Vegetable Science (2022) 49(2): 190-196

Off-season vegetable cultivation under low tunnel technology in Bikaner District of Rajasthan: An economic analysis

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Received: July 2022/ Accepted: October 2022

Abstract

The arid western part of Rajasthan is well known for Indian segment of the Thar Desert. The hot arid regions of India cover 31.7 million hectares, with the majority of the area (61.9%) located in Rajasthan. In Rajasthan, the region is spread over 12 districts including Bikaner. The region is characterized by harsh climatic conditions. In such a situation, protected structures like low tunnels play an important role in vegetable cultivation. Off-season cultivation under protected structures is one of the ways to fulfill demand for vegetables. Although technology can make available better quality vegetable produce around the year but, at the same time it should be economically feasible for the farmers too. The present study was conducted to examine the economics of off-season vegetable cultivation under low tunnel technology in the Bikaner district of Rajasthan. The cost concepts given by Commission for Agricultural Cost and Prices (CACP) were used to calculate the cost of cultivation. Major cucurbits viz bottle gourd, ridge gourd, watermelon, muskmelon, long melon were selected for the study. The study revealed that the highest cost was incurred on human labour which was followed by expenditure on transportation and seeds. Quality production during off-season helps the farmer in fetching higher prices in the market. The B: C ratio of selected cucurbits was observed 1:2.05 to 1:3.35 which shows the economic profitability of the low tunnel technology.

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Key words: Hot arid region, Cucurbits, Off-season cultivation, Low Tunnel, CACP Cost Concepts, B:C Ratio.

Introduction

The area under the hot arid zone in India is 31.7 mha (12% of the country's total geographical area) which is mainly spread over Rajasthan, Gujarat, Andhra Pradesh, Punjab, Haryana, Karnataka and Maharashtra. The major part of the hot arid region lies in western Rajasthan (19.62 mha) followed by north-western Gujarat (2.16 mha). The region is characterized by extremes of temperature, low and erratic rainfall, high evapotranspiration rate, high wind velocity, dust storm, high soil pH, high infiltration rate, limited groundwater availability, and saline ground irrigation water. The studies of various researchers reported that arid region soils are low in organic matter, macronutrients and micronutrients (Jatav et al. 2016a & 2016b, Meena et al. 2016, Saroj et al. 2020, Meghwal et al. 2022). Despite adverse climatic conditions the region has good potential to grow cucurbits. But, due to high temperature and hot wind in the summer season, low yield and poor quality of the product are obtained (Choudhary et al. 2015).

Under such harsh climatic conditions, vegetable cultivation in open condition yield poor-quality produces and less returns. By creating a suitable micro-climate for plant growth through protected cultivation structures like low tunnel, the cultivation of vegetables can be done around the year even under adverse climatic conditions. Low tunnels are modified miniature structures working on the greenhouse concept. These are the structures built on a steel frame and covered with polythene roofs (Lodhi et al. 2015). Thakur and Devi (2013) in their study revealed that vegetable cultivation under low

tunnel technology can fetch very high prices in the market. Lodhi et al. (2015) reported that the technology is cost-effective as its infrastructure can be easily dismantled and used again in the next year saving costs of cultivation. Choudhary and Saroj (2018 and 2019) in their study reported that with the use of low tunnels, cucurbits can be grown very early in the spring or summer season which can be sold for higher prices in the market. Saroj et al. (2020) observed low-cost and lesser-height structures like a shade net and tunnel cultivation is suitable for the arid ecosystem, where extremes of temperature and high wind velocity, and dust storms are the common phenomena. Considering the importance of low tunnel technology, this study was conducted in the Bikaner districts of Rajasthan with the objective to analyze the economic impact of vegetable cultivation under low tunnel technology in the district.

Materials and Methods

A total of nine villages viz; Pemasar, Udasar, Raysar, Sagar, Ridmalsar, Surdhana Chauhan, Gheegasar, Palana, and Meghasar (where low tunnel technology was used for vegetable cultivation) were selected randomly from the Bikaner district. The primary data were collected from vegetable growers under low tunnel technology from selected villages. A pre-tested survey schedule was prepared for this purpose. A total of 40 farmers were interviewed and data were collected for the year 2020-21. The farmers of the selected villages were cultivating mainly cucurbits on large scale, while some were growing radish and tomato on a very small scale or for their own consumption under the low tunnels. So, major cucurbits cultivated in the study area viz; bottle gourd, ridge gourd, watermelon, muskmelon, and long melon were selected for the study. The cost of cultivation was analyzed by using cost concepts given by the Commission for Agricultural Costs and Prices (CACP) which are explained below (Directorate of Economics and Statistics, Government of India):

