Impact of shade nets on tomato output and quality 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 2020-21 to ascertain the impact of shade nets on tomato output and quality 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 (13 kg/plant) where plants were not covered with shade net inside the polyhouse during afternoon day time. It was also found that the tomatoes that were grown in shade nets showed good colour development and a glossy appearance 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 without shade net as compared to polyhouse with shade net (6.7, 0.51 and 38.52) respectively.

Thus, use of shade net brought improvement in yield and no significant improvement was observed 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

Crop cultivation makes considerable use of greenhouse technology. It offers the ideal microclimate for growing a broad range of vegetables. In high mountain regions, inexpensive passive solar greenhouses are often used for winter food cultivation. Nevertheless, these greenhouses have a severe summer duration overheating issue, which restricts their use to the winter and spring seasons (Ango *et al.* 2019). Within the passive solar greenhouses, shading and ventilation are efficient ways to lower heat stress. Shade net reduces the maximum daily temperature by 1 to 5 ˚C (Ilic´ *et al.* 2017; Shahak 2008). While the use of shade nets for vegetable production is common in sub-tropical and tropical nations (Dı´az-Pe´rez 2014), its potential to improve crop output in high altitude regions with cold climates has not been investigated.

Temperate region of Kashmir valley finds immense potential in the field of 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, cloches, floating covers, mulching *etc.* finds huge applications in the temperate zone of Kashmir Valley region. Crops grown in open fields are difficult to cultivate during the cold winter months. Consequently, "Protected cultivation" is applied where the crop can be shielded from adverse weather circumstances. 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 number as well as quality) 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. Vegetables could be grown under protected condition to increase output and quality (Singh *et al.*, 1999; Ganesan, 2004; Shahak *et al.*, 2008). A study

was conducted on tomato quality indicators in conjunction with crop output by Ilic *et al.*, 2012 in different coloured shade net houses with varying intensities. According to the study's findings, red-coloured shade net houses have the highest lycopene concentration. Usually, translucent or transparent materials like plastic or glass cover the greenhouse. Polyhouse" refers to a greenhouse that has a basic plastic sheet covering it. 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, short-wave radiation enters the greenhouse through the ground and is reflected back. The vegetables, floor, and other items in the greenhouse absorb the sunshine that enters into it. In the infrared spectrum, the reflected light transforms into long-wave heat radiation, which is why the glazing material is less transparent. Because of this, the greenhouse's temperature rises as the solar energy is trapped inside of it. 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, it's possible that the protected cultivation will prolong the crop's growing season. A more effective use of land and other resources could be the protected production of vegetable crops appropriate for export and domestic markets (Sanwal *et al.*, 2004). Profitability in protected agriculture is contingent upon various factors such as crop selection and structure selection.

In order to increase agricultural productivity, protected agriculture has greatly expanded now adays. The shade net houses commonly used as protected cultivation are designed for temperate or moderately warm regions. In hotter, arid climates, these designs must be updated with climate control to prevent overcooling in the winter and overheating in the summer. The soil within the greenhouse, which makes up the majority of the thermal mass and the "greenhouse effect," determines the climate in the greenhouse. In most greenhouses, ventilation plays a major role in controlling the greenhouse effect, while crop transpiration has a dominant impact on temperature and vapor-pressure deficit. Taller structures with appropriate roofs would improve light transmission, ventilation, inertia against external climatic variations, and condensation drainage. The typical structures used in the region are small (low and small volume) and have inappropriate roof-slopes, which reduces light transmission. Studies have been conducted for the purpose of developing nurseries under various types of shade net houses 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 winter month 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 in two 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 undertaken is shown in Plate 1-3.

Shade Nets

Similar to polyhouses; GI pipes, angle iron, wood, plastic, and other materials are used to build shade net constructions. The majority of the plastic net covering the framed structure is made of polymer-based materials. Through changes in shade net factor brought about by a decrease in light intensity and heating settings, it modulates the crop's microclimate. Since each crop has a unique photoperiodic requirement, shade net structures that can regulate abiotic parameters can help with this in part.

