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Effect of Irrigation and Fertigation Regimes on Growth and Yield Parameters of Chilli Crop Under Different Colours of Shadenet

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Abstract

An experiment was conducted to decide suitable agro techniques for drip-fertigated chilli cultivation under coloured shadenets, during late *rabi* season of 2021-2022. The experiment was conducted in split-split design at the Institutional Farm of Precision Farming Development Centre, Department of Irrigation and Drainage Engineering, Dr. A. S. College of Agril. Engineering and Technology, Mahatma Phule Krishi Vidyapeeth, Rahuri Maharashtra. The main treatments consisted of three irrigation regimes *viz*., 0.60 (I_1), 0.80 (I_2) and 1.0 ETc (I_3), the sub treatments had three fertigation regimes *viz*., 100 (F_1), 120 (F_2) and 140% RDF (F_3) and shadenets of different colours *viz*., white shadenet (S_1), black shadenet (S_2), green+white shadenet (S_3), green+black shadenet (S_4) and no shadenet (i.e. control (S_5), open field), were the sub sub treatments, with three replications. Water soluble fertilizers were scheduled at alternate days through drip and daily irrigation was scheduled on the basis of crop evapo-transpirtation approach. The MPKV recommended Phule Jal software was used to estimate the reference evapotranspiration using FAO Penman-Monteith formula. The study revealed maximum plant height and stem girth under drip irrigation @ 1.0 ETc and fertigation at 140% RDF under black shadenet house (i.e. I_3 F_3 S_2). Similarly, the maximum number of branches per plant and plant spread was observed for daily drip irrigation @ 1.0 ETc and fertigation at 140% RDF under white shadenet house (i.e. $I_3F_3S_1$). The weight of chilli fruit (6.95 g) and yield of chilli (16.09 q per 1000 m^2) was maximum under treatnment $I_3F_3S_1$ (1.0 ETc x 140% RDF x White shadenet), which was at par with that of $I_3F_2S_1$, $I_3F_1S_1$, $I_2F_3S_1$, $I_2F_2S_1$, $I_2F_1S_1$, $I_3F_3S_3$, $I_3F_2S_3$ and $I_3F_1S_3$. The benefit cost ratio was found to be higher 1.52 in treatement $I_3F_3S_1$. The study reveals drip fertigated chilli cultivation to be profitable under white and green+white shadenet with daily drip irrigation @ 1.0 ETc and fertigation @ 140% RDF. The experimental result will be useful to the farmers engaged in chilli cultivation under semi-arid conditions.

Key words : Chilli, Colour shadenet, irrigation and fertigation regimes, growth, protected cultivation, yield.

Chili (*Capsicum annum* L.) is a vegetable crop grown throughout the world in a wide range of climatic conditions from Solanaceae family and classified as fruit vegetable crop. As the world becomes increasingly dependent on vegetable production, it is necessary to make efficient use of available water and bring more area under irrigation. Drip irrigation provides potential for higher crop yields and better water use efficiency through control of the soil environment and water conservation. Drip irrigation is a modern pressurized irrigation techniques that has being highly effective in applying water and nutrients directly to the root zone, where the crop needs most. Drip irrigation system reduces the unwanted water loss and results in higher (more than 90%) application efficiency with uniform water application, in precise quantities. Fertigation involves fertilizer application along with the irrigation water through the drip system. Fertigation, besides providing several advantages over traditional methods, gives the flexibility of fertilizer application precisely according to the plant's requirements. This ensures applying the proper amount of N, P_2O_5 and K_2O at the specific growth stage to ensure nutrient absorption at the correct time, enhancing the effectiveness of fertilizer use, reducing leaching and minimizing environmental contamination (Spehia *et al*., 2021).

A shadenet house is a structure surrounded by agricultural nets or another type of woven cloth to let the air, moisture, and sunlight through the openings as needed. It develops a suitable microclimate that is beneficial to the growth of plants. These nets offer a partially controlled environment by significantly lowering the light and heat reaching crops planted underneath them. This enables extending the cultivation seasons and also facilitates off-season cultivation of crops (Behera *et al.*, 2016). According to research findings, compared to open environments, protected cultivation can increase vegetable crop productivity by 3 to 5 times (Bhardwaj *et al.,* 2012). The coloured shadenet are reported to alter the spectral characteristics and micro climatic environment, enhancing the crop growth and productivity.

Material and Methods

The present investigation was carried out at Institutional Farm of Precision Farming Development Centre, Department of Irrigation and Drainage Engineering, Dr. A. S. College of Agril. Engineering and Technology, Mahatma Phule Krishi Vidyapeeth, Rahuri Maharashtra.

Location, climate and weather condition : The study area falls under the tropical zone with an average annual rainfall of 511 mm. The maximum and minimum temperature ranges from 21.4 to 42°C and 8.7 to 30.8°C, respectively with the average annual temperature about 25.9°C. The annual pan evaporation ranges from 3.7 to 12.4 mm per day. The annual wind speed ranges from 3.2 to 13.09 km per hr. The annual maximum and minimum relative humidity ranges from 59 to 90 per cent and 21 to 61 per cent, respectively.

