

Original Research Article

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## Small Scale Protected Cultivation for Off-season Vegetables: A Promising Option for Terai Farmers towards Income Generation

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### ABSTRACT

To evaluate the prospect of small-scale protected cultivation unit in homestead areas for growing off-season vegetables, low-cost bamboo made structures were constructed at Dhalaguri and Uttar Chokowakheti villages in the sub-Himalayan Terai region of West Bengal, India. Five crops, namely, cucumber, capsicum, coriander leaf, spinach beet and cauliflower were grown in different seasons during the period 2016-17. Results indicated the feasibility of protected cultivation for off season vegetable crops as a remunerative agro-enterprise with a high Benefit-Cost (B:C) ratio. The maximum and minimum B:C ratio were 10.58 for off-season coriander leaf and 1.62 for off-season cucumber. The pest and disease problems in the poly-house crops were minimal. The major part of crop water requirement could be met from the residual soil moisture owing to low evaporation rate from the cladded and shaded poly-houses. Crops like off-season cauliflower could be grown without any supplemental irrigation. The farmers' response towards adoption of low-cost, small-scale protected cultivation technique was encouraging. The demonstrated technology could be a source of additional livelihood generation for the small, marginal and women farmers of the region.

#### Keywords

Poly-house,  
Off-season,  
Vegetables,  
Soil moisture

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### Introduction

Crop response to the environment is the ultimate decisive factor towards a quality harvest and hence simulation of an ideal microclimate is one of the essential pre-requisites of modern horticulture coupled with judicious application of agro-inputs to get higher quantum of healthy product per unit area through an environment safe sustainable

approach leading to manifold return. Here lies the prospect of protected cultivation i.e. growing crops inside artificially constructed structures for favourable microclimate simulation.

Besides this, protected cultivation may also provide advantages like, year round cultivation, off-season cultivation, improvement in quality of produce

(Kuswardhani *et al.*, 2014), increase in yield per unit area (Negi *et al.*, 2013), protection of crops from vagaries of climatic conditions such as heavy precipitation, chilling (Mishra *et al.*, 2010), scorching etc., judicious application of space and agro-inputs, reduced use of water, production of seedlings for off-season cultivation, thereby realizing manifold return on investment (Singh and Sirohi, 2006).

Almost every country in the world is producing greenhouse crops to get quality production at higher magnitude per unit of land area. The difference between the principle of protected cultivation of the temperate world and the tropical world is lying in the fact that protected houses in temperate region target to step up the temperature but in the tropical and sub-tropical regions the main objective is to lower down the temperature and that's why the techniques differ between regions.

Upto the Second World War, glass was the predominating cladding material but with the advent of polyethylene as cladding material, the technique spread from the developed world to the developing countries (Maitra and De, 2016).

In India the concept has become popular amongst the farmers quite recently. Singh (2014) reported that an area of 40,000 ha is presently under protected cultivation of horticultural crops in India. Spehia (2015) indicated that out of 1,70,000 ha of vegetable farming, an area of 223.18 ha was under greenhouse cultivation in Himachal Pradesh, India.

Effective water management strategies are major impetus which can be achieved by providing drip irrigation system in the protected structures. Singh and Hasan (2011) recommended zero energy naturally

ventilated greenhouses for high value vegetable cultivation which can be equipped with low-pressure drip irrigation system to make them energy efficient eco-friendly model.

Construction of state of the art protected structures is costly and requires large initial investment by the farmers. This often restricts small and marginal farmers of India to adopt and harvest the benefits of protected cultivation.

But, such farmer groups are major and potential growers of a number of horticultural crops. Keeping this limitation in view, in the present study the scope of using small bamboo frame protected structures in homestead areas for protecting the crops from excessive precipitation, solar radiation, heat and cold were investigated. Simple poly-house farming techniques were used so that small, marginal as well as women farmers could easily manage their poly-houses themselves.

The poly-houses were equipped with low-pressure drip irrigation systems for optimum and efficient water application to the crops. Perceiving the relative prospects of protected cultivation in the region, four low cost, bamboo made protected structures were constructed in two villages of West Bengal, India, namely, Dhalaguri and Uttar Chokowakheti.

The crops like cucumber, capsicum, coriander leaf, spinach beet and cauliflower were grown during off-seasons to study their feasibility and performance. This research trial was monitored and supported by the Australian Centre for International Agricultural Research (ACIAR) sponsored project 'Improving water use for dry season agriculture by marginal and tenant farmers in the Eastern Gangetic Plains'.

