a week after sowing. Seedlings were drenched with 19:19:19 @ 3 g L^{-1} solution at 22 days after sowing. The seedlings were ready for transplanting in 31 days.

3.6.3 Land preparation

The land was thoroughly ploughed inside the shade net with tractor mounted mould board plough and soil was brought to fine tilth. Raised beds were prepared in the shade net after bringing soil to fine tilth. The well decomposed vermicompost @ 12.5 t ha^{-1} was mixed with soil. Raised beds were prepared in such a way that they are of 22.8 m length, 90 cm wide, 30 cm height and a walking space of 30 cm was left between the adjacent beds for ease of cultural operations.

3.6.4 Transplanting

The raised beds for planting were watered to field capacity before transplanting. Seedlings of 32 days old were transplanted manually in paired row planting on either side of the bed at a depth of 5 cm in zig-zag manner for all treatments. The crop geometry of 45× 40 cm was adopted. Care was taken to see that no damage occurred to the root portion while taking out the seedlings from individual cells of portray. After transplanting, soil around seedlings were drenched with 3 g L^{-1} copper oxy chloride solution to the base of seedlings at the rate of 30 ml $plant^{-1}$. Healthy seedlings of capsicum varieties Indra, Orebelle and bomby were planted on the raised beds. During planting, care was taken such that the plants should be 5 mm below soil without disturbing the root ball.

3.6.5 Gap filling

Gap filling was done at 10 days after transplantation (DAT) to maintain optimum plant population in all the treatments.

3.6.6 Weed Management

Hand weeding was done regularly throughout the crop growth period to maintain weed free environment inside the shade net.

3.6.7 Fertilizer Application

A common dose of phosphorus was applied to all the treatments. Nitrogen and Potassium were applied through drip fertigation at different growth stages. Fertigation was given at 4 days interval starting from 10 DAT to 153 DAT. The fertigation schedule is presented in the Appendix-B.

3.6.8 Plant protection

Plant protection measures were followed for the control of pests and diseases. Chemicals like Fipronil @ 2 ml L^{-1} (5 sprays), Spinosad @ 0.25 ml L^{-1} (2 sprays), Dimethoate @ 2 ml L^{-1} (3 sprays), Neem oil @ 1ml L^{-1} (5 sprays), Monocrotophos @ 2 ml L^{-1} (5 sprays), Copper oxy chloride (30 ml drenching $plant^{-1}$) and Acephate @ 1.5 g L^{-1} (3 sprays) were used to control thrips, mites, aphids, fruit borer, dieback and powdery mildew.

3.6.10 Harvesting

The mature fruits from the plant were harvested from 95 days after transplanting. Pickings were done once in 8-10 days at morning time and fruits were kept in a cool shade place avoiding direct exposure to sunlight. Care was taken to keep the fruits from each treatment separately and then weighed.

3.7 MONITORING OF MICROCLIMATE

The microclimatic parameters like temperature, relative humidity, light intensity and vapour pressure deficit was monitored throughout the crop growth period at four times in a day (8.30 AM, 12.00 PM, 2.00PM and 4.30 PM) respectively inside and outside the shade net.

3.7.1 Temperature (^{o}C)

Air temperature inside the shade net was recorded by using Thermo hygrometer four times a day as above mentioned and expressed as standard weekly data throughout the crop growth period.

3.7.2 Relative humidity (%)

The relative humidity was measured inside the shade net house by using Thermo hygrometer four times a day as above mentioned and expressed as standard weekly data throughout the crop growth period.

3.7.3 Light intensity (lux)

The light intensity inside the shade net house was measured four times a day as above mentioned with the help of Lux meter and recorded the data in lux and expressed as standard weekly data throughout the crop growth period.

3.8 OBSERVATIONS RECORDED

3.8.1 Sampling technique

Five plants were selected randomly in all treatments in the rows and labeled. All the successive biometric observations during the crop growth were recorded periodically from these labeled plants. Destructive sampling technique was adopted for recording periodical Leaf Area Index (LAI) and Dry Matter Production (DMP).

3.8.2 PLANT OBSERVATIONS

3.8.2.1 Plant height (cm)

Five plants were tagged at random in each treatment for recording the plant height at an interval of 30 days starting from the date of transplanting. The plant height was measured from the ground level to the growing tip of the main stem at 30, 60, 90, 120, 150 DAT and at harvest. The average height was calculated and expressed in centimeters.

3.8.2.2 Number of leaves plant^{-1}

Number of leaves plant^{-1} were recorded from the five randomly selected plants at 30, 60, 90, 120, 150 DAT and at final harvest.

3.8.2.3 Number of branches plant^{-1}

Number of branches plant^{-1} were recorded from the five randomly selected plants at 30, 60, 90, 120 and 150 DAT and at final harvest.

3.8.2.4 SPAD chlorophyll meter readings (SCMR)

SPAD readings were recorded from the five randomly selected plants at 30, 60, 90, 120, 150 DAT and at final harvest.

3.8.2.5 Leaf area index (LAI)

Leaf area was estimated on three randomly selected plants in each plot at 30, 60, 90, 120 and 150 DAT and at final harvest with LI 3100 leaf area meter (LI-COR, INC. Linocoln, Nebraska, USA). At each sampling three plants were cut, green leaves were separated and were inserted into leaf area meter for recording the leaf area. The leaf area index is the ratio of leaf area plant^{-1} (A) to land area plant^{-1} (P). LAI was computed taking into account the area occupied by each plant according to Watson (1952).

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

3.8.2.6 Days to 50% flowering

The number of days taken from transplanting to flowering in half of population in each treatment was recorded to get days to 50 percent flowering.

3.8.3 YIELD AND YIELD ATTRIBUTES

The following yield and yield attributes data was collected at each picking for assessing the effect of different irrigation schedules on yield and yield attributes of coloured capsicum varieties.

3.8.3.1 Fruit length (cm) and fruit diameter (cm)

From the five randomly selected fruits in each treatment average length of the fruit was computed from fruit apex to its tip and the thickness of fruits from shoulder portion at marketable stage were measured for fruit diameter using Vernier caliper. The average from 1st, 3rd and 5th pickings was worked out and expressed as mean fruit length and fruit diameter.

3.8.3.2 Pericarp thickness (mm)

The fresh pericarp thickness of fruits from tagged plants was measured with the help of “Vernier caliper” after cutting the transverse section of fruits and average pericarp thickness from 1st, 3rd and 5th pickings was computed.

3.8.3.3 Number of fruits plant^{-1} (each picking)

The total number of fruits plant^{-1} were counted during each picking from the five tagged plants in each plot and the average was worked out and expressed as mean number of fruits plant^{-1}.

3.8.3.4 Average fruit weight (g)

The fresh capsicum fruits harvested from the labeled plants from each treatment were weighed, averaged from 1st, 3rd and 5th pickings and recorded in grams.

3.8.2.6 Total dry matter production (kg ha^{-1})

The three plants used for LAI were uprooted carefully at 30, 60, 90, 120, 150 DAT and at final harvest and roots were removed from basal portions. The fruits were collected at 1st, 2nd, 3rd, 4th and 5th pickings. Both samples were first air dried in shade for one day and then oven dried at 60^{0} C till a constant weight was obtained. The mean dry weight of plant samples and dry fruit samples were expressed as kg ha$^{-1.}$

3.8.3.5 Fruit yield (t ha^{-1})

The weight of mature fruits harvested from each picking was recorded till final harvest and total yield of fruits were recorded in tonnes ha^{-1}.

3.9 QUALITY PARAMETERS:

3.9.1 Ascorbic acid content (mg 100 g^{-1} of fruit)

It was estimated in fresh green, yellow and red fruits at 1st, 3rd and 5th pickings using 2, 6-dichlorophenolindophenol dye and expressed as mg 100 g^{-1} of samples (Ranganna, 1986).

3.9.1.1. Procedure:

3.9.1.2 Reagents

1. Metaphosphoric acid (HPO_3) of 3 %: Prepared by dissolving the sticks or pellets of HPO_3 in glass distilled water.

2. Ascorbic acid standard: 100 mg of L-ascorbic acid was dissolved in 3% HPO_3 and volume was made up to 100 ml. Then 10 ml of this solution was diluted to 100 ml with 3% HPO_3 (1 ml = 0.1 mg of ascorbic acid).

3. Dye solution: 50 mg of the sodium salt of 2, 6-dichlorophenol-indophenol was dissolved in approximately 150 ml hot glass distilled water containing 42 mg of sodium bicarbonate. Cooled and diluted with distilled water to 200 ml stored in a refrigerator.

3.9.1.3. Standardization of Dye

To 5 ml of standard ascorbic acid solution, 5 ml of HPO_3 was added. Micro burrete was filled with the dye and was titrated until a pink colour which persisted for 15 sec. Dye factor i. e. mg of ascorbic acid per ml of dye was determined using the formula given by Ranganna (1986):

$$\text{Dye factor} = 0.5 \div \text{titre value}$$

3.9.1.4. Preparation of Sample

Ten ml of sample was taken and volume made up to 100 ml with 3% HPO_3, filtered or centrifuged.

3.9.1.5. Assay of Extract

Ten ml of the HPO_3 extract of sample and titrated with the standard dye up to a pink end point which persisted for 15 seconds. Titration was done rapidly for preliminary determination of the titre. In the next determination, most of the dye required was added and then titrated accurately. The aliquot of sample was taken such that the titer did not exceeded 3 to 5 ml.

3.9.1.6. Calculation

$$\text{Ascorbic acid (mg) } 100\text{ g}^{-1} = \frac{\text{Titre value x Dye factor x Volume made up x 100}}{\text{Aliquot of extract taken for estimation x weight of the sample taken for estimation}}$$

3.9.2 Total soluble soilds (Brix°)

The content of total soluble solids was determined in green, yellow and red fruits by refraction index, according to AOAC (1998), using refractometer. To determine the TSS, 1.0 ml aliquot was placed in a digital refractometer Reichert AR200 and results were expressed as Brix**°.**

3.9.3 Oleoresin (%):

The green, yellow and red fruits harvested were oven dried. The seeds and pedicels are separated from the dried capsicum fruits. The ground pericarp material was passed through mesh sieve No. 40 to get a fine powder for analysis. Percentage of oleoresin was estimated as per the procedure outlined by Roserbrook *et al*. (1968) and Woodbury *et al*. (1977). Five grams of ground powder was taken in wide glass funnels whose bottom was plugged with non absorbent cotton. Later the ground powder covered with some more cotton. Then acetone in small lots was added till the powder becomes colourless. The filtrate was collected in to a pre weighed (W1) 250 ml beaker.

The collected solvent was evaporated on water bath. The beaker was cooled and weighed (W2). Difference in weights was the oleoresin content in 5 g powder. Finally expressed in percentage.

$$\text{Oleoresin (\%)} = \frac{W2 - W1}{\text{Weight of sample (g)}} \times 100$$

Where,

W1= Empty beaker weight (g)

W2 = Beaker weight with oleoresin (g)

3.9.4 Capsanthin (EOA colour value):

For capsanthin estimation, 0.1 g of oleoresin collected from green, yellow and red fruits during estimation of oleoresin (3.9.3) was weighed in to a 25 ml volumetric flask and made up the volume (0.4 % concentration) with acetone and kept for overnight in dark for extraction. 0.25 ml of above solution was diluted to 10 ml with acetone and the absorbance value was read at 458 nm using a UV-VIS spectrophotometer (Systronics 108). A blank without oleoresin was prepared simultaneously and blank absorbance was subtracted from sample reading. The per cent capsanthin content was computed by multiplying the absorbance with 61,000 (EOA, 1985).

Capsanthin content = (Sample reading - acetone blank) x 61,000

3.9.5 Capsaicin (%):

The capsaicin content in the sample was estimated as per the method given by Palacio (1977). 0.5 g of fruit ground powder was placed in 25 ml volumetric flask, made up the volume with ethyl acetate and kept for 24 hours incubation. 5 ml of the above solution was taken in 25 ml volumetric flask, diluted with 4 ml of ethyl acetate. To this 0.5 ml of 0.1% Vanadium oxy trichloride ($VoCl_3$) was added and final volume made to 25 ml with ethylacetate. Absorbance was recorded in spectrophotometer at 720 nm. The reading of 0.5 ml of 0.1% Vanadium oxytrichloride ($VoCl_3$) in ethyl acetate was noted as blank and subtracted from the above reading. A standard curve was prepared by using 10, 20, 30, 40, 50, 60 and 80 mg of standard capsaicin L^{-1}. The optical density (OD) reading of the sample was matched with the standard curve to obtain the capsaicin content in mg L^{-1} and it was expressed in percentage.

3.10 WATER MEASUREMENTS:

3.10.1 Irrigation water applied (mm)

Irrigation water was applied separately for each treatment based on Epan for capsicum and was measured by a water meter attached to the irrigation system. The time of irrigation for different pan evaporation levels were calculated as per the formula given under 3.5.5 for drip irrigation scheduling (Appendix-C).

3.10.2 Effective rainfall (mm)

Daily evaporation (mm) for the growing season was recorded from the USWB Class A pan evaporimeter situated at the Agricultural Research Institute, Agromet centre, Rajendranagar (Appendix B). The cumulative daily evaporation during crop growth period was 737.5 mm. Effective rainfall during the crop growth period estimated was 58.6, 64.2, 74.62, 82.6 mm for 100, 80, 60 and 40 per cent irrigation treatments respectively out of 127.4 mm of rainfall as per water balance method. (Appendix-C)

3.10.3 Total water used (mm)

Total water used in each irrigation treatment was calculated as detailed below.

Total water used (mm) = water applied at all irrigations (mm) + effective rainfall (mm) + special operations (mm).

3.10.4 Water use efficiency (%)

It is the ratio of crop yield (kg ha^{-1}) to the amount of water used in evapotranspiration. It can be calculated by the following equation.

$$\text{Water use efficiency (kg m}^{3}\text{)} = \frac{\text{Total yield (kg ha}^{-1}\text{)}}{\text{Water applied (m}^{3}\text{)}}$$

3.11 NUTRIENT UPTAKE STUDIES

Plant samples and fruit samples were first dried under shade and then in hot air oven at 60^{0}C. The dried samples were ground in grinder and stored in butter paper covers. Powdered plant samples of 30, 60, 90,120 DAT and at final harvest with fruit samples at first, third and at fifth harvest were analyzed for total N, P and K contents separately by adopting the standard procedures and the contents were expressed as percentage.

3.11.1 Nitrogen content (%)

The plant sample powders of 0.1 g were digested in Kelplus digestion block using concentrated sulphuric acid and catalytic mixture of copper sulphate and potassium sulphate. Micro kjeldhal distillation method was used to determine nitrogen content in plant sample using Kelplus instrument (AOAC 1960).

3.11.2. Phosphorus content (%)

Phosphorus content of the triacid extract was determined by vanado-molybdo phosphoric acid yellow colour method on spectrophotometer at 420 nm (Jackson, 1973).

3.11.3 Potassium content (%)

Potassium content of the triacid extract was determined by flame photometer (Muhr *et al.,* 1965).

3.11.4 Nutrient uptake (kg ha^{-1})

Uptake of N, P and K was calculated using nutrient concentrations and dry matter yield or fruit yield as follows.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (\%) X Dry matter (kg ha}^{-1}\text{)}}{100}$$

3.12. ECONOMIC ANALYSIS

3.12.1 Cost of cultivation (₹ ha^{-1})

The expenditure incurred from field preparation to harvest of capsicum was worked out and expressed as ₹ ha^{-1} (Appendix E).

3.12.2 Gross returns (₹ ha^{-1})

The prevailing market price of green capsicum fruits (₹ 20.0 kg^{-1}), yellow and red fruits (₹ 30.0 kg^{-1}) was multiplied with fruit yield to work out gross returns in all treatments.

3.12.3 Net returns (₹ ha^{-1})

The net returns were worked out after deducting the cost of cultivation including operational costs, input expenditure and other items from gross retrurs ha^{-1}.

Net returns (₹ ha^{-1}) = Gross returns (₹ ha^{-1}) - Cost of cultivation (₹ ha^{-1})

3.12.4 Benefit: cost ratio (B: C Ratio)

The benefit cost ratio (BCR) was worked out by using the formula

$$\text{Benefit: Cost ratio} = \frac{\text{Gross returns (₹ ha}^{-1}\text{)}}{\text{Cost of cultivation (₹ ha}^{-1}\text{)}}$$

3.13 EVAPORATION (mm) OUTSIDE AND INSIDE THE SHADE NET

A measuring beaker was maintained outside and inside the shade net to observe evaporation losses. Beaker specification was 7.4 cm height, 15 cm diameter and 1000 ml was maintained.

3.14 STATISTICAL ANALYSIS

The data collected on various parameters from the experiment were statistically analyzed by applying the technique of analysis of variance contained in the procedures suggested by Gomez and Gomez (1984).Whenever the treatment differences were found significant (F test), critical difference was worked out at five per cent probability level and the values were furnished. The treatment differences that were not significant were expressed as non-significant and denoted by “NS”.

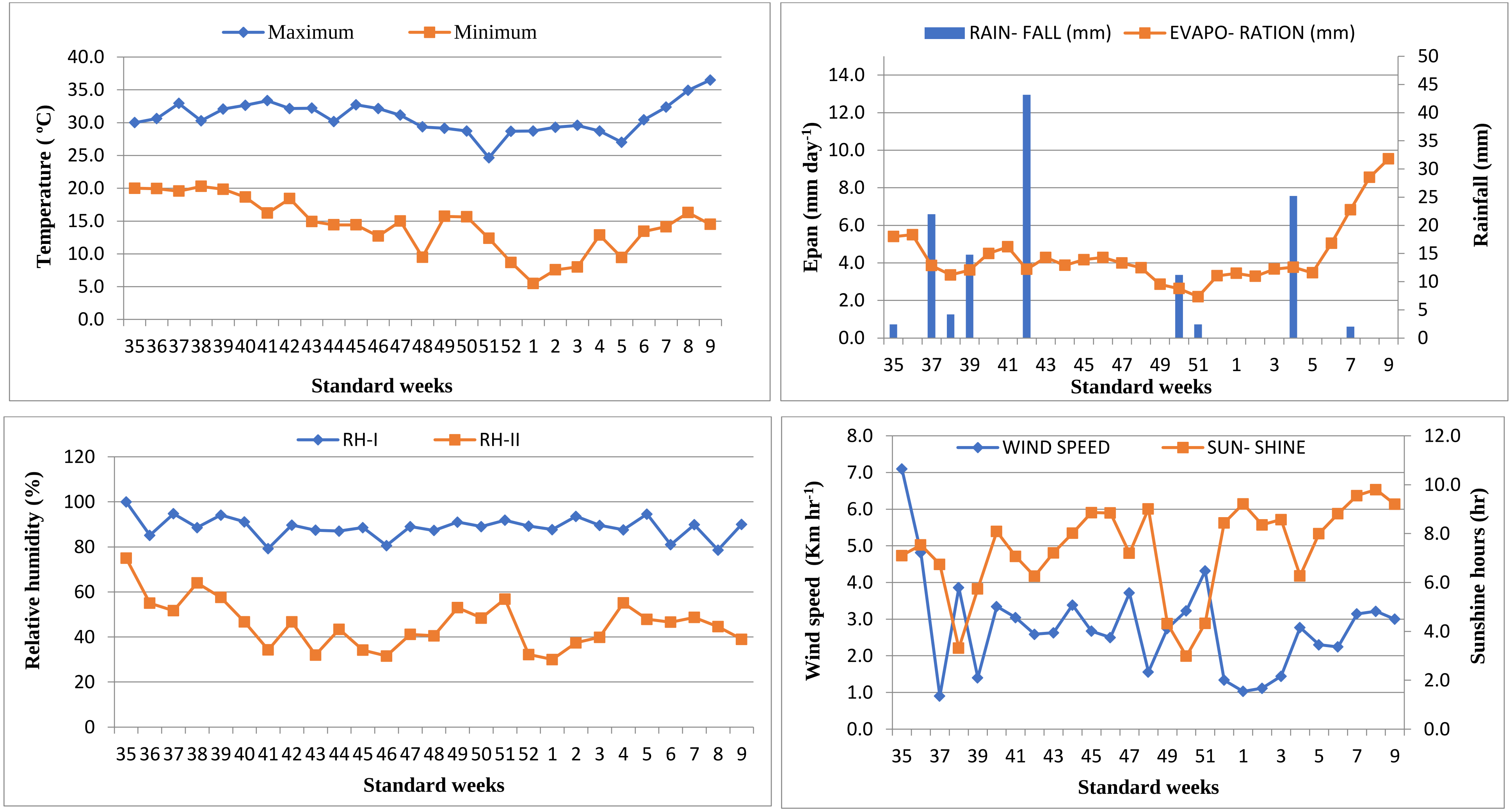

Figure 3.2 Weekly mean meteorological data during crop growth period *rabi* 2018-19.

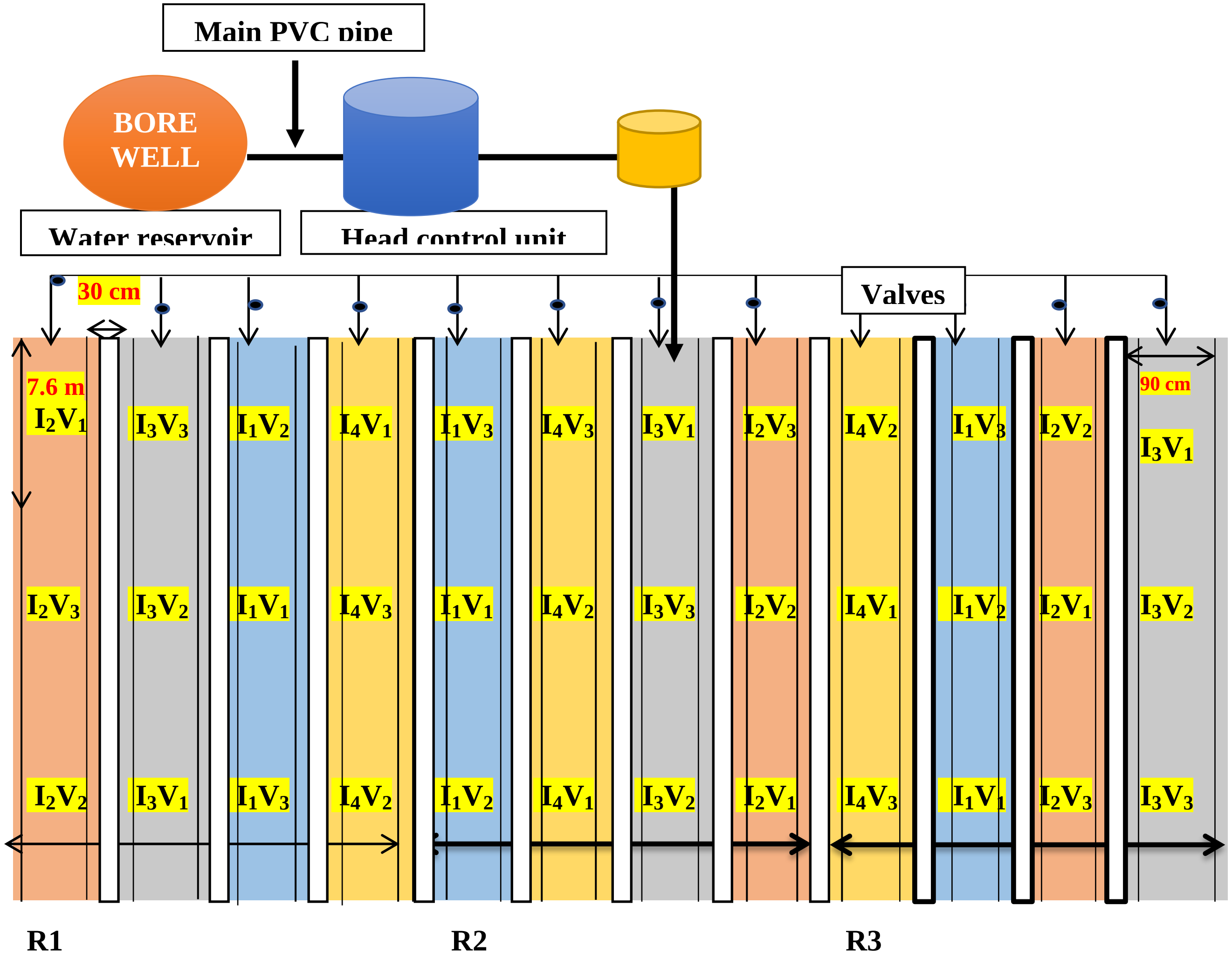

Fig. 3.3. Experimental site layout of *rabi* capsicum through drip irrigation system.

Design : Split plot design

Replications : Three

Row spacing : 0.45 m

Plant spacing : 0.40 m

Plot size : 7.6 m x 0.9 m

Method of irrigation : Surface drip

Type of emitter : Integral dripperline

Lateral spacing : 0.6 m

Lateral size : 16 mm

Emitter spacing : 0.4 m

Emitter discharge : 4 L h^{-1}

Application rate : 16.666

Main plot (Irrigation level)

I_1 : 0.4 Epan

I_2 : 0.6 Epan

I_3 : 0.8 Epan

I_4 : 1.0 Epan

Sub plot (Varieties)

V_1 : Indra (Green)

V_2 : Orobelle (Yellow)

V_3 : Bomby (Red)

Chapter IV

RESULTS AND DISCUSSION

The results of the field experiment entitled **"Response of coloured capsicum (*Capsicum annuum var. grossum*) varieties for different irrigation levels under shade net"** was carried out at Horticultural farm, College of Agriculture, Rajendranagar, Hyderabad in a shade net during *rabi* season, 2018-2019. The experimental results pertaining to the effect of various levels of drip irrigation and different capsicum hybrids on plant growth parameters, yield parameters, qualitative characters, yield, water use efficiency and economics of capsicum under shade net were presented with the help of tables and figures. Further, the results in respect to present study are discussed and justified with possible scientific reasons available in literature.

WEATHER CONDITIONS DURING CROP GROWTH SEASON

Weather plays a major role in successful growth of any crop for realizing the potentials. Rainfall of 127.4 mm was received during the entire crop growth period. The mean weekly maximum and minimum temperature ranged from 34.9 ºC to 24.6 ºC and 20.3 ºC to 5.5 ºC respectively. The other weather parameters viz., relative humidity, bright sunshine hours and wind speed were normal and relatively dry weather prevailed during the crop growth period (Appendix-A). In general, the weather was favourable for crop growth and no incidence of major disease and pests were observed during the crop growth period.

4.1 PLANT GROWTH PARAMETERS

Significant variation in plant height (cm), number of branches plant^{-1}, number of leaves plant^{-1}, SPAD Chlorophyll Meter readings (SCMR), Leaf area index (LAI), Days to 50% flowering was observed due to different drip irrigation levels and varieties. However, there was no interaction effect between drip irrigation levels and varieties on these parameters.

4.1.1 Plant height (cm)

Perusal of data represented in Table 4.1 indicated that there was no significant difference between different drip irrigation levels on plant height at 30, 150 and 178 days after transplanting (DAT).

