Impact of microclimatic modification on tomato quality through mulching inside and outside the polyhouse

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ABSTRACT
An experiment was conducted to study the effect of polyhouse and different plastic mulches on yield, quality and shelf life of tomato. Experiment was carried out at Birsa Agricultural University Ranchi during December 2012 to May 2013. Fruits were harvested at full mature stage to determine fruit yield, number of fruits per plant and average fruit weight. Random fruit samples from cluster were used to determine fruit outer and inner quality and shelf life. The results showed that fruit yield improved by mulching in both growing systems. Fruit yield increased by 2 times inside the polyhouse. Fruit quality in terms of total soluble solids and lycopene content were slightly improved by mulching in both growing systems. However, fruit size and shelf life were affected and fruit firmness improved by mulching. The result also showed that using simplified open system with mulch improved productivity and fruit quality of tomato in terms of fruit size, shelf life and firmness.

Key words: Microclimate, Plastic mulches, Polyhouse, Tomato fruit quality.

INTRODUCTION
Tomato (Lycopersicon esculentum Mill.) is one of the most important and popular vegetables in India. It ranks third in the world’s vegetable production, next to potato and sweet potato, placing itself first as processing crop among the vegetables. It is a cheap source of vitamin-C and minerals. Prevailing low temperature and frost injury during winter season are limiting factor for successful cultivation of tomato under the agro-climatic region of Eastern plateau and Hills. It is difficult to grow this vegetable under open conditions during November –March because of adverse effects of low temperature on overall morphological growth and fruit setting. Protected agriculture, by manipulating microclimate, is more relevant in Jharkhand state than in other parts of the country. With increasing consciousness of consumer towards quality, providing an adequate growing condition can increase the yield, fruit quality, fruit size, keeping quality, colour and taste of tomato.

In general, visible evidence of heat injury on tomatoes appears as yellowish-white patches on the side of fruits (Mohammed et al. 1996). Although no significant changes in firmness were observed for these treatments following storage at 20°C for 18 days, the percentage of infected fruits was 35% higher in fruits exposed to direct sunlight. Exposure of tomato fruit to elevated temperatures affected quality determining characteristics. Titratable acidity and soluble solids content were 20% higher and 10% lower, respectively, in those tomatoes exposed to direct sunlight (Mohammed et al., 1996). Frequent exposure of apple fruit to high temperatures, such as 40°C, can result in sunburn, development of watercore and loss of texture (Ferguson et al. 1999). Below 12°C almost no growth is expected for tomato (Criddle et al., 1997). Chilling injury occurs when tomato plants are exposed to these temperatures for a long period of time. Depending on the intensity and duration of exposure to the chilling temperatures, photosynthesis, respiration, membrane integrity, water relations and the hormone balance of the plants may be affected (Graham and Patterson, 1982).

Keeping this in view, the investigation was undertaken to study, how changes in microclimate can potentially impact the postharvest quality of tomato under polyhouse and open condition with the aim to mitigate the adverse effects of weather under Jharkhand conditions.

MATERIALS AND METHODS
The present study was conducted at agricultural engineering field of BAU, Ranchi, to observe the effects of different plastic mulches on the growth, quality and yield of tomato (cv - All Roun der) inside and outside the polyhouse during December 2012 to May 2013. The experiment was conducted in the newly built polyhouse (approximately 12m x 4m size) facing east to west constructed with insect net proof material (40 mesh) except roof. The roof was covered with ultra-violet stabilized high density polythene sheet (200 micron thickness) on bamboo frame.

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 mulches.
mulches, 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.

