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Study on changes in microclimatic parameters under poly-house with different color plastic mulching during tomato cultivation

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Abstract
Partial control of the microclimatic conditions can be achieved in low cost polyhouses with detachable roof during summer season. One means of alleviating climatically induced stress is through modifications of microclimate which include any artificially introduced changes in the composition, behavior or dynamics of the atmosphere near the ground so as to improve the environment in which crops grow. The present investigation was carried out to study the performance of Tomato (cv:All rounder) under both polyhouse and open condition with different plastic mulches. This experiment was conducted at field of the department of agricultural engineering, Birsa Agricultural University, Kanke, Ranchi during the period from December 2011 to May 2013. Air temperature inside the polyhouse was distinctly higher than the open field condition from December to March and after March air temperature at outside was found higher. Relative humidity showed a reverse trend with respect to temperature under both environmental conditions. The light intensity inside the greenhouse was always lower (30 – 50%) than the open field. Soil under polyhouse always maintained 2- 5ºC lower temperature as compared to the open field irrespective of the growing periods of the crop. Among the mulches, soil temperature was recorded higher under transparent mulch followed by silver black mulch under both conditions. Highest yield of 22.2 kg/plot (73.9 t/ha) and 376 fruits/ plot were obtained inside the polyhouse under black mulch. The fruit yield inside the greenhouse was nearly two times more than in the open field condition. Detachable roof Polyhouse has been found to be a good alternative to have minor alterations under microclimatic conditions for achieving almost double yield of tomato compared to open field. Among the mulches, black and silver black mulches, have been found to bring about the desired conditions both within the polyhouse as well as open conditions. When farmers are not able to grow tomato under polyhouse conditions application of these two mulches would be advantageous even under open conditions.

Keywords: Plastic mulching, Detachable roof polyhouse, microclimate

Introduction

In protected environment, the natural environment is modified for optimum plant growth which ultimately provides quality vegetables. Microclimate modification is an intended change in the soil-plant-atmosphere system, which alleviates stress or prevents damage with the aim of attaining improved yields. Main purpose of protected cultivation is to create a favourable environment for the sustained growth of plant so as to realize its maximum potential even in adverse climatic conditions. Greenhouses, rain shelter, plastic tunnel, mulches, shade nets etc. are used as protective structures. Enviromental conditions inside the greenhouse can be modified suiting to the potential growth of plants. Partial control of microclimatic conditions, which have major influence on plant growth characteristics, can be achieved in poly greenhouses (Ganeshan, 1999). Greenhouses protect the crop from varied climatic conditions like wind, rainfall, excess solar radiation, extreme temperature conditions and also incidence of pests and diseases. Plastic mulches are used in many horticultural crops to suppress weed growth, conserve soil moisture and to alter temperature in the rhizosphere. One of the main benefits associated with plastic mulching is the modification of the microclimate around the plant. Mulching is effective means of microclimatic modifications, both under protected as well as open conditions. Tomato (*Lycopersicon esculentum*) belongs to the Solanaceae family is one of most popular and nutritious vegetables worldwide. Tomato requires a relatively cool, dry climate for high yield and premium quality. However, it is adapted to a wide range of climatic conditions from temperate to hot and humid tropical. Optimum temperature for most of the varieties lies between 21 and 24° C. Plants can survive a range of temperatures, but the plant tissues are damaged below 10°C and above 38°C. Tomato plants react to temperature variation during the growth cycle for seed germination, seedling growth, flower and fruit set and fruit quality. Protected cultivation of vegetables not only overcome the stresses but also open the gates for off-season and year round supply of vegetables with remunerative prices to the growers. Location specific growing system is essential for quality product along with to meet the market demand throughout the year. Poly-greenhouse structures and use of different plastic mulches have provided a new scope for commercial application of high value crops. However, feasibility of this technology and its effect on tomato are not well known under the agroclimatic condition of Jharkhand. To mitigate these problem, efforts were made to modified micro climate with the help of plastic mulch of different colours.