## **Materials and Methods**

### **Study area**

The villages, namely, Dhalaguri and Uttar Chokowakheti are situated at the Ambari Gram Panchayat, Block II of Cooch Behar district and Uttar Chokowakheti Gram Panchayat, Block I of Alipurduar district, respectively, in the sub-Himalayan *Terai* region of West Bengal, India. The main characteristics of these two villages are heavy annual precipitation (2200-2500 mm) in rainy season followed by a comparatively dry and prolonged winter season. The rainy season is characterized by much higher relative humidity than the winter season. Usually rainfall is minimal to nil during the winter months. The demography of both the villages is dominated by economically weak low caste population. Agriculture is the main source of livelihood in Dhalaguri whereas in Uttar Chokowakheti the livelihoods mostly revolve around natural forest resources with some seasonal practice of agriculture. The average farmers are mostly marginal with low operational land holding size (0.8 ha) and tenants working as agricultural labourer. Due to limited irrigation infrastructure in both the villages, dry season winter crops are not cultivated extensively.

### **Protected structures**

Two numbers of poly-houses, each having dimensions of 12 m × 4 m (48 m<sup>2</sup>), were constructed in each of the two villages. The height of the poly-houses was 3 m at the centre. The structure of the poly-houses was made of bamboo poles fitted with nut and bolt. UV stabilized polyethylene sheet of 200 micron thickness was used as cladding material. Aluminium channels were fixed on bamboo poles for attaching the polyethylene sheet using metal springs. Above the polyethylene sheet 50% agro-shade net was

used as shading material. The poly-houses were equipped with drip irrigation facility from an overhead tank having an effective head of about 4 m. Four rows of drip irrigation laterals with 20 emitters per lateral were fitted to the main line. The nominal discharge of the drip emitters used was 2 lit/h. The flow to individual laterals was controlled through inlet valves. The capacity of the overhead tank was 1000 lit. A 0.25 HP electric pump was used to lift the water to the tank either from surface or groundwater source. Being small sized structures the poly-houses could be accommodated easily in the homestead areas which made it highly feasible for the women farmers to manage the crops. The cost involvement for such a bamboo made protected structure of 4 m (width) × 12 m (length) × 3 m (central height) is presented in Table 1.

## **Results and Discussion**

### **Crop production in poly-houses**

The choice of the crops to be cultivated in the poly-houses were decided considering the factors like crop feasibility, climate, potential yield, off-season market demand and acceptability, crop economic return, and farmers' skill and crop preference. Considering above mentioned factors and based on a participatory approach with the local farmers, the crops like cucumber, capsicum, cauliflower, coriander leaf and spinach beet were selected for off-season production in the poly-houses of the two villages during the period 20016-17. Local market survey indicated that these vegetable crops have high demand and market price during the off-season. Due to climatic limitations these crops are not feasible for open field cultivation. Therefore, it was presumed that off-season cultivation of these vegetable crops could be highly remunerative to the small and marginal farming community

of the region. The cropping sequences of different crops cultivated in the poly-houses are enumerated in Table 2. The cultivars and time of planting of the selected vegetable crops are presented in Table 3.

In the research trial conducted the target groups of farmers were marginal, tenant and women farmers of the region. Therefore, it was critical to provide skill development hands-on trainings to the farmers on maintenance of protected structures, operation of drip irrigation system, water management of crops, raising of seedling, and soil nutrient and crop management practices in poly-houses.

Crop protection advices were also provided to the farmers through field demonstration and technical trainings. Close monitoring and farmers' awareness on crop management was key to success as the off-season vegetable crops are highly sensitive. The relevant crop inputs, supplemental water application and cost of cultivation are given in Table 4.

### **Production economics and water management**

The crop production and crop economic data were collected for all the crops cultivated in the poly-houses in different seasons. Production economics were analysed to estimate benefit cost ratio (B:C ratio) for all the crops (Table 5). Supplemental irrigation was provided to the crops through the installed drip irrigation systems. The soil moisture level of the poly-houses was regularly monitored using a TDR soil moisture meter. Irrigation was scheduled based on moisture extraction pattern of the respective crops. The volume of irrigation water applied to different crops and actual percent of crop water requirement supplied through supplemental irrigation are enumerated in Table 6.

Amongst the five crops cultivated in the poly-houses, capsicum was the longest duration crop (6 months) and the other crops were harvested within 3 months. The short duration crops like spinach beet and coriander leaf had the advantage that in off-season two successive crops could be grown within a span of five months. These two crops were found to be highly remunerative to the farmers. Capsicum was found to be the highest nutrient demanding crop and therefore the cost of production was higher compared to the other crops (Tables 4 and 5). The cost of production was found to be least for coriander leaf (Rs. 248.78/-) and maximum for capsicum (Rs. 908.16/-).

