IMPACT OF DIFFERENT COLOUR LOW TUNNEL SHADE NETS AND MULCHES ON WATER USE EFFICIENCY AND NUTRIENT USE EFFICIENCY IN CHRYSANTHEMUM

ABSTRACT

An investigation was carried out in an experimental field of the College of Agricultural Engineering, University of Agricultural Sciences, Raichur, to investigate the effect of different coloured low tunnel shade nets and different mulches on water use efficiency and nutrient use efficiency of chrysanthemum. The results revealed that the values of daily evapotranspiration under different colours' low tunnel shade net were less than the values of evapotranspiration under open field for all months. It is because of the green-house effect and low radiation. The values of ET during the seasons were lower under white-coloured shade net compared to open field conditions. The results indicate that significant irrigation water savings occur in chrysanthemums under different coloured low tunnel shade nets as compared to open field cultivation. It is also found that the chrysanthemum crop requires approximately 31%, 28%, and 23% less water under white, green, and black shade net compared to the total water required under open field cultivation. The highest water use efficiency was recorded with the white colour low tunnel shade net (28.78 kg ha^{-1} mm^{-1}) and this was followed by the green shade net (28.64 kg ha^{-1} mm^{-1}), black shade net (13.09 kg ha^{-1} mm^{-1}) and lowest water use efficiency was recorded under open field conditions (10.58 kg ha^{-1} mm^{-1}). Among the different mulches, the highest water use efficiency was recorded by the use of white coloured mulch (24.36 kg ha^{-1} mm^{-1}) and this was followed by silver mulch (21.75 kg ha^{-1} mm^{-1}), black mulch (20.82 kg ha^{-1} mm^{-1}), and jute mulch (19.38 kg ha^{-1} mm^{-1}). The lowest water use efficiency was recorded where mulch was not used (15.05 kg ha^{-1} mm^{-1}). The highest nutrient use efficiency was recorded with the white colour low tunnel shade net (Nitrogen (N)=72.51 kg ha^{-1}, Phosphorous (P)=12.37 kg ha^{-1} and Potassium (K)=73.84 kg ha^{-1}) and this was followed by the green shade net (N=66.77 kg ha^{-1}, P=10.28 kg ha^{-1} and K=64.33 kg ha^{-1}), open field conditions (N=58.08 kg ha^{-1}, P=8.72 kg ha^{-1} and K=56.36 kg ha^{-1}) and lowest nutrient use efficiency was recorded under black shade net (N=51.60 kg ha^{-1}, P=6.98 kg ha^{-1} and K=49.75 kg ha^{-1}). Among the different mulches, the highest nutrient use efficiency was recorded by the use of white colour mulch (N=77.53 kg ha^{-1} P=11.74 kg ha^{-1} and K=73.20 kg ha^{-1}) and this was followed by silver mulch (N=70.50 kg ha^{-1}, P=10.61 kg ha^{-1} and K=66.86 kg ha^{-1}), black mulch (N=65.08 kg ha^{-1}, P=9.51 kg ha^{-1} and K=64.09 kg ha^{-}

^{1}), and jute mulch (N=57.75 kg ha^{-1}, P=8.96 kg ha^{-1}and K=64.09 kg ha^{-1}). The lowest nutrient use efficiency was recorded where mulch was not used (N=40.22 kg ha^{-1}, P=7.11 kg ha^{-1} and K=44.44 kg ha^{-1}). The results indicated that there is a bright scope for cultivation of chrysanthemum under white colour low tunnel shade net with white plastic mulch.

Keywords- Chrysanthemum, Low tunnel shade net, Mulches, Drip irrigation and Water use efficiency.

Introduction

"Growing cut-flowers has become one of the most important high-value agricultural industries worldwide. Chrysanthemum (Asteraceae) with high ornamental value. It is the fourth most popular cut flower in the world, and therefore, this flower occupies a very important position in the world cut flower industry" (Sun *et al.,* 2010, 2011). "Chrysanthemum is a long-lasting cut flower and it can be propagated vegetatively either through root suckers or terminal cuttings" (Shatnawi *et al.,* 2010). "It is estimated that there are more than 20,000 chrysanthemum cultivars in the world" (Anderson, 2007).

"Protected cultivation provides an option to increase chrysanthemum production by promoting an environment that improves the growth and development of plants. An economical alternative is the shade net, which protects horticultural plants (leaf and flower) from strong direct sun radiation, obtaining more vigorous plants with higher yields and flowers of better quality than in the open field" (Tafoya *et al.,* 2018). They can also provide natural medicine for humans and some animals. In India, the availability of water is limited. Therefore, farmers need to adopt various types of water-saving irrigation techniques like growing crops under protected cultivation.