Materials and Method

Present investigation was carried out to study the performance of Tomato (*Lycopersicon esculentum*) under both protected and open conditions with different plastic mulches. This experiment was conducted in a polyhouse along with an open field with different plastic mulches at Birsa Agricultural University, Kanke, Ranchi during the period from December 2012 to May 2013. Location of the experimental site on globe is between $23^0 17^{'}$ N latitude, 85^0 $19^{'}$ E longitude and at an altitude of 625 m above mean sea level. The polyhouse (approximately 12 m x 4 m size) was constructed with ultra-violet stabilized polyethylene film (200 µm thickness) as cladding material on a bamboo frame. To reduce high temperature during summer months, polyethylene film was replaced into shadenet of green colour during first week of march, for free air flow. The open field was prepared in parallel to the length of polyhouse with a plot size of 12m x 4m.The experiment comprised of two factors; (A) Two microclimatic treatments viz. polyhouse climate and natural climate (*i.e.* open field), and (B) Three different plastic mulch, Black, Silver black, Transparent and a Control plot (without mulch) following a Completely Randomized Design (CRD) with four replications. Size of a unit plot was 3m x 1m. Two adjacent unit plots and blocks were separated by 0.5 and 0.75 m, respectively.

Observations on height, number of nodes and branches were collected in the randomly selected plants. The fruit yield of tomato in greenhouse was compared with that in open field conditions and correlated with other data. These investigations were carried out using four treatments replicated four times. Treatments were tested in Completely Randomized Design. Treatments were tested in Completely Randomized design. The details of four treatments are:

Under Polyhouse	Under Open Field
T_1- Black Plastic Mulch	T_1- Black Plastic Mulch
T_2- Silver black Plastic mulch	T_2- Silver black Plastic mulch
T_3- Transparent Plastic mulch	T_3- Transparent Plastic mulch
T_4- No mulch	T_4- No mulch

Experimental plots of 12 x 4m were prepared for transplantation of the seedlings of tomato and maintained with row to row (0.50 m) and plant to plant (0.50 m) spacing. Different colour mulches of 25-micron thickness like black, silver black and transparent were cut as per the size of the plots. Seedlings of four weeks old having 4-5 leaves and of uniform size, well developed and healthy seeds were uprooted and transplanted with the utmost care in the afternoon during last week of December. Daily relative humidity, temperature, solar radiation was recorded inside the polyhouse and in an open environment daily at 7.00 AM and 2.00 PM. The observations were recorded in the centre of the poly-greenhouse and open field. Daily meteorological data on temperature, rainfall, humidity, sunshine, and soil temperature were obtained. Vegetative growth parameters and yield contributing parameters were also recorded.

Results and Discussion

The mean weekly temperatures were found to be higher by 2 to 9 ºC inside the polyhouse than in the open field. However, the temperature differences between polyhouse and open field were small at 7 am which increased gradually with the advancement of time and amounted to a difference of about 10 ºC at 2.00 PM irrespective of the growing stages of the crops. During this period the average weekly air temperature at 2 pm under polyhouse and open field varied from 25.2 to 32.2 ºC and 18.1 to 28.5 ºC, respectively. Nimje and Shyam (1993) also obtained similar results. Polyhouse permits restricted entrance of lower amount of incident solar radiation of short-wave radiation due to the greater inference of the roof of polyhouse against the incoming solar beam but it traps the outgoing long-wave radiation. As a result the air temperature inside the polyhouse gradually increased due to the greenhouse effect. Thus, the inner of the polyhouse became warm to warmer and temperature remained at optimum level (about 28 ºC) for the growth and development of tomato plants during the cooler months (December to February).

