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# Design Construction and Testing of Textile Material Based Polyhouse on Roof Top

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***Abstract***: *A polyhouse is designed and constructed on the terrace using bamboo, polythene sheet and textile materials; to increase the Organic Food Intake, to create a natural way of burning calories, to reduce considerable amount of room temperature this poly house is designed for. The polyhouse is based on textile raw materials; growing plants and maintenance of the polyhouse where ropes, twines etc., are used in construction; coir mulch, coir pith etc., issued in growing plants; coir net, coir fibre bunches, shade net is used in protecting the plants and humidity maintenance, sunlight control in the polyhouse. The advantages and statistics which is related to the growth of plants is also experimented along with the stability of the polyhouse at various environmental conditions is also analyzed.*

**Keywords:** *Polyhouse, Roof Top, Textile materials, Crop, Yield*

## INTRODUCTION

A polyhouse which is also known as greenhouse is a structure which is covered with a transparent material like polythene sheet, polycarbonate sheet or glass. Since glass is no longer used as a covering material, currently polythene sheet and polycarbonate sheet is extensively used. These structures range in size from small sheds to industrial-sized buildings. A miniature greenhouse is known as a cold frame. The interior of a greenhouse exposed to sunlight becomes significantly warmer than the external ambient temperature, protecting its contents in cold weather.

Agriculture is the backbone of India; more than 30% of India's population is dependent on agriculture. The scarcity of food is increasing drastically as the farmers are losing interest in farming. This is causing food inflation every year which is highly affecting urban areas. The hike in prices of vegetables is affecting the urban life every year. Theimpact of floods in recent years is destroying a huge amount of crops. Lack of knowledge of the farmers are making them to use pesticides and the fertilizers excessively thus polluting the soil's fertility and also making the vegetableswe get very toxic. All these aspects are causing a huge impact in urban areas. Most of the terrace area is not used in India, utilizing this space for agriculture by Textile made polyhouse on roof is the solution to overcome the food scarcity.

## METHODOLOGY

### Process outlook

1. To design and construct the polyhouse on terrace.
2. To utilize Textile materials for building polyhouse.

3. To utilize coir fibre and its by-products for growing plants in polyhouse.

**Material Selection Process:**

1. Bamboo polyhouse is preferred.
2. Keeping the affordability in mind the partly controlled polyhouse can be built with the available budget.

Durability wise medium life span polyhouse can be built.

**Planned Polyhouse Structure:-**

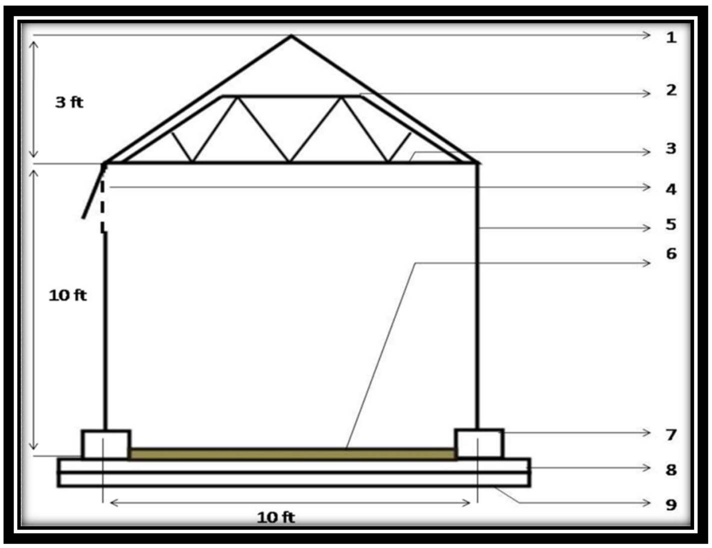


**Fig. 1** Planned Polyhouse Structure

1. **Ridge:** Peak of the structure.
2. **Purlin:** Member who connects member supporting bar to column.
3. **Girder:** Horizontal structure membrane connecting columns.
4. **Ventilation:** Opening in the wall of the structure for air flow.
5. **Column:** Vertical structure carrying polyhouse.
6. **Foundation pipe:** Structure connecting the column at ground level.
7. **Base:** Concrete base built around to support the column.
8. **Water proofing layers:** A root repellent rubber layer and water proof cement layer.
9. **Roof:** The concrete roof which is the basement here.

