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REVIEW ARTICLE

PROTECTED CULTIVATION OF TOMATO, CAPSICUM AND CUCUMBER UNDER KASHMIR VALLEY CONDITIONS

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ABSTRACT

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. Another potential approach is perfection and promotion of protected cultivation of vegetables. In hilly areas parts of the country especially in Northern plains the soils are highly fertile but extremes of temperature ranging from 0 - 48^{O}C during the year do not allow year round outdoor vegetable cultivation. Similarly, in several parts of the country biotic stresses mainly during rainy & post rainy season do not allow successful production of vegetables like tomato, chilli, okra, cauliflower etc in the fields. In upper reaches of Himalayas, cool desert conditions period where the temperature is extremely low (-5to -30^{0}C) during winter season and most of the region remain cut off from rest of the country from November to March due to very heavy snowfall therefore it is very difficult to grow vegetables in such climate. In many European Countries, USA, Japan, China, Israel, Morocco, Turkey etc where climate reduces the choices for year round outdoor production, vegetables are being produced in protected environments. Greenhouses being the most efficient means to overcome climatic diversity. Greenhouse vegetable production make the use of recent advances in technology to control the environment for maximizing crop productivity percent area and increasing the quality of vegetables produce. India has entered into the area of greenhouse vegetables cultivation more recently and the total area under protected vegetable production is not more than 10,000 hectares. India being a vast country with diverse and extreme agro-climatic conditions, the protected vegetables cultivation technology can be utilized for year round and off-season production of high value, low volume vegetables, crops production of virus free quality seedlings, quality hybrid seed production and as a tool for disease resistance breeding programes.

Key words: Tomato, Chilli, Okra, Cauliflower etc in the fields, Vegetable crops

INTRODUCTION

Why Greenhouses

1. **Socio-economic consideration**

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.

2. **Geographical consideration**

The topography of NEH 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.

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

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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.

Benefits of Greenhouse

1. Vegetable forcing for domestic consumption and export

During winters in NEH region, the temperature and solar radiations are sub-optimal for growing off season vegetables namely tomato, capsicum, brinjal, cucumber, okra and chilli. In tomato, low temperature and low radiation cause puffiness and blotchy ripening. Hence during extreme conditions of winter season (October-February) 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 chilli, 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 NEH region during winter it may be useful to grow tomato and capsicum in plastic tunnels as the plants which are protected from cold and frost will manifest faster and better growth resulting in earlier fruiting than the crops grown in the open.

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 18-20^{0}C. But in polyhouse their seedlings can be raised during December and January in polythene bags. By planting these seedlings during end of February and Ist 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, chilli, 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.

3. Productivity is manifold in greenhouses in comparison to growing the vegetables in open field

Table 2. Performance of tomato varieties under polyhouse and open field conditions in NEH region

Varieties	Polyhouse yield (q/ha)	Open field yield (q/ha)
BT-117-5-3-1	342.00	115.00
KT-10	283.60	117.40
BT-10	294.00	111.65
Arka Alok	260.00	57.90
BT-12	302.40	101.00
Selection-2	233.00	73.83
Selection-1	2000.60	84.03
KT-15	211.60	51.65
H-24	243.17	58.75
Arka Abha	193.50	70.33

4. Vegetable seed production

Seed production in vegetables is the limiting factor for cultivation of vegetables in NEH region of India as well as in 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.

5. Hybrid seed production

In 21st century, protected vegetable production is likely to be commercial practice not only because of its potential but out of sheer necessity. In vegetable production hybrids seeds, transgenic, stress resistant varieties, micro propagated transplants, synthetic seeds are likely to replace conventional varieties. Protected environments will be helpful in production of hybrid seeds of cucumber and summer squash by using gynoecious lines. Gibberlic acid is used to maintain such lines followed by selfing. The desired pollen can be used for production of hybrid seed of cucumber. Similarly in summer squash use of Ethaphone in inducing female flower at every node would help in the hybrid seed production by using desired pollen parent.

6. 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 F_1 hybrid seed. Temporary elimination of the self incompatibility with the use of CO_2 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% CO_2 gas which allows successful fertilization by temporarily eliminating the self-incompatibility.

7. 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.

Status

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, India has very little area under greenhouses as is evident from Table 3.

Table 3: **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

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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 4), the maximum area being in Sikkim.

