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Short communication

Thermal environment inside single shade-net, double shade-net, and polythene sheet houses and effect on wheat seedling growth

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Food is an essential part of our life. The increasing population is putting new challenges in crop production. Irrigation, being the most important part of farming, provides much challenge for the scientists to work on its effectiveness. The amount of fresh water being used for irrigation is around 80% globally (Lee *et. al*, 2020) and hence, ensuring efficient use of water in irrigation is important. The single shade net, double shade net, and polythene sheet housings are evolved to create favourable micro-climates to achieve increased crop production (Bharathi and Ravishankar, 2018, Prakash *et al*, 2019). Hirich and Choukr (2017) compared the water and energy use efficiency between greenhouse covered with polythene sheet and the single shade-net housing systems under desert conditions. They have observed that polythene sheet resulting into 2.6 to 3.5 times more water consumption than the required irrigation while 0.25 times less water consumption than the required irrigation in case of shade-net. Samanta and Hazra (2019) also reported a comparison between single shade-net and poly house environments. But they report polyhouse system consuming relatively less water than the single shade-net system. The experiments were carried out in a warm tropical region in India. Further, to assess the microclimate and initial growth of wheatgrass under the three systems i.e. a) Single Shade Net - SSN, b) Double Shade Net - DSN and c) Polythene Sheet - PS house, and the study was undertaken at Vellore Institute of Technology, Tamilnadu, India

The experiments were carried out at Vellore Institute of Technology (VIT) campus Vellore, India which has a hot-tropical climate. The experimental set-up essentially had three separate housing systems: single shade-net, double shade-net and polythene sheet housing as shown in Fig. 1. Each of these had 1.0 m x 0.5 m x 0.5 m (L x B x H) dimensions; the double shade-net had a gap of 0.15 m between the shade-nets. The inner shade-net was green in colour and the outer one white in colour. The experimental set-ups were planned over the terrace of a building ensuring no tree / surrounding building shading during the dates of experiments. Each of the set-ups had an expanded polystyrene sheet (thermocol) 25 mm thick over the floor to ensure minimized heat loss or gain through the floor. All the three housings *viz.*, Single Shade Net – SSN; Double Shade Net - DSN and Polythene Sheet - PS house were set-up without germinated wheat seeds during 26 and 27 February, 2020 and the housings were set-up with pots containing germinated wheat seeds inside them during 7 – 9 March, 2020.

Thermo-hygrometer (THD-172 data loggers) data loggers (Fig. 2 a) were used for temperature (T) and relative humidity (RH) measurements. The measurements had ±1^{o}C and ±3% accuracy in temperature and relative humidity, respectively and were pre-calibrated. The data were recorded for every ten minutes. Each of the data loggers were covered with 9 aluminium foil plates and white shade-net for radiation shielding (Joshi, 2020; Ramesh and Arakeri, 2019; Al-Helal and Abdel-Ghany, 2010) as shown in Fig. 2 b and 2 c.

To carry out experiments, small plastic pots with holes at the bottom containing well mixed red soil on top and stones at the bottom were used. 11 germinated wheat seeds were seeded into each of the pots at a depth of 25 mm from the soil surface. The seeds were watered (100 ml) each day around 08:30 hrs. The pots used and the soil preparation have been depicted in Fig. 3 a, b and c. The soil and watering conditions remained same during the days of experiments.

Data analysis of the systems without seeded soil pots

The first sets of measurements were carried out without crops grown inside the housings. The temperature

Table 1: The length of the grass grown per day of each plant in each of the housings.

Housing type	Day 1					Day 2					Day 3				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Single shade net	0.8	0.4	0.1	0.0	0.0	2.1	1.2	0.9	0.6	0.0	5.3	4.3	2.8	1.7	1.3
Double shade net	0.8	0.0	0.0	0.0	0.0	2.1	0.4	0.0	0.0	0.0	5.5	4.0	2.1	0.0	0.0
Polythene	0.5	0.2	0.0	0.0	0.0	1.5	0.7	0.5	0.0	0.0	2.7	2.3	2.5	0.0	0.0

S represents the seedling

Fig. 1: Three housing systems (a) Single shade-net, (b) double shade-net, and (c) Polythene sheet housing