"The recent rise in global warming across the world has posed severe challenges to crop production. The challenges include an increase in air temperature and the intensity of solar radiation" (Meena *et al.,* 2014). Sustained high temperatures (35–40 °C) caused by high solar radiation might have increased the occurrence of abiotic disorders due to climate change (Ili *et al.,* 2012). "Nets have a long history in agricultural production, the documented benefits are physical protection against excessive radiation and environmental changes" (Shahak *et al.,* 2004). "Net covers have also been documented to maintain higher soil moisture and relative humidity within the immediate vicinity of crops" (Gogo *et al.,* 2014; Muleke *et al.,* 2014), "besides reducing the speed of wind blowing over the plants" (Shahak *et al.,* 2004). "There is vast potential for lowering crop irrigation requirements while maximizing yields per unit of water supplied. Colored shade netting not only influences the microclimate to which the plant is exposed but also exhibits special optical properties to optimize desirable physiological responses in plants" (Costa *et al.,* 2010). "Colored shade nets can be used to change the red to far-red light ratios that influence plant growth and development" (Stamps, 2009).

"Crops grown in open fields in a semi-dry climate are subjected to direct sunlight, high temperatures, and wind, resulting in high crop evapotranspiration and, therefore, demanding large amounts of water. In contrast, shade-houses favour plant growth since plants are less stressed when direct sunlight is avoided, the temperature is lower, the humidity is higher, wind velocity reduced and the ETc is low. Irrigation water requirements of 23% to 31% pan evaporation have been used for plants grown under 70% light reduction. In addition, water use efficiency increases under shade net conditions" (Jifon and Syvertsen, 2003).

MATERIALS AND METHODS

Raichur belongs to North Eastern Dry Zone-II of Karnataka under state agro-climatological classification. The weather data pertaining to the study area was collected from Meteorological Observatory, located at a distance of 500 m away in Main Agricultural Research Station, University of Agricultural Sciences, Raichur. The station receives an average rainfall of 630 mm. Average annual evaporation is 5.9 mm day^{-1} with 5.98 kmph wind speed, 7 hours of sunshine a day and relative humidity of 76.7 and 41.08% in morning and evening respectively. This experiment was under taken in the month of August-December 2020 at research fields of AICRP (PEASEM), College of Agricultural Engineering, University of Agricultural Sciences, Raichur. The experiment was laid out in a split plot design with two replications. The experiment consisted of different coloured shade nets i.e., white, green, black and control as the main treatment and different mulches as sub treatments i.e., white plastic mulch, silver plastic mulch, black plastic mulch, jute and no mulch condition. The experiment was replicated twice. Raised beds of 35 m in length, 1 m in width and 15 cm in height were prepared with a spacing of 1.5 m between two beds as a path, to enable easy cultural operations like weeding, spraying, harvesting etc. The beds were levelled after mixing well rotten farm yard manure and vermicompost. Drip lateral with a discharge capacity of 4 LPH was placed on the raised beds. As per the treatment plan, 30 microns of black, white and silver plastic mulch and jute mulches were laid on the bed every 7 m. After this, holes were made on the mulches at a distance of 30 cm by using a 3-inch diameter of PVC pipe. For erecting the low tunnel shade nets over the individual beds, arches made out of 6 mm iron rods were fixed at a distance of 1.5 m in such a way that the height of the midpoint was 1 m from the bed surface. Then the three different coloured shade nets (White, green and black colours) of 50 % light intensity were cladded on the arches to from low tunnels. Irrigation was provided to the beds a day before transplanting. Nearly 28 days old seedlings were transplanted in the main field. Healthy and uniformly grown nursery plants of chrysanthemum cv. marigold were planted at a spacing of 30 cm between rows and 30 cm between plants. Immediately light irrigation was provided with the help of the drip system. Subsequent irrigations were provided whenever it was required (1 to 2 hours in a day). The plant growth parameters like plant height, number of branches, plant spread, leaf area index and plant chlorophyll content was recorded by selecting five plants randomly in each replication in all the treatments after the 30 days of transplanting of chrysanthemum seedlings and those plants were tagged with a yellow tag to identify them for further observations. The plant height was measured from ground level to the tip of the plant with the help of meter scale, the average plant height was calculated by dividing the summation with five and the average was expressed in centimeters. Plant spread is also an important parameter of vegetative growth of the plant and it was measured with a help of meter scale. It was measured between outermost leaves in East West and North South direction and expressed in centimeter square. Number of branches per plant arising from the main stem were counted and recorded at each replication under each treatment and expressed in number of branches per plant.

The chlorophyll content of the tagged plants was recorded with SPAD-502 Plus chlorophyll meter. The leaf area index describing the plant canopy structure is a measure of crop growth and productivity. LAI was recorded with ACCUPARLP-80 ceptometer (Decagon Devices, Inc., Pullman, WA, USA) that estimate LAI using the amount of light energy transmitted by the plant canopy. The instrument measures Photo synthetically Active Radiation (PAR) with an accuracy of 1 $\mu mol\ m^{-2}\ s^{-1}$ and estimates LAI through PAR inversion technique based on Beer's law (Eq. (1) (Anonymous, 2013). A modified version of canopy light transmission and scattering model developed by Norman and Jarvis (1974) is used here as described in eq. (2).