Cost A1: It includes all actual expenses in cash and kind in production by the farmer.
Value of hired human, animal, and machine labour
Value of owned animal and machine labour
Value of seeds (farm produced and purchased)
Value of manure (owned and purchased)
Value of fertilizers
Value of insecticides and pesticides
Depreciation of implements and machinery
Irrigation charges (Electricity)
Land revenue
Interest on working capital
Miscellaneous expenses
Cost A2: Cost A1 + rent paid for leased-in land
Cost B1: Cost A1 + interest on value of owned fixed capital excluding land
Cost B2: Cost B1+ Rental value of owned land (net of land revenue) and rent paid for leased-in land
Cost C1: Cost B1 + Imputed value of family labour
Cost C2: Cost B2 + Imputed value of family labour
Cost C3: Cost C2 + 10 % of cost C2 to account for managerial input of the farmer

Results and Discussion

The study revealed that farmers in villages of Bikaner districts leased out their land for low tunnel vegetable cultivation. As it is highly laborious and requires continuous supervision during the entire season it becomes difficult for the landowners to manage the entire business. Almost all the farmers to whom the land was leased out were from Uttar Pradesh. They were doing it either in a fifty percent partnership or as their own business after paying rent for leased land. The sowing was started from mid-November to the first week of December. With the growth of plants the polythene cover was opened and closed as per their pollination schedule and other requirements. In the second fortnight of February, with the increase in temperature, the polythene roofs started to open permanently. The first harvesting of cucurbits starts in the last week of February which varies among all the farmers depending upon various factors. Almost all the farmers were growing hybrid varieties of the crops. The seeds were purchased from Bikaner as well as outside the districts i.e. from Jaipur and Suratgadh. The cost of the seeds varies depending upon the crops, type of crops (hybrid/ local), and company engaged in selling these seeds. Taking the prices of seeds of different types i.e. hybrids/ local, the average cost was calculated and presented in Table 1 which shows that the seeds of the hybrid cucurbits were very expensive which later contributes to their higher cost of cultivation. The data were collected on different indicators and the item-wise cost was calculated and presented in Table 2

Table 1: Cost of seeds of major cucurbits

S. No.	Vegetable	Type	Av. seed rate (kg/ ha)	Av. Seed cost (Rs./ kg)	Total Seed Cost (Rs./ ha)
1	Bottle gourd	Hybrid	2.75	8145.00	22400.00*
2	Ridge gourd	Hybrid	2.50	9500.00	23720.00*
3	Watermelon	Hybrid	1.50	29000.00	43500.00
4	Muskmelon	Hybrid	1.50	33000.00	49500.00
5	Long melon	Local	1.25	1360.00	1700.00

*round off figures

Table 2: Item-wise breakup of cost of cultivation of cucurbits under low tunnel technology

S. No.	Particulars	No. or Volume/ ha	Rate	Total Cost (Rs./ ha)
1	Total machine labor (hired and owned both)	2 labor	Rs. 300 per labor	600.00
2	Machine charges	-	-	1600.00
3	Manure	150 q	Rs. 2.5 per kg	37500.00
4	Fertilizers:			
	Urea	400 kg	Rs. 270 per 50 kg	2160.00
	DAP	200 kg	Rs. 1250 per 50 kg	5000.00
	Potash	80 kg	Rs. 300 per 20 kg	1200.00
	NPK 19:19:19	15 kg	Rs. 100 per kg	1500.00
5	Electricity charges for irrigation	750 unit/ month for 5 months	Rs. 5 per unit	18750.00
6	Plant protection chemicals	Imidacloprid 17.8 % SL @ 0.3 ml/ litre water	Rs. 340 per litre	61.20
		Diamethoate 30 % EC @ 2 ml/ litre water	Rs. 400 per litre	480.00
		Malathion 50 % EC @ 2 ml/ litre water	Rs. 400 per litre	480.00
7	Floor cover (*Sarkanda*)	-	-	10000.00
Total Working/ Material Cost (excluding seed and transportation cost)				79331.20
8	Low tunnel structure			
	Plastic	140 kg	Rs. 130 per kg	18200.00
	Steel wire	100 kg	Rs. 60 per kg	6000.00
9	Drip irrigation system			
	Plastic Pipe (3 inch)	40 kg	Rs. 130 per kg	5200.00
	Pipe line	2 Bundles	Rs. 2500 per bundle	5000.00
Total Cost of Installation				34400.00
10	Rent for leased in land per season	-	-	20500.00
11	Total human labor (owned)	2 labor/ day/ ha/season	Rs. 300 per labor	90000.00