At 60 DAT, drip irrigation scheduled at 1.0 Epan recorded significantly higher plant height (38.7 cm) than rest of the treatments except that it was on par with drip irrigation at 0.8 Epan (37.2 cm). Drip irrigation at 0.6 Epan (33.6 cm) was significantly higher than drip irrigation at 0.4 Epan (33.4 cm). Significantly higher plant height at 90

Table 4.1 Plant height (cm) of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

Treatments	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	178 DAT
Main (Irrigation levels) :						
I_1: Drip irrigation at 0.4 Epan	15.4	33.4	43.6	52.7	54.0	50.0
I_2: Drip irrigation at 0.6 Epan	15.5	33.6	43.8	53.2	54.0	53.1
I_3: Drip irrigation at 0.8 Epan	16.1	37.2	44.4	56.1	57.6	54.1
I_4: Drip irrigation at 1.0 Epan	17.2	38.2	48.5	58.6	59.6	53.3
SEm ±	0.6	0.5	1.0	0.4	1.3	1.4
C.D (P=0.05)	NS	1.7	3.5	1.6	NS	NS
Sub (Varieties) :						
V_1 : Indra	17.8	37.5	47.8	57.4	58.5	54.8
V_2 : Orobelle	16.5	36.5	44.8	54.7	56.9	53.3
V_3 : Bomby	13.9	33.6	42.7	53.3	53.5	49.8
SEm ±	0.4	0.5	0.7	0.6	0.6	1.0
C.D (P=0.05)	1.4	1.5	2.2	1.8	1.7	2.9
Interaction : **Varieties at same level of irrigation levels :**						
SEm ±	1.0	0.9	1.4	1.2	1.1	1.9
C.D (P=0.05)	NS	NS	NS	NS	NS	NS
Irrigation levels at same or different varieties :						
SEm ±	1.0	0.9	1.6	1.1	1.6	2.1
C.D (P=0.05)	NS	NS	NS	NS	NS	NS

DAT was recorded with drip irrigation at 1.0 Epan (48.5 cm) than rest of the treatments. Drip irrigation at 0.8 Epan (44.4 cm) was significantly higher than drip irrigation at 0.4 Epan (43.6 cm) and was at par with 0.6 Epan (43.6 cm).

Significantly higher plant height at 120 DAT was observed with drip irrigation at 1.0 Epan (58.6 cm) than drip irrigation at 0.8 Epan (56.1 cm). Drip irrigation at 0.6 Epan (53.2 cm) was significantly lower than 0.8 Epan and was at par with drip irrigation at 0.4 Epan (52.7 cm). Reason was due to availability of adequate soil moisture positively influenced the microbial activity thereby facilitated increased uptake of nutrients (Tables 4.13, 4.14 and 4.15) which might have improved cellular growth and development of the better canopy coverage with available of solar radiation and responsible to produce higher photosynthates. These results are in similarity with those of Pattanaik *et al.* (2003), Paul *et al.* (2013) in capsicum.

Among the hybrids at 30, 60, 150 and 178 DAT, plant height was significantly higher with Indra (17.8, 37.5, 58.5 and 54.8 cm, respectively) than Bomby and was at par with Orobelle (16.5, 36.5, 56.9, 53.3 respectively). Significantly lower plant height was recorded with Bomby (13.9, 33.6, 53.5 and 49.8 respectively) than rest of the hybrids. This may be attributed to the enhanced plant metabolic activities, formation of optimum photosynthetic area and respiration due to favourable moisture, nutrient uptake (Tables 4.13, 4.14 and 4.15) at early stage and micro-climatic conditions might have resulted in higher plant height. (Pattnaik *et al.* (2003), Antony and Singandhupe (2004) for sweet pepper and Kattimani (2004), Alliyu (2002) and Ramakrishna and Palled (2004) in chilli.

4.1.2 Number of branches plant^{-1}

Number of branches plant^{-1} were not significantly influenced by drip irrigation treatments at 30, 60 and 178 DAT (Table 4.2).

At 90, 120 and 150 DAT, drip irrigation at 1.0 Epan recorded significantly higher number of branches (4.64, 6.53 and 6.66 respectively) than 0.6 and 0.4 Epan and was on par with drip irrigation at 0.8 Epan (4.58, 6.31 and 6.40 respectively). However, significantly lower number of branches were observed with drip irrigation at 0.4 Epan (4.18, 5.02, 5.27 respectively) than 1.0 and 0.8 Epan and was on par with 0.6 Epan (4.20, 5.33, 5.49 respectively). This might be due to the availability of soil moisture at desirable level which enhances the early vegetative growth as indicated by higher plant height (Table 4.1) with availability and uptake of nutrient (Tables 4.13, 4.14 and 4.15) and vigorous growth character facilitates more number of branches plant^{-1} (Table 4.2). These results are in close agreement with the findings of Ali and Kelly (1993), Polowick and Sawlancy (1985) and Beese *et al.* (1982) in capsicum.

Among the hybrids, significantly higher number of branches at 30 DAT was recorded with Indra (1.3) than Bomby and was at par with Orobelle (1.2). Significantly lower number of branches were observed with Bomby (0.8) than other two hybrids. At 90 DAT, Indra (4.72) was found significantly higher than Orobelle (4.32) and Bomby (4.17) and Orobelle was found on par with Bomby. This might be due to better development of photosynthetic area at early stages, vigorous plant growth, higher plant height (Table 4.1) facilitates more number of branches (Table 4.2) in that hybrid due to its genetic makeup.

Table 4.2 Number of branches plant^{-1} of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

Treatments	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	178 DAT
Main – (Irrigation levels) :						
I_1: Drip irrigation at 0.4 Epan	1.02	3.67	4.18	5.02	5.27	4.73
I_2: Drip irrigation at 0.6 Epan	0.91	3.76	4.20	5.33	5.49	5.02
I_3: Drip irrigation at 0.8 Epan	1.16	3.78	4.58	6.31	6.40	5.11
I_4: Drip irrigation at 1.0 Epan	1.24	3.84	4.64	6.53	6.66	5.44
SEm ±	0.13	0.08	0.07	0.13	0.16	0.17
C.D (P=0.05)	NS	NS	0.24	0.45	0.54	NS
Sub – (Varieties) :						
V_1 : Indra	1.29	3.83	4.72	6.18	6.37	5.43
V_2 : Orobelle	1.15	3.77	4.32	5.88	5.99	5.12
V_3 : Bomby	0.82	3.68	4.17	5.33	5.50	4.68
SEm ±	0.09	0.09	0.08	0.07	0.09	0.11
C.D (P=0.05)	0.27	NS	0.24	0.20	0.27	0.32
Interaction : **Varieties at same level of irrigation levels :**						
SEm ±	0.18	0.18	0.16	0.13	0.18	0.21
C.D (P=0.05)	NS	NS	NS	NS	NS	NS
Irrigation levels at same or different varieties :						
SEm ±	0.20	0.17	0.15	0.17	0.21	0.25
C.D (P=0.05)	NS	NS	NS	NS	NS	NS

4.1.2 Number of leaves plant^{-1}

Number of leaves were not significantly influenced by drip irrigation levels at 30, 60 and 178 DAT as indicated by data presented in (Table 4.3).

At 90, 120 and 150 DAT, significantly higher number of leaves was observed with drip irrigation at 1.0 Epan (42.9, 52.6 and 53.4 respectively) than 0.6 and 0.4 Epan and was on par with drip irrigation at 0.8 Epan (41.8, 52.1 and 52.3 respectively). Drip irrigation at 0.6 Epan (40.7, 51.7 and 52.2 respectively) recorded on par with drip irrigation at 0.8 Epan and 0.4 Epan (38.2 and 50.2 respectvely). At 150 DAT, drip irrigation at 0.4 Epan was significantly lower than 0.6 Epan and rest of the treatments. The increased number of branches plant^{-1} might be due to availability of water and nutrients in adequate proportion, thereby uptake of nutrients (Table 4.13, 4.14 and 4.15) thereby more plant height (Table 4.1) and higher branches (Table 4.2) which resulted in triggering the production of plant growth hormone, *viz.* indole acetic acid (IAA) and higher number of leaves throughout the cropping period as reported by Sanker *et al.* 2008.

At 30 DAT, Indra was recorded significantly higher number of leaves (11.3) than Orobelle (10.4) and Bomby (9.9) and was on par with each other. At 60 DAT, number of leaves were not significantly influenced by hybrids. At 90 DAT, significantly higher number of leaves were observed with Indra than Bomby (41.8) which was on par with Orobelle (41.5). Significantly lower number of leaves were recorded with Bomby. This might be due to inherence character with dense vegetative growth resulted in higher plant height (Table 4.1), higher number of branches (Table 4.2) and hence facilitated higher number of leaves. These results are in agreement with Paul *et al.* (2013).

Table 4.3 Number of leaves plant^{-1} of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

Treatments	**30 DAT**	**60 DAT**	**90 DAT**	**120 DAT**	**150 DAT**	**178 DAT**
Main – (Irrigation levels) :						
I_1: Drip irrigation at 0.4 Epan	10.2	33.7	38.2	50.2	50.6	46.3
I_2: Drip irrigation at 0.6 Epan	10.2	36.0	40.7	52.1	52.2	47.5
I_3: Drip irrigation at 0.8 Epan	10.5	36.4	41.8	52.2	52.3	47.9
I_4: Drip irrigation at 1.0 Epan	11.2	38.0	42.9	52.6	53.4	48.2
SEm ±	0.3	1.0	0.9	0.4	0.4	0.7
C.D (P=0.05)	NS	NS	3.0	1.3	1.5	NS
Sub – (Varieties) :						
V_1 : Indra	11.3	36.7	41.5	55.1	53.9	48.7
V_2 : Orobelle	10.4	36.1	41.8	51.0	52.2	47.6
V_3 : Bomby	9.9	35.2	39.4	48.9	50.3	46.0
SEm ±	0.2	0.6	0.6	0.5	0.6	0.7
C.D (P=0.05)	0.7	NS	1.7	1.5	1.9	2.1
Interaction : **Varieties at same level of irrigation levels :**						
SEm ±	0.5	1.2	1.1	1.2	1.3	1.4
C.D (P=0.05)	NS	NS	NS	NS	NS	NS
Irrigation levels at same or different varieties :						
SEm ±	0.5	1.4	1.2	1.1	1.1	1.3
C.D (P=0.05)	NS	NS	NS	NS	NS	NS

4.1.4 SPAD Chlorophyll Meter readings (SCMR)

The leaf chlorophyll content, a key factor in determining the rate of photosynthesis, is also considered as an index of the metabolic efficiency of plants.

At 30, 90, 150 and 178 DAT, there was significantly higher SCMR were observed with drip irrigation at 1.0 Epan (50.2, 58.4, 62.4 and 60.4 respectively) than rest of the treatments except with drip irrigation at 0.8 Epan (49.4, 57.1, 61.9 and 56.2 respectively) which was on par with each other (Table 4.4). Drip irrigation at 0.8 Epan which was on par with 0.6 Epan (46.2, 61.1 and 56.2 respectively) and also drip irrigation at 0.6 Epan was on par with 0.4 Epan (41.2, 52.7 and 54.9 respectively). At 60 and 120 DAT, significantly higher SCMR was observed with drip irrigation at 1.0 Epan (52.4 and 62.1 respectively) than 0.6 and 0.4 Epan and was on par with 0.8 Epan (50.8 and 61.0 respectively).

At 60 DAT, drip irrigation at 0.6 Epan (47.0) was observed significantly lower SCMR than 0.8 and 1.0 Epan and was on par with drip irrigation at 0.4 Epan (46.6) and significantly lower than 1.0 and 0.8 Epan. At 120 DAT, drip irrigation at 0.8 Epan was significantly higher than 0.4 Epan and was on par with drip irrigation at 0.6 Epan (60.6). This could be due to the fact that plants receiving optimum moisture condition which facilitated favourable environment and the plant was accelerated by their increased chlorophyll content due to higher uptake of nutrients particularly nitrogen (Table 4.13). These results are in conformity with the results obtained by Naik (2005) and Ngouajio *et al.* (2008) in capsicum and Hartz (1993) in tomato.

Among the hybrids, at 30 and 90 DAT, significantly higher SCMR were observed with Indra (48.3 and 59.0 respectively) than Orobelle (45.8 and 54.0 respectively) and Bomby (46.2 and 53.1 respectively). However, SCMR of Bomby was lower which was on par with Orobelle. This could be due to enhanced vegetative growth, higher photosynthetic area and vigorous plant growth leads better development of chlorophyll content as reported by Salunkhe (2017).

Table 4.4 SPAD Chlorophyll Meter readings (SCMR) of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

Treatments	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	178 DAT
Main – (Irrigation levels) :						
I_1: Drip irrigation at 0.4 Epan	41.2	46.6	52.7	54.5	54.9	53.2
I_2: Drip irrigation at 0.6 Epan	46.2	47.0	53.2	60.6	61.1	56.2
I_3: Drip irrigation at 0.8 Epan	49.4	50.8	57.1	61.0	61.9	59.8
I_4: Drip irrigation at 1.0 Epan	50.2	52.4	58.4	62.1	62.4	60.4
SEm ±	1.7	1.0	1.2	1.5	1.1	1.3
C.D (P=0.05)	6.0	3.6	4.1	5.1	4.0	4.7
Sub – (Varieties) :						
V_1 : Indra	48.3	50.7	59.0	60.9	61.7	60.5
V_2 : Orobelle	45.8	49.1	54.0	59.9	61.1	60.2
V_3 : Bomby	46.2	47.7	53.1	57.8	57.5	52.4
SEm ±	0.4	0.8	0.9	0.6	0.9	1.1
C.D (P=0.05)	1.4	2.3	2.7	2.0	2.8	3.2
Interaction : **Varieties at same level of irrigation levels :**						
SEm ±	0.9	1.5	1.8	1.3	1.8	2.0
C.D (P=0.05)	NS	NS	NS	NS	NS	NS
Irrigation levels at same or different varieties :						
SEm ±	1.9	1.6	1.9	1.9	1.9	2.1
C.D (P=0.05)	NS	NS	NS	NS	NS	NS

4.1.5 Leaf area index (LAI)

Leaf area index, defined as the ratio of green leaf area to a unit ground area, is one of the important indicators of growth and productivity of the crops (Table 4.5).

Leaf area index was not significantly influenced by different drip irrigation levels at 30, 60, 150 and 178 DAT.

At 90 DAT, significantly higher LAI was observed with drip irrigation at 1.0 Epan (0.98) than 0.4 Epan and was at par with drip irrigation at 0.8 Epan (0.95). Drip irrigation at 0.6 Epan was significantly lower than 1.0 Epan and was on par with drip irrigation at 0.8 Epan. Drip irrigation at 0.6 Epan which was on par with 0.4 Epan (0.82).

Significantly higher LAI was recorded at 120 DAT with drip irrigation at 1.0 Epan (1.82) than 0.4 Epan and 0.6 Epan and was on par with drip irrigation at 0.8 Epan

Table 4.5 Leaf area index of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

Treatments	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	178 DAT
Main – (Irrigation levels) :						
I_1: Drip irrigation at 0.4 Epan	0.028	0.39	0.82	1.50	1.37	0.95
I_2: Drip irrigation at 0.6 Epan	0.028	0.41	0.84	1.49	1.41	0.96
I_3: Drip irrigation at 0.8 Epan	0.031	0.43	0.95	1.72	1.47	0.96
I_4: Drip irrigation at 1.0 Epan	0.035	0.47	0.98	1.82	1.56	1.00
SEm ±	0.003	0.02	0.04	0.05	0.06	0.03
C.D (P=0.05)	NS	NS	0.12	0.16	NS	NS
Sub – (Varieties) :						
V_1 : Indra	0.031	0.44	0.95	1.72	1.54	1.06
V_2 : Orobelle	0.031	0.43	0.90	1.62	1.50	0.98
V_3 : Bomby	0.029	0.40	0.85	1.57	1.32	0.86
SEm ±	0.002	0.01	0.02	0.04	0.04	0.03
C.D (P=0.05)	NS	0.03	0.07	0.12	0.11	0.08
Interaction : **Varieties at same level of irrigation levels :**						
SEm ±	0.003	0.02	0.05	0.08	0.07	0.05
C.D (P=0.05)	NS	NS	NS	NS	NS	NS
Irrigation levels at same or different varieties :						
SEm ±	0.004	0.02	0.05	0.08	0.09	0.05
C.D (P=0.05)	NS	NS	NS	NS	NS	NS

(1.72). However lower LAI was noticed with drip irrigation at 0.4 Epan and was at par with drip irrigation at 0.6 Epan. This might be due to higher metabolism of cells, better canopy coverage, better availability of solar radiation and high chlorophyll content for photosynthesis resulted in higher LAI.

Among the hybrids, LAI was not significantly influenced by different hybrids at 30 DAT. Significantly higher LAI was recorded with Indra (0.44) than Orobelle (0.43) and Bomby (0.40). Significantly lower LAI was recorded with Bomby than rest of the hybrids. At 90, 120, 150 and 178 DAT, significantly higher LAI was observed with Indra (0.95, 1.72, 1.54 and 1.06 respectively) than and was on par with Orobelle (0.9, 1.62, 1.5 and 0.98 respectively). Bomby (0.85 and 1.57 respectively) recorded lower LAI which was on par with orobelle. At 150 and 178 DAT, significantly lower LAI was observed with Bomby (1.32 and 0.86 respectively) than other two hybrids. This could be due to inherence character of Indra variety which have vigorous growth character with higher SCMR, higher plant height, higher number of leaves and branches (Table 4.4, 4.1, 4.3 and 4.2, respectively) and hence more photosynthetic activity is performed.

4.1.6 Days to 50% flowering

Drip irrigation at 1.0 Epan (60.3 days) observed significantly lesser number of days to 50 per cent flowering than drip irrigation at 0.4 and 0.6 Epan and was on par with 0.8 Epan (59.9 days). Drip irrigation at 0.8 Epan was significantly higher than drip irrigation at 0.4 Epan (59.3) and was on par with 0.6 Epan (59.4). This attributed to the earliness in flowering was due to moisture stress prevailing in growth period. Plants under any kind of stress conditions tends to shortened their life span and try to complete their life cycle quickly which causes early flowering. These results observed in the present study are in agreement with the findings of Antony and Singandhupe (2004) in capsicum (Table 4.6).

Table 4.6 Days to 50% flowering of capsicum as influenced by different drip irrigation levels and varieties under shade net.

Treatments	Days to 50% flowering
Main – (Irrigation levels) :	
I_1: Drip irrigation at 0.4 Epan	60.3
I_2: Drip irrigation at 0.6 Epan	59.9
I_3: Drip irrigation at 0.8 Epan	59.4
I_4: Drip irrigation at 1.0 Epan	59.3
SEm ±	0.1
C.D (P=0.05)	0.5
Sub – (Varieties) :	
V_1 : Indra	58.9
V_2 : Orobelle	59.6
V_3 : Bomby	60.8
SEm ±	0.3
C.D (P=0.05)	0.8
Interaction : **Varieties at same level of irrigation levels :**	
SEm ±	0.5
C.D (P=0.05)	NS
Irrigation levels at same or different varieties :	
SEm ±	0.5
C.D (P=0.05)	NS

Among the hybrids, significantly lesser days to 50 per cent flowering was recorded with Indra (50.8 days) than Orobelle (59.6 days) and Bomby (58.9 days). However significantly higher days taken for flowering by Bomby than Indra and was on par with Orobelle. This might be due to good vegetative growth besides effective pollination and fertilization and lower abscission rate of flowers. Similar results were recorded by Backer (1989) in sweet pepper.

4.1.7 Total dry matter production (kg ha^{-1})

Total DMP at various crop growth DAT was significantly influenced by different drip irrigation levels and varieties (Table 4.7 and Fig 4.1) and among the different irrigation levels, drip irrigation at 1.0 Epan was significantly higher than 0.6 and 0.4 Epan and was on par with 0.8 Epan (22.8 kg ha^{-1}) and 0.6 Epan (22.6 kg ha^{-1}). Significantly lower DMP was observed with 0.4 Epan than 1.0 Epan and was on par with drip irrigation at 0.6 and 0.8 Epan at 30 DAT.

Table 4.7 a. Total dry matter (kg ha^{-1}) of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

Treatments	30 DAT	60 DAT	90 DAT		
	Shoot	Shoot	Shoot	Fruit	Total
Main – (Irrigation levels) :					
I_1: Drip irrigation at 0.4 Epan	22.4	173.8	469.3	145.6	614.9
I_2: Drip irrigation at 0.6 Epan	22.6	179.4	484.4	146.7	631.1
I_3: Drip irrigation at 0.8 Epan	22.8	187.4	505.9	148.1	654.0
I_4: Drip irrigation at 1.0 Epan	24.7	195.1	526.7	160.9	687.6
SEm ±	0.4	3.0	8.2	2.9	9.6
C.D (P=0.05)	1.5	10.5	28.3	10.0	33.3
Sub – (Varieties) :					
V_1 : Indra	25.1	181.7	490.6	163.2	653.8
V_2 : Orobelle	22.8	189.8	512.4	148.3	660.7
V_3 : Bomby	21.5	180.3	486.7	139.5	626.2
SEm ±	0.4	2.6	7.0	2.9	6.93
C.D (P=0.05)	1.3	7.8	21.0	8.6	20.7
Interaction : **Varieties at same level of irrigation levels :**					
SEm ±	0.9	5.2	14.0	5.5	13.85
C.D (P=0.05)	NS	NS	NS	NS	41.53
SEm ±	0.8	5.2	14.0	5.5	14.85
C.D (P=0.05)	NS	NS	NS	NS	47.42

At 60 DAT, drip irrigation scheduled at 1.0 Epan (195.1 kg ha^{-1}) recorded significantly higher DMP than 0.6 and 0.4 Epan and was on par with drip irrigation at 0.8 Epan (187.4 kg ha^{-1}). Drip irrigation at 0.4 Epan (173.8 kg ha^{-1}) was significantly lower than 0.8 and 1.0 Epan and was on par with drip irrigation at 0.6 Epan. At 90 DAT, 1.0 Epan (687.6 kg ha^{-1}) recorded significantly higher DMP than 0.6 and

Table 4.7 b. Total dry matter (kg ha^{-1}) of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

Treatments	120 DAT			150 DAT			178 DAT		
	Shoot	Fruit	Total	Shoot	Fruit	Total	Shoot	Fruit	Total
Main – (Irrigation levels) :									
I_1: Drip irrigation at 0.4 Epan	629.9	424.0	1053.9	702.7	807.3	1510.1	859.8	1034.2	1894.0
I_2: Drip irrigation at 0.6 Epan	648.2	426.8	1075.0	718.5	808.7	1527.2	896.4	1079.4	1975.8
I_3: Drip irrigation at 0.8 Epan	674.3	430.2	1104.6	742.5	815.5	1558.0	948.6	1187.7	2136.3
I_4: Drip irrigation at 1.0 Epan	699.6	462.1	1161.7	761.7	879.2	1640.9	999.2	1159.5	2158.7
SEm ±	9.9	7.2	14.3	8.5	15.7	18.8	19.9	16.6	30.7
C.D (P=0.05)	34.4	24.9	49.4	29.3	54.3	64.9	68.7	57.4	106.4
Sub – (Varieties) :									
V_1 : Indra	655.8	468.0	1123.8	724.6	894.3	1618.9	911.5	1189.8	2101.3
V_2 : Orobelle	682.2	430.6	1112.9	743.5	816.3	1559.8	964.5	1111.9	2076.4
V_3 : Bomby	651.0	408.7	1059.7	726.0	772.4	1498.5	902.0	1043.9	1945.9
SEm ±	8.5	7.2	9.8	5.4	14.5	13.6	17.0	22.2	28.4
C.D (P=0.05)	25.4	21.5	29.4	16.2	43.4	40.6	50.9	66.7	85.1
Interaction : **Varieties at same level of irrigation levels :**									
SEm ±	17.0	14.4	19.6	10.8	28.9	27.1	33.9	44.5	56.8
C.D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Irrigation levels at same or different varieties :									
SEm ±	17.0	13.8	21.4	12.2	28.4	29.0	34.1	39.9	55.6
C.D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

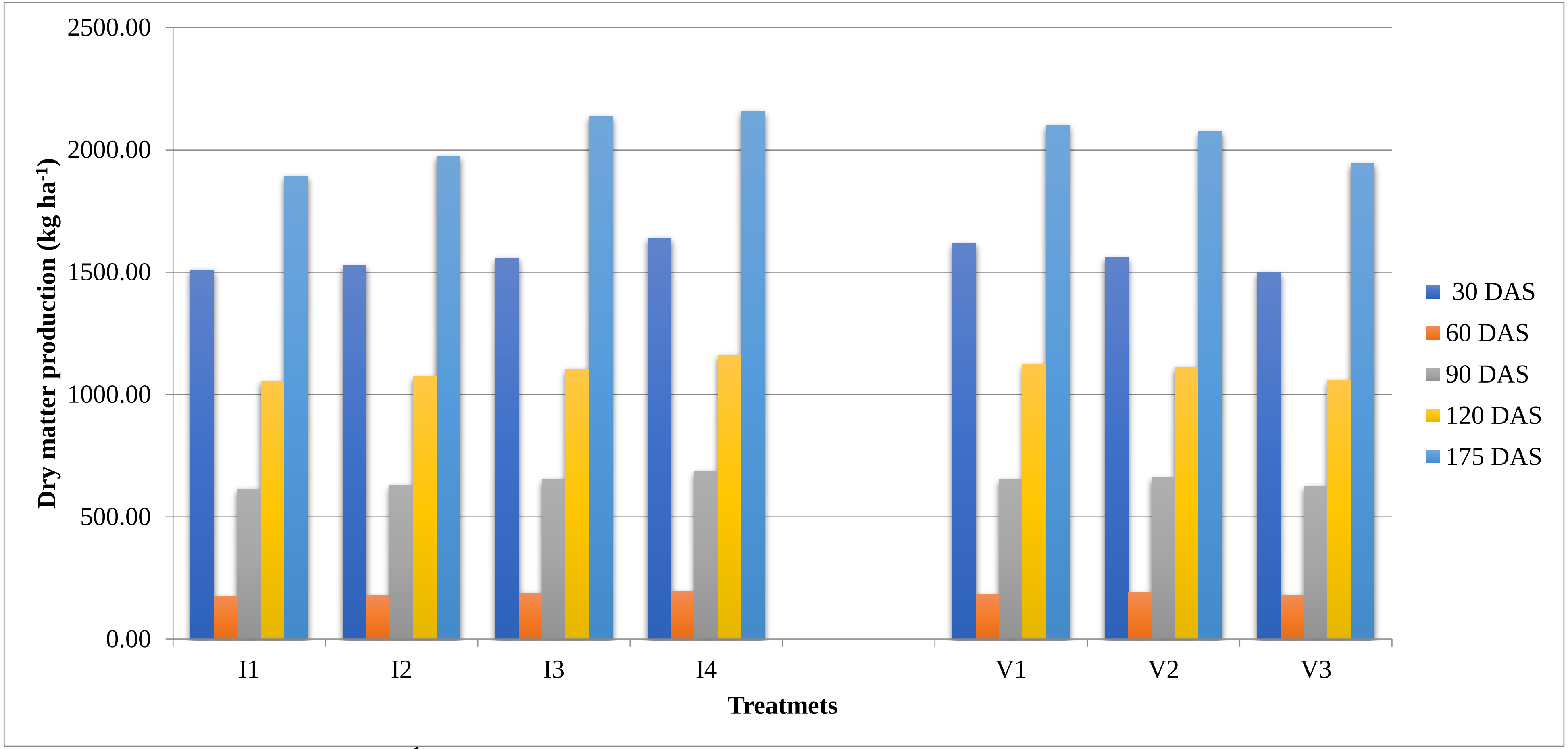

Figure 4.1 Total dry matter (kg ha^{-1}) of capsicum at different days after transplanting as influenced by different drip irrigation levels and variables under shade net

0.4 Epan and was on par with drip irrigation at 0.8 Epan (654.0 kg ha^{-1}) and drip irrigation at 0.4 Epan (614.92 kg ha^{-1}) was significantly lower than 0.8 Epan and was on par with drip irrigation at 0.6 Epan in DMP.

At 120 DAT, DMP was realized significantly higher with drip irrigation at 1.0 Epan (1161.6 kg ha^{-1}) than 0.6 and 0.4 Epan and was at par with drip irrigation at 0.8 Epan (1104.5 kg ha^{-1}). Drip irrigation at 0.4 Epan (1053.8 kg ha^{-1}) recorded significantly lower DMP than 0.8 and 1.0 Epan and was on par with drip irrigation at 0.6 Epan (1075.0 kg ha^{-1}). Significantly higher DMP at 150 DAT was observed with drip irrigation at 1.0 Epan (1640.9 kg ha^{-1}) than 0.8 Epan (1527.1 kg ha^{-1}). However, significantly lower DMP recorded with drip irrigation at 0.4 Epan (1510.0 kg ha^{-1}) than 0.8 and 1.0 Epan and was on par with drip irrigation at 0.6 Epan (1377.2 kg ha^{-1}).

