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Effect of Low-Cost Poly House on Production of Tomato in a Hillock of Assam

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Abstract—*Production of vegetables in open field during the hot-wet season in humid climates in a hilly terrain is limited because of unfavourable conditions such as high temperature, humidity, rainfall, strong winds and high incidence of diseases. The high vulnerability to natural calamities like floods, submergence, landslides, soil erosion, etc. has also resulted in low and uncertain agricultural productivity. Thus, the present study was undertaken to develop a low-cost poly house (16 m^2) for production of Tomato with the semi control environment on hillock of Assam. The structure is arched type bamboo with the height of 2.3 m, length 5.2 m and width 3 m, and covered with UV resistance clear transparent PE with 200 micron. The unit cost involved for set-up of the structure was found 1000 rupees which is 45.68% lower than the local price of high-tech poly house. The growth parameters such as the average height of plant, number of branches, leaves, fruits and yield of plant were found as 1300mm, 23, 367, 26.01 and 0.93 kg, respectively which are found better and sustainable than the open field. The production cost and economics of the low-cost poly house revealed the benefit cost ratio of 1.06 and payback period of 6.4 years. Thus, it is suggested for wider implementation of low-cost poly house to promote the technology in small scale production of vegetables throughout the year in hilly terrain.*

Keywords*: Assam, hillock, low cost poly house, tomato, benefit cost ratio, payback period.*

1. INTRODUCTION

Availability of land for agriculture is decreasing day by day. More intensive and productive agricultural practices are needed to meet the food demands of the growing population. The productivity of a crop is influenced not only by its heredity, but also by micro climate around it. Generally production done during winter seasons however rest of the season could not meet the demand [1, 2]. In North East the production of vegetables in open field during the hot-wet season in humid climates in a hilly terrain is limited because of unfavourable conditions such as high temperature, humidity, rainfall, strong winds, and high incidence of diseases. The region suffers from weaknesses such as subsistence agriculture with poor infrastructure like roads and markets [3]. Protected cultivation is a cropping technique wherein the micro environment surrounding the plant body could be controlled partially/ fully as per plant need during their period of growth to maximize the yield and resource saving [4]. High tech poly house is one of the most practical methods of achieving the objectives of protected agriculture, where natural environment is modified by the use of sound engineering principles to achieve optimum plant growth and yield (more produce per unit area) with increased input use efficiency [5, 7]. Tomato, Cabbage, Capsicum and Cucumber are the most extensively grown vegetables under Poly house and give higher returns [13, 14, 15, 16]. However, very few research have been carried out to study the feasibility of low cost poly house and high tech poly house for increasing the production of vegetables round the year[9, 10, 11, 12]. The Tomato species *Lycopersicon esculentum* (formerly *Solanum lycopersicon* belongs to the Solanacea family). This is an herbaceous, usually sprawling plant of the nightshade family that is typically cultivated for its edible fruit. Tomato is also one of the most important protective food crops of India [6, 8]. It is grown in 0.458 m/ha area with 15.9 m/ha productivity. Tomato seed of Sweet Aperitif F1 Hybrid was selected with crop spacing of 75 x 50 cm. Crop grows well under an average monthly temperature range of 21°C to 23°C but commercially it may be grown at temperatures ranging from 18°C to 27 °C. Temperature and light intensity affect the fruit-set, pigmentation and nutritive value of the fruits. The best soil for Tomato is fertile loam soil with more sand in the surface layer and clay in the sub-surface layers. The most favourable range of soil pH is 6 to 7. Cropping duration 90 to 120 days, moreover the schedule of planting should be between August to November or June/July for summer in December for winter [14, 15].

In the present study, a field experiment was carried out with low-cost poly house, rain shelter structure for Tomato production to control the environment by providing protection from the excessive heat, rain and cold and also increase the crop productivity. During winter season under north eastern Indian conditions, it is extremely difficult to grow Tomato capsicum, Cabbage, French bean, amaranth etc. in open field condition, however various types of protected structures have been developed for growing some high value crops continuously by providing protection from the excessive cold.