The equipment consists of a light bar with 80 linearly spaced PAR sensors for measuring PAR under the plant canopy and an external PAR sensor to quantify incident PAR.

$$PAR_t = PAR_i \exp(-kz) \qquad \text{Eq. (1)}$$

Where,

PAR_t=PAR transmitted, measured near the ground surface

PAR_i=PAR incident at the top of the canopy

z=zenith angle (or path length of photons through some attenuation medium)

k=extinction coefficient.

In case of vegetation canopy ‘z’ account for LAI (Eq. (4)).

$$LAI = \frac{\left[\left(1-\frac{1}{2K}\right) f_b - 1\right] \ln \tau}{A\left(1-0.047 f_b\right)} \qquad \text{Eq. (2)}$$

Where,

A = Leaf absorptivity (by default it is set as 0.9 in LP-80)

f_b = Beam fraction (ratio between diffuse and beam radiation (LP-80 calculate f_b by comparing measured PAR values to the solar constant)

τ = Ratio of transmitted and incident PAR

K = Extinction coefficient, calculated by eq. (3)

$$K = \frac{\sqrt{x^2 + \tan\theta^2}}{x + 1.744(x+1.182)^{-0.733}} \qquad \text{Eq. (3)}$$

Where,

x = Leaf angle distribution parameter (<1 for vertical orientations)

θ = Solar zenith angle (calculated by the input data on local time, date, latitude, and longitude).

The yield is mainly depended on number of flower produced per plant, as a general tendency more number of flower more will be the flower yield per plant. Yield was recorded by counting the number of flowers at the time of each harvest and average number of flowers produced per plant was calculated. Fully opened flower were harvested from the representative plants at peak flowering stage and weighed using an electronic balance and expressed in grams. Fully bloomed or opened flower from tagged plants were collected and weighed using an electronic balance in each harvest, the arrived value was expressed as weight of flower per plant in grams. This was worked out by totaling the weight of flowers recorded at each harvest from net plots, and yield was expressed in tonnes per hectare. The observations were collected on the growth, reproductive and quality traits of the chrysanthemum flower. To record the various observations, five plants were randomly selected from each replication and in each treatment

3. Installation of pan evaporimeter:

A Class-A pan evaporimeter was installed in an extended portion inside the different coloured low tunnel shade net in order to measure daily evaporation and calculate the crop water requirement of chrysanthemum by following standard procedure. The amount of water required to compensate for the evapotranspiration loss from the cropped field is defined as the crop water requirement. Crop water requirement encompass the total amount of water used in evapotranspiration (Phocaides, 2001). Evaporation data were collected at the Main Agriculture Research Station, UAS, Raichur, under the control condition. Evaporation was monitored daily as per the standard of IMD (Pan Coefficient 0.70). Three types of different coloured low tunnel shade nets were used as main treatments, i.e., (white, green black shade nets and open field conditions), sub treatments i.e., (White, silver, black plastic mulch, jute mulch and without mulch). All covering types of treatments were compared with open field condition as (control). Air temperature relative humidity light intensity, soil moisture and soil temperature were measured using a digital thermometer, hygrometer, lux meter and digital theta probe, respectively. Evapotranspiration was measured using a class A pan under the shade net and control conditions. Water requirement under shade net was calculated. The amount of water required to compensate for the evapotranspiration loss from the cropped field is defined as the crop water requirement. Crop water requirement encompasses the total amount of water used in evapotranspiration (Phocaides, 2001). The weather data (temperature-minimum and maximum, sunshine hours, relative humidity and wind speed at the 10 m height and evapotranspiration) were collected from MARS, UAS, Raichur.

Water requirement of each plant was determined by using the following formula.

$$ET_c = K_c \times ET_0 \qquad \text{Eq. (4)}$$

Where,

ET_c = crop evapotranspiration / Crop water requirement, (mm day^{-1})

K_c = crop coefficient

ET_0 = Reference crop evapotranspiration (mm day^{-1})

The water requirement for each drip treatment was worked out based on this equation and the same was considered for providing irrigation.

Water use efficiency:

The water use efficiency (WUE) was calculated according to FAO (1982) as follows: The ratio of crop yield (Y) to the total amount of irrigation water use in the field for the growth season (IR);

$$\text{Water use efficiency (WUE)} = \frac{\text{Total crop yield (kg ha}^{-1}\text{)}}{\text{Total amount of water applied (mm)}} \qquad \text{Eq. (5)}$$

Nutrient use efficiency (NUE)

The nutrient use efficiency was calculated for each treatment separately for the nutrient components, N, P, and K with the eq. (6) (Dobermann, 2007).

$$\text{Nutrient use efficiency (NUE)} = \frac{\text{Crop yield (kg ha}^{-1}\text{)}}{\text{Total nutrient applied (N, P and K) (kg ha}^{-1}\text{)}} \qquad \text{Eq. (6)}$$