Shade net structures are highly remunerative during periods of high intensity sunlight. They are helpful in producing graft saplings with increased survival rates and in nurseries. Losses from a variety of biotic and abiotic sources are greatly reduced. They are very important in hardening treatments, which also apply to tissue-cultured seedlings. Because they have more control over abiotic conditions, they are utilized as a drying place for a variety of agricultural produce. Because they effectively manage the nearby environment, they are utilized in various composting units and reduce the degree of pest incidence as compared to open field settings.

They are quite helpful for cultivating a variety of growth habitats for crops, fruits, ornamental flowers, and vegetables.

Applications of shade nets

Having numerous advantages, they play a great role in the field of olericulture, floriculture, horticulture along with nursery growing and management of saplings and bonsai cultivation, greenhouse cultivation, terrace gardening and fencing. They have wide applications in drying of rice, wheat, maize, sorghum, pulses and oilseeds, mushroom cultivation, fish rearing, diary unit and poultry farming etc. Also, they have wide application in farm yard manure (FYM) composting, rural and urban composting and vermiculture based composting. Shade net can be used as a wind break structure if it is tall enough.

Colour variations in shed nets

Color-nets are an addition to the more recent realm of agro-technology; on the one hand, they aid in physical protection; on the other, they modify light intensity and associated chromatic parameters. The aforementioned effects are the consequence of the cladding material's manufacturing process incorporating different chromatic additions, light dispersive elements, and reflecting elements. It can be applied directly over net-house constructions or in conjunction with greenhouse technology, among other two-dimensional uses. These shade nets work by changing the spectral compositions and dispersing light. The basis for the production of photo-selective net products is the addition of different colorants, light-dispersive agents, and reflecting components to the netting materials. These shade nets include “colored-Color Nets” (e.g. Violet, Red, Yellow, Green, Blue net products) as well as “neutral-Color Nets” (e.g. Pearl, White and Grey) absorbing spectral bands like infrared or ultraviolet rays. The specific goal of the spectrum manipulation is to enhance photo morphogenetic-physiological responses. The color net 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 mitigated climate extremes to increase productivity.

- Green × Black – The effects are similar to cutting off undesirable, shorter-than-visible wave length rays while maintaining an attractive appearance. It serves as a beneficial shade source and drying purpose in vineyards.
- Black × Black – Its obvious effect is to heat the inside of the shade net home by radiating heat and absorbing solar radiation. Utilized for growing in nurseries.
- White × Black - It facilitates the diffusion of light within the shade net home. Most beneficial for cultivating crops such as anthurium, gerbera, *etc.*

- Green × Green – Better growth and output of decorative crops are the outcome of increased net photosynthesis among the plants inside the structure.