2. MATERIALS AND METHODS

2.1 Study Area

The focus area of study was a 3.9 m^2 plot inside a low-cost poly house (16 m^2) situated in the hilly terrain of the Department of Agricultural Engineering, Assam University, Silchar, India.

2.2 Development of Low-cost Poly House

In this present study arched type single bed bamboo structure is chosen for the construction as per the local availability can resist against environmental extremes and moreover lowering the construction cost. The first step in construction was to mark the position of the posts. Then we have made holes with a post digger and buried the two corner posts 50 cm deep. Buried the rest of the foundation posts on both sides of the bed at 50 cm. Fixed all the bamboos in the holes and for strengthen the poles filled and fixed with cement and concrete materials. The height of the bamboo is 2 m above the ground level.

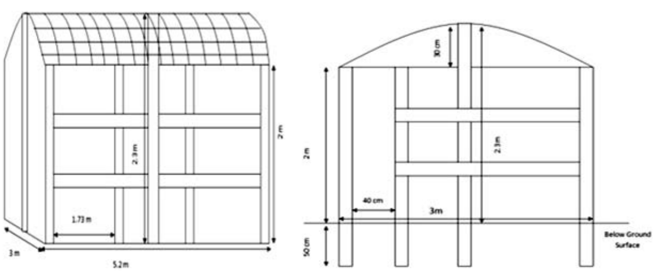

Fig. 1. Selected Structure of Low- cost Poly House

Table 1: Materials Selected for Construction of Low cost Poly House

Sl No	Materials	Specification
1	Foundation posts (Vertical and Horizontal)	Bamboo = 7 piece of 15 feet each
	Arches	Thin layer/Sliced part of Bamboo
	Size bamboo used for posts and arches	50 mm inner diameter big
2	Covering material	Ultraviolet (UV)-resistant clear or transparent polyethylene (PE) film same as the covering material used in High tech Polyhouse
	Thickness of polyethylene (PE) film	200 micron
	Size of polyethylene (PE) film	10 m Long and 8 m Wide
3	Connecting materials	Coconut rope= 6 kg Wire belt and Plastic wire = 2 kg
4	Foundation materials	Cement=50 kg, Sand=100 kg, Gravel=200 kg Ratio = 4:2:1

Plate 1 A View for Construction of Low-cost Poly House

2.3 Selection of Crop

Among the vegetables that are grown in North Eastern region and Assam, growing of Tomato, in open field condition is very difficult because excessive fertilization and certain environment extremes like scorching heat, heavy rainfall etc. may negatively affect the plant growth and thus results in low yield. Tomato grows best in deep (minimum of 24 cm) loamy and well drained soils. Soil pH should be in the range of 5.0-6.5. Moreover, the plant cannot be grown round the year so low-cost poly house is the only alternative to grow Tomato throughout the year. Therefore in the present study Tomato seeds of (Sweet Aperitif F1 Hybrid Tomato) were selected for the feasibility of the low-cost poly house in hilly terrain as experimental trials.To maximize the growth and yield of Tomato and to minimize the loss, proper nutrient management is required. Thus, the recommended dose of N:P:K for Tomato production is 45:45:45. In order to assess the suitability of soil inside the low-cost poly house for agriculture soil sampling was carried out using soil core cutter and sampler at three observation points and 3 depths (0-10, 10-20 and 20-30cm). The depth wise samples were considered for the analysis of soil physico-chemical status and composite samples for the analysis of soil nutrient status.