RESULTS AND DISCUSSION

Weather and climatic conditions

The weather data recorded during the experiment period under different colour low tunnel shade nets and control are presented in fig 1, fig 2 and fig 3. During the experiment period, the maximum temperature (37.90°C) was recorded under control conditions followed by the black shade net (35.80°C) and the green shade net (34.60°C). The minimum temperature (33.00°C) was recorded under the white shade net. Maximum relative humidity (86.20 %) was recorded under white shade net followed by, green shade net (82.30 %) and black shade net (79.00 %). Minimum relative humidity (77 %) was recorded under control conditions. Maximum light intensity (49600 lux) was recorded under control condition followed by white shade net (46800 lux) and green shade net (3700 lux). Minimum light intensity (33210 lux) was recorded under black shade net. The transmittance was recorded to be maximum in white coloured shade net and minimum under black shade net. White shade nets allowed higher Photo synthetically active radiation (PAR) and higher transmittance than other colour nets. The transpiration rate was minimum under white shade net due to the lower temperature. A similar trend was also reported by Gaurav *et al.* (2016), Meena *et al.* (2014) and Meena *et al.* (2015).

Growth parameters

Data depicted in table 1 indicates that there were significant differences in vegetative parameters i.e. plant height, the number of branches, plant spread, leaf area index and chlorophyll content of chrysanthemum where grown under different coloured low tunnel shade nets.

The growth parameters i.e. plant height (41.68 cm), number of branches (11.28), plant spread (42.70 cm), leaf area index (2.11), chlorophyll content (48.78) of chrysanthemum plants grown under white coloured low tunnel shade net was significantly higher followed by plants grown under green shade net at different stages of growth. The lowest growth parameters such as plant height (34.41 cm), number of branches (7.96), plant spread (35.20 cm), leaf area index (1.71) and chlorophyll content (42.96) were recorded under black shade net. The plant height (39.80 cm), number of branches (11.70), plant spread (40.88 cm), leaf area index (2.04), chlorophyll content (47.38) of chrysanthemum plants grown with white plastic mulch were significantly higher followed by silver mulch. The lowest vegetative parameters such as plant height (35.88 cm), number of branches (10.17), plant spread (37.74 cm), leaf area index (1.66), chlorophyll content (41.00) were recorded under no mulch condition.

The improved vegetative growth as evidenced by plant height, number of branches, leaf area index, and chlorophyll content under the different colour low tunnel shade nets may be due to the favourable weather conditions, i.e., lower and optimum temperature, and light intensity in white shade net when compared with black coloured shade net (Iglesias and Alegre, 2006). The results of the present study are in agreement with Hashem *et al.* (2011) and Soud *et al.* (2014), who found that vegetative growth of the chrysanthemum plants under a white shade net was higher than under other treatments. The influence on plant height by the white plastic mulch might be due to the fact that sun radiation enters through the white plastic mulch, but very little amount of radiation goes back to the environment, which slightly improved the soil temperature underneath the white mulch. A similar trend was also reported by Tegen *et al.* (2016) and Kishor *et al*. (2018).

Yield parameters

There was a significant difference among the treatments in yield parameters (Table 3). The higher flower yield per plant (0.15 kg) average flower weight (6.56 g) and flower yield per ha (8.72 t ha^{-1}) were recorded in plants grown under white colour shade net and this was followed by green shade net. The lowest flower yield per plant (0.07 kg) average flower weight (5.10 g) and flower yield per ha (4.43 t ha^{-1}) was recorded in plants under black colour shade net. The flower yield per plant (0.13 kg) average flower weight (6.25 g) and flower yield per ha (8.81 t ha^{-1}) of chrysanthemum plants grown under white plastic mulch was significantly higher followed by silver plastic mulch. Lower yield parameters such as flower yield per plant (0.08 kg), average flower weight (5.30 g) and flower yield per ha (4.59 t ha^{-1}) were noticed under no mulch conditions.

Significantly higher flower yield parameters were observed under the white colour shade net. The environment created by colored net increased average flower weight and the number of flower per plant due to the positive effect on increasing the plant biomass by increasing the availability of solar radiation and the efficiency of photosynthesis, promoting the growth rate of individual flowers, decreasing the growth period from anthesis to harvest and increasing production. The result obtained in the current study was in agreement with Soud *et al.* (2014), Hashem *et al.* (2011) and (Tafoya et al., 2018). Among the different mulches, white plastic mulch resulted in better growth parameters such as plant height, the number of branches, leaf area index and chlorophyll content. This could be due to efficient utilization of resources, high moisture retention for growth of plants and optimum soil temperature which led to higher flower yield. This is in confirmation with studies conducted by Rajablariani *et al.* (2012).

The total amount of water applied in irrigation treatment was 320.2, 336.6, 359.5 and 463.5 mm through drip irrigation in white, green, black shade nets and open field conditions, respectively and presented in table 2.

A significantly higher amount of water was applied under open field conditions (463.5 mm) followed by black shade net (395.5 mm) and green shade net (336.6 mm). Significantly less water was applied under white shade net (320.2 mm). This was due to the fact that under shade net evaporation losses were prevented which resulted in a higher amount of water available for plants, than the treatment without a shade net (control conditions). Higher WUE was noticed and then was saving of irrigation water under a white shade net. Similar results were obtained by Acharya *et al.* (2019), and Moller and Assouline (2007).