Shading Percentage

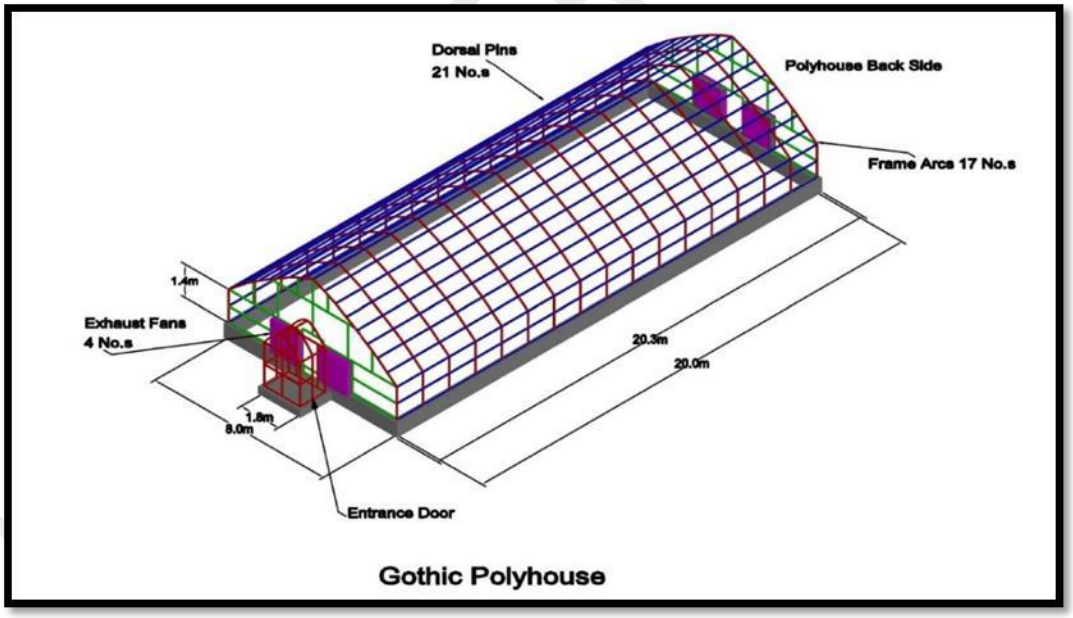
Shade nets are available in different shade percentages or shade factor *i.e.*, 15%, 35%, 40%, 50% 75% and 90% (for example 35% shade factor means - the net will cut 35% of light intensity and would allow only 65% of light intensity to pass through the net). It varies from crop to crop and variety to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

Nursery Raising

The nursery raising of Tomato crop (*variety:* GS 600) was conducted in plastic plug trays, each having 50 conical shaped cells inside a polyhouse which had the provision of raised platforms for keeping the trays (Plate 4). Coco peat that had been drenched with fertilizer solution was placed within the cells. 1.0–1.5 cm deep impressions were produced in the cells prior to the seed being planted in growth media. A small amount of coco peat was sprinkled over the seeds after they were positioned in the center of each cell at a depth of 1.5 cm. Within two to three days of seeding, the seeds began to germinate and emerge. Depending on the needs, the nutrient solution was applied once or twice a day, taking into account the crop's conditions and evaporative demand.

Plate 1: Front view of the polyhouse

Plate 2: Side view of the polyhouse



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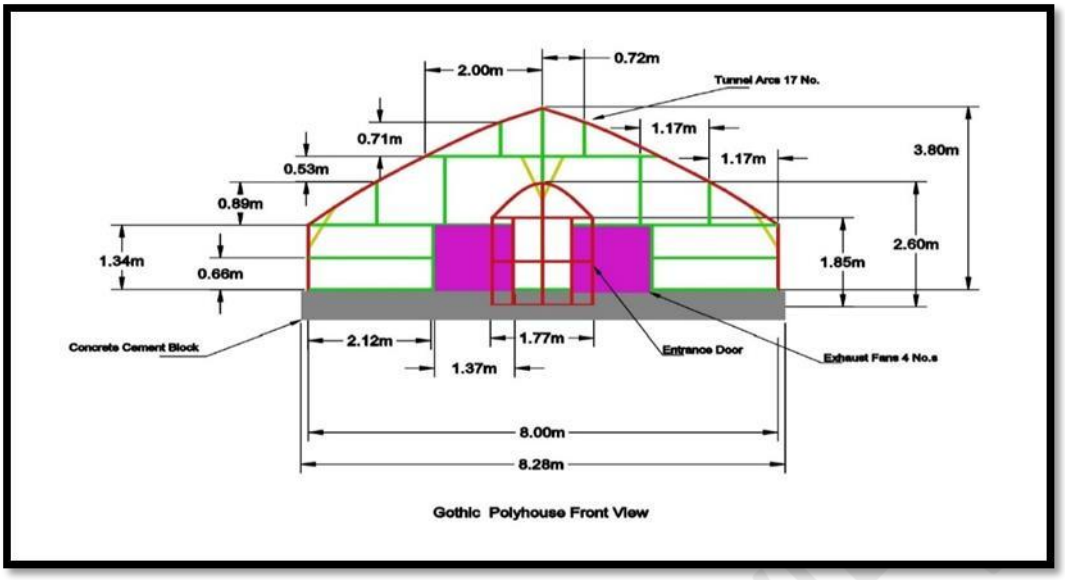

