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Economic viability of soilless cucumber cultivation under naturally ventilated greenhouse conditions

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ABSTRACT

A study was carried out to evaluate the economic feasibility of soilless cucumber cultivation under naturally ventilated greenhouse conditions (with and without considering a subsidy of 50% on components of fixed cost of the greenhouse structure and plant support system). The study reveals that the fertigation levels and varieties significantly affected the economics of soilless cucumber cultivation, with being similar under growing seasons. Multistar under 100% level of fertigation recorded the highest B:C values of 1.7 and 1.4 respectively with and without considering subsidy. Irrespective of the fertigation levels, varieties and growing seasons, the average B:C value was computed to be 1.46 and 1.18 respectively with and without including subsidy. The payback period was estimated as 3.2 years from the start of the project (capital investment). However, with consideration of subsidy, the payback period was estimated to be just 1.8 years. Thus, soilless cucumber cultivation under naturally ventilated greenhouse conditions was found economically viable and the profits can further be improved through year-round cultivation of soilless cucumbers under a greenhouse aided with optimal microclimatic conditions.

Key words: *Cucumis sativus,* greenhouse, fertigation.

INTRODUCTION

Cucumber belonging to a cucurbitaceae family, is a popular vegetable crop widely cultivated all through the world (Soleimani *et al*., 20). However, the climate change (Wang *et al*., 22), soil borne diseases and dwindling land holdings have started producing a negative impact on both quantity and quality of the production as well as the production system. Under such situation, protected cultivation may serve as a viable option to feed the ever growing population. However, protected cultivation of vegetable crops with soil as a growing media may not help to achieve the yield potential of the crop due to prevalence of so called soil-borne diseases (Hussain *et al*., 5) and other associated problems. Thus, soilless cultivation under protected environment may prove to be an alternative sustainable vegetable production technology/system, where both quality as well as desired quantities can be achieved. Further, the protected cultivation in soilless systems under optimal plant microclimatic conditions (Singh *et al*., 14; Singh *et al*., 15; Singh *et al*., 16; Singh *et al*., 17) may help to multiply the income to many folds through off-season/year-round cultivation (Singh, 10).

The cost of protected structure (Schatzer *et al*., 9; Singh and Kumar, 11) including soilless system, irrigation coupled fertigation system and variable cost (Engindeniz, 2) significantly affect the economic viability of crop production. Thus, Engindeniz (2) has emphasized on economic study and cost-benefit analysis at local level and under grower conditions. According to Spehia (21), the productivity of cucumber inside a polyhouse is more than four times of that obtained under open field cultivation. Engindeniz and Gul (3) reported a 20.0% higher return from cucumber cultivated in a mixture of perlite and zeolite compared to that obtained in conventional soil-based system. Based on the analysis of the data collected from farmers of Karnal district of Hayrana, Kumar *et al.* (7) reported a 45.0% higher yield of cucumber cultivated under polyhouses compared to that in open field conditions. It has been observed that the benefit cost ratio (B:C) of cucumber cultivation in protected conditions varies from 2.3-3.4 (Singh *et al.,* 12; Janapriya *et al*., 6; Mohammadi and Omid, 8; Hakkim and Chand, 4). The main objective of protected cultivation of vegetable crops particularly in soilless media is to increase the yield with minimum energy input and cost of production. Thus, the economic analysis of cucumber cultivation in soilless media under greenhouse conditions becomes imperative to compare the investment and the profits made. Apart from this, the adoption of land and water saving technologies such as soilless cultivation (substrate or hydroponic) under protected conditions (Singh *et al*., 18; Singh *et al*., 19) is very much needed for sustainable agriculture due to the dwindling of land and water resources. The present study was thus undertaken to investigate the economic feasibility of

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cucumber cultivation in soilless media (coco-peat) under a naturally ventilated greenhouse.