Water use efficiency

Water use efficiency indicates, the yield produced per unit the volume of water utilized. The yield obtained, volume of water applied and water use efficiencies were calculated and presented in table 3.

Maximum water use efficiency was recorded with white shade net (28.78 kg ha^{-1} mm^{-1}) which was closely followed by green shade net (28.64 kg ha^{-1} mm^{-1}) and black shade net (13.09 kg ha^{-1} mm^{-1}) while the lowest WUE was recorded under open field conditions (10.58 kg ha^{-1} mm^{-1}). The water use efficiency increases with increase in the yield and decreases with an increase in irrigation. This was due to the fact that under shade net evaporation losses were prevented which resulted in higher amount of water available for plants, than the treatment without a shade net (control conditions). The white colour low tunnel shade net distinctly improved the water use efficiency by reducing the water evaporation from the soil where chrysanthemum was planted. The present results obtained are in line with the findings of Acharya *et al.* (2019), Moller and Assouline (2007).

Among the mulches, maximum water use efficiency was recorded with application of white plastic mulch (24.36 kg ha^{-1} mm^{-1}), which was closely followed by silver plastic mulch (21.75 kg ha^{-1} mm^{-1}), black plastic mulch (20.82 kg ha^{-1} mm^{-1}) and jute mulch (19.38 kg ha^{-1} mm^{-1}) while the lowest WUE was recorded with no mulch (15.05 kg ha^{-1} mm^{-1}). The highest water use efficiency was found in treatment using white colour plastic mulch, similarly minimum water use efficiency was found in control conditions. This was due to fact that white and silver plastic colour mulch might have provided a better condition for better plant height, and more number of leaves, this led to the increase in yield of the crop when compared to unmulched treatment (control). The present results obtained are in line with the findings of Paul *et al.* (2013).

Nutrient use efficiency

The nutrient use efficiency by the chrysanthemum plant was significantly affected by different colour low tunnel shade nets and mulching conditions presented in table 3.

The nutrient use efficiency exhibited significant difference among the different colour low tunnel shade nets. The treatment with white colour low tunnel shade net exhibited highest nitrogen use efficiency (Nitrogen (N)=72.51 kg ha^{-1}, Phosphorous (P)=12.37 kg ha^{-1} and Potassium (K)=73.84 kg ha^{-1}) and this was followed by green colour low tunnel shade net (N=66.77 kg ha^{-1}, P=10.28 kg ha^{-1} and K=64.33 kg ha^{-1}). The nutrient use efficiency (N=51.60 kg ha^{-1}, P=6.98 kg ha^{-1} and K=49.75 kg ha^{-1}) was lowest in black colour low tunnel shade net. With respect to different colour mulches, white mulch exhibited higher nutrient use efficiency (N=77.53 kg ha^{-1} P=11.74 kg ha^{-1} and K=73.20 kg ha^{-1}) and this was followed by silver colour mulch (N=70.50 kg ha^{-1}, P=10.61 kg ha^{-1} and K=66.86 kg ha^{-1}). The lowest nutrient use efficiency N=40.22 kg ha^{-1}, P=7.11 kg ha^{-1} and K=44.44 kg ha^{-1}) was recorded in the treatment where no mulch was used. Significantly higher Nutrient use efficiency was observed under white colour shade net. Nutrient use efficiency was higher because of good root growth due to congenial growing conditions provided by the white shade net and white mulch might have resulted in higher root growth. The above results are in agreement with Airadevi (2014).

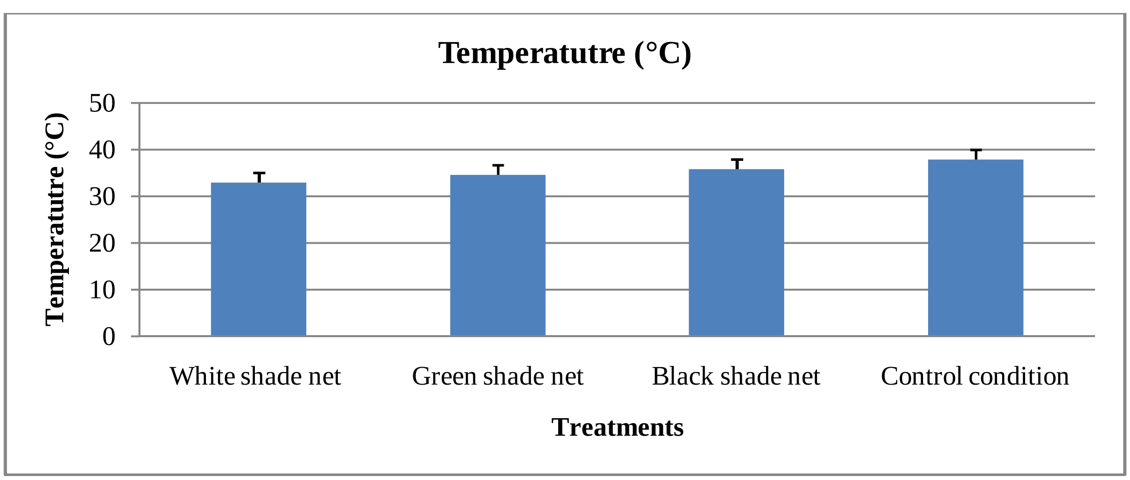

Fig 1 Temperature recorded during the experimental period in different treatments

