__Original Research Article__

Effect of shade nets on yield and quality of tomato in temperate region of Kashmir Valley

Abstract

A field trial was conducted at Sher-e-Kashmir University of Agricultural Sciences and Technology, Kashmir, Shalimar Campus during 2020-21to ascertain the effect of shade nets on yield and quality of tomato inside the protected structure. During the study, it was found that no significant difference was observed in average monthly temperature and relative humidity inside polyhouse with shade net and without shade net. Significant difference was recorded in yield and the light intensity. Highest average plant yield of (15.5 kg/plant) was found in polyhouse in which the plants were covered with shade net and lowest yield was observed (13kg/plant) where plants were not covered with shade net inside the polyhouse during afternoon day time. It was also found that the tomatoes grown under shade net were glossy in appearance with good colour development as compared to plants grown under protected structures without shade net. No significant difference was observed in quality attributes *viz.,* TSS, acidity and ascorbic acid by shade net. However, the higher TSS (7.1 ^{o}Brix), Acidity (0.77%) and Ascorbic acid (45.86 mg/100gm) was recorded in polyhouse with shade net as compared to polyhouse without shade net(6.7, 0.51 and 38.52) respectively. Thus, the use of shade net brought improvement in quality of tomato grown in temperate region of Kashmir valley. Also, the shade net application during winter duration of 2021-22 during evening/night hours led to increase in the temperature inside polyhouse.

Keywords: Tomato, shade net, temperature, yield, fruit quality, polyhouse cultivation

Introduction

Temperate region of Kashmir valley finds immense potential for protected cultivation due to long harsh winter duration when outside crop cultivation is not possible. The different protected cultivation methods *viz.* greenhouses, low tunnels/row covers, floating covers, mulching *etc.* finds huge applications in the temperate zone of Kashmir Valley region. The harsh winter conditions hinder the cultivation of crops in the open field. Thus, the application of 'Protected Cultivation' comes into force where the crop can be protected from the inclement weather conditions. Using this concept as the basic idea, a microclimatic environment can be created for best possible growth of plant in comparison to open field conditions. Off-season and round the year crop cultivation (both in terms of quality and quantity) is the obvious goal for creation of microclimatic environment.It requires high precision technical knowledge of fabrication/ construction of greenhouses under different climatic conditions, environment control systems, and best method of crop cultivation practices. The technicality of these three aspects and its applications can create a greenhouse for growing plants.A cultivation practice that involves partial or complete control of the localized climate (micro-climate) for a particular crop during its growth period is known as Protected Cultivation.Protected cultivation of vegetables could be used to improve yield quantity and quality (Singh *et al*., 1999; Ganesan, 2004; Shahak *et al*., 2008).The greenhouse is generally covered by transparent or translucent material such as glass or plastic. The green house covered with simple plastic sheet is termed as 'Polyhouse'. The greenhouse generally reflects back 43% of the net solar radiation incident upon it allowing the transmittance of the "Photo-synthetically Active Radiation (PAR)" in the spectral range of solar radiation varying from 400-700 nanometers.

During the day time, the short-wave radiation entersinto the greenhouse and gets reflected from the ground surface. The sunlight admitted to the greenhouse is absorbed by the crops, floor, and other objects. They reflected radiation becomes long-wave thermal radiation in the infrared region for which the glazing material has lower transparency. As a result, the solar energy remains trapped inside the greenhouse, thus raising its temperature. This phenomenon is called the "Greenhouse Effect". The greenhouse's partially closed structure trapped short wave radiation, which led to a higher temperature during the day (Nimje &Shyam, 1993). Thus, the protected cultivation could possibly extend the growing season of crops. Protected cultivation of vegetable crops suitable for domestic and export purposes could be a more efficient alternative for land use and other resources (Sanwal *et al*., 2004). However, profitability in protected cultivation depends upon the choice of structure, selection of crop *etc.*

Protected agriculture has expanded immensely to help improve agricultural productivity.These designs need to be upgraded with climate control to overcome overheating in summer and overcooling in winter when used in warm, arid regions. The greenhouse climate is dictated by the soil inside the greenhouse, which constitutes the major thermal mass the 'greenhouse effect' itself, which can be controlled mainly by ventilation in most greenhouses; the crop's transpiration, which has a dominant effect on temperature and vapor-pressure deficit. Structures commonly used in the region are small (low and small volume) and have inappropriate roof-slopes (reducing light transmission); taller structures with appropriate roofs would improve light transmission, ventilation, inertia against external climatic variations, and drainage of condensation. Some studies under different types of shade net house have been carried out for growing of nursery as well as for production of vegetables in off-season in temperate region of Kashmir. The present study was undertaken with the following objectives:

1. To study the effect of shade net on yield and quality of tomato inside protected structure
2. To study effect of shade net on temperature inside protected structure during wintermonth duration

Materials and Methods

Study Area

The experiment for tomato crop under protected condition was carried out at experimental research farm of College of Agricultural Engineering and Technology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar campus, Srinagar which fall under the temperate region. It is located at 34^{o} 08′ 30.5″ North latitude and 74^{o} 51′ 42.0″ East longitude with an altitude of 1586 meters above mean sea level. The experiment was carried out intwo protected structures in a gothic arch shape polyhouse.During the growing season, the crop was covered with shade net in one polyhouse and in other polyhouse the conditions were controlled (without shade net). The dimensions of experimental greenhouse were 20 m length 8 m width and 3.8 m centre height. The protected structure in which the experiment was carried out is shown in Plate 1.

