Agricultural Economics of Protected Cultivation Structures with Drip Irrigation for Tomato Production in a Hilly Terrain of Assam

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Abstract—*Cultivation of vegetables like tomato, capsicum, cucumber, okra, etc. year round in North-Eastern hilly terrain the soils particularly in Assam is not feasible in open field because of extremes climatic variation of rainfall, temperature and humidity and other constrains constraints like photo stress, moisture stress, temperature stress, and weeds growth, deficiencies and soil nutrients. So, the present study was carried out production of tomato vegetables constructing protected structures such as green house and shade-net house. The costs and returns were analyzed for the production of tomato crop in three different conditions of cultivation, i.e., green house, shade-net house and open field in the experimental plot of Department of Agricultural Engineering, Assam University, Silchar. The study has revealed that per hectare cost of production of tomato was lowest in case of greenhouse cultivation (□4,34,250.00) followed by shade-net house (□4,50,900.00) and highest cost of production was obtained from open field cultivation (□4,56,750.00), but the yield and net return values are more in green house (438.09 q/ha and □ 880007.41/Ha) cultivation followed by the shade-net house one (346.44 q/ha and □ 588434.20/Ha). However, net profit per quintal is also more in green house cultivation of Tomato (□2008.76/q) than shade-net house (□1698.49/q) and open field cultivation (□453.51/q). Costs of protected structures and drip irrigation system has been the major constituents of cost of production in both the cases of green house (□9920000.00/Ha) and shade-net house (□4020000.00/Ha) than any other cost involved in the production after excluding the Govt. subsidy for the same. But as the net return per unit area is maximum in case of green hose cultivation, though the payback period is more (3.76 years) than shade-net house (2.28 years) cultivation and open field (1.48 years), as the life of the structure and irrigation system is more so the ultimate net profit will be from greenhouse cultivation only. Thus, the study has suggested that to promote the protected cultivation structures in north eastern hilly region to produce high value seasonal and off-seasonal vegetables, mainly for tomato cultivation green house is most suitable and cost effective giving higher net return on investments with the least payback period.*

Keywords*: Greenhouse, gross return, hilly terrain, net return, protected cultivation, shade-net house.*

1. INTRODUCTION

The north-east region of India has several unique features: fertile land, abundant water resources, evergreen dense forests, high and dependable rainfall, mega biodiversity and agriculture-friendly climate. Yet it has failed to convert its strengths optimally into growth opportunities for the well-being of the people. The region suffers from weaknesses such as subsistence agriculture with poor infrastructure like roads and markets [5]. The high vulnerability to natural calamities like floods, submergence, landslides, soil erosion, etc. has resulted in low and uncertain agricultural productivity. So, there is urgent need to introduce cost effective protected cultivation for increasing vegetable production in north east region.

Tomato, Capsicum and cucumber are the most extensively grown vegetables under green houses and give higher returns [1]. During winter season under north-east Indian conditions, it is difficult to grow tomato, capsicum, cucurbits, 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. This is called greenhouse technology which provides favorable environment condition to the plants. Tomato is one of the most important and has the highest acreage of any vegetable crop in the world and also one of the most important protective food crops of India. India is the second largest producer of Tomato and is grown in 0.458 M ha area with 7.277 M mt production and 15.9 mt/ha productivity.

Greenhouse is the most practical method 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. Drip irrigation

can distribute water uniformly, precisely control water amount, increase plant yields, reduce evapotranspiration (ET) and deep percolation, and decrease dangers of soil degradation and salinity. An easy-operation irrigation scheduling method is very stringent for tomato drip irrigation condition. Ultimately, by selecting the best irrigation scheduling with drip irrigation system, best method of cultivation and proper application of nutrients the goals of water saving, better quality, cost effective and higher yield of tomato can be achieved with higher return.

In response to a shift toward specialization and mechanization during the 20th century, there has been momentum on the part of a vocal contingent of consumers, producers, researchers, and policy makers who call for a transition toward a new model of agriculture production. So, the present study was carried out production of tomato vegetables constructing protected structures such as green house and shade-net house. The costs and returns were analysed for the production of tomato crop in three different conditions of cultivation, i.e., green house, shade-net house and open field in the experimental plot of Department of Agricultural Engineering, Assam University, Silchar.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was conducted at experimental field located in hilly terrain of Department of Agricultural Engineering, Assam University, Silchar, Assam, India, during July 2014 to June 2015. The experimental field is situated at $24^0$41' N latitude and $92^0$45' E longitude at an elevation of 41 meters from the mean sea level. The climate of the north eastern region is subtropical, warm and humid. The average rainfall of the region is 3180 mm with average rainy days of 146 days per annum. The experiment was laid out in three different blocks viz. green house, shade-net house and open field with two replications in each block. In each block textural analysis of soil was performed by hydrometer method to evaluate the percentage of sand silt and clay. The soil physical characteristics were also determined for each set of experimental plot. There were in total 6 unit plots, each plot of 4m x 5m were made and raised by 10 cm which was separated by 0.50 m space. The treatments included 1 crop, 3 blocks and 2 replications.