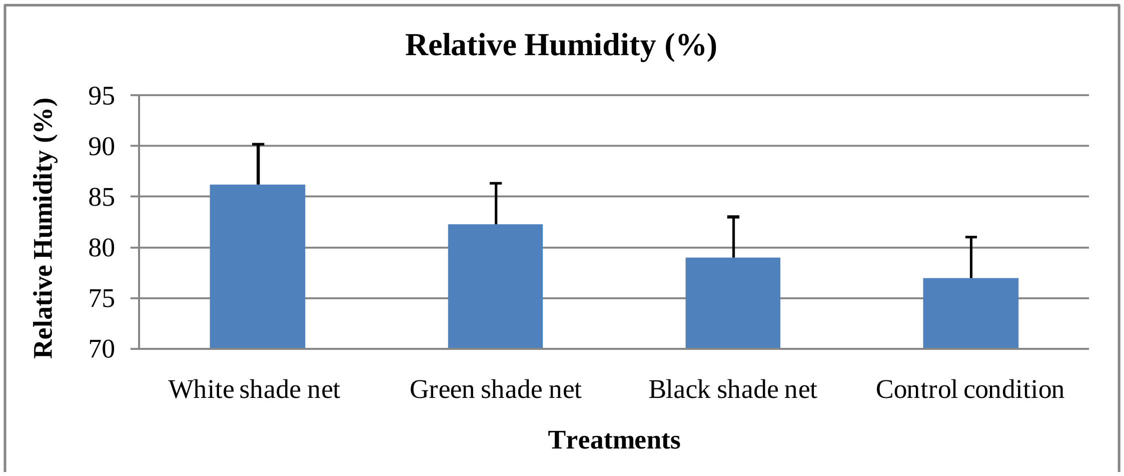

Fig 2 Relative humidity recorded during the experimental period in different treatments

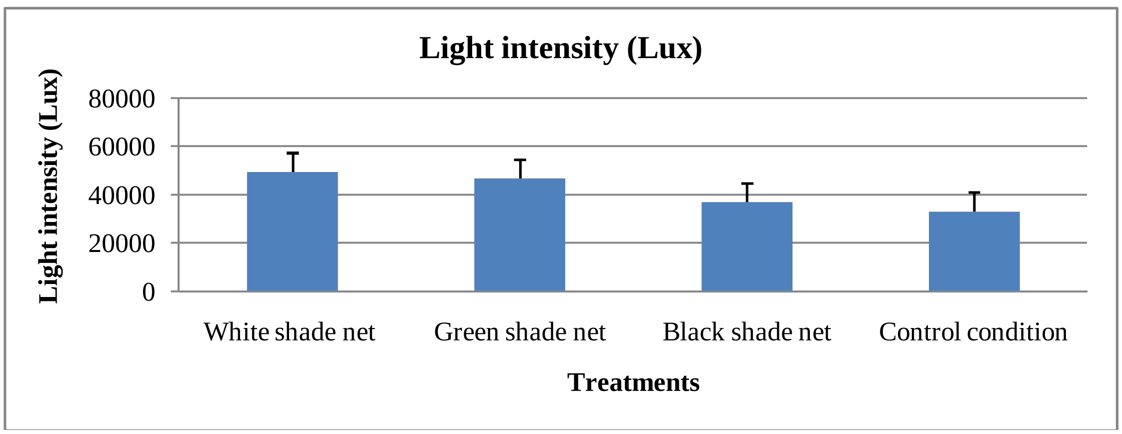

Fig 3 Light intensity recorded during the experimental period in different treatments

Table.1 Effect of different colour low tunnel shade nets and mulches on plant vegetative parameters of chrysanthemum

Treatment	Plant height (cm)	Number of branches (No's)	Plant Spreads (cm)	Leaf Area index	Plant chlorophyll content
Shade nets (S)					
S_1	38.52	10.70	40.88	2.04	45.46
S_2	41.68	11.28	42.70	2.11	48.78
S_3	34.41	7.96	35.20	1.71	42.69
S_4	36.19	8.44	39.32	1.92	44.86
SE m±	0.04	0.08	0.21	0.08	0.25
C.D. at 5%	0.16	0.29	0.75	0.02	0.86
Mulches (M)					
M_1	39.89	11.70	40.88	2.04	47.38

M_2	37.29	9.53	39.17	1.87	45.79
M_3	38.46	10.28	40.58	1.96	47.88
M_4	36.71	10.75	38.68	1.79	44.24
M_5	35.88	10.17	37.74	1.66	41.00
SE m±	0.13	0.09	0.09	0.01	0.30
C.D. at 5%	0.39	0.17	0.28	0.03	0.86
Interaction	NS	NS	NS	NS	NS