**Table 1:** Selected Raw Materials

| MATERIAL | JUSTIFICATION |
|---|---|
| Bamboo Poles 1 ½" dia | For the construction of frame pole diameter of 1 ½ inch is sufficient to withstand the load of wind at 110 kmph. |
| Epoxy Water Proofing Cement | Epoxy based water proofing is an effective advanced and economical way of waterproofing. |
| Concrete | To makes the poles stand, the concrete with gravel is mixed and a small concrete base was formed where the bamboo poles are formed as pillars at the corners. |
| Polythene Sheet | Due to its higher transmission rate, affordable price and fits into the budget range so polythene sheet is selected as covering material. |
| Shade Cloth | To protect the plants from intensive sunlight in the summer this could cause severe damage to the plants and also to stop fast evaporation of water from the soil so shade cloth is used. |
| Polythene Mesh | The mesh selected was 4o Number mesh which is extensively used in agriculture to prevent insects entering inside and also keep the polyhouse ventilated. |
| Grow bags | Grow bags are cheap, highly durable hence it will fit in to the budget range, moreover they apply less load on the roof. The grow bags are U.V. Stabilized which makes them highly durable. |
| Tying wire | G.I. Wire of 0.75 mm gauge is used for tying the joints of the frame because of its affordable price and Durability. |
| Coir ropes and Twines | They are selected to tying small joints. |
| Metallic brush | For rubbing the roof surface before applying the epoxy cement. This brush removes loose particles From the surface of the roof. |

# METHOD OF CONSTRUCTION

### *1. Selection of Area:*

This is an important aspect that should be considered because; selecting suitable area will help in decreasing the danger levels that occurs to the polyhouse and also its production. Hence the following points have to be considered:-

1. The area should be open.
2. The corners on the terrace are highly preferred because the wall will be acting as an additional supporting tool. This also gives additional grip and strength to the polyhouse frame.
3. The area selected on terrace should be in less wind flow area, example:
   a) The wind velocity is cut down by any object like the buildings, neighbors wall, a tree etc.,
   b) By this the wind velocity hitting the polyhouse will decrease at least in the obstructing area.
   c) This prevents the polyhouse from severe damages from wind.
4. The area selected on terrace should not allow water to log.
5. Most importantly there should be abundant sunlight falling in that area.
6. The area should be marked with a chalk, so here 10*10 feet area is marked on the surface.

**Note: -** the obstructing object should not restrict sunlight falling in the selected area.

7. On the other hand bamboo poles should be cut according to the length mentioned below.

**Table 2:** Measurement of Bamboo Poles

| MEASUREMENT IN FEET | NOS. | USED FOR |
|---|---|---|
| 5.6 | 4 | **Main Column :**Main poles at four corners. |
| 5.6 half cut | 10 | **Side Column:** Supporting standing poles and door frame.1 |
| 10 | 4 | **Girder**<br>Top links or standing pole connectors |
| 10 half cut | 4 | Supporting side wall links. |
| 11.6 quarter cut | 8 | **Roof** |
| 16.4 | - | For minor supporting frames, links and connectors. |

### *2. Concrete Pillar Construction:-*

Cement concrete has to be prepared using gravel.

1. A die should be taken which may be in any shape or form.
2. Here a15 ltr metallic oil tin is taken, top and bottom of the tin is cut and used as a die.
3. Then the standing pole is placed in position inside the tin and concrete is poured inside the die till the die isfilled completely.
4. Care should be taken so that the pole is held straightly by hands.

## 2.1 FRAME DESIGNING AND FRAME CONSTRUCTION:-

The very next step and time consuming step is construction of skeleton of the polyhouse. Here lots of work is done on the frame because of the following Constrains:-

1. The structure should be stable against high velocity wind which hits at 110 km/h.
2. The structure should assist the maximum amount of sunlight to enter into the poly house.
3. The connecting of poles by tying should be performed correctly, and also ensure that tied joints should not getloosened due to any mechanical force and thereby prevent weakening of the structure.