MATERIALS AND METHODS

The economic analysis of cucumber cultivation for two successive growing seasons under a naturally ventilated greenhouse of 560 m^2 area was carried out at the research farm of department of Soil and Water Engineering, PAU, Ludhiana. The study site is situated between latitude 30° 56´ N and longitude 75° 52´ E with an altitude of 247 m above mean sea level. Parthenocarpic cucumber genotypes, *viz.* Kafka, Multistar and PBRK-4 were transplanted in soilless growing media (coco-peat) in three replicates with three fertigation treatments, *viz*. 100.0% (F1), 85.0% (F2) and 70.0% (F3), respectively. The water soluble fertilizers used as the source of macro and micronutrients to be supplied to cucumbers (growth stage-wise) are presented in Table 1. The cucumbers were fertigated with nutrient solution prepared from a mixture of macro (N, P, K, Ca, Mg and S) and micronutrients (Fe, Mn, Mo, Cu, Zn and B) in desired proportion. Water soluble fertilizers were used for preparing nutrient solution (Table 1). The plants were trained vertically up through strings connected to overhead wire with the help of roller hooks. Fruit thinning was done to keep a single fruit at each node.

Economic analysis was carried out for both actual and subsidized cost (50.0% subsidy) of the components of fixed cost. The capital cost (fixed cost) of different components of greenhouse and plant support system is listed in Table 2. The variable cost of different components is presented in Table 3. A 10.0% allowance was made for salvage value from the capital cost of the component. The interest or sum paid for the use of capital was computed by the formula given in BIS: 1964-1979.

A flat interest rate of 12.5% was taken to compute the fair return to the individual component.

Table 1. Water soluble fertilizers applied to cucumbers for 100.0% level of fertigation.

Fertilizer	Fertilizer consumption (mg $litre^{-1}$)			
	Slab saturation	28-42 DAT	Normal feed	Heavy fruit load
Calcium nitrate	1121.1	1010.0	1010.0	1010.0
Potassium nitrate	257.2	257.2	257.2	410.0
Monopotassium phosphate	227.0	227.0	220.0	220.0
Potassium sulphate	225.0	500.0	510.0	493.0
Magnesium sulphate	700.0	780.0	670.0	780.0
Iron chelate	6.667	6.667	6.667	6.667
Manganese sulphate	1.803	1.803	1.803	1.803
Zn-EDTA	1.000	1.000	1.000	1.000
Borax (boron)	2.500	2.500	2.500	2.500
Copper sulphate	0.208	0.208	0.208	0.208
Ammonium molybdate	0.096	0.096	0.096	0.096

Table 2. Components of fixed cost and their current capital cost.

Components of fixed cost	Life (year)	Capital cost (Rs.)
Metallic structure	30	4,41,000.0
UV stabilized polyethylene sheet	03	58,800.0
Main line, sub main, pumping and filtration unit (irrigation and foging)	20	58,800.0
Lateral and foggers	10	29,400.0
Components of plant support system		
Weed mat	5	16800.0
Trough	5	34560.0
Spacing trays	5	11836.0
Roller hooks	5	24000.0

Table 3. Components of variable cost and their current cost.

Components of variable cost	Cost (Rs.)
Coco-peat	60.0 slab^{-1}
Seed	6.0 seed^{-1}
Labour	297.0 day^{-1}
Plant protection	Cost kg^{-1} (Rs.)
Aries TOTAL	1,150.0
Ridomil Gold	1,600.0
Polo (Diafenthiuron 50.0 % WP)	2,300.0
Fertilizer	Cost kg^{-1} (Rs.)
Calcium nitrate	49.0
Potassium nitrate	102.0
Monopotassium phosphate	141.0
Potassium sulphate	90.0
Magnesium sulphate	22.0
Iron chelate	480.0
Mangnese sulphate	53.0
Zn EDTA	480.0
Borax (boron)	228.0
Copper sulphate	196.0
Ammonium molybdate	6,000.0

Under variable cost, the labour cost was calculated separately for different months as a result in change in labour cost with time. The labour cost was Rs. 287.72 day^{-1} for Oct 2016, Rs. 299.21 day^{-1} from Nov 2016 to Apr 2017 and Rs. 303.62 day^{-1} for May 2017. The economic analysis of cucumber cultivation in soilless media under a naturally ventilated greenhouse was carried out on seasonal/ annual basis. It was assumed that cucumber can be cultivated thrice in a year under a protected structure as suggested by Singh (10). Moreover, for year-round cultivation of parthenocarpic cucumbers, naturally ventilated greenhouses are highly suitable (Singh *et al.,* 13).

The selling price of cucumber was taken as Rs. 20.0 per kg. However, for most of the time the market price was ≥ Rs. 35.0 per kg. A subsidy of 50.0% was considered on fixed cost of the components of protected structure. The different economic indicators computed while carrying out economic analysis are listed in Table 4.