In spite of this, the maximum net return was realized from capsicum crop (Rs. 4691.84/-) as the crop yield was good and market price of off-season capsicum was also high (Table 5). The minimum return was obtained from cucumber crop (Rs. 183.10/-) as the crop was already abundant in the market even in the off-season and thus price was not significantly high. Kaddi *et al.*, (2014) also reported a lower B:C ratio in naturally ventilated poly-house grown cucumber than open field cultivation. The crop economic data revealed that the B:C ratio was maximum for coriander leaf (10.58) amongst the short duration crops.

For capsicum the B:C ratio was also quite high (6.17) due to higher market prices owing to low local supply from conventional agriculture during off-season. Dhaliwal *et al.*, (2017) reported an early as well as higher yield in poly-house grown bell pepper or capsicum. Similar observation was also made by Lal *et al.*, (2016) for coriander leaf. Early cauliflower grown in the poly-houses were of good quality and had decent demand in market. The crop was found to be highly profitable for the farmers. Agrawal *et al.*, (2003) also reported the profitability of early

cauliflower under protected situation in Chhattisgarh region of India. It was also evident that in off-season production of vegetable crops the pest and disease

infestation was minimal and no chemical or pesticides were required to be applied to the crops.

**Table.1** Cost of construction of one poly-house (12 m × 4 m)

Sl. No.	Item	Quantity	Rate	Amount (Rs.)
1.	Bamboo	40 numbers	Rs. 80/piece	Rs. 3200/-
2	UV-stabilized polyethylene sheet of 200 micron thickness	162 m <sup>2</sup>	Rs. 65/m <sup>2</sup>	Rs. 10530/-
3	Nails	2 kg	Rs.80/kg	Rs.160/-
	Spring	100 pieces	Rs. 2.5/piece	Rs.250/-
	Channel	100 m	Rs. 3/m	Rs.300
	Nylon Rope	1 kg	Rs.80/kg	Rs.80/-
	Ribbon	100 m	Rs.2/m	Rs.200/-
	Frame of Door	1 piece	Rs.100/piece	Rs.100/-
4	50% Agro-shade Net	100 m <sup>2</sup>	Rs.20/m <sup>2</sup>	Rs.2000/-
5	Wages	2 man-days for 2 days	Rs.250/man-day	Rs.1000/-
6	Miscellaneous cost	-	-	Rs.400/-
			<b>Grand Total</b>	<b>Rs.18220/-</b>

**Table.2** Cropping sequences in the poly-houses of (2016-17)

Production Month	Crops Cultivated Poly-house - 1	Production Month	Crops Cultivated Poly-house - 2
<i>Village: Dhalaguri</i>			
Dec, 16 – Jun, 17	Off-season capsicum	Dec, 16 – Apr, 17	Cucumber
Jul, 17 – Nov, 17	Cauliflower	May, 17 – Aug, 17	Off-season coriander leaf and off-season spinach beet
		Sept, 17 – Nov, 17	Cauliflower
<i>Village: Uttar Chokowakheti</i>			
Jun, 17 – Sept, 17	Off-season coriander leaf and off-season spinach beet	Jun, 17 – Sept, 17	Off-season coriander leaf and off-season spinach beet
Sept,17 – Nov, 17	Cauliflower	Sept, 17 – Nov, 17	Cauliflower

**Table.3** The cultivars of different vegetable crops and seed requirement and cost

Sl. no.	Crop	Botanical name	Family	Unit Size (m <sup>2</sup> )	Variety	Seed Required (g)	Cost of Seed (Rs.)
1.	Cucumber	<i>Cucumis sativus</i>	Cucurbitaceae	24	Malini	10	220/-
2.	Capsicum	<i>Capsicum annuum</i> var. <i>grossum</i>	Solanaceae	48	Mekong F1	5	400/-
3.	Coriander leaf	<i>Coriandrum sativum</i>	Umbelliferae	24	Local	500	150/-
4.	Spinach Beet	<i>Beta vulgaris</i> var. <i>bengalensis</i>	Chenopodiaceae	24	Local	500	240/-
5.	Cauliflower	<i>Brassica oleracea</i> var. <i>botrytis</i>	Cruciferae	48	Dawn – 175 and SV4051AC	5	200/-

