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Prospects of Protected Cultivation of Vegetable Crops in North Eastern Hilly Region

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Abstract—*Cultivation of vegetables year round in North-Eastern hilly terrain the soils particularly in Assam is not possible because of extremes variation of rainfall, temperature and humidity. In addition, the biotic stresses also do not allow successful production of vegetables like tomato, chili, capsicum, cucumber, okra, cauliflower etc. in the fields mainly during rainy & post rainy season. In spite of the great importance of vegetable crops, it faces a lot of constraints like photo stress, moisture stress, temperature stress, and weeds growth, deficiencies in soil nutrients, excessive wind velocities and atmospheric carbon-dioxide. These constraints can be alleviated by adopting a unique, specialized hi-technology known as protected cultivation. Different protected cultivation structures having different temperature, humidity, UV radiation ranges and also having different cost involvement in construction of structure which may results the production of vegetables with distinct advantage of quality, productivity and favorable market price to the growers. So, the present study was carried out to evaluate the prospects of protected cultivation with construction of hi-tech green house and low cost shade-net house for cultivation of vegetable year around in the hilly terrain of Assam. On experimental trials, the vegetables such as Tomato (Feb- June), Spinach beat (June-July), Tomato (Aug.-Nov), Cucumber (Nov.-Feb) were grown and the cost of production evaluated. The benefit cost ratio for hi-tech green house and low cost shade-net house for cultivation of vegetable year around in the hilly terrain of Assam was found 1.48:1 and 2.29:1, respectively. Thus, 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 round the year.*

Keywords: *Benefit cost ratio, Hilly terrain, green house, protected cultivation, shade-net house.*

1. INTRODUCTION

India is the second largest producer of vegetable crops in the world. However, its vegetable production is much less than the requirement if balanced diet is provided to every individual. There are different ways and means to achieve this target, e.g., bringing additional area under vegetable crops using hybrid seeds, use of improved agro-techniques, and another potential approach is perfection and promotion of protected cultivation of vegetables.

As a profession, agriculture is not attractive for the educated youth, which is partly due to the drudgeries associated with field work. To motivate the educated youth agriculture has to be developed to be a remunerative and drudgery-less industry as competitive as any other industry using agro-technologies like greenhouse. Then only a sense of pride will be associated with agriculture. This is especially true for the NEH region where percentage of literacy among indigenous people is higher than national average [9].

Greenhouse cultivation is the most intensive form of crop production with a yield per cultivated unit area up to ten times superior to that of a field crop [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. It is rather used to protect the plants from the adverse climatic conditions such as wind, cold, precipitation, excessive radiation, extreme temperature, insects and diseases. It is also of vital importance to create an ideal micro climate around the plants. This is possible by erecting a greenhouse / glass house, where the environmental conditions are so modified that one can grow any plant in any place at any time by providing suitable environmental conditions. Protected technology in high value vegetable crops can be established as a small scale industry in major vegetable growing areas of our country by progressive farmers especially in periurban areas.

Production of off-season vegetable nurseries under protected structure has become a profitable business. The main purpose of raising nursery plants in protected structure is to get higher profit and disease free seedlings in off season to raise early crop in protected condition or/and open field condition. The low cost Poly house is economical for small and marginal farmers, who cannot afford huge cost of high-tech poly house [12]. The temperature inside the poly house is 6-10^{0}C higher

than outsides during winter. The cold waves during winter season (December to February) do not enter inside the poly house and inside environment becomes conducive for quick germination of seed and growth of seedlings. Many times farmers produce good amount of cucumber, capsicum and tomatoes during main season, which eventually leads to the market glut and fall in price. On the other hand, due to weather extremes during winter, it is difficult to grow high value vegetables like tomato, capsicum, cucumber, gherkin etc. in open condition [10]. Therefore, low-cost poly house technology was introduced for off-season production of vegetable nurseries as well as for raising crops of high value vegetables.

The topography of north east region is not uniform. Some of the areas are inaccessible as well as inhospitable where normal cultivation is not possible. To cater the needs of the population in the inaccessible areas greenhouse cultivation could be an answer. There is very good and sustainable demand for fresh vegetables around the cities and towns.

2. MATERIALS AND METHODS

2.1 Study area

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. During the summer months the temperature generally varies from 25 to 40oC, while during the winter season the temperature ranges between 10 to 25°C. The relative humidity varies from 58 to 91 percent and the sunshine hour varies from 10 to 12 hours.