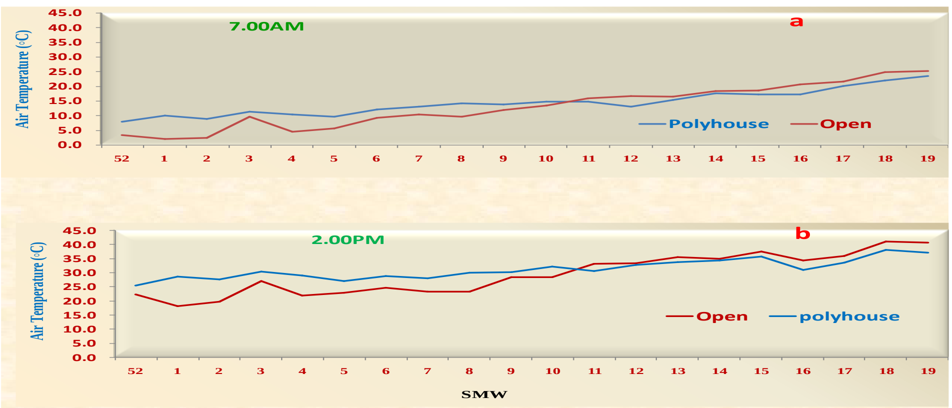


Fig 1: (a, b) Average weekly air temperature under polyhouse and open condition

The most important function of a greenhouse is to regulate and maintain inside temperature at higher level. Enhanced temperature accelerates plant growth and allows sustaining plant growth even when outside ambient temperatures are unfavourably low. However, during summers, inside temperatures rise higher than the optimum levels and therefore cooling/ventilation provision are necessary. Partial shading is provided to reduce the intensity of radiation in the polyhouse which could be achieved by replacing the UV stabilized polyhouse roof by shade net (50%) material of green colour. Atmospheric temperature gradually increased from 11th week and tomato crops outside the polyhouse were exposed to higher minimum and maximum temperature as compared to polyhouse condition by altering the microclimate. Average weekly temperature inside the polyhose at 7.00 AM and 2.00 PM varied for 13 to 23.6 ºC and 30.5 to 38.1 ºC which was about 1.0 to 3.7 ºC lower than open condition with the temperature varying from15.9 to 25.6 ºC and 33.1 to 41.0 ºC, respectively.

Vegetative and reproductive processes in tomatoes are strongly modified by temperature alone or in conjunction with other environmental factors (Abdalla and Verkerk, 1968). High temperature stress disrupts the biochemical reactions fundamental for normal cell function in plants. It primarily affects the photosynthetic functions of higher plants (Weis and Berry, 1988).It is evident, from temperature data maintained above, that temperature with in polyhouse could desirably be maintained at higher level than ambient temperature(outside)till 11th march(10thSMW) by utilising the green house effect of the polyhouse. While for the later stages of crop the temperature within the polyhouse could successfully be maintained at lower levels when the outside temperature rose .Temperature, so maintained with in the poly house provided very congenial condition for growing tomato crop which has reflected at the performance of the crop. Transport of nutrients from soil to plant organ is governed by water uptake and transpiration, which is essential for proper growth and development of crops. Humidity affects leaf area development and stomatal conductance thereby interfering with the photosynthesis and dry matter production (Jolliet, 1994). Daily relative humidity recorded at 7 AM and 2 PM showed more or less reverse trend with respect to temperature under both environmental conditions *i.e.* lower RH was found at 2.00 PM and higher RH was found at 7.00 AM,both within and outside the polyhouse. Average weekly relative humidity inside the polyhouse was always 2-7 % lower than that of the outside environment during winter season (January – February) but it was always found higher(upto 4%) inside the greenhouse during summer (Mid Feb-May) at 7 AM (fig 2 a,b).Contrary to temperature pattern, the relative humidity had maintained opposite patterns with that of air temperature *i.e.* it was lower inside the polyhouse as compared to open field in initial condition and higher or almost similar during later stages. Almost a similar trend at 2.00 PM was also observed but differences in RH were higher (2-6.5 %) between open and greenhouse condition. Relative humidity was higher by 10 % in the months of March and April inside the polyhouse. The minimum value of relative humidity in the polyhouse was common because of its inverse function with higher temperature (Parvej *et al.*, 2010). However, Nimje and Shyam (1993) observed that the relative humidity was higher inside the greenhouse than in the open field condition. Optimum relative humidity of air for most of the plants (vegetables and fruits) is 60 – 85 %. Relative humidity inside polyhouse as well as open condition ranged between 71 to 80 % and 73 to 78 %, respectively and maintained at optimum range throughout the growing season of tomato.

