J. Hortl. Sci.
Vol. 4 (2): 148-152, 2009

Economic feasibility of vegetable production under polyhouse: A case study of capsicum and tomato

D. Sreenivasa Murthy, B.S. Prabhakar[1], S.S. Hebbar, V. Srinivas[2] and M. Prabhakar[1]
Section of Economics and Statistics
Indian Institute of Horticultural Research
Hesarghatta Lake Post, Bangalore – 560 089, India
E-mail : srinivasiihr@yahoo.co.in

ABSTRACT

Polyhouse cultivation of vegetables is emerging as a specialized production technology to overcome biotic and abiotic stresses and to break the seasonal barrier to production. It also ensures round the year production of high-value vegetables, like capsicum, especially, during off-season. Cost is the major issue in sustaining this technology. The present study examined the economic viability of production of capsicum and tomato in a naturally ventilated polyhouse of medium cost category with drip irrigation system. Data were generated by cost accounting method for estimating the feasibility of production and was analyzed by using project evaluation methods, like Pay Back Period (PBP), Benefit Cost Ratio (BCR), Net Present Value (NPV) and Internal Rate of Return (IRR). Cultivation of capsicum in a polyhouse was found to be highly feasible as reflected in higher values of NPV (Rs.3,23,145/500 m^2), BCR (1.80) and IRR (53.7%) with payback period of less than two years. Breakeven price for capsicum production in a polyhouse (Rs.11.80 /kg) was lesser than average wholesale price. Production of tomato in a polyhouse was found not feasible, as the breakeven price was more than the average market price and all the project appraisal parameters indicated that it was not feasible. Only at about 48% premium price over the prevailing market price or reduction of cost of polyhouse structure by 60% from Rs.400 to Rs.160 /m^2, could make the tomato production viable in a poly house.

Key words: Capsicum, economics, polyhouse, production, tomato, vegetables

INTRODUCTION

The main objectives of cultivation of vegetables in a polyhouse condition are, to protect the crop against biotic (pests, diseases and weeds) and abiotic (temperature, humidity light,) stresses and to ensure round the year production of high-value quality vegetables like capsicum especially, during the off-season. Vegetable cultivation in polyhouse, not only increases the productivity but also, enhances the quality of vegetables and it is being practiced in more than fifty countries all over the world. However, in India, it is a new phenomenon and is still in its initial stage (Singh, 1998; Singh *et al*, 1999; Phookan and Saikia, 2003; Rai et al, 2004; Singh and Asrey, 2005).

The cost of the polyhouse structure plays the decisive factor for adoption and sustainability of vegetable production. The cost of a polyhouse mainly depends on the quality of materials used for the structure and glazing and others like drip and mist systems. Polyhouses are of various sizes ranging from 1000 to 10,000 m^2 depending on the requirement. Polyhouses differ in terms of cost as (a) low cost ranging from Rs.250-400/ m^2, (b) medium cost ranging from Rs.500-1000/ m^2 and (c) high cost polyhouse Rs.1000-2000/ m^2. The present study was taken up to examine the economic viability of production of capsicum and tomato in a naturally ventilated polyhouse of medium cost category with drip irrigation and misting system.

MATERIAL AND METHODS

In a mission mode project on 'Protected cultivation of vegetables and flowers in plains and hills' under the National Agricultural Technology Project (NATP) sponsored by one of the world Bank projects of Indian Council of Agricultural Research (ICAR), experiments were carriedout on standardization of production and protection technologies for capsicum and tomato and its economic feasibility in a naturally ventilated polyhouse at Indian Institute of Horticultural Research, Bangalore during 2002-2004. Capsicum and tomato were selected, as these two crops are known to be best suitable and mostly grown under

1. Division of Vegetable Crops, Indian Institute of Horticultural Research (IIHR), Bangalore 560 089
2. Progressive farmer, Bangalore

greenhouse in the world. Capsicum is a season specific crop, winter being the best suitable season in the tropics. It is a high volume and high value vegetable compared to tomato. On the other hand, tomato is a high volume and relatively low value crop, but in demand throughout the year. Though tomato is grown nearly in all seasons, the yields are low during summer and monsoon.

Data were generated by cost accounting method from 2002 to 2004. Economic feasibility of investment on production of capsicum and tomato under polyhouse conditions was evaluated by using project evaluation measures. Payback Period (PBP), Benefit Cost Ratio (BCR), Net Present Value (NPV) and Internal Rate of Return (IRR) were used for project evaluation. Except PBP, which is an undiscounted measure, all others, BCR, NPV and IRR, are discounted measures of project worthiness (Berry *et al*, 1979; Gittinger, 1982). A discount rate of ten per cent was used in the present study to estimate these parameters. The average reference rate of interest given by the different financial institutions for the investment of long term projects was used as a decision criterion for selection of the discount rate.