The payback period (PP) and break-even analysis (BEP) was carried out as per Chito (1). Payback period is the time duration (time length) from the start of the project to till the revenue generated reaches the total capital investment. The break-even point (BEP) is a point where lines of total cost and profit (revenue) intersect each other. In other words,

Table 4. Indicators used in economic analysis.

Indicator used	Formulae used	Description
Fixed cost of individual components (Rs.)	$FC = D + I$ $D = \frac{C - S}{L}$ $I = \left(\frac{(C + S)}{2}\right) \times R$ $FC = \frac{(C - S)}{L} + \left(\frac{(C + S)}{2}\right) \times R$	FC = Fixed cost (Rs.) D = Depreciation (Rs.) I = Interest (%) C = Capital cost (Rs.) S = Salvage value (Rs.) L = Life of component (Years) R = Rate of interest (%)
Total cost of cultivation	$TC = FC + VC$	TC = Total cost (Rs.) VC = Variable cost (Rs.)
Payback period (years)	$PP = \frac{CI}{NAI}$	PP = Payback period (years) CI = Cost of investment (Rs.) NAI= Net annual income (Rs.)
Benefit-cost ratio (B:C)	$B : C = \frac{\text{Benefit (Rs.)}}{\text{Total cost (Rs.)}}$	B:C<1.0 is not acceptable B:C>1.0 is acceptable
Break-even analysis	At BEP, TR = TC Thus, SP × BEP = TFC + VC* × BEP SP × BEP - VC* × BEP = TFC (SP - VC*) × BEP = TFC BEP = TFC / (SP - VC*) VC* = TVC / Total wt. per year	BEP = Break-even point TFC = Total fixed cost (Rs.) SP = Selling price per kg VC* = Variable cost per kg TVC = Total variable cost (Rs.)

BEP is a point where, the total cost and profits are equal.

RESULTS AND DISCUSSION

The variable cost was computed to be higher by 48.6% and 68.2% than fixed cost during season 1 and 2 respectively without subsidy. However, with a subsidy of 50%, the fixed cost decreased by 66.4% and 70.3% compared to variable cost during season 1 and 2 respectively. The total fixed cost remained same for both seasons. The average fruit yield was statistically similar for season 1 and 2. As suggested in Engindeniz (2), the variable cost was found to be the major cost involved in crop production resulting in lower B:C values. During season 1, the variable cost was about 197% and 48.6% higher compared to fixed cost with and without considering subsidy on fixed cost. The variable cost was about 74.8% and 59.8% of total cost of production with and without considering the subsidy. Similarly, during season 2, the variable cost was about 236.4% and 68.2% higher compared to fixed cost with and without considering subsidy on fixed cost. The variable cost was about 77.1% and 62.7% of total cost of production with and without considering the subsidy. Also, the variable cost during season 2 was observed to be 13.2% higher compared to season 1 mainly due to increased use of fertilizers or nutrient solution. The benefit-cost ratio (B:C) and cost of different components involved in benefit-cost analysis are presented in Table 5.

During season 1, the benefit cost ratio (B:C) was computed to be in the range of 1.23-1.74 and 0.98-1.39 with average values of 1.48 and 1.19 respectively, with and without considering subsidy. In terms of fertigation management, the B: C value under F1 fertigation level was 15.6% and 37.6% higher compared to F2 and F3 respectively. The B:C value under F2 fertigation level was 19% higher compared to F3 level of fertigation. Under crop varities, the B:C value under Multistar was 4.4% and 11.8% higher compared to Kafka and PBRK-4 respectively. The B:C value under Kafka was 7.1% higher compared to PBRK-4. The B:C value with subsidy (50%) was about 25.0% higher compared to without subsidy.

During season 2, B:C was computed to be in the range of 1.16-1.69 and 0.95-1.38 with average values of 1.43 and 1.16 respectively with and without subsidy (Table 6). In terms of fertigation management, the B:C value under F1 fertigation level was 10.5% and 35.8% higher compared to F2 and F3 respectively. The B:C value under F2 fertigation level was 22.9% higher compared to F3 level of fertigation. Under crop varieties, the B:C value under Multistar was 6.6% and 15.0% higher compared to Kafka and PBRK-4 respectively. The B:C value under Kafka was 7.9% higher compared to PBRK-4. The B:C value with subsidy (50%) was about 22.7% higher compared to without subsidy. Irrespective of the fertigation management, varieties and growing season, the average B:C value was computed to be 1.46 and 1.18 respectively with and without subsidy. The profit made was higher during season 2 by 5.7% in comparison to season 1. However, the B:C value was higher during season 1 compared to season 2 by 3.5% and 2.6% respectively with and without considering subsidy mainly due to increased input cost of cultivation during season 2. Besides, if we consider the actual market price per kg (Rs. 35-40/kg), the actual B:C ratio (i.e. income earned) was significantly higher.