The structure is a ridge like structure, this structure is designed aerodynamically the angle of inclination of the roof to girder is 45$^o$ and the reason for changing the roof type is the structure type was allowing less amount of sunlight compared to the dome structure. The coverage of sun light on the roof is shown in the **fig.Ridge Type Structure**. More sunlight will help in more photosynthesis of plants and also it will intern help the yield of the plants to increase in the polyhouse. The another reason is the dome structure is far more aerodynamically designed by reducing the angle of

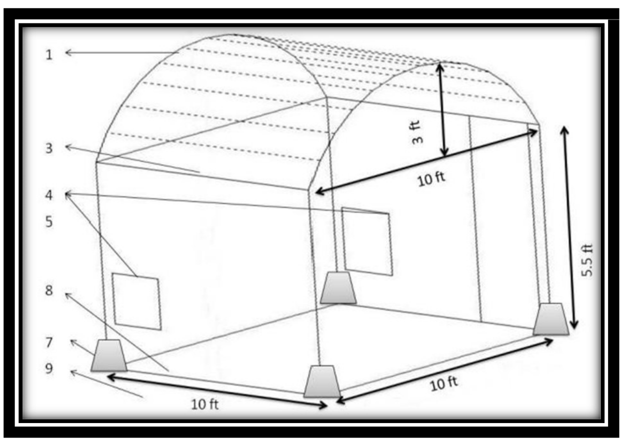


**Fig. 3** Measurement of the Structure

1. The frame was stable and tight even after continuous shaking the frame after frame construction. This satisfies
2. The roof was constructed in such a way that the corners is angled at 40$^o$.this will assist the easy wind flow and
3. After few minutes hands can be taken off from the pole.
4. In this project only two poles are made to stand in this fashion, the remaining two poles are drilled to the sidewall and screwed tightly to the wall.

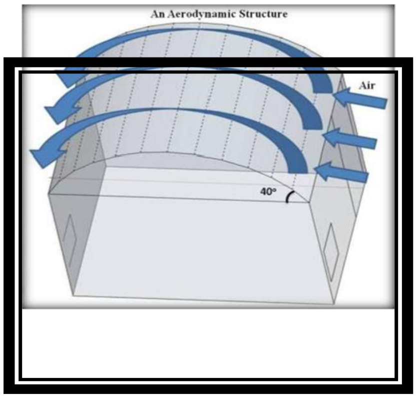


**Fig.4** Aerodynamic Structure of polyhouse

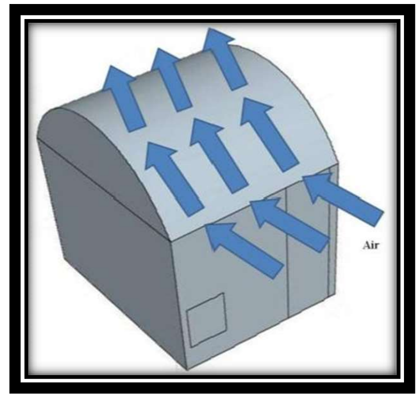


**Fig.5** Air passing above the polyhouse

## 2.2 Construction of Roof:-

The bulged or a dome shape is constructed in such a way that the two descending ends are at east and west side, sothere is maximum exposure of roof to the sunlight. This means maximum light entering the polyhouse.

1. From the below figure we can see that the selected design allows more surface exposed to sunlight whichsatisfies

**xposure to sunlight** **Position of the day**

**Early morning**

**Noon**

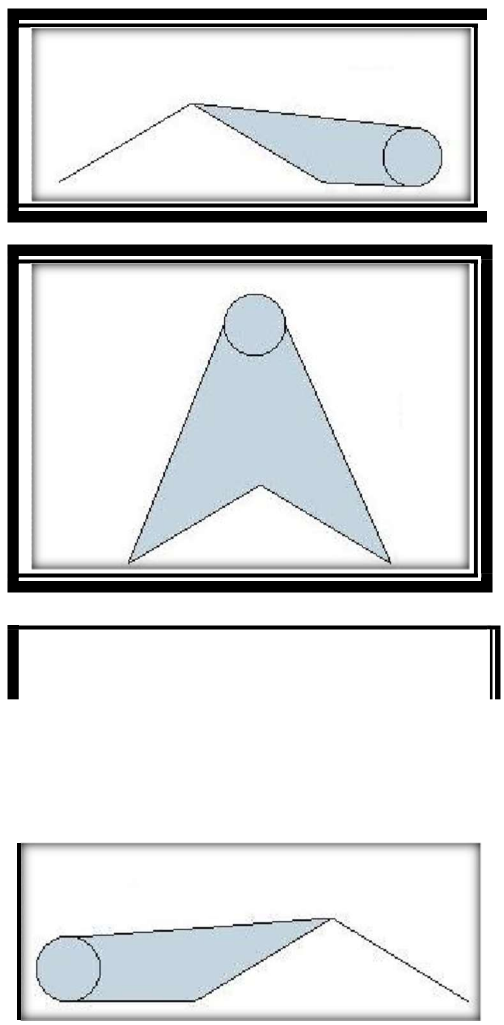

**Fig. 7** Sunlight Falling on Ridge type of Structure.

2. The connecting joints is tied tightly in such a way that when the pole was suspended at one end tied, thesuspended end was almost bent at other end was held tightly. This satisfies **constrain number 3.**

**Note: -** Additional supporting can be provided to the frame by tying extra bamboo poles wherever is felt necessary.

### 2.3 Door and Window Construction:-

The door and window frame should be constructed separately and fitted to the main frame. The door can be kept atany place of the polyhouse. In this case the door is facing east.