These project evaluation measures were derived based on certain assumptions. First and the foremost assumption was that the life span of present project is six years. Normally 5-6 months are required for one crop and hence, in the present study two crop seasons were included for every annual cash flow. For estimating the cash flows, actual data was used for first two years and the remaining years the cash flows were extrapolated appropriately based on the available information.

An attempt was also made in the study to estimate the cost of production of the tomato and capsicum under polyhouse cultivation, which provides indication to farmers whether the cultivation of tomato and capsicum earning profit over the market price or not i.e, breakeven in terms of cost of production and market price. For this purpose, cost of production was estimated by accounting all costs included in the cultivation under polyhouse and compared with the prevailing market price. Estimation of cost of production is bit tricky as three types of costs were involved viz. establishment, annual production and seasonal costs. Annul and seasonal production costs were used directly and it is only a question of apportion the cost of establishment. It is well-known fact that 'depreciation', a systematic and rational process of distributing the cost of tangible assets over the life of assets, is used to apportion the cost. Straightline depreciation method was used in the present study to apportion the total value of the assets like GI pipes, polythene sheets, irrigation equipments, etc., depending on their life span. Once the annual costs of all items were estimated, the cost of production (Rs/kg) per crop (season) was estimated. The price prevailed in the market during same period was also obtained and compared for the profitability of production.

RESULTS AND DISCUSSION

Cost of Establishment

Polyhouse production is a capital-intensive technology requiring a substantial investment especially during the initial establishment period. The details of cost components in establishing a poly house are given in Table 1. A non-land capital investment of Rs.2,36,000 (Rs.47.20 lakh ha^{-1}) was required for erecting 500 m^2 polyhouse. This includes, costs on initial land preparation, basic structure GI Square tubes, low-density polyethylene sheet (LDPE- UV Stabilized - 200-micron thick), 40 mesh nylon net, drip irrigation and mist system and construction costs. The LDPE sheet normally lasts for 2-3 years and needs to be replaced depending on wear and tear. Break-up of these establishment costs indicates that the major cost of establishment was incurred on GI frame (58.5%) followed by that on polythene sheet (12.7%) and labour (13.6%). Irrigation-fertization system, misting and shade net accounted for 3.8, 5.1 and 2.1% of the total establishment costs, respectively.

The other costs involved in the establishment of polyhouse was grouped under miscellaneous costs such as initial land preparations costs, preparing bunds and making furrows, weeding, neem cake applied to soil, etc. which accounted for about Rs.5000/500 m^2.

Table 1. Cost of establishment of a polyhouse structure (2001-02)

Sl No	Particulars	500 m^2	Per ha
1	Structure and Sheet	2,00,000(84.8)	40,00,000
A	GI pipe	138000(58.5)	2760000
B	Polythene sheet	30000(12.7)	600000
C	Labour	32000(13.6)	640000
2	Irrigation and Fertigation system	9,000(3.8)	1,80,000
3	Misting	12,000(5.1)	2,40,000
5	Shade net (500 m^2 @ Rs. 20 per m^2)	10,000(4.2)	2,00,000
6	Miscellaneous (Initial land preparation cost, preparing the land for planting, initial weeding, incidental chargers, etc.)	5,000(2.1)	1,00,000
	Total cost	2,36,000(100)	47,20,000

Figures in parentheses are the percentage to the total of that column

Variable costs of cultivation of tomato and capsicum in polyhouse

Normally two crops are taken in a year, as the crop duration for both crops is about six months. Two types of expenses are incurred on cultivation of vegetables in a polyhouse. (1) Inputs like farmyard manure (FYM), fumigating agents and mulching materials that are used annually. In the present case, these inputs lasted for two crop seasons and were grouped under annual variable costs. (2) Inputs used during each cropping period, such as nutrients; plant protection chemicals, seeds etc., were grouped as seasonal variable costs.

The average annual variable cost for a poly house cultivation was Rs.10,340/500 m^2 (Rs. 2.06 lakh ha^{-1}), comprising cost on FYM, mulching and the fumigation (Table 2). The mechanism of fumigation and mulching as well as the recommended doses of FYM were same for both capsicum and tomato. The details on cost of these items are given in the Table.

The details on seasonal variable costs (working expenses) incurred on cultivation of tomato and capsicum in a poly house are given in Table 3. The average cost of cultivation under poly house was Rs.12,494/500 m^2 (Rs.2,49,880/ha) for tomato and Rs.16,334/500 m^2 (Rs.3,26,680/ha) for capsicum. The cost for capsicum was more because of its higher requirement of plant protection chemicals.

