CHAPTER – III
MATERIALS AND METHODS

The present investigation entitled, ‘Performance of Sweet pepper (Capsicum annuum L.) cultivars and economics under protected structures in Punjab’ was carried out for the two consecutive cropping seasons of 2014-15 and 2015-16 under Naturally Ventilated Polyhouse, Nethouse and walk-in tunnel at Centre of Excellence for Vegetables (An Indo-Israel project), Kartarpur, Jalandhar (Pb).

3.1 Geographical Location

Kartarpur (Jalandhar) is located at 31.44° N (latitude) and 75.5° E (longitude) at the altitude of 228 m above sea level.

3.2 Climate

Kartarpur (Jalandhar) had a humid sub-tropical climate having hot summers associated with desiccating winds during April-June followed by hot-humid rainy season and cold winters with occasional ground frost in December-January. The average annual rainfall of the region is 1110.7 mm

3.3 Methodology

Nursery of the crop was raised using black plastic pro-trays of 99 cells or cavities in polyhouse in SLCM (soilless culture media) during August 2014 and seedlings were transplanted during September 2014 for the first season 2014-15 (Sept - May); and in August 2015 and seedlings were transplanted during September 2015 for the second season 2015-16 (Sept - May).

Soilless culture media for nursery raising was prepared by using coco peat: vermiculite: perlite (v/v) in the ratio 3:1:1 (v/v). Cocopeat was soaked in water for 12 hours before mixing. The pH value of 6.5 was recorded for coco peat media. The cavities of black plastic pro-trays were filled with the growing media and the one seed per cavity was sown and covered with media. A thin layer of vermiculite was spread over the plastic tray cavities to check the water loss through evaporation for better germination of seeds. The seeds were germinated in 9-10 days after sowing.
**Fertigation schedule (Nursery)**

<table>
<thead>
<tr>
<th>Nursery stage</th>
<th>Component name</th>
<th>Dose</th>
<th>Mode of application</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-10 days after germination</td>
<td>N.P.K (19:19:19)</td>
<td>2 g / litre</td>
<td>Root drenching</td>
</tr>
<tr>
<td>Once in a week</td>
<td>Captan/Bavistan</td>
<td>1 g / litre</td>
<td>Root drenching</td>
</tr>
<tr>
<td>15-20 days after</td>
<td>Calcium Nitrate/ Magnesium sulphate</td>
<td>1 g / litre</td>
<td>Root drenching</td>
</tr>
</tbody>
</table>

For transplanting of seedlings under the different protected structures; the experiment was laid out in split plot design keeping naturally ventilated polyhouse (NVPH), nethouse and walk-in-tunnel (WIT) as main plots and different hybrids of following groups as sub plot treatments.

I. Green coloured sweet pepper hybrids: Indra, Pasrella, and starlet

II. Yellow coloured sweet pepper hybrids: Bomby, Inspiration, and Mazillia

III. Red coloured sweet pepper hybrids: Orobell, Bachata, and Sven

**Lay out design of experiment**

<table>
<thead>
<tr>
<th>Structure</th>
<th>Replication – I</th>
<th>Replication – II</th>
<th>Replication – III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capsicum</td>
<td>G1 R1 Y1 G2 R3 Y2 G3 R2 Y1</td>
<td>G1 R1 Y1 G2 R3 Y2 G3 R2 Y1</td>
<td>G1 R1 Y1 G2 R3 Y2 G3 R2 Y1</td>
</tr>
<tr>
<td>Naturally Ventilated PolyHouse (NVPH)</td>
<td>G2 R2 Y2 G1 R1 Y3 G2 R1 Y3</td>
<td>G2 R2 Y2 G1 R1 Y3 G2 R1 Y3</td>
<td>G2 R2 Y2 G1 R1 Y3 G2 R1 Y3</td>
</tr>
<tr>
<td>Nethouse</td>
<td>G1 R1 Y1 G2 R1 Y2 G3 R3 Y3</td>
<td>G1 R1 Y1 G2 R1 Y2 G3 R3 Y3</td>
<td>G1 R1 Y1 G2 R1 Y2 G3 R3 Y3</td>
</tr>
<tr>
<td>Walk-in-Tunnel (WIT)</td>
<td>G1 R1 Y1 G1 R2 Y1 G2 R3 Y2</td>
<td>G1 R1 Y1 G1 R2 Y1 G2 R3 Y2</td>
<td>G1 R1 Y1 G1 R2 Y1 G2 R3 Y2</td>
</tr>
</tbody>
</table>
Note:

- G1, G2 and G3 represented Green coloured hybrids of Capsicum, i.e., Indra, Pasrella, and starlet respectively.
- R1, R2 and R3 represented Red coloured hybrid of Capsicum, i.e., Bomby, Inspiration, and Mazillia respectively.
- Y1, Y2 and Y3 represented Yellow coloured hybrid of Capsicum, i.e., Orobelle, Bachata, and Sven.