The window should be at the high wind flow positions.

1. Hence the window can be planned such that most of the portion of window is exposed to North-West andSouth-East portion.

2. There are two windows placed at the Polyhouse, one at east another at west.

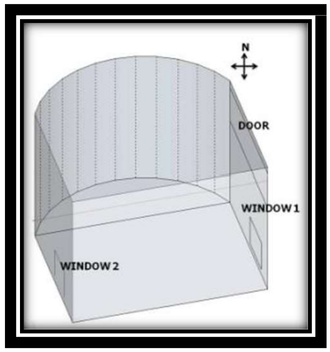


**Fig. 8** Covering of Polythene sheet to the Frame

### *3. Water Proofing:-*

1. An **epoxy resin** based water proofing cement is mixed with water and a thick paste is formed.

   **Note:-** only half of the prescribed amount of cement is mixed for first coating.

2. The Surface is rubbed with a metallic brush which will remove the loose stones and dust attached on thesurface.
3. The area is swept and cleaned with water.
4. After drying the resin is applied.
5. The cement is applied in two layers, for example:-
6. First apply the cement vertically and then horizontally shown in the figure.
7. An hour of gap is given before applying the second layer of cement.
8. This above action will help in covering up all the gaps on the surface in all the directions.

### *4. Covering Material:*

1. The covering material should always be planned to use in single piece to cover entire polyhouse.
2. The amount of polythene sheet required should be calculated and brought according to the calculated length.
3. Minimizing cut joints of polythene sheet will help in reducing the risk of creation of gaps which may causedamages to the sheet.

4. Here three sides of the frame are covered with a single sheet shown below.

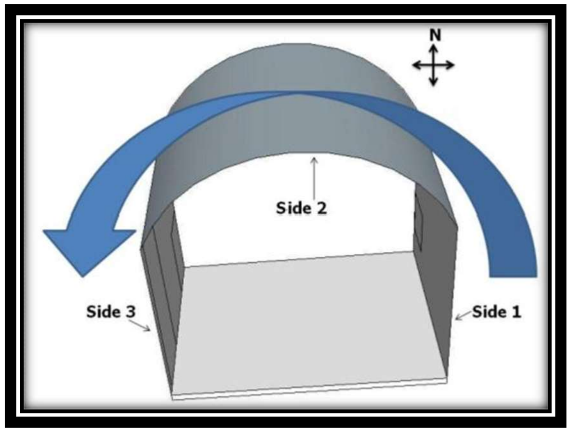


**Fig. 9** Covering of Polythene sheet to the Frame

5. The north and south side walls are covered by separate cut pieces and plastered and pinned round the edges. The entire surface is tightly held and to keep it held stapling is done to cover and bamboo.
6. Stapling should be done in length wise of the bamboo so the pin can get easily pierced into the bamboo andholds the cover tightly.
7. Stapling is done in order in a line, extra stapling is done wherever it is felt necessary.
8. The entire polythene sheet is stapled throughout the body of the frame.
9. The door should be covered separately.
10. The area of door positioning is marked on the polythene sheet and the sheet is cut according to the size and theedges of the frame are also stapled.
11. To close the window another polythene sheet should be cut larger than the actual window size; this piece isattached to window frame outside the polyhouse with the help of **Velcro.**

### 4.1 Mesh Installation:-

1. A specialized mesh called **geniger mesh** with a **mesh No.40** is cut according to the size of the window andattached to window from inside of the polyhouse.
2. Shade net in humidity control,
   i. Controlling humidity in polyhouse is very much required to control the temperature inside polyhouse.
   ii. The humid conditions are very much necessary for boosting the plant growth rate.

### 4.2 Shade Net Installation:

1. Next the **Shade Net** should be tied at north and south end with wire so that the net moves freely at east andwest side which helps in controlling the allowance of sunlight inside the polyhouse.
2. i.e., whenever you require more sunlight to enter inside you can open the shade net.

