INFLUENCE OF DIFFERENT COLOUR LOW TUNNEL SHADE NETS AND MULCHES ON WATER USE EFFICIENCY AND NUTRIENT USEEFFICIENCYIN CHRYSANTHEMUM

ABSTRACT

An investigation was carried out in experimental field ofCollege of Agricultural Engineering, University of Agricultural Sciences, Raichur, to investigate the effect of different coloured low tunnel shade nets and different mulcheson water use efficiency and nutrient use efficiency of chrysanthemum.The results revealed that the values of daily evapotranspiration under different coloured low tunnel shade net were found to be 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 saving in irrigation water occurs in chrysanthemums under different coloured low tunnel shade nets as compared to open field cultivation. It is also found that 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 coloured low tunnel shade net (28.78 kg ha^{-1} mm^{-1}) and this was followed by 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, 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}), jute mulch (19.38 kg ha^{-1} mm^{-1}).Lowest water use efficiencywas recorded where mulch was not used (15.05 kg ha^{-1} mm^{-1}).

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 industry 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

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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 which might have increased the occurrence of abiotic disorders due to climate change (Ili *et al.,* 2012).Nets has 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; Mulekе*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 optimise 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, resulted 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 shady conditions (Jifon and Syvertsen, 2003).

MATERIALS AND METHODS

This experiment was under taken inthe month of August-December 2020 and 2021 at research fields of AICRP (PEASEM), College of Agricultural Engineering, University of Agricultural Sciences, Raichur. The experiment was laid out in split plot design with two replications. The experiment consisted of different coloured shade nets i.e., white, green, black and control as 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 length, 1 m width and 15 cm height were prepared leaving a space of 1.5 m between two beds as a path, to enable easy cultural operations like weeding, spraying, harvesting etc. The beds were leveled 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 micron black, white and silver plastic mulch and jute mulches were laid on the bed for 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 drip system. Subsequent irrigations were provided whenever it was required (1 to 2 hours in aday). The observations were collected on growth, reproductive and quality traits of 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 the evapotranspiration loss from the cropped field is defined as 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 treatments were compared with open field condition as (control).Air temperature relative humidity light intensity, soil moisture and soil temperature were measured using digital thermometer, hygrometer, lux meter and digital theta probe, respectively. Evapotranspiration were measured using class A pan under the shade net and control conditions. Water requirement under shade net was calculated. The amount of water required to compensate the evapotranspiration loss from the cropped field is defined as crop water requirement. Crop water requirement encompass the total amount of water used inevapotranspiration (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.

$$ET_c = K_c \times ET_0$$

Where,

ET_c = cropevapotranspiration / 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);

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

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RESULTS AND DISCUSSION

Weather and climatic conditions

The weather data recorded during the experiment period under different coloured low tunnel shade nets and control are presented in fig 1, fig 2 and fig 3. During the experiment period maximum temperature (37.90°C) was recorded under control condition followed by black shade net (35.80°C) and green shade net (34.60°C). Minimum temperature (33.00°C) was recorded under 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 ~~under~~control condition. 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 lower temperature. Similar trend was also reported byGaurav*et al.* (2016),Meena *et al.* (2014) and Meena *et al.* (2015).

Growth parameters

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

Thegrowth 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), 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 was significantly higher followed by silver mulch. The lowest vegetative parameters such as plant height (35.88

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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 favorable 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 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. Similar trend was also reported byTegen*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 (8.72t ha^{-1}) were recorded in plants grown under white coloured 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 tha^{-1}) was recorded in plants under black coloured shade net. The flower yield per plant (0.13 kg)average flower weight (6.25 g) and flower yield per ha (8.81tha^{-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 (4.59tha^{-1}) were noticed under no mulch conditions.

Significantly higher flower yield parameters were observed under white coloured shade net. The environment created by colored net increased average flower weight and 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),

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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, 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, respectivelyand presented intable 2.

Significantly higher amount of water was applied under open field conditions (463.5mm) followed by black shade net (395.5mm) and green shade net (336.6mm).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 higher amount of water available for plants, than the treatment without shade net (control conditions).Higher WUE was noticed and then was saving of irrigation water under white shade net. Similar results were obtained byAcharya *et al.* (2019), Moller and Assouline (2007).

Water use efficiency

Water use efficiency indicates, yield produced per unit 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 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 shade net (control conditions).The white coloured 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 ofAcharya *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 coloured plastic mulch, similarly minimum water use efficiency was found in control conditions. This was due to fact that white and silver plastic coloured 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).