Significantly higher DMP was observed at 178 DAT with drip irrigation at 1.0 Epan (2158.7 kg ha^{-1}) than 0.6 and 0.4 Epan and was at par with drip irrigation at 0.8 Epan (2136.3 kg ha^{-1}). Drip irrigation at 0.6 Epan (1975.8 kg ha^{-1}) was significantly lower than drip irrigation with 0.8 Epan and was on par with 0.4 Epan (1894.0 kg ha^{-1}). Increased in DMP was observed due to higher uptake of nutrients (Tables 4.13, 4.14 and 4.15) and moisture from early stage of the crop resulted in better utilization of nitrogen led to higher plant height (Table 4.1), higher leaf area and leaf area index (Table 4.5) with higher photosynthetic rate for building of organic substances in the plant and these increase in DMP results are in accordance with those of Antony and Singandhupe (2004) and Choudhary and Bhambri (2012) in capsicum and Veeranna *et al*. (2000), Ramakrishna and Palled (2004) and Katttimani (2004) in chilli.

Among different hybrids, significantly higher DMP was observed at 30 DAT and 60 DAT with Indra (25.1 and 189.8 kg ha^{-1}) than Orobelle (22.8 and 181.7 kg ha^{-1}) and Bomby (21.5 and 180.3 kg ha^{-1}). Significantly lower DMP was recorded in Bomby than Indra and was on par with Orobelle. At 90, 120 and 178 DAT, there was significantly higher DMP was observed with Indra (660.68, 1123.7 and 2101.3 kg ha^{-1}) than Bomby and was on par with Orobelle (660.7, 1112.8 and 2076.4 kg ha^{-1}). Significantly lower DMP was observed with Bomby (626.2, 1059.7 and 1945.9 kg ha^{-1}) than rest of the treatments.

At 150 DAT, Indra was observed significantly higher (1618.89 kg ha^{-1}) than Orobelle (1559.7 kg ha^{-1}). Orobelle was observed significantly higher than Bomby (1498.4 kg ha^{-1}). This might be attributed to higher vegetative growth contributing to more number of flowers, more number of fruits, higher per cent of fruit set and hence higher shoot and fruit DMP. Similar results are coincides with the results of Nagendra Prasad (2001) and Biwalkar (2015).

4.2 YIELD AND YIELD ATTRIBUTES

Significant variation in fruit length (cm), fruit diameter (cm), pericarp thickness (mm), fruits plant^{-1} (number), average fruit weight (g fruit^{-1}), yield plant^{-1} (g plant^{-1}), fruit yield (t ha^{-1}) was observed due to different drip irrigation levels and varieties. However, there was no interaction effect between drip irrigation levels and varieties on these parameters (Table 4.9).

4.2.1 Fruit length (cm)

Among drip irrigation levels, average fruit length of capsicum was significantly higher (9.8 cm) with drip irrigation at 1.0 Epan (I_4) than 0.8 Epan (I_3), 0.6 Epan (I_2) and 0.4 Epan (I_1). This could be attributed to availability of soil moisture in sufficient range with higher uptake of nutrients which possibly led to enhanced photosynthetic area, cell metabolism and cell enlargement resulting in better partitioning of dry matter produced and finally induced the fruit length. Drip irrigation scheduled at 0.4 Epan (I_1) recorded significantly lower average fruit length (8.4 cm). Similar findings were also reported by Khalkho (2013), Choudhary and Bhambri (2012) and Ertek (2007) in bell pepper.

Fruit length differed significantly among the hybrids and significantly higher fruit length (9.4 cm) was noticed with Bomby (V_3) than Orobelle (9.1 cm) and Indra (8.9 cm) (Table 4.10). This could be due to higher uptake of nutrients and higher leaf area which enables higher build up of sufficient photosynthates enabling the increase in length of fruit in that hybrid. Significantly lower fruit length was recorded in hybrid Indra (V_1) than Orobelle and Bomby. This is in concordance to the results of Biwalker *et al.* (2015), Yellava and Patil (2009) in capsicum and Mohomedien (1991) in cucumber.

4.2.2 Fruit diameter (cm)

Significantly higher average fruit diameter (7.5 cm) was observed with drip irrigation at 1.0 Epan than 0.8 Epan and 0.6 Epan. Reason was due to optimum level of moisture which enhances the cell metabolism resulting in an increase of released energy which ultimately induces growth of fruits. Significantly lower average fruit diameter (6.0 cm) was noticed in drip irrigation at 0.4 Epan (I_1). This is in close conformity to the findings of Pandey *et al.* (2005), Sezen *et al.* (2011), Khalkho (2013) and Verma (2014) in bell pepper, Hedge and Srinivas (1989) in tomato and Bandi (1994) in green chilli.

Table 4.9 Yield attributes of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

Treatments	Fruit Length (cm)	Fruit diameter (cm)	Pericarp thickness (mm)	Fruits plant^{-1} (number)	Average fruit weight (g fruit^{-1})	Fruit yield (kg plant^{-1})
Main – (Irrigation levels) :						
I_1: Drip irrigation at 0.4 Epan	8.4	6.0	4.7	9.3	71.1	0.73
I_2: Drip irrigation at 0.6 Epan	8.9	6.3	4.9	10.7	75.3	0.92
I_3: Drip irrigation at 0.8 Epan	9.3	6.9	5.0	12.5	83.2	1.08
I_4: Drip irrigation at 1.0 Epan	9.8	7.5	5.1	13.6	91.7	1.27
SEm ±	0.0	0.1	0.1	0.2	2.6	0.02
C.D (P=0.05)	0.1	0.2	0.3	0.8	9.0	0.08
Sub – (Varieties) :						
V_1 : Indra	8.9	6.4	4.6	14.5	70.9	1.07
V_2 : Orobelle	9.1	6.6	4.9	10.8	79.6	1.00
V_3 : Bomby	9.4	6.9	5.1	9.2	90.4	0.92
SEm ±	0.0	0.0	0.1	0.1	1.8	0.02
C.D (P=0.05)	0.1	0.1	0.2	0.4	5.4	0.05
Interaction : **Varieties at same level of irrigation levels :**						
SEm ±	0.1	0.1	0.1	0.3	3.6	0.04
C.D (P=0.05)	NS	NS	NS	NS	NS	NS
Irrigation levels at same or different varieties :						
SEm ±	0.1	0.1	0.1	0.3	3.9	0.04
C.D (P=0.05)	NS	NS	NS	NS	NS	NS

Note : Fruit length, diameter, pericarp thickness, fruit weight of capsicum were recorded at 1st, 3rd and 5th pickings and average value as picking wise data as Appendix-

Fruits plant^{-1} and fruit yield plant^{-1} were recorded at 1st to 5th pickings and totally presented (picking wise data-Appendix)

Average fruit diameter was in the range of 6.4 to 6.9 and significantly higher fruit diameter (6.9 cm) was recorded with Bomby (V_3) than Orobelle (6.6 cm) and Indra hybrids (6.4 cm). This might have resulted due to varietal inherited characteristics and proper uptake of nutrients by the plant system at active reproductive stage. Significantly lower fruit diameter was recorded with Indra (V_1). Similar findings were also reported by Biwalkar (2015) in bell pepper.

4.2.3 Pericarp thickness (mm)

Influence of different levels of drip irrigation levels was found to be significant with respect to pericarp thickness of capsicum fruit. However, higher average pericarp thickness (5.1 mm) was obtained with drip irrigation at 1.0 Epan and found significantly higher over the treatment 0.4 Epan and was on par with 0.8 Epan (5 mm) and 0.6 Epan (4.9 mm). The fruit assimilate partitioning capacity at favourable moisture conditions might have resulted in thickest fruit pericarp. Similar results were also reported by Choudhary and Bhambri, (2012) and Biwalker (2015) in capsicum.

Drip irrigation at 0.8 Epan was significantly higher than 0.4 Epan and was on par with 0.6 Epan (4.9 mm). However, lower pericarp thickness was observed with 0.4 Epan and was on par with drip irrigation at 0.6 Epan. This might be due to water deficit was more pronounced water deficit in the reproductive phase leading to unfavourable plant water relation and fruit development. Similar findings were also reported by Dagdelon (2004) in bell pepper.

Among different hybrids, significantly higher pericarp thickness (5.1 mm) was recorded with Bomby than Indra and was on par with Orobelle (4.9 mm). Significantly lower pericarp thickness (4.6 mm) was observed with Indra variety than other two hybrids. Pericarp thickness (4.94 mm) of Orobelle (V_2) was next to Bomby (V_3), also on par with it and significantly superior over Indra (V_1). Similar findings were also reported by Biwalkar (2015) in bell pepper.

4.2.4 Fruits plant^{-1} (number)

Significantly higher number of fruits plant^{-1} (13.6) of capsicum was obtained with drip irrigation at 1.0 Epan (I_4) due to better microclimate responsible for efficient water utilization at vegetative growth stages which led to higher dry matter accumulation and proper translocation of food materials to the fruits resulted in increased physiological activities and fruit bearing nodes, less flower and fruit dropping as well as better uptake of nutrients. The results were in accordance with Salunkhe (2017), Kumar and Kumar (2016), Choudhary and Bhambri (2012) in capsicum.

Drip irrigation at 0.4 Epan recorded significantly lower number of fruits plant^{-1} (9.3) than 0.6 Epan (I_2), 0.8 Epan (I_3) and 1.0 Epan (I_4). Reason as reported by Gowda (1998) was moisture stress accumulation of ABA and increase in ethylene resulted in abscission of flowers thus resulting in less number of fruits per plant. Similar observation was reported by Chartzoulakis *et al.* (1997).

Among the performance of hybrids, Indra (14.5) recorded significantly higher number of fruits plant^{-1} than Orobelle variety (V_2) and Bomby (V_3). Significantly lower number of fruits was observed with Bomby (9.2) than other two hybrids. This might be due to varietal differences, more uptake of nutrients by plant at active reproduction stage and high fruit set percentage because of healthy and vigorous growth characters occurred in Indra. Similar observations were reported by Backer (1989) in sweet pepper.

4.2.5 Average fruit weight (g fruit^{-1})

Among drip irrigation levels, average fruit weight of capsicum was significantly higher (91.7 g fruit^{-1}) with drip irrigation at 1.0 Epan (I_4) over rest of the treatments and was on par with drip irrigation at 0.8 Epan (83.2 g fruit^{-1}). Drip irrigation at 0.8 Epan (I_3) was significantly higher than 0.4 Epan (I_1) and was at on par with drip irrigation at 0.6 Epan. Drip irrigation at 0.4 Epan (71.1 g fruit^{-1}) was significantly lower than 0.8 Epan and was on par with 0.6 Epan. Sankar *et al.* (2008) stated that more nutrient availability, especially near the root zone might have increased the translocation of photosynthates to storage organ resulting in an increased fruit weight of capsicum under drip irrigation. The increased biochemical activities in the soil, high uptake of nutrients, reduction of evaporation led to higher soil moisture content, build up of sufficient photosynthates and better nutrient availability to the plants. The results were in consonance with Sharma *et al.* (2015) in tomato.

Significantly lower fruit weight was recorded with drip irrigation at 0.4 Epan (I_1) than 0.6 Epan (I_2), 0.8 Epan (I_3) and 1.0 Epan (I_4). This could be due to the fact that fruit weight is closely associated with a lack of optimum soil moisture in the root zone; when soil water deficit in root zone increases, there is loss of turgidity leading to reduction in average fruit weight as reported by Sezen *et al.* (2011) and Smittle *et al.* (1994).

Average fruit weight ranged from 70.9 to 90.4 g and Bomby, among the hybrids, recorded significantly higher fruit weight (90.4 g) than Orobelle (79.6 g) and Indra (70.9 g). Significantly lower fruit weight was recorded with Indra over rest of the hybrids. This could be due to a high uptake of nutrients and build up of sufficient photosynthates enabling the increase in size of fruits (length and breadth), resulting in the increased fruit weight and volume in that hybrid. The results are in similarity to the observations of Roy *et al.* (2011).

4.2.6 Fruit yield plant^{-1} (kg)

Among the different irrigation levels, 1.0 Epan (I_4) recorded significantly higher yield plant^{-1} (1.27 kg) than 0.8 Epan (I_3) and 0.6 Epan (I_2). Significantly lower fruit yield plant^{-1} (0.73 kg) was recorded with drip irrigation at 0.4 Epan (I_1) over rest of the treatments. In drip irrigation system, water is applied at a low rate for a longer period at frequent intervals near the plant root zone through lower pressure delivery system, which increases the availability of nutrients near the root zone with a reduction in leaching loss. More nutrient availability, especially near the root zone might have increased the translocation of photosynthates to storage organ of capsicum resulting in increased fruit number and fruit weight (Table 4.9) which ultimately increased yield of the plant (Sankar *et al.* 2008).

Fruit yield plant^{-1} differed significantly from each other among different varieties and was significantly higher (1.07 kg) with Indra (V_1) than Orobelle (1.00 kg) and Bomby (0.92 kg). This might be due to vigorous plant growth which led to more fruit bearing nodes and resulted in higher fruit set percentage per plant in Indra among the three varieties. Similar results were obtained by Grangs and Leger (1989) in capsicum.

4.2.7 Fruit yield (t ha^{-1})

Fruit yield of capsicum was significantly influenced between different drip irrigation levels (Table 4.8 and Fig. 4.2). Significantly higher fruit yield was recorded in drip irrigation at 1.0 Epan (47.50 t ha^{-1}) than rest of the treatments. Drip irrigation at 0.8 Epan (40.52 t ha^{-1}) was significantly higher than drip irrigation at 0.6 Epan (34.54 t ha^{-1}). Significantly lower fruit yield was observed with drip irrigation at 0.4 Epan (27.50 t ha^{-1}). This might be due to higher total matter accumulation and proper translocation of food materials to the fruits, helped in more number of shoots per plant, higher number of flowers, fruits and maximum extent of fruit set as well as better uptake of nutrient (Tables 4.13, 4.14 and 4.15) and moisture due to favourable conditions created by micro climate. Similar observations were reported by Salunkhe *et al.* (2017), Choudhary and Bhambri (2012), Kumar *et al.* (2016), Padron *et al.* (2015) and Rao *et al.* (2013) in bell pepper.

Among hybrids, significantly higher fruit yield was recorded with Indra (40.27 t ha^{-1}) than Orobelle (37.65 t ha^{-1}) and Bomby (34.64 t ha^{-1}). Bomby recorded significantly lower fruit yield than Orobelle. This was due to inherent character of that variety to produce vigorous growth, more internodes and higher number branches

(Table 4.2) bearing more fruits leading to maximum fruit yield. Similar observations were reported by Grangs and Leger (1989) in capsicum.

Table 4.8 Yield (t ha^{-1}) of capsicum as influenced by different drip irrigation levels and varieties under shade net.

Treatments	Yield (t ha^{-1})*
Main – (Irrigation levels) :	
I_1: Drip irrigation at 0.4 Epan	27.50
I_2: Drip irrigation at 0.6 Epan	34.54
I_3: Drip irrigation at 0.8 Epan	40.52
I_4: Drip irrigation at 1.0 Epan	47.50
SEm ±	0.82
C.D (P=0.05)	2.84
Sub – (Varieties) :	
V_1 : Indra	40.27
V_2 : Orobelle	37.65
V_3 : Bomby	34.64
SEm ±	0.67
C.D (P=0.05)	2.02
Interaction : **Varieties at same level of irrigation levels :**	
SEm ±	1.34
C.D (P=0.05)	NS
Irrigation levels at same or different varieties :	
SEm ±	1.37
C.D (P=0.05)	NS

*Fresh weight

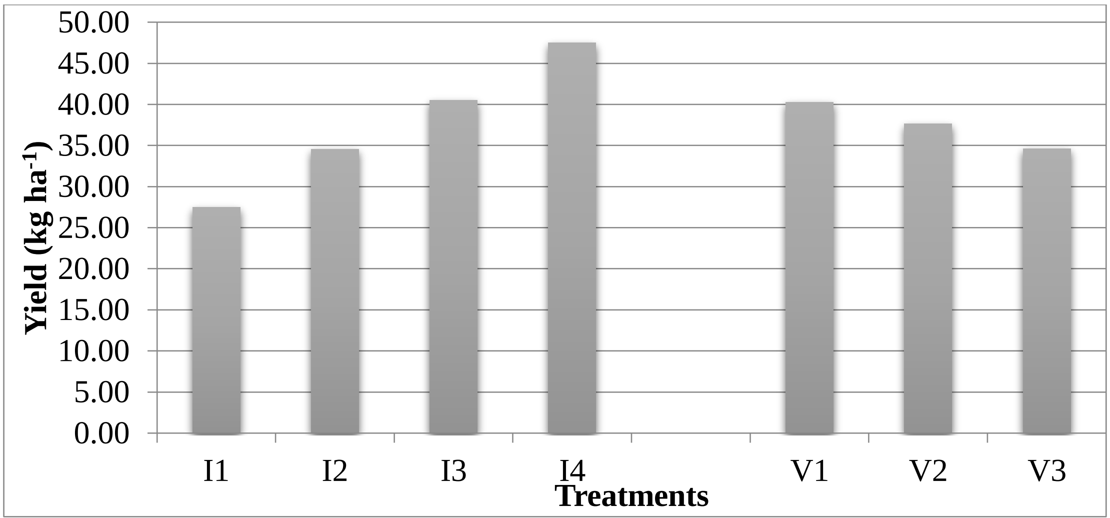

Figure 4.2 Yield (t ha^{-1}) of capsicum as influenced by different drip irrigation levels and varieties under shade net.

4.3 QUALITY CHARACTERS

Significant variation in TSS (ºBrix), ascorbic acid (mg 100 g^{-1}), Oleoresin (%), Capsanthin (EOA values) and Capsaicin (%) was observed due to different drip irrigation levels and varieties. However, there was no interaction effect between drip irrigation levels and varieties on these parameters (Table 4.10).

4.3.1 TSS (ºBrix)

TSS of capsicum was not significantly effected by different drip irrigation levels. Significantly higher TSS was recorded with Bomby (6.15) than Orobelle (5.24). Significantly lower TSS was observed with Indra (4.48) than rest of the treatments. This might be due to total soluble solid content of bell peppers is found to increase as the ripening of the fruit increases. This results in the greater degradation or biosynthesis of polysaccharides and the accumulation of sugars. The increase in the total soluble content may be due to the hydrolysis of polysaccharides like starch, cellulose and pectin sub-stances into simpler substances (Rathod and Chidanand, 2011).

4.3.2 Ascorbic acid (mg 100 g^{-1})

Ascorbic acid was not significantly influenced due to different irrigation levels. Among hybrids, Significantly higher ascorbic acid was found with Orobelle (124.7 mg 100 g^{-1}) than Bomby (119.5 mg 100 g^{-1}). Significantly lower ascorbic acid was recorded with Indra (87.6) than rest of the treatments. This huge difference in different coloured bell peppers is attributed to the cultivars and the growing conditions. The reduction in ascorbic acid content might be due to the activity of oxidative enzymes (Myrene, 2013).

Table 4.10 Quality parameters of capsicum as influenced by different drip irrigation levels and varieties under shade net.

Treatments	TSS (^{0}Brix)	Ascorbic acid (mg 100g^{-1})	Oleoresin (%)	Capsanthin (EOA value)	Capsaisin(%)
Main – (Irrigation levels) :					

I_1: Drip irrigation at 0.4 Epan	5.35	108	7.06	16783	0.097
I_2: Drip irrigation at 0.6 Epan	5.17	104	6.97	15736	0.091
I_3: Drip irrigation at 0.8 Epan	5.33	114	7.22	19335	0.103
I_4: Drip irrigation at 1.0 Epan	5.31	115	7.11	18860	0.108
SEm ±	0.10	3.0	0.12	462	0.003
C.D (P=0.05)	NS	NS	NS	1599	0.009
Sub – (Varieties) :					
V_1 : Indra	4.48	87.6	6.14	6900	0.081
V_2 : Orobelle	5.24	124.7	7.23	8510	0.076
V_3 : Bomby	6.15	119.5	7.90	37627	0.143
SEm ±	0.08	1.5	0.11	515	0.003
C.D (P=0.05)	0.24	4.4	0.34	1544	0.008
Interaction : **Varieties at same level of irrigation levels :**					
SEm ±	0.16	2.9	0.23	1030	0.005
C.D (P=0.05)	NS	NS	NS	NS	NS
Irrigation levels at same or different varieties :					
SEm ±	0.16	3.9	0.22	959	0.005
C.D (P=0.05)	NS	NS	NS	NS	NS

Note : Mean values of quality parameters recorded at 1st, 3rd and 5th pickings.

4.3.3 Oleoresin (%)

Oleoresin of capsicum was not significantly differed by different drip irrigation levels. Significantly higher oleoresin was found in Bomby (7.9 %) than Orobelle (7.23 %). Significantly lower oleoresin was observed with Indra (6.14 %). This might be due to bomby having various carotenoids with pungent properties and colorants superior to other hybrids.

4.3.4 Capsanthin (EOA values)

Capsanthin content was significantly influenced due irrigation levels. Among the irrigation levels, significantly higher capsanthin content was observed with drip irrigation at 0.8 Epan (19335) than drip irrigation with 0.6 and 0.4 Epan and in turn was at par with drip irrigation at 1.0 Epan (18860). Drip irrigation at 0.4 Epan was significantly lower than rest of the treatments and was at par with drip irrigation at 0.6 Epan. Among the hybrids, significantly higher capsanthin content was found in Bomby (37627) than Orobelle (8510) and Indra (6900). Significantly lower capsanthin content was observed with Indra. The amount and intensity of surface colours of the Bell pepper depends on the type of the cultivar used and is of prime importance to its appeal (Sokona *et al.* 2013).

4.3.5 Capsaicin (%)

Capsaicin content among irrigation levels differed and drip irrigation with 1.0 Epan (0.108) was recorded significantly higher than drip irrigation at 0.6 and 0.4 Epan and was on par with drip irrigation at 0.8 Epan (0.097). Drip irrigation at 0.6 Epan (0.103) which was on par with 0.4 Epan (0.091).

Among hybrids, significantly higher capsaicin content was observed with Bomby (0.143 %) than Indra (0.081) and Orobelle (0.076). However, lower capsanthin content was observed with Orobelle, which was on par with Indra. Pungency in pepper is due to the amount of capsaicinoids, including capsaicin and four other structurally related compounds, namely nordihydrocapsaicin, dihydrocapsaicin, homocapsaicin, and homodihydrocapsaicin (Hoffman *et al*., 1983). The increase or decrease in n capsaicin content with maturity observed in different genotypes may be attributed to the inherent variation in the levels of peroxidase enzymes in different Bell pepper cultivars (Estrada *et al.* 2000).

4.4 MICROCLIMATE DATA OBSERVATIONS

The variation of the climatic parameters inside and outside shade net were observed such temperature, relative humidity and light intensity with the help of thermo hygrometer and lux meter (Table 4.17, 4.18 and 4.19).

Table.17 Inside and outside temperature (°C) variation of the shade net recorded throughout the crop growth period at different times in a day.

Standard weeks	Dates	8:30 AM		12:00 AM		2:00 PM		4:00 PM	
		Open field	Shade net	Open field	Shade net	Open field	Shade net	Open field	Shade net
36	03-09 Sep	25.1	24.0	29.6	28.4	30.7	29.4	27.3	26.5
37	10-16 Sep	27.2	25.8	31.7	30.7	32.7	32.0	29.5	28.3
38	17-23 Sep	24.7	23.8	29.3	28.4	30.3	29.3	26.9	25.8
39	24-30 Sep	26.2	25.2	30.9	29.9	32.2	31.0	28.5	27.5
40	01-07 Oct	27.0	25.8	31.6	30.5	32.6	32.0	29.5	28.3
41	08-14 Oct	27.7	26.5	32.2	31.1	33.4	32.3	29.9	28.9
42	15-21 Oct	26.4	25.2	31.0	29.9	32.1	32.0	28.6	27.7
43	22-28 Oct	26.4	25.4	31.1	29.8	32.2	31.1	28.5	27.5
44	29-04 Nov	24.6	23.6	28.9	27.8	30.1	29.0	27.1	26.0
45	05-11 Nov	27.1	25.9	31.7	30.6	32.6	31.6	29.5	28.2
46	12-18 Nov	26.5	25.4	31.0	29.9	32.2	30.0	28.7	27.5
47	19-25 Nov	25.3	24.1	30.0	28.9	31.1	30.0	27.7	26.5
48	26-02 Dec	23.9	22.7	28.3	27.3	29.4	28.3	26.1	25.2
49	03-09 Dec	23.5	22.4	28.0	26.9	29.1	29.0	25.8	24.7
50	10-16 Dec	23.1	22.3	27.5	26.4	28.5	27.5	25.4	24.2
51	17-23 Dec	21.0	20.1	25.2	24.5	26.3	26.3	23.3	22.4
52	24-31 Dec	23.0	21.9	27.6	26.5	28.7	27.7	25.4	24.2
1	01-07 Jan	23.0	21.9	27.6	26.6	28.6	28.6	25.4	24.3
2	08-14 Jan	23.4	22.3	28.2	27.1	29.3	28.1	25.8	24.7
3	15-21 Jan	24.1	23.0	28.4	27.4	29.6	28.5	26.5	25.4
4	22-28 Jan	23.9	22.9	28.2	27.1	30.0	28.9	26.2	25.0
5	29-04 Feb	22.7	21.7	26.8	25.7	27.8	25.9	25.1	24.0
6	05-11 Feb	24.5	23.4	29.3	28.1	30.5	29.3	26.8	25.7
7	12-18 Feb	26.9	25.8	31.4	30.2	32.4	30.9	29.1	28.2
8	19-25 Feb	29.2	27.7	33.7	32.1	34.9	33.3	31.7	30.1
Mean		**25.1**	**24.0**	**29.6**	**28.5**	**30.7**	**29.7**	**27.4**	**26.3**
Max.		**29.2**	**27.7**	**33.7**	**32.1**	**34.9**	**33.3**	**31.7**	**30.1**
Min.		**21.0**	**20.1**	**25.2**	**24.5**	**26.3**	**25.9**	**23.3**	**22.4**

Table.18 Inside and outside relative humidity (%) variation of the shade net recorded throughout the crop growth period at different times in a day.