2.2 Principle of Greenhouse

A greenhouse is generally covered with a transparent material such as polythene or glass. Depending upon the cladding material and its transparency major fraction of sunlight is absorbed by vegetable crops and other objects. These objects in greenhouse in turn emit long wave thermal radiations for which cladding material has lower transparency. With the result, solar energy is trapped ENVIS Bulletin Vol 12(2): Himalayan Ecology and raises the temperature inside the greenhouse. This is popularly known as greenhouse effect. This rise in temperature in greenhouse is responsible for growing vegetable in cold climates. During summer months, air temperature in greenhouse is to be brought down by providing cooling device. In commercial greenhouses besides temperature-controlled humidity, carbon dioxide, photoperiod, soil temperature, plant nutrients etc. facilitate round the year production of desired vegetable crops. Controlled climatic and soil conditions provide an opportunity to the vegetable crops to express their yield potentials [1].

Greenhouse is a framed structure covered with glass or plastics film (transparent and translucent) in which plants are grown under the partially or fully controlled environment. The greenhouse technology has been considerable importance in better space utilization, growing crops in extreme climatic conditions and high rainfall areas. The plastics film used in greenhouse act as selective radiation filters. The solar radiations pass through it and trap the thermal energy inside the greenhouse, which is emitted by the objects that are kept inside, this phenomena is known as "greenhouse effect".

2.3 Benefits of Greenhouse

2.3.1 Vegetable forcing for domestic consumption and export

During winter and summer in NE region, the temperature and solar radiations are sub-optimal for growing off season vegetables namely tomato, capsicum, brinjal, cucumber, okra and chili. In tomato, low temperature and low radiation cause puffiness and blotchy ripening. Hence during extreme conditions of winter and summer season these vegetables will be cultivated under polyhouse. In a medium cost greenhouse, the yield of tomato and capsicum can be taken @ 98.6-110.5 tonnes/ha and 87.2 tonnes/ha, respectively. The protected environments would be well adapted in the field where winter is prolonged. A polyhouse can be made which will receive sunlight for growing chili, tomato, brinjal, capsicum and cucumber. The improved varieties and hybrids of these crops would be evaluated. The high priced vegetables- asparagus, broccoli, leek, tomato, cucumber and capsicum are most important crops for production around metropolis and big cities during winter season or off-season. Thus, in the NE region during winter and summer it may be useful to grow tomato and capsicum in plastic tunnels as the plants which are protected from cold and excess rain will manifest faster and better growth resulting in earlier fruiting than the crops grown in the open field.

2.3.2 Raising off season nurseries

The cost of hybrid seeds is very high. So, it is necessary that every seed must be germinated. For 100% germination, it requires the controlled conditions. The cucurbits are warm season crops. They are sown in last week of March to April when night temperature is around 18-200C. But in polyhouse their seedlings can be raised during December and January in polythene bags. By planting these seedlings during end of February and 1st week of March in the field, their yield could be taken in one and one and a half months in advance than the normal method of direct sowing. This technology fetches the bonus price due to marketing of produce in the off-season. Similarly, the seedlings of tomato, chili, capsicum, brinjal, cucumber, cabbage, cauliflower and broccoli can be grown under plastic cover protecting them against frost, severe cold and heavy rains. The environmental conditions particularly increase in temperature inside polyhouse hastens the germination and early growth of warm season vegetable seedlings for raising early crops in spring summer. Vegetable

nursery raising under protected conditions is becoming popular throughout the country especially in hilly regions. Management of vegetable nursery in protected structure is easier and early nursery can be raised. Needless to emphasize, this practice eliminates danger of destruction of nurseries by hail storms and heavy rains because world highest rains occur in this region and the period of rainy season is also wide (April to October). Protection against biotic and abiotic stresses becomes easier.

2.3.3. Vegetable seed and hybrid seed production

Seed production in vegetables is the limiting factor for cultivation of vegetables in NE region of India as well as in other parts of India. The vegetables require specific temperature and other climatic conditions for flowering and fruit setting. Seed production of brinjal, capsicum, cauliflower and broccoli is very difficult in open conditions in this area due to high rainfall at maturity stage. To reduce such micro climatic condition a protected environment is essential. Therefore, the seed production of highly remunerative crops namely tomato, capsicum and cucumber is performed under protected environments. The maintenance and purity of different varieties/lines can be achieved by growing them under greenhouse without giving isolation distance particularly in cross-pollinated vegetables namely onion, cauliflower and cabbage. Hence vegetable production for domestic consumption and export in low and medium cost greenhouse is a technical reality in India. Such production system has not only extended the growing season of vegetables and their availability but also encouraged conservation of different rare vegetables.

2.3.4. Maintenance and multiplication of self-incompatible line for hybrid seed production

In case of cauliflower, there is problem of maintaining and multiplication of potential self-incompatible lines for the production of F1 hybrid seed. Temporary elimination of the self-incompatibility with the use of CO2 gas has solved this problem. For this purpose, the self-incompatible line is planted in a greenhouse and bees are allowed to pollinate the crop when it is bloom. Then keeping the greenhouse closed tightly within 2-6 hours of pollination, it is treated with 2-5% CO2 gas which allows successful fertilization by temporarily eliminating the self-incompatibility.