Main treatments (S):
S_1 - Green shade net
S_2 - White shade net
S_3 - Black shade net
S_4 - Control

Sub treatments (M):
M_1 - White mulch
M_2 - Black mulch
M_3 - Silver mulch
M_4 - Jute mulch
M_5 - No mulch

Table 2 Depth of water applied based on crop growth stage under different colour low tunnel shade nets and mulches in chrysanthemum

Water applied (mm)				
Crop growth stages	**White shade net**	**Green shade net**	**Black shade net**	**Open field**
Initial	27.0	28.4	30.7	40.0
Development	67.5	72.9	78.6	90.7
Mid	175.0	182.5	94.7	252.8
Last/ Maturity	50.7	52.8	55.5	80.0
Total	**320.2**	**336.6**	**359.5**	**463.5**

Table 3 Water use efficiency and flower yield under different colour low tunnel shade nets and mulches

Treatments	**Water use efficiency ($kg\ ha^{-1}\ mm^{-1}$)**	**Nutrient use efficiency ($kg\ ha^{-1}$)**			**Average flower weight (g)**	**Flower yield per plant (kg)**	**Flower yield ($t\ ha^{-1}$)**
Shade nets (S)		**N**	**P**	**K**			
S_1	28.64	66.77	10.28	64.33	6.00	0.14	7.95
S_2	28.78	72.51	12.37	73.84	6.56	0.15	8.72
S_3	13.09	51.60	6.98	49.75	5.10	0.07	4.43
S_4	10.58	58.08	8.72	56.36	5.86	0.07	7.18
SE m±	3.88	2.46	1.64	3.60	0.04	0.003	0.03
C.D. at 5%	17.44	11.08	7.40	16.20	0.72	0.01	0.16
Mulches (M)							

M_1	24.36	77.53	11.74	73.20	6.25	0.13	8.81
M_2	20.82	65.21	9.51	64.09	5.86	0.11	6.78
M_3	21.75	70.50	10.61	66.86	6.14	0.12	7.95
M_4	19.38	57.75	8.96	56.74	5.63	0.1	6.23
M_5	15.05	40.22	7.11	44.44	5.30	0.08	4.59
SE m±	2.74	2.46	0.88	5.15	0.09	0.003	0.1
C.D. at 5%	8.2	7.38	2.63	15.43	0.28	0.007	0.29
Interaction	NS	NS	NS	NS	NS	NS	NS

Main treatments (S):
S_1 - Green shade net
S_2 - White shade net
S_3 - Black shade net
S_4 - Control

Sub treatments (M):
M_1 - White mulch
M_2 - Black mulch
M_3 - Silver mulch
M_4 - Jute mulch
M_5 - No mulch

Conclusions

The results of the experiment exhibited that the growth and yield parameters were higher in chrysanthemum grown under white shade net than other colour shade nets. Growth and yield of chrysanthemum were maximum where white colour plastic mulch was used, when compared to other mulches and no mulch. The total water requirement of drip irrigated chrysanthemum crop in different coloured low tunnel shade nets is reduced by 31%, 28% and 23% under white shade net , green shade net and black shade net respectively. White shade net exhibits the highest water use efficiency (28.78 Kg ha^{-1} mm^{-1}) and white plastic mulch has given maximum WUE (24.36 Kg ha^{-1} mm^{-1}). White shade net exhibits the highest nutrient use efficiency (N=72.51 kg ha^{-1}, P=12.37 kg ha^{-1} and K=73.84 kg ha^{-1}) and white plastic mulch has given maximum NUE (N=77.53 kg ha^{-1} P=11.74 kg ha^{-1} and K=73.20 kg ha^{-1}). Application of white colour low tunnel shade net with white plastic mulch reduces the soil moisture evaporation which will enhance the uniform distribution of soil moisture for longer days. White colour shade net on low tunnel structure and white colour plastic mulch con be recommended for chrysanthemum cultivation.

Acknowledgement: The support of All India Coordinated Research Projects on Plastic Engineering in Agricultural Structure and Environment Management in conducting this research at College of Agricultural Engineering, Raichur is acknowledged.

REFERENCES

Acharya TP, Welbaum GE, Arancibia RA. Low tunnels reduce irrigation water needs and increase growth, yield, and water-use efficiency in Brussels sprouts production. Hort. Sci. 2019;54(3): 470-475.

Anderson N, O. Dendranthema grandiflora tzvelv in flower breeding and genetics. Springer, Amsterdam, The Netherlands, 2007; pp.389–437.

Angadi AP. Effect of integrated nutrient management on yield, economics and nutrient uptake of garland chrysanthemum (Chrysanthemum coronarium L.). Asian J. Hort., 2014;9(1): 132-135.

Costa LC, Pinto JE, Castro EM, Alves E, Bertolucci SK, Rosal LF. Effects of coloured shade netting on the vegetative development and leaf structure of Ocimum selloi. Bragantia Journal, 2010;69: 349-359

Dobermann. Nutrient use efficiency-measurement and management. *International Workshop on Fertilizer Best Management Practices*. Brussels, Belgium. 2007;pp. 1-30

Gaurav AK, Raju DV, Janakiram T, Singh BH, Jain RI, Krishnan SG. Effect of different coloured shade nets on production and quality of cordyline. Indian J. Agric. Sci., 2016;86(7): 865-869.