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Plate 3: (i) 3-D View and (ii) Front View of Experimental polyhouse

Plate 4: Seed germination in the cells of plastic plug trays

Transplanting

Transplanting of tomato was undertaken in month of April. After that, the slabs of coco-peat were kept under saturation for a minimum of twenty-four hours before being transplanted. 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 and water applied through drippers having discharge capacity of 2 lph (litres per hour).

Training of Plants

Approximately 2.0 meters above the greenhouse floor, plastic roller hooks suspended

from an overhead horizontal support wire were used to train the plants vertically upward by connecting the main stem to each other using 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. The first pruning involved removing the older leaves from the base of plants that ranged in height from 0.30 to 0.45 meters. Throughout the growing seasons, just one main stem (side shoots) was retained by removing branching branches or suckers. 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 5.

Disease Management

Yellow sticky cards were positioned at different points throughout the greenhouse to deter whiteflies, if any, from harming the crop. Three days prior to the transplanting date, a spray of Polo (Diafenthiuron 50.0% WP) @ 1.0 g litre^{-1} was also administered. Before transplanting, the greenhouse's insect net was cleaned with a high-pressure water spray to remove any insects that may have stuck to it. As few plants have experienced fungal infection, Ridomil Gold fungicide was also applied.

Manures

Table 1. List of manure/fertilizer used for tomato cultivation

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 5: Tomato crop inside polyhouse under drip irrigation without shade net

Physical parameters

Physical parameters like Fruit length (cm) and width (cm) were measured using a digital vernier caliper, and fruit weight (g) was determined using an electronic balance.

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 relative humidity data is shown in Plate 6.

Plate 6: Data logger used for monitoring environmental data inside the polyhouse

Results and Discussions

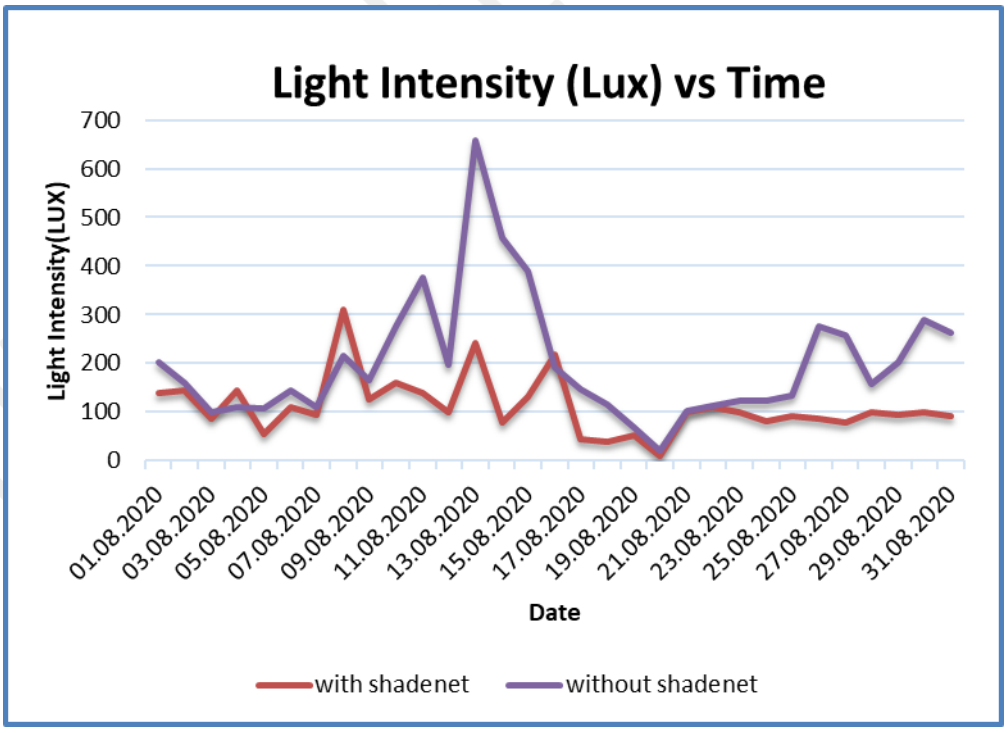
Polyhouse under shade net condition during hot summers