Shade Net

Similar to polyhouses, shadenet structures are constructed using various materials like plastics, wood, GI pipes, angle ironetc. The framed structure is covered mostly with plastic net whicharemostly polymer-based materials. It modifies the microclimate of crop by altering thelight intensity which is the result of reduction in intensity of light and heating parameters. As different crops have different photoperiodic requirement, this can be partially done by the shade net structures which is able to control the abiotic parameters.

Shade net structures are highly remunerative during periods of high intensity sunlight. They are useful in nursery raising and raising of graft saplings with higher survival efficacy.Losses due to various biotic and abiotic factors are significantly minimized. They play a great role in hardening treatments including the same for tissue cultured seedlings. They are used as a drying area for various agricultural produce due to better control over abiotic factors. They lower the pest incidence level as compared to open field conditions and are used in various composting unitsdue to efficient control over immediate environment. They are highlyuseful in growing vegetables, flowers, fruits, and ornamental crops of various growth habitat**.**Having numerous advantages, they play a great role in the field olericulture, floriculture, horticulture along with nursery growing and management of saplings and bonsai cultivation. They have wide applications in drying of rice, wheat, maize, sorghum, pulses and oilseeds, mushroom cultivation, fish rearing, diary unit and poultry farming etc.as they have wide application in FYM composting, rural and urban composting and vermiculture based composting.With sufficient height, shade net can be utilized as a wind break structure.

Colour variations in shed nets

Colour-nets add to the newer dimension of agro-technology, which on one side helps in physical protection and altering of light intensity and related chromatic parameters on the other side. These effects are the results of the incorporation of the various chromaticadditives, light dispersive and reflective elements into the cladding material during the process of manufacture. It has two dimensional usages like being directly used directly over net-house constructions, or else it is applied along with the greenhouse technologies. These shade nets acts both by scattering of light and altering the spectral compositions. The photo selective net products are based on the incorporation of variouschromatic additives, light dispersive and reflective elements into the netting materials during manufacturing. These shade nets include "colored-Color Nets" (e.g. Violet, Red, Yellow, Green, Blue netproducts) as well as "neutral-ColorNets" (e.g. Pearl, White and Grey) absorbing spectral bands like infrared or ultraviolet rays. The spectral manipulation is aimed at specifically promoting photo morphogenetic-physiological responses. The colornet approach was researched in various ornamentals (Nissim-Levi *et al*., 2008), vegetables (Fallik *et al*., 2008; 2010), fruit trees (Shahak *et al*., 2004) and vineyards. Color-shade nets improved productivity by moderating climatic extremes.

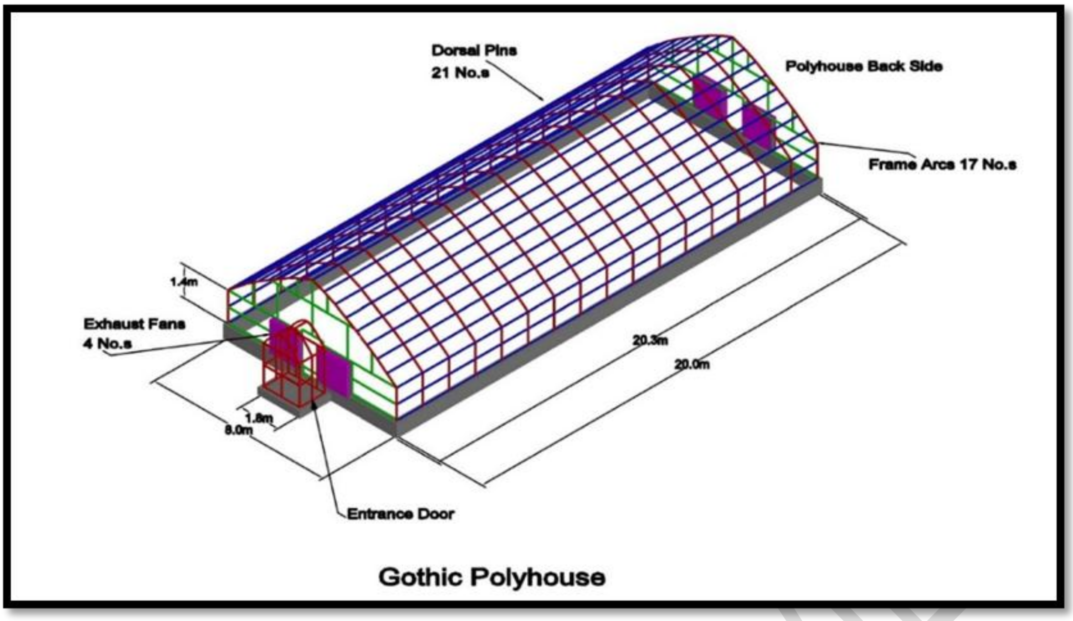
- Green × Black – The effects are like cut off unwanted shorter wave length rays than visible range and gives aesthetic look. It is useful in vineyard for the provision of the shade and for drying purpose.
- Black × Black –As obvious it absorbs the insolation and radiates heat causing heating effect inside the shade net house. Used in nursery growing.
- White × Black - it helps in diffusing the light inside the shade net house. Mostly useful for growing of crops like Gerbera, Anthurium *etc.*
- Green × Green –the net photosynthesis of the plants inside the structure increases which results in better growth and yield of the ornamental crops.