***Fig. 10 Shade net and backing cloth arrangement***

***5. Growing Containers:-***

1. To grow the plants and vegetables containers are very much essential.
2. The containers vary in material which is studied in sourcing chapter.
3. Here an U.V. Stabilized Grow bag is preferred.
4. These poly-bags are cheap and durable; more importantly apply fewer loads on the roof.

**Fig. 11** Mixing of Coir Pith to Soil

5. And also organic manure added and all three are mixed well.
6. The final mixture is filled into the grow bag and kept into the polyhouse.

***6. Sowing:***

1. Required vegetables and herbs have to be listed and seeds should be purchased.
2. Sowing can be separately done in a tray and left for seeds to germinate and cross certain stage.
3. Then they are shifted to the growing containers.
4. During sowing a line should be drawn in the soil then the seeds are sown in the line, this helps in propergermination of seeds.

**6.1 Crop Production Plan:**

1. Firstly time required for getting the yield of a particular crop or vegetable should be considered andaccordingly seeds are sowed at different interval of days.
2. This is because the plants should yield continuously all seven days of a week.
3. For example:-
   i. If a hybrid tomato seed requires 40 days to get its first yield.
   ii. Let us consider first tomato plant as plant No.1.
   iii. In its first yield the plant produces 16 tomatoes. On an average a family of four consumes 4 tomatoes a day; ittakes 4 days to consume all the 16 tomatoes.
   iv. When plant No.1 is sown on day 1 then the plant No.2 should be sowed in day 5.
   v. This is because plant No.1 provides tomatoes from day 41 to 44 then plant No.2 provides tomatoes for day45-48 for their respective first yield.
4. By the above example we can conclude that seven plants provide tomatoes for 28 days when each plant issowed in a 4 day intervals.
5. The above plan is set as a guideline for all the crops which is produced in polyhouse.

***7. Maintenance:***

1. After completing the project maintenance has to be made to keep the polyhouse full of plants and also toprotect the polyhouse from the damages.
2. The maintenance like clearing the logged water, sowing seeds, regular watering to the plants, checking thejoints and tying etc., can be easily done.
3. The challenge lies in protecting the polyhouse from external damages namely high velocity wind.
4. If the poly-sheet is tightly stapled less care can be taken but there is a room for loosening of the sheet in certainparts due to improper straightness of the bamboo frame.

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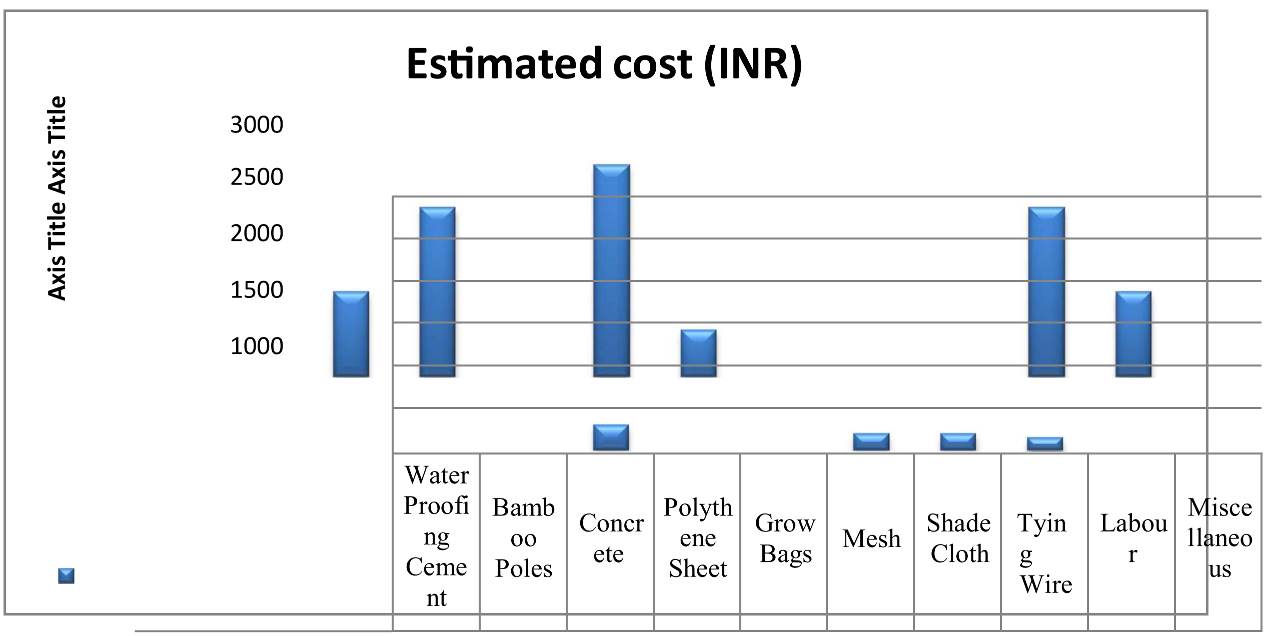
## I. MODELING AND ANALYSIS



| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Estimated cost (NR) | 500,0 | 200,0 | 30,00 | 250,0 | 550 | 2000 | 2000 | 1500 | 2000 | 1000 |