Gogo EO, Saidi M, Ochieng JM, Martin T, Baird V, Ngouajio M. Microclimate modification and insect pest exclusion using agronet improve pod yield and quality of French bean. J. Hort Sci. 2014;49(10): 1298-1304..

Hashem F, MA M, EM Abd EM, MMF A. Influence of green-house cover on potential evapotranspiration and cucumber water requirements. J. Agric. Sci. 2011;19(1): 205-215.

Iglesias I, Alegre S. The effect of anti-hail nets on fruit protection, radiation, temperature, quality and profitability of ‘Mondial Gala’apples. J. Appl. Hortic. 2006;8(2): 91-100,

Ilić ZS, Milenković L, Stanojević L, Cvetković D, Fallik E. Effects of the modification of light intensity by color shade nets on yield and quality of tomato fruits. J. Sci. Hortic. 2012;139: 90-95.

Jifon JL, Syvertsen JP. Kaolin Particle Film Applications Can Increase Photosynthesis and Water Use Efficiency ofRuby Red'Grapefruit Leaves. J. Am. Soc. Hortic. Sci. 2003;128:107-112.

Kishore G, Babu BM, Kandpal K, Satishkumar U, Ayyangowdar MS. Effect of plastic mulching and irrigation levels on plant growth parameters of tomato crop (Solanum lycopersicum). J. Pharmacogn. Phytochem. 2018;7(5): 3059-3064.

Meena R, Vashisth A, Singh A, Singh B, Manjaih KM. Microenvironment study under different colour shade nets and its effects on biophysical parameters in spinach (Spinacia oleracea). Agriculture: towards a new paradigm of sustainability I. J. Agric. Meteorol. 2015;16(1): 11-17.

Meena RK, Vashisth A, Singh R, Singh B, Manjaih KM. Study on change in microenvironment under different colour shade nets and its impact on yield of spinach (Spinacia oleracea L.). J. Agric. Meteorol. 2014;16: 104-111.

Möller M, Assouline S. Effects of a shading screen on microclimate and crop water requirements. J. Irrig. Sci. 2007;25(1): 171-181.

Muleke E, Saidi M, Itulya FM, Martin T, Ngouajio M. Enhancing cabbage (Brassica oleraceae Var capitata) yields and quality through microclimate modification and physiological improvement using agronet covers. Int. J. Sustain. Agric. Res. 2014;3(2): 24-34.

Phocaides A. Technical handbook on pressurized irrigation techniques. Food and Agriculture Organization (FAO) Publisher, Rome, Italy. pp. 2001;1-195.

Rajablariani HR, Hassankhan F, Rafezi R. Effect of colored plastic mulches on yield of tomato and weed biomass. Int. J. Environ. Sci. Dev. 2012;3(6):590-599.

Shahak Y, Gussakovsky EE, Gal E, Ganelevin R. Colornets: crop protection and light-quality manipulation in one technology. InVII International Symposium on Protected Cultivation in Mild Winter Climates: Production, Pest Management and Global Competition 659 2004; 23 (pp. 143-151).

Shatnawi M, Al-Fauri A, Megdadi H, Al-Shatnawi MK, Shibli R, Abu-Romman S, Al-Ghzawi A. In vitro multiplication of Chrysanthemum morifolium Ramat and it is responses to NaCl induced salinity. J. Biol. Sci. 2010;3: 101–110.

Soud MA, Emam MS, Abdrabbo MA, Hashem FA, Shaimaa H. Sustainable urban horticulture of sweet pepper via vermicomposting in summer season. Journal: J. Adv. Agri. 2014;3(1): 110-122.

Stamps, R. H. Use of colored shade netting in horticulture. J. Hort. Sci. 2009;44(2): 239-241.

Sun CQ, Chen FD, Teng NJ, Liu ZL, Fang WM, Hou XL. Interspecific hybrids between Chrysanthemum grandiflorum (Ramat.) Kitamura and C. indicum (L.) Des Moul. and their drought tolerance evaluation. Euphytica. 2010;174(1):51-60.

Sun CQ, Huang ZZ, Wang YL, Chen FD, Teng NJ, Fang WM, Liu ZL. Overcoming pre-fertilization barriers in the wide cross between Chrysanthemum grandiflorum (Ramat.) Kitamura and C. nankingense (Nakai) Tzvel. by using special pollination techniques. Euphytica. 2011;178(2):195-202.

Tafoya FA, Juárez MG, Orona CA, López RM, Alcaraz TD, Valdés TD. Sunlight transmitted by colored shade nets on photosynthesis and yield of cucumber. Ciência Rural. Santa Maria 2018;48(9):1-9

Tegen, Yigzaw D, Wassu M.. Influence of mulching and varieties on growth and yield of tomato under polyhouse. J. Hort. For. 2016;8(1): 1-11.