Standard weeks	Dates	8:30 AM		12:00 AM		2:00 PM		4:00 PM	
		Open field	Shade net	Open field	Shade net	Open field	Shade net	Open field	Shade net
36	03-09 Sep	57.6	60.5	42.9	46.1	33.9	36.9	53.3	56.6
37	10-16 Sep	53.3	56.6	36.6	39.5	26.9	29.7	48.6	51.3
38	17-23 Sep	48.9	51.8	33.7	37.0	25.9	28.9	44.4	47.6
39	24-30 Sep	54.4	57.4	39.9	42.6	30.6	33.6	49.0	51.9
40	01-07 Oct	48.7	51.7	34.7	38.0	25.3	28.6	44.0	47.5
41	08-14 Oct	50.0	53.2	35.0	38.0	26.9	29.9	44.7	47.9
42	15-21 Oct	46.6	49.6	33.0	36.1	24.7	27.7	42.3	45.4
43	22-28 Oct	53.1	56.1	34.9	38.0	26.4	29.1	45.4	48.5
44	29-04 Nov	55.4	58.6	39.9	42.7	30.9	34.0	50.4	53.4
45	05-11 Nov	57.7	60.7	43.0	46.0	33.9	36.6	53.1	56.2
46	12-18 Nov	61.0	64.0	46.4	49.4	38.0	41.1	56.6	59.6
47	19-25 Nov	54.6	57.4	39.7	42.7	30.6	33.7	50.0	53.2
48	26-02 Dec	52.3	55.6	36.3	39.4	26.7	29.7	47.7	50.9
49	03-09 Dec	63.0	66.0	47.9	50.5	40.0	43.4	58.4	61.7
50	10-16 Dec	72.9	75.9	56.9	60.0	47.9	51.1	68.1	71.1
51	17-23 Dec	68.0	71.0	52.4	55.4	43.7	47.0	63.4	66.6
52	24-31 Dec	58.4	61.3	43.3	46.1	33.7	36.9	54.1	57.6
1	01-07 Jan	71.3	74.4	55.9	59.3	47.9	51.1	66.6	69.4
2	08-14 Jan	68.0	71.0	53.3	56.1	45.7	48.4	63.4	66.6
3	15-21 Jan	67.6	70.5	50.0	52.7	41.0	44.1	63.0	66.3
4	22-28 Jan	75.3	78.3	58.7	61.9	50.1	53.5	70.1	73.4
5	29-04 Feb	57.9	60.7	43.4	46.6	34.1	37.1	53.3	56.6
6	05-11 Feb	59.7	62.7	45.1	48.1	35.7	39.0	55.3	58.5
7	12-18 Feb	58.3	61.5	44.4	47.3	34.7	37.8	53.7	56.7
8	19-25 Feb	63.8	65.7	47.7	50.1	39.0	41.6	59.0	61.0
Mean		**59.1**	**62.1**	**43.8**	**46.8**	**35.0**	**38.0**	**54.3**	**57.4**
Max.		**75.3**	**78.3**	**58.7**	**61.9**	**50.1**	**53.5**	**70.1**	**73.4**
Min.		**46.6**	**49.6**	**33.0**	**36.1**	**24.7**	**27.7**	**42.3**	**45.4**

Table. 19 Inside and outside light intensity (lux) variation of the shade net recorded throughout the crop growth period at different times in a day.

Standard weeks	Dates	8:30 AM		12:00 AM		2:00 PM		4:00 PM	
		Open field	Shade net	Open field	Shade net	Open field	Shade net	Open field	Shade net
36	03-09 Sep	23906.1	17442.9	37401.3	23714.3	55867.1	28115.7	28675.1	22142.9
37	10-16 Sep	26859.3	20666.1	35368.1	22657.1	54510.4	26980.0	28019.1	21514.3
38	17-23 Sep	25205.4	19357.1	36872.7	22614.3	63201.4	27585.7	30221.9	22014.3
39	24-30 Sep	25506.0	18635.7	36979.2	22228.6	61845.0	24585.7	30791.4	22371.4
40	01-07 Oct	24694.3	18100.0	35968.1	22391.4	60845.3	25928.6	30172.0	22400.0
41	08-14 Oct	22917.3	18414.3	32626.8	21800.0	48779.6	25857.1	28110.3	22657.1
42	15-21 Oct	24470.0	18328.6	35974.6	22414.3	59730.3	25300.0	29394.3	21900.0
43	22-28 Oct	24675.4	18585.7	33742.3	21371.4	56640.1	26585.7	29636.0	22371.4
44	29-04 Nov	25616.3	18700.0	36598.1	22242.9	62955.4	27371.4	30542.9	22328.6
45	05-11 Nov	26244.6	19028.6	37088.2	22677.1	64943.4	28314.3	30464.4	22342.9
46	12-18 Nov	24907.3	18028.6	39331.9	23657.1	64833.4	27857.1	28811.4	20671.4
47	19-25 Nov	24696.0	18500.0	34644.7	21885.7	59918.0	27871.4	29380.9	22228.6
48	26-02 Dec	24625.1	18228.6	37496.2	23257.1	64662.9	29014.3	30091.4	22528.6
49	03-09 Dec	15620.4	11842.9	24444.5	15714.3	37041.7	17912.9	18835.3	14528.6
50	10-16 Dec	9148.1	6428.6	15389.8	9457.1	22273.4	9342.9	9302.7	6542.9
51	17-23 Dec	10330.7	7650.0	16536.2	10057.1	29589.4	12814.3	12996.3	9485.7
52	24-31 Dec	15403.0	11242.9	19642.5	11971.4	40519.0	17891.4	15289.4	11171.4
1	01-07 Jan	13947.4	11471.4	18677.8	12557.1	34000.3	18328.6	14807.3	11862.9
2	08-14 Jan	14513.4	10842.9	24798.9	15505.7	39931.9	18100.0	19566.9	14614.3
3	15-21 Jan	14467.0	11071.4	22807.9	14542.9	34740.6	16857.1	16077.7	12542.9
4	22-28 Jan	7839.4	5628.6	11775.1	7085.7	21593.9	9329.3	8695.1	6214.3
5	29-04 Feb	11602.1	8391.4	20101.7	12342.9	32129.7	14300.0	14352.4	10600.0
6	05-11 Feb	14553.6	9890.0	26033.7	14551.4	48367.0	17955.1	18147.6	12300.0
7	12-18 Feb	16766.4	13014.3	32167.5	20642.9	53940.6	26542.9	22486.7	17400.0
8	19-25 Feb	18419.3	13757.1	34417.4	22285.7	57862.0	27771.4	26646.9	20457.1
Mean		**19477.4**	**14529.9**	**29475.4**	**18385.0**	**49228.9**	**22340.5**	**23260.6**	**17407.7**
Max.		**26859.3**	**20666.1**	**39331.9**	**23714.3**	**64943.4**	**29014.3**	**30791.4**	**22657.1**
Min.		**7839.4**	**5628.6**	**11775.1**	**7085.7**	**21593.9**	**9329.3**	**8695.1**	**6214.3**

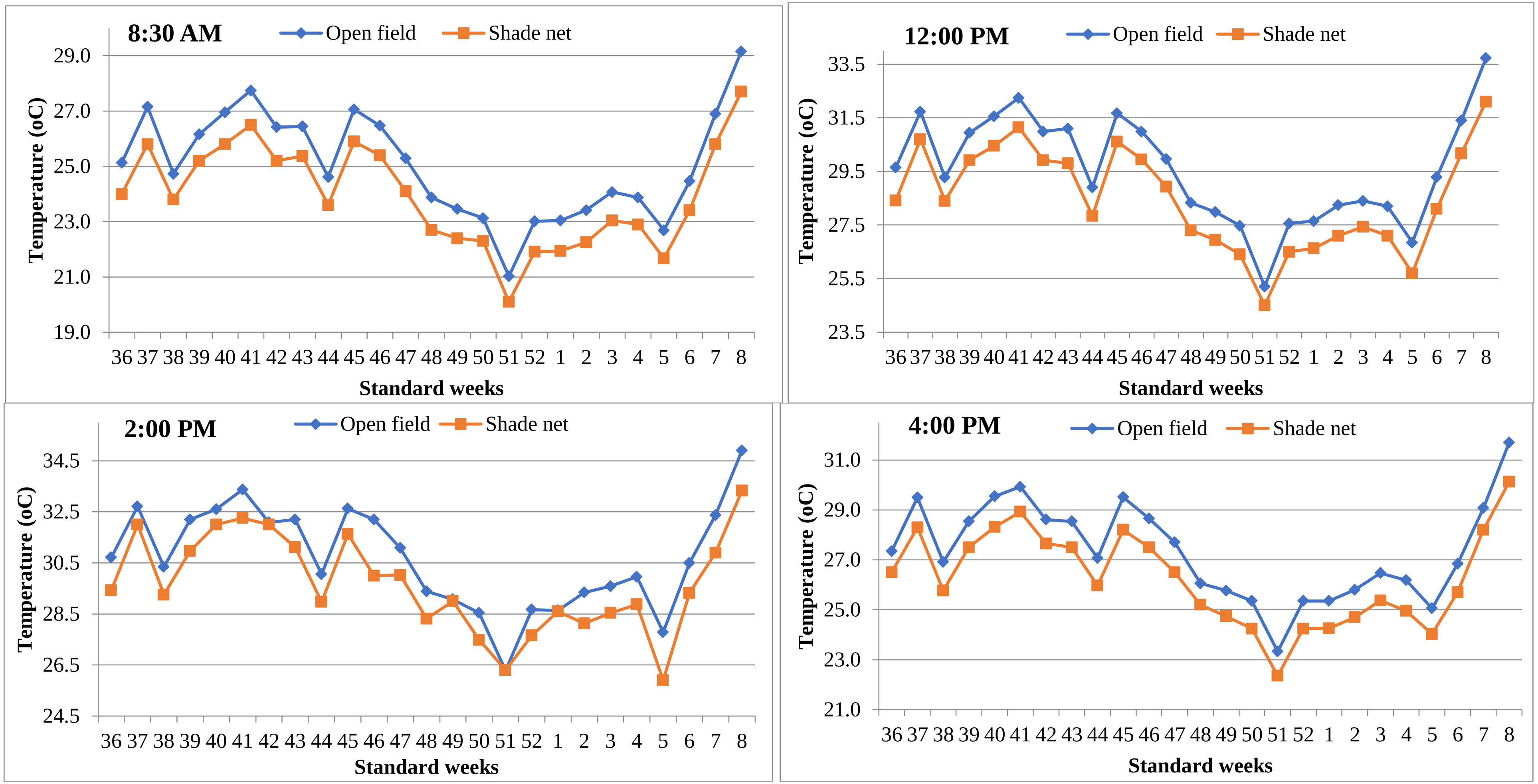

Figure 4.5 Inside and outside temperature (^oC) variation of the shade net recorded throughout the crop growth period at different times in a day

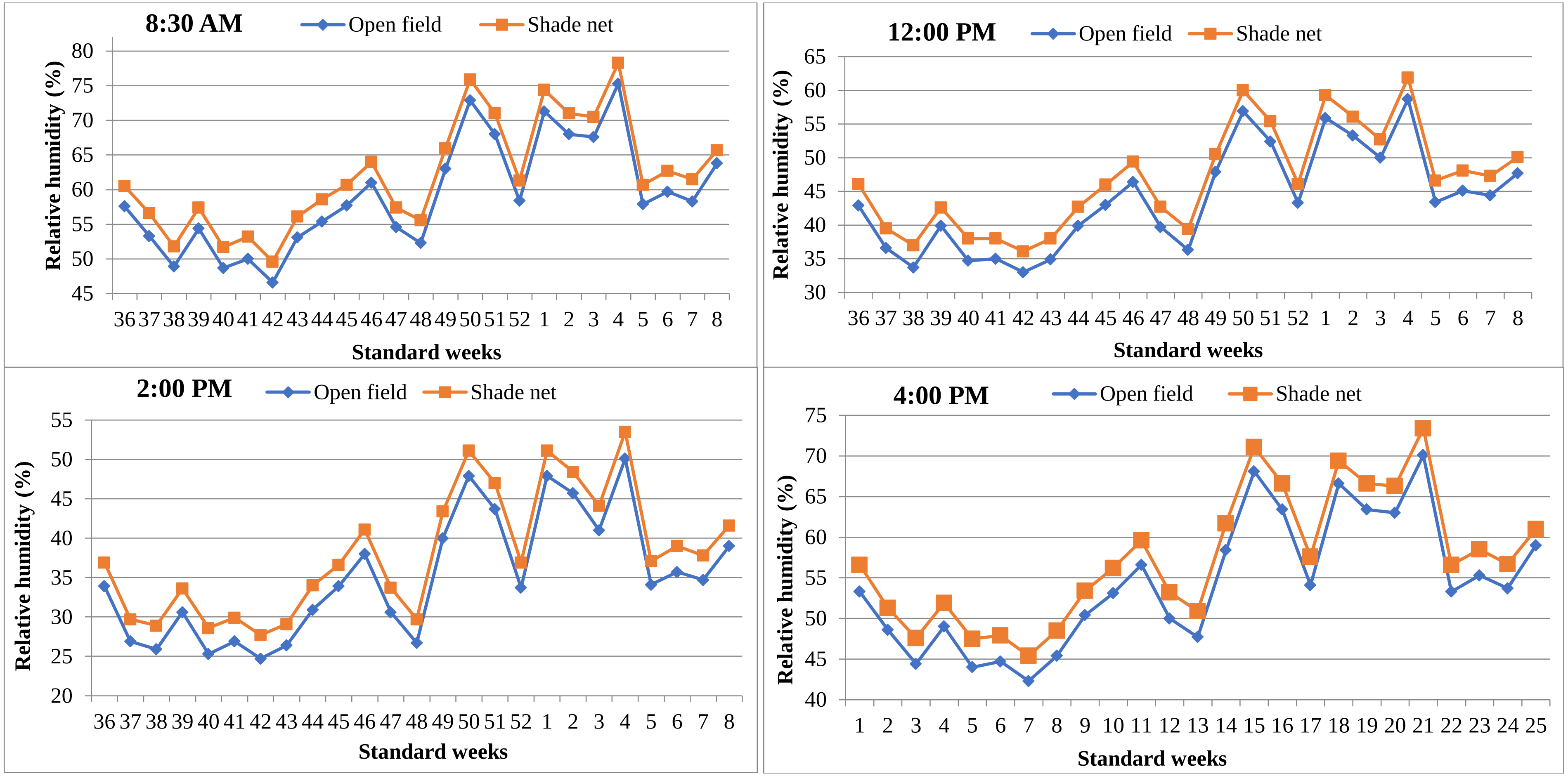

Figure 4.6 Inside and outside relative humidity (%) variation of the shade net recorded throughout the crop growth period at different times in a day

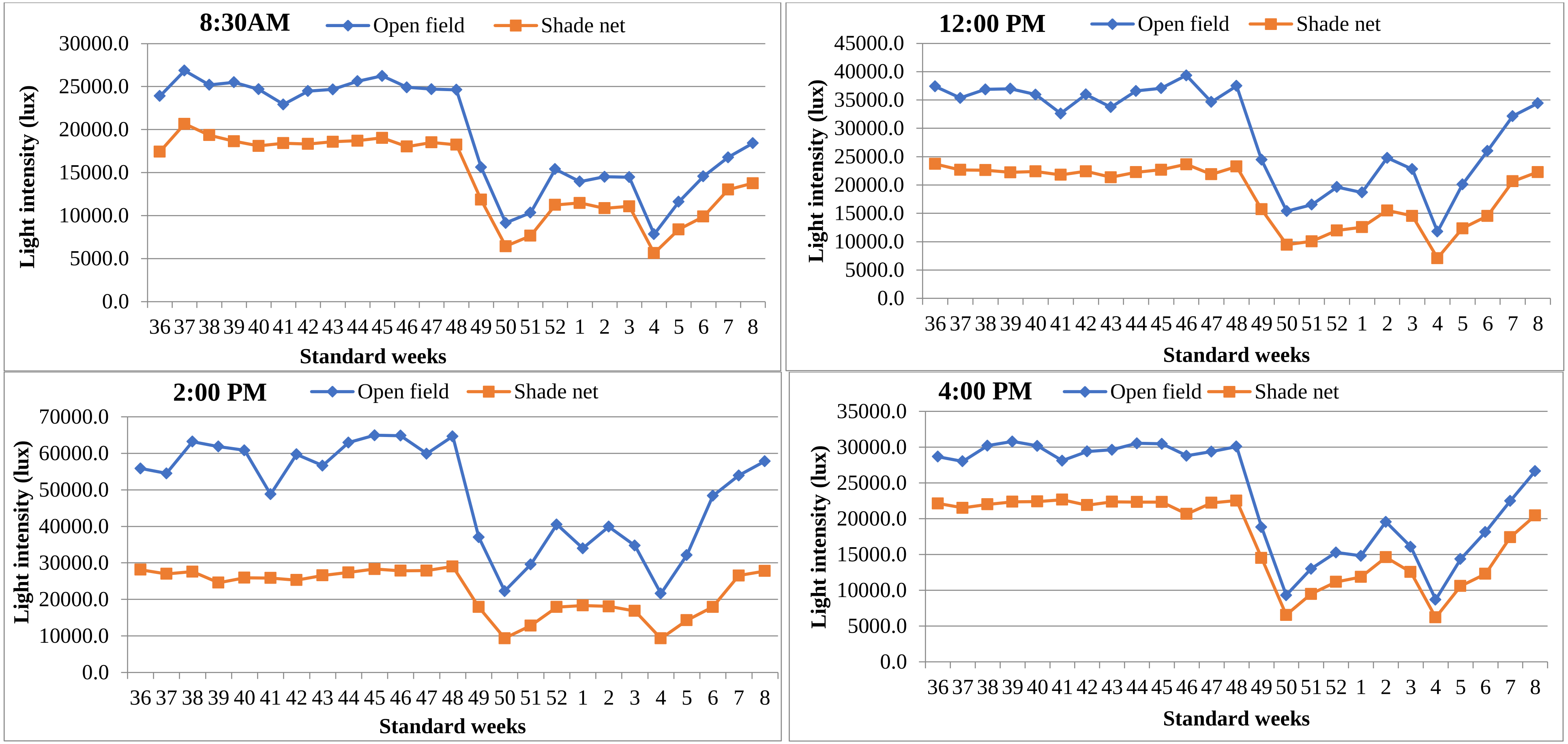

Figure 4.7 Inside and outside light intensity (lux) variation of the shade net recorded throughout the crop period at different times in a day

4.4.1 Temperature (ºC)

Mean temperature observed during crop growth period at 8.30 AM, 12.00 PM, 2.00 PM and 4.00 PM were 25.1 ºC and 24.0 ºC, 29.6 and 28.5 ºC, 30.7 and 29.7 ºC and 27.4 and 26.3 ºC in open field and shade net respectively, with average reduction of 1.1 ºC inside the shade net.

In open field and shade net the maximum temperature was observed at 8.30 AM, 12.00 AM, 2.00 PM, 4.00 PM were 29.2 and 27.7 ºC, 33.7 and 32.1 ºC, 34.9 and 33.3 ºC, 31.7 and 30.1 ºC respectively, with average reduction of 1.6 ºC inside the shade net..

During crop growth period, the minimum temperature was observed in open field and shade net at 8.30 AM, 12.00 AM, 2.00 PM and 4.00 PM were 21.0 and 20.1 ºC, 25.2 and 24.5 ºC, 26.3 and 25.9 ºC and 23.3 and 22.4 ºC respectively, with average reduction of 0.7 ºC inside the shade net.

4.4.2 Relative humidity (%)

Mean RH was observed during crop growth duration in open field and shade net at 8.30 AM, 12.00 AM, 2.00 PM and 4.00 PM were 59.1 and 62.1 per cent, 43.8 and 46.8 per cent, 35.0 and 38.0 per cent, 54.3 and 57.4 per cent, respectively, with average reduction of 3.0 per cent in open field.

In open field and shade net the maximum relative humidity was observed at 8.30 AM, 12.00 AM, 2.00 PM and 4.00 PM were 75.3 and 78.3 per cent, 58.7 and 61.9 per cent, 50.1 and 53.5 per cent, 70.1 and 73.4 per cent, respectively, with average reduction of 3.2 per cent in open field. .

During crop growth stage, the minimum relative humidity was observed in open field and shade net at 8.30 AM, 12.00 AM, 2.00 PM and 4.00 PM were 46.6 and 49.6 per cent, 33.0 and 36.1 per cent, 24.9 and 27.7 per cent, 42.3 and 45.4 per cent, respectively, reduction of 3.0 per cent in open field. .

4.4.3 Light intensity (Lux)

Mean light intensity was observed during crop growth duration in open field and shade net at 8.30 AM, 12.00 AM, 2.00 PM and 4.00 PM were 19477.4 and 14529.9 lux with reduction of 25.4 per cent, 29475.4 and 18385.0 lux reduction of 37.6 per cent, 49228.9 and 22340.5 lux reduction of 54.6 per cent and 23260.6 and 17407.7 lux reduction of 25.1 per cent inside the shade net, respectively.

In open field and shade net the maximum light intensity was observed at 8.30 AM, 12.00 AM, 2.00 PM, 4.00 PM were 26859.3 and 20666.1 lux with reduction of 23.0 per cent, 39331.9 and 23714.3 lux with reduction of 39.7 per cent, 64943.4 and 29014.3 lux with reduction of 55.3 per cent, 30791.4 and 22657.1 lux with reduction of 26.4 per cent inside the shade net, respectively.

During crop growth period, the minimum light intensity was observed in open field and shade net at 8.30 AM, 12.00 AM, 2.00 PM and 4.00 PM were 7839.4 and 5628.6 lux with reduction of 28.2 per cent, 11775.1 and 7085.7 lux with reduction of 39.8 per cent, 21593.9 and 9329.3 lux with reduction of 56.7 per cent and 8695.1 and 6214.3 lux with reduction of 28.5 per cent inside the shade net, respectively.

4.5 IRRIGATION WATER MEASUREMENTS

4.5.1 Irrigation water applied (mm)

Table 4.11 Irrigation water applied, effective rainfall, total water and water productivity of capsicum as influenced by different drip irrigation levels and varieties under shade net.

Treatments	Irrigation Water applied (mm)	Special operations (mm)*	Effective Rainfall (mm)	Total irrigation water (mm)	Total irrigation water (m^3)	WUE (kg m^{-3})
Main – (Irrigation levels) :						
I_1: Drip irrigation at 0.4 Epan	219.3	26.0	82.6	327.9	3279	8.4
I_2: Drip irrigation at 0.6 Epan	366.0	26.0	74.6	466.6	4666	7.4
I_3: Drip irrigation at 0.8 Epan	520.5	26.0	64.2	610.7	5907	6.6
I_4: Drip irrigation at 1.0 Epan	672.5	26.0	58.6	757.5	7575	6.3
SEm ±	-	-	-	-	-	0.15
C.D (P=0.05)	-	-	-	-	-	0.53
Sub – (Varieties) :						
V_1 : Indra	444.6	26.0	70.0	520.7	5406	7.7
V_2 : Orobelle	444.6	26.0	70.0	520.7	5406	7.2
V_3 : Bomby	444.6	26.0	70.0	520.7	5406	6.6
SEm ±	-	-	-	-	-	0.13
C.D (P=0.05)	-	-	-	-	-	0.38
Interaction : **Varieties at same level of irrigation levels :**						
SEm ±	-	-	-	-	-	0.26
C.D (P=0.05)	-	-	-	-	-	NS
Irrigation levels at same or different varieties :						
SEm ±	-	-	-	-	-	0.26
C.D (P=0.05)	-	-	-	-	-	NS

*Nursery and at transplantation.

Irrigation water was applied separately for each treatment based on Epan indicated that the quantity of water increased as Epan ratio increased from 0.4 to 1.0 Epan. The quantity of irrigation water applied for different drip irrigation treatments such as 0.4, 0.6, 0.8 and 1.0 Epan including special operations (water applied at nursery and transplanting) was 245.3, 391.9, 546.5, 698.5 mm respectively (Table 4.11 and Fig.4.4).

4.5.1 Effective rainfall (mm)

Effective rainfall during the crop growth period estimated was 58.6, 64.2, 74.62, 82.6 mm for 100, 80, 60 and 40 per cent irrigation treatments respectively out of 127.4 mm of rainfall as per water balance method.

4.5.2 Water use efficiency (kg m^{-3})

Different irrigation practices significantly influenced the WUE of the capsicum crop. The WUE was significantly higher with drip irrigation at 0.4 Epan (8.4 Kg m^{-3}) than 0.6, 0.8 and 1.0 Epan and was on par with drip irrigation at 0.6 Epan (7.4 Kg m^{-3}). Drip irrigation at 0.8 (6.6 Kg m^{-3}) was significantly higher than drip irrigation at 1.0 Epan (6.3 Kg m^{-3}). Though the fruit yield was higher, drip irrigation at 1.0 Epan recorded significantly lower WUE With the increase in irrigation level, the water productivity decreases gradually. Similar results were obtained and reported by Lodhi *et.al.* (2014).

Significantly higher WUE (7.7 Kg m^{-3}) was recorded with Indra than Orobelle (7.2 Kg m^{-3}) and Bomby (6.6 Kg m^{-3}). Significantly lower WUE was noticed with Bomby than Orobelle and Indra.

4.6 NUTRIENT UPTAKE

Significant variation in NPK uptake was observed due to different drip irrigation levels and varieties. However, there was no interaction effect between drip irrigation levels and varieties on these parameters (Table 4.13, 4.14 and 4.15).

4.6.1 Nitrogen uptake (kg ha^{-1})

At 30 DAT, nitrogen uptake at drip irrigation at 1.0 Epan (0.94 kg ha^{-1}) recorded significantly higher than rest of the treatments. Drip irrigation at 0.6 Epan (0.84 kg ha^{-1}) was on par with drip irrigation at 0.4 Epan. However lower nitrogen uptake was noticed with 0.4 (0.83 kg ha^{-1}) and 0.8 Epan (0.83 kg ha^{-1}) which were on par with each other. At 60, 90 and 178 DAT, drip irrigation at 1.0 Epan observed higher (6.82 kg ha^{-1} and 20.41 kg ha^{-1} and 71.85 kg ha^{-1}) and was on par with 0.8 Epan (6.38 kg ha^{-1} and 21.74 kg ha^{-1} and 71.27 kg ha^{-1}). Drip irrigation at 0.6 Epan (6.08 kg ha^{-1}and 22.95 kg ha^{-1} and 63.45 kg ha^{-1}) which was on par with drip irrigation at 0.4 Epan (5.68 kg ha^{-1}, 23.99 kg ha^{-1} and 59.2 kg ha^{-1}) respectively. Drip irrigation at 0.6 Epan which was on par with 0.8 Epan.

Significantly higher nitrogen uptake at 120 DAT with drip irrigation at 1.0 Epan (41.02 kg ha^{-1}) was recorded than rest of the treatments. Drip irrigation at 0.8 Epan (37.57 kg ha^{-1}) was on par with drip irrigation at 0.6 Epan (36.38 kg ha^{-1}). Drip irrigation at 0.6 Epan was on par with drip irrigation at 0.4 Epan (34.18 kg ha^{-1}).

4.6.2 Phosphorus uptake (kg ha^{-1})

At 30, 60, 90 and 178 DAT, phosphorous uptake at drip irrigation at 1.0 Epan (0.05, 0.37, 1.61 and 3.59 kg ha^{-1}) recorded higher and was on par with drip irrigation at 0.8 Epan (0.05, 0.34, 1.45 and 1.44 kg ha^{-1}). Drip irrigation at 0.6 Epan (0.04, 0.30, 1.33 and 3.03 kg ha^{-1}) was on par with drip irrigation at 0.4 Epan irrigation (0.04, 0.28, 1.25 and 2.71 kg ha^{-1}) respectively. At 120 DAT, drip irrigation at 1.0 Epan (2.78 kg ha^{-1}) recorded significantly higher phosphorus uptake than rest of the treatments. Drip irrigation at 0.8 Epan (2.53 kg ha^{-1}) was on par with 0.6 Epan (2.34 kg ha^{-1}). However lower phosphorus uptake was noticed with 0.4 Epan (2.16 kg ha^{-1}) which was on par with 0.6 Epan.

Among the hybrids, at 30 and 90 DAT, significantly higher phosphorous uptake was recorded with Indra (0.05 and 1.46 kg ha^{-1}) than Bomby and was on par with Orobelle (0.05 and 1.45 kg ha^{-1}). Significantly lower phosphorus uptake was observed with Bomby (0.04 and 1.32 kg ha^{-1}). At 60 DAT, significantly higher phosphorous uptake was recorded with Indra (0.34 kg ha^{-1}) than Bomby and was on par with Orobelle (0.31 kg ha^{-1}). However significantly lower phosphorus uptake was observed with Orobelle than Indra which was on par with bomby (0.31 kg ha^{-1}). At 120 DAT, phosphorus uptake with Indra (2.60 kg ha^{-1}) was recorded significantly higher than Orobelle (2.50 kg ha^{-1}). Significantly lower phosphorus uptake was observed with Bomby (2.26 kg ha^{-1}) than other two hybrids. At 178 DAT, significantly higher phosphorus uptake was observed with Indra (1.32 kg ha^{-1}) than Orobelle and Bomby.