The experiment was carried out in split-split plot design with three main factors as shadenet colours, irrigation regimes and fertigation regimes with three replications. The 45 days old healthy chilli seedlings (variety- VNR-277) were transplanted on the raised bed during the first week of January, 2022. All shading nets had 50 % shading. The soil media used in shadenet houses was made up of red soil (30%), FYM (30%), sand (30%) and rice husk (10%). The open field had clayey soil . The pH and EC of soil media used in shadenet house was 6.77 and 0.10 dS m-1, respectively and pH and EC of soil in open field was 7.20 and 0.27 dS m^{-1}, respectively.

The experimental plot had forty-five treatment combinations of shadenet colours i.e. white shadenet (S_1), black shadenet (S_2), Green+white shadenet (S3), Green+Black shadenet (S_4) and No shadenet (S_5) (i.e. open field), three irrigation regimes i.e. 0.60 (I_1), 0.80 (I_2) and 1.0 (I_3) ETc and three fertigation regimes i.e. 100 (F_1), 120 (F_2) and 140 (F_3) % RDF (recommended dose of fertilizers) with three replications. Water soluble fertilizers were scheduled at alternate days through drip irrigation as per recommended dose of fertilizers (i.e. 150:75:75 NPK kg ha^{-1}). The irrigation water was applied daily to the crop through drip irrigation system and soluble fertilizers were applied by using ventury assembly. The irrigation scheduling was done as per the treatment, on the basis of crop evapo-transpirtation (ETc). The reference evapotranspiration was calculated using FAO Penman-Monteith formula using a MPKV recommended Phule Jal software. The volume of water to be applied for each treatment plot was computed by the equation (1.1)

$$V = d \times A \quad \ldots. (1.1)$$

Where, V is volume of water, lit, d is depth of water, mm and A is area of plot, m^2.

The time of operation (hr) of drip irrigation system for each treatment was calculated by equation (1.2)

To = V/ q.n.EU ….(1.2),

Where, To is time of operation of drip irrigation unit for respective treatment (hr), V is volume of water to be applied per irrigation, lit; q is average discharge of emitter in respective treatments (lph), EU is emission uniformity of drip irrigation unit (0.95) and n is number of emitters per plot.

The different biometric observations *viz*. Plant height, Stem girth, No. of branches plant^{-1}, days to 50% flowering, crop spread were recorded periodically at an interval of 30 days. Similiarly, the environmental parameter viz. temperature and relative humidity, were monitored on daily basis. The yield parameters viz. fruit weight, fruit girth, fruit length and yield (q per 1000 m^2) were recorded for sample plants in each plot at harvest.

Result and Discussion

Growth Parameters : The observation on various growth parameters *viz*., plant height, stem girth, number of branches plant^{-1}, plant spread at harvest and days required to 50 per cent flowering were recorded and are presented in Table 1.

Plant height : The chilli plant height at 150 DAP was significantly influenced by irrigation regimes, fertigation regimes and colours of shadenet.

Table 1. Growth parameters as affected by different treatments

Treatments	Plant height (cm)	Stem girth (cm)	No. of branches plant^{-1}	North-South direction spread (cm)	East-West direction spread (cm)	Days to 50% flowering
A. Irrigation regimes (I)						
I_1 : 0.6 ETc	72.13	3.2	5.49	36.65	32.58	64.98
I_2 : 0.8 ETc	92.95	3.36	6.73	47.54	43.38	62.58
I_3 : 1.0 ETc	104.09	4.1	10.14	60.65	54.46	59.99
S.E.m±	0.697	0.086	0.059	0.481	0.229	0.141
C.D. at 5%	2.746	0.339	0.234	1.92	0.892	0.554
B. Fertigation regimes (F)						
F_1 : 100% RDF	86.25	3.35	6.58	45.91	39.58	63.33
F_2 : 120% RDF	89.65	3.5	7.52	49.34	43.56	62.68
F_3 : 140% RDF	92.11	3.76	8.28	52.96	46.54	61.54
S.E.m±	0.296	0.049	0.097	0.25	0.328	0.099
C.D. at 5%	0.915	0.151	0.298	0.769	1.01	0.306
C. Shadenet colour (S)						
S_1 : White shadenet	105.33	3.8	8.6	56.77	51.32	53.4
S_2 : Black shadenet	105.08	3.85	6.99	55.89	50.22	65.94
S_3 : Green + White shadenet	100.97	3.71	8.13	55.5	49.3	60.2
S_4 : Green + Black shadenet	95.77	3.61	7.62	53.56	48.58	63.93
S5 : Open Field	41.48	2.69	5.96	26.95	16.64	69.11
S.E.m±	0.379	0.046	0.089	0.376	0.259	0.126
C.D. at 5%	1.059	0.128	0.251	1.047	0.727	0.354
D. Interaction (I x F x S)						
S.E.m±	1.113	0.293	0.254	0.805	0.766	0.377
C.D. at 5%	3.138	0.865	0.764	2.404	2.285	NS

Effect of irrigation regimes : The maximum plant height was recorded in regime I3 (104.09 cm). While, the minimum plant height was recorded under the regime I_1 (72.13 cm). This might be due to availability of sufficient moisture under the I_3 (1.0 ETc) regime to support better growth, while I_1 (0.6 ETc) and I2 (0.8 ETc) regime showed limited growth as these treatments were subjected to moisture stress. Similar results were also reported by Firake *et al*. (2019) for broccoli and Maida *et al*. (2017) for chilli crop.