The sunlight intensity during afternoon hours is too high due to high altitude location of Srinagar. Application of shade net (75% shade factor) during summer duration (May – September) has cut substantial amount of light intensity and sustained heat stress which has resulted in good foliar growth. In summers during afternoon time, the application of shade net protected the crop from harsh intensity of sunrays and 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 2.5 m) to cover both sides of the crop zone during night hour durations (Plate 7). In harsh winter duration (December – February), 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 ℃ temperature was enhanced as shown in comparative graphs in Fig. 2 & 3.

Plate 7: Application of Shade nets during night hours inside the polyhouse



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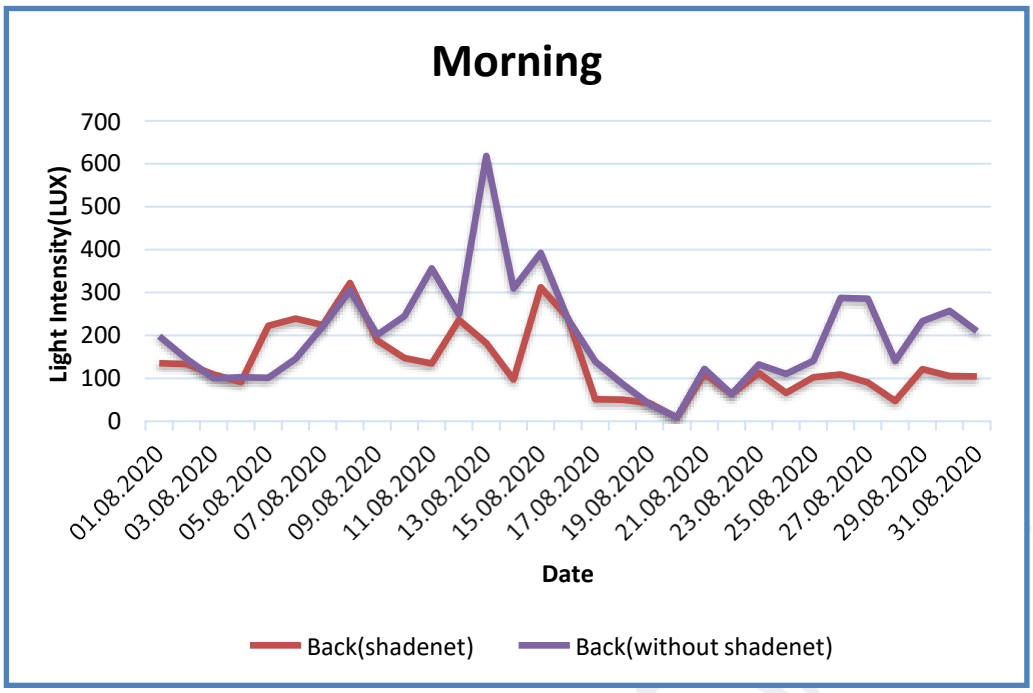