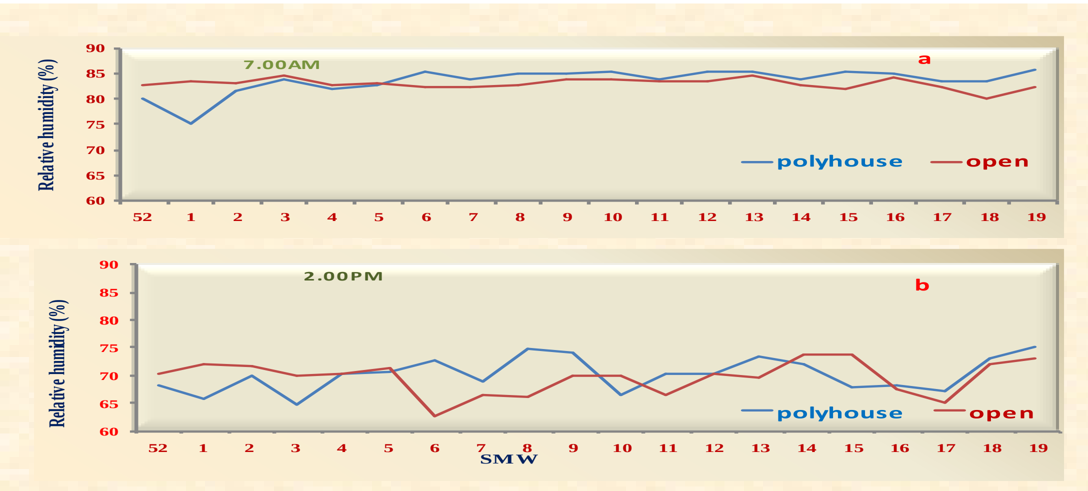


Fig 2: (a, b) Average weekly relative humidity under polyhouse and open condition

Light intensity affects the colour of the leaves, fruit set and fruit colour. Light intensity inside the polyhouse was reduced by about 30 to 40 % compared to the outside (*i.e.* open field). The lower amount of incident solar radiation under polyhouse as compared to the open field was due to the greater inference of the roof of polyhouse against the incoming solar beam. Daily light intensity measured at 7 AM and 2 PM during the growing period of tomato plants is presented as weekly average in figure 3 (a & b).

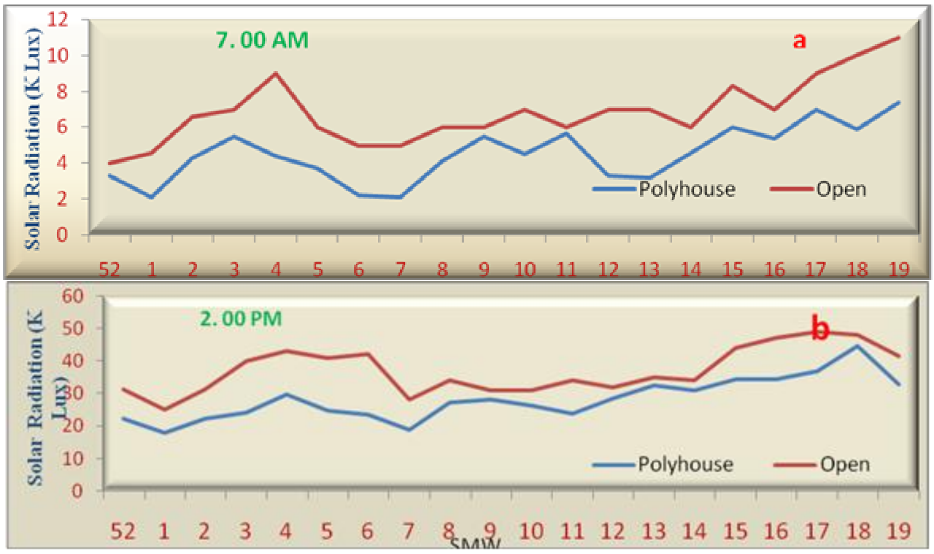
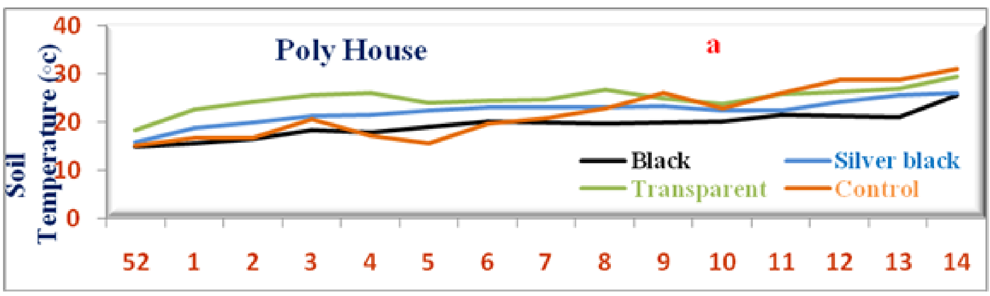