Effect of fertigation regimes : The maximum value of plant height was recorded in regime F_3 (92.11cm) indicating that the plant height positively responds to higher levels of fertilizers, The minimum plant height was recorded under the regime F_1 (86.25 cm) as shown in Table 1. This might be due to reduced the nutrients availability to the plants. Similar result were reported by Firake *et al*. 2019 and Maind *et al*. 2018 for chilli crop.

Effect of shadenet : The maximum plant height was recorded (105.33 cm) in white shadenet (S_1) which was at par with (S_2) black shadenet as compared to the other shadenets. It might be due to spectral modification due to the white and black shadenet resulting in increase in plant height. The minimum plant height (41.48 cm) in open field (S_5), was due to unfavourable climatic conditions like high temperature during crop growing season of chilli crop as presented in Table 3. Firake *et al*. (2019) reported similar results for broccoli crop.

Effect of interaction : The statistically higher plant height (123.36 cm) was observed under treatment I3F3S2 (1.0 ETc x 140% RDF x Black shadenet), which was at par with that of $I_3F_3S_1$, $I_3F_2S_1$ and $I_3F_2S_2$ treatment and statistically lower plant height (46.47 cm) was observed under I1F1S5 (0.6 ETc x 100% RDF x No shadenet i.e. (Open field), as presented in Table 2.

Table 2. Interaction effect on growth parameters by different treatments

Treatments	Plant height (cm)	Stem girth (cm)	No. of branches plant^{-1}	NSD	EWD
$I_1 F_1 S_1$	80.73	3.16	7.62	40.79	33.3
$I_1 F_2 S_1$	81.06	3.3	8.35	41.07	36.3
$I_1 F_3 S_1$	82.31	3.44	8.89	46.17	37.2
$I_2 F_1 S_1$	99.31	3.46	10.01	50.17	45.1
$I_2 F_2 S_1$	108.98	3.54	10.09	54.17	47.8
$I_2 F_3 S_1$	112.15	3.64	10.53	55.49	49.6
$I_3 F_1 S_1$	118.14	4.5	10.85	63.83	56.7
$I_3 F_2 S_1$	122.48	5.21	13.8	75.47	64.7
$I_3 F_3 S_1$	122.56	5.44	15.06	76.02	66.4
$I_1 F_1 S_2$	78.22	3.2	6.27	36.19	31.83
$I_1 F_2 S_2$	80.98	3.25	7.24	37.98	35.1
$I_1 F_3 S_2$	83.78	3.36	8.03	44.31	36.3
$I_2 F_1 S_2$	98.87	3.54	7.98	51.7	42.8
$I_2 F_2 S_2$	112.78	3.72	7.81	54.02	46.2
$I_2 F_3 S_2$	115.12	4	8.01	55.03	48.22
$I_3 F_1 S_2$	119.78	4.2	10.39	64.04	52.3
$I_3 F_2 S_2$	122.12	5.3	11.76	71024	54.55
$I_3 F_3 S_2$	123.36	5.45	13.76	72.94	57.2
$I_1 F_1 S_3$	78.19	3.14	7.27	37.44	30.52
$I_1 F_2 S_3$	79.75	3.21	7.96	37.52	35.19
$I_1 F_3 S_3$	83.49	3.52	8.7	40.67	35.49
$I_2 F_1 S_3$	99.15	3.81	9.24	49.7	43.88
$I_2 F_2 S_3$	103.99	4	9.33	51.06	46.57
$I_2 F_3 S_3$	106.99	4.25	9.89	55.39	48.24
$I_3 F_1 S_3$	111.66	4.27	10.62	62.28	56.79
$I_3 F_2 S_3$	114.73	5.1	13.46	71.73	61.39
$I_3 F_3 S_3$	117.78	5.28	14.75	74.54	65.4
$I_1 F_1 S_4$	74.1	3.02	6.66	33.27	30.1
$I_1 F_2 S_4$	78.2	3.1	7.78	35.01	33.62
$I_1 F_3 S_4$	79.66	3.33	8.41	42.79	34.28
$I_2 F_1 S_4$	96.12	3.51	8.61	50.79	41.28
$I_2 F_2 S_4$	97.33	3.68	8.82	53.3	44.76
$I_2 F_3 S_4$	101.34	3.91	8.62	53.42	45.58
$I_3 F_1 S_4$	102.92	4	11.27	61.75	53.25
$I_3 F_2 S_4$	108.99	4.12	12.38	67.47	59.71
$I_3 F_3 S_4$	112.66	4.93	14.15	73.16	62.4
$I_1 F_1 S_5$	33.24	2.21	5.97	22.16	17.51
$I_1 F_2 S_5$	34.04	2.27	6.69	22.29	18.22
$I_1 F_3 S_5$	34.67	2.31	7	22.47	19.95
$I_2 F_1 S_5$	37.04	2.44	7.36	22.8	20.65
$I_2 F_2 S_5$	38.47	2.47	7.28	23.14	20.33
$I_2 F_3 S_5$	40.87	2.51	7.62	24	22.29
$I_3 F_1 S_5$	42.65	2.54	9.05	24.02	24.03
$I_3 F_2 S_5$	45.31	2.61	10.16	26.6	24.87
$I_3 F_3 S_5$	46.47	2.72	10.22	27.05	26.82
S.E. m±	1.113	0.293	0.254	0.805	0.766
C. D. at 5%	3.138	0.865	0.764	2.404	2.285

NSD=North-South Direction Spread(cm), EWD=East-West Direction Spread(cm)

Stem girth : An average stem girth of chilli plant was significantly influenced by irrigation and fertigation regimes under different colours of shadenet), as presented in Table 1.