2.1 Selection of Crop

The tomato crop was cultivated during winter and summer seasons. It grows well under an average monthly temperature range of 21^0 - 23^0 C but commercially it may be grown at temperatures ranging from 18^0 C to 27^0 C. The best soil for tomato is a fertile loam soil with more sand in the surface layer, and clay in the sub-surface layers. The most favorable range of soil pH is 6.0–7.0. Hence, tomato seeds of Hybrid S-41 MAHY GOTYA from Mahyco with germination of 70% and purity 90% is selected. The seeds were sown in October 28, 2014. Seeds were soaked in water for 12 hour prior to sowing in half cut piece of poly tank and fifteen days old seedlings were transplanted in green house, twenty days old seedlings were transplanted in shade-net house and twenty five days old seedlings were transplanted in open field at each planting time with 2 cm depth maintaining single seedling per hill. The crop spacing for tomato was chosen as 50cm x 30cm which was recommended by Assam Agricultural University, Jorhat, Assam, India.

2.3 Monitoring and Analysis of Tomato Yield

One of the oldest methods in plant growth analysis is the 'classical' approach. In this method, introduced in the beginning of this century (Blackman 1919, West et al. 1920), a relative growth rate (RGR) is calculated by dividing the difference in transformed plant weight at two harvests by the time difference between those harvests. Although straightforward, this approach has been considered unsatisfactory. Tomato fruits and weight of fruits and yield were monitored analysed for three conditions of cultivations.

2.4 Agricultural Production Economics

Agricultural production economics includes how economically and efficiently the production can be done. It includes the cost and economics parameters including payback period of production system.

2.4.1 Cost of Production

The cost of production components such as land preparation, nursery/Seedlings, manures and fertilizers, plant protection, hired human labour and land revenue are considered for estimation of cost of production.

2.4.2 Economics of Production

The economics of production of tomato cultivation includes the following components:-

- Gross returns (□/Ha)
- Net returns per unit area (□/Ha)
- Net profit per unit production (□/q)

2.4.3 Payback Period

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.

The payback period for cultivation of tomato and capsicum crop grown in protected cultivation structures against the open field condition with drip irrigation system was calculated for more precise economical aspect of agricultural production.

3. RESULTS AND DISCUSSION

3.1 Yield of Tomato

The observed yield of fruits per plant and plot were analysed for three condition of cultivation. Protected cultivation has significant effect on yield quintal per hectare (Table 1). It is found to be maximum for green house cultivation followed by shade-net house and significantly lower production in open field. The greenhouse cultivation produced the maximum yield of fruit (1.10 kg) and the open field cultivation showed the minimum (0.45 kg) fruit yield per plant.

Table 1: Fruit yield Observed in three cultivation conditions

Cultivation conditions	Replication wise fruit yield (q)				Average Yield (q)
	R 1	R 2	R 3	R 4	
Green House	441.19	410.00	467.65	433.52	438.09
Shade-net House	349.65	342.31	325.07	368.74	346.44
Open Field	204.09	180.81	181.71	150.85	179.36

Plants grown inside green house gives maximum average yield of 438.09 q/ha than shade-net house (346.44 q/ha) and open field (179.36 q/ha) cultivation. Figure 1 shows the yield from three different conditions of cultivations.

It was observed that the yield of fruits per unit area was inversely related to the condition of cultivation i.e. the green house produced the higher yield of fruits per plot and per hectare.

3.2 Cost of Production of Tomato

Based on the production cost for the three conditions of cultivations, the gross return (☐/ha), net return per unit area (☐/ha) and net profit per unit production (☐/q) values were estimated and presented in Table 2.

Table 2: Cost of production of Tomato in three cultivation conditions

Items of Cost (□)	Cultivation conditions		
	Green House	Shade-net House	Open Field
Land Preparation	35.00	40.00	40.00
Nursery/Seedlings	30.00	32.00	35.00
Manures and Fertilizers	260.00	260.00	260.00
Plant Protection	45.00	60.00	70.00
Hired Human Labour	570.00	585.00	600.00
Land Revenue	25.00	25.00	10.00
Total Cost for 20m2 Area	965.00	1002.00	1015.00
Total Cost in □/Ha	434250.00	450900.00	456750.00

Since, the production cost values differs in different conditions of cultivations, the gross return (☐/ha), net return per unit area (☐/ha) and net profit per unit production (☐/q) values were found significantly higher in green house followed by shade-net house and open field cultivation of tomato.

The cost of production of tomato is more in open field (□4,56,750.00) cultivation in compare to shade-net house (□4,50,900.00) and green house (□4,34,250.00) cultivation.