One month old seedlings of tomato were transplanted in polyhouse and open field conditions. Regular irrigation was given by inline drip irrigation system. Fertilization, stacking and crop protection measures were adopted as per the package of cultivation practices. Experimental site has loamy soil and falls under the sub tropical humid zone. Physical properties of the soil such as field capacity, wilting point, bulk density and soil texture were determined by usual standard methods. Quality of tomato was determined by measuring TSS, lycopene (mainly for flavors), firmness, grading of fruits and shelf life. Total soluble solids (TSS) were recorded with the help of a hand refractometer. Content of total lycopene was estimated spectrophotometrically using Anthrone method. Grading was done on the basis of fruit weight, fruit length, fruit diameter. Fruits were divided into A, B, C and D grade. This investigation was carried out using three randomly selected plants of each treatment of each replication. The tomato fruits were categorized into following grades.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Weight (gm)</th>
<th>Diameter (cm)</th>
<th>Length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&gt;75</td>
<td>&gt;15.5</td>
<td>&gt;7.5</td>
</tr>
<tr>
<td>B</td>
<td>65-75</td>
<td>10 - 15</td>
<td>5 - 7</td>
</tr>
<tr>
<td>C</td>
<td>50-65</td>
<td>6-10</td>
<td>3 - 5</td>
</tr>
<tr>
<td>D</td>
<td>&lt;50</td>
<td>&lt; 6</td>
<td>&lt; 3</td>
</tr>
</tbody>
</table>

Fully ripe tomato fruits were harvested and kept at room temperature for checking the shelf life of tomatoes. This investigation was carried out using fruits of three randomly selected plants of each treatment of each replication. These fruits were kept in ambient condition until they remain fresh and at acceptable quality. The number of days was calculated to express the shelf life. Firmness was recorded with the help of penetrometer. Fully ripen fruits of each treatment were taken and with the help of penetrometer needle readings in Newton (N) were taken.

RESULTS AND DISCUSSION

Microclimate under polyhouse and open condition: On an average, the air temperature difference between inside and outside the polyhouse ranged between 2–5°C (Fig. 1). The air temperature inside the polyhouse was higher than outside the polyhouse during January to March and about 2°C lower during April to May. Higher temperature during daytime was due to retention of outgoing long wave radiation caused by green house effect in the polyhouse under partially closed conditions. During 2nd week of March to May, mean weekly temperature were found to be lower by 1 to 4 °C under polyhouse than open condition due to replacement of UV stabilized high density polyethylene sheet roof of polyhouse with shade net of green colour.

![FIG 1: Average weekly temperature and humidity inside the polyhouse and open condition. (T) average weekly temperature, (H) average weekly humidity,(P) polyhouse and (O) open condition.](image1.png)

![FIG 2: Average weekly solar radiation (K lux) inside (P) and outside (O) the polyhouse.](image2.png)
against the incoming solar beam. The reduction of solar energy received by the plants also resulted into the reduced evapotranspiration. Wind speed in the polyhouse as expected, was nil. The advantages of low wind speed include low evapotranspiration rate that means lower water requirements (Abou-Hadid et al., 1994).

Quality parameter
Grading of fruits: The extent of production of A, B, C, and D grade quality fruits, based on fruit weight, length and diameter, under different microclimatic conditions are presented in Table 1. All fruit grades differed significantly due to different growing conditions. Higher percentage of A, B, C and D grade (25, 36, 20 and 17 %, respectively) were observed in polyhouse as compared to open field condition (13, 23, 38 and 24%, respectively). The maximum (38%) C grade fruits were obtained from open fields.

Among the different mulching treatments, the higher extent of A and B grade fruits (28.0 and 36.0 %) was observed in black mulch followed by silver black mulch (24.0 and 39.0 %) under polyhouse condition. The lower (22.0 and 31.0 %) extent of A and B grade fruits was observed under transparent mulch.

Under open condition, the maximum extent of A and B grade fruits was recorded under black mulch (16.0 and 26.0%, respectively). No mulch produced lower (11 and 22.0%) extent of A and B grade fruits, respectively and maximum (37.0%) extent of D grade fruits. First (A) and second (B) quality yield were decreased with increasing ambient as well as soil temperature. High temperatures can cause significant losses in tomato productivity due to reduced fruit set, and smaller and lower quality fruits (Stevens and Rudich, 1978).

Shelf life (days): The shelf life of tomato is also very important quality parameter because it directly influences the market distance. The ventilated polyhouse recorded significantly higher (19.0 days) shelf life than open condition (15.0 days) (Fig. 3), which is mainly because of bigger fruits having thick pericarp thickness.