Effect of irrigation regimes : The maximum value of stem girth (150 days after transplanting) was recorded in the treatment I3 (1.0 ETc), (4.10 cm), it was significantly superior over the other irrigation regimes. While, the minimum stem girth was recorded under the regime I_1 (3.20 cm, as presented in Table 1. This might be due to chilli plants under I_3 (1.0 ETc) regime were able to receive the amount of water they needed to support their growth, while those under the I1 (0.6 ETc) and I_2 (0.8 ETc) regime might have experienced some degree of water stress, which limited their growth. Similar results were also reported by Firake *et al*. (2019) for broccoli crop.

Effect of fertigation regimes : The maximum value of stem girth was recorded (3.76 cm) in F3 (140% RDF) and it was significantly superior to other fertigation regimes while minimum value of stem girth was recorded (3.35cm) under the regime F_1 (100% RDF), as presented in Table 1. It might be due to higher levels of fertilizer in F_3 (140% RDF) f to satisfy the nutrient requirement of the crop. Similar result were reported by Firake *et al*. (2019).

Effect of shadenet : The maximum value of stem girth (3.85 cm) was recorded in black shadenet (S_2) followed by white colour of shadenet (S_1). The minimum stem girth (2.69 cm) was observed in open field (S_5). This might be due to the adverse climatic conditions viz. high temperature during crop growing season. Similar result were reported by Firake *et al*. (2019).

Effect of interaction : The stem girth (5.45cm) was observed significantly more under I3F3S1 (1.0 ETc x 140 % RDF x White shadenet), which was at par with that of $I_3F_3S_2$, $I_3F_2S_2$, $I_3F_3S_3$, $I_3F_2S_1$ and $I_3F_2S_3$ treatments. However, the minimum stem girth was (2.72 cm) due to $I_1F_1S_5$ (0.6 ETc x 100% RDF x No shadenet (Open field)), as presented in Table 2.

Number of branches plant^{-1} : The number of branches per plant of chilli was significantly influenced by irrigation and fertigation regimes under different shadenets.

Effect of irrigation regimes : The maximum number of branches per plant was recorded (10.14 cm) in I_3 (1.0 ETc) irrigation regime, which was significantly superior to other irrigation regimes, as presented in Table 1. This might be due to sufficient moisture availability, optimal nutrients uptake and optimum soil temperature under 100% ETc treatment. While, the minimum number of branches per plant was recorded under the regime I1 (5.49cm). Similar finding was reported by Maida *et al*. 2017 in chilli.

Effect of fertigation regimes : The maximum value of number of branches per plant was recorded (8.28) by F_3 (140% RDF) regime which was followed by F_2 (120% RDF), as presented in Table 1. This might be due to better nutrients availability under F_3 (140% RDF) regime resulting in better branching in chilli crop as compared to F_1 (100% RDF) and F_2 (120% RDF) regime. Similar results were reported by Kaur *et al*. 2019 in cucumber.

Effect of shadenet : The maximum value of number of branches per plant (8.60) was recorded in white shadenet (S_1), which was significantly superior due to other shadenet. The minimum number of branches per plant (5.96) was due to open field (S_5). This might be due unfavourable climatic conditions in open field. Similar result were reported by Rajasekar *et al*. 2013.

Effect of interaction : The number of branches per plant (15.06) was observed

significantly more under $I_3F_3S_1$ (1.0 ETc x 140% RDF x White shadenet), which was at par with that of $I_3F_3S_3$ treatment and minimum number of branches per plant (10.12) due to $I_1F_1S_5$ (0.6 ETc x 100% RDF x No shadenet (Open field)) presented in Table 2. The results indicates that white shadenet promotes better branching in chilli crop.

Plant spread : The plant spread was significantly influenced by irrigation and fertigation regimes under different colours of shadenet, as presented in Table 1.

Effect of irrigation regimes : The maximum north-south direction spread was recorded (60.65 cm) for I_3 (1.0 ETc), which was significantly superior over the other irrigation regimes, as presented in Table 1. Similarly, the maximum east-west direction spread was also recorded (54.46 cm) in I_3 regime (1.0 ETc), which was significantly superior over other irrigation regimes. This might be due to sufficient moisture availability, optimal nutrients uptake and optimum soil temperature under 100% ETc irrigation regime. Similar findings were also reported by Firake *et al*. 2019 for broccoli crop.

Effect of fertigation regimes : The maximum north-south direction spread of chilli plant was recorded (52.96 cm) under regime F_3 (140% RDF), which was significantly superior over other regimes. Similarly, the maximum east-west direction spread was recorded (46.54 cm) for F_3 regime (140% RDF), which was significantly superior over other fertigation regimes. This might be due to high nutrients availability under F_3 (140% RDF) than F_1 (100% RDF) and F_2 (120% RDF) Similar findings were also reported by Maind *et al*. 2018 for chilli crop, Nikzad *et al*. 2020 for cabbage crop and Nandeshwar *et al*. 2019 for chilli crop.