The break-up of costs indicated that the highest cost was incurred on labour in both capsicum and tomato cultivation indicating that poly house cultivation is both capital and labour intensive. In capsicum, nearly 44% of the working costs were incurred on labour and 26.3% in capsicum. Tomato requires more labour for training plants and harvesting fruits. The cost incurred on plant protection was lower than that in open field production because of lower intensity of pests and diseases in the polyhouse. The other costs include twines, staking material costs and annual irrigation costs (imputed). The investment made on the irrigation structure for polyhouse cultivation like pump sets, mist units, drips systems, and conveyance pipes was separately accounted under establishment costs. .

Table 2. Annual working expenses (Rs.) of tomato and capsicum cultivation

SL No		Items	Capsicum/Tomato
		500 m^2	Per ha
1	FYM (8 t /500 m^2)	4,000	80,000
2	Formaldehyde (37%) @ 400 ml/m^2	4,000	80,000
3	Mulching	2,340	46,800
4	Total	10,340	206,800

Table 3. Expenditure on cultivation of tomato and capsicum under polyhouse (2003-04)

Sl No	Particulars	Tomato		Capsicum	
		500 m^2	Per ha	500 m^2	Per ha
1	Labour cost *	5450	109000	4300	86000
2	Seedling cost **	750	15000	2400	48000
3	Chemical fertilizers	1140	22800	3828	76560
4	Plant protection costs (Pesticides and insecticides)	704	14080	3006	60120
5	Other capital costs (twines, staking material costs, irrigation costs and miscellaneous)	4450	89000	2800	56000
	Total	12494	249880	16334	326680

* The no.of seedling in tomato was 750/500 m^2 and in capsicum it was 2400/500 m^2

** Human labour for tomato cultivation was 73 man days/500 m^2 and for capsicum it was 57 man days/500 m^2

Fertilizers used were CAN, SSP, MOP and 19 all WSF

Note : Standard plant protection procedures were followed for the management of pests and diseases

The average yield of capsicum during 2003 and 2004 was 126 t/ha/season in a polyhouse compared to about 22.3 t/ha/season in the open field.

Cash flows of tomato and capsicum production

The cash inflows and outflows were worked out for the project period of six years. Actual costs and returns during 2002-03 and 2003-04 in tomato and capsicum was documented and used for the cash flows. During this period four crops were taken. For remaining periods the costs and returns were projected based on the actual costs and returns. The year-wise details on the cost structure are given in Table 4. The polythene sheets which were used in polyhouse is normally replaced every two years and hence, every alternate years there is an additional costs, as seen in 3rd year, 5th years etc.

Economic feasibility of production of tomato and capsicum in polyhouse

Economic feasibility indicators (PBP, NPV, BCR, and IRR) were worked out for both tomato and capsicum using the cash flows presented in Table 4. The details of the economic feasibility indicators are given in Table 5.

Table 4. Cash flow of costs and returns of tomato and capsicum (500 m²)

SlNo	Year	Tomato		Capsicum	
		Costs	Returns	Costs	Returns
1	Base Year - 2001-02	236000	0	236000	0
2	First Year - 2002-03	35328	65859	43008	183707
3	Second Year - 2003-04	35328	65859	43008	183707
4	Third Year	50865	65859	58545	183707
5	Fourth Year	35328	65859	43008	183707
6	Fifth Year	50865	65859	58545	183707
7	Sixth Year	35328	65859	43008	183707

Table 5. Economic Feasibility of polyhouse cultivation of tomato and capsicum (2003-04)

SlNo	Economic Indicator	Capsicum	Tomato
1	Payback period (years)	1.5	More than 10
2	Net present value (Rs/500 m²)	3,23,145	-1,13,046
3	Benefit Cost Ratio	1.80	0.69
4	Internal Rate of Return (%)	53.71	-11.50

- (10% discount rate)
- Actual market price prevailing in Bangalore market during different months was taken for calculating returns

Capsicum: The pay back period for polyhouse production of capsicum was found to be less than two years or four production seasons. Total net returns (undiscounted) for six years period was of Rs.115.4 lakhs/ha (Rs.5.77 lakhs/500 m²) with an annual average net return of Rs.19.2 lakhs/ha (Rs.0.96 lakhs/500 m²). Net present value (NPV) of the total net returns at 10 % discount rate for six years period worked out to be Rs 64.62 lakhs/ha (Rs 3.23 lakhs/500 m²) with the benefit cost ratio (BCR) of Rs.1.80. Internal rate of return (IRR) in polyhouse production of capsicum is likely to be 53.71 per cent per annum. Therefore, production of capsicum in a polyhouse is highly feasible and profitable.

