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Case Study

Benefit-cost analysis of high tunnels: a case study of Fatehjang field station of NARC, Punjab-Pakistan

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Abstract

The purpose of this study was to assess the benefit-cost ratio of two high tunnels at the project site of the National Agricultural Research Centre (NARC) in tehsil Fatehjang of Punjab, Pakistan. The two high tunnels were established in 2012 by the Climate, Energy and Water Research Institute (CEWRI) of NARC with the financial collaboration of ICARDA and USDA under the project of "Watershed Rehabilitation and Irrigation Technology Improvements". The tunnels' finances are calculated on a per square foot basis and the costs and returns presented are based on farm data collected from two high tunnels during the growing season from September to March. Each high tunnel had a surface area of 1620ft^2 (20ft wide by 81ft long) and a height of 12ft. The fixed and initial investment cost of each high tunnel was Rs.72150, and the vegetables cultivated for demonstration in both tunnels were tomatoes, sweet pepper, cucumber, and pumpkin. In tunnel-A (250 transplants of tomato and sweet pepper each) and in tunnel-B (150 transplants of cucumber and pumpkin each) were grown. The study found that tomato, sweet pepper, cucumber, and pumpkin output were 692kg, 410kg, 450kg, and 670kg, and total net revenues received from tunnel-A and tunnel-B were Rs. 56700 and Rs. 40300. Tunnels-A and B have cost-benefit ratios of 1.69 and 1.27, respectively. According to the findings, tunnel-A had higher returns than tunnel B due to higher per-plant yield, particularly in tomatoes, which is one of the more profitable crops in a high tunnel. The major causes of less produce were soaring frost, which smashed the vegetables in the early stages, marketing of produce, which reduced the profitability of both tunnels because only 10% of vegetable produce was sold out at the fruit and vegetable market, and technical incompetence of farmers at the project site all contributed to lower yields.

Keywords: Tunnel farming, off-seasons vegetables, productivity, BCR.

Introduction

Tunnel farming is the practice of growing off-season crops in a controlled environment inside a polythene tunnel. They are basic, plastic-covered, passive solar-heated buildings that are better suited to off-season crops and high yields. Because of the numerous benefits of high tunnels in the production of fruits and vegetables, they have been promoted as a production technology. Insects, pests, weeds, and diseases can all cause crop damage[1-3]. Tunnel farming has a lot of potential since it allows us to grow vegetables in the off-season and extend vegetable growing seasons for considerably longer periods of time than we could in open fields[4]. High tunnels are trouble-free because they provide the largest yield and make land preparation, picking, spraying, and other duties easier due to their width and height. They are frequently utilized in the production of melons, tomatoes, and other high-value warm-season crops throughout Europe and the Middle East[5].

Off-season crops have the potential to meet the rising demand for ‘‘locally grown" and ‘‘fresh" in recent years. Locally grown vegetables are fresher and have a superior flavor. Their sales provide indirect benefits such as lower transportation costs, reduced fuel consumption, and reduced pollution. It benefits local farmers as well as the state and regional economies as a whole[6,7]. Tunnel farming is more expensive in terms of structure construction and crop inputs. It is a scientific farming that demands proper producer education and training[8]. Tomatoes are ideally suited to high tunnels, as they have an upright growth habit and a considerable economic premium for a valuable return. Row covers are more important due to frost and can be removed once the risk of frost has passed[9].

The primary benefit of the high tunnel's structure is crop expansion. Tomato production in high tunnels is three to four weeks ahead of tomato production in plasticulture[10]. Increasing output in the early and late seasons by extending the growing season by sheltering plants from cold temperatures. In certain areas, high tunnels have been found to successfully and profitably extend the growing season for warm and cool season crops[11].Off-season vegetable growing is more profitable than on-season vegetable production. To increase farmer revenue and improve their socioeconomic condition, farmers should be given with the appropriate equipment for off-season vegetable production[12].

Pakistan's economy is strongly based on agriculture and there is a strong correlation between agricultural growth and economic prosperity. Changing dietary patterns and a high population growth rate have created high demand for vegetables in the country. Tunnel farming is the viable option that can add worth to the farmer's produce because it extends the growing season of vegetables[13]. Pakistan's agriculture sector is the backbone of the country's economy. This industry accounts for roughly 20.9 percent of Pakistan's gross domestic product (GDP). It's not only contributes to Pakistan's GDP, but also provides a source of income for 43.5 percent of the country's rural population[14]. The production of horticulture crops including fruits and vegetables has been estimated at 15.12 Million Tones[15]. Tunnel farming with drip irrigation can make earnings of Rs. 1.24 to 1.98 million per hectare annually[16].

