Int.J.Curr.Microbiol.App.Sci (2018) Special Issue-7: 96-104

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 Special Issue-7 pp. 96-104
Journal homepage: http://www.ijcmas.com

Original Research Article

Economic Feasibility of Greenhouse Technology for Crop Production in Cold Desert Conditions

B. K. Yadav[1*] and Indu Bhushan Bhagat[2]

[1](Agril. Engg.) KVK, Garhwa, BAU, Ranchi, Jharkhand, India
[2]College of Agricultural Engineering, RAU, Pusa-848125, Samastipur, Bihar, India
**Corresponding author*

Keywords

Greenhouse, Crop Production, Cost Economics, Yield, Return, BCR

A B S T R A C T

Energy conservation and the use of renewable energy in greenhouse environment control is essential in present time especially in cold deserts to grown vegetables. Four different types of greenhouses (Soil trench, round arc, mud wall/Ladakhi and polyench type) were erected in Lari. The experiment was designed by using RBD with three replications. Cost of greenhouses per sq. meter was Rs. 102.00, Rs. 170.00, Rs. 170.00 and Rs. 311.00 for trench type, Ladakhi type (mud wall), polyench type and round arc type greenhouses respectively. Cost of crop production was minimum (Rs. 393) for mustard whereas maximum (Rs. 541) for mint. Maximum yield was obtained from beet leaves of Pusa Harit variety compare to eight crops grown. Maximum gross return and net return of Rs. 3523.67 and Rs. 2570.67, respectively, was obtained from beet leaf grown in soil trench type greenhouse. BCR was 1: 2.73 in soil trench type greenhouse where coriander grown and maximum negative BCR was (1: - 0.82) in round arc greenhouse where radish grown.

Introduction

The agricultural production, productivity and quality of produce depend upon the cultural practices, quality of input and environmental parameters. Worldwide the climate varies to a great extent. The greenhouse cultivation technology could be used to alter the environmental conditions and provide a feasible solution for raising vegetables and horticultural crops while improving crop productivity. Control over the crop microclimate results in several fold increase in crop photo synthesis and thus increase in the yield. Also, crops can be taken over a wider period of time as compared to normal season, thus making fresh fruits and vegetables available for a larger part of the year.

Greenhouses are usually space frame covered with transparent UV stabilized film in which crops can be grown under controlled environment. The cultivation inside greenhouses becomes more important when the climatic conditions are very much adverse and nothing can be given in natural conditions in cold desert areas of India and for day-to-day requirements everything has to be brought from far off distances.

Cold desert zone of India lies in the high attitude ranges of North- Western Himalayas in the northern most latitudes of the country covering Ladakh provience of Jammu & Kashmir and Lahul- Spiti division of the Himachal Pradesh. India is having about 74, 809 km^2 of cold desert areas in states of Jammu & Kashmir and Himachal Pradesh (Singh *et. al.* 2000). The cold desert zone exhibits greater diversity of soil, topography and climate with severer winter high wind and low rainfall. It is not possible to grow any crop during winter season in these zones. To meet out the food needs of people is great challenge. Green house technology is a viable alternative of this problem. Cultivation of vegetable crops under plastic house condition is common practice in western countries with good success (Chandra, 1985). By adopting greenhouse technology the climate parameters could be modified and conditions could be made favorable for some crop production activity.

Abdullah (1993) studied the environmental conditions of greenhouse and revealed that the yield was two times higher than outside condition when greenhouse temperature was maintained at the temperature range of 16°-30°C throughout the year whereas outside air temperature varied from 8.5°C – 45.5°C. The greenhouse floor temperature is maximum and the temperature of canopy is minimum in the beginning. The relative humidity inside the greenhouse should be 60-75% for desirable growth of plants inside it. (ASHRAE, 1997; Jolliet, 1994).

There have been several studies related to the evaluation of properties and effects of glazing materials (Walker and Slack, 1970; Townsend and Chandra, 1975; Manbeck, and Aldrich 1967) but there are few unqualified recommendations, which could be made. Experiments of Aldrich and White (1973) suggested that a glasshouse would provide earlier blooming, shorter but stockier geraniums than a rigid plastic dome shaped house at 15.5°C night and 21°C day temperature. Hanan (1965) demonstrated that greenhouse-covering materials greatly influence the heat absorbed by plants and thus the temperature differential between plant and air. Better plant growth under some greenhouse coverings is due to light diffusion and reduction of infrared energy by frosted white fiberglass and clear PVC was a major factor in better growth under these coverings even though plants under glass received upto 20% more total energy.