2.3.5. Polyhouse for plant propagation

Asparagus, sweet potato, pointed gourd and ivy gourd are sensitive to low temperature. The propagating materials of these vegetables can be well- maintained under polyhouse in winter season before planting their cuttings in early spring-summer season for higher profit.

2.4 Present Status of Greenhouse

Commercial greenhouses with climate controlled devices are very few in the country. Solar greenhouses comprising of glass and polyethylene houses are becoming increasingly popular both in temperate and tropical regions. In early sixties, Field Research Laboratory (FRL) of DRDO at Leh attempted solar greenhouse vegetable production research and made an outstanding contribution to the extent that almost every rural family in Leh valley possesses a polyhouse these days. Indian Petro Chemical Corporation Ltd (IPCL) boosted the greenhouse research and application for raising vegetables by providing Ultra Violet (UV) stabilized cladding film and Aluminium polyhouse structures. Several private seed production agencies have promoted greenhouse production of vegetables. In comparison to other countries, [1] India has very little area under greenhouses as is evident from Table 1.

Table 1: Approximate area (ha) under greenhouses

Country	Area
Japan	54000
China	48000
Spain	25000
South Korea	21000
Italy	18500
Turkey	10000
Holland	9600
USA	4000
Israel	1500
India	525

The major share has been in the Leh & Ladakh region of Jammu and Kashmir where commercial cultivation of vegetables is being promoted. In NEH region, polyhouse cultivation is still a new emerging technology for raising nursery of vegetable crops. Assistance provided under the plasticulture scheme since the VIII & IX plan has helped in generating awareness about the importance of greenhouses in enhancing productivity and production, particularly of horticultural crops. Out of 525 ha area under greenhouses in India, 83 ha has been covered in the NE states (Table 2), the maximum area being in Sikkim.

Table 2: Approximate area (ha) under greenhouses

	VIII Plan	1997-98	1998-99	1999-00
All India	211.12	359.35	414.05	525.05
NEH Region	29.05	42.89	59.55	83.4

2.5 Types of greenhouse/polyhouse

2.5.1. Low-cost greenhouse/polyhouse

The low cost polyhouse is a zero-energy chamber made of polythene sheet of 700 gauge supported on bamboos with sutli (ropes) and nails. It will be used for protecting the crop from high rainfall. Its size depends upon the purpose and availability of space. The structure depends on the sun for energy. The temperature within polyhouse increases by 6-100C more than outside. In UV stabilized plastic film covered pipe framed polyhouse, the day temperature is higher and night temperature is lower than the outside. The solar radiation entering the polyhouse is 30-40% lower than that reaching the soil surface outside.

2.5.2. Medium-cost greenhouse/polyhouse

With a slightly higher cost, a Quonset-shaped polyhouse (greenhouse) can be framed with GI pipe (class B) of 15 mm bore. This polyhouse will have a single layer covering of UV-stabilized polythene of 800 gauge. The exhaust fans are used for ventilation. These are thermostatically controlled. Cooling pad is used for humidifying the air entering the polyhouse. The polyhouse frame and glazing material have a life span of about 20 years and 2 years, respectively.

2.5.3. High cost greenhouse/polyhouse

It is constructed on the structure (frame) made of iron/aluminum structure, designed domed shaped or cone shaped (as per choice). Temperature, humidity and the light are automatically controlled as per requirement of the users. Floor and a part of walls are made of concrete. It is highly durable, about 5-6 times costlier, required qualified operator, proper maintenance, care and precautions while operating. The low and medium-cost greenhouses have wide scope in production of domestic as well as export-oriented vegetables. NEH region recorded highest rainfall in the world. The duration of rainy season is also wide (April-October). During this period, growing of vegetables such as cabbage, cauliflower, broccoli, tomato, brinjal and French bean in open conditions is very difficult. Severe attacks of pest and diseases occur due to heavy rains. So growing of vegetable crops in low cost polyhouse during this period is very profitable. Control of disease and pest in polyhouse is also easy [12].