2.4. Initial Status of Soil inside Low-cost Poly House

Soil texture refers to the proportion of the soil separates that make up the mineral component of soil. These separates are called sand, silt and clay. Hydrometer method and International pipette method are commonly used to determine the particle size of the soil. However, in the present study, hydrometer method was used to estimate particle size distribution. Moisture content (MC) of soil was calculated by oven drying method (Soil Survey Standard Test method) using moisture box, electronic weight machine and soil core. Bulk density is the proportion of the weight of a soil relative to its volume. It is expressed as a unit of weight per volume and is commonly measured in units of grams per cubic centimetres (g/cc). Bulk density of soil was estimated by Soil Corer method [1] using soil core with a known diameter (d) and height (h).The pH of soil and vermicompost was analysed using Electrometric method using pH meter (REMI Instruments). The calibration of the electrode was done with standard buffer solution and the standard procedure. Soil utilizes organic materials for a variety of uses, including providing plants with nutrients, aiding in irrigation, lowering evaporation rates, increasing the nutrient holding capacity of the soil and providing food for worms, bacteria and other soil organisms. Electrical conductivity of soil was analysed with the help of a conductivity meter.

2.5. Plantation Bed and Crops

The treatment area (3.9 m^2) inside the low-cost poly house was divided into 4 numbers of replication rows and 1 number of control row with 5 number of Tomato plants in each row. After the 25 days of sowing Tomato nursery seedlings were then transplanted maintaining a row to row and plant to plant distance of 75 x 50 cm and supplied with drip irrigation.

2.6. Growth and Yield Analysis

The parameters of agricultural production such as plant height in millimetres (mm), number of fruits per replication, yield per replication in kilograms (kg) and total yield in kg/hectare (kg/ha) were also evaluated. The growth parameters such as plant height was monitored at 10 days interval however the yield parameters such as fruits per replication, yield per replication and total yield were monitored after flowering.

2.7. Agricultural Production Economics

2.7.1 Cost, economic analysis and payback period of Low-cost Poly House

Protected Structure (Rs./m^2): The total cost involved for the complete set up of the protected structure per m^2 of land. It includes the cost of the raw materials required for the construction of the protected structure

Govt. Subsidy 60% for NEH Region (Rs./m^2): It is 60% of the cost of the protected structure which is deducted as government subsidy for NEH Region.

Drip Irrigation System (Rs./m^2): The total cost involved for the complete setup of the drip irrigation system per sq. meters, including all the components required for the drip irrigation system.

Govt. Subsidy 40% for NEH Region (Rs./m^2): It is 40% of irrigation set up cost which is deducted as government subsidy for NEH Region.

Total Cost per unit Area (Rs./m^2): Sum of all the cost involved excluding the government subsidies.

Total Cost in Rs/Ha: It is the total cost per hectare. It is calculated by multiplying the total cost with 10^4. Net returns per unit area (Rs./ha): It is the difference between the gross returns (Rs./ha) to the cost of cultivation (Rs./ha).

Net returns per Year (Rs./ha):An annualized total return is the geometric average amount of money earned by an investment each year over a given time period. It is calculated as a geometric average to show what an investor would earn over a period of time if the annual return was compounded. Life of rain shelter structures (Years):It is the shelf life of a protected structure. The average shelf life of any protected structure is 5 to 12 years. Life of Drip Irrigation System (Years): It is the shelf life of the drip irrigation system under any protected structure. The average shelf life of drip irrigation system is about 10-12 years. Payback Period in year: It is the ratio of amount to be invested to the estimated annual net cash flow.

Payback period refers to the period of time required to recoup the funds expended in an investment, or to reach the break-even point. The time value of money is not taken into account. Payback period intuitively measures how long something takes to "pay for itself." All else being equal, shorter payback periods are preferable to longer payback periods.

3. RESULTS AND DISCUSSION

3.1. Physical status of soil

The sample wise soil texture status of the study site is presented in Table 2. However, the depth wise variations of sand-silt-clay percentage in the treatment are presented in Fig. 1. The initial soil physico-chemical properties of the soil inside low-cost poly house at the depths of 0-10 cm was found as sandy loam, for depths 10-20 cm, it was found as loam, and for 20-30 cm, it was found loam, respectively. The variation in the moisture content with respect to its soil depth of the study site is represented in Table 3 and it revealed that the moisture content of soil was (15.33%). The depth wise variation of bulk densities in the study site is represented in Table 3 and from Fig. 3 and 4, it can be seen that the bulk density is found more with the increase in soil depth due to compaction of the soil.