**Chart.1** Estimated Cost (NR)

**Grand total:- 985,250 NAIRA**

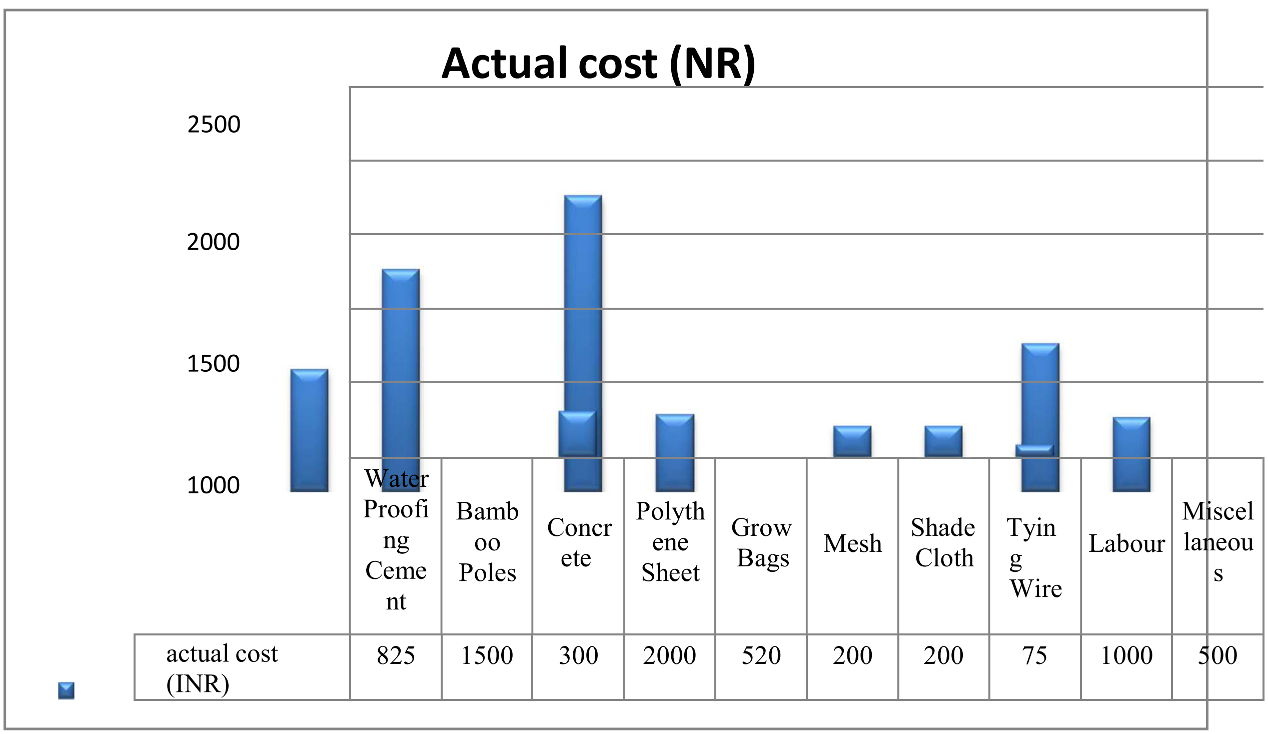



**Chart.2** Actual Cost (INR)

**Grand total: - 7,120 NAIRA**

Fibre sheet is having a durability period of 10 years and maintenance is low compared to polythene sheet with 2years durability.

Growth rate was carried out for fifteen days and a chart was drawn from the analysis. The tables below show theimages of Tomatoes seeds sown for the particular test.