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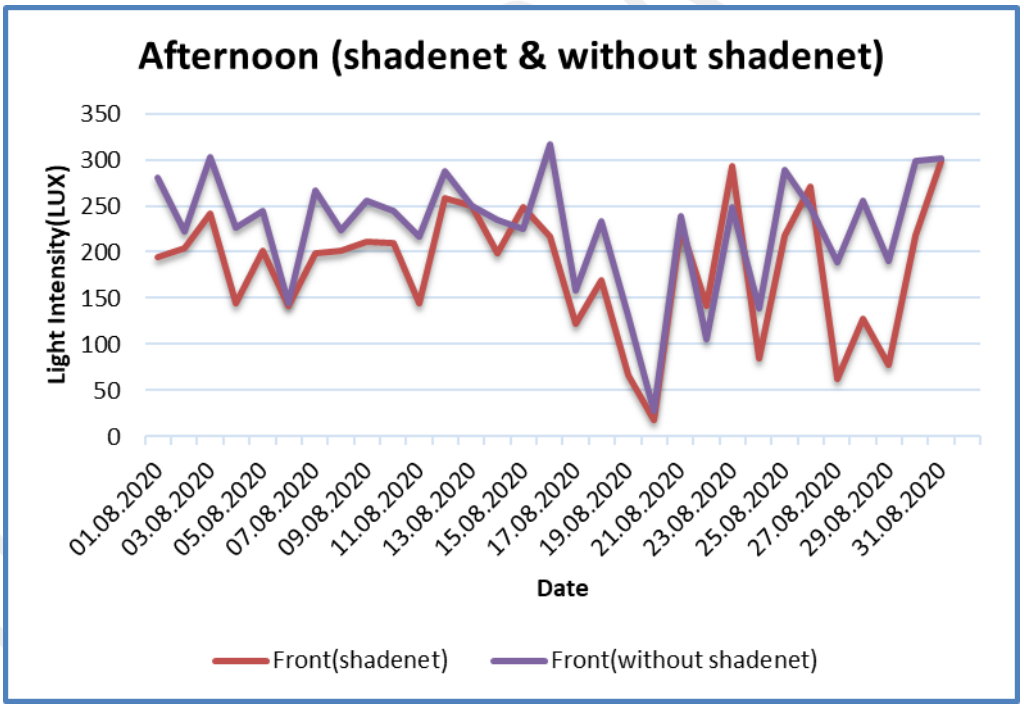

(iii)