Shading Percentage

Shade nets are available in different shade percentages or shade factor *i.e.*, 15%, 35%, 40%, 50% 75% and 90% (for example 35% shade factor means - the net will cut 35% of light intensity and would allow only 65% of light intensity to pass through the net). It varies from crop to crop and variety to variety. For majority of the crops shade factor ranging between 50 and 70% is considered as the standard range.

Nursery Raising

The nursery raising of Tomato crop (*variety:* GS 600) was done in plastic plug trays, each having 50 conical shaped cells inside a polyhouse which had the provision of raised platforms for keeping the trays. The cells were filledwith coco peat saturated with nutrient solution. Before the placement of the seed in growing media in the cells, impressions of 1.0-1.5 cm deep were made. The seeds were placed in the centre of each cell at 1.5 cm depth and covered with small amount of coco peat. The seed germination and emergence were noticed within 2-3 days after sowing. The nutrient solution was applied once or twice daily as per the requirement keeping in view the evaporative demand and crop conditions (Plate 2).



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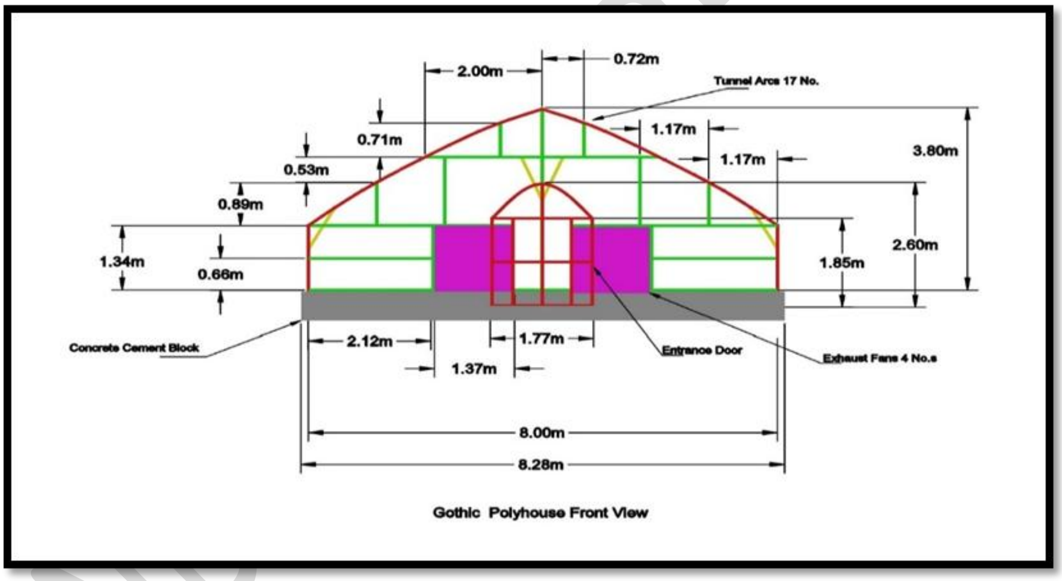

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Plate1: (i) 3-D View and (ii) Front View of Experimental polyhouse

Plate 2: Seed germination in the cells of plastic plug trays

Transplanting

Transplanting of tomato was undertaken in month of April. The coco-peat slabs were then kept under saturation for at least 24 hours before transplanting. The seedlings were transplanted after 25 to 27 days, when they attained 3-4 true leaves.Irrigation at an interval of 7-10 days with drip irrigation system was undertaken.

Training of Plants

The plants were trained vertically upwards by using plastic roller hooks strung from an overhead horizontal support wire at a height of about 2.0 m above the greenhouse floor to interlink the main stem with a nylon thread. A loose non-slipping loop knot was used to secure the nylon thread to the base of each plant.The height of plants increased linearly with time and the nylon strings were loosened to maintain the top ends of plants to a height of 1.80 m and the plants moved from their tops by sliding the roller hooks on the overhead support wire. The plants of first row supported on overhead wire were shifted to second row on the second overhead support wire in clockwise rotation to form a cyclic process between two consecutive plant rows and so on.