**Table 3:** Growth Rate of Tomatoes seeds and Pepper

| **Outside Polyhouse** | **Inside Polyhouse** |
|---|---|
| **Day - 1** | |
| | |
| **No Germination** | **No Germination** |
| **Day -2** | |
| | |
| **No Germination** | **Few seeds have germinated** |
| **Day -3** | |
| | |
| **Few seeds have germinated** | **Almost all the seeds have germinated** |
| **Day -4** | |
| |  |
| **Almost all the seeds have germinated** | **Growing in length** |

| | |
|---|---|
| **Day -5** | |
| | |
| **No growth in length** | **Growing in length** |
| **Day -6** | |
| | |
| **No growth in length** | **Growing in length** |
| **Day -15** | |
| | |
| **Few centimeters of growth** | **Harvesting time** |

**Table 4:** Growth Rate of Pepper

| Outside Polyhouse | Inside Polyhouse |
|---|---|
| **Day - 1** | |
|  | |
| **No Germination** | **Few seeds have germinated** |
| **Day -2** | |
| | |
| **No Germination** | **Few seeds have germinated** |
| **Day -3** | |
| | |
| **Few seeds have germinated** | **Almost all the seeds have germinated** |
| **Day -4** | |
| |  |

| | |
|---|---|
| **Almost all the seeds have germinated** | **Growing in length** |
| **Day -5** | |
| |  |
| **No growth in length** | **Growing in length** |
| **Day -6** | |
| |  |
| **No growth in length** | **Growing in length** |
| **Day -15** | |
| |  |
| **Few centimeters of growth** | **Harvesting time** |

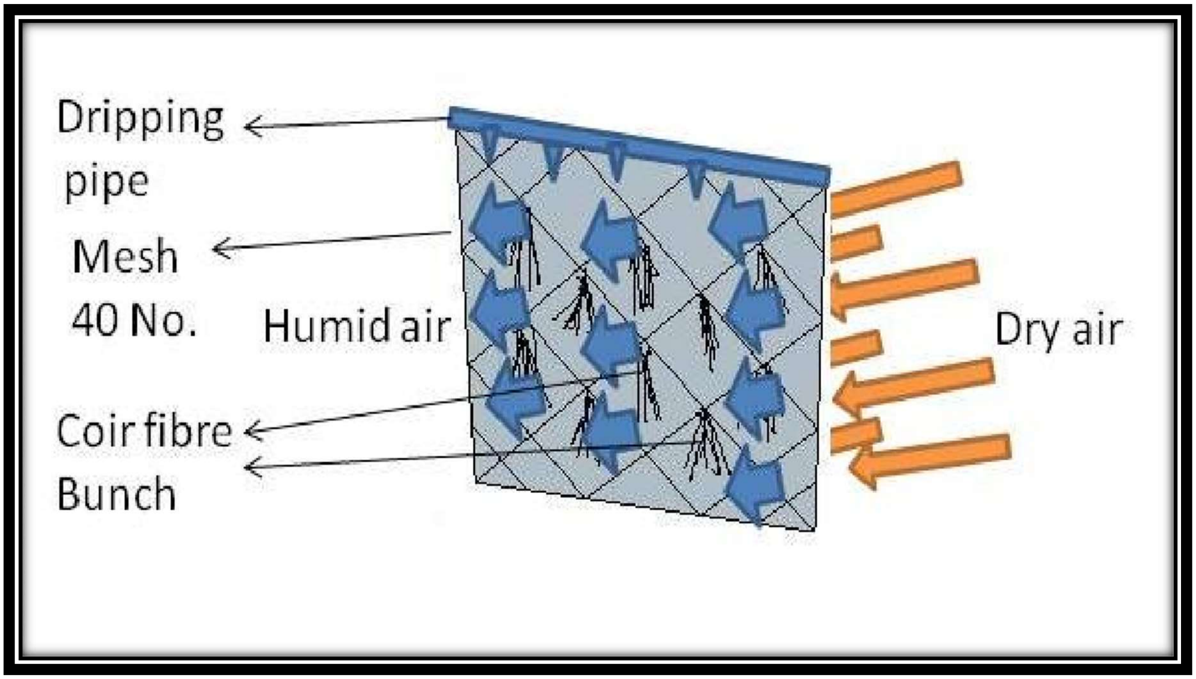
The above table shows the plants inside polyhouse has a faster growth rate than the plants outside the polyhouse.