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

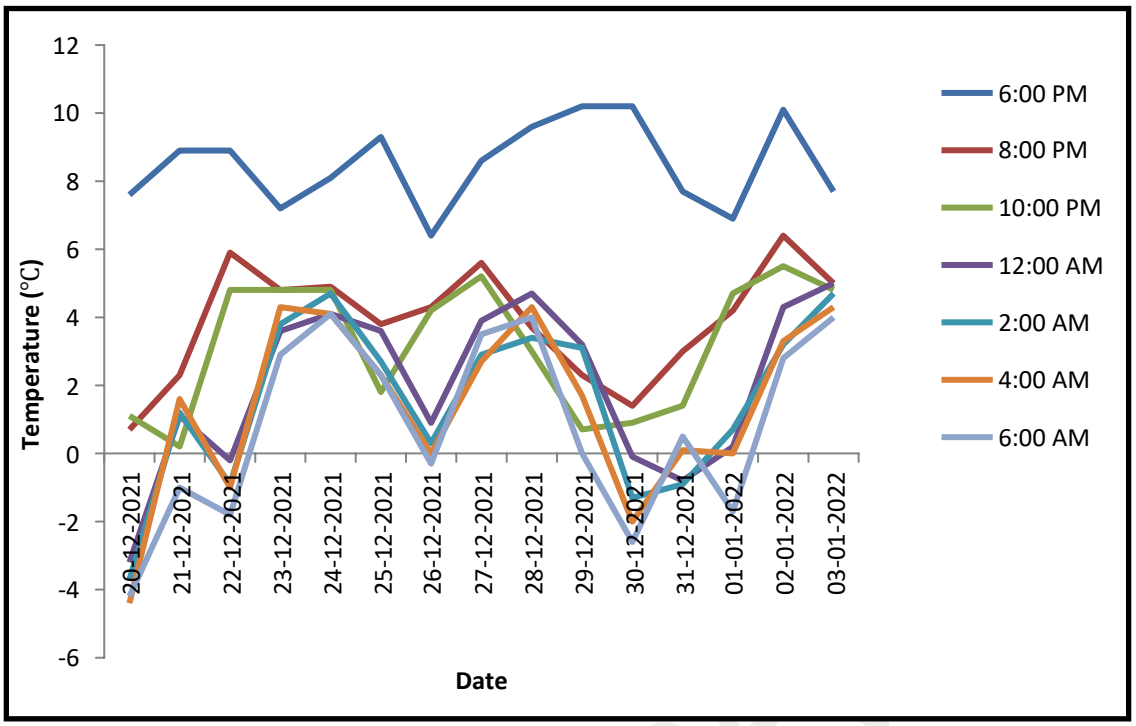

Fig. 2: Figure showing variation in Temperature (℃) at different time intervals inside Polyhouse 2 (without shade net cover) in harsh winters

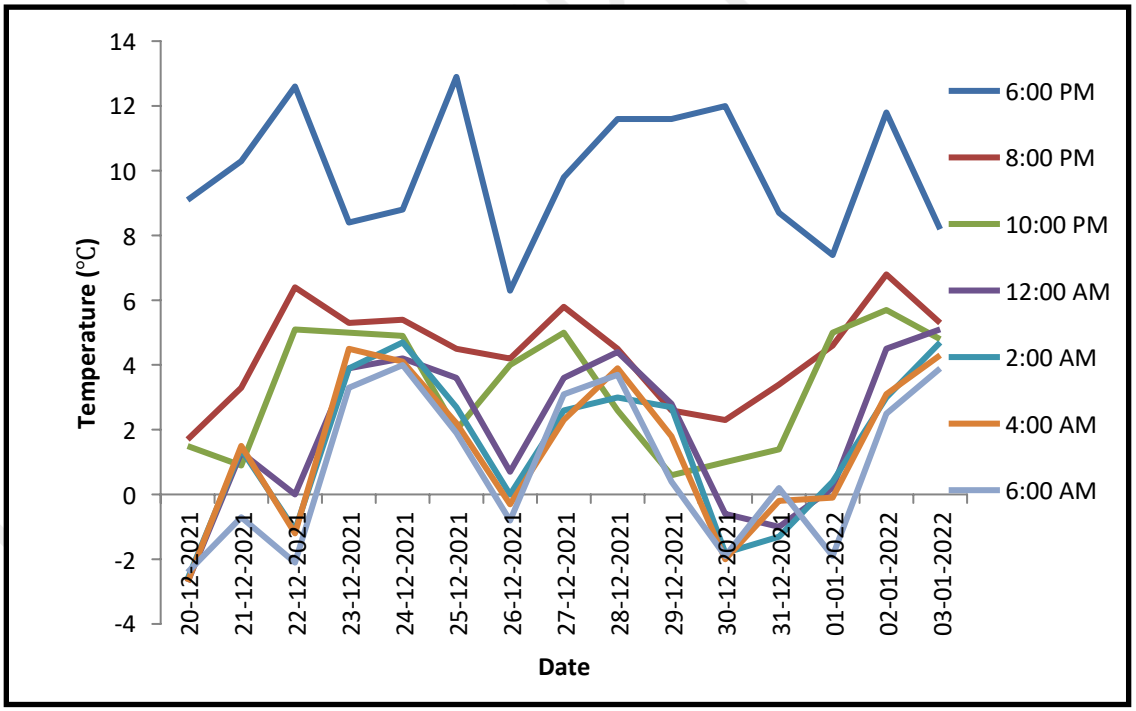

Fig. 3: Figure showing variation in Temperature (℃) at different time intervals inside Polyhouse1 (with shade net cover) in harsh winters

Yield under shade net and without shade net

Because of the higher photosynthesis and respiration brought about by the favourable microclimatic conditions under the shade net, the yield of tomatoes was observed and found to be greatest under the shade net as compared to the region without the shade net as shown in Fig. 4. When compared to an area without shade net, the tomatoes grown beneath shade net structures had a glossy appearance and developed a vivid red color. Because of light compensation for increased photosynthesis, tomato yields were higher under shade nets as shown in Plate 8.