Effect of colours of shadenet : The maximum north-south direction and east-west direction spread (56.77 cm and 51.32 cm) was recorded for S_1 (white shadenet), which was at par with black colours shadenet. It might be the effect of optical properties of the shadenet. The minimum north-south direction spread of 26.95 cm and minimum east-west direction spread of 16.64 cm was observed in open field (S_5). This might be due unfavourable climatic conditions. Similar results were also reported by Firake *et al*. 2019 for broccoli crop.

Effect of interaction : The spread of chilli plant (76.02 cm and 66.4 cm) was observed significantly more under $I_3F_2S_1$ (1.0 ETc x 120% RDF x White shadenet), which was at par with that of $I_3F_2S_1$ and $I_3F_3S_3$ treatments and minimum spread of chilli plant (27.05 cm and 26.82 cm) was observed in $I_1F_1S_5$ (0.6 ETc x 100% RDF x No shadenet) i,e, Open field, as presented in Table 2.

Days to 50 % flowering

Effect of irrigation regimes : The days to 50% flowering for chilli plant was significantly influenced by irrigation regimes. It is observed that the minimumdays required to 50% flowering of chilli plant was (59.99 days) due to regime I_3 (1.0 ETc) which was significantly superior over other irrigation regimes. This might be due to sufficient moisture availability, optimal nutrients uptake and optimum soil temperature under @ 100% ETc irrigation. Similar finding was reported by Maida *et al*. 2017 in chilli.

Effect of fertigation regimes : The days to 50% flowering of chilli was significantly influenced by fertigation regimes. It is observed that the minimum days required to 50% flowering of chilli plant was recorded (61.54 days) due to regime F_3 (140% RDF) which was significantly superior over other fertigation regimes F_1 (100% RDF) and F_2 (120% RDF). This might be due to high nutrients availability

under F_3 (140% RDF) Similar finding was reported by Maind *et al*. 2018 for chilli crop.

Effect of colours of shadenet : The days to 50% flowering of chilli was significantly influenced by different colours of shadenet. It is observed that the minimum days required to 50% flowering of chilli plant was recorded (53.40 days) due to S_1 (white shadenet) which was significantly superior over other colours of shadenet. The white shadenet house resulted in early flowering. This might be due to effect of optical properties of the covering material. The crop grown in open field condition recorded late due to unfavorable climatic conditions and heat stress. Similar finding was also reported by Rajasekar *et al*. 2013.

Effect of interaction : The interaction of all the three factors in respect of final days to 50 % flowering of chilli plant was non-significant as presented in Table 2.

Environmental parameter : During the research work, it was found that the environmental parameter play an important role in growth, development and production of chilli. Temperature and relative humidity are the major factors for plant growth and it was recorded throughout the experiment from 3rd January, 2022 to 1st June, 2022.

Temperature : The temperature inside the white shadenet, black shadenet, green+white shadenet, green+black shadenet and in open field has been recorded for 150 days of period and the average monthly readings were presented in Table 3.

Effect of temperature on yield of chilli under different colours of shadenet : During the experiment, the temperature inside the shadenet house has great influenced on crop growth. It has been observed minimum temperature in white shadenet as compare to the other shadenet during the growth stages of crop. On the other hand open field temperature was observed higher as compare to the shadenet house. The highest production of chilli was found in white shadenet and lowest production was found in open field. Production of chilli in white shadenet was higher due to it provide favourable temperature for the germination, growth and development of crop (Bastias Richard, 2013; Bhardwaj, 2013, Bhadur, 2009 and Kakade *et al*. 2018 in okra).

Table 3. Average temperature values inside different shadenets

Months	W	B	G+W	G+B	Open field
Jan	22.32	26.18	23.54	25.27	27.55
Feb	26.10	29.32	27.83	28.49	31.22
March	30.98	34.85	32.41	34.22	35.68
April	33.23	37.52	35.00	36.70	38.24
May	34.56	42.16	38.32	39.20	43.56

Relative humidity : The relative humidity inside the white shadenet, black shadenet, green+white shadenet, green+black shadenet and in open field has been recorded for 150 days of period and the average monthly readings were presented in Table 4.

Effect of relative humidity on yield of chilli under different colours of shadenet: During the experiment, the relative humidity inside the shadenet house has great influenced on crop growth. The white shadenet observed maximum relative humidity as compare to the

Table 4. Average relative humidity values inside different shadenets

Months	W	B	G+W	G+B	Open field
Jan	47	38	45	41	35
Feb	31	27	30	29	27
March	27	24	25	25	22
April	25	23	24	23	17
May	23	20	22	21	15

other shadenets during the growth stages of crop. On the other hand relative humidity in open field was observed minimum among the shadenet house (Navale, 2003 and Naraghi, 2010). White shadenet had higher relative humidity than green+white, green+black and black shadenet. The highest production of chilli was found in white shadenet and lowest production was found in open field. Production of chilli in white shadenet was higher due to it provide favourable temperature for the germination, growth and development of crop.

Yield parameter : The observations for different parameters effecting the chilli yield are presented in Table 5 and Table 6.

Fruit weight : The average weight of chilli at the time of harvest was significantly influenced by irrigation and fertigation regimes under different colours of shadenet.