Sebesta and Reiersen (1981) reported 50% reduction in heat loss in case of a double acrylic greenhouse cover as compared to a glasshouse. The acrylic house admitted 15% less light and had higher humidity. Also higher leaf temperatures were observed during night. The concluded the double acrylic glazing to be a sound alternative to glass. Nakashima *et al.*, (1978) observed that the use of plastic films, if they are properly maintained, would not result in inferior yield as compared to those for glasshouse. Tantau (1978) stated that materials with high reflectivity to long wave (thermal) radiation caused lower heat consumption and relatively high transpiration rates.

Energy conservation and the use of renewable energy in greenhouse environment control have become essential in present time. Since equipments for active collection, storage and retrieval of solar energy for greenhouse temperature control are quite expensive at present, the greenhouse design incorporating passive options such as added thermal mass, installation of permanent insulation, use of night curtains etc. are being developed and tested. Permanently insulating the north side of a greenhouse is northern locations is stated to reduce the winter heating requirements by about 50% provided the greenhouse is oriented east- west (Lawand *et. al.* 1974; Chandra, 1976). The effect of such a position on plant growth has not been much studied.

The usual recommendation for greenhouse temperature control, depending upon the crop being grown is a set of constant day and night temperature e.g. 25°C/ 20°C day/ night temperature for lettuce (Hanan *et. al.* 1978) requiring step changes in the morning and in the evening. This requirement of "blue print temperature" puts a considerable burden on the heating/ cooling equipments and consequently, the overall requirements are high. If the greenhouse temperature followed a smooth natural course, similar to that of ambient air temperature but satisfying crop requirement in some way, the energy expenditure for environmental control could be reduced considerably.

Langhans, *et al.*, (1981) reported growth studies with several crops grown with variable night temperature concluding that vegetative growth was a function of average night temperature at a particular time as long as damaging conditions were avoided. The concept of sliding night temperature sliding from 22°C to 11°C instead of holding a constant 16.5°C was assessed for roses and chrysanthamus. Timing of flowering and quality were unaffected compared to the controls.

Willits *et al.*, (1981) studied the transpiration phenomenon for lettuce and tomato crops and observed that in case of a closed ventilation system the net solar energy available is highly dependent upon transpiration load under conditions of limited solar radiation but less so during the periods of high insulations.

Greenhouses are, evidently closed structure where crops utilize the CO_2 available in the greenhouse air. The CO_2 in the greenhouse air keeps getting replenished with the help of infiltration- exfiltration and ventilation. However, under bright sunshine hours, greenhouse crops have been noticed to suffer from a lack of CO_2 availability because of a gap between demand and supply. Adequate ventilation during this period of augmentation with artificial supply of CO_2 is, therefore recommended to ensure plant growth.

Use of plastics as greenhouse glazing material in place of glass has resulted into more air tightness of the greenhouses and consequently higher humidity within them (Sebesta and Reiersen, 1981). It was observed that variations in the RH from 35 to 100% had no significant effect on the growth and yield of red kidney beans. There are some other references which suggest higher rates of photosynthesis at higher humidity environment, 70 % RH found to be optimum for tomatoes.

Materials and Methods

The research activity was carried out at Choudhari Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalya (CSKHPKV), Palampur research station, Lari (30° 42' N and 70° 37' E) in Lahaul and Spiti district of Himachal Pradesh (India). Four different types of greenhouses namely Soil Trench type, Round Arc type, Mud Wall type and Polyench type greenhouses were erected and the studies were under taken to find out the cost benefit analysis of greenhouse for growing different vegetable crops.

Erection of greenhouses

Soil trench type greenhouse

A soil trench of 10 X 5 X 0.75 m size was made, wooden poles were provided at a distance of 10 m each on the top of the trench to hold UV stabilized polythene sheet. Black poly film was provided over UV stabilized polythene sheet to conserve more heat and reduce heat losses. For improving the soil structure, the lower 15 cm soil was replaced with clay loam soil and FYM. Table 1 gives the details of material required and cost of greenhouse construction.