which depicts the cost of items, which were common in the cultivation of all the major cucurbits excluding seed and transportation costs. Transportation cost is one of the major items contributing a significant share of the total cost of cultivation. It was found that the harvested produce was sold at Punjab and Bikaner markets. In the beginning, the produce was sold in the Punjab market to get higher returns. Approximately one-third of the total production was sold in the Punjab market at comparatively higher prices as the produce arrived early in the market and being the off-season

crop, the demand for the product is more than its market supply. The remaining two third produce was sold in the Bikaner market at comparatively lower prices than Punjab but still higher than the regular season crops. The average production per hectare of the different cucurbits was recorded and the transportation cost of the respective crop is presented in Table 3.

Due to variation in seed rate and crop yield, the total material and operational cost of cucurbits varied. The crop-wise cost of cultivation of selected cucurbits was calculated and presented in Table 4.

Table 3: Transportation cost of selected cucurbits

S. No.	Name of Vegetable	AP (q/ ha)	Produce sold at Punjab		Produce sold at Bikaner		Total transportation Cost (Rs./ ha)
			Quantity (q/ ha)	Cost (Rs./ ha)	Quantity (q/ ha)	Cost (Rs./ ha)	
1	Bottle gourd	400	130	52000	270	13500	65500
2	Ridge gourd	200	60	24000	140	7000	31000
3	Muskmelon	210	70	28000	140	7000	35000
4	Watermelon	380	120	48000	260	13000	61000
5	Longmelon	200	60	24000	140	7000	31000

AP: Average Production; Transportation rate for Punjab: Rs. 12000/- 30q; Transportation rate for Bikaner: Rs. 1500/- 30 q

Table 4: Cost of cultivation (Rs./ ha) of major cucurbits

Cost (Rs/ha)	BG	RG	MM	WM	LM
Seed Cost	22400.00 (7.08)	23720.00 (8.51)	49500.00 (15.84)	43500.00 (12.99)	1700.00 (0.67)
Transportation cost	65500.00 (20.71)	31000.00 (11.12)	35000.00 (11.20)	61000.00 (18.21)	31000.00 (12.21)
Working capital excluding seed and transportation	79331.20 (25.09)	79331.20 (28.45)	79331.20 (25.39)	79331.20 (23.68)	79331.20 (31.24)
Interest on working capital @ 12.5 % p. a.	4354.98 (1.38)	3490.92 (1.25)	4266.44 (1.37)	4787.27 (1.43)	2917.48 (1.15)
Depreciation of implements & Machinery	3975.00 (1.26)	3975.00 (1.43)	3975.00 (1.27)	3975.00 (1.19)	3975.00 (1.57)
Cost A1	175561.18	141517.12	172072.64	192593.47	118923.68
Rent for leased in land	20500.00 (6.48)	20500.00 (7.35)	20500.00 (6.56)	20500.00 (6.12)	20500.00 (8.07)
Cost A2	196061.18	162017.12	192572.64	213093.47	139423.68
Interest on Fixed capital excluding land @ 10 % p.a.	1433.33 (0.45)	1433.33 (0.51)	1433.33 (0.46)	1433.33 (0.43)	1433.33 (0.56)
Cost B1	176994.51	142950.45	173505.97	194026.80	120357.01
Cost B2	197494.51	163450.45	194005.97	214526.80	140857.01
Imputed value of family labour	90000.00 (28.46)	90000.00 (32.28)	90000.00 (28.81)	90000.00 (26.87)	90000.00 (35.44)
Cost C1	266994.51	232950.45	263505.97	284026.80	210357.01
Cost C2	287494.51	253450.45	284005.97	304526.80	230857.01
Managerial cost (10 % of cost C2)	28749.45 (9.09)	25345.04 (9.09)	28400.60 (9.09)	30452.68 (9.09)	23805.70 (9.09)
Cost C3	316243.96 (100)	278795.49 (100)	312406.56 (100)	334979.48 (100)	253942.71 (100)

Note: Figures in parenthesis shows percentage share of each component to total cost (Cost C3).
BG: Bottle gourd; RG: Ridge gourd; MM: Muskmelon; WM: Watermelon; LM: Long melon