Plate 8: Tomatoes under protected cultivation with shade net having glossy appearance

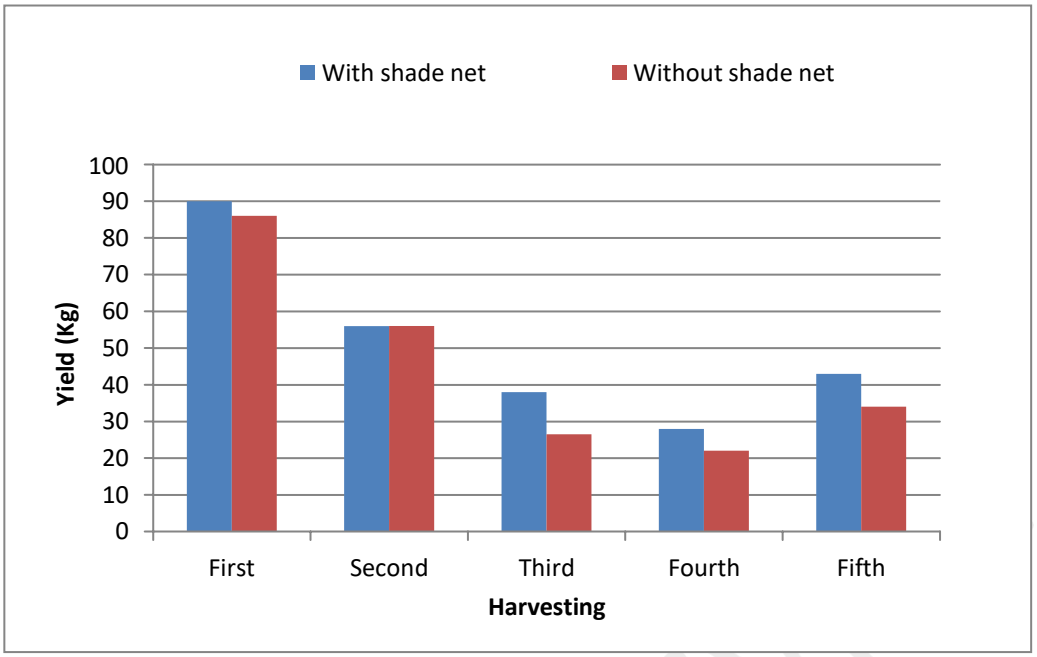

Fig. 4: Yield variation with and without shade net

Tomato quality both with and without a shade net

Shade net structures did not significantly alter the quality parameters of TSS, acidity, or ascorbic acid. However, the higher TSS (7.1 ^{o}Brix), Acidity (0.77%) and ascorbic acid (45.86 mg/100 g) was recorded in polyhouse without shade net conditions, while inside polyhouse with 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 without shade net cover was better but as far as physical appearance is considered it was getter in polyhouse with shade net cover. The findings point to the benefit of cultivating tomatoes under light-dispersive shade nets in terms of increased yield, improved quality, and somewhat longer 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 Kashmir Valley's temperate zone. The application of shade net during hot summer months during day time protected the crop from harsh light intensity of sunlight insolation. Shade net application 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. The application of shade net during onset of winter during evening hours has resulted in enhancing the heat energy leading to rise in temperature. With usage of shade net, 3-4 °C rises in temperature was noted. Temperature decreases from 6 pm

onwards but application of shade net has resulted in trapping ample amount of daytime solar heat energy inside the polyhouse leading to temperature enhancement during 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.

Acknowledgment

The authors thankfully acknowledge the ICAR-All India Coordinated Research Project on Plastic Engineering in Agriculture Structure and Environment Management (AICRP on PEASEM), CIPHET, Ludhiana for the financial support to conduct the experimental study.

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