Pruning of Plants

Pruning is essential for tomato production because it guarantees that energy is used efficiently in the growth of fruits and the main stem. In the initial pruning, the older leaves from the bottom of plants with a height of around 0.30-0.45 m were removed. By eliminating branching branches or suckers, just one main stem was kept throughout the growth seasons (side shoots). The ideal way of trimming tomatoes is to remove suckers 2 to

2.5 mm in length once a week by hand.The tomato crop grown inside polyhouse as shown in Plate 3.

Disease Management

For reducing whiteflies incidence (if any) to the crop, yellow adhesive cards were placed throughout the greenhouse at various locations, and a spray of Polo (Diafenthiuron 50% WP) @ 1.0 g $litre^{-1}$ was applied three days before to the transplanting date. The insect net of the greenhouse was cleansed with a spray of water under sufficient pressure before transplanting to eliminate insects adhered to it (if any). As few plants have experienced fungal infection, Ridomil Gold fungicide was also applied.

Manures

Table 1. List of manure/fertilizer used for the study

Manure/Fertilizer	**Quantity**	**Remarks**
FYM	1.8 kg/m^2	Entire FYM, Phosphorus, Potash and half dose Nitrogen applied as basal dose and remaining half dose Nitrogen as top dressing 30-40 days after transplanting (DAT).
Nitrogen	15 g/m^2	
Phosphorus	9 g/m^2	
Potash	6 g/m^2	

Plate 3: Tomato crop inside polyhouse under drip irrigation without shade net

Physical parameters

Physical parameters like fruit weight (g) measured by electronic balance and fruit length (cm) and width (cm) weremeasured by using digital vernier caliper.

Chemical parameters

Chemical attributes include determination of total soluble solids (TSS) in tomato juice (in ^{o}Brix) was recorded by digital refractometer; Total acidity (%) was determined as per AOAC, 1980 method while ascorbic acid (mg/100gm) determined as per Ranganna, 1994 methodology.

Instrumentation for measuring environmental parameters

The daily environmental data inside the polyhouse was recorded by Relative humidity and Temperature USB data logger (EL-USB-2). This data logger measures and stores up to 16,382 relative humidity and 16,382 temperature readings over 0% to 100% RH and -35 to 80 ^{o}C measurement ranges. The logging rate and start time can be easily set by the user and the stored data can be downloaded by plugging the module straight in PC's USB port and a software is used to run the Programme. The logger used for monitoring temperature and humidity data is shown in Plate 4.

Plate 4: Data logger used for monitoring environmental data inside the polyhouse

Results and Discussions

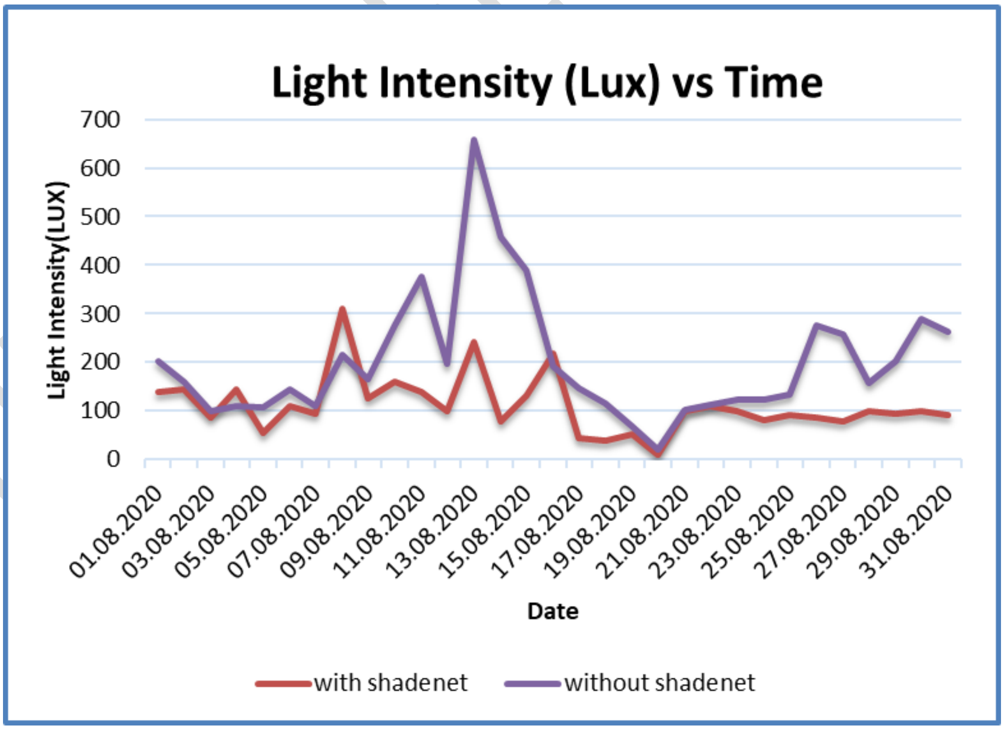
Polyhouse under shade net condition during hot summers