3.3 Economics of production of Tomato

Economic analysis was carried out based on investment, operation and production costs, and the results are presented in table above. It was observed that among all the components that are responsible for the total cost of production of tomato in three conditions of cultivation, the hired labour cost is maximum, followed by the cost of manures and fertilizers, plant protection measures and seedling nursery, etc. So, if farmers can utilize their own family members for the cultivation for such high value crop, they can minimize the production cost to the maximum extent.

As the production cost values differs in different conditions of cultivations, the gross return (□/ha), net return per unit area (□/ha) and net profit per unit production (□/q) values are found significantly higher in green house followed by shade-net house and open field cultivation for both tomato and capsicum crop (Table 3).

Table 3: Economics of production of Tomato

Particulars	Green House	Shade-net House	Open Field
Cost of Cultivation (□/Ha)	434250.00	450900.00	456750.00
Average yield (q/ha)	438.09	346.44	179.36
Average cost of production (□/q)	991.24	1301.51	2546.49
Average price received (□/q)	3000.00	3000.00	3000.00
Gross returns (□/Ha)	1314257.41	1039334.20	538094.41
Net returns per unit area (□/Ha)	880007.41	588434.20	81344.41
Net profit per unit production (□/q)	2008.76	1698.49	453.51

According to economical evaluation, considering the average price received (☐/q) are same for three different conditions of cultivation for both the crops, the maximum net return per unit area for tomato was obtained as ☐8,80,007.41 per hectare cultivated in green house cultivation, shade-net house gives ☐5,88,434.20 per hectare and open field gives ☐81,344.41 per hectare only which gives the lowest net return among the three. It was noted that the cost of cultivation is less but net return is more is case of tomato crop grown inside greenhouse but in case of open field cultivation it is inverse.

3.4 Payback Period

Payback period for tomato crop was evaluated considering two main parameters as protected cultivation structures and drip irrigation system (Table 4). Since, there is Govt. subsidy

for drip irrigation system and green house structure, the cost and economics analysis considers subsidy as 60% for greenhouse structure and 40% for drip irrigation system for North Eastern Hilly Region.

The result for payback period of tomato cultivation in three conditions of cultivations revealed that the initial cost of erection of green house with drip irrigation system is higher as compared to shade-net house and open field cultivation only involves the cost of drip irrigation system. But in green house tomato crops can grow three times thus gives maximum net return per year. Also the average life of green house is considered as 12 years and the life of drip irrigation systems installed inside the green house is minimum 15 years. So, the payback period is 3.76 years from the total life of 12 years and after the payback period the net return is totally the net profit. But in case of low-cost bamboo structured shade-net house, as its life is maximum 3 years and the cost of structure and irrigation system is □4020000.00 and tomato crops can be grown twice in a year thus giving net return per year as □1765303.00, so the payback period is 2.28 years in this case. In case of open field cultivation of tomato, as the crop can be grown only once in a year and the major cost involvement is only the drip irrigation system cost and the life of the system is 10 years in ambient condition, so here in this condition the payback period is calculated as 1.48 years. Though, the protective cultivation with shade net provides more economic return [10] as compared to hi-tech green house, but the crop productivity is more with amenable to automation, conserve water and land longer sustainability.

Table 4: Payback period for cultivation conditions of Tomato in north east region

Items of Cost	Green House	Shade-net House	Open Field
Protected Structure (□/m2)	1970.00	840.00	0.00
Govt. Subsidy 60% for NEH Region (□/m2)	788.00	336.00	0.00
Drip Irrigation System (□/m2)	340.00	110.00	110.00
Govt. Subsidy 40% for NEH Region (□/m2)	204.00	66.00	66.00
Total Cost per unit Area (m2)	992.00	402.00	66.00
Total Cost in □/Ha	9920000.00	4020000.00	120000.00
Net returns per unit area (□/Ha)	880007.00	588434.00	81344.41
Net returns per Year (□/Ha)	2640022.00	1765303.00	81344.41
Life of Protected Structures, Years	12	3	0
Life of Drip Irrigation System (Years)	15	12	10
Payback Period in years	3.76	2.28	1.48

4. CONCLUSIONS

The present study revealed that the protected cultivation structures are the only solution to produce the high value crop with higher income and more yield from small or marginal land of undulating north eastern hilly terrain. The higher yield of fruits was mainly contributed by the high-tech greenhouse structures which got sufficient irrigation water through drip irrigation system, optimum temperature and humidity for plant growth and also provide protection from insects and pests. The initial cost for cultivation in green house is quite higher as compare to low cost shade-net house cultivation. But off-seasonal tomatoes could be produced with higher return hi-tech green house in north eastern hilly region. The protected cultivation could be the only one alternative to control the environment for maximizing crop productivity percent area and increasing the quality of vegetables produce year around in the hilly terrain of Assam.

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