4.6.2 Potassium uptake (kg ha^{-1})

Significantly higher K uptake was recorded at 30, 60, 120 and 178 with drip irrigation at 1.0 Epan (0.33, 2.49, 10.72 and 18.69 kg ha^{-1}) than 0.6 and 0.4 Epan and was on par with 0.8 Epan (0.30, 2.24, 9.55 and 17.61 kg ha^{-1}). At 30 and 120 DAT, significantly lower potassium uptake recorded with 0.4 Epan (0.25 kg ha^{-1} and 4.66 kg ha^{-1}) than 1.0 Epan and was on par with 0.6 (0.27 and 8.42 kg ha^{-1}) and 0.8 Epan (0.30 and 9.55 kg ha^{-1}). At 60 and 178 DAT, significantly lower potassium uptake recorded with 0.4 Epan (1.61 and 12.97 kg ha^{-1}) than 1.0 and 0.8 Epan and was on par with 0.6 Epan (1.84 and 14.55 kg ha^{-1}). At 90 DAT, drip irrigation at 1.0 Epan (7.65 kg ha^{-1}) recorded significantly higher than 0.8 (6.48 kg ha^{-1}), 0.6 (5.22 kg ha^{-1}) and 0.4 Epan (4.68 kg ha^{-1}). Significantly lower potassium uptake was observed with drip irrigation at 0.4 Epan than 0.8 and 1.0 Epan and was on par with 0.6 Epan.

At 60, 90, 120 and 178 DAT, potassium uptake not significantly influenced by hybrids and at 30 DAT, Indra recorded significantly higher potassium uptake than other two hybrids. Significatly lower potassium uptake was recorded with Bomby (0.26 kg ha^{-1}) than Indra (0.32 kg ha^{-1}) and was on par with Orobelle (0.27 kg ha^{-1}).

Table 4.13 a. Nitrogen uptake (kg ha^{-1}) of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

Treatments	30 DAT	60 DAT	90 DAT		
	Shoot	**Shoot**	**Shoot**	**Fruit**	**Total**
Main – (Irrigation levels) :					
I_1: Drip irrigation at 0.4 Epan	0.83	5.68	14.80	5.61	20.41
I_2: Drip irrigation at 0.6 Epan	0.84	6.08	15.88	5.86	21.74
I_3: Drip irrigation at 0.8 Epan	0.83	6.38	17.03	5.92	22.95
I_4: Drip irrigation at 1.0 Epan	0.94	6.82	17.50	6.49	23.99
SEm ±	0.02	0.15	0.35	0.14	0.46
C.D (P=0.05)	0.07	0.50	1.22	0.48	1.60
Sub – (Varieties) :					
V_1 : Indra	0.93	6.25	16.49	6.43	22.92
V_2 : Orobelle	0.85	6.48	16.86	5.93	22.80
V_3 : Bomby	0.80	6.00	15.55	5.55	21.10
SEm ±	0.02	0.12	0.33	0.12	0.34
C.D (P=0.05)	0.05	0.36	0.98	0.35	1.03
Interaction : **Varieties at same level of irrigation levels :**					
SEm ±	0.03	0.24	0.65	0.23	0.69
C.D (P=0.05)	NS	NS	NS	NS	NS
Irrigation levels at same or different varieties :					
SEm ±	0.03	0.24	0.64	0.23	0.73
C.D (P=0.05)	NS	NS	NS	NS	NS

Table 4.13 b. Nitrogen uptake (kg ha^{-1}) of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

Treatments	120 DAT			178 DAT		
	Shoot	Fruit	Total	Shoot	Fruit	Total
Main – (Irrigation levels) :						
I_1: Drip irrigation at 0.4 Epan	19.73	14.45	34.18	25.20	34.00	59.20
I_2: Drip irrigation at 0.6 Epan	20.92	15.46	36.38	25.87	37.58	63.45
I_3: Drip irrigation at 0.8 Epan	21.71	15.86	37.57	28.63	42.64	71.27
I_4: Drip irrigation at 1.0 Epan	23.75	17.26	41.02	29.61	42.25	71.85
SEm ±	1.02	0.49	0.73	1.20	1.82	2.00
C.D (P=0.05)	3.52	1.68	2.51	4.16	6.29	6.90
Sub – (Varieties) :						
V_1 : Indra	22.03	17.17	39.21	27.39	43.09	70.49
V_2 : Orobelle	21.64	15.59	37.23	27.98	38.01	65.99
V_3 : Bomby	20.91	14.51	35.42	26.6	36.25	62.85
SEm ±	0.67	0.38	0.70	1.03	1.57	1.90
C.D (P=0.05)	2.02	1.14	2.10	3.09	4.71	5.70
Interaction : **Varieties at same level of irrigation levels :**						
SEm ±	1.35	0.76	1.40	2.06	3.14	3.8
C.D (P=0.05)	NS	NS	NS	NS	NS	NS
Irrigation levels at same or different varieties :						
SEm ±	1.50	0.79	1.35	2.07	3.15	3.69
C.D (P=0.05)	NS	NS	NS	NS	NS	NS

Table 4.14 a. Phosphorus uptake (kg ha^{-1}) of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

Treatments	30 DAT	60 DAT	90 DAT		
	Shoot	Shoot	Shoot	Fruit	Total
Main – (Irrigation levels) :					
I_1: Drip irrigation at 0.4 Epan	0.041	0.28	0.67	0.58	1.25
I_2: Drip irrigation at 0.6 Epan	0.042	0.30	0.71	0.61	1.33
I_3: Drip irrigation at 0.8 Epan	0.045	0.34	0.82	0.63	1.45
I_4: Drip irrigation at 1.0 Epan	0.052	0.37	0.90	0.71	1.61
SEm ±	0.002	0.01	0.04	0.02	0.05
C.D (P=0.05)	0.007	0.05	0.13	0.06	0.16
Sub – (Varieties) :					
V_1 : Indra	0.048	0.31	0.74	0.72	1.46
V_2 : Orobelle	0.045	0.34	0.83	0.62	1.45
V_3 : Bomby	0.041	0.31	0.75	0.57	1.32
SEm ±	0.001	0.01	0.02	0.01	0.03
C.D (P=0.05)	0.004	0.03	0.07	0.04	0.09
Interaction : **Varieties at same level of irrigation levels :**					
SEm ±	0.003	0.02	0.05	0.03	0.06
C.D (P=0.05)	NS	NS	NS	NS	NS
Irrigation levels at same or different varieties :					
SEm ±	0.003	0.02	0.05	0.03	0.07
C.D (P=0.05)	NS	NS	NS	NS	NS

Table 4.14 b. Phosphorus uptake (kg ha^{-1}) of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

Treatments	120 DAT			178 DAT		
	Shoot	Fruit	Total	Shoot	Fruit	Total
Main – (Irrigation levels) :						
I_1: Drip irrigation at 0.4 Epan	0.63	1.53	2.16	0.45	2.71	3.16
I_2: Drip irrigation at 0.6 Epan	0.72	1.62	2.34	0.53	3.03	3.56
I_3: Drip irrigation at 0.8 Epan	0.87	1.67	2.53	0.77	3.41	4.18
I_4: Drip irrigation at 1.0 Epan	0.91	1.87	2.78	0.72	3.59	4.31
SEm ±	0.05	0.05	0.07	0.03	0.16	0.15
C.D (P=0.05)	0.16	0.18	0.25	0.11	0.57	0.53
Sub – (Varieties) :						
V_1 : Indra	0.73	1.87	2.60	0.70	3.49	4.19
V_2 : Orobelle	0.87	1.63	2.50	0.65	3.15	3.79
V_3 : Bomby	0.75	1.51	2.26	0.50	2.91	3.41

SEm ±	0.03	0.03	0.05	0.03	0.12	0.12
C.D (P=0.05)	0.09	0.10	0.15	0.09	0.35	0.36
Interaction : **Varieties at same level of irrigation levels :**						
SEm ±	0.06	0.07	0.10	0.06	0.23	0.24
C.D (P=0.05)	NS	NS	NS	NS	NS	NS
Irrigation levels at same or different varieties :						
SEm ±	0.07	0.08	0.11	0.06	0.25	0.25
C.D (P=0.05)	NS	NS	NS	NS	NS	NS

Table 4.15 a. Potassium uptake (kg ha^{-1}) of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

Treatments	30 DAT	60 DAT	90 DAT		
	Shoot	**Shoot**	**Shoot**	**Fruit**	**Total**
Main – (Irrigation levels) :					
I_1: Drip irrigation at 0.4 Epan	0.25	1.61	4.17	1.07	4.68
I_2: Drip irrigation at 0.6 Epan	0.27	1.84	4.74	1.11	5.22
I_3: Drip irrigation at 0.8 Epan	0.30	2.24	5.80	1.12	6.48
I_4: Drip irrigation at 1.0 Epan	0.33	2.49	6.38	1.28	7.65
SEm ±	0.01	0.14	0.32	0.05	0.30
C.D (P=0.05)	0.05	0.47	1.12	NS	1.05
Sub – (Varieties) :					
V_1 : Indra	0.32	2.08	5.37	1.29	5.87
V_2 : Orobelle	0.27	2.07	5.28	1.10	6.15
V_3 : Bomby	0.26	2.00	5.16	1.05	6.01
SEm ±	0.01	0.07	0.18	0.03	0.32
C.D (P=0.05)	0.02	NS	NS	0.09	NS
Interaction : **Varieties at same level of irrigation levels :**					
SEm ±	0.02	0.14	0.36	0.06	0.63
C.D (P=0.05)	NS	NS	NS	NS	NS
Irrigation levels at same or different varieties :					
SEm ±	0.02	0.18	0.44	0.07	0.60
C.D (P=0.05)	NS	NS	NS	NS	NS

Table 4.15 b. Potassium uptake (kg ha^{-1}) of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

Treatments	120 DAT			178 DAT		
	Shoot	**Fruit**	**Total**	**Shoot**	**Fruit**	**Total**
Main – (Irrigation levels) :						
I_1: Drip irrigation at 0.4 Epan	4.66	3.02	7.67	6.05	6.92	12.97
I_2: Drip irrigation at 0.6 Epan	5.37	3.05	8.42	7.12	7.44	14.55
I_3: Drip irrigation at 0.8 Epan	6.36	3.19	9.55	9.12	8.50	17.61
I_4: Drip irrigation at 1.0 Epan	7.16	3.56	10.72	10.24	8.45	18.69
SEm ±	0.51	0.14	0.65	0.61	0.44	1.04
C.D (P=0.05)	1.77	NS	2.23	2.10	NS	3.60
V_1 : Indra	6.04	3.48	9.52	8.31	8.66	16.97
V_2 : Orobelle	5.84	3.16	9.00	8.16	7.59	15.75
V_3 : Bomby	5.78	2.97	8.75	7.92	7.23	15.15
SEm ±	0.28	0.10	0.35	0.34	0.34	0.64
C.D (P=0.05)	NS	0.29	NS	NS	1.01	NS
Interaction : **Varieties at same level of irrigation levels :**						
SEm ±	0.55	0.19	0.69	0.67	0.67	1.28
C.D (P=0.05)	NS	NS	NS	NS	NS	NS
Irrigation levels at same or different varieties :						
SEm ±	0.68	0.21	0.86	0.70	0.70	1.47
C.D (P=0.05)	NS	NS	NS	NS	NS	NS

Table 4.16 Post harvest available soil nutrient status (kg ha^{-1}) of capsicum under different drip irrigation levels and varieties under shade net.

Treatments	Nitrogen (N)	Phosphorus (P_2O_5)	Potassium (K_2O)
Main – (Irrigation levels) :			
I_1: Drip irrigation at 0.4 Epan	141.3	42.8	120.0
I_2: Drip irrigation at 0.6 Epan	139.8	42.4	118.7
I_3: Drip irrigation at 0.8 Epan	138.2	41.9	117.4
I_4: Drip irrigation at 1.0 Epan	136.9	40.7	113.5
SEm ±	0.91	0.6	1.6
C.D (P=0.05)	NS	NS	NS
Sub – (Varieties) :			
V_1 : Indra	139.3	42.0	117.9
V_2 : Orobelle	138.7	41.8	116.6
V_3 : Bomby	139.2	42.0	117.7
SEm ±	0.61	0.2	0.7
C.D (P=0.05)	NS	NS	NS
Interaction : **Varieties at same level of irrigation levels :**			
SEm ±	1.2	0.4	1.4
C.D (P=0.05)	NS	NS	NS
Irrigation levels at same or different varieties :			
SEm ±	1.4	0.6	2.0
C.D (P=0.05)	NS	NS	NS

Note: Initial soil nutrient status: N- 145.51 kg ha^{-1}, P_2O_5- 47.15 kg ha^{-1}, K_2O- 156.7 kg ha^{-1}.

4.7 ECONOMIC ANALYSIS

There was significant variation in cost of cultivation, gross and net returns and B:C ratio was observed due to different drip irrigation levels and among the hybrids. However, there was no interaction effect between drip irrigation levels and varieties on these parameters (Table 4.12).

4.7.1 Cost of cultivation

Cost of cultivation varied from ₹337310 to ₹344525 ha^{-1} in different treatments of capsicum. Main variation in cost of cultivation was due to cost of water, man power for irrigation, cost of seed for different varieties and other operations among treatments.

4.7.2 Gross returns

Gross returns obtained with individual drip irrigation levels were significantly different from each other. Drip irrigation at 1.0 Epan recorded significantly higher gross returns (₹ 1254352) than drip irrigation at 0.8 Epan (₹1072000). Significantly lower gross returns were observed with drip irrigation at 0.6 Epan than 0.8 Epan. Similarly, 0.6 Epan (₹913447) has recorded significantly higher gross returns than drip irrigation at 0.4 Epan (₹725081) which recorded the lowest gross returns. Similarly higher gross returns were due to higher yield recorded in these treatment. These results are in similarity with the Choudhary *et al.* (2012).

Table 4.12 Cost of cultivation, gross, net returns and B: C ratio of as influenced by drip irrigation levels and varieties of capsicum under shade net.

Treatments	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
Main – (Irrigation levels) :				
I_1: Drip irrigation at 0.4 Epan	338612	725081	386417	2.14
I_2: Drip irrigation at 0.6 Epan	340497	913447	572898	2.68
I_3: Drip irrigation at 0.8 Epan	342341	1072000	729608	3.13
I_4: Drip irrigation at 1.0 Epan	343987	1254352	910313	3.64
SEm ±	-	25925	25925	0.08
C.D (P=0.05)	-	89711	89711	0.26
Sub – (Varieties) :				
V_1 : Indra	339902	805133	465179	2.37
V_2 : Orobelle	342432	1129417	786933	3.29
V_3 : Bomby	341742	1039109	697315	3.04
SEm ±	-	18307	18307	0.05
C.D (P=0.05)	-	54883	54883	0.16
Interaction : **Varieties at same level of irrigation levels :**				
SEm ±	-	36613	36613	0.11
C.D (P=0.05)	-	NS	NS	NS
Irrigation levels at same or different varieties :				
SEm ±	-	39570	39570	0.12
C.D (P=0.05)	-	NS	NS	NS

Cost of Indra –₹ 20/- kg^{-1}; Orobelle and Bomby –₹ 30/- kg^{-1}

Significantly higher and lower gross returns among different drip irrigation levels were recorded with Orobelle (₹ 1129417) and Indra (₹ 805133), respectively. Significantly higher gross returns were observed with Bomby (₹1039109) than Indra. The variation in the gross returns were due to the variation in yields and cost of cultivation with the different treatments.

4.7.3 Net returns

Net returns recorded with individual drip irrigation levels were significantly different from each other. Drip irrigation at 1.0 Epan realized significantly higher net returns (₹910313)

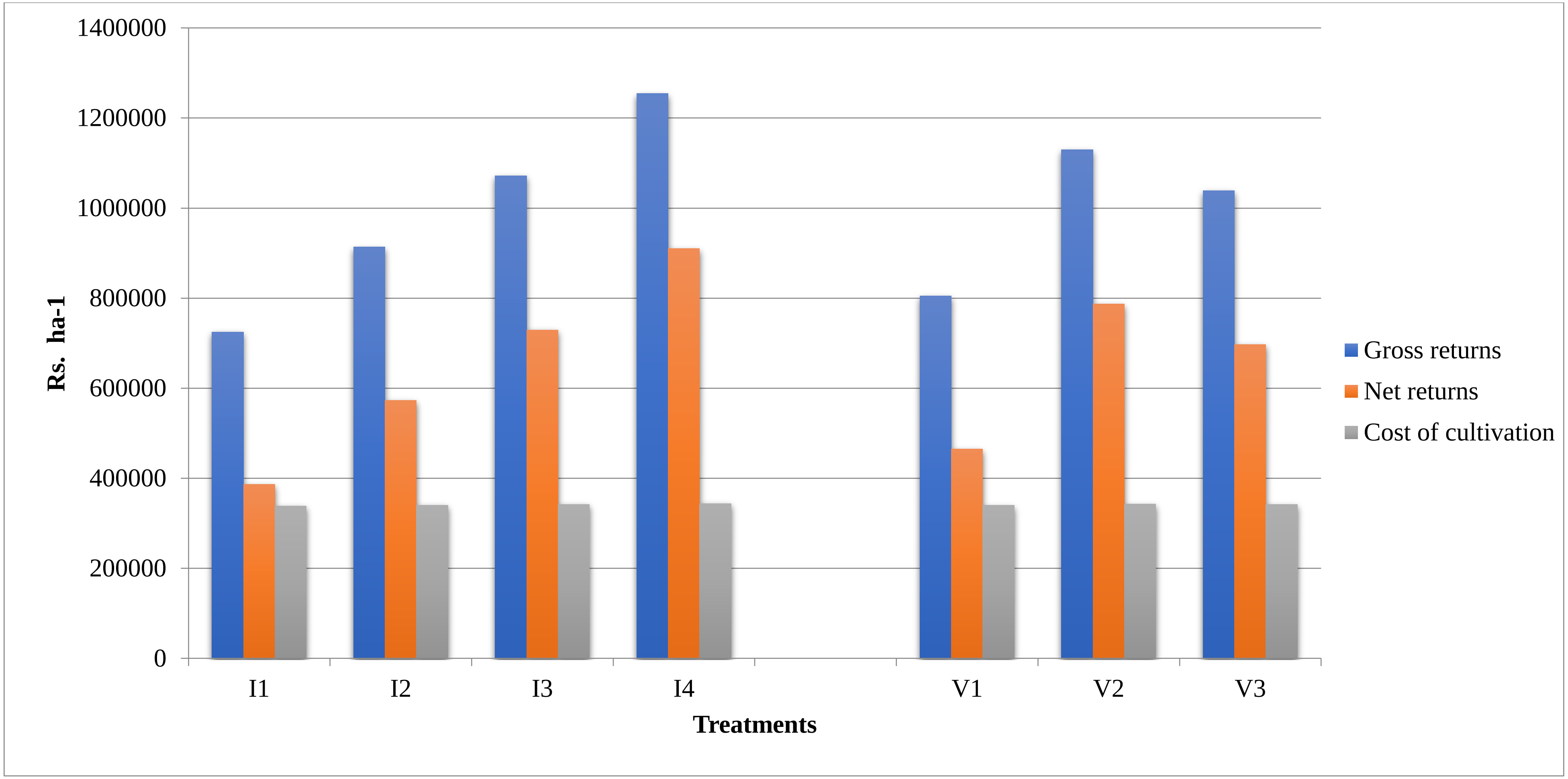

Figure 4.3 Cost of cultivation, gross and net returns as influenced by drip irrigation levels and varieties of capsicum under shade net.

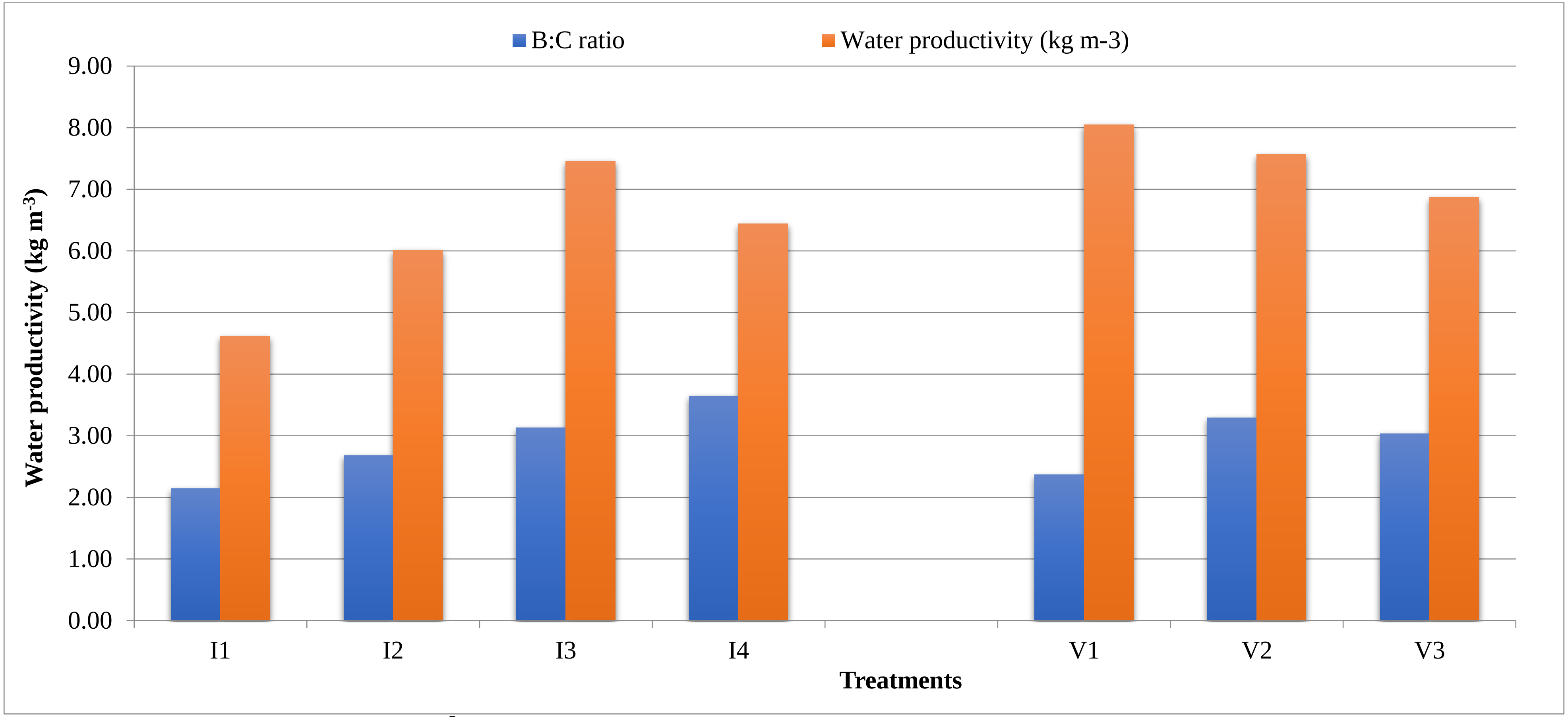

Figure 4.4 Water productivity (kg m^{-3}) and B:C ratio as influenced by drip irrigation levels and varieties of capsicum under shade net

than drip irrigation at 0.8 Epan (₹729608). Significantly lower gross returns were recorded with drip irrigation at 0.6 Epan than 0.8 Epan. Similarly, 0.6 Epan (₹572898) resulted significantly higher gross returns than drip irrigation at 0.4 Epan (₹38641) which recorded the lowest gross returns. The higher net returns were due to more returns with less cost of cultivation. These results are in similarity with the Choudhary *et al.* (2012).

Net returns were significantly higher in Orobelle (₹786933) than other two hybrids studied. Significantly higher net returns were observed with Bomby (₹697315) than Indra (₹465179). Significantly lower net returns were observed with Indra than rest of the hybrids. The higher net returns were due to higher productivity and fetch better returns at premium price for excellent quality produce. These results are in concordance with Singh *et al.* (2003).

4.7.4 B:C ratio (Benefit : Cost ratio):

Among the varied drip irrigation levels, significantly higher B:C ratio was obtained with drip irrigation at 1.0 Epan (3.64) than rest of the irrigation treatments. This was followed by drip irrigation at 0.8 Epan (3.13) than 0.6 Epan (2.68). Significantly lower B:C ratio was recorded with 0.4 Epan (2.14) than 0.6 Epan. The higher B:C ratio was due to higher net returns with less cost of cultivation. Results reported by Paul *et al.* (2013) was in similar with the present investigation results.

Significantly higher B:C ratio was observed with Orobelle (3.29) followed by Bomby (3.04) and Indra (2.37). Higher B:C ratio was due to higher productivity and higher returns with less cost of cultivation. These results are in accordance with Singh *et al.* (2003).

4.8 CORRELATION STUDIES

In general the correlations indicated that the fruit yield is positively correlated with growth parameters, yield attributes, quality parameters and nutrient uptake and the data was presented in Table 4.20a and 4.20b.

The yield of three capsicum hybrids correlated significantly and positively with plant height, number of branches, number of leaves, SCMR, LAI, Total DMP, Total N, P and K uptake at 99 per cent of confidence level except plant height at 60 DAT in Indra, 90 DAT in Orobelle and Bomby, number of leaves at 120 DAT in Bomby and SCMR at 60 DAT which were significantly and positively correlated at 95 per cent of confidence level. Similarly, the yield was significantly and positively correlated at 99 per cent of confidence level with yield attributes *viz.*, fruit length, fruit diameter, pericarp thickness, fruit plant^{-1}, average fruit weight, fruit yield plant^{-1}, ascorbic acid, capsanthin and capsaicin except ascorbic acid in Orobelle and capsaicin in Indra and Bomby which were not significant.

4.20 a. Correlation studies between fruit yield versus growth parameters and nutrient uptakes of capsicum as influenced by different drip irrigation levels and varieties under shade net.

S.No.	Parameter	DAT	r^2 value		
			Indra	Orobelle	Bomby
1.	Plant height (cm)	60	0.6731*	0.9029**	0.7937**
		90	0.9055**	0.6600*	0.5898*
		120	0.9962**	0.8240**	0.8659**
		150	0.9388**	0.9641**	0.7239**
2.	Number of branches	90	0.9753**	0.7232**	0.4422
		120	0.9391**	0.9212**	0.9461**
		150	0.9012**	0.9522**	0.9673**
3.	Number of leaves	60	0.9740**	0.9181**	0.5026
		90	0.9740**	0.9181**	0.5026
		120	0.7515**	0.4237	0.6335*
		150	0.8508**	0.5597	0.5298
4.	SCMR	60	0.9779**	0.9268**	0.5798*
		90	0.9518**	0.7915**	0.9945**
		120	0.8152**	0.9189**	0.6678**
		150	0.9270**	0.8142**	0.7838**
5.	LAI	60	0.9234**	0.7943**	0.9133**
		90	0.9956**	0.8761**	0.7926**
		120	0.9956**	0.8761**	0.7926**
		150	0.8783**	0.7995**	0.9687**
6.	Total DM (kg ha^{-1})	60	0.9747**	0.9337**	0.9191**
		90	0.9643**	0.9300**	0.7837**
		120	0.9582**	0.9198**	0.6354**
		150	0.9258**	0.9360**	0.6437**
7.	Total N (kg ha^{-1})	60	0.9456**	0.9966**	0.8750**
		90	0.9884**	0.9756**	0.9285**
		120	0.9938**	0.9754**	0.9527**
8.	Total P (kg ha^{-1})	60	0.8305**	0.9605**	0.9747**
		90	0.8626**	0.9723**	0.9791**
		120	0.9227**	0.9655**	0.9786**
9.	Total K (kg ha^{-1})	60	0.9786**	0.9770**	0.9946**
		90	0.7579**	0.9611**	0.9988**
		120	0.9968**	0.9651**	0.9871**

* = Significant at 95% and ** =Significant at 99% of confidence level.
r^2 : Equal or above of 0.576 at 95% and 0.708 at 99% level of significance

4.20 b. Correlation studies between fruit yield versus yield attributes and quality parameters of capsicum as influenced by different drip irrigation levels and varieties under shade net.