Round arc type greenhouse

The foundation was laid in pits of 10 cm wide and 60 cm depth. The GI pipes of 25mm diameter having 70 cm in length were fixed in these pits. Bending of GI pipes (15 mm ϕ and 6.1 m length), hoops were made by keeping 30 cm length straight from each end. The spacing between two hoops was 1.0 m apart to keep the hoops equidistance from the top and to increase structural stability. The hoops were fastened with straight GI pipe of 10 cm length using 2 mm GI wire. The end frames were made from GI square pipes. The plain galvanized sheet of 22 gauges was cut into pieces of 5 and 15 cm width for making poly grip assembly. A 15 cm piece was used to make the channel and 5 cm piece was used to make angle. The UV stabilized film was gripped between channel and angle, using 6 cm from rods. UV stabilized polyethylene film (200 micron thickness) was used to cover the green house. The sheet was anchored with poly grip assembly on the sides and remaining portion of sheet was buried in the soil on both the ends, sheet was fastened to end frames using button of 2.5 cm width.

Mud wall type greenhouse

Mud wall greenhouse of floor area (10 x 5 m) was constructed with two mud walls measuring 3.0 m height on one side and one meter on opposite side. The foundation was made one meter deep. GI pipes were fixed in slanting at one-meter distance and were joined with metallic wires and electric welding. The entire structure was centrally supported by one GI pipe having 5 cm diameter. A wooden door (1.2 X 0.75 m) was fixed at the western side whereas wooden ventilator (0.6 X 0.475 m) was fixed on the southern side of the structure. Wooden strips were provided at the top of both the mud wall. Wooden strips were provided for fining the UV stabilized polyethylene sheet (200 micron). The wooden framework was developed to support the polyethylene sheet on the other sides.

Polyench type greenhouse

Three-side mud wall greenhouse, triangular in shape, with a wall of 3.0 m height on one side was constructed. A trench (10 X 5 X 0.75 m) was made inside the walls. The foundation was kept one meter deep.

GI pipes were fixed in slanting at one-meter distance and joined with metallic wires and electric welding. The entire structure was centrally supported by on GI pipe having 5.0 cm diameter. A wooden door (0.6 X 0.45m) was fixed at the western side. A wooden ventilator (1.2 X 0.75 m) fixed on the eastern side of the structure. Wooden strips were provided at the top of both the mud wall. Wooden strips were provided for fining the UV stabilized polyethylene sheet (200 micron). The wooden framework was done to support the polyethylene sheet on the other sides.

Crop production

Selection of crops

As discussed earlier, in cold desert region temperature goes beyond 50°C in summer and touches -30°C to -40°C during peak winter (Dec/Jan) season which also affects the growth of crops. Under these circumstances selection of crops is really a challenging task. Crops in winter cultivation should not only be able to tolerate the sub-zero temperature but also grow under the cover where very little and diffused sun light is available. Fast growing and ratoon yielding crops should be preferred so that more number of cutting/harvesting can be taken. After studying these factors in winter crops like Beet leaf, Coriander, Methi, Lettuce, Mint, Radish, Carrot, and Cabbage and in summer Capsicum, Brinjal, Tomato, French bean, Cucumber were selected and grown in greenhouses. Cropping Sequences Capsicum-Spinach-Radish, Tomato- Methi-Radish, Cucumber-Spinach-Spinach, Brinjsal –Green onion- Methi, Cauliflower-Tomato, Cabbage-Capsicum was taken for monetary cost return evaluation.

Statistical analysis

The experiment was designed by using RBD with three replications. Cost economics was calculated by straight-line method.

Results and Discussion

Cost of erection of greenhouses

Costs of different greenhouses were given in Table 1. Cost of greenhouses per sq meter was Rs. 102.00 Rs. 170.00 Rs 170.00 and Rs. 311.00 for Trench type, Ladakhi type (mud wall), Polyench type and Round arc type greenhouses respectively.

Crop production under covered structures

Maximum yield was obtained from beet leaves of Pusa Harit variety compare to other crops; where as minimum yield was obtained from Pusa Himani variety of radish. Among the type of greenhouses, trench type greenhouse was recorded higher yield over Ladakhi and polyench.