The sunlight intensity during afternoon hours is too high due to high altitude location of Srinagar. Application of shade net (75% shade factor) during hot summershas cut substantial amount of light intensity and sustained heat stress which has resulted in good foliar growth. In hot summers during afternoon time, the application of shade net protected the crop from harsh intensity of sunraysand had cooling effect on crop as Lux intensity decreased by applying shade net inside polyhouse. The Fig. 1 (i), (ii) and (iii) shows variation in lux intensity inside polyhouse at different zones.

Polyhouse under shade net conditions in harsh winters

Gothic arch shape polyhouse (Polyhouse 1) was covered with shade net during evening hours from 6 pm to 6 am and other similar polyhouse (Polyhouse 2) was without shade net. Shade net was utilized at a side height level of Polyhouse (at 2.5m) to cover both sides of the crop zone during night hour durations. In harsh winter duration, the application of shade net has resulted in trapping ample amount of heat energy of day time duration inside the polyhouse, thereby leading to temperature enhancement during night period duration. With the application of shade net, 3 - 4 °C temperature was enhanced as shown in comparative graphs in Fig. 2 & 3.

Plate 5: Application of Shade nets during night hours inside the polyhouse



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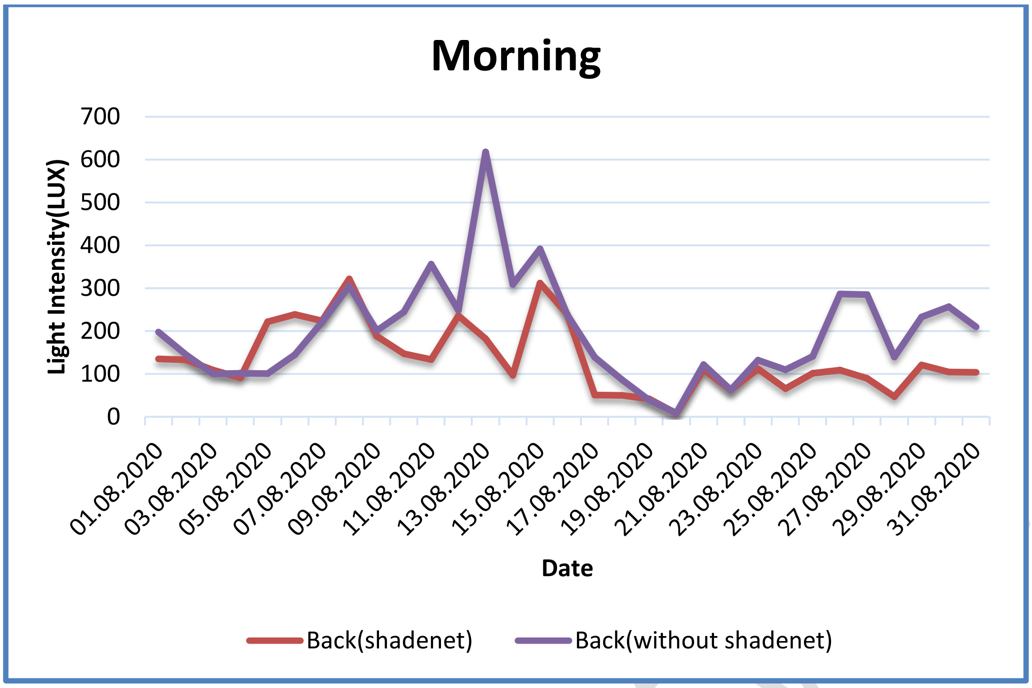