Table 2: Depth Wise Status of Soil Texture observed in the Study Site

Location	Depth (cm)	No. of Trials	Sand (%)	Silt (%)	Clay (%)	Soil type
Low cost poly house	0-10	1	59.29	27.01	10	Sandy loam
		2	60.25	27	10.32	
		3	61.33	28	10.3	
	Average		60.29	27.33	10.2	
	SD		1.02	0.57	0.17	
	10-20	1	47.33	24.01	24.55	Loam
		2	48.34	26	25.4	
		3	49.01	25.99	25.05	
	Average		48.22	25.33	25	
	SD		0.84	0.14	0.42	
	20-30	1	36.68	36.98	22.69	Loam
		2	38.24	37.01	23.59	
		3	38.27	37.06	25.72	
	Average		37.73	37.01	24	
	SD		0.9	0.04	1.55	

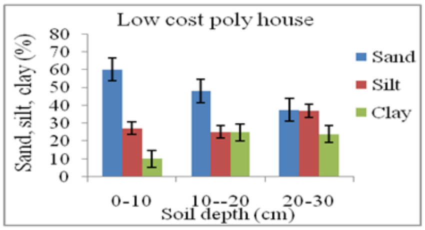

Fig. 2. Depth Wise Variations of Sand-Silt-Clay Percentage in the Study Site

Table 3: Depth wise Soil Bulk Density and Moisture content status observed

Location	Depth (cm)	No. of Trials	Wet bulk density (g/cc)	Dry bulk density (g/cc)	Moisture content (%)
Low cost poly house	0-10	1	2.2	1.85	19.42
		2	2.43	2.09	20.76
		3	2.27	1.47	22.51
	Average		2.3	1.80	20.89
	SD		0.11	0.31	1.54
	10-20	1	2.43	1.92	12.9
		2	2.6	2.46	16.18
		3	1.92	1.79	15.45
	Average		2.31	2.05	14.84
	SD		0.35	0.35	1.72
	20-30	1	2.68	2.45	9.17
		2	2.71	2.5	11.48
		3	1.99	1.88	10.16
	Average		2.46	2.27	10.27
	SD		0.40	0.34	1.15

3.2. Chemical status of soil

The soil pH and Electrical Conductivity (EC) of the soil profiles were determined by "Electrometric method" using pH meter and a conductivity meter, respectively. The observed pH and EC of different soil samples are shown in Table 4.The pH of the soil samples were found in the range of 4.74 to 4.2 which indicates that the soil is acidic in nature and about 50% of applied fertilizer may be available to plants. The pH was found more at a depth of 0-10 cm. The EC of the soil samples were found in the range of 0.73 to 0.74 mili Siemen (mS).

Table 4: Depth wise pH and EC Status Observed inside Low-cost Poly House

Depth (cm)	No. of Trials	Low-cost poly house	
		pH	EC (mS)
0-10	1	4.54	0.7
	2	4.22	0.8
	3	4.30	0.7
Average		4.35	0.73
SD		0.16	0.05
10-20	1	4.55	0.8
	2	4.20	0.7
	3	4.23	0.7
Average		4.32	0.73
SD		0.19	0.05
20-30	1	4.01	0.8
	2	4.05	0.8
	3	3.99	0.7
Average		4.01	0.76
SD		0.03	0.05

3.2. Response of Growth and Yield

The plant growth parameter such as plant height was also monitored to study the effect of low-cost poly house. The plant height was found highest in R_1 and R_3 (1800 mm). The replication wise yield parameters such as variation of fruit weight and yield observed in the study site is presented in Table 5, 6 and 7, respectively; replication wise variation of fruit number observed in the study site is presented in Table 7.

The total yield was found to be 47692.30 kg/ha. The variation of fruit weight throughout the growing season and variation of total yield per replication in the study site is illustrated in Table 5 and 6, respectively. However, the variation of fruit number throughout the growing season in the study site is illustrated in Fig. 3 and 4, respectively.