Effect of irrigation regimes : The highest weight of chilli was recorded in regime I3 (6.19 g), followed by regime I_2 (5.23 g).The lowest weight of chilli was recorded in regime I_1 (4.73 g) as presented in Table 5. Similar finding were reported by Maida *et al*. 2017 and Supekar *et al*. 2021 for chilli crop.

Effect of fertigation regimes : The highest weight of chilli was recorded in regime F_3 (5.53 g) which was at par with regime F_2 (5.45 g). The lowest weight of chilli was recorded in regime F_1 (5.16 g) as presented in Table 5. Similar finding was reported by Supekar *et al*. 2021 for chilli crop.

Effect of colours of shadenet : The highest weight of chilli was recorded under shadenet S_1 (6.22 g) which was at par with shadenet S_3 (5.66 g), followed by shadenet S_2 (5.63 g) and S_4 (5.48 g). While, the control treatment (open field) S5 (3.92 g) recorded lowest weight of chilli fruit. Similar finding was reported by Jakhar *et al*. 2016 in cucumber.

Effect of interaction : Table 5, reveals that the maximum weight of chilli (6.95 g) under treatment $I_3F_3S_1$ (1.0 ETc x 140 % RDF x White shadenet), which was at par with that of $I_3F_2S_1$, $I_3F_1S_1$ and $I_3F_3S_2$ treatments.

Fruit girth

Effect of irrigation regimes : The highest fruit girth of chilli was recorded in regime I_3 (1.13 cm) which was at par with regime I_2 (1.07 cm). The lowest fruit girth of chilli was recorded in regime I_1 (1.02 cm). Similar finding was reported by Supekar *et al*. 2021.

Effect of fertigation regimes : The fruit girth of chilli in regime F_3 (1.10 cm) was at par

Table 5. Yield parameters affected by different treatments

Treatments	Fruit weight (g)	Fruit girth (cm)	Fruit length (cm)	Yield (q)
A. Irrigation regimes (I)				
I_1 : 0.6 ETc	4.73	1.02	8.12	7.82
I_2 : 0.8 ETc	5.23	1.07	8.81	10.61
I_3 : 1.0 ETc	6.19	1.13	9.49	11.5
S.E.m±	0.108	0.008	0.09	0.27
C.D. at 5%	0.424	0.031	0.352	1.059
B. Fertigation regimes (F)				
F_1 : 100% RDF	5.16	1.04	8.44	9.21
F_2 : 120% RDF	5.45	1.08	8.91	10.01
F_3 : 140% RDF	5.53	1.1	9.08	10.7
S.E.m±	0.029	0.009	0.1	0.254
C.D. at 5%	0.089	0.028	0.309	0.783
C. Shadenet colour (S)				
S_1 : White shadenet	6.22	1.22	10.56	15.88
S_2 : Black shadenet	5.63	1.1	10.44	6.78
S_3 : Green + White shadenet	5.66	1.09	9.2	12.99
S_4 : Green + Black shadenet	5.48	1.03	8.65	10.21
S_5 : Open Field	3.92	0.92	5.2	4.01
S.E.m±	0.034	0.014	0.128	0.359
C.D. at 5%	0.094	0.039	0.361	1.013
D. Interaction (I x F x S)				
S.E.m±	0.103	0.042	0.385	1.078
C.D. at 5%	0.29	NS	NS	2.89

Table 6. Interaction effect of different treatments

Treatments	Weight (g)	Fruit girth (cm)	Fruit length, (cm)	Yield, q per 1000 sq. m
$I_1 F_1 S_1$	5.05	0.99	7.73	11.14
$I_1 F_2 S_1$	5.98	1.17	8.81	11.25
$I_1 F_3 S_1$	6.05	1.19	9.91	13.17
$I_2 F_1 S_1$	6.07	1.2	9.96	14.12
$I_2 F_2 S_1$	6.15	1.24	10.27	14.39
$I_2 F_3 S_1$	6.15	1.26	10.42	14.73
$I_3 F_1 S_1$	6.76	1.27	10.44	14.95
$I_3 F_2 S_1$	6.78	1.29	11	15.79
$I_3 F_3 S_1$	6.95	1.39	11.48	16.09
$I_1 F_1 S_2$	4.13	1.01	6.79	5.55
$I_1 F_2 S_2$	4.6	1.04	7.43	6.12
$I_1 F_3 S_2$	4.97	1.09	8.59	6.56
$I_2 F_1 S_2$	5.4	1.06	9.64	6.58
$I_2 F_2 S_2$	5.92	1.07	10.19	6.79
$I_2 F_3 S_2$	5.95	1.08	10.27	6.9
$I_3 F_1 S_2$	6.4	1.08	10.33	6.98
$I_3 F_2 S_2$	6.64	1.14	10.37	7.37
$I_3 F_3 S_2$	6.69	1.12	10.44	8.14
$I_1 F_1 S_3$	4.57	1.02	7.24	9.47
$I_1 F_2 S_3$	4.88	1.04	8.73	9.73
$I_1 F_3 S_3$	5.04	1.06	8.8	11.34
$I_2 F_1 S_3$	5.08	1.06	9.85	12.13
$I_2 F_2 S_3$	5.77	1.07	10.28	12.6
$I_2 F_3 S_3$	5.77	1.08	10.34	12.91
$I_3 F_1 S_3$	6.61	1.11	10.38	13.36
$I_3 F_2 S_3$	6.62	1.13	10.41	13.89
$I_3 F_3 S_3$	6.63	1.2	10.65	14.04
$I_1 F_1 S_4$	4.16	0.98	6.86	7.19
$I_1 F_2 S_4$	4.74	1.01	7319	7.42
$I_1 F_3 S_4$	4.8	1.01	8.64	7.88
$I_2 F_1 S_4$	4.9	1.01	9.71	8.31
$I_2 F_2 S_4$	5.59	1.02	10.24	8.65
$I_2 F_3 S_4$	5.62	1.03	10.3	9.75
$I_3 F_1 S_4$	6.43	1.02	10.36	9.945
$I_3 F_2 S_4$	6.54	1.05	10.38	10.32
$I_3 F_3 S_4$	6.6	1.14	10.52	10.95
$I_1 F_1 S_5$	3.26	0.79	3.89	1.92
$I_1 F_2 S_5$	3.52	0.82	4.23	2.09
$I_1 F_3 S_5$	3.54	0.83	4.56	2.89
$I_2 F_1 S_5$	3.77	0.89	4.58	3.48
$I_2 F_2 S_5$	3.97	0.89	4.68	4.05
$I_2 F_3 S_5$	3.99	0.92	4.97	4.81
$I_3 F_1 S_5$	4.35	0.99	5.91	5.16
$I_3 F_2 S_5$	4.38	1.03	6.42	5.79
$I_3 F_3 S_5$	4.52	1.07	7.17	5.95
S.E. m±	0.103	0.042	0.385	1.078
C. D. at 5%	0.290	NS	NS	2.89