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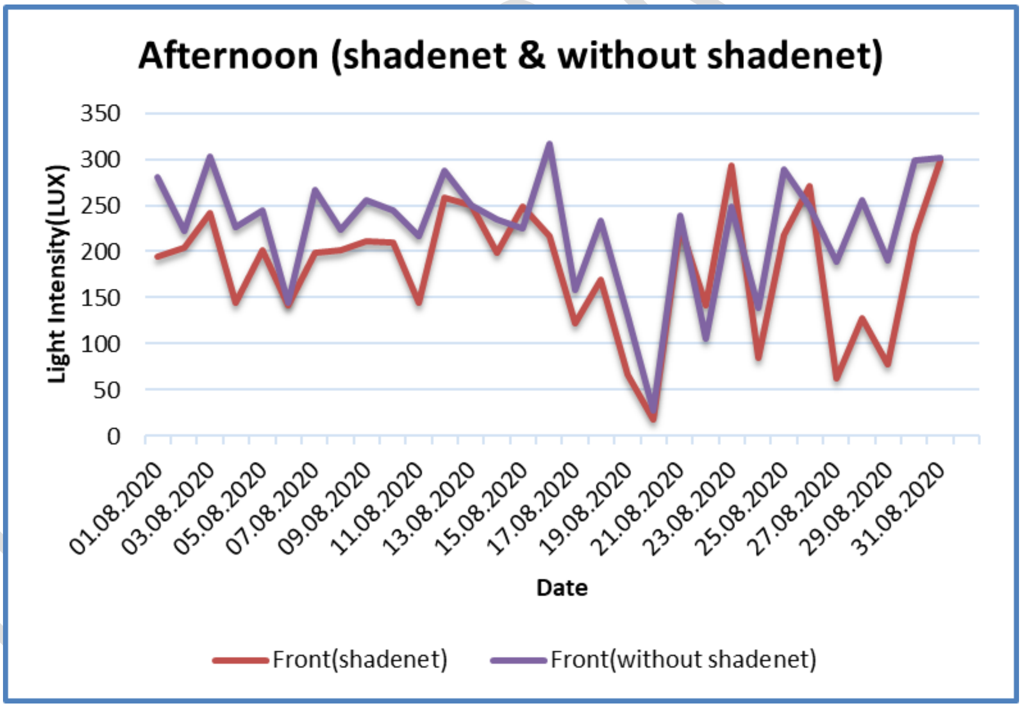

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Fig. 1: Above (i), (ii) and (iii) figure showing variation in lux intensity inside polyhouse at different zones

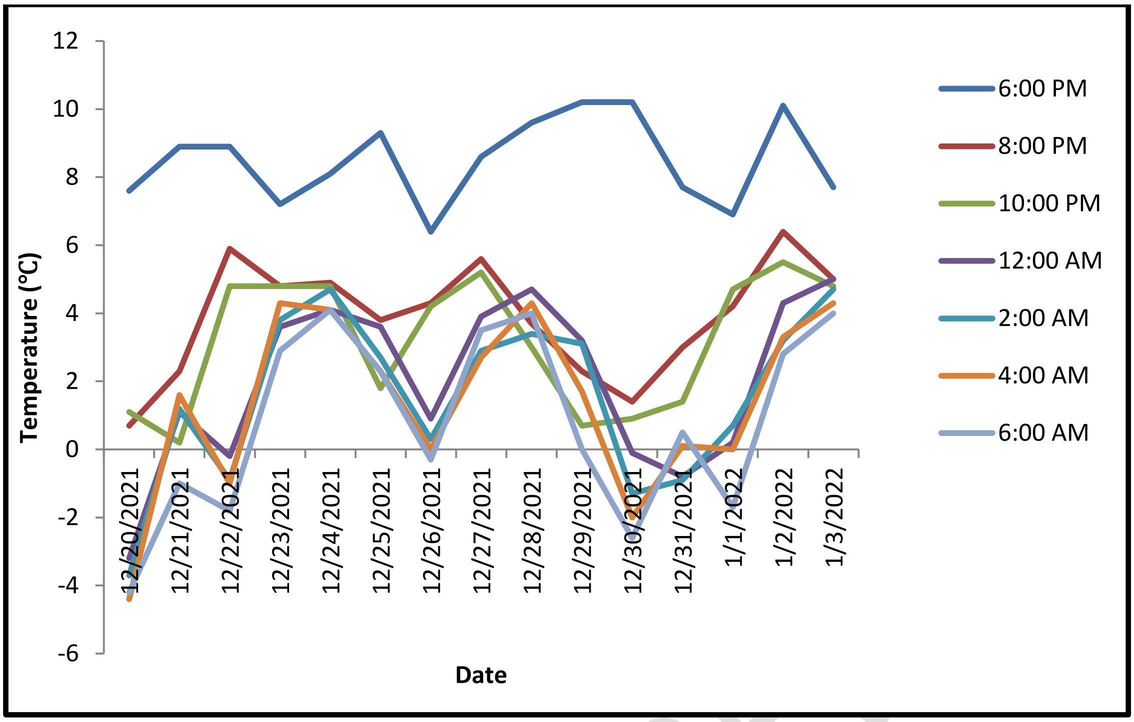

Fig. 2: Figure showing variation in Temperature (°C) at different time intervals inside Polyhouse 2 (without shade net cover) in harsh winters