In Pakistan, the tunnel farming method is very young, and farmers typically have three to five years of experience with single and multiple cropping systems in tunnels. As a result, it's unsurprising that these systems' farmers have less experience[17]. Similarly, Insects, pests, and diseases are becoming more prevalent in tunnel farming, and farmers are unsure how to combat this[18]. Due to the perishable nature of vegetables, Pakistan has failed to export them, despite a high demand in the worldwide market. To achieve the target of food security and reduction of poverty, the cultivation of vegetables is necessary. High tunnels are increasingly popular on diversified farms across the country. They can be an incredible tool to enhance crop protection, quality, yield, and a reduction in pesticide applications. The objectives of this study were to conduct a cost-benefit analysis of high tunnels and to provide suggestions to the project in-charge and stakeholders to realign and modify tunnel farming activities at the project site.

Methodology

The present study was carried out at the project site in tehsil Fatehjang of Punjab, Pakistan. The site was purposively selected, because the two high tunnels have been established at this site by CEWRI, NARC under the watershed project with the financial collaboration of ICARDA and USDA.

Data Source: The two high tunnels trials were conducted by the Climate, Energy, and Water Research Institute at Fatehjang field station of NARC. The crops selected for assessment were tomato, sweet pepper, cucumber and pumpkin. The data used in this study consist of primary and secondary sources. The primary data was collected from the farmer at the project site through a well-structured and pre-tested questionnaire during the year, 2014. The secondary data and information were collected from the available literature, internet and research studies. The tunnel's fixed costs; variable costs and yield were collected from the concerned department and the host farmers.

Data Analysis: The Benefit-cost ratio of the tunnels was analyzed because the economic analysis is a critical element and it is not only evaluating the economic justification but it can assist in plan formulation. The benefit-cost ratio is the ratio of total revenue with the total cost and shows the return received on the costs of one rupee. The benefit-cost ratio was also estimated.

Benefit-cost ratio (BCR) = TR/ TC

Where, "TR" is the total revenue per square foot, "TC" is the total cost per square foot.

The benefit-cost ratio is directly proportional to the net return, i.e. higher the cost-benefit ratio will result in the higher net return.

Results and discussion

The costs and returns presented in this study are based on farm data collected from two high tunnels at NARC's Fatehjang field station during a single growing season, from September to March.

Figure-1: Tomato, sweet pepper, cucumber and pumpkin grown in high tunnels at Fatehjang Field Station of PARC-NARC.

The first section presented the sizes and fixed costs of both the tunnels in the study area. The tunnels were 20ft.x81ft. (1620 sq. ft.) in size, with a fixed and initial investment cost of Rs. 72150 per high tunnel, which included the cost of iron pipes, drip system, storage tank, tunnel material transportation, and labour charges for tunnel and drip preparation.

The 2nd section revealed the total receipts and the records were kept on both sales unit and land unit (square foot) basis. The yields were calculated based on the harvesting of the two tunnels over a period of 8 to 12 weeks. Tunnel-A was used to grow tomatoes and sweet peppers, while tunnel-B was used to grow cucumber and pumpkin. Tomato, sweet pepper, cucumber, and pumpkin yields were 692kg, 410kg, 450kg, and 670kg, respectively, and total incomes from tunnel-A and tunnel-B were Rs. 56700 and Rs. 40300. Tomato, sweet pepper, cucumber, and pumpkin yielded 0.84kg, 0.51kg, 0.55kg, and 0.83 kg per square foot, respectively.

The 3rd section (Table-3) described the total average variable costs (cost of planting and growing the crop) of the tunnels which were Rs. 16.82 and Rs. 15.68 per square foot, respectively. Plastic cover, mulching, FYM, chemical fertilizer, land lease expenses, land preparation expenses, seed/transplant cost, labour cost, herbicides and insecticides cost, and irrigation cost were all on average Rs. 6.11, 2.47, 0.22, 0.68, 0.37, 0.56, 2.47, 3.09, 0.34, and 0.52 per square foot in tunnel-A, and Rs. 6.11, 2.47, 0.15, 0.68, 0.37, 0.561.54, 3.09, 0.34 and 0.37 per square foot in tunnel-B.

The fourth section is about the costs of ownership. Each producer owns or controls assets such as land, high tunnels, machinery, irrigation equipment, and other items that are used to generate income. Ownership costs are a cost of doing business that allows you to get a return on your assets. According to the project director, the high tunnels and storage tank have a 15-year life span, while the drip has a 7-year life span. Based on a fixed high tunnel construction cost of Rs. 51400, the total ownership costs of each tunnel were Rs. 31.73 per square foot, while drip replacement and storage tank costs were Rs. 9.72 and 3.09 per square foot. The total costs include the annual tunnel ownership cost as well as operating expenses such as plastic cover, mulching, fertilizers, seed, irrigation, labour, and so on.

Total receipts minus total costs equal return over total costs. Annual returns were calculated in two ways: overall and per square foot. Tomato yield and return are higher in tunnel-A, while pumpkin yield and return are higher in tunnel-B. Tunnels-A and B had benefit-cost ratios of 1.69 and 1.27, respectively. Similar results were also discovered, with benefit-cost ratios of 1.62, and 1.48 in greenhouse tomato production, respectively[19].