Crops like spinach, mint coriander, methi, lettuce, radish, carrot and cauliflower were grown inside the greenhouse in cold desert area during winter and an experiment was conducted to test the performance of vegetables in terms of yield inside different greenhouses viz Polyhouse, Soil trench, Ladakhi polyhouse, Polyench. Among these greenhouses, soil trench type was found best for growing off season leafy vegetables during winter (October-April) as it recorded the highest yield for all the vegetables followed by polyench greenhouse Fig.7.

On an average, soil trench recorded 27.3 and 66.3 percent higher yield over Ladakhi and round arc greenhouse respectively. Among different vegetable crops, beet leaf recorded the maximum yield in all the greenhouses. Cabbage fails to grow in round arc polyhouse due to low average minimum temperature inside the greenhouse. Yield of different vegetables crops inside greenhouse were also evaluated during summer season and it was found that 2 to 5 times higher yield as compared to open. The production of capsicum and brinjal were 2.5 times higher than open whereas French bean was 5 times (Fig. 8)

Performance evaluation of nursery

The performance of different vegetable crops nursery (tomato, capsicum, cucumber, cabbage, cauliflower) were evaluated in open, laddakhi and soil trench type greenhouses. It was observed that germination of all seeds were 10 to 20 days earlier in soil trench type greenhouse as compare to open and Ladakhi type greenhouse. Also the seedlings were ready 20 to 30 days earlier for transplantation in soil trench type greenhouse. Nursery sown on 15^{th} March or 30^{th} March failed to grow in open field due to low temperature (-15°C).

Effect of dates of planting and spacing

Among planting dates 15th April was most suitable for tomato, capsicum, cucumber and cauliflower production. Productivity of cabbage & tomato was maximum when it was planted on 15th May and 15th April respectively. The production of all vegetable crops except cabbage on 15th April planting was approximately 1.2 to 3 times higher as compared to 15th March and 15th June planting dates. An experiment was also conducted to study the effect of date of planting and row spacing for different vegetable crops. The results shows that the yield of crops planted on 15th April of 40 cm spacing recorded higher yield as compare to 5th May, 15th June and 15th July with 60 cm spacing plated crop.

Among the varieties, Naveen variety of tomato, Poinset of cucumber, California wonder of Capsicum and Pusa snow ball-K_1 of cauliflower recorded significantly higher yield than the other varieties.

Row spacing had also marked effect on the yield of various crops and it was observed that 40 cm row spacing recovered significantly higher yield than 60 cm row spacing. The highest yield recorded at 40 cm row spacing may be due to the more number of plants per unit area, which might be resulted in higher yield.

Table.1 Detailed cost of construction of different type of green houses

S. No	Detail of material work	Cost (Rs.)			
		ST	LT	PT	RAT
1.	Digging of trench (10 m x 5, x 0.75 m) (15man/ day @ Rs. 80/day)	1200.00	-	1200.00	-
2.	Cost of wooden poles @ Rs 100/pole	1100.00	1100.00	1100.00	-
3.	Cost of UV stabilized sheet /Glazing sheet	2800.00	2800.00	2800.00	3250.00
4.	Foundation with material	-	1200.00	-	-
5.	Construction of mud wall	-	1400.00	1400.00	-
6.	Cost of wooden door and ventilator	-	1500.00	1500.00	-
7.	Poly grip	-	-	-	2350.00
8.	Foundation pipes	-	-	-	1790.00
9.	Cement concrete	-	-		400.00
10.	End frame	-	-	-	2000.00
11.	Hoops	-	-	-	3710.00
12.	Ridge line	-	-	-	1060.00
13.	Miscellaneous charges	-	500.00	500.00	500.00
	Total cost of greenhouse (Rs.)	5100.00	8500.00	8500.00	15,560.00
	Cost per unit (m^2) surface area (Rs)	102.00	170.00	170.00	311.00

Where, ST = Soil Trench type, LT= Ladakhi type, PT – Polyench type, RAT- Round arc type

Table.2 Average yield of vegetable (kg/ m^2) and gross return (Rs./m^2)