**Table.4** Irrigation and nutrient requirements to crops cultivated in the poly-houses

Crop	Manures and fertilizer application	Cost of manure and fertilizer	Theoretical water requirement in open field	Water applied through drip (lit)	Cost of water application
<b>Cucumber</b>	Vermicompost - 10.5 kg Urea – 0.70 kg SSP - 1.40 kg MOP – 0.35 kg	Rs. 62.16/-	20 ha-cm	686.40	Rs. 8.24/-
<b>Capsicum</b>	Vermicompost - 60 kg Urea – 5 kg SSP – 20 kg MOP – 3 kg 19:19:19(liquid fertilizer) – 100g	Rs. 486.20/-	25-40 ha-cm	1830.20	Rs. 21.96/-
<b>Coriander leaf</b>	Vermicompost - 24 kg	Rs. 96/-	5-10 ha-cm	232.00	Rs. 2.78/-
<b>Spinach beet</b>	Vermicompost - 24 kg	Rs. 96/-	5-10 ha-cm	225.60	Rs. 2.71/-
<b>Cauliflower</b>	Vermicompost - 8.50 kg	Rs. 34/-	15-30 ha-cm	0.00	Rs. 0.00/-

**Table.5** Production economics of different crops cultivated in the poly-houses

Crop	Cost of production (Rs.)	Yield	Selling price (Rs.)	Net return (Rs.)	B:C Ratio (Gross return/ Total Cost)
Cucumber	296.90/-	40 kg	480/-	183.10/- (in 3 months)	1.62
Capsicum	908.16/-	100 kg	5600/-	4691.84/- (in 6 months)	6.17
Coriander leaf	248.78/-	9.6 kg (7200 plants)	2880/-	2631.22/- (in 2.5 months)	10.58
Spinach beet	338.71/-	66 kg	2310/-	1971.29/- (in 2.5 months)	6.82
Cauliflower	314.00/-	68 kg	2040/-	1726.00/- (in 2.5 months)	6.50

**Table.6** Comparative use of water in protected cultivation of vegetables in 2016-17

Crop	Standard crop water requirement (ha-cm)	Plot area (m <sup>2</sup> )	Volume of water required by the crop (lit)	Irrigation water applied through drip (lit)	Percent of crop water requirement supplied through irrigation (%)
Cucumber	20	24	4800	686.4	14.30
Capsicum	25-40	48	9200 –12000	1830.2	19.89 - 15.25
Coriander leaf	5-10	24	1200–2400	232.0	19.33 - 9.67
Spinach Beet	5-10	24	1200–2400	225.6	18.80- 9.40
Cauliflower	15-30	48	7200–14400	0.0	0

This can be very encouraging for the promotion of organic farming in the poly-houses. Water management in the poly-houses is also a critical factor as poor water management can lead to crop water stress, reduced yield, increased risk pest and disease, and higher cost of cultivation. Regular monitoring of soil moisture and efficient application of irrigation water through drip irrigation was found to be beneficial. The cost of irrigation for all the crops were low. The majority of crop water requirement was met up from the residual soil moisture.

Due to presence of polyethylene sheets as cladding material, the evaporation loss from the soil was very low and therefore sufficient

residual moisture was available to the crops. The amount of residual moisture depends on climate, crop season and rainfall. Crop like cauliflower could be grown fully based on residual moisture with no requirement of supplemental irrigation. Table 6 clearly shows that the percent of water requirement supplied through irrigation for different crops were low in the poly-houses (0% to 19.89%).

In both the piloted sites the outcome of the research trial and farmers’ response towards adoption of small-scale poly-house farming was encouraging. The study clearly demonstrated that low-cost poly-houses constructed using locally available construction materials can be a feasible option

to the small and marginal farming community of the region.

The initial investment of the demonstrated technology is quite low and thus easily affordable to the farmers having low investment capacity. Protected cultivation of off-season vegetable crops has been identified as a remunerative agro-enterprise. However, profitability largely depended on proper choice of crop and their growing season should ensure good market price as well as demand. The quality of off-season vegetables grown in the poly-houses was good. Pest and disease problems were very rare.

Efficient water management strategies were found to be a critical factor in the poly-house farming practice. Due to low evaporation rate in the poly-houses, the major crop water requirement was met from residual soil moisture. In general irrigation requirement for off-season production of vegetables was quite low. Therefore, the drip irrigation system was used occasionally for some of the crops. Therefore, considering the observed regional trend, the initial investment of the poly-house farming could potentially be further reduced by considering drip irrigation system as a dispensable option.

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