The Table 4 reveals that family labour is the most expensive input, which contributed the maximum share of the total cost of cultivation (Cost C3). It varies from 26.87 % to 35.44%, which shows that vegetable cultivation under low tunnel technology is labour intensive and requires at least two labours on daily basis around the season. It is followed by transportation cost and seed cost which also share a significant percentage of the total cost of cultivation. The average production was used to calculate the gross returns. Per hectare production and returns of cucurbits vary with the type of crops selected for cultivation. As already discussed in Table 3, one-third of the product is sold to the Punjab market at comparatively higher prices as the market arrival of the product is earlier than the regular season. The remaining produce is sold at local markets i.e. Bikaner at slightly lower prices. Total returns from Punjab and Bikaner markets are calculated and presented in table 5.

Table 5 unveils that the total return varies from 5.5 lakh to 10.6 lakh per hectare depending upon the total production of crops and selected market for the sale of the produce. Further, the net return and B: C ratio was calculated and presented in Table 6. The table 6 reveals that the net return from cucurbits cultivation varies from 2.66 lakh to 7.43 lakh. Further, the B: C ratio varies from 1:2.05 to 1:3.35 which depicts the profitability of cucurbits cultivation under low tunnel technology. The findings were supported by the observation of Thakur and Devi (2013) where the B: C ratio of cucurbits cultivation under low tunnel ranges from 1:2 to 1: 4 in peri-urban areas of northern India.

Table 5: Total returns from the cultivation of major cucurbits

Name of Vegetable	Produce sold at Punjab			Produce sold at Bikaner			Total Return (Rs./ ha)
	Quantity (kg/ ha)	Price (Rs./ kg)	Return (Rs./ ha)	Quantity (kg/ ha)	Price (Rs./ kg)	Return (Rs./ ha)	
Bottle gourd	13000	40	520000	27000	20	540000	1060000
Ridge gourd	6000	60	360000	14000	30	420000	780000
Muskmelon	7000	60	420000	14000	40	560000	980000
Watermelon	12000	40	480000	26000	20	520000	1000000
Long melon	6000	40	240000	14000	20	280000	552000

Table 6: Per hectare returns of cucurbits cultivation under low tunnel technology

Cost/ Returns	Bottle gourd	Ridge gourd	Muskmelon	Watermelon	Long melon
Gross Returns (Rs./ha)	1060000.00	780000.00	980000.00	1000000.00	520000.00
Cost C_3 (Rs./ha)	316243.96	278795.49	312406.56	334979.48	253942.71
Net Return (Rs./ha)	743756.04	501204.51	667593.44	665020.52	266057.29
B: C Ratio	3.35	2.80	3.14	2.99	2.05

Verma et al. (2019) observed significantly higher net income and B: C ratio (1: 2.16) of long melon grown under low tunnels than in open field conditions in the hot arid region of Rajasthan. Choudhary and Saroj (2019) observed that tunnel cultivation of cucurbits offers a good opportunity for successful early-season cultivation with a B: C ratio of 1:2.21 to 1:2.43.

Initially, in 2011 the area under low tunnel technology was about 1015 ha in the Bikaner district as per information received from different agencies. Due to the techno-economic feasibility of the technology, it gained popularity among the farming community for getting high economic returns as well as the availability of vegetables in the off-season. The farmers fetched premium prices of their produce by selling the produce in the markets of major cities of Rajasthan, Punjab, and Delhi. Figure 1 shows that in 2021, the area under low tunnel technology has increased by 1378% (approx. 15000 ha) in comparison to year 2011.