Soil Preparation

The soil was ploughed using rotary tiller and covered with white polythene sheet (30 micron) for soil solarisation/soil sterilization. The soil was irrigated by drip system of irrigation after every 2nd day for 30 minutes up to 4-5 weeks to maintain moisture in the soil. The soil was treated to destroy the insect-pest and disease pathogens that persisted in the soil during June month.

Bed preparation

The beds were prepared at the distance of 2 metre (from center of 1st bed to the center of 2nd bed). The beds having 80 cm wide base and 45 cm wide top were prepared. The 35-40 days old seedlings were transplanted on the beds with 40 x 30 cm plant to plant and row to row spacing respectively.

Mulching

Mulching was done by using silver black polythene sheet of 30 micron thickness for the management of unwanted weeds and to conserve soil moisture. It is also helpful in maintaining the soil temperature of bed in December and January.

From the beginning of flower initiation to fruit setting boron @ 1-2 g per litre of water was sprayed twice with the interval of 10 days. Other recommended cultural operations were carried out according to the crop requirement as per the improved package of practices for cultivation. Fertigation schedule (after transplanting) is as per Table.
Fertigation schedule (after transplanting)

<table>
<thead>
<tr>
<th>Stage</th>
<th>Duration Days</th>
<th>NPK 19:19:19</th>
<th>NPK 12:61:0</th>
<th>Calcium Nitrate</th>
<th>NPK 0:52:34</th>
<th>NPK 13:0:45</th>
<th>Ammonium Sulphate</th>
<th>Magnesium Sulphate</th>
</tr>
</thead>
<tbody>
<tr>
<td>After transplanting</td>
<td>0 – 30</td>
<td>1.5</td>
<td>1.5</td>
<td>2.5</td>
<td>--</td>
<td>2</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Flowering/ Fruit Setting</td>
<td>31 – 65</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>--</td>
<td>4</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>First Harvest</td>
<td>66 – 95</td>
<td>2</td>
<td>--</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Upto end of Harvest</td>
<td>96 – 300</td>
<td>2</td>
<td>--</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>1.5</td>
<td>4</td>
</tr>
</tbody>
</table>

Note:
- Foliar Spray of Micronutrients like Mn Sulphate @ 2 gm per litre and Boron @ 1 gm per litre once in a week.
- Once in a week give plain Irrigation.
3.4 Observations Recorded

The observations on the following growth and development parameters, earliness, fruit yield and fruit quality characteristics were recorded from each replication during entire period of experiment on the following parameters for two continuous seasons and the data was pooled:

1. **Plant height (cm)**: Plant height was recorded from ten randomly selected plants from each replication at final harvest. Plant height from the ground level to the tip of the plant was measured in centimeter and averaged.

2. **Number of branches per plant**: Plants were pruned after one month of transplanting and two branches per plant were retained for longer fruiting span.

3. **First flower initiation (Days)**: Observation was recorded for the number of days taken to open the first flower from the date of sowing.

4. **First fruit harvest (Days)**: Observation was recorded for the number of days taken to harvest the first fruit from the date of sowing.

5. **Number of fruits per plant**: Total number of fruits from different pickings from ten selected plants for each replication during the cropping season was added and average was made for fruits per plant.

6. **Percent fruit set (%)**: Observation was recorded by tagging flowers at the time of anthesis of selected plants at weekly intervals and the fruits with tags were counted to work out percentage.

7. **Fruit length (cm)**: Length of ten randomly selected mature fruits at marketable stage was measured in centimetre using vernier calliper and average was worked out.

8. **Fruit diameter (cm)**: Ten mature fruits at marketable stage were used to measure the diameter of fruit in centimetres using Vernier Calipers at the widest point of the fruit and average was computed.

9. **Individual fruit weight (gm)**: Fresh weight of ten randomly selected mature fruits at marketable stage was recorded in grams using electronic balance and the average was calculated.
10. **Fruit volume (cc)**: Fruit volume was recorded from ten randomly selected individual fruits by water displacement method in a jar containing water and the displaced water was measured by using measuring cylinder.

11. **Fruit rind thickness (cm)**: Thickness of rind of ten randomly selected fruits for each replication was measured using Vernier Caliper.

12. **Shelf life (Days)**: Ten randomly selected mature fruits were kept at ordinary room temperature with shrink wrapping immediately after harvest and the days for which the fruit remained consumable were calculated.

13. **Total fruit yield per plant (kg)**: Fruits harvested from ten randomly selected plants at each harvest were weighed using electronic balance and the data was recorded and summarized to work out total fruit yield.

14. **Total fruit yield per square metre (kg)**: Total number of plants \((n)\) was calculated in 1 m\(^2\) cropping area and total yield was worked out as \((n \times x)\) on the basis of total fruit yield per plants \((x)\).

15. **Total fruit yield per hectare (Tonnes)**: Fruit yield per square metre was used to calculate fruit yield per hectare as area of 1 Hectare = 10000 m\(^2\).