Name of the vegetable	Round arc		Soil Trench		Ladakhi		Polyench	
	Yield	Gross Return	Yield	Gross Return	Yield	Gross Return	Yield	Gross Return
Beet leaf	1.42	31.24	3.203	70.47	2.50	55.00	2.69	59.18
Coriander	0.86	18.92	3.108	68.38	1.34	29.48	1.51	33.22
Methi	1.393	30.65	2.765	60.83	2.18	47.96	2.45	53.90
Lettuce	0.673	14.81	1.822	40.08	1.358	29.88	1.613	35.49
Mint	1.327	29.19	2.530	55.66	1.94	42.68	2.221	48.86
Radish	0.327	07.19	1.326	29.17	0.86	18.92	1.137	25.01
Carrot	0.513	11.29	1.877	41.29	1.288	28.34	1.549	34.08
Mustard	0.713	15.68	1.952	42.94	1.20	26.40	1.394	30.67

Table.3 Cost benefit ratio of the vegetable crops under different type of greenhouses

Name of the vegetable	Cost of Production				Gross Returns				Net Return (Gross-CIST of Production)				BCR			
	RAT	ST	LT	PT	RAT	ST	LT	PT	RAT	ST	LT	PT	RAT	ST	LT	PT
Beet leaf	1999	953	1293	1293	1558.33	3523.67	2585.37	2963.03	-440.67	2570.67	1292.37	1670.03	0.22	2.70	1.00	1.29
Coriander	1962	916	1256	1256	946.00	3419.17	1470.33	1665.03	-016.00	2503.17	214.33	409.03	0.52	2.73	0.17	0.33
Methi	1965	919	1259	1259	1532.67	3041.50	2394.33	2695.37	-432.33	2122.50	1135.33	1436.37	0.22	2.31	0.90	1.14
Lettuce	2009	963	1303	1303	740.67	2003.83	1494.17	1774.67	1268.33	1040.83	191.17	471.67	0.63	1.08	0.15	0.36
Mint	2097	1051	1391	1391	1459.33	2783.00	2117.50	2442.73	-637.67	1732.00	726.50	1051.73	0.30	1.65	0.52	0.76
Radish	1984	938	1278	1278	359.33	1524.23	946.00	1250.33	1624.67	586.23	-332.00	-27.67	-0.82	0.62	0.26	0.02
Carrot	1984	938	1278	1278	564.67	2064.70	1417.17	1703.90	-419.33	1126.70	139.17	425.90	0.72	1.20	0.11	0.33
Mustard	1949	903	1243	1243	784.67	2146.83	1320.00	1533.03	1164.33	1243.83	77.00	290.03	0.60	1.38	0.06	0.23

Cost of production

Cost of production of different crops under different greenhouse were calculated. Cost of production including, human labour, seed, fertilizer, FYM, plant protection, depreciation and interest on assets @ 12% half of the growing season. Cost of crops production are Rs, 428, Rs. 428, Rs, 453, Rs, 406, Rs. 443, Rs. 541 and Rs. 393 for methi, radish, carrot, lettuce, coriander, beet leaf, mint and mustard, respectively. Depreciation on greenhouses (life span of 5 years) was Rs. 510, Rs 850, Rs. 850 and Rs, 1556 in trench type greenhouse, ladakhi type greenhouse, polyench type greenhouse and round arc green house during winter season respectively.

Gross return

Three-year average of vegetables has been taken to calculate cost benefit. Average rate of all vegetable during 3 year was taken as Rs. 22 per kg in cold desert region (Table 3). Maximum return of Rs. 3523.67 was obtained from beet leaf grown in soil trench type greenhouse whereas minimum return of Rs. 359.33 was obtained from radish grown under round arc type houses (Table 4).

Net return

Net return was calculated that gross return from the sale of vegetable crops minus the cost of production of vegetable crops. Maximum net return of Rs. 2570.67 was obtained from beet leaf grown in soil trench type greenhouses whereas net loss of Rs. 1624.67 was found in radish grown under round arch greenhouses.

Benefit Cost ratio

Benefit cost ratio (BCR) was calculated dividing net return by cost of production. It was clear from Table 4 that BCR was maximum (1:2.73) in soil trench type green house where coriander grown. Maximum negative BCR was 1: –0.82 in round arc greenhouse where radish grown.