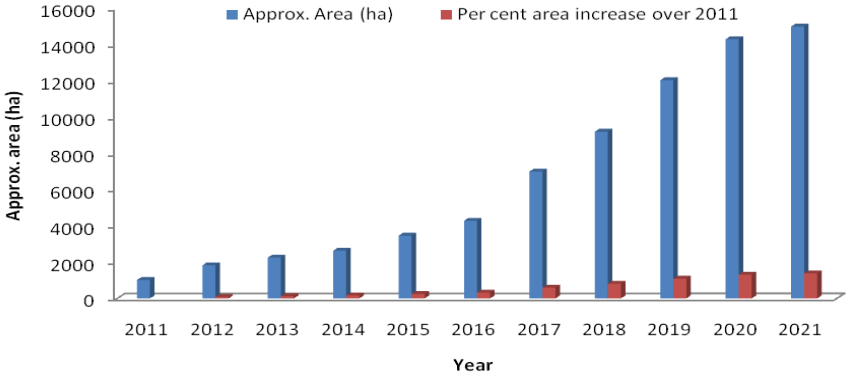

Figure 1: Area (ha) under the low tunnel technology in Bikaner

The rapid increase in area under this technology was possible due to regular efforts made by the ICAR-Central Institute for Arid Horticulture, Bikaner (Rajasthan) in the form of training, demonstrations, on/ off farm field visits, advisory, and supply of the quality seed of cucurbits identified from the institute. Day by day the technology is gaining popularity in the arid regions due to less water and fertilizer requirements as compared to other field crops. Based on economic analysis it is evident that this technology enhanced the farmers' income, improved livelihood, and nutritional security.

Conclusion

Low tunnel technology is used to grow vegetables in hot arid conditions by creating a favourable microclimate for plant growth. Using this technology, farmers can grow vegetables twice or thrice in a year. The consumers are also getting the product for a longer period of time for which they are willing to pay more in the off-season. Thus vegetable cultivation under low tunnel technology creates a win-win situation for both farmer and consumer as the former is getting additional income while later is having vegetables round the year. In this regard policy interventions are required to impart technical knowledge so that more farmers can adopt the low tunnel technology for vegetable cultivation in hot arid districts of Rajasthan. Few advantages of tunnel technology were observed during the study which area i) off-season availability of vegetables, ii) higher marketable yield and good quality of the produce, iii) premium market returns due to early market arrival of the produce, iv) due to deep tunnel, moisture retains in soil for longer period which reduces the irrigation frequency, v) early and protected cultivation of crops reduces the incidence of pests and diseases, vi) polythene roof cover protects the crop from strong wind, rain, frost, etc. and ensures minimum production loss, vii) production is possible even in salty water due to drip irrigation under tunnel cultivation, viii) environment friendly, as the polythene used to cover tunnels, is either sold or can be used again for next season, ix) budget-friendly, as low tunnel structures are easy to construct and dismantle, and, x) higher water and nutrient use efficient technology.

सारांश

राजस्थान का शुष्क पश्चिमी भाग, भारतीय खंड के थार रेगिस्तान के लिए अच्छी तरह से जाना जाता है। भारत में गर्म शुष्क क्षेत्र 31.7 मिलियन हेक्टेयर क्षेत्र में फैला हुआ है, जिसमें अधिकांश क्षेत्र राजस्थान (61.9 प्रतिशत) में स्थित है। राजस्थान में यह क्षेत्र बीकानेर सहित 12 जिलों में फैला हुआ है। कठोर जलवायु परिस्थितियाँ इस क्षेत्र की विशेषता है। ऐसे में कम सुरंग जैसी संरक्षित संरचनाएं सब्जी की खेती में अहम् भूमिका निभाती हैं। सब्जियों की मांग को पूरा करने के लिए संरक्षित संरचनाओं के तहत बे–मौसम खेती विभिन्न तरीकों में से एक है। यद्यपि प्रौद्योगिकी वर्ष भर बेहतर गुणवत्ता वाली सब्जियाँ उपलब्ध करा सकती है किन्तु, साथ ही साथ यह किसानों के लिए आर्थिक रूप से व्यवहार्य भी होनी चाहिए। वर्तमान अध्ययन राजस्थान के बीकानेर जिले में कम सुरंग प्रौद्योगिकी के तहत बे–मौसम सब्जी की खेती के अर्थशास्त्र की जांच करने के लिए किया गया। खेती की लागत की गणना के लिए, कृषि लागत और मूल्य आयोग (सीएसीपी) द्वारा दी गई लागत अवधारणाओं का उपयोग किया गया। अध्ययन के लिए प्रमुख कद्दू वर्गीय सब्जियाँ जैसे– लौकी, नसदार तोरई, तरबूज, खरबूजा और ककरी का चयन किया गया। अध्ययन से पता चला कि मानव श्रम पर सबसे अधिक लागत खर्च की गई थी जिसके बाद परिवहन और बीजों पर खर्च किया गया था। बे–मौसम खेती के दौरान गुणवत्तापूर्ण उत्पादन से किसान को बाजार में अधिक मूल्य प्राप्त करने में मदद मिलती है। चयनित कद्दू वर्गीय सब्जियों का लाभ–लागत

अनुपात 1:2.05 से 1:3.35 देखा गया जो कम सुरंग प्रौद्योगिकी की आर्थिक लाभप्रदता को दर्शाता है।

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