3.7. Agricultural Production Economics

The agricultural production economics of Tomato crop were estimated, considering the different components of cost of production and presented in Table 9. The unit cost for each component were collected and used for analysis of production cost. The cost of production does not include the cost for erection of Low-cost poly house involved in setting up of drip irrigation system. The total cost of production of Tomato in Low-cost poly house, the hired labour cost is maximum, followed by the cost and fertilizers of manures, plant protection measures and seedling nursery, etc. The cost of production of Tomato was Rs 280.00.

Economic analysis was carried out considering the investment, operation and production costs and the results are presented in table , the gross return (Rs./ha), net return per unit area (Rs./ha) net profit per unit production (Rs./ton) and BC ratio. According to economical evaluation, considering the selling price (Rs/ha) for Tomato was Rs. 25.00 the net return per unit area for Tomato was found Rs.474351.00 per hectare, respectively. The benefit cost ratio found for the production of Tomato crop was 1.06.

Payback period for Tomato crop were evaluated in Table 10, considering two components of the system such as rain shelter structures and drip irrigation system and presented in Table. In addition, there are provisions of Govt. subsidy of 60% for protected structure and 40% for drip irrigation system on total set up cost for North Eastern Hilly Region. The payback period for the production of Tomato was found 6.4 years.

Table 5: Replication Wise Variation of Number of Fruits Observed in the Study Site

Days after plantation	Low cost poly house (No. of fruits)									
	Replication 1					Replication 2				
	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5
90	20	21	22	24	25	23	24	21	20	23
100	24	25	25	26	28	24	25	22	26	27
110	33	30	30	32	31	30	29	30	35	32
	Replication 3					Replication 4				
90	22	23	23	21	27	23	22	20	22	21
100	23	26	27	25	28	24	28	26	25	29
110	29	26	30	30	31	30	30	32	25	26

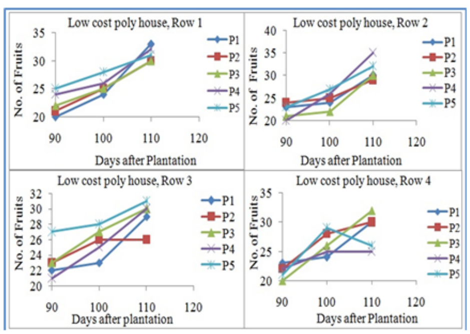

Fig. 3: Replication Wise Variation of Number of Fruits Observed in the Study Site

Table 6: Replication wise Variation of fruit width

Low cost poly house (width of fruit in mm)									
Replication 1					Replication 2				
P1	P2	P3	P4	P5	P1	P2	P3	P4	P5
55.5	52.3	57.4	51.2	53.3	54.7	55.8	58.1	55.3	53.1
Replication 3					Replication 4				
49.2	56.7	54.8	59.4	55.5	51.09	55.2	56.3	57.4	53.1

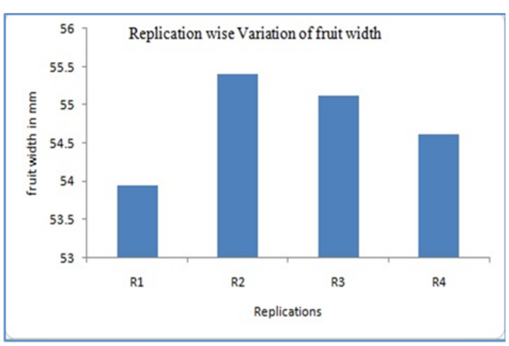

Fig. 4: Replication wise Variation of Fruit Width

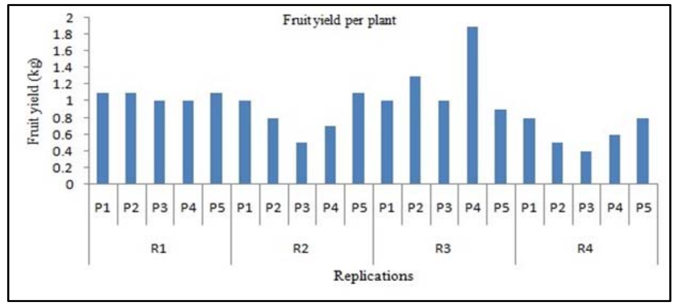

Fig. 5. Variation of Fruit Yield per Plant (kg)