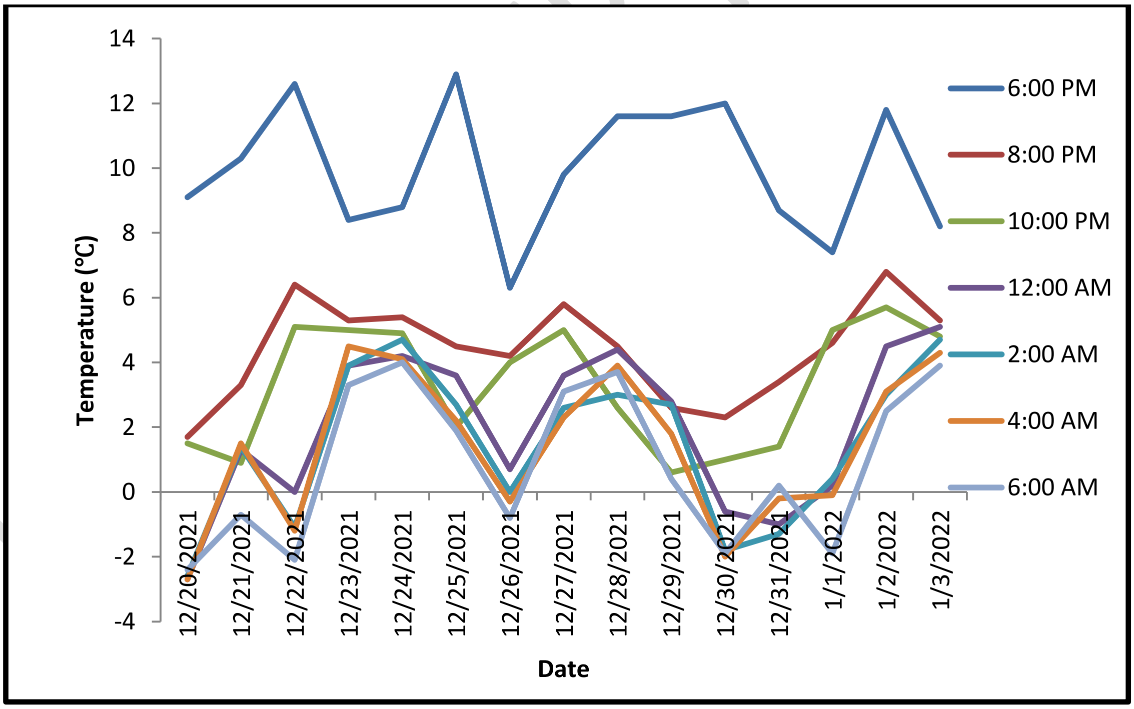

Fig. 3: Figure showing variation in Temperature (°C) at different time intervalsinside Polyhouse1 (with shade net cover) in harsh winters

Yield under shade net and without shade net

The yield of tomatoes was recorded and it was found to be maximum under shade net as compared to area without shade netdue to enhanced photosynthesis and respiration due to favorable micro-climatic conditions under shade net as shown in Fig. 4.The tomatoes grown under shade net structures were glossy in appearance with bright red colour development as compared to area without shade net.Tomato had higher yield under shade net due to light compensation for higher photosynthesis as shown in Plate 6.

Plate 6: Tomatoes under protected cultivation with shade net having glossy appearance

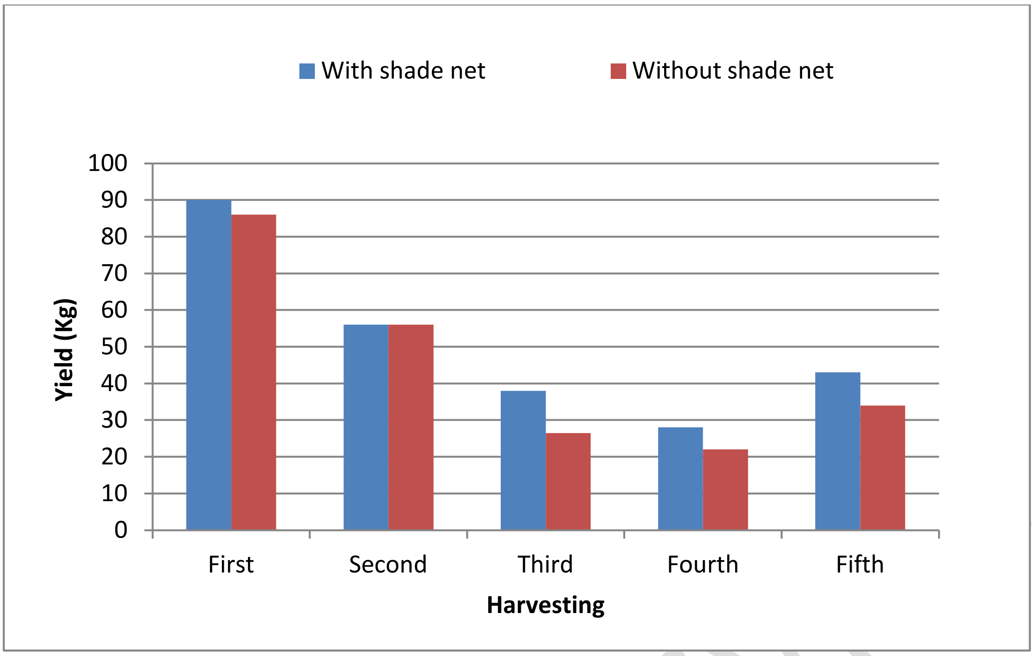

Fig. 4: Yield variation with and without shade net

Quality of tomato with shade net and without shade net

No significant difference was observed in quality attributes *viz.,* TSS, Acidity and ascorbic acid by shade net structures. However, the higher TSS (7.1 ^{o}Brix), Acidity (0.77%) and ascorbic acid (45.86 mg/100g) was recorded in polyhouse under shade net conditions, while inside polyhouse without shade net cover, lower TSS, Acidity and ascorbic acid (6.7, 0.51 and 38.52) respectively was observed. Thus, quality of tomato grown in protected cultivation under shade net cover was better but as far as physical appearance and parameters is considered as compared to it without shade net cover. The results suggest the advantage of growing tomato crop under light-dispersive shade nets for improving productivity, quality and to some extent the shelf life.