The breakeven price for capsicum production in a polyhouse was Rs.10.25/kg and for both production and marketing was Rs.11.80/kg (Table 6). The average wholesale price prevailed in Bangalore market during 2003 was Rs.15.80 per kg.

Tomato: Production of tomato in a polyhouse was not found to be economically feasible. Even continuous cultivation of tomato for six years was not even sufficient to recover the investment made. It takes nearly eleven years of continuous production to make it breakeven. The net present value of tomato production at 10% discount rate was negative (Rs.1.13 lakhs/500 m²), the benefit cost ratio (BCR) was less than one (0.69) and the internal rate of returns to investment was negative (-11.50% per annum), suggesting that the tomato production in poly house is not economical.

Table 6. Estimate of cost of production of tomato and capsicum (per season) in polyhouse (500 m²)

Particulars	Cost details	
	Tomato	Capsicum
Apportioned cost of fixed inputs		
Frame work (10 years)	10,000	10,000
Polyhouse sheet (2 years)	7,769	7,769
Shade net (5 years)	1,000	1,000
Drip and Fertigation (5 Years)	900	900
Misting (10 years)	600	600
FYM	2,000	2,000
Formaldehyde	2,000	2,000
Black Polyethylene mulch	1,170	1,170
Sub total	25,439	25,439
Working expenses	12,494	16,334
Interest on fixed inputs	11,800	11,800
Interest on working expenses	817	565
Total expenditure (Rs.)	50550	54130
Yield (Kg)*	7,775	5,280
Cost of Production (Rs./kg)	6.50	10.25

*Average yield realized for two seasons in polyhouse

With about 48% premium price over the prevailing market price, tomato cultivation in a polyhouse is likely to be economical (Table 7).

If the present cost of a poly house structure is brought down by 60% from Rs.400/ m² to Rs.160, then only it will be feasible (Table 7).

Table 7. Sensitivity analysis of costs and returns for tomato production in polyhouse (500 m²)

Premium	Payback period (yrs)	NPV (Rs) (@10% discount)	BCR (10% discount)	IRR (%)
No reduction and at market price	Not sufficient	-1,13,046	0.69	-0.115
Premium price				
20 % premium price	7.5	-74207	0.80	4.50
30 % premium price	6.5	-48891	0.87	6.49
40 % premium price	5.5	-23576	0.94	8.35
50 % premium price	3.5	1740	1.00	10.12
Cost reduction				
20 % reduction	9.5	-81930	0.76	2.05
30 % reduction	8.5	-60475	0.81	3.46
40 % reduction	7.5	-39021	0.87	5.22
50 % reduction	6.5	-17566	0.94	7.50
60 % reduction	4.5	3889	1.02	10.67
20 % reduction in cost and premium price				
No premium price	7.5	-81930	0.76	2.05
20 % premium price	6.5	-31298	0.91	7.22
30 % premium price	5.5	-5983	0.98	9.48
40 % premium price	4.5	19335	1.06	11.62
50 % premium price	3.5	44649	1.13	13.67

With twenty per cent of reduction in the cost of polyhouse structure from Rs.400 to Rs.320/m^2 and a premium price of 35% over the existing market price the tomato production in polyhouse is also likely to be feasible. The breakeven price for tomato production in a polyhouse was Rs.6.50/kg (not including marketing costs) as against the average wholesale price of Rs.4.90/kg prevailed in Bangalore market during the same period, which makes it very difficult to economically produce tomato in a polyhouse. An alternative technology to grow vegetables in a net house, where it is possible to reduce the cost of the structure to the extent of Rs.160 to Rs. 200/ m^2, is being developed.

The major policy implications based on the present study are as follows:

Cultivation of capsicum under polyhouse with initial investment emerged as a profitable and economically viable option to increase the farmers' income. Besides yield, the quality of fruits was found to be superior in terms of its size, colour and shining. Thus, there is a need to further strengthen existing institutional credit to provide initial capital requirement. The technology should also be promoted under different government and non-government schemes, as the returns for this technology is high.

Protected technology breaks the seasonal barriers of production and thus, ensures availability of the capsicum throughout the year. By proper crop planning, i.e. coinciding production with the higher market price, the returns could further be enhanced. This aspect should be emphasized while delivering this technology to the farmers.

Higher establishment costs as shown in case of tomato proved to be the major constraint for the viability of this technology. Therefore, research efforts should be initiated to reduce the cost of establishment of poly house so that this protected technology may be used for large number of vegetable crops. Production of vegetables under low-cost net house instead of polyhouse is already showing promising results.

ACKNOWLEDGEMENT

The authors are thankful to the NATP, ICAR, New Delhi for providing funds for investigation and to the Director, IIHR, Bangalore for facilitating the conduct of the investigation**.**

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(MS Received 2 March 2009, Revised 3 September, 2009)