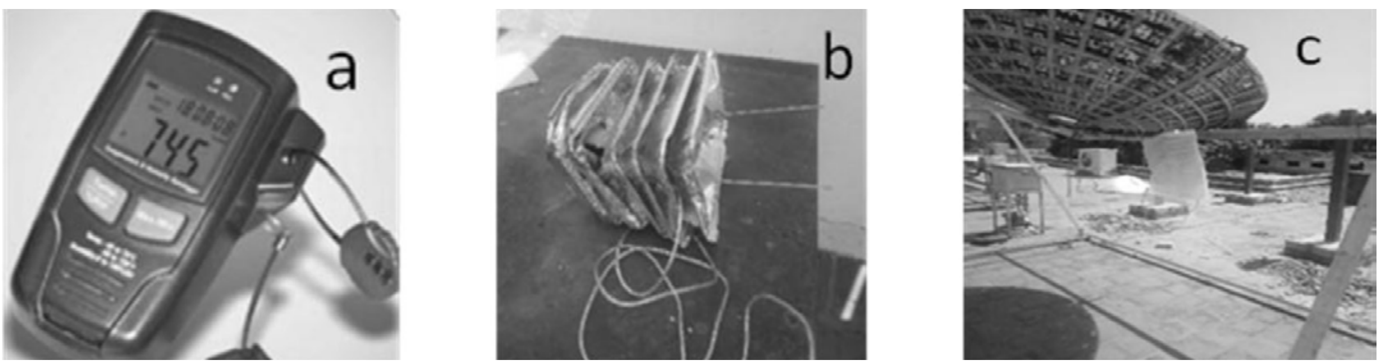

Fig. 2: (a) Thermo-hygrometer model used (b) Aluminium foil radiation shield put over the thermo-hygrometer, and (c) white shade net wrapped over the shield

Fig. 3: (a) Pots with holes in the bottom, (b) Stones put into the pots (around 1.5 inch height) and (c) The germinated seeds (eleven in each pot) later seeded at a depth of around 1 inch from the soil surface.

and humidity variations have been shown in Fig. 4 and Fig. 5. Fig. 4 depicts temperature variations inside all the three envelops were relatively similar from 17:30 hrs to 7:30 hrs. During the peak hours, single shade net and double shade net provided relatively lower air temperatures whereas poly house provided warmer temperatures inside the envelope. On the other hand, looking into relative humidity, during morning hours (01:30 hrs to 07:30 hrs) single shade net envelope was moister compared to double shade net and polyhouse envelopes. During day time (09:30 hrs to 17:30 hrs), the polyhouse envelope was much drier in the vicinity of the floor as compared to the

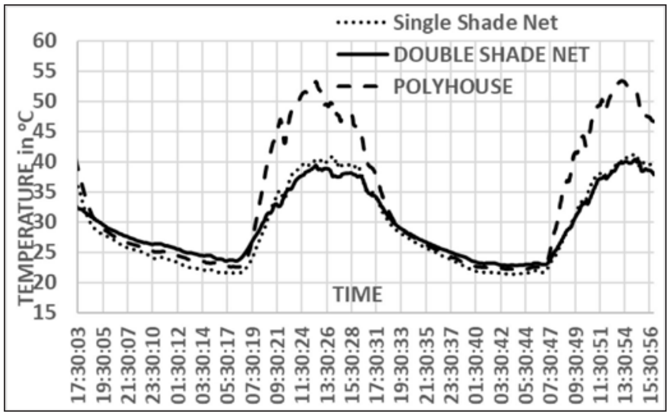

Fig. 4: Temperature variation inside the three housings (without seeded soil pots)

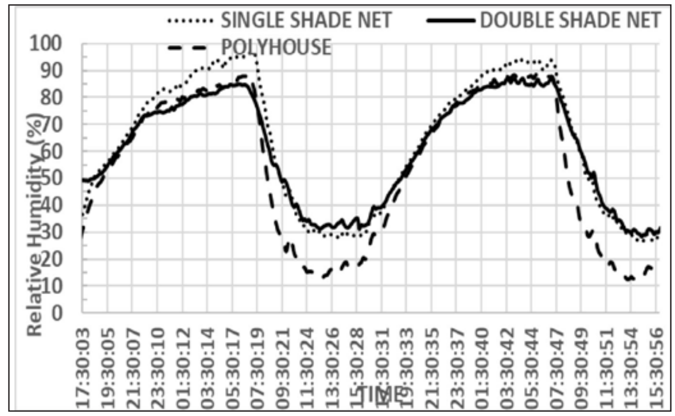

Fig. 5: Relative humidity variation inside the three housings (without seeded soil pots):

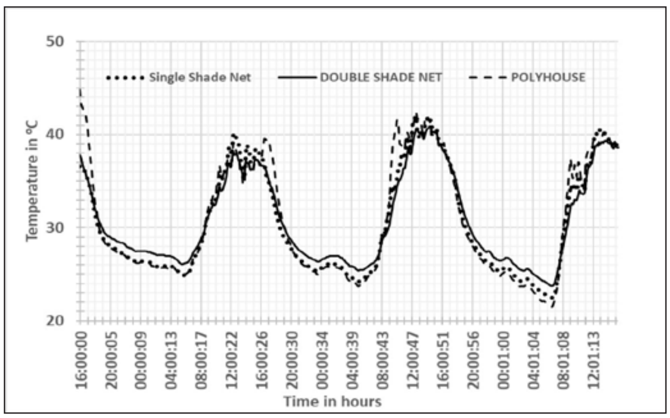

Fig. 6: Temperature variation inside the three housings

Fig. 7: Relative humidity variation inside the three housings (with seeded soil pots)

other two envelopes which may result in maximising the evapotranspiration (Fig. 5).