Conclusions

The application of shade net with 75% shade factor inside polyhouse was found much suitable for the cultivation of tomato crop during peak summer months in the temperate region of Kashmir valley. The application of shade net during hot summer months during day time protected the crop from harsh light intensity of sunlight insolation. Application of shade net increased the yield of tomatoes due to optimum temperature and relative humidity. The shade net usage enhanced the physical appearance of tomatoes and had a glossy appearance as compared to one without shade net.Application of shade net during onset of winter during evening hours has resulted in enhancing the heat energy leading to rise in temperature. With the application of shade net, 3-4 °C rises in temperature was noted. Temperature decreases from 6pm onwards but application of shade net has resulted in trapping ample amount of daytime solar heat energy inside the polyhouse leading to temperature enhancementduring evening/ night period.Passive solar greenhouse technique was utilized under this study.In order to protect the crop from excess humidity, a provision was provided for ventilation, for which insect proof net of 40-micron mesh was utilized for adequate side ventilation.

In temperate regions of Kashmir valley, growers of vegetables can boost their earnings by cultivating early crops under covered buildings, primarily in inexpensive greenhouses.Vegetable nursery raising in protected structures has numerous advantages, including simple maintenance, early nursery, and defense against biotic and abiotic stressors. This method is very productive, can be automated, and saves a lot of water and land. Self-help organizations and marginal farmers ought to be urged to switch to polyhouse farming in order to double their revenue levels.

References

A.O.A.C. 1980. Official Methods of Analysis of the Association of Official Agricultural Chemists. 12th Ed. Washington. D.C.

Fallik, E., Alkalai-Tuvia, S., Parselan, Y., Aharon, Z., Elmann, A., Offir, Y., Matan, E., Yehezkel, H., Ratner, K., Zur, N. &Shahak, Y. 2008. Can colored shade nets maintain sweet pepper quality during storage and marketing? In *IV Balkan Symposium on Vegetables and Potatoes 830*, pp. 37-44.

Fallik, E., Goren, A., Alakali-TuviaSh, Perzelan, Y., Aharon, Z. and Sharak, Y. 2010. The effect of colored shade nets on sweet bell pepper quality after prolonged storage and shelf-life. Book of abstracts of 28th International Horticultural Congress, Lisbon, Portugal, Vol. II, 198.

Ganesan, M. 2004. Effect of poly-greenhouse on plant microclimate and fruit yield of tomato. *Karnataka Journal of Agricultural Sciences, 15(4)*, 750-752.

Nimje, P. M., &Shyam, M. 1993. Effect of Plastic Greenhouse on PlantMicroclimate and Vegetable Production. *Farming Systems, 9*, 13-19.

Nissim-Levi, A., Farkash, L., Hamburger, D., Ovadia, R., Forrer, I., Kagan, S. and Michal, O. S. 2008. Light-scattering shade net increases branching and lowering in ornamental pot plants. *The Journal of Horticultural Science and Biotechnology, 83(1)*, 9-14.

Ranganna, S. 1994. Handbook of Analysis and Quality control for fruits and vegetable products. 2nd Edition, Tata Mc. Graw-Hill Publishing Co. Ltd. New Delhi.

Sanwal, S. K., Patel, K. K., & Yadav, D. S. 2004. Vegetable production under protected conditions in NEH region: Problems and prospects. *ENVIS Bulletin: Himalayan Ecology*, *12*(2), 7.

Shahak, Y., Gussakovsky, E. E., Cohen, Y., Lurie, S., Stern, R., Kfir, S., Naor, A., Atzmon, I., Doron, I. and Greenblat-Avron, Y. 2004. ColorNets: A new approach for light Manipulation in fruit trees. *ActaHorticulturae., 636*, 609-616.

Shahak, Y., Ratner, K., Zur, N., Offir, Y., Matan, E., Yehezkel, H., Messika, Y., Posalski, I., & Ben-Yakir, D. 2008. Photoselective netting: an emerging approach in protected agriculture. *ActaHorticulturae, 807,* 79-84.

Singh, N., Diwedi, S. K., & Paljor, E. 1999. *Ladakh Mein Sabjion Kei SanrakshiKheti*. Regional Research Laboratory of DRDO, Leh. Pub. By DRDO, Leh, 56 A.P.O.