Table 7: Variation of Total Yield in Study Site

Low cost poly house (yield per kg)										Total yield (kg)
Replication 1					Replication 2					
P1	P2	P3	P4	P5	P1	P2	P3	P4	P5	
1.1	1.1	1	1	1.1	1	0.8	0.7	0.5	1.1	18.6
Replication 3					Replication 4					
1	1.3	1	1.9	0.9	0.8	0.5	0.4	0.6	0.8	

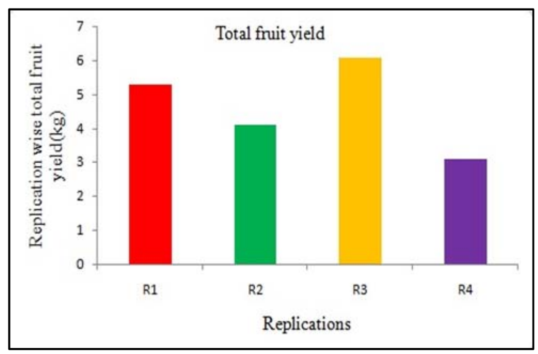

Fig. 6. Replication wise Total fruit yield (kg)

Table 8: Set-up Cost of Low-cost Poly House per meter square from Market Survey

Sl. No.	Details	Unit Cost (Rs.)
1	Cost of Low cost poly house structural material	205.00
2	Cost of civil work	300.00
3	Cost of labour	300.00
4	Cost of input	200.00
	Total cost in (Rs.)	1005.00

Table 9: Cost of Production and Economic Analysis for Tomato

Components	Cost of production	Components	Economics of production
Land Preparation	35.00	Yield (kg/plot)	18.6
Nursery/Seedlings	20.00	Selling Price(Rs./kg)	25
Manures and Fertilizers	50.00	Cost of Cultivation (Rs./Ha)	717949.00
Hired Human Labour	150.00	Total Yield (kg/ha)	47692
Land Revenue	25.00	Gross Returns (Rs./Ha)	1192300.00
Total Cost for 3.9 m^2 Area	280.00	Net returns per unit area (Rs./Ha)	474351.00
Total cost in Rs/ Ha	717949.00	B:C Ratio	1.06

Table 10: Payback period for Low-cost Poly House

Components	Low-cost poly house
Protected Structure (Rs./m^2)	1005.00
After Govt. Subsidy 60% for NEH Region (Rs./m^2)	402.00
Drip Irrigation System (Rs./m^2)	340.00
After Govt. Subsidy 40% for NEH Region (Rs./m^2)	204.00
Total Cost per unit Area (m^2)	606.00
Total Cost in Rs./Ha	6060000.00
Net Returns per unit area (Rs./Ha)	948702.00
Life of Protected Structures (Years)	5
Life of Drip Irrigation System (Years)	12
Payback Period in years	6.4

4. CONCLUSION

The study on effect of Low-cost poly house on productivity of Tomato revealed that Yield of Tomato was 47692.30 kg/ha. The production cost of Tomato Rs. 717940.00 and the maximum net return per unit area (Rs./ha) for Tomato was obtained as Rs. 474351.00. The benefit cost ratio for the productions of Tomato 1.06. Crops, the payback period for production of Tomato were found 6.4 years. Plants under protected cultivation system could be better option to increase the production round the year in a hilly terrain. The study revealed that the 5.21 times increase of fruit weight increased and 4.02 times increase of the fruit number than in the control. Therefore, it is suggested to use low-cost poly house as one of the alternate source by which crop productivity can be increased.

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