with regime F_2 (1.08 cm), while, the control F_1 (1.04 cm) recorded lowest fruit girth. Similar finding was reported by Supekar *et al*. 2021

Effect of colours of shadenet : The fruit girth of chilli under white shadenet S_1 (1.22 cm) was at par with black shadenet S_2 (1.10 cm), while, the control treatment (open field) S_5 (0.92 cm) recorded lowest fruit girth. Similar finding was reported by Jakhar *et al*. 2016 for cucumber crop.

Effect of interaction : The fruit girth of chilli was not influenced significantly by interaction effect of irrigation and fertigation regimes under different colours of shadenet as shown in Table 6.

Fruit length

Effect of irrigation regimes : The longest length of chilli fruit was recorded in regime I_3 (9.49 cm) which was at par with regime I_2 (8.81 cm). The shortest length of chilli fruit was recorded in regime I_1 (8.12 cm) as presented in Table 5. Similar findings were reported by Maida *et al*. 2017 and Supekar *et al*. 2021 for chilli crop.

Effect of fertigation regimes : The longest length of chilli fruit was recorded in regime F_3 (9.08 cm) which was at par with regime F_2 (8.91cm).The shortest length of chilli fruit was recorded in regime F_1 (8.44 cm) as presented in Table 5. Similar finding were reported by Nandeshwar *et al*. 2019 and Supekar *et al*. 2021 for chilli crop.

Effect of colours of shadenet : The longest length of chilli fruit was recorded under white shadenet S_1 (10.56 cm) which was at par with black shadenet S_2 (10.44 cm), while, the control treatment (open field) S_5 (5.20 cm) recorded shortest length of chilli fruit Similar finding was reported by Jakhar *et al*. 2016 in cucumber.

Effect of interaction : The fruit length of chilli was not influenced significantly by interaction effect of irrigation and fertigation regimes under different colours of shadenet as shown in Table 6.

Yield per 1000 m^2 : The irrigation regimes and fertigation regimes under different colours of shadenet has significant effect on the yield of chilli.

Effect of irrigation regimes

It is observed that the maximum yield of chilli per : 1000 m^2 was observed in irrigation regime I_3 (11.50 q 1000 m^{-2}), which was at par with irrigation regime I_2 (10.61 q 1000 m^{-2}). It might be due to the optimum soil moisture content maintained near the field capacity throughout the crop growth period. Under regime I_1 and I_2 the plants were subjected to water stress during growth period. The lowest yield was recorded in regime I_1 (7.82 q 1000 m^{-2}). Similar finding was reported by Maida *et al*. 2017 in chilli.

Effect of fertigation regimes : The maximum yield of chilli per 1000 m^{-2} was observed in F_3 regime (10.70 q 1000 m^{-2}) which was at par with F_2 regime (10.01 q 1000 m^{-2}). While the lowest yield was recorded in F_1 regime (9.21q 1000 m^{-2}) This might be due to high nutrients availability under F_3 (140% RDF) regime, than F_1 (100% RDF) and F_2 (120% RDF) regimes. Similar finding were reported by Maind *et al*. 2018 and Supekar *et al*. 2021 for chilli crop.

Effect of colours of shadenet : It is observed that the maximum yield of chilli per 1000 m^2 was observed under white shadenet S_1 (15.88 q 1000 m^{-2}), followed by green+white shadenet S_3 (12.99 q 1000 m^{-2}). This might be due to spectral modification of white colour shadenet resulting in favourable growing conditions. The lowest yield was recorded under open field S_5 (4.01 q per 1000 m^2). This adverse climatic conditions in open field. Similar finding were reported by Nangare *et al*. 2015 in tomato and Jakhar *et al*. 2016 in cucumber.