Table 4: Cumulative coverage of area (ha) under greenhouse

	VIII Plan	1997-98	1998-99	!999-00
All India	211.12	359.35	414.05	525.05
NEH Region	29.05	42.89	59.55	83.4

Types of greenhouse/polyhouse

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 6-10^{0}C 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.

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.

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.

Other plant protection structures

1. **Plastic low tunnels:**

   Plastic low tunnels are miniature form of greenhouses to protect the plants from rains, winds, low temperature, frost and other vagaries of weather. The low tunnels are very simple structures requiring very limited skills to maintain are easy to constructs and offer multiple advantages. For construction of low tunnels, film of 100 micron would be sufficient. The cost of a 100 micron thick film would be about Rs.10/m^2.

2. **Net houses**

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.

Approximate cost estimate

Cost of production (for one year) for 100 m^2 polyhouse cum rainshelter

A) With hired labour
Cost of labour = Rs. 6400.00
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Cost of inputs = Rs. 1500.00
Cost of structure = Rs. 3000.00
Total =Rs. 10900.00
B) With 50% hired + 50% family labour
Cost of labour = Rs. 3200.00
Cost of inputs = Rs. 1500.00
Cost of structure = Rs. 3000.00
Total =Rs. 7700.00
C) With family labour only
Cost of inputs = Rs. 1500.00
Cost of structure = Rs. 3000.00
Total =Rs. 4500.00

Cropping sequence

Crop	Duration	Income (Rs.)
Tomato	Feb- June	6000
Spinch beat	June-July	1500
Tomato	Aug.-Nov.	6000
Cucumber	Nov.-Feb.	6000
Total		19500
Or		
Tomato	Feb- June	6000
Spinch beat	June-July	1500
Capsicum	Aug.-Nov.	2250
Cucumber	Nov.-Feb.	6000
Total		15750

Gross income from cropping sequence
Tomato + Palak + Tomato + Cucumber = Rs. 19500.00
Tomato + Palak + Capsicum + Cucumber = Rs. 15750.00
Annual net return from 100 m2 polyhouse cum rainshelter

Nature of labour	Gross income	Net income	B: C ratio
With hired labour	19,500	8,600	1.79:1
With 50% hired + 50%own	19,500	11,800	2.53:1
With family labour only	19,500	15,000	4.33:1

[Source: Phookan and Saikia, 2003]

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.

Prospects of protected vegetable production

There is a good potential to promote the technology in this region for cultivation of vegetables. In temperate areas, vegetable growers can increase their income by raising early crops in protected structures mainly in low-cost greenhouses. Raising of vegetable nursery in protected structures has many fold benefits such as easy management, early nursery, and protection from biotic and abiotic stresses *ENVIS Bulletin Vol 12(2): Himalayan Ecology*. This technology is highly productive, amenable to automation, conserve water and land. In 21st century, protected vegetable production is likely to be common commercial practice not only because of its potential but out of sheer necessity.

Standardization of tomato, Capsicum and Cucumber hybrids appropriate time of transplanting under controlled conditions in Kashmir valley

Experiment No 1:-Standardization of appropriate time of transplanting under controlled conditions for early and quality production of vegetables at SKUAST-K Shalimar.

Crop : Shalimar Tomato Hybrid-1 (SH-TH-1)
Year /Season : 2008/ Kharief
Treatment details : As given below
Design : RBD
Replications : 3
Spacing : 60x45
Plot size : 3.6 x3 m^2
RFD : 24-30tonnes FYM/ha,120-150N,90-150P_2O_5,60-90K_2O kgs/ha

Experiment No 3:- Standardization of appropriate time of transplanting under controlled conditions for early and quality production of vegetables at SKUAST-K Shalimar.

Crop : Shalimar Cucumber Hybrid-1 (SH-CH-1)
Year /Season : 2008/ Kharief
Treatment details : As given below
Design : RBD
Replications : 3
Spacing : 60x50
Plot size : 3.6 x3.0 m^2
RFD : 30 t FYM/ha,70N,30 P_2O_5,30K_2O/ha

Experiment No 1

Table 1: Effect of different dates of transplanting on yield and yield attributing traits of Tomato under protected conditions at SKUAST-K Shalimar

S. No.	Date of transplanting	Tomato							
		Average fruit number/plant				Average fruit wt.(g)			
		R1	R2	R3	Mean	R1	R2	R3	Mean
1	15March (D1)	143.80	137.20	139.20	140.07	80	85	81	82.00
2	15April (D2)	124.00	126.00	132.40	127.47	86	83	75	81.33
3	15May (D3)	129.00	123.20	128.80	127.00	84	81	88	84.33
4	15 June (D4)	91.20	99.00	94.40	94.87	85	76	83	81.33