Fig. 3: (a, b) Average weekly solar radiation under polyhouse and open condition

On an average, the weekly measured solar radiation at 7.00 AM varied from 2.1 to 7.4 Klux and 4 to 11 Klux inside the polyhouse and open environment, respectively. Similarly, at 2.00 PM it varied between 18 to 44.7 Klux and 25 to 49 klux under polyhouse and open condition, respectively. It suggests that the plants inside the polyhouse received less energy in the form of net solar radiation than outside the polyhouse. Kaname and Itagi (1973) also found similar results for tomato cultivation under protected cultivation. The type of roof material used caused the reduction of the total solar radiation in the polyhouse. The reduction of solar energy received by the plants also results in the reduced evapotranspiration.

Soil temperature influences the rate of chemical reactions, water content, and nutrient transport in soil, but it simultaneously affects plant physiological aspects of ion uptake, root growth, and the composition and function of soil microbial communities. Soil temperature extremes influence the germination of seeds, functional activity of root system and development of crop. As evident from the Figure 4 (a,b) the effect of mulches on soil temperature were found more pronounced upto 10th week (5 to 11th March) under polyhouse as well as open condition. In general, this effect was more pronounced during the early crop season when tomato plants shaded less soil surface (Kamal and Singh, 2011). Temporal variation in soil temperature both within and outside the polyhouse showed that it was less for poly house as compared to open field. The highest soil temperature occurred under transparent mulch followed by silver black, black and no mulch plot during 52 to 10th week (December to mid March) at 7 Am and 2 PM. It was found to be higher by about 1 to 10^{o}C as compared to no mulch plot inside and outside the polyhouse. After 10th week, soil temperature was found 2 to 4^{o}C higher under no mulch plot as compared to transparent mulch under polyhouse. But there was no definite pattern observed under mulched or no mulched condition,either at 7:00AM or 2:00PM in open field condition. Black mulch always maintained an optimum temperature ranged from 10 to 26 ^{0}C and 19 to 32^{0}C at 7AM and 2PM respectively inside polyhouse and in open field it ranged from 10.5 to 28^{0}C and 18 to 36^{0}C at 7:00AM and 2:00PM, respectively. Among the treatments soil temperature under black mulch recorded lowest average temperature during the growing period of tomato inside and outside the polyhouse (20 and 23.2^{0} C). Average soil temperature during crop period of tomato inside and outside the polyhouse with transparent mulch, silver black mulch and no mulch were recorded as 25.2 & 27.5 ^{0}C, 22.8 & 26.7 ^{0}C and 22.5 & 23.4 ^{0}C, respectively. Black plastic mulch, an opaque blackbody absorber and radiator absorbs most ultra-violet (UV), visible, and infrared wavelengths (IR) of incoming solar radiation and re-radiates absorbed energy in the form of thermal radiation or long-wavelength infrared radiation. Much of the solar energy absorbed by black plastic mulch is lost to the atmosphere through radiation and forced convection. The efficiency with which black mulch increases soil temperature can be improved by optimizing conditions for transferring heat from the mulch to the soil. Because thermal conductivity of the soil is high relative to that of air, much of the energy absorbed by black plastic can be transferred to the soil by conduction if contact is good between the plastic mulch and the soil surface. Transparent plastic mulch absorbs little solar radiation but transmits 85 to 95 percent, with relative transmission depending on the thickness and degree of opacity of the polyethylene. The under surface of clear plastic mulch is usually covered with condensed water droplets. This water is transparent to incoming shortwave radiation but opaque to outgoing long wave infrared radiation. Hence, much of the heat lost to the atmosphere from a bare soil by infrared radiation is retained by clear plastic mulch.