Benefit-Cost Analysis of Tunnel-A:

High Tunnel Size (20ft x 81ft)	1620 (Sq. ft)
High Tunnel Fixed and Initial Investment Cost	72150 (Rs.)
Types of Vegetable Cultivated	Tomato, Sweet Pepper

Benefit-Cost Analysis of Tunnel-B

High Tunnel Size (20ft x 81ft)	1620 (Sq. ft)
High Tunnel Fixed and Initial Investment Cost	72150 (Rs.)
Type of Vegetables Cultivated	Cucumber, Pumpkin

Table-1: Revenue and production of Tunnel-A.

Receipts	Yield (kg)	Area (sq. ft)	Price (kg)	Total Income (Rs.)	Yield (sq. ft)	Gross (sq. ft)
Tomato (250 transplants)	692	810	50	34150	0.84	42.16
Sweet Pepper (250 transplants)	410	810	55	22550	0.51	27.84
Total receipts		1620		56700		70.00

Table-2: Inputs and cost of production of Tunnel-A.

Variable costs	Total (Rs.)
Plastic cover cost	9900
Mulching cost	4000
FYM cost	350
Chemical fertilizer cost	1100
Land lease expenses	600
Land preparation expenses	900
Seed/ transplant cost	4000
Labor cost	5000
Herbicides and insecticide cost	550
Irrigation cost	850
Total expenses	27250

Table-3: Total cost of ownership of Tunnel-A.

Ownership cost	Materials	Labor	Life (years)	Cost/year
Depreciation-tunnel	51400	-	15	3427
Depreciation-drip	15750	-	07	2250
Storage tank	5000	-	15	333
Construction	-	1050	15	70
Drip application	-	2000	07	286
Total ownership	72150	3050		6366

Table-4: Total cost, return sand benefit-cost ratio of Tunnel-A.

Total cost per year	33616
Total cost per square foot	20.75
Annual return per year	56700
Annual return per square foot	35.00
BCR	1.69

Table-5: Revenue and production of Tunnel-B.

Receipts	Yield (kg)	Area (sq. ft)	Price (kg)	Total Income (Rs.)	Yield (sq. ft)	Gross (sq. ft)
Cucumber (150 transplants)	450	810	30	13500	0.55	16.67
Pumpkin (150 transplants)	670	810	40	26800	0.83	33.09
Total receipts		1620		40300		49.76

Table-6: Inputs and cost of production of Tunnel-B.

Variable costs	Total (Rs.)
Plastic cover cost	9900
Mulching cost	4000
FYM cost	250
Chemical fertilizer cost	1100
Land lease expenses	600
Land preparation expenses	900
Seed/ transplant cost	2500
Labor cost	5000
Herbicides and insecticide cost	550
Irrigation cost	600
Total Expenses	25400

Table-7: Total cost of ownership of Tunnel-B.

Ownership Cost	Material	Labor	Life (years)	Cost/year
Depreciation-tunnel	51400	-	15	3427
Depreciation-drip	15750	-	07	2250
Storage tank	5000	-	15	333
Construction	-	1050	15	70
Drip application	-	2000	07	286
Total Ownership	72150	3050		6366

Table-8: Total cost, returns and benefit-cost ratio of Tunnel-B.

Total cost per year	31766
Total cost per square foot	19.61
Annual return	40300
Annual return per square foot	24.88
BCR	1.27

Conclusion

High tunnels provide an opportunity for small farmers to compete in a market and increase profitability by extending the production season. It also ensures a continuous flow of products especially when the outside environment is not favorable for field production. Results of the study indicated that vegetables in both tunnels were badly affected in the early stages mostly in tunnel-B due to severe frost in the study area. The first reason was a single-layer plastic-covered tunnel, which quickly loses its stored heat, and the second reason was the host farmers' technical and marketing deficiencies. They were experts in the cultivation of tomatoes and sweet peppers, but not in the cultivation of other vegetables. Furthermore, at the vegetable market, only a small percentage of vegetables (10%) were sold out by the farmer.

The vegetable production was found to be profitable with a benefit-cost ratio of 1.69 and 1.27 respectively. Tomatoes and sweet peppers produce a higher net return for the host farmer than cucumber and pumpkin. Tunnel farming is a capital-intensive business that raises production costs, with different benefits depending on the crop and the growing season. However, returns and profitability of the high tunnels are highly dependent on the entrepreneur having some practical knowledge about agriculture & farming, selection of fertile land, selection of best seed, cultivating the in-demand vegetables and selection of the right time for vegetable cultivation.

Higher prices can be obtained by producing the right crops at the right times and of better quality. Farmers' training and field days are critical for the widespread adoption of tunnel farming. The government must provide technical knowledge to those farmers who are willing and interested in tunnel farming. Pests and diseases, as well as internal temperature and humidity, must be controlled on a timely basis in tunnels. It is important to use high-quality hybrid seeds and protect the plants against severe frost.

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