Data analysis of the systems with seeded soil pots

The temperature and RH data were collected for 3 days and are depicted in Fig. 6 and Fig. 7. The air temperature reduced considerably in case of polythene sheet during solar peak hours by around 10.0°C as compared to without plants case; while the same has got increased by around 1.0 – 2.0°C in case of both the shade-net housings. The total number of seedlings succeeded each day were 3, 4, 5 in SSN; 1.2.3 in DSN and 2,3,3 in PS housings and the seedling length of the wheat grown per day in each case have been depicted in Table 1. The seedlings under the single shade net housing were observed to have maximum growth rate.

The maximum numbers of seedlings were observed to be in case of single shade net case. By third day the number of seedlings in case of both double shade net and polythene sheet had been the same. However, the growth rate of the wheat grass in case of double shade net was much higher as compared to polythene sheet (Table 1). On the other hand, the growth rate was observed to be maximum in case of single shade net. Hence, both in terms of number of seedlings and the growth rate, single shade net was observed to be the best suitable for the wheatgrass.

The comparison of single shade-net, double shade-net and polythene sheet houses through temperature and RH measurements with and without plants was found to provide useful insight. This can help in making better decision while selecting an appropriate envelope for a particular crop or mixture of crops. Double shade-net case was found to have relatively lower RH values during late evening / night hours. On the other hand, during solar radiation peak hours the RH in double shade-net case was relatively higher with temperatures being relatively low. This can ensure relatively less water evaporation during the solar radiation peak hours.

It may be concluded that the double shade-net could be a better option for the crops which demand lower RH during evening / night hours and higher RH during day time. Polythene sheet house was observed to achieve stratified RH conditions with higher concentration of water vapour near the inner surfaces of the sheet while keeping the micro-climate near the ground relatively dry during day time. It was also concluded that polyhouse can be a better choice for the crops which may require warm and dry micro-climatic conditions. Wheat seedlings were found to grow more in number with relatively maximum growth rate in case of single shade-net as compared to the other two. This may be attributed to the fact that, single shade net is allowing relatively more sunlight as compared to the double shade net envelope; on the other hand temperature and RH variations are observed to be similar which could have considerably affected the seedling growth rate. Hence, single shade-net housing could be a better choice for wheatgrass growing in hot humid tropical regions.

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REFERENCES

Al-Helal, I. M., and Abdel-Ghany, A. M. (2010). Responses of plastic shading nets to global and diffuse PAR transfer: Optical properties and evaluation. *NJAS-Wageningen J. Life Sci*., 57(2): 125–132.

Bharathi, P. V. L., and Ravishankar, M. (2018). Vegetable nursery and tomato seedling management guide for south and central India. *World Veg Publ*., (18–829): 3.

Hirich, A., and Choukr-Allah, R. (2017). Water and energy use efficiency of greenhouse and net house under desert conditions of UAE- Agronomic and Economic analysis. *Water Resources in Arid Areas*: *The Way Forward* (pp. 481–499). Springer Link.

Joshi, V. V. (2020). Heat transfer characterization of test rooms with six different roofs. *Int. J. Heat Tech*., 38(1): 131-136

Lee, S. K., Truongan, D., and Ngo, M. L. T. (2020). Assessment of improving irrigation efficiency for tomatoes planted in greenhouses in Lam Dong Province, Vietnam. *J. Agrometeorol*., 22(1): 52–55.

Prakash, P., Kumar, P., Kar, A., Singh, A. K., and Anbukkani, P. (2019). Progress and performance of protected cultivation in Maharashtra. *Indian J. Econ Dev*., 15(4): 555–563.

Ramesh, N. T., and Arakeri, J. H. (2019). Actively and passively aspirated temperature sensors in a windless environment like greenhouses. *Sadhana*, 44(4): 91. https://doi.org/10.1007/s12046-019-1066-4

Samanta, M. K., and Hazra, P. (2019). Microclimate suitability for green and coloured sweet pepper hybrids in open and protected structures in sub-tropical humid climate of West Bengal. *J. Agrometeorol*., 21(1), 12–17.

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