S.No.	Parameter	r^2 value		
		Indra	Orobelle	Bomby
1.	Fruit length (cm)	0.9964**	0.9953**	0.9994**
2.	Fruit diameter (cm)	0.9923**	0.9882**	0.9885**
3.	Pericarp thickness (mm)	0.8781**	0.9544**	0.9905**
4.	Fruit plant^{-1} (no.)	0.9887**	0.9835**	0.9830**
5.	Average fruit weight (g)	0.9336**	0.9705**	0.9519**
6.	Fruit yield plant^{-1}	1.0000**	1.0000**	1.0000**
7.	Ascorbic acid (mg 100 g^{-1})	0.8825**	0.1792	0.6314**
8.	Capsanthin (EOA value)	0.8860**	0.7876**	0.5836*
9.	Capsaisin (%)	0.1827	0.8370**	0.5034

* = Significant at 95% and ** =Significant at 99% of confidence level.
r^2 : Equal or above of 0.576 at 95% and 0.708 at 99% level of significance

4.9 EVAPORATION (mm) OUTSIDE AND INSIDE THE SHADE NET (*rabi,* 2018-19)

Weekly and monthly mean data is presented in Table 4.20 a and Table 4.20 b and Figure 4.8, 4.9 and 5.0.

The data from weekly mean evaporation clearly indicated that a considerable reduction in evaporation inside the shade net when compared to the outside shade net (open field). Minimum and maximum mean weekly evaporation outside the shade net were 3.1 mm and 6.3 mm with overall mean of 4.6 mm and inside the shade net were 2.0 mm and 4.4 mm with overall mean of 3.0 mm, respectively. The minimum and maximum difference between the outside and inside evaporation was 0.8 mm and 2.1 mm with overall mean of 1.6 mm.

Minimum and maximum mean monthly evaporation outside the shade net were 4.1 mm during December and 5.4 mm during January with overall mean of 4.5 mm and inside the shade net were 2.5 mm during December and 3.7 mm during January with overall mean of 3.0 mm, respectively. The minimum and maximum difference the outside and inside evaporation was 1.0 mm during Febraury and 1.7 mm during November with overall mean of 1.5 mm.

Table 4.21 a. Weekly mean evaporation data outside and inside the shade net during non rainy days of crop growth period (*rabi*, 2018-19)

Standard weeks	Date	Outside shade net (mm)	Inside shade net (mm)	Difference (mm)	Percentage of reduction*
44	29-04 **NOV**	4.5	3.0	-1.5	-33.3
45	05-11	4.2	2.7	-1.5	-35.6
46	12-18	4.7	2.5	-2.1	-45.7
47	19-25	4.3	2.5	-1.8	-42.0
48	26-02 **DEC**	3.9	2.6	-1.3	-32.8
49	03-09	3.3	2.0	-1.3	-40.2
50	10-16	4.2	2.6	-1.6	-38.2
51	17-23	3.2	2.1	-1.2	-36.1
52	24-31	5.3	3.3	-2.0	-38.6
1	01-07 **JAN**	4.7	3.0	-1.7	-36.3
2	08-14	5.8	4.0	-1.8	-31.6
3	15-21	6.2	4.4	-1.8	-29.6
4	22-28	6.3	4.4	-1.9	-29.6
5	29-04 **FEB**	3.1	2.2	-0.8	-27.4
6	05-11	4.7	3.6	-1.0	-21.6
Minimum		**3.1**	**2.0**	**-2.1**	-45.7
Maximum		**6.3**	**4.4**	**-0.8**	-21.6
Overall mean		**4.6**	**3.0**	**-1.6**	-34.6
S.D. ±					**6.1**

Table 4.28 b. Monthly mean evaporation data outside and inside the shade net during non rainy days of crop growth period (*rabi*, 2018-19)

Months	Outside shade net (mm)	Inside shade net (mm)	Difference (mm)	Percentage of reduction*
November	4.4	2.7	-1.7	-37.9
December	4.1	2.5	-1.6	-38.4
January	5.4	3.7	-1.7	-31.6
February**	4.2	3.3	-1.0	-22.9
Minimum	**4.1**	**2.5**	**-1.7**	-38.4
Maximum	**5.4**	**3.7**	**-1.0**	-22.9
Over all mean	**4.5**	**3.0**	**-1.5**	-32.7
S.D. ±				**7.2**

***** Percentage reduction of evaporation inside the shade net when compared to outside the shade net.

**February data was calculated for 10 days since the crop was harvested.

There existed a significant (P = 0.01) and determination coefficient R^2 (0.9233) obtained with polynomial curve (Figure 5.0) between evaporation (mm) inside and outside the shade net.

During the rainy days, on 17th of October with 42.7 mm and 20.2 mm, 18th of October with 9.7 mm and 1.3 mm, 14th of December with 37.0 mm and 25.6 mm, 18th of December with 8.1 mm and 4.6 mm, 27th of January with 46.0 mm and 29.2 mm, 28th of January with 57.2 mm and 43.6 mm of excess quantity of water was recorded in outside and inside the shade net, respectively.

Variation in average mean temperature was lesser by 1.1 ^{o}C, RH was higher by 3 per cent and light intensity was lesser by 25.4 to 54.6 per cent inside the shade net when compared to the open field (outside the shade net) and these weather parameters influenced the evaporation losses and resulted in lesser evaporation inside the shade net which ranged from 21.6 to 45.7 per cent. Similarly, the monthly mean reduction in evaporation ranged from 22.9 to 38.4 per cent. Evaporation loss was increased as the change in season from winter (6.7 % evaporation loss higher from December to January) to summer season (8.8 % evaporation loss higher from January to February). The reason could be very well understood that inside the shade net variation in microclimate resulted in reduction of evaporation losses (Table 17, 18, 19, 20 a, 20 b and Figure 4.8, 4.9 and 5.0).

Thus all these microclimate parameters put together resulted in considerable reduction in evaporation losses and the data revealed that shade net is not only providing congenial microclimate of crop production, but also saves water from evaporation losses and conserves the valuable natural resourse. Such information on evaporation losses of water inside and outside the shade net is very scanty and could not find. These findings from the present research work forms a valuable source of information in this line.

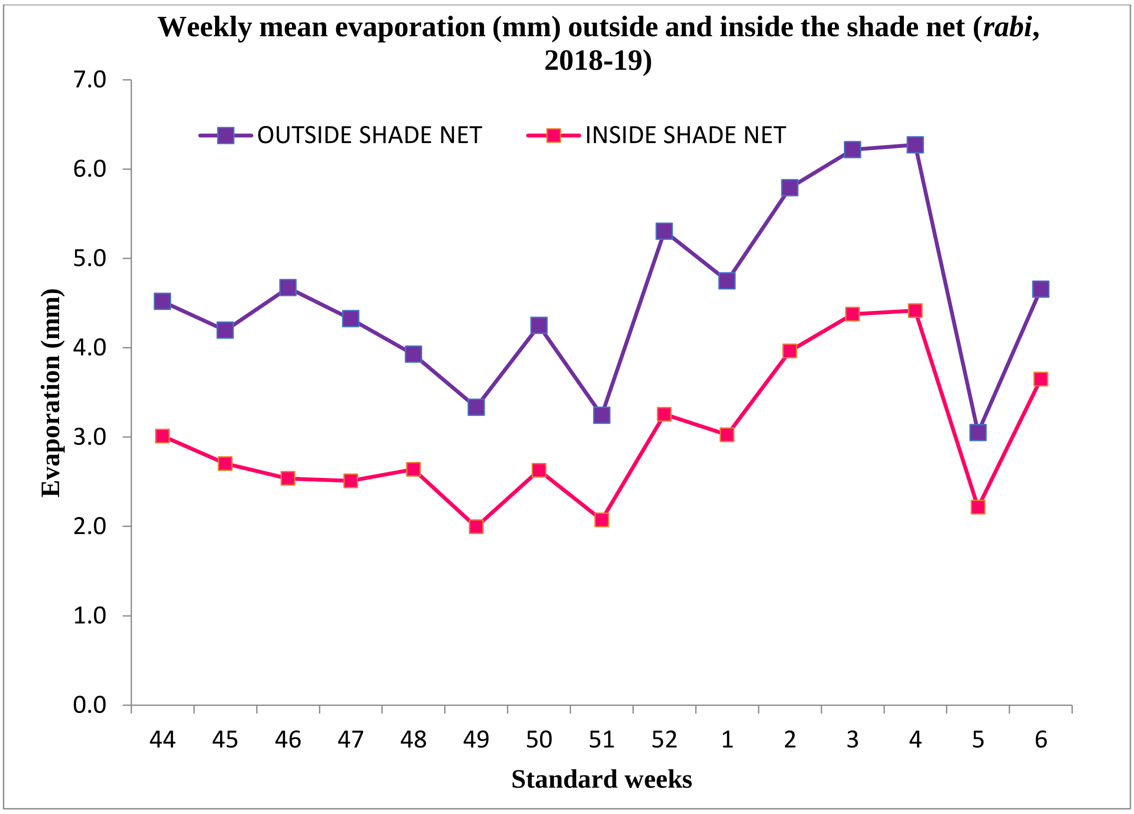

Figure 4.8 Weekly mean evaporation (mm) outside and inside the shade net (*rabi,* 2018-19) during the crop growth period

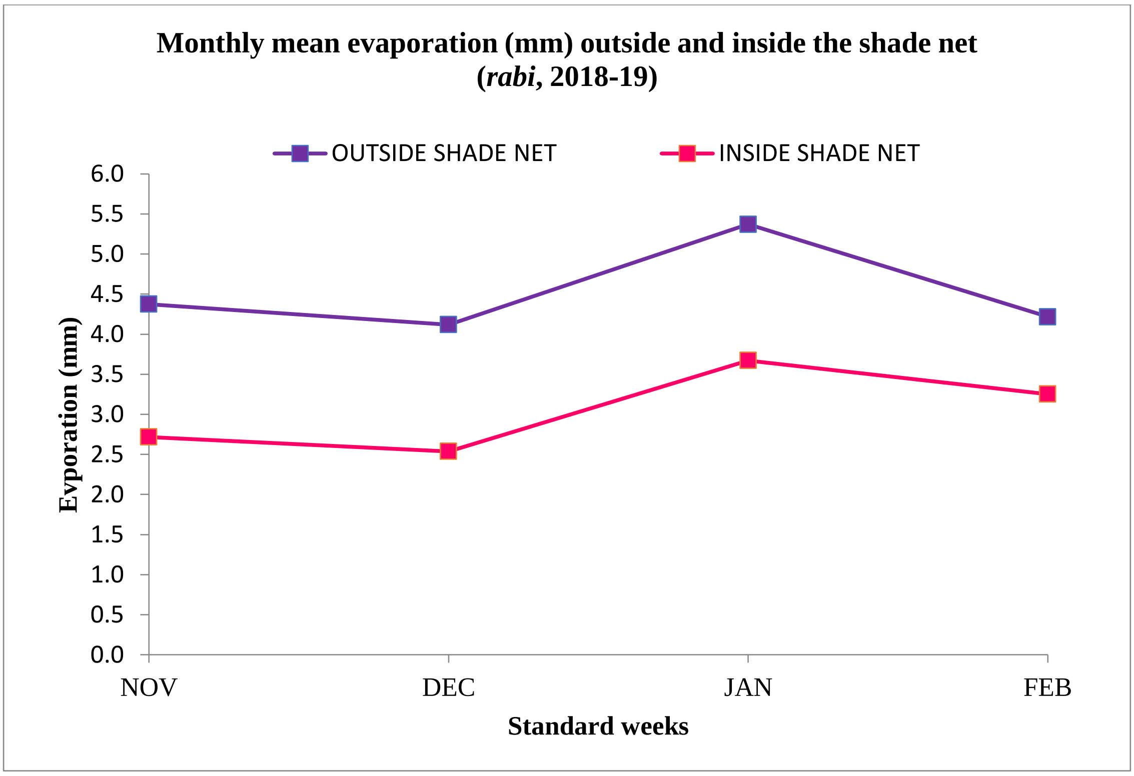

Figure 4.9 Monthly mean evaporation (mm) outside and inside the shade net during the crop growth period (*rabi,* 2018-19)

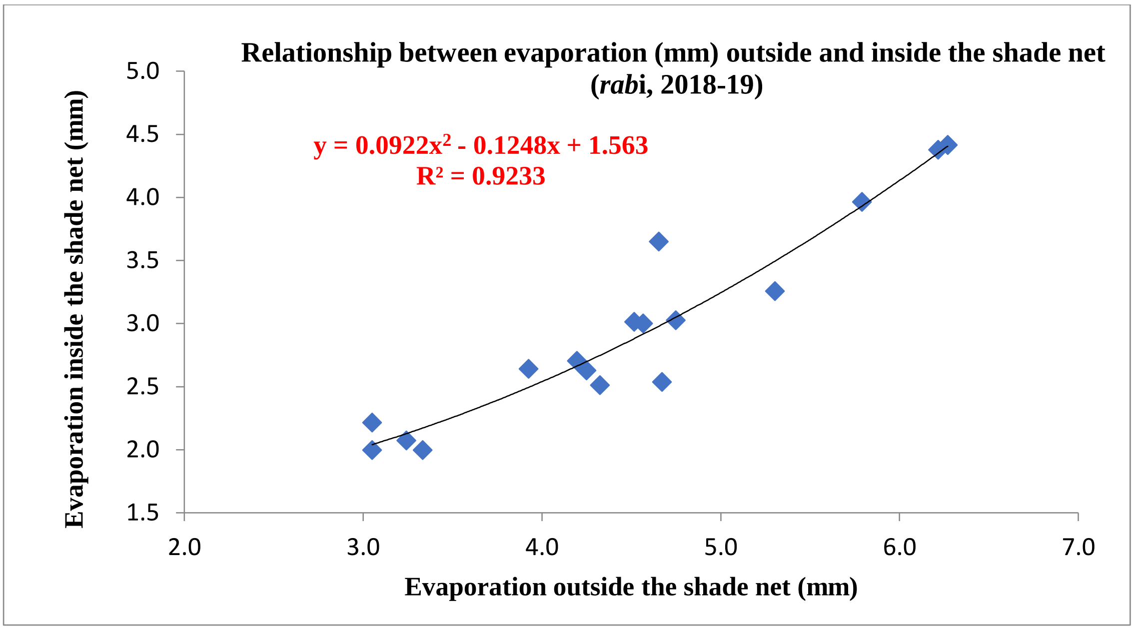

Figure 5.0 Regression between weekly mean evaporation (mm) outside and inside the shade net (*rabi*, 2018-19)

Chapter IV

SUMMARY AND CONCLUSIONS

Capsicum is a cash crop able to fetch very good marketable rates due to its high demand in hotels and restaurants. Besides the limited land availability and water for cultivation hamper the vegetable production. Hence, to obtain a good quality produce and production during off season, there is need to cultivate capsicum crop under protected cultivation such as shade net and poly house with drip irrigation system. Climate condition and water requirement could be different from one region to another region. By concerning these issues, the present investigation on **"Response of coloured capsicum (*Capsicum annuum* var. *grossum* L.) varieties for different irrigation levels under shade net"** was conducted at Horticultural farm (17°19'11" N latitude and 78°24'58" E longitude at an altitude of 542.3 m above mean sea level) College of Agriculture, Rajendranagar, Hyderabad. In this study the capsicum has been grown under, shade net with drip irrigation system. The study aimed to determine crop water requirement, develop irrigation scheduling, water use efficiency and to calculate the cost economics. Experiment has been undertaken as per above objectives in shade net of 500 m^2. Irrigation was given through drip irrigation system. The crop was taken during 6th September 2018 to 26th Febraury 2019.

The experimental soil was sandy loam in texture, slightly alkaline in reaction. The fertility status of the experimental soil was high in organic carbon, low in available nitrogen, medium in available phosphorus and low in available potassium. The experiment was conducted in a split plot design with 12 treatments, comprising of four drip irrigation levels *viz.*, drip irrigation at 0.4 Epan (I_1), 0.6 Epan (I_2), 0.8 Epan (I_3) and 1.0 Epan (I_1) as main treatments and hybrids, Indra (green) (V_1), Orobelle (yellow) (V_2) and Bomby (red) (V_3) as sub treatments and replicated thrice. The water source for irrigation was from a bore well. Irrigation scheduling was done based on daily evaporation data recorded from USWB class 'A' pan evaporimeter in agro-meteorological station, ARI Farm, Rajendranagar, Hyderabad. The cumulative daily evaporation during crop growth period was 737.5 mm. Effective rainfall during the crop growth period estimated was 58.6, 64.2, 74.62, 82.6 mm for 100, 80, 60 and 40 per cent irrigation treatments respectively out of 127.4 mm of rainfall as per water balance method. The recommended dose of fertilizer (RDF) was 100, 80 and 60 kg N, P_2O_5 and K_2O ha^{-1}, respectively which were applied in form of Urea, Single Super Phosphate (SSP) and white Muriate of Potash (MOP). A common dose of 80 kg P_2O_5 ha^{-1} SSP was applied as common basal dose in all the treatments and N and K_2O applied as fertigation in three days interval. The crop was transplanted at 45cm x 40 cm spacing in September. Plant protection measures were followed for the control of pests and diseases. Chemicals like Fipronil, Spinosad, Dimethoate, Neem oil, Monocrotophos, Copper oxy chloride and Acephate were used to control thrips, mites, aphids, fruit borer, dieback and powdery mildew.

During the course of investigation, data were recorded on plant growth parameters *viz.*, plant height (cm), number of leaves plant^{-1}, number of branches plant^{-1}, leaf area index (LAI), days to 50% flowering, yield parameters viz., fruit length (cm), fruit diameter (cm), pericarp thickness (mm), fruits plant^{-1}, fruit weight (g), yield plant^{-1}, total dry matter production , fruit yield (kg ha^{-1}), quality parameters *viz.*, total soluble solids (TSS), ascorbic acid, oleoresin, capsanthin, capsaicin, nutrient uptake, irrigation water measurements. Finally gross returns, net returns and B:C ratio were calculated based on prevailing operating costs and market prices of the produce.

The data was statistically analyzed and the results were critically interpreted with appropriate justification wherever necessary with the pertinent literature. The salient findings observed in the present investigation were concluded and summarized under.

5.1 SUMMARY

There was no significant interaction between drip irrigation levels and different capsicum varieties on growth parameters, yield and yield attributes, quality parameters, N, P and K uptake, water productivity and economics of capsicum.

- There was no significant difference in plant height, number of branches and LAI at 30, 150 and 178 DAT due to drip irrigation levels and were significantly influenced by hybrids.
- Significantly higher plant height at 90 and 120 DAT was recorded with drip irrigation at 1.0 Epan (48.5 and 58.6 cm, respectively) than rest of the treatments *i.e.* 0.8, 0.6 and 0.4 Epan. Significantly lower plant height was observed with drip irrigation at 0.4 Epan and was on par with 0.6 and 0.8 Epan at 90 DAT and with 0.6 Epan at 120 DAT. Among varieties, Indra recorded significantly higher plant height at 90 and 120 DAT (47.8 and 57.4 cm) than Orobelle and Bomby and was on par with Orobelle at 30, 60 and harvest. Bomby recorded significantly lower plant height than Orobelle and Indra at 30, 60, 150 and 178 DAT and was on par with Orobelle at 90 and 120 DAT.
- Number of branches recorded with drip irrigation at 1.0 Epan (4.64 and 6.53) and 0.8 Epan (4.58 and 6.31) were significantly higher than 0.4 and 0.6 Epan at 90 and 120 DAT, respectively. Significantly lower number of branches were observed with drip irrigation at 0.4 and 0.6 Epan which were on par with each other. Indra recorded significantly higher number of branches at 90, 120, 150 and 178 DAT (4.72, 4.18, 4.37 and 5.43, respectively) and was on par with Orobelle at 30 DAT. At 60 DAT, there was no significant difference in number of branches among varieties. Significantly lower number of branches were recorded with Bomby at growth stages except 60 DAT.

- There was no significance difference in number of leaves among drip irrigation levels at 0.8 (41.8, 52.2 and 52.3) and 1.0 Epan (42.9, 52.6, 53.4) which were significantly superior over 0.4 Epan and were on par with 0.6 Epan (40.7, 52.1 and 52.2) at 90, 120 and 150 DAT, respectively. Significantly lower number of leaves were recorded with drip irrigation at 0.4 Epan at 90, 120 and 150 DAT than 0.8 and 1.0 Epan and was on par with 0.6 Epan at 90 DAT. Indra recorded significantly higher number of leaves (11.3 and 55.1) than other two hybrids at 30 and 120 DAT, respectively and was on par with Orobelle at 90, 150 and 178 DAT. Significantly lower number of leaves recorded Bomby at 90 and 120 DAT and was on par with Orobelle at 30, 150 and 178 DAT.
- At all growth stages, drip irrigation at 1.0 Epan recorded significantly higher SPAD chlorophyll meter readings (SCMR) readings than 0.4 Epan and was on par with 0.8 Epan. Similarly, at all growth stages, drip irrigation at 0.8 and 0.6 Epan were on par with each other in SCMR. Drip irrigation at 0.4 Epan recorded lower SCMR readings at all growth stages and was on par with 0.6 Epan at 30, 60, 90 and 178 DAT. Indra recorded significantly higher SCMR than Bomby at all growth stages and was on par with Orobelle at 60, 120, 150 and 178 DAT. Bomby recorded significantly lower SCMR at all growth stages over Indra and was on par with Orobelle at 30, 60 and 90 DAT.
- There was no significant difference in LAI with all irrigation treatments at 60 DAT. At 90 and 120 DAT, drip irrigation with 1.0 Epan recorded significantly higher LAI (0.98 and 1.82) than 0.4 and 0.6 Epan and was on par with 0.8 Epan (0.95 and 1.72). Significantly higher LAI was observed with Indra (0.44, 0.95, 1.72, 1.54 and 1.06) than Bomby and was on par with Orobelle at 60, 90, 120, 150 and 178 DAT, respectively. At 60, 90 and 120 DAT, there was no significant difference was observed with LAI between Orobelle and Bomby.
- Drip irrigation at 1.0 Epan recorded significantly lower number of days to 50 per cent flowering (59.3 days) than 0.6 and 0.4 Epan and was on par with drip irrigation at 0.8 Epan (59.4 days). Drip irrigation at 0.4 and 0.6 Epan recorded significantly higher number of days to 50 per cent flowering which were on par with each other.

  Indra and Orobelle recorded significantly lower number of days to 50 per cent of flowering than Bomby and was on par with each other.
- Significantly higher fruit length and diameter, fruits plant^{-1} and fruit yield plant^{-1} were observed with drip irrigation at 1.0 Epan (9.81 and 7.48 cm, 13.6 and 1.27 kg plant^{-1}, respectively) than rest of the irrigation treatments. There was no significant difference was observed with pericarp thickness and fruit weight between drip irrigation at 0.8 and 1.0 Epan and were significantly superior than 0.4 Epan. Significantly higher fruit length and

diameter, pericarp thickness and fruit weight were observed with Bomby (9.35 and 6.91 cm, 5.09 cm and 90.4 g fruit^{-1}, respectively) than Indra. Fruits plant^{-1} and yield plant^{-1} (14.5 g fruit^{-1} and 1.07 kg plant^{-1}) were significantly higher with Indra than rest of the treatments.

- Drip irrigation at 1.0 Epan recorded significantly higher DMP at 30, 90, 120 and 150 DAT (24.7, 687.6, 1161.7 and 1640.9 kg ha^{-1}) than rest of the treatments. DMP at 60 and 178 DAT was not significantly influenced by drip irrigation at 1.0 and 0.8 Epan and were significantly superior over 0.4 Epan, respectively. Indra recorded significantly higher DMP at 30, 90, 150 and 178 DAT (25.1, 653.8, 1618.9 and 2101.3 kg ha^{-1}). At 60 and 120 DAT, Orobelle recorded significantly higher DMP than Bomby and was on par with Indra at 120 DAT.
- Significantly higher yield (47.50 t ha^{-1}) was recorded with drip irrigation at 1.0 Epan than rest of the treatments. Indra recorded significantly higher yield (40.27 t ha^{-1}) than other two hybrids.
- TSS (^{o}Brix), ascorbic acid (mg 100 g^{-1}) and oleoresin (%) were not significantly influenced by different drip irrigation levels. Significantly higher capsanthin and capsaicin recorded with drip irrigation at 0.8 (19335 and 0.103) and 1.0 Epan (18860 and 0.108) over 0.4 and 0.6 Epan and were on par with each other. Bomby recorded significantly higher TSS (6.15 ^{o}Brix), oleoresin (7.90 %) and capsanthin (37627 EOA value) than rest of the treatments. Orobelle recorded significantly higher ascorbic acid (87.6 mg 100 g^{-1}) than Bomby and Indra. Significantly higher capsaicin was observed with Bomby (0.143 %) than Indra and Orobelle which were on par with each other.
- Water productivity recorded with drip irrigation at 0.4 Epan (8.4 kg m^{-3}) was significantly higher compared to all other treatments. There was no significance difference recorded in water productivity between drip irrigation at 0.8 and 1.0 Epan. Indra recorded significantly higher water productivity (7.7 kg m^{-3}) than other Orobelle and Bomby. Total water applied with 0.4, 0.6, 0.8 and 1.0 Epan were 327.9, 466.6, 610.7 and 757.1 mm.
- Gross, net returns and B:C ratio (₹1254352, 910313 ha^{-1} and 3.64) were significantly higher with drip irrigation at 1.0 Epan than rest of the drip irrigation treatments. Orobelle recorded significantly gross, net returns and B:C ratio (₹1129417, 786933 ha^{-1} and 3.29) than Bomby and Indra.
- Significantly higher N and K uptakes were achieved at all growth stages with drip irrigation at 1.0 Epan than 0.6 and 0.4 Epan and was on par with 0.8 Epan except N uptake at 30 and 120 DAT and K uptake at 90 DAT. P uptake was significantly influenced at all growth stages except 30 DAT. Significantly higher P uptake was observed with drip irrigation at 1.0 Epan than 0.4 Epan. 0.4 and 0.6 Epan except 178 DAT and was on par with 0.8 Epan.

Among varieties, Indra recorded significantly higher N uptake than Bomby and was on par with Orobelle at 90, 120 and 178 DAT. There was no significance difference in nitrogen uptake was observed between Orobelle and Bomby which were significantly lower than Indra at 30, 120 and 178 DAT. There was no significant difference was observed between hybrids at 60 DAT in P uptake. Significantly higher P uptake was by Indra at 30,90, 120 and 178 DAT than Bomby and was on par with Orobelle at 30, 90 and 120 DAT. There was no significant different was observed in K uptake at all growth stages except 30 DAT where Indra recorded higher K uptake over Orobelle and Bomby which were on par with each other.

- Variation in average mean temperature, RH and light intensity were 1.1 ^{o}C lesser inside the shade net, 3 per cent higher inside the shade and 25.4 to 54.6 per cent lux lesser inside the shade net when compared to the open field.

5.2 CONCLUSION

It may be conclude from the above results for achieving maximum yield and net profit from capsicum under shade net the following practices may be followed

- Drip irrigation at 1.0 Epan recorded significantly higher growth parameters at different growth periods and were lower with drip irrigation at 0.4 Epan throughout the crop growth. Higher growth parameters and yield attributes were recorded with Indra (green) and were significantly lower with Bomby. Significantly higher and lower yields were observed with drip irrigation at 1.0 Epan and 0.4 Epan throughout the crop growth than other drip irrigation treatments. Indra recorded significantly higher yield than Orobelle (yellow) and Bomby (red). Significant lower yield were recorded with Bomby.
- Among the drip irrigation levels, 1.0 Epan and 0.4 Epan recorded significantly higher and lower uptakes of N, P and K throughout the crop growth than other drip irrigation levels. Indra (green) recorded significantly higher NPK uptake throughout the crop growth period than Bomby (red) and on par with Orobelle (yellow).
- Under shade net temperature was reduced by 1.1 ^{o}C, RH was increased by 3 per cent and light intensity was reduced by 25.4 to 54.6 per cent compared to open field.
- Gross returns, net returns and B:C ratio obtained with drip irrigation at 1.0 Epan were higher than other drip irrigation treatments. Orobelle (yellow) recorded significantly higher gross returns, net returns and B: C ratio than Bomby (red) and Indra (green).
- The interaction effect of growth parameters, yield and yield attributes, nutrient uptake and economics of capsicum between drip irrigation levels and hybrids was found non-significant.