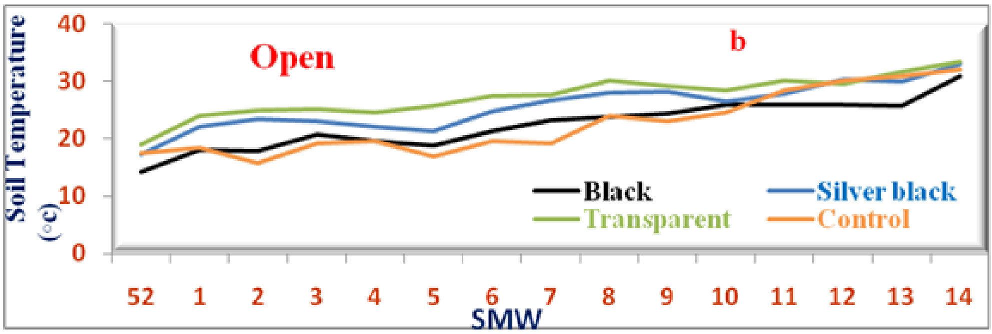


Fig 4: (a, b) Average weekly soil temperature under polyhouse and open condition

Plastic mulches directly impact the microclimate around the plant by modifying the radiation budget (absorbitivity vs. reflectivity) of the surface and decreasing the soil water loss (Liaktas et al., 1986). Colour affects the surface temperature of the mulch and the underlying soil temperature. The soil temperature under a plastic mulch depends on the thermal properties (reflectivity, absorbitivity, or transmittancy) of a particular material in relation to incoming solar radiation (Lamont, 1999). The effects of various mulches on soil microclimate have been reviewed by Streck *et al.* (1995) and reported that opaque mulches (black, white and colored plastics, paper, petroleum, bitumen, and straw) decrease the soil heat flux and the daily amplitude of the soil temperature. Transparent and translucent mulches promote a relatively large net radiation at the soil surface, increase soil heat flux and, as a consequence, the minimum and maximum soil temperature is increased.

Table 1: Total no. of fruits/plot, Fruit yield/ plot (kg),Fruit wt. (g/fruit) and total yield (t/ha)

Treatments/ Stages	**Total no. of fruits/plot**		**Fruit yield/ plot (kg)**		**Fruit wt. (g/fruit)**		**Total Yield (t/ha)**	
	P	O	P	O	P	O	P	O
Black	376	193	22.2	11.2	58.9	57.9	73.9	37.3
Silver Black	333	180	20.0	10.3	60.0	57.3	66.5	34.5
Transparent	320	178	18.8	9.8	58.8	54.6	62.8	32.6
No mulch	273	172	17.3	8.6	73.0	49.8	57.7	28.6
Average	316.4	181.0	19.6	9.9	61.8	9.9	65.2	33.2
S. Em. ±	22.16	12.75	1.54	0.34			6.16	1.36
CD (5 %)	68.31	39.31	4.75	1.05			19.0	4.2
CV %	14.01	14.09	15.7	15.8			15.7	16.4

The total yield as influenced by growing environment with mulch treatments are presented in Table 1. The growing conditions had a significant influence on fruit yield per hectare. The plants grown in polyhouse recorded significantly higher (65.2 t/ha) mean yield as compared to open field (33.2 t/ha).

Higher fruit yield (73.9 t/ha) was recorded under black mulch inside the polyhouse. The lower (57.7 t/ha) fruit yield was recorded in no mulch condition. The silver black and transparent mulch were at par with each other.