Cost of production was minimum of Rs. 903 in soil trench type greenhouses whereas maximum amount spent of Rs. 2097 was in round arch type greenhouse where mint has grown. Maximum expenditure was incurred on round arc type greenhouse. Minimum cost of production was in soil trench type of greenhouse. Gross return of Rs. 3523.67 was maximum in beetleaf followed by coriander and methi grown under soil trench type greenhouse. Minimum gross return was obtained in round arc type greenhouse.

It is clear from Table 3 that net return was negative in all crops grown in round arc greenhouses. It is due to higher cost of production in which depreciation of greenhouses amount was more. Maximum net return was obtained in soil trench type greenhouse irrespective of crop grown compare to Ladakhi, polyench and round arc green houses. Soil trench type greenhouses were shown above 1 BCR in all crops grown except radish, which was 0.62. It was also noticed that BCR was negative in round arch type greenhouses. Only beet leaf and methi grown in polyanch greenhouse shown more than 1 BCR and other crops are below one BCR. It is better to grow the beet leaf and methi under Ladakhi and polyanch greenhouses and not to go for crop growing in round arc type greenhouse in cold desert region of India.

It was observed that low cost greenhouse as soil trench was suitable to grow all type of crops during winter season of cold desert, where as its impossible to grow vegetables in open field. Coriander, beet leaf and methi are grown with higher cost benefit ratio.

Round arc type greenhouse is costly and its BCR was not satisfactory.

References

Abdullah, K.M 1999. Drying of vanilla pods using a greenhouse effect solar dryer, Drying Technology, 15(2): 685-698.

Aldrich, R.A. and J.W. White 1973. Q- Mats as passive solar collectors. Proc. Solar Energy for Heating Greenhouse – Residence Combinations. Rutgers University, Piscataway, N.J.

ASHRAE 1997. Fundamental handbook. Environmental control for animals and plants. New York, pp. 17.

Chandra P. 1985. Applications of greenhouse technology. Proceeding of the summer institute on greenhouse on greenhouse design and environmental control. Technical Report. CIAE/EME85/ 35, CIAE Bhopal, pp A 21-31.

Chandra, P 1976. Predicting the effect of greenhouse orientation and insulation on energy conservation. M. Sc. Thesis, University of Manitoba, Canada.

Hanan J.J., W.D. Holley and K.L. Goldsberry 1978. Greenhouse management. Springerverlag, New York.

Jolliet O.H. 1994. A model for predicting and optimizing humidity and transpiration in greenhouses. J. Agril. Engg. Les, 57; 23-37.

Langhans, R.W. M, Wolfe and L.D. Albright 1981. Use of average night temperatures for plant growth for potential energy saving. Acta Horticulture, 115: 31 38.

Lawand, T. A. R. Alward, B. Saulriez, and E. Brunet. 1974. The development and testing of an environment designed greenhouse for colder regions. Proc. Int. Sol. Energy Soc. U.S. Section, Colorado State University, Ft. Collins.

Manbeck, H.B. and R. A. Aldrich 1967. Analytical determination of direct visible solar energy transmitted by rigid greenhouse. Trans. ASAE, 10: 564-572.

Nakashima. J.S. Kagohashi and Y. Natio 1978. Utilisatio of plastic film for protected cultivation. Acta. Hort. 87:171:176.

Sebesta, Z. and D. Reiersen 1981. A comparison of single glass and double acrylic sheeting with respect to heat loss and effect on plant environment. Acta. Hort., 115: 409.

Singh B; Dwivedi S K; Sharma J P 2000. Greenhouse technology and winter vegetable production in cold arid zone. Dynamics of cold arid agriculture, Kalyani Publishers, Ludhiana, pp. 279-293

Tantau, H.J. 1978. The influence of single and double shelter on the climate and heat consumption of greenhouses. Acta. Hort., 87:119.

Townsend, J.S. and P. Chandra. 1975. Conclusions of weathering trials for radiant energy transmission of plastic greenhouse covering materials ASAE paper no. NC-75-403.

Walker, J. N. and D.C. Slack 1970. Properties of greenhouse covering materials. Trans. ASAE., 13(5):682-684.

Willits, D.H., M.M. Peet and P. Chandra 1981. Effect of transpiration on solar collection potential of greenhouse. ASAE Paper no. 71-4041.