FUTURE LINE OF WORK

1. Studies are to be conducted on root volume and relation between root to shoot ratios under varied moisture and nutrient levels.

2. Aquacrop model utilization for evaluation in different agro-climatic conditions, especially for capsicum to determine crop biometric growth coefficients.

3. Performance of different varieties needs to be evaluated under different growing conditions such as polyhouse, shade net and open field with changes in altered environment to be studied.

4. Detailed study of different organic and inorganic manurial combinations on growth and yield of capsicum under protected condition needs to be taken up.

5. Standardization of optimum level of environmental factors (relative humidity, temperature, light intensity etc.) for higher yield of capsicum needs to be taken up.

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The pattern of 'Literature Cited" presented above is in accordance with the "Guidelines" for thesis presentation for Professor Jayashankar Telangana state Agricultural university.

APPENDIX-A

WEEKLY METEOROLOGICAL DATA RECORDING DURING THE CROP GROWTH PERIOD (02, Sep 2018 to 26, Feb 2019)

WEEK	DATE	TEMPERATURE (°C)		R.H. (%)		RAIN-FALL (mm)	RAINY DAYS	SUN-SHINE (hrs.)	WIND SPEED (km h^{-1})	EVAPO-RATION (mm)
		MAX.	MIN.	I	II					
35	02 – **SEP**	30.0	20.0	100	75	2.4	0.0	7.1	7.1	5.4
36	03-09	30.6	19.9	85.1	55.0	0.0	0.0	7.5	4.8	5.5
37	10-16	32.9	19.6	94.7	51.7	22.0	1.0	6.7	0.9	3.9
38	17-23	30.3	20.3	88.6	64.0	4.2	1.0	3.3	3.9	3.4
39	24-30	32.1	19.9	94.1	57.6	14.8	1.0	5.7	1.4	3.6
40	01-07 **OCT**	32.6	18.6	91.1	46.7	0.0	0.0	8.1	3.3	4.5
41	08-14	33.4	16.2	79.3	34.3	0.0	0.0	7.1	3.0	4.9
42	15-21	32.1	18.4	89.7	46.7	43.2	2.0	6.3	2.6	3.7
43	22-28	32.2	14.9	87.4	32.0	0.0	0.0	7.2	2.6	4.3
44	29-04 **NOV**	30.1	14.4	87.0	43.4	0.0	0.0	8.0	3.4	3.9
45	05-11	32.7	14.4	88.6	34.1	0.0	0.0	8.9	2.7	4.2
46	12-18	32.1	12.7	80.6	31.6	0.0	0.0	8.8	2.5	4.3
47	19-25	31.1	15.0	89.0	41.1	0.0	0.0	7.2	3.7	4.0
48	26-02 **DEC**	29.4	9.5	87.3	40.6	0.0	0.0	9.0	1.6	3.7

49	03-09	29.1	15.7	91.0	53.0	0.0	0.0	4.3	2.7	2.9
50	10-16	28.7	15.6	89.0	48.4	11.2	1.0	3.0	3.2	2.6
51	17-23	24.6	12.4	91.9	56.9	2.4	0.0	4.3	4.3	2.2
52	24-31	28.7	8.7	89.3	32.3	0.0	0.0	8.4	1.3	3.3
1	01-07 **JAN**	28.7	5.5	87.7	30.0	0.0	0.0	9.2	1.0	3.4
2	08-14	29.3	7.6	93.6	37.4	0.0	0.0	8.4	1.1	3.3
3	15-21	29.6	8.0	89.6	39.9	0.0	0.0	8.6	1.4	3.7
4	22-28	28.7	12.9	87.6	55.1	25.2	2.0	6.3	2.8	3.8
5	29-04 **FEB**	27.0	9.4	94.6	47.9	0.0	0.0	8.0	2.3	3.5
6	05-11	30.4	13.4	81.0	46.6	0.0	0.0	8.8	2.2	5.0
7	12-18	32.4	14.1	89.9	48.7	2.0	0.0	9.6	3.1	6.8
8	19-25	34.9	16.3	78.6	44.6	0.0	0.0	9.8	3.2	8.6
9	26	36.5	14.5	90	39	0.0	0.0	9.2	3.0	9.5
	TOTAL	-	-	-	-	127.4	8.0	-	-	-
	AVG.	30.6	14.1	88.2	44.8	-	-	7.4	2.8	4.4

APPENDIX-B

Calender of operations for capsicum during *rabi*, 2018-19

DATE	DAS/DAT	OPERATIONS
1-Aug-18	1 DAS	Filling of pluck trays
2-Aug-18	2 DAS	Sowing and watering capsicum seeds in trays
12-Aug-18	12 DAS	Ploughing the shadenet with tractor
13-Aug-18	13 DAS	Main field preparation
22-Aug-18	22 DAS	NPK spray for seedlings @3g L^{-1} for trays, Field layout
23-Aug-18	23 DAS	Vermicompost application @ 6kg bed^{-1} (7.2t/ha-12 beds)
24-Aug-18	24 DAS	Bed preparation (length-22.8m, width-0.9m,bed size-246.24m^2)
29-Aug-18	29 DAS	Basal dose of SSP-1.02kg/bed, neem cake-1kg/bed,$ZnSo_4$-102.6g/bed
2-Sep-18	1 DAT	Transplanting
15-Sep-18	14 DAT	Copper oxy chloride drenching (3g L^{-1})) + gap filling
18-Sep-18	17 DAT	Fipronil spray @ 2ml L^{-1}
22-Sep-18	21 DAT	Spinosad spray @ 3ml L^{-1}
25-Sep-18	24 DAT	Weeding on beds
27-Sep-18	26 DAT	Dimethoate spray @ 2ml L^{-1}
29-Sep-18	28 DAT	Monocrotophos spray @ 2ml L^{-1}
6-Oct-18	35 DAT	spraying spinosad @3ml L^{-1}
9-Oct-18	38 DAT	Fipronil spray @ 2ml L^{-1}
12-Oct-18	41 DAT	Dimethoate spray @ 2ml L^{-1}
20-Oct-18	49 DAT	Weeding on beds
23-Oct-18	52 DAT	Fipronil spray @ 2ml L^{-1}
30-Oct-18	59 DAT	Dimethoate spray @ 2ml L^{-1}
1-Nov-18	61 DAT	Monocrotophos spray @ 2ml L^{-1}
8-Nov-18	68 DAT	Weeding on beds
12-Nov-18	72 DAT	Trellising + Monocrotophos spray @ 2ml L^{-1}
13-Nov-18	73 DAT	Neem oil spray+ trellising
24-Nov-18	84 DAT	Irrigation+ potassium nitrate spray(3g/l)
26-Nov-18	86 DAT	Fertigation+ Irrigation
2-Dec-18	92 DAT	1^{st} picking – Indra

DATE	DAS/DAT	OPERATIONS
6-Dec-18	96 DAT	Neem oil spray @ 1 ml L^{-1}
18-Dec-18	108 DAT	Fipronil spray @ 2ml L^{-1}
20-Dec-18	110 DAT	1st picking – Orobelle
24-Dec-18	114 DAT	1st picking – Bomby, Monocrotophos @ 2ml L^{-1}
28-Dec-18	118 DAT	2nd picking – Indra +Neem oil spray @ 1 ml L^{-1}
30-Dec-18	120 DAT	Fipronil spray @ 2ml L^{-1}
2-Jan-19	123 DAT	3rd picking – Indra, 2nd picking – Orobelle
3-Jan-19	124 DAT	Neem oil spray @ 1 ml L^{-1}
9-Jan-19	130 DAT	2nd picking– Bomby, 4th picking–Indra, 3rd picking-Orobelle
19-Jan-19	140 DAT	Neem oil spray @ 1 ml L^{-1}
21-Jan-19	142 DAT	3rd picking – Bomby, 4th picking – Orobelle
23-Jan-19	144 DAT	Acephate spray @ 1.5g L^{-1}
27-Jan-19	148 DAT	Weeding on beds
29-Jan-19	150 DAT	4th picking – Bomby
6-Feb-19	158 DAT	Irrigation + Neem oil spray
8-Feb-19	160 DAT	5th picking – Indra
12-Feb-19	164 DAT	Acephate spray @ 1.5g L^{-1}
20-Feb-19	172 DAT	5th picking – Orobelle, Neem oil spray @ 1 ml L^{-1}
26-Feb-19	178 DAT	5th picking – Bomby

Note: Irrigation was given daily based on Epan.
Fertigation was given every 4th day from 10 DAT.

APPENDIX – C

Total water applied (mm) of capsicum under different drip irrigation treatments

S.No.	Treatments	Amount of water applied (mm)	Special operations	Effective rainfall (mm)	Total water applied (mm)
1	T_1-Drip irrigation at 0.4 Epan + Indra variety	219.3	26.00	82.60	327.9
2	T_2-Drip irrigation at 0.4 Epan + Orobelle variety	219.3	26.00	82.60	327.9
3	T_3-Drip irrigation at 0.4 Epan + Bomby variety	219.3	26.00	82.60	327.9
4	T_4-Drip irrigation at 0.6 Epan + Indra variety	366.0	26.00	74.62	466.6
5	T_5-Drip irrigation at 0.6 Epan + Orobelle variety	366.0	26.00	74.62	466.6
6	T_6-Drip irrigation at 0.6 Epan + Bomby variety	366.0	26.00	74.62	466.6
7	T_7-Drip irrigation at 0.8 Epan + Indra variety	520.5	26.00	64.22	610.7
8	T_8-Drip irrigation at 0.8 Epan + Orobelle variety	520.5	26.00	64.22	610.7
9	T_9-Drip irrigation at 0.8 Epan + Bomby variety	520.5	26.00	64.22	610.7
10	T_{10}-Drip irrigation at 1.0 Epan + Indra variety	672.5	26.00	58.58	757.1
11	T_{11}-Drip irrigation at 1.0 Epan + Orobelle variety	672.5	26.00	58.58	757.1
12	T_{12}-Drip irrigation at 1.0 Epan + Bomby variety	672.5	26.00	58.58	757.1

Note: Special operations – water used during nursery raising and at transplanting.

APPENDIX D

Fertigation schedule for nitrogen and potassium nutrients (g^{-1} bed^{-1} split) during different crop growth stages of capsicum (*rabi*, 2018-19)

	9-13 DAT		**17-45 DAT**		**49-73 DAT**		**77-153 DAT**	
	N	**K**	**N**	**K**	**N**	**K**	**N**	**K**
Fertilizer (%) N & K_20	5	5	3.75	2.50	2.86	2.86	2.00	2.5
Number of splits	2	2	8	8	7	7	20	20
Urea ($g^{-1}bed^{-1}$ split) (100% RDF of N & K_20)	22.3	10.2	16.7	5.1	12.7	5.8	8.9	5.1

Source of fertilizers: Urea and Muriate of potash

Fertilizer dose at 100 % N and K = 100 kg N & 60 kg K_2O ha^{-1}.

Estimation of fixed cost of cultivation for shade net				
Sl.no.	**Particular**	**Amount (Rs)**	**Lifespan**	**Cost (Rs) Per annum**
1	**Structure**			
	GI pipes	81000	-	-
	C-channels	35700	-	-
	Zigzag springs	17500	-	-
	Clamps	10000	-	-
	Screws	1600	-	-
	Total structure cost	**145800**	**10 years**	**14580**
2	**Micro irrigation**	20000	10 years	2000
3	**Cladding material**	37440		12480
4	Labour changes for installation	42000		4200
5	Transport cost	4000		400
	Total cost	**249240**		33660
a)	Actual cost after deducting 75% subsidy	-	-	8415
b)	Two crops per year	-	-	4207.5
c)	Cost of interest @10% for each crop			420.7
d)	Cost of depreciation @ for each season			420.7
e)	Total (b+c+d)	-	-	5048.9
f)	Repairs and maintenance	-	-	1000
g)	Total cost for 500 m^2	-	-	6048.9
h)	Total cost for 1 m^2	-	-	12.0978
i)	Total cost for 1 ha	-	-	120978

APPENDIX E

COST OF CULTIVATION (₹.ha^{-1})

Operations	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12
Land preparation	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Layout & Bed preparation	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500
Cost of seed	34500	37030	36340	34500	37030	36340	34500	37030	36340	34500	37030	36340
Transplanting	3750	3750	3750	3750	3750	3750	3750	3750	3750	3750	3750	3750
Vermicompost & Neem cake	55333	55333	55333	55333	55333	55333	55333	55333	55333	55333	55333	55333
Red soil	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Bio-fertilizer	200	200	200	200	200	200	200	200	200	200	200	200
Weeding	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
Plant protection	28185	28185	28185	28185	28185	28185	28185	28185	28185	28185	28185	28185
Shadenet cost & drip cost	12098	12098	12098	12098	12098	12098	12098	12098	12098	12098	12098	12098
Harvesting and packaging	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000
Transportation	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
Marketing cost	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Trellising	15750	15750	15750	15750	15750	15750	15750	15750	15750	15750	15750	15750
Irrigation	1830	1830	1830	2263	2263	2263	2325	2325	2325	2418	2418	2418
Cost of water(₹ ha mm^{-1})	3020	3020	3020	4510	4510	4510	5890	5890	5890	7310	7310	7310
Cost of fertilizer	10504	10504	10504	10504	10504	10504	10504	10504	10504	10504	10504	10504
Total cost	**334550**	**337080**	**336390**	**336473**	**339003**	**338313**	**337915**	**340445**	**339755**	**339428**	**341958**	**341268**

Capsicum price per kg = Indra variety - ₹ 20 kg^{-1}, Orobelle and Bomby variety - ₹ 30 kg^{-1}.

Description of cost of cultivation

1. **Nursery cost: ₹ 5655/-**
   - ✓ Labour cost – ₹ 280/-
   - ✓ Trays - ₹ 10 x 420 trays = ₹ 4200/3 = ₹ 1400/-
   - ✓ Cocopeat - ₹12/- kg^{-1} x 300 kg = ₹3600/-
   - ✓ Neem cake – 5 kg x ₹ 40/- =₹ 200/-
   - ✓ Azospirillum- ₹50/-
   - ✓ Copper oxy chloride - ₹125/- kg^{-1}
2. **Land preparation: Total cost ₹2000/-**
   - ✓ Cultivator cost – ₹ 1000 ha^{-1} – 2 times = ₹ 2000/-
3. **Seed cost:**
   - ✓ Seed rate – 200 g ha^{-1}
   - ✓ Gap filling – 30 g (15% additional seed requirement for each variety)
   - ✓ 200 g + 30 g = 230 g (each variety)
   - ✓ Cost of one packet –₹ 1500/- (Indra), ₹ 1610/- (Orobelle), ₹ 1580/- (Bomby)
   - ✓ Weight of one packet – 10 g
   - ✓ **Total seed cost : ₹ 34,500/- (Indra), ₹ 37,030/- (Orobelle), ₹ 36340/- (Bomby)**
4. **Cost of vermi compost and neem cake and application:**
   - ✓ Vermi compost – 12.5 t ha^{-1}
   - ✓ Cost of vermi compost – ₹ 8/- kg^{-1}
   - ✓ Total cost of vermicompost – ₹ 100000/- ha^{-1} (3 crop season)
   - ✓ One crop season – ₹ 33333 /-
   - ✓ Neem cake – 1500 kg ha^{-1}
   - ✓ Cost of neem cake – ₹40/- kg^{-1}
   - ✓ Total cost of neem cake – ₹ 60000/- (3 crop season)
   - ✓ One crop season – ₹ 20000/-
   - ✓ **Total cost = ₹ 33333 + ₹20000 = ₹ 53333/-**
   - ✓ **Application cost – ₹ 2000/-**
   - ✓ Women labour cost/day- ₹ 250/- ; No. of. Labour- 4
   - ✓ For two days – (250 x 4) x 2 = ₹ 2000/-
5. **Cost of Red soil:**
   - ✓ Cost per load – ₹ 3000/-
   - ✓ Number of loads – 20
   - ✓ Total cost of red soil – ₹ 60000/- (3 crop season)
   - ✓ **One crop season – ₹ 20000/-**
6. **Cost of biofertilizer:**
   - ✓ *Azospirillum* – 2 kg ha^{-1}
   - ✓ *Pseudomonas* – 2 kg ha^{-1}
   - ✓ Cost of *Azospirillum & Pseudomonas* – ₹ 50 kg^{-1}
   - ✓ **Total cost – ₹ 200/-**
7. **Labour cost:**
   - ✓ **Hand weeding – ₹8000/-**
   - ✓ Women labour cost/day- ₹ 250/- ; No. of. Labour- 4

- ✓ Total cost - (250 x 4) x 6 times = ₹ 6000/-
- ✓ **Transplanting – ₹ 3750/-**
- ✓ Women labour cost/day- ₹ 250/- ; No. of. Labour- 15
- ✓ Total cost – (250 x 15) = ₹ 3750/-
- ✓ **Bed preparation – ₹ 10000/-**
- ✓ **Irrigation cost:** (8 hrs –₹ 250/- ; 1 hr- ₹31/-)

  $I_{0.4}$ – 62 days x ₹31/- = ₹ 1922/-
  $I_{0.6}$ – 70 days x ₹31/- = ₹ 2170/-
  $I_{0.8}$ – 77 days x ₹31/- = ₹ 2387/-
  $I_{1.0}$ – 80 days x ₹31/- = ₹ 2480/-

8. Plant protection:

- ✓ **Neem oil** – ₹800/- (500ml - ₹ 160/- x 5 times = ₹ 800)
  (1 ml L^{-1}; 500 ml ha^{-1}; 2.5 L; 1 lit - ₹320/-)
  Labour charge for spraying – ₹1750/- (1 men labour – ₹350/- x 5 times = ₹1750/-)
- ✓ **Spinosad** – ₹ 7750/- (2 times -375 ml; ₹1550 x 5 = ₹ 7750/-)
  (0.25 ml^{-1}; 187.5 ml ha^{-1}; ₹ 1550/- 75 ml^{-1})
  Labour charge – ₹700 (1 men labour – ₹ 350/- x 2 times = ₹ 700/-)
- ✓ **Dimethoate** – 1200/- (₹ 400/- X 3 times = ₹ 1200/-)
  (2 ml L^{-1}; 1 L ha^{-1}; ₹ 400 L^{-1})
  Labour charge – ₹1050/- (1 men labour - ₹ 350/- x 3 times = ₹1050/-)
- ✓ **Fipronil** – ₹7000/- (₹ 1400/- X 5 times = ₹7000/-)
  (2ml L^{-1}; 1 L ha^{-1}; ₹1400 L^{-1})
  Labour charge – ₹ 1750/- (1 men labour – ₹350/- x 5 times = ₹ 1750/-)
- ✓ **Monocrotophos** – ₹ 550 L^{-1}
  (2 ml L^{-1}; 1 L ha^{-1}; ₹ 550 L^{-1})
  Labour charge – ₹350/- (1 men labour – ₹350/- x 5 times = ₹1750/-)
- ✓ **Copper oxy chloride** –₹ 1800/- (₹250 x 7.2 =1800/-)
  (3 g L^{-1}; 3.6 kg ha^{-1}; 30 ml drenching per plant; ₹250 500 g^{-1})
  Labour charge – ₹1250/- (5 women labour x 250/- = ₹1250/-)
- ✓ **Acephate** – 1125/- (1.5 x 250 = ₹ 375/- x 3 times = ₹ 1125/-)
  (1.5 g L-1; 750 g ha-1; ₹250 500 g^{-1})
  Labour charge – ₹ 1050/- (1 men labour - ₹350/- x 3 times = 1050/-)

9. Cost of fertilizer:

Recommended dose of fertilizer – 100:80:60 kg N P_2O_5 K_2O ha^{-1}
Cost of urea – ₹ 300/- bag^{-1} (50 kg)
Cost of SSP - ₹ 450/- bag^{-1} (50 kg)
Cost of MOP- ₹950/- bag^{-1} (50 kg)
Total fertilizer cost: F_{100}- 100% RDF
(217.41 kg Urea ha^{-1} = ₹1304.4/- ; 100.00 kg MOP ha-1= ₹1900/-)
Cost of SSP – ₹500 kg = ₹ 4500/-
19:19:19 – 20 kg ha^{-1}
Cost of 19:19:19 – ₹125/- kg ha^{-1}
Total cost of 19:19:19 = ₹ 2500/-
Potassium nitrate - 3.75 kg ha^{-1}
Cost of Potassium nitrate – ₹ 2000/- (25 kg bag)
Total cost of Potassium nitrate = ₹300/-

Fertigation – ₹ 3740/- (₹ 350/- for 8 hrs; 1 hr =₹ 44/-) (44 x 85 =₹3740)

10. **Trellising cost:**

G.I wire – 80 kg = ₹ 6400/- (₹80 kg^{-1})

Trellising thread – 200 kg = ₹24000/- (₹120 kg^{-1})

Labour cost – ₹4200/- (5 men labour; 350 x 6 x 2 days)

Total trellising cost – ₹36200 /- (2 season) = ₹18100 (1 season)

11. **Harvesting and packaging cost – ₹12000/- (250 x 40 women labour)**
12. **Transporting and Marketing -₹7000/-**
13. **Cost of water: ₹10/- ha mm^{-1}**
14. **Shade net cost per crop season – ₹120978/-**

APPENDIX E

Plant height (cm) of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

S.No.	Treatments	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	175 DAT
1	T_1 - Drip irrigation at 0.4 Epan + Indra	17.2	35.1	45.2	52.5	55.1	51.8
2	T_2 - Drip irrigation at 0.4 Epan + Orobelle	15.0	33.3	44.5	53.4	54.3	52.5
3	T_3 - Drip irrigation at 0.4 Epan + Bomby	14.0	31.9	41.5	52.1	52.7	45.7
4	T_4 - Drip irrigation at 0.6 Epan + Indra	17.2	35.8	46.3	55.9	54.9	55.4
5	T_5 - Drip irrigation at 0.6 Epan + Orobelle	15.7	33.1	41.6	51.8	55.3	52.5
6	T_6 - Drip irrigation at 0.6 Epan + Bomby	13.6	31.8	43.5	51.9	51.7	51.3
7	T_7 - Drip irrigation at 0.8 Epan + Indra	17.5	40.9	46.9	59.2	60.6	55.3
8	T_8 - Drip irrigation at 0.8 Epan + Orobelle	17.3	39.1	43.9	55.9	57.1	53.8
9	T_9 - Drip irrigation at 0.8 Epan + Bomby	13.7	36.0	42.5	53.2	55.1	53.2
10	T_{10} - Drip irrigation at 1.0 Epan + Indra	19.2	38.3	53.0	62.1	63.4	56.7
11	T_{11} - Drip irrigation at 1.0 Epan + Orobelle	18.0	40.3	49.2	57.8	60.8	54.2
12	T_{12} - Drip irrigation at 1.0 Epan + Bomby	14.4	34.8	43.2	55.8	54.6	49.1

Number of branches plant^{-1} of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

S.No.	Treatments	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	175 DAT
1	T_1 - Drip irrigation at 0.4 Epan + Indra	1.1	3.7	4.3	5.3	5.7	4.9
2	T_2 - Drip irrigation at 0.4 Epan + Orobelle	1.3	3.8	4.2	5.0	5.3	4.9
3	T_3 - Drip irrigation at 0.4 Epan + Bomby	0.7	3.5	4.1	4.7	4.8	4.3
4	T_4 - Drip irrigation at 0.6 Epan + Indra	1.2	3.7	4.4	5.7	5.8	5.2
5	T_5 - Drip irrigation at 0.6 Epan + Orobelle	0.8	4.0	4.0	5.5	5.7	5.3
6	T_6 - Drip irrigation at 0.6 Epan + Bomby	0.7	3.6	4.2	4.8	5.0	4.6
7	T_7 - Drip irrigation at 0.8 Epan + Indra	1.3	3.9	4.9	6.8	6.9	5.6
8	T_8 - Drip irrigation at 0.8 Epan + Orobelle	1.3	3.7	4.5	6.5	6.5	5.0
9	T_9 - Drip irrigation at 0.8 Epan + Bomby	0.9	3.8	4.3	5.6	5.8	4.7
10	T_{10} - Drip irrigation at 1.0 Epan + Indra	1.6	4.1	5.3	6.9	7.0	6.0
11	T_{11} - Drip irrigation at 1.0 Epan + Orobelle	1.3	3.6	4.5	6.5	6.6	5.3
12	T_{12} - Drip irrigation at 1.0 Epan + Bomby	0.9	3.9	4.1	6.2	6.4	5.1

Number of leaves plant^{-1} of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

S.No.	Treatments	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	175 DAT
1	T_1 - Drip irrigation at 0.4 Epan + Indra	10.3	32.0	38.7	52.7	50.1	47.6
2	T_2 - Drip irrigation at 0.4 Epan + Orobelle	9.7	33.9	40.4	50.3	48.8	45.6
3	T_3 - Drip irrigation at 0.4 Epan + Bomby	10.6	35.1	35.5	47.7	47.9	45.6
4	T_4 - Drip irrigation at 0.6 Epan + Indra	10.7	36.4	42.1	56.0	51.1	47.5
5	T_5 - Drip irrigation at 0.6 Epan + Orobelle	10.5	36.5	41.5	51.0	51.8	48.6
6	T_6 - Drip irrigation at 0.6 Epan + Bomby	9.4	35.0	38.4	49.4	50.1	46.4
7	T_7 - Drip irrigation at 0.8 Epan + Indra	11.7	38.2	42.3	53.5	52.6	50.5
8	T_8 - Drip irrigation at 0.8 Epan + Orobelle	10.5	36.4	42.2	51.9	53.8	47.5
9	T_9 - Drip irrigation at 0.8 Epan + Bomby	9.4	34.5	41.0	49.6	50.3	45.8
10	T_{10} - Drip irrigation at 1.0 Epan + Indra	12.5	40.4	43.0	58.1	57.7	49.5
11	T_{11} - Drip irrigation at 1.0 Epan + Orobelle	11.0	37.5	42.9	50.8	52.0	48.9
12	T_{12} - Drip irrigation at 1.0 Epan + Bomby	10.2	36.3	42.7	48.9	50.5	46.2

SPAD Chlorophyll Meter readings (SCMR) of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

S.No.	Treatments	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	175 DAT
1	T_1 - Drip irrigation at 0.4 Epan + Indra	41.2	46.6	54.2	53.5	55.3	52.0
2	T_2 - Drip irrigation at 0.4 Epan + Orobelle	41.9	46.9	53.0	57.3	55.4	56.1
3	T_3 - Drip irrigation at 0.4 Epan + Bomby	40.5	47.4	50.9	52.6	51.0	51.5
4	T_4 - Drip irrigation at 0.6 Epan + Indra	48.6	49.6	55.3	63.1	57.9	59.5
5	T_5 - Drip irrigation at 0.6 Epan + Orobelle	45.9	46.8	52.1	57.8	59.3	58.5
6	T_6 - Drip irrigation at 0.6 Epan + Bomby	44.2	43.4	52.1	61.0	56.8	50.7
7	T_7 - Drip irrigation at 0.8 Epan + Indra	50.5	52.7	62.2	62.8	62.4	64.4
8	T_8 - Drip irrigation at 0.8 Epan + Orobelle	47.9	49.7	55.3	62.1	60.8	62.5
9	T_9 - Drip irrigation at 0.8 Epan + Bomby	49.8	49.9	53.8	58.2	58.5	56.0
10	T_{10} - Drip irrigation at 1.0 Epan + Indra	52.7	54.1	64.3	64.1	65.1	66.0
11	T_{11} - Drip irrigation at 1.0 Epan + Orobelle	47.5	53.0	55.6	62.6	62.7	63.7
12	T_{12} - Drip irrigation at 1.0 Epan + Bomby	50.3	50.0	55.4	59.5	59.3	51.5