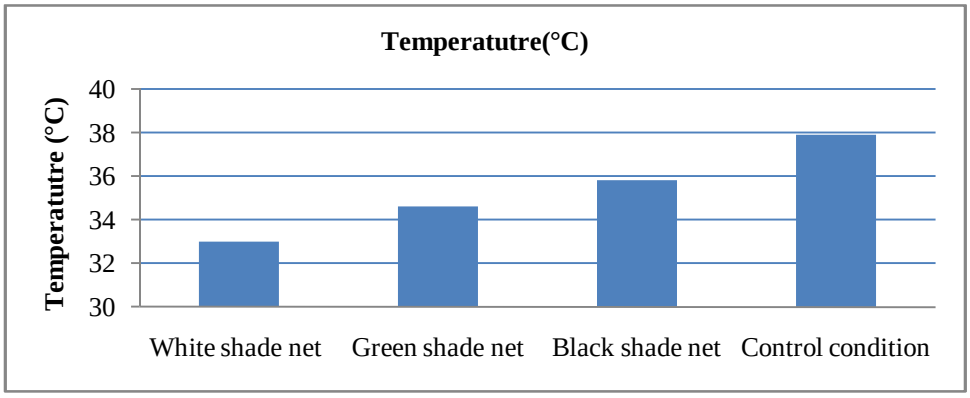

Fig 1 Temperature recorded during the experimental period

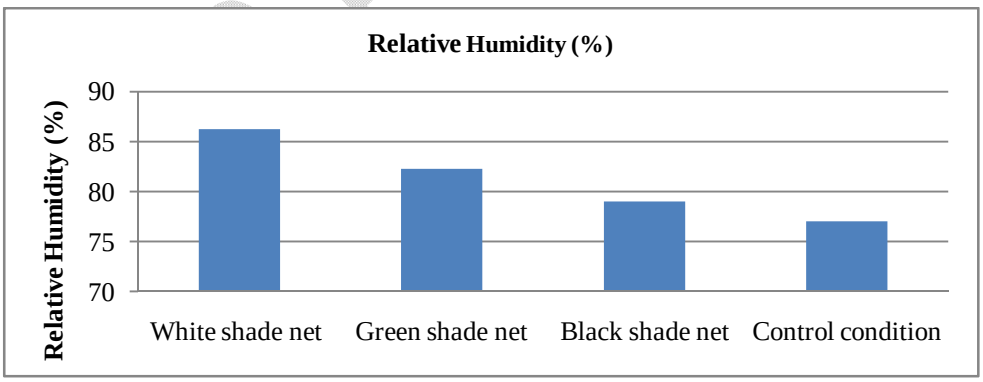

Fig 2 Relative humidity recorded during the experimental period

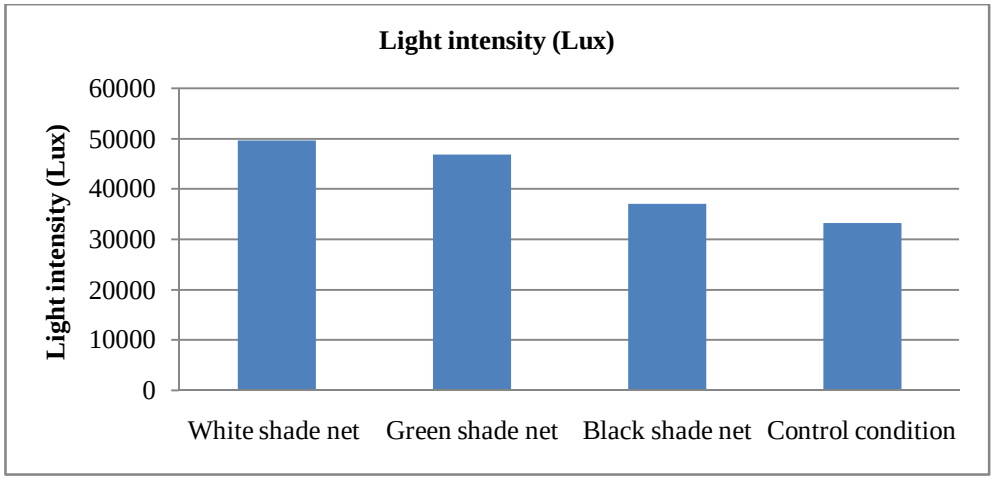

Fig 3 Light intensity recorded during the experimental period

Table.1Effect of different coloured 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

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Table .2 Depth of water applied based on crop growth stage under different coloured 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 coloured low tunnel shade nets and mulches

Treatments	Water use efficiency (kg ha^{-1} mm^{-1})	Average flower weight (g)	Flower yield per plant (kg)	Flower yield (t ha^{-1})
Shade nets (S)				
S_1	28.64	6.00	0.14	7.95
S_2	28.78	6.56	0.15	8.72
S_3	13.09	5.10	0.07	4.43
S_4	10.58	5.86	0.07	7.18
SE m±	3.88	0.04	0.003	0.03
C.D. at 5%	17.44	0.72	0.01	0.16
Mulches (M)				
M_1	24.36	6.25	0.13	8.81
M_2	20.82	5.86	0.11	6.78
M_3	21.75	6.14	0.12	7.95
M_4	19.38	5.63	0.1	6.23
M_5	15.05	5.30	0.08	4.59
SE m±	2.74	0.09	0.003	0.1
C.D. at 5%	8.2	0.28	0.007	0.29
Interaction	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
M_5 - No mulch

Sub treatments (M):
M_1 - White mulch
M_2 - Black mulch
M_3 - Silver mulch
M_4 - Jute mulch

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Conclusions

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 netrespectively. White shade netexhibits 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}). Application of white coloured 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.

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