Similar trend of tomato yield has been observed under open field condition. The maximum (37.3 t/ha) fruit yield was obtained in black mulch which was significantly superior over the no mulch condition (28.6 t/ha). The silver black and transparent mulch were at par with each other under open field condition. Black plastic mulch significantly affects the tomato yield. Kamal & Singh (2011) found that the yield increased with black plastic mulch was 21.7 to 29.8 % as compared to bare soil. One of the main benefits associated with plastic mulching is the higher total yield due to a positive influence on the microclimate around the plants (Lamont, 2005). The result revealed that the performance of tomato crop grown inside the polyhouse was comparatively better than that grown in open condition and increase was nearly two times higher in fruit yield. This may be attributed to the favourable climatic conditions like optimum temperature, light intensity and relative humidity that prevailed under polyhouse, leading to higher vegetative growth, contributing to more number of flowers, more number of fruits and maximum fruit weight. The low yield obtained in open condition with no mulch could be attributed to the uncontrolled environmental conditions than polyhouse. Similar results were obtained by Nagendra prasad (2001). Ganesan (1999) also observed that fruit yield was about two times higher inside greenhouse than in the open field due to warm and humid weather inside.

Conclusions

The present investigation was taken at Birsa Agricultural University, Ranchi to study the performance of tomato grown inside and outside the polyhouse with Black, Silver black, Transparent mulch and No mulch condition indicated that better growth, development and yield of tomato were achieved under polyhouse due to the higher (optimum) temperature and lower relative humidity during the winter months (December to February) and lower temperature and relative humidity during summer month (March to May) which positively influenced the morpho-phenological and physiological events of tomato plants.

This simple and low cost polyhouse may be suitable for the regions like Jharkhand where the temperature falls during winter and sudden rise in temperature during summer season is very common. The growth and development of tomato plant becomes restricted during the cold winter months of December to February because of its season bound nature. Polyhouse has been found to be a good alternative to have minor alterations under microclimatic conditions for achieving almost double yield as well as better quality of tomato compared to open field. The optimum temperature accompanied by low relative humidity at initial stage and low temperature and high humidity at later stage with low solar intensity inside polyhouse provide the most suitable growing environment, so growers are benefited by being able to produce higher and off-season tomato which fetched premium prices in the market Among different mulches, black and silver black mulches have been found to bring about the desired conditions both within the polyhouse as well as open conditions When farmers are not able to grow tomato under polyhouse conditions application of these two mulches would be advantageous even under open conditions.

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References:

1. Abdalla AA, Verderk K. Growth, flowering and fruit set of tomato at high temperature. The Netherlands Journal of Agricultural Sciences. 1968; 16:71-76.
2. Ganesan M. Effect of poly-greenhouse models on plant growth and yield of tomato (Lycopersicon esculentum). Indian Journal of Agricultural Sciences, 1999; 72(10):586-588.
3. Jolliet O, Hortitrans A. model for predicting and optimising humidity and transpiration in greenhouse. Journal of Agricultural Engineering Research. 1994; 57:23-37.
4. Kamal S, Singh AK. Effect of black plastic mulch on soil temperature and tomato yield. Progressive Horticulture. 2011; 43 2:337-339.
5. Lamont WJ. Vegetable production using plasticulture. Food and fertilizer Center. Extension Bulletein. 1999; 476:10.
6. Liakats AJ, Clark A, Monteita JL, Measurement of the heat balance under plastic mulches. Part 1. Radiation balance and soil heat flux. Agric. Meteorol. 1986; 36: 227-239.
7. Nagendra Prasad HN. Effect of plant density on growth and yield of capsicum grown under greenhouse and open conditions. M. Sc. (Agri.) Thesis submitted to University of Agricultural Sciences Bangalore. 2001.
8. Nimje PM, Shyam M. Effect of Plastic Greenhouse on Plant Microclimate and Vegetable Production. Farming Systems. 1993; 9:13-19.
9. Parvej MR, Khan MAH, Awal MA. Phenological evelopment and production potentials of Tomato under polyhouse climate, The Journal of Agricultural Science. 2010; 5(1):19-31.
10. Weis E, Berry JA. Plants and high temperature stress. Soc of Expt Biol. 1988; 329-346.
11. Aggarwal S, Korla BN, Raina JN. Effect of mulches on soil hydrothermal regime, weed incidence, yield and quality of ginger. Journal of the Indian Society of Soil Science. 2003; 51:65-67.