### Humidity Control:

1. The humidity control is done by dripping the water on the mesh of the window.

2. Wind control

**Fig. 12** Principle of Humidity Control




## Light Transmission Control By Using Shade Net:-

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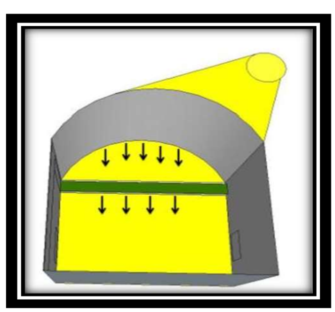
Sun Light is very essential to plants growth and also sunlight also transmits heat and other



rays along with sunlight. The intensity of sunlight especially in Noon of a midsummer is relatively high which could damage the plants and affects its growth. Hence shade net is employed.

**Fig.13** Increase in Sunlight Entering polyhouse When Shade Net is open

1. More light is transmitted when shade net is taken off completely and also increases the temperature inside thepolyhouse.

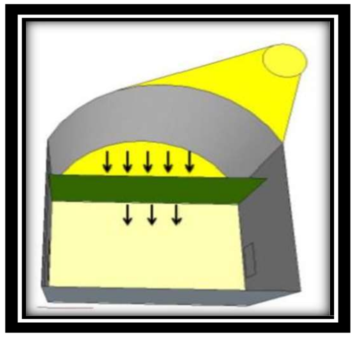


**Fig. 14** Increase in Sunlight Entering polyhouse When Shade Net is half closed

2. Partially the shade net is closed to half, which blocks the light partially

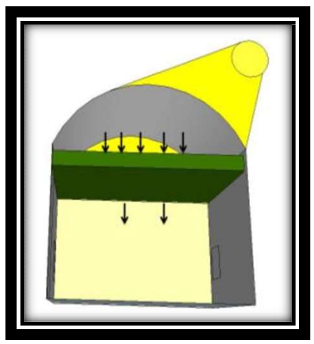


**Fig.15** Increase in Sunlight Entering polyhouse When Shade Net is fully closed

3. When shade net is fully closed most of the light transmitted from the roof is obstructed which indeed keeps the

# II. RESULTS AND DISCUSSION

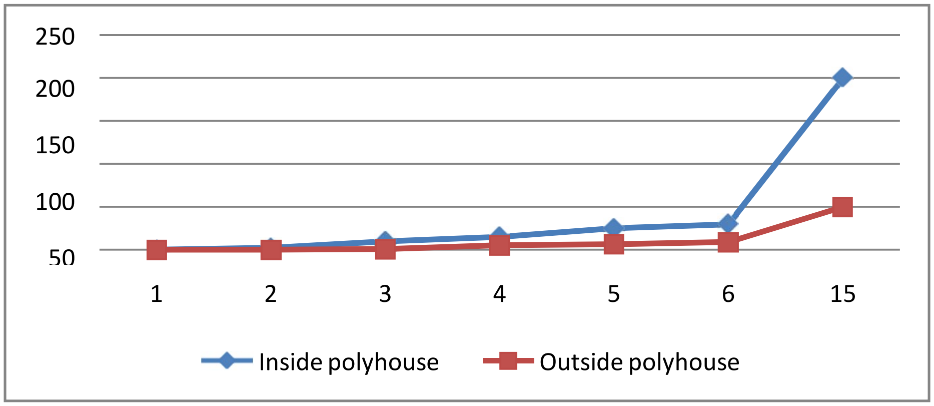



**Chart.2** Growth rate of tomatoes in mm

1. The growth rate of **tomatoes** is 3.5 times higher and **Pepper** is 4.5 times higher in polyhouse when compared to the plant outside polyhouse.
2. Truly organic food intake drastically improved.
3. Very high sweating of the body was found which a healthy sign was and lots of calories can be burnt.
4. Best utilization of roof was achieved.
5. Decrease in room Temperature was noticed upto 3°C was noticed.

# CONCLUSION

1. The polyhouse is based on textile raw materials; textile materials are used for construction of polyhouse, growing plants and maintenance of the polyhouse. Where ropes, twines etc., are used in construction; coir mulch, coir pith etc., is used in growing plants; coir net, coir fibre bunches, shade net is used in protecting and humidity maintenance, sunlight control in the polyhouse respectively.
2. The polyhouse shows excellent stability to various atmospheric conditions like heavy rain, thunder storms, duststorms etc., and the application of the textile materials is also helping the polyhouse to be stable for different environmental conditions.
3. Coir pith and mulch helps in water retaining and supplying it to plants, overall the plants in polyhouse is showing excellent growth rate than the plants outside polyhouse; this means lot more production can be done in limited space which is suitable for terrace gardening where space availability is restricted.
4. All the above developments is due to utilizing textile materials and its by-products for betterment of structure's stability, durability and maintenance and also for the betterment of growth rate of the plants.

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