Effect of interaction : Table 6, reveals maximum yield of chilli per m^2 (16.09 q) under $I_3F_3S_1$ treatment (1.0 ETc x 140% RDF × White shadenet), followed by $I_3F_2S_1$ (15.79 q), $I_3F_1S_1$ (14.95 q), $I_2F_3S_1$ (14.73 q), $I_2F_2S_1$ (14.39 q) and $I_2F_1S_1$ (14.12 q). The lowest yield of chilli (0.192 q) was due to unfavourable climatic conditions in open field (control). The higher yields in the treatments of different shadenets with irrigation and fertigation regimes may be due to favourable moisture maintained in the root zone, its availability to plants, high nutrient availability and favourable environment maintained in the shadenet house than open field conditions.

Benefit : Cost ratio : The B:C ratio obtained under different treatments varied from 0.35 to 1.52 shown in Table 7. The maximum B:C ratio of 1.52 was obtained under treatment of $I_3F_3S_1$ (i.e. 1.0 ETc x 140 % RDF x White shadenet) which was at par with $I_3F_2S_1$ and the minimum B:C ratio of (0.29) was under $I_1F_1S_5$ (i.e. 0.6 ETc x 100% RDF x Open field). Patil *et al*. (2018) also reported that the economic analysis of cucumber production under open field with different fertigation levels revealed that the production is not economically viable as the B:C was less than 1.0.

Conclusion

1. The maximum plant height and stem girth was observed for treatment with scheduling of drip irrigation daily at 1.0 ETc and fertigation at 140% RDF to chilli under black shadenet house (i.e. $I_3F_3S_2$).

2. The maximum number of branches per plant and plant spread was observed for treatment with scheduling of drip irrigation daily at 1.0

Table 7. Benefit cost ratio influenced by different treatments

Treatments	B:C ratio	Treatments	B:C ratio
$I_1 F_1 S_1$	1.07	$I_2 F_3 S_3$	1.32
$I_1 F_2 S_1$	1.07	$I_3 F_1 S_3$	1.3
$I_1 F_3 S_1$	1.24	$I_3 F_2 S_3$	1.36
$I_2 F_1 S_1$	1.36	$I_3 F_3 S_3$	1.36
$I_2 F_2 S_1$	1.37	$I_1 F_1 S_4$	0.74
$I_2 F_3 S_1$	1.39	$I_1 F_2 S_4$	0.75
$I_3 F_1 S_1$	1.44	$I_1 F_3 S_4$	0.79
$I_3 F_2 S_1$	1.51	$I_2 F_1 S_4$	0.85
$I_3 F_3 S_1$	1.52	$I_2 F_2 S_4$	0.87
$I_1 F_1 S_2$	0.57	$I_2 F_3 S_4$	0.97
$I_1 F_2 S_2$	0.62	$I_3 F_1 S_4$	1.02
$I_1 F_3 S_2$	0.66	$I_3 F_2 S_4$	1.04
$I_2 F_1 S_2$	0.67	$I_3 F_3 S_4$	1.09
$I_2 F_2 S_2$	0.69	$I_1 F_1 S_5$	0.29
$I_2 F_3 S_2$	0.69	$I_1 F_2 S_5$	0.3
$I_3 F_1 S_2$	0.71	$I_1 F_3 S_5$	0.41
$I_3 F_2 S_2$	0.74	$I_2 F_1 S_5$	0.52
$I_3 F_3 S_2$	0.81	$I_2 F_2 S_5$	0.58
$I_1 F_1 S_3$	1.11	$I_2 F_3 S_5$	0.67
$I_1 F_2 S_3$	1.14	$I_3 F_1 S_5$	0.77
$I_1 F_3 S_3$	1.16	$I_3 F_2 S_5$	0.84
$I_2 F_1 S_3$	1.27	$I_3 F_3 S_5$	0.83
$I2 F_2 S3$	1.31		

ETc and fertigation at 140% RDF to chilli crop under white shadenet house (i.e. $I_3F_3S_1$).

3. The maximum weight of chilli (6.95 g) was observed under treatment $I_3F_3S_1$ (1.0 ETc x 140% RDF x White shadenet), which was at par with that of $I_3F_2S_1$, $I_3F_1S_1$ and $I_3F_3S_2$ treatments. The result showed the clear effect of colours of shadenet on fruiting ability of chilli crop. The weight of fruits observed in open field was lower than that shadenet house.

4. The significantly higher yield of chilli was obtained by the treatment $I_3F_3S_1$ (1.0 ETc x 140% RDF x White shadenet), which was at par with other treatments *viz*. $I_3F_2S_1$, $I_3F_1S_1$, $I_2F_3S_1$, $I_2F_2S_1$ and $I_2F_1S_2$. However, in shadenet cultivation, the goal is to maximize the crop yield and minimize the cost of inputs. In this case, the treatment $I_3F_3S_1$, though utilize the higher inputs over other treatments, the yield of chilli was highest i.e. 16.09 q 1000 m^2 or 16,090 q ha^{-1}. Therefore, $I_3F_3S_1$ treatment is better over others as it results in highest B:C ratio (1.52).

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