16. **Tolerance to major pests**: Infestation of major pests, i.e., thrips and mites on plants was recorded on the visual basis and resistance of different hybrid genotypes to pest was worked out using rating scale 0 (Highly resistant) to 10 (Highly susceptible).

17. **Temperature (°C)**: Temperature at weekly intervals was recorded to know the optimum temperature range for getting higher yield.

18. **Relative humidity (%)**: RH at weekly intervals was recorded to know the optimum RH range for getting higher yield.

19. **Light intensity (klux)**: It was measured with Klux metre.

### 3.5 Economics

Economics of sweet pepper production under different protected structures was worked out by considering the market price of inputs and produce. The following formula was used to calculate the benefit : cost ratio :-

\[
\text{Net returns (Rs/500 m}^2) = \text{Gross returns (Rs/500 m}^2) - \text{cost of cultivation (Rs/500 m}^2)\]
Benefit: Cost (B:C) Ratio = \frac{\text{Gross returns (Rs/500 m}^2\text{)}}{\text{Cost of cultivation (Rs/500 m}^2\text{)}}

3.6 Statistical analysis

The data so recorded were analyzed as per method suggested by Steel and Torrie (1981). For this data were recorded for all the observations under study as per the data collection methods (heading 3.4) for both the cropping season of 2014-15 and 2015-16 separately for the three replications from each main plot (protected structures). The replication wise data were pooled over the two seasons and subjected to the pooled analysis of variance for the design using computer programme CPCS1 (Cheema and Singh 1990) to obtain estimate of experimental error mean squares, which was used for further analysis.

It involved modeling the data using the linear model shown below:

Model: \ Y_{ijk}= \mu+\rho_i+\tau_j+\delta_{ij}+\beta_k+(\tau\beta)_{jk}+\epsilon_{ijk} \]

Such that:

\ Y_{ijk} = \text{observation corresponding to } k^{th} \text{ level of sub-plot factor (B), } j^{th} \text{ level of main plot factor (A) and the } i^{th} \text{ replication.} \\
\mu = \text{general mean} \\
\rho_i = i^{th} \text{ block effect} \\
\tau_j = j^{th} \text{ block effect} \\
\beta_k = k^{th} \text{ main plot treatment effect} \\
(\tau\beta)_{jk} = \text{interaction between } j^{th} \text{ level of main-plot treatment and the } k^{th} \text{ level of sub-plot treatment.} \\
\epsilon_{ijk} = \text{experimental error}

The error components \delta_{ij} \text{ and } \epsilon_{ijk} \text{ are independently and normally distributed with means zero and respective variances } \sigma^2_{\delta} \text{ and } \sigma^2_{\epsilon}.\]
### Analysis of variance

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole plot analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Replication</td>
<td>r-1</td>
<td>ssR</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Main plot treatment (A)</td>
<td>a-1</td>
<td>ssA</td>
<td>MsA</td>
<td>msA/msE₁</td>
</tr>
<tr>
<td>Main plot error (E₁)</td>
<td>(r-1)(a-1)</td>
<td>ssE₁</td>
<td>msE₁=Ea</td>
<td></td>
</tr>
<tr>
<td>Sub-plot analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sub-plot treatment (B)</td>
<td>b-1</td>
<td>ssB</td>
<td>MsB</td>
<td>msB/msE₂</td>
</tr>
<tr>
<td>Interaction (AxB)</td>
<td>(a-1)(b-1)</td>
<td>ss(AB)</td>
<td>ms(AB)</td>
<td>ms(AB)/msE₂</td>
</tr>
<tr>
<td>Sub-plot error (E₂)</td>
<td>a(r-1)(b-1)</td>
<td>ssE₂</td>
<td>msE₂=E_b</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>rab-1</td>
<td>Sstot</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Where:

- \( ssR \) = Sum of squares due to replication
- \( ssA \) = Sum of squares due to main plot
- \( MsA \) = Mean squares due to main plot
- \( msE₁ \) = Mean squares due to main plot error
- \( ssB \) = Sum of squares due to sub-plots
- \( MsB \) = Mean squares due to sub-plots
- \( ms(AB) \) = Mean squares due to interaction
- \( msE₂ \) = Mean squares due to sub-plot interaction error

The mean square due to replication, main plot and interaction were tested against error variance by ‘F’ test at 5 percent levels of significance.
3.7 Different Protected Structures and Fruits of Capsicum hybrids

(a) Structures used for experimental work

1. Hi-Tech Poly House (Fan & Pad System)

2. Naturally Ventilated Polyhouse (NVPH)
3. Walk-in-Tunnel (WIT)

4. Net House (NH)
(b) Fruits of different Capsicum hybrids

(1) Green group hybrids

Pasrella

Indra

Starlet
(2) Red group hybrids

Bomby

Inspiration

Mazillia
(3) Yellow group hybrids

Orobelle

Bachata

Sven