Among the mulches the maximum shelf life was recorded under black mulch (25.0/20.0 days) followed by silver black and transparent mulch (18.0/15.0 and 18/12.0 days) and lowest self life was noticed under no mulch (15/11.0 days) under polyhouse/open condition. Similar results were observed by Rai et al. (1995) in capsicum.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Grade</th>
<th>P</th>
<th>O</th>
<th>P</th>
<th>O</th>
<th>P</th>
<th>O</th>
<th>P</th>
<th>O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>A</td>
<td>426 (28)</td>
<td>212 (16)</td>
<td>548 (36)</td>
<td>200 (26)</td>
<td>321 (21)</td>
<td>272 (35)</td>
<td>209 (14)</td>
<td>179 (23)</td>
</tr>
<tr>
<td>Silver Black</td>
<td>B</td>
<td>320 (24)</td>
<td>108 (15)</td>
<td>521 (39)</td>
<td>189 (26)</td>
<td>240 (18)</td>
<td>278 (39)</td>
<td>249 (19)</td>
<td>146 (20)</td>
</tr>
<tr>
<td>Transparent</td>
<td>C</td>
<td>281 (22)</td>
<td>96 (13)</td>
<td>400 (31)</td>
<td>134 (19)</td>
<td>350 (27)</td>
<td>345 (48)</td>
<td>250 (20)</td>
<td>140 (20)</td>
</tr>
<tr>
<td>Control</td>
<td>D</td>
<td>248 (26)</td>
<td>76 (11)</td>
<td>360 (38)</td>
<td>149 (22)</td>
<td>140 (15)</td>
<td>212 (31)</td>
<td>200 (21)</td>
<td>252 (37)</td>
</tr>
</tbody>
</table>

FIG. 3. Shelf life (days) of Tomato under polyhouse and open condition

Color of fruits: Color of tomato fruits affects the grade and appearance of the end processing products and is a result of the presence of different pigments, particularly lycopene, the expression of which is influenced by physical factors, such as surface topography and shape of fruit (Lancaster et al. 1997), as well as the rate of fruit maturity (Batu, 2004) and environmental factors, above all temperature and solar radiation (Brant et al. 2006). Results indicated that (Fig. 1) the colour of tomato fruits was significantly influenced with the microclimatic conditions. Fruits produced under polyhouse had darker and more intensely red fruit skins, with significantly higher lycopene content (2.1 mg/100 g) than fruits obtained from open field (1.68 mg/100g) (Fig. 4).

FIG. 4. Lycopene content (mg/100g) of Tomato under polyhouse and open condition
Plants grown in more suitable microclimatic condition under polyhouse were found to be in red at maturity stage. Inside and outside the polyhouse silver black mulch showed maximum lycopene content (3.3 and 2.57 mg/100g) followed by black (2.97 and 2.15mg/100g) and transparent mulch (1.59 and 1.47 mg/100g). Lower content was observed in the fruits obtained from no mulch condition inside as well as outside the polyhouse (0.67 and 0.55 mg/100g).

**Fruit firmness (N):** The average firmness of fruits harvested from inside and outside the polyhouse is presented in figure 2. The fruits picked from polyhouse had lower average firmness (2.6N) than the open condition (3.4 N). Among the mulches, black mulch showed the maximum firmness inside and outside the polyhouse (2.9 & 3.8 N) followed by silver black mulch (2.6 & 3.5 N) and no mulch condition (2.4 & 3.4N). Lower firmness was detected in the fruits of transparent mulch (2.4 & 2.9N). Highest temperature (25°C) range resulted in two weeks earlier harvest and improved fruit shape and firmness in tomato than at lowest constant temperature (Buitelaar and Janse, 1987) (Fig. 5).

**Total soluble solid:** Quality parameter like total soluble solid (TSS) was recorded maximum under polyhouse (5.0°Brix) as compared to open condition (4.2°Brix) and presented in Fig. 1. Tomato fruits grown under transparent mulch recorded maximum TSS content of 5.3 and 4.9°Brix inside and outside the polyhouse, respectively but variation among the mulch treatment were not found significant under both environmental conditions. No significant variation has been observed in TSS content under polyhouse and open condition (Fig. 6).

**CONCLUSION**

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. Quality parameters in terms of self life, grading of fruits, fruit colour etc. of tomato fruits was found to be higher under polyhouse with black mulch. 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 black and silver black mulches would be advantageous even under open conditions.

**REFERENCES**