Leaf area index of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

S.No.	Treatments	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	175 DAT
1	T_1 - Drip irrigation at 0.4 Epan + Indra	0.027	0.38	0.80	1.50	1.47	1.06
2	T_2 - Drip irrigation at 0.4 Epan + Orobelle	0.029	0.42	0.86	1.51	1.48	0.98
3	T_3 - Drip irrigation at 0.4 Epan + Bomby	0.028	0.37	0.80	1.48	1.16	0.81
4	T_4 - Drip irrigation at 0.6 Epan + Indra	0.027	0.45	0.88	1.53	1.42	1.07
5	T_5 - Drip irrigation at 0.6 Epan + Orobelle	0.030	0.40	0.87	1.51	1.49	0.97
6	T_6 - Drip irrigation at 0.6 Epan + Bomby	0.026	0.37	0.76	1.43	1.32	0.85
7	T_7 - Drip irrigation at 0.8 Epan + Indra	0.030	0.45	1.00	1.86	1.60	1.02
8	T_8 - Drip irrigation at 0.8 Epan + Orobelle	0.033	0.43	0.94	1.67	1.48	0.92
9	T_9 - Drip irrigation at 0.8 Epan + Bomby	0.029	0.40	0.91	1.64	1.33	0.94
10	T_{10} - Drip irrigation at 1.0 Epan + Indra	0.041	0.49	1.10	1.99	1.69	1.10
11	T_{11} - Drip irrigation at 1.0 Epan + Orobelle	0.032	0.48	0.93	1.77	1.54	1.04
12	T_{12} - Drip irrigation at 1.0 Epan + Bomby	0.032	0.45	0.92	1.71	1.45	0.86

Total dry matter (kg ha^{-1}) of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

S.No.	Treatments	30 DAT	60 DAT	90 DAT		
				Shoot	Fruit	Total
1	T_1 - Drip irrigation at 0.4 Epan + Indra	23.5	172.7	466.4	152.7	619.1
2	T_2 - Drip irrigation at 0.4 Epan + Orobelle	22.4	180.2	486.5	145.3	631.8
3	T_3 - Drip irrigation at 0.4 Epan + Bomby	21.4	168.5	455.1	138.8	593.9
4	T_4 - Drip irrigation at 0.6 Epan + Indra	23.3	175.1	472.7	151.6	624.3
5	T_5 - Drip irrigation at 0.6 Epan + Orobelle	21.7	181.1	489.0	141.4	630.3
6	T_6 - Drip irrigation at 0.6 Epan + Bomby	22.7	182.1	491.6	147.2	638.8
7	T_7 - Drip irrigation at 0.8 Epan + Indra	25.9	185.6	501.1	168.1	669.1
8	T_8 - Drip irrigation at 0.8 Epan + Orobelle	22.7	196.5	530.5	147.3	677.7
9	T_9 - Drip irrigation at 0.8 Epan + Bomby	19.8	180.1	486.2	129.0	615.2
10	T_{10} - Drip irrigation at 1.0 Epan + Indra	27.8	193.5	522.4	180.5	702.8
11	T_{11} - Drip irrigation at 1.0 Epan + Orobelle	24.5	201.4	543.8	159.1	702.9
12	T_{12} - Drip irrigation at 1.0 Epan + Bomby	22.0	190.4	514.0	142.9	657.0

Contd…

Total dry matter (kg ha^{-1}) of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

S.No.	Treatments	120 DAT			150 DAT			178 DAT		
		Shoot	Fruit	Total	Shoot	Fruit	Total	Shoot	Fruit	Total
1	T_1 - Drip irrigation at 0.4 Epan + Indra	626.3	441.8	1188.1	852.7	851.5	1705.7	704.2	1078.6	1931.3
2	T_2 - Drip irrigation at 0.4 Epan + Orobelle	650.7	423.2	1194.0	901.5	801.5	1507.9	706.4	1089.7	1991.2
3	T_3 - Drip irrigation at 0.4 Epan + Bomby	612.6	407.0	1139.6	825.2	769.0	1466.6	697.6	934.3	1759.5
4	T_4 - Drip irrigation at 0.6 Epan + Indra	634.0	439.0	1193.0	867.9	833.0	1541.6	708.7	1133.6	2001.5
5	T_5 - Drip irrigation at 0.6 Epan + Orobelle	653.7	413.4	1187.1	907.5	781.8	1506.4	724.6	1030.2	1937.7
6	T_6 - Drip irrigation at 0.6 Epan + Bomby	656.9	428.1	1205.0	913.8	811.2	1533.5	722.3	1074.3	1988.1
7	T_7 - Drip irrigation at 0.8 Epan + Indra	668.4	480.2	1268.6	936.8	915.3	1638.6	723.2	1293.8	2230.7
8	T_8 - Drip irrigation at 0.8 Epan + Orobelle	704.1	428.2	1252.3	1008.3	811.3	1580.5	769.1	1171.2	2179.4
9	T_9 - Drip irrigation at 0.8 Epan + Bomby	650.4	382.4	1152.8	900.8	719.8	1454.9	735.1	1098.0	1998.8
10	T_{10} - Drip irrigation at 1.0 Epan + Indra	694.3	511.2	1325.5	988.6	977.4	739.7	762.3	1253.2	2241.8
11	T_{11} - Drip irrigation at 1.0 Epan + Orobelle	720.3	457.7	1298.0	1040.6	870.4	1644.2	773.7	1156.5	2197.1
12	T_{12} - Drip irrigation at 1.0 Epan + Bomby	684.2	417.4	1221.5	968.3	789.7	1538.9	749.2	1068.8	2037.1

Yield attributes of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

S.No.	Treatments	TSS (°Brix)	Ascorbic acid (mg 100 g^{-1})	Oleoresin (%)	Capsanthin (EOA value)	Capsaicin (%)
1	T_1 - Drip irrigation at 0.4 Epan + Indra	4.9	83	5.9	6484	0.08
2	T_2 - Drip irrigation at 0.4 Epan + Orobelle	5.1	123	7.3	7968	0.07
3	T_3 - Drip irrigation at 0.4 Epan + Bomby	6.0	119	7.9	35900	0.14
4	T_4 - Drip irrigation at 0.6 Epan + Indra	4.4	81	6.0	6218	0.08
5	T_5 - Drip irrigation at 0.6 Epan + Orobelle	5.1	123	7.2	6894	0.06
6	T_6 - Drip irrigation at 0.6 Epan + Bomby	6.0	110	7.8	34096	0.13
7	T_7 - Drip irrigation at 0.8 Epan + Indra	4.2	92	6.2	6997	0.08
8	T_8 - Drip irrigation at 0.8 Epan + Orobelle	5.4	130	7.2	8957	0.08
9	T_9 - Drip irrigation at 0.8 Epan + Bomby	6.4	121	8.2	42052	0.15
10	T_{10} - Drip irrigation at 1.0 Epan + Indra	4.5	95	6.4	7902	0.08
11	T_{11} - Drip irrigation at 1.0 Epan + Orobelle	5.3	123	7.2	10221	0.09
12	T_{12} - Drip irrigation at 1.0 Epan + Bomby	6.1	128	7.7	38458	0.15

Yield attributes of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

S.No.	Treatments	Fruit length (cm)	Fruit diameter (cm)	Pericarp thickness (mm)	Fruits plant^{-1} (no.)	Avg fruit weight (g fruit^{-1})	Fruit yield (kg plant^{-1})
1	T_1 - Drip irrigation at 0.4 Epan + Indra	8.26	5.84	4.36	11.53	63.19	0.80
2	T_2 - Drip irrigation at 0.4 Epan + Orobelle	8.45	5.94	4.76	9.03	70.06	0.76
3	T_3 - Drip irrigation at 0.4 Epan + Bomby	8.63	6.09	4.89	7.33	79.98	0.64
4	T_4 - Drip irrigation at 0.6 Epan + Indra	8.78	6.12	4.65	13.91	69.37	0.98
5	T_5 - Drip irrigation at 0.6 Epan + Orobelle	8.84	6.25	4.95	10.03	72.84	0.93
6	T_6 - Drip irrigation at 0.6 Epan + Bomby	9.18	6.50	5.00	8.13	83.59	0.85
7	T_7 - Drip irrigation at 0.8 Epan + Indra	9.07	6.64	4.78	15.63	69.03	1.15
8	T_8 - Drip irrigation at 0.8 Epan + Orobelle	9.17	6.85	4.95	11.73	82.67	1.07
9	T_9 - Drip irrigation at 0.8 Epan + Bomby	9.61	7.20	5.18	10.07	97.96	1.02
10	T_{10} - Drip irrigation at 1.0 Epan + Indra	9.68	7.17	4.77	17.10	82.17	1.37
11	T_{11} - Drip irrigation at 1.0 Epan + Orobelle	9.75	7.43	5.09	12.53	92.97	1.25
12	T_{12} - Drip irrigation at 1.0 Epan + Bomby	9.99	7.84	5.31	11.23	99.96	1.18

Nitrogen uptake (kg ha^{-1}) of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

S.No.	Treatments	30 DAT	60 DAT	90 DAT		
				Shoot	Fruit	Total
1	T_1 - Drip irrigation at 0.4 Epan + Indra	0.87	5.9	14.9	5.9	20.8
2	T_2 - Drip irrigation at 0.4 Epan + Orobelle	0.83	5.8	15.4	5.6	21.0
3	T_3 - Drip irrigation at 0.4 Epan + Bomby	0.79	5.4	14.1	5.3	19.4
4	T_4 - Drip irrigation at 0.6 Epan + Indra	0.87	5.9	15.9	6.1	22.0
5	T_5 - Drip irrigation at 0.6 Epan + Orobelle	0.81	6.2	16.1	5.6	21.8
6	T_6 - Drip irrigation at 0.6 Epan + Bomby	0.85	6.2	15.6	5.9	21.5
7	T_7 - Drip irrigation at 0.8 Epan + Indra	0.92	6.4	17.2	6.6	23.8
8	T_8 - Drip irrigation at 0.8 Epan + Orobelle	0.83	6.7	17.7	6.0	23.6
9	T_9 - Drip irrigation at 0.8 Epan + Bomby	0.74	6.0	16.2	5.2	21.5
10	T_{10} - Drip irrigation at 1.0 Epan + Indra	1.05	6.9	17.9	7.2	25.1
11	T_{11} - Drip irrigation at 1.0 Epan + Orobelle	0.94	7.2	18.3	6.5	24.8
12	T_{12} - Drip irrigation at 1.0 Epan + Bomby	0.83	6.4	16.3	5.7	22.0

Contd….

Nitrogen uptake (kg ha^{-1}) of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

S.No.	Treatments	120 DAT			178 DAT		
		Shoot	Fruit	Total	Shoot	Fruit	Total
1	T_1 - Drip irrigation at 0.4 Epan + Indra	20.3	15.7	35.9	24.7	36.5	61.2
2	T_2 - Drip irrigation at 0.4 Epan + Orobelle	20.5	14.2	34.7	27.2	36.1	63.3
3	T_3 - Drip irrigation at 0.4 Epan + Bomby	18.4	13.5	31.9	23.7	29.4	53.1
4	T_4 - Drip irrigation at 0.6 Epan + Indra	21.6	15.8	37.4	25.7	41.4	67.2
5	T_5 - Drip irrigation at 0.6 Epan + Orobelle	20.9	15.0	35.9	25.1	35.6	60.7
6	T_6 - Drip irrigation at 0.6 Epan + Bomby	20.3	15.6	35.9	26.8	35.7	62.5
7	T_7 - Drip irrigation at 0.8 Epan + Indra	22.2	17.8	40.0	28.2	47.9	76.0
8	T_8 - Drip irrigation at 0.8 Epan + Orobelle	22.1	16.0	38.0	30.9	40.7	71.7
9	T_9 - Drip irrigation at 0.8 Epan + Bomby	20.8	13.8	34.7	26.8	39.3	66.1
10	T_{10} - Drip irrigation at 1.0 Epan + Indra	24.1	19.4	43.5	31.0	46.6	77.6
11	T_{11} - Drip irrigation at 1.0 Epan + Orobelle	23.0	17.3	40.3	28.7	39.6	68.3
12	T_{12} - Drip irrigation at 1.0 Epan + Bomby	24.2	15.1	39.3	29.1	40.6	69.7

Phosphorus uptake (kg ha^{-1}) of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

S.No.	Treatments	30 DAT	60 DAT	90 DAT		
				Shoot	Fruit	Total
1	T_1 - Drip irrigation at 0.4 Epan + Indra	0.045	0.30	0.70	0.64	1.34
2	T_2 - Drip irrigation at 0.4 Epan + Orobelle	0.041	0.29	0.70	0.57	1.27
3	T_3 - Drip irrigation at 0.4 Epan + Bomby	0.037	0.26	0.61	0.53	1.13
4	T_4 - Drip irrigation at 0.6 Epan + Indra	0.041	0.28	0.65	0.66	1.31
5	T_5 - Drip irrigation at 0.6 Epan + Orobelle	0.042	0.31	0.74	0.59	1.33
6	T_6 - Drip irrigation at 0.6 Epan + Bomby	0.044	0.31	0.75	0.59	1.35
7	T_7 - Drip irrigation at 0.8 Epan + Indra	0.049	0.32	0.77	0.72	1.49
8	T_8 - Drip irrigation at 0.8 Epan + Orobelle	0.047	0.37	0.89	0.62	1.52
9	T_9 - Drip irrigation at 0.8 Epan + Bomby	0.040	0.33	0.79	0.54	1.33
10	T_{10} - Drip irrigation at 1.0 Epan + Indra	0.057	0.36	0.85	0.83	1.68
11	T_{11} - Drip irrigation at 1.0 Epan + Orobelle	0.053	0.39	0.98	0.70	1.68
12	T_{12} - Drip irrigation at 1.0 Epan + Bomby	0.046	0.36	0.87	0.61	1.48

Contd….

Phosphorus uptake (kg ha^{-1}) of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

S.No.	Treatments	120 DAT			178 DAT		
		Shoot	Fruit	Total	Shoot	Fruit	Total
1	T_1 - Drip irrigation at 0.4 Epan + Indra	0.63	1.69	2.32	0.51	3.05	3.56
2	T_2 - Drip irrigation at 0.4 Epan + Orobelle	0.70	1.51	2.21	0.48	2.80	3.27
3	T_3 - Drip irrigation at 0.4 Epan + Bomby	0.57	1.38	1.95	0.36	2.27	2.63
4	T_4 - Drip irrigation at 0.6 Epan + Indra	0.64	1.73	2.37	0.58	3.36	3.94
5	T_5 - Drip irrigation at 0.6 Epan + Orobelle	0.78	1.56	2.34	0.57	2.86	3.43
6	T_6 - Drip irrigation at 0.6 Epan + Bomby	0.74	1.57	2.31	0.42	2.87	3.29
7	T_7 - Drip irrigation at 0.8 Epan + Indra	0.79	1.91	2.69	0.75	3.84	4.59
8	T_8 - Drip irrigation at 0.8 Epan + Orobelle	0.95	1.66	2.61	0.81	3.36	4.16
9	T_9 - Drip irrigation at 0.8 Epan + Bomby	0.86	1.44	2.30	0.75	3.02	3.78
10	T_{10} - Drip irrigation at 1.0 Epan + Indra	0.86	2.16	3.03	0.95	3.72	4.68
11	T_{11} - Drip irrigation at 1.0 Epan + Orobelle	1.03	1.80	2.83	0.73	3.57	4.30
12	T_{12} - Drip irrigation at 1.0 Epan + Bomby	0.85	1.64	2.49	0.48	3.47	3.96

Potassium uptake (kg ha^{-1}) of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

S.No.	Treatments	30 DAT	60 DAT	90 DAT		
				Shoot	Fruit	Total
1	T_1 - Drip irrigation at 0.4 Epan + Indra	0.27	1.64	4.25	1.16	5.41
2	T_2 - Drip irrigation at 0.4 Epan + Orobelle	0.24	1.65	3.34	1.08	4.42
3	T_3 - Drip irrigation at 0.4 Epan + Bomby	0.23	1.52	3.24	0.98	4.22
4	T_4 - Drip irrigation at 0.6 Epan + Indra	0.29	1.90	3.00	1.21	4.21
5	T_5 - Drip irrigation at 0.6 Epan + Orobelle	0.25	1.85	4.74	1.06	5.80
6	T_6 - Drip irrigation at 0.6 Epan + Bomby	0.26	1.79	4.60	1.06	5.66
7	T_7 - Drip irrigation at 0.8 Epan + Indra	0.35	2.32	4.61	1.31	5.92
8	T_8 - Drip irrigation at 0.8 Epan + Orobelle	0.29	2.29	5.92	1.07	7.00
9	T_9 - Drip irrigation at 0.8 Epan + Bomby	0.26	2.15	5.55	0.97	6.52
10	T_{10} - Drip irrigation at 1.0 Epan + Indra	0.37	2.49	6.45	1.48	7.93
11	T_{11} - Drip irrigation at 1.0 Epan + Orobelle	0.30	2.48	6.20	1.18	7.38
12	T_{12} - Drip irrigation at 1.0 Epan + Bomby	0.31	2.49	6.47	1.18	7.65

Contd….

Potassium uptake (kg ha^{-1}) of capsicum different days after transplanting as influenced by different drip irrigation levels and varieties under shade net.

S.No.	Treatments	120 DAT			178 DAT		
		Shoot	Fruit	Total	Shoot	Fruit	Total
1	T_1 - Drip irrigation at 0.4 Epan + Indra	4.76	3.06	7.83	6.19	7.47	13.65
2	T_2 - Drip irrigation at 0.4 Epan + Orobelle	4.71	3.11	7.82	6.19	7.35	13.54
3	T_3 - Drip irrigation at 0.4 Epan + Bomby	4.49	2.88	7.37	5.76	5.95	11.71
4	T_4 - Drip irrigation at 0.6 Epan + Indra	5.59	3.34	8.93	7.36	8.30	15.65
5	T_5 - Drip irrigation at 0.6 Epan + Orobelle	5.36	3.06	8.42	7.12	7.00	14.13
6	T_6 - Drip irrigation at 0.6 Epan + Bomby	5.15	2.74	7.90	6.87	7.01	13.88
7	T_7 - Drip irrigation at 0.8 Epan + Indra	6.39	3.61	9.99	9.33	9.44	18.77
8	T_8 - Drip irrigation at 0.8 Epan + Orobelle	6.69	3.09	9.78	9.39	8.19	17.58
9	T_9 - Drip irrigation at 0.8 Epan + Bomby	6.01	2.86	8.88	8.63	7.86	16.49
10	T_{10} - Drip irrigation at 1.0 Epan + Indra	7.41	3.92	11.34	10.38	9.45	19.82
11	T_{11} - Drip irrigation at 1.0 Epan + Orobelle	6.60	3.36	9.96	9.94	7.81	17.75
12	T_{12} - Drip irrigation at 1.0 Epan + Bomby	7.47	3.41	10.88	10.40	8.11	18.51

Yield (t ha^{-1}) of capsicum as influenced by different drip irrigation levels and varieties under shade net.

S.No.	Treatments	1st picking	2nd picking	3rd picking	4th picking	5th picking	Total
1	T_1 - Drip irrigation at 0.4 Epan + Indra	5.88	6.43	6.72	5.92	4.88	29.82
2	T_2 - Drip irrigation at 0.4 Epan + Orobelle	5.63	5.85	6.45	5.81	4.72	28.45
3	T_3 - Drip irrigation at 0.4 Epan + Bomby	4.74	5.61	4.13	5.46	4.24	24.18
4	T_4 - Drip irrigation at 0.6 Epan + Indra	6.50	8.55	8.13	7.30	6.38	36.85
5	T_5 - Drip irrigation at 0.6 Epan + Orobelle	6.24	8.02	7.57	6.76	6.43	35.02
6	T_6 - Drip irrigation at 0.6 Epan + Bomby	6.23	6.46	7.13	6.72	5.23	31.76
7	T_7 - Drip irrigation at 0.8 Epan + Indra	7.64	9.75	8.61	9.00	8.07	43.07
8	T_8 - Drip irrigation at 0.8 Epan + Orobelle	7.54	9.09	8.24	8.09	7.26	40.22
9	T_9 - Drip irrigation at 0.8 Epan + Bomby	6.73	8.78	8.13	7.57	7.04	38.26
10	T_{10} - Drip irrigation at 1.0 Epan + Indra	11.11	10.88	9.75	10.88	8.68	51.29
11	T_{11} - Drip irrigation at 1.0 Epan + Orobelle	9.32	10.00	8.82	10.25	8.51	46.90
12	T_{12} - Drip irrigation at 1.0 Epan + Bomby	8.10	9.76	8.75	9.72	8.01	44.34

Cost of cultivation, gross, net returns and B: C ratio of as influenced by drip irrigation levels and varieties of capsicum under shade net.

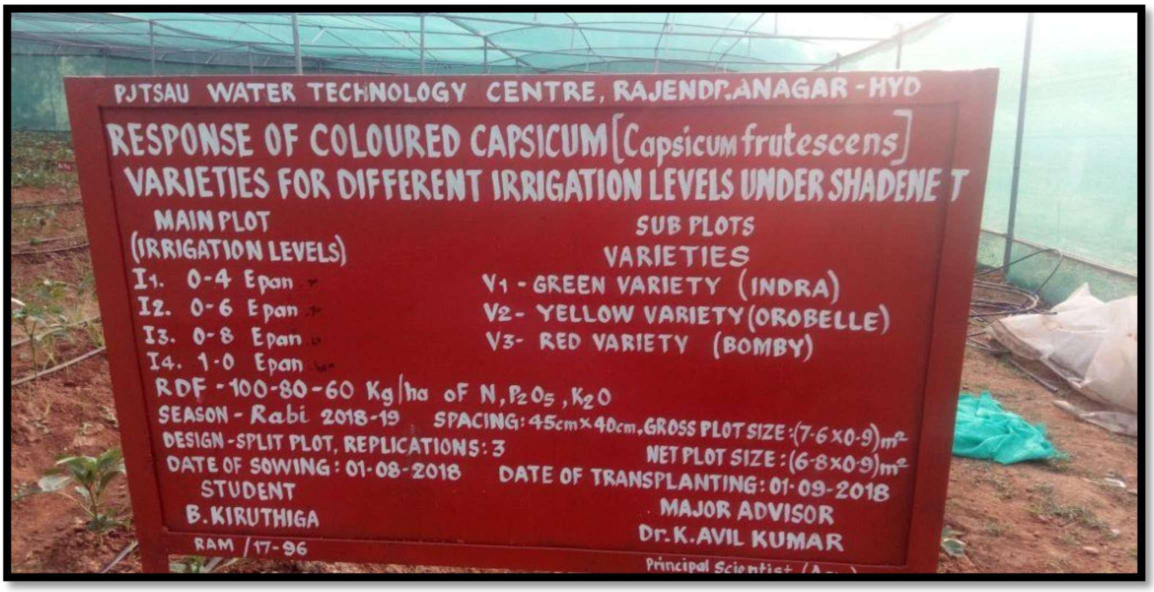
S.No.	Treatments	Cost of cultivation	Gross returns	Net returns	B:C ratio
1	T_1 - Drip irrigation at 0.4 Epan + Indra	337207	596367	259160	1.8
2	T_2 - Drip irrigation at 0.4 Epan + Orobelle	339737	853460	513723	2.5
3	T_3 - Drip irrigation at 0.4 Epan + Bomby	339047	725415	386368	2.1
4	T_4 - Drip irrigation at 0.6 Epan + Indra	339092	736970	397878	2.2
5	T_5 - Drip irrigation at 0.6 Epan + Orobelle	341622	1050488	708866	3.1
6	T_6 - Drip irrigation at 0.6 Epan + Bomby	340932	952883	611951	2.8
7	T_7 - Drip irrigation at 0.8 Epan + Indra	340936	861450	520514	2.5
8	T_8 - Drip irrigation at 0.8 Epan + Orobelle	343466	1206713	863247	3.5
9	T_9 - Drip irrigation at 0.8 Epan + Bomby	342776	1147838	805062	3.3
10	T_{10} - Drip irrigation at 1.0 Epan + Indra	342582	1025745	683163	3.0
11	T_{11} - Drip irrigation at 1.0 Epan + Orobelle	345112	1407008	1061896	4.1
12	T_{12} - Drip irrigation at 1.0 Epan + Bomby	344422	1330302	985880	3.9

Irrigation water applied, effective rainfall, total water and water productivity of capsicum as influenced by different drip irrigation levels and varieties under shade net.

S.No.	Treatments	Irrigation water applied (mm)	Special operations (mm)	Effective rainfall (mm)	Total irrigation water (mm)	Total irrigation water (m^3)	Water productivity (kg m^{-3})
1	T_1 - Drip irrigation at 0.4 Epan + Indra	219.3	26.0	82.6	3278.7	327.9	9.1
2	T_2 - Drip irrigation at 0.4 Epan + Orobelle	219.3	26.0	82.6	3278.7	327.9	8.7
3	T_3 - Drip irrigation at 0.4 Epan + Bomby	219.3	26.0	82.6	3278.7	327.9	7.4
4	T_4 - Drip irrigation at 0.6 Epan + Indra	366.0	26.0	74.6	4666.2	466.6	7.9
5	T_5 - Drip irrigation at 0.6 Epan + Orobelle	366.0	26.0	74.6	4666.2	466.6	7.5
6	T_6 - Drip irrigation at 0.6 Epan + Bomby	366.0	26.0	74.6	4666.2	466.6	6.8
7	T_7 - Drip irrigation at 0.8 Epan + Indra	520.5	26.0	64.2	6107.2	610.7	7.1
8	T_8 - Drip irrigation at 0.8 Epan + Orobelle	520.5	26.0	64.2	6107.2	610.7	6.6
9	T_9 - Drip irrigation at 0.8 Epan + Bomby	520.5	26.0	64.2	6107.2	610.7	6.3
10	T_{10} - Drip irrigation at 1.0 Epan + Indra	672.5	26.0	58.6	7571.2	757.1	6.8
11	T_{11} - Drip irrigation at 1.0 Epan + Orobelle	672.5	26.0	58.6	7571.2	757.1	6.2
12	T_{12} - Drip irrigation at 1.0 Epan + Bomby	672.5	26.0	58.6	7571.2	757.1	5.9

Post harvest available soil nutrient status (kg ha^{-1}) of capsicum under different drip irrigation levels and varieties under shade net.

S.No.	Treatments	N	P_2O_5	K_2O
1	T_1 - Drip irrigation at 0.4 Epan + Indra	141.6	42.9	120.1
2	T_2 - Drip irrigation at 0.4 Epan + Orobelle	140.9	42.7	120.0
3	T_3 - Drip irrigation at 0.4 Epan + Bomby	141.3	42.8	120.0
4	T_4 - Drip irrigation at 0.6 Epan + Indra	140.2	42.5	119.1
5	T_5 - Drip irrigation at 0.6 Epan + Orobelle	139.0	42.1	117.9
6	T_6 - Drip irrigation at 0.6 Epan + Bomby	140.3	42.5	119.1
7	T_7 - Drip irrigation at 0.8 Epan + Indra	138.2	41.9	117.5
8	T_8 - Drip irrigation at 0.8 Epan + Orobelle	137.7	41.7	117.0
9	T_9 - Drip irrigation at 0.8 Epan + Bomby	138.7	42.0	117.7
10	T_{10} - Drip irrigation at 1.0 Epan + Indra	137.3	40.7	115.0
11	T_{11} - Drip irrigation at 1.0 Epan + Orobelle	137.0	40.7	111.4
12	T_{12} - Drip irrigation at 1.0 Epan + Bomby	136.3	40.6	114.0



Experimental field board

Bed preparation

Fertigation unit (Venturi system)

General view at 30 DAT

Plants at flowering stage (60 DAT)

Plants at 90 DAT

Indra (Green variety)

Orobelle (Yellow variety)

Bomby (Red variety)


Review visit by chairman


Pan evaporimeter


Taking SCMR observation

SPAD meter

Refractometer

Lux meter

Thermohygrometer

Vernier calipher