2.5.4. Shade-net houses

Shade-net house is a framed structure made of materials such as GI pipes, angle iron, wood or bamboo. It is covered with plastics net (Nets are made of 100% Polyethylene thread with specialized UV treatment) having different shade percentages. It provides partially controlled atmosphere and environment by reducing light intensity and effective heat during day time to crops grown under it. Hence round the year seasonal and off-season cultivation is possible. Shade-nets are available in different shade percentages or shade factor i.e 15%, 35%, 40%, 50% 75% and 90% (for example 35% shade factor means - the net will cut 35% of light intensity and would allow only 65% of light intensity to pass through the net). Each plant has its individual requirements for sunlight and shade under which it flourishes at its best. To create optimum climatic conditions, selection of the correct percentage of shade factor plays an important role to enhance plant's productivity to its optimum. Shade-net houses are used for raising vegetable crops in high rainfall regions. Roof of the structure is covered with suitable cladding material. Sides are made of wire mesh of different gauges. Such structures are useful for NEH region.

3. RESULTS AND DISCUSSION

3.1 Selection of protected cultivation structure

In the experimental site two different types of protected cultivation structures have been selected based on the condition, cost involvement and availability of resources. These are high-tech poly green house and low cost bamboo structured shade-net house.

High-tech poly green house is a tubular structure covered with 200 micron UV film and shade net, which is designed to withstand wind up to 120km/hr., and trellising loads up to 25 kg/m2, with 4-way fogger irrigation system and cooling system by foggers, cooling pads and exhaust fans (shown in Fig. 1). It's a high cost structure.

Fig. 1: High-tech poly green house structure

Presently shade-nets are available in different colours i.e. white, black, red, blue, yellow and green and in combinations:

Green x Black - cut off un-wanted U.V rays and gives aesthetic look. Used in grape for providing shade and helps in drying.

Black x Black - it absorbs and radiates heat inside the shadenet house. Used in nursery raising.

White x Black - diffuses the light inside the shadenet house. Mainly used for flowers such as Gerbera, Anthurium etc.

Fig. 2. Low cost shade-net house structure

Green x Green - enhance the process of photosynthesis in plants resulting better foliage in ornamental plants. Low cost shade-net house is a bamboo structured of height 2.2 m with 50% shading shade nets with all the sides and ceiling are covered with the same shade net (shown in Fig. 2). It's a low cost structure.

3.2 Approximate cost estimate

Table 3: Cost of production (initial) per sq. m for hi-tech green house

Sl. No.	Details	Amount in Rs.
1	Cost of greenhouse structural materials	920.00
2	Cost of cooling pad and exhaust fans	180.00
3	Cost of irrigation materials including pump set	340.00
4	Cost of Civil work	295.00
5	Cost of labour	300.00
6	Cost of inputs	200.00
	Total cost in Rs.	2235.00

Table 4: Cost of production (initial) per sq. m for low cost shade-net house

Sl. No.	Details	Amount in Rs.
1	Cost of shade-net house structural materials	380.00
2	Cost of irrigation materials	110.00
3	Cost of Civil work	160.00
4	Cost of labour	100.00
5	Cost of inputs	200.00
	Total cost in Rs.	950.00

3.3 Constraints in protected vegetable production

In NEH region polyhouse culture is in infant stage and has not become popular as yet. High cost and non-availability of various components are the two major limiting factors in the adoption of polyhouse technology for commercial cultivation. Many of the polyhouse components like fiber glass, cooling pads, fans, etc have to be imported at high costs including freight and custom duty. Greenhouse and other structures design for different agro-climatic of the region is not standardized. Lack of awareness among farmers pertaining to potentials of protected vegetable production and lack of major research programme on protected vegetable farming are other limiting factors.

Table 5: Cropping Sequence for 1 year round cultivation and income per sq. m

Crop	Duration	Income from Green House (Rs.)	Income from Shade-net House (Rs.)
Tomato	Feb- June	110.00	70.00
Spinach beat	June-July	35.00	18.00
Tomato	Aug.-Nov.	95.00	75.00
Cucumber	Nov.-Feb.	80.00	55.00
Total		320.00	218.00
OR			
Tomato	Feb- June	110.00	70.00
Spinach beat	June-July	35.00	18.00
Capsicum	Aug.-Nov.	105.00	75.00
Cucumber	Nov.-Feb.	80.00	55.00
Total		330.00	218.00

Table 6: Gross income, net income and benefit cost ratio per sq. m

Type of Protected Structure	Gross income	Net income	B: C ratio
High-tech Green House	330.00	106.50	1.48:1
Low cost Shade-net House	218.00	123.00	2.29:1

4. CONCLUSIONS

The present study revealed that the seasonal as well as off seasonal vegetables could be grown with the use of protected cultivation with construction of low cost shade-net house and also hi-tech green house. The benefit cost ratio for hi-tech green house and low cost shade-net house for cultivation of vegetable year around in the hilly terrain of Assam was found 1.48:1 and 2.29:1, respectively. Though, the protective cultivation with shade net provides more economic return as compared to hi-tech green house, but the crop productivity is more with amenable to automation, conserve water and land longer sustainability. 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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