Average fruit yield/plant (Kg)				Average fruit yield/plot (Kg)			
R1	R2	R3	Mean	R1	R2	R3	Mean
11.504	11.662	11.2752	11.48	414.14	419.83	405.91	413.29
10.664	10.458	9.93	10.35	383.90	376.49	357.48	372.62
10.836	9.9792	11.3344	10.72	390.10	359.25	408.04	385.80
7.752	7.524	7.8352	7.70	279.07	270.86	282.07	277.33

Average Fruit yield (q/ha)			
R1	R2	R3	Mean
3834.67	3887.33	3758.40	3826.80
3554.67	3486.00	3310.00	3450.22
3612.00	3326.40	3778.13	3572.18
2584.00	2508.00	2611.73	2567.91

Conclusion: Highest average fruit yield of 3826.80 q/ha was recorded with D1 followed byD3 (3572.18.22 q/ha).

Experiment No 2

Table 1: Effect of different dates of transplanting on yield and yield attributing traits of Capsicum under protected conditions at SKUAST-K Shalimar

S.No.	Date of transplanting	Capsicum							
		Average fruit number/plant				Average fruit wt.(g)			
		R1	R2	R3	Mean	R1	R2	R3	Mean
1	12March (D1)	47.40	42.80	42.80	44.30	93.00	95.00	85.00	86.00
2	27March (D2)	43.00	42.60	44.40	43.30	90.00	90.00	83.00	97.00
3	11April (D3)	35.00	38.60	43.20	38.90	82.00	83.00	75.00	64.00
4	26 April (D4)	28.60	33.40	41.00	34.33	70.00	64.00	75.00	69.00

Average Fruit yield/plant (Kg)				Average Fruit yield/plot (Kg)			
R1	R2	R3	Mean	R1	R2	R3	Mean
4.41	4.07	3.64	4.04	158.70	146.38	130.97	145.35
3.87	3.83	3.69	3.80	139.32	138.02	132.67	136.67
2.87	3.20	3.24	3.10	103.32	115.34	116.64	111.77
2.00	2.14	3.08	2.40	72.07	76.95	110.70	86.58

Average Fruit yield/hectare(q)			
R1	R2	R3	Mean
1355.33	1212.67	1345.80	1304.60
1278.00	1228.40	1265.47	1257.29
1067.93	1080.00	1034.87	1060.93
712.53	1025.00	801.62	846.39

Conclusion: Highest average fruit yield of 1304.60 q/ha was recorded with D_1 followed by D_2 (1257.29 q/ha). Highlights of the achievements of the year 2008-2009

Experiment No 2

Table 1: Effect of different dates of transplanting on yield and yield attributing traits of Cucumber under protected conditions at SKUAST-K Shalimar

S.No	Date of transplanting	Cucumber							
		Average fruit number/plant				Average fruit wt.(g)			
		R1	R2	R3	Mean	R1	R2	R3	Mean
1	15 March	388.05	375.44	374.44	379.31	27.4	16.40	16.34	20.05
2	15 April	383.88	377.96	386.66	382.83	27.4	19.60	30.00	25.67
3	15 May	395.78	379.55	395.65	390.33	31.6	21.80	29.80	27.73
4	15 June	393.40	390.58	404.45	396.14	30.8	25.60	32.20	29.53

Average Fruit yield/plant (Kg)				Average Fruit yield/plot (Kg)			
R1	R2	R3	Mean	R1	R2	R3	Mean
10.63	6.16	6.12	7.64	382.77	221.66	220.26	274.90
10.52	7.41	11.60	9.84	378.65	266.69	417.59	354.31
12.51	8.27	11.79	10.86	450.23	297.87	424.45	390.85
12.12	10.00	13.02	11.71	436.20	359.96	468.84	421.67

Average Fruit yield/hectare (q)			
R1	R2	R3	Mean
2052.41	2039.42	2545.34	2212.39
2469.31	3866.60	3280.65	3205.52
2758.06	3930.12	3619.01	3435.73
3332.95	4341.10	3904.32	3859.45

Conclusion: Highest average fruit yield of 3859.45 q/ha was recorded with D4 followed by D3 (3435.73 q/ha)

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