Payback period was drastically affected with total fixed cost as a result of its direct relationship with it. Higher the investment cost, longer was the payback period (fixed cost without subsidy in this case). In contrast, lower the investment cost, lower was the payback period (fixed cost with subsidy in this case). Payback period was inversely related to total income generated. Higher the income, lower was the payback period. A subsidy of 50% helped to attain the payback period before two years of the project under operation (Table 7). The payback period with a subsidy (50%) was nearly 56.3% of that without subsidy. The payback periods with and without subsidy were obtained as 1.8 and 3.2 years respectively.

BEP was achieved at an income (revenue) of Rs. 2,51,469 per annum in a period of 3.2 years. However, by considering subsidy, BEP was achieved at an annual income of Rs. 1,25,735 in a period of 1.8 years (Table 7). In Fig. 1, TR denoted the total revenue generated. The B:C value is having increasing trend with years to come due to reducing cost (fixed cost) and increasing revenue.

The economics of soilless cucumber cultivation was significantly affected by fertigation levels and varieties with no effect of growing seasons. Multistar under 100% level of fertigation recorded the highest B:C values of 1.7 and 1.4 respectively with and without considering subsidy. The payback period (3.2 years) was significantly affected by the initial capital investment on the components of the greenhouse structure and plant support system. With consideration of 50% subsidy on components of fixed cost of the greenhouse structure and plant support system, the payback period was estimated to be just 1.8 years. Overall, growing seedless cucumbers in soilless media under naturally ventilated greenhouse conditions was economically feasible.

Table 5. Cost of different components and benefit:cost ratio.

Area of naturally ventilated greenhouse = 560.0 m^2				
Components of FC (A)	Season 1		Season 2	
Greenhouse (A1)	Actual cost (Rs.)	Cost with Subsidy (Rs.)	Actual cost (Rs.)	Cost with Subsidy (Rs.)
Metallic structure	12495.0	6247.5	12495.0	6247.5
UV stabilized polyethylene sheet	6958.0	3479.0	6958.0	3479.0
Main line, submain, pumping and filtration unit (irrigation coupled fertigation+fogging)	1960.0	980.0	1960.0	980.0
Lateral and foggers	1421.0	710.5	1421.0	710.5
Plant support system (A2)				
Weed mat	1316.0	658.0	1316.0	658.0
Trough	2707.2	1353.6	2707.2	1353.6
Spacing trays	927.2	463.6	927.2	463.6
Roller hooks	1160.0	580.0	1160.0	580.0
Total A (i.e. A1+A2)	28944.4	14472.2	28944.35	14472.18
Components of VC (B)				
Coco-peat	8000.0	8000.0	8000.0	8000.0
Seed	7200.0	7200.0	7200.0	7200.0
Fertilizer	8323.3	8323.3	11711.0	11711.0
Foliar plant nutrition	155.3	155.3	103.5	103.5
Insecticide	-	-	103.5	103.5
Fungicide	-	-	667.2	667.2
Labour	17745.8	17745.8	19237.6	19237.6
Electricity	590.8	590.8	666.4	666.4
Water	-	-	-	-
Miscellaneous	1000.0	1000.0	1000.0	1000.0
Total B	43015.1	43015.1	48689.2	48689.2
Total cost = Total A+ Total B	71959.4	57487.3	77633.5	63161.4
Yield (kg)	4266.660	4266.660	4508.655	4508.655
Income (Rs.)	85333.2	85333.2	90173.1	90173.1
B:C	1.19	1.48	1.16	1.43

Table 7. Economic indicators for soilless cucumbers under a naturally ventilated greenhouse.

Economic indicator	With subsidy (50%)	Without subsidy
Revenue required/annum to acquire BEP within payback period (Rs.)	1,25,734	2,51,470
Benefit cost ratio obtained (B:C)	1.43-1.48	1.16-1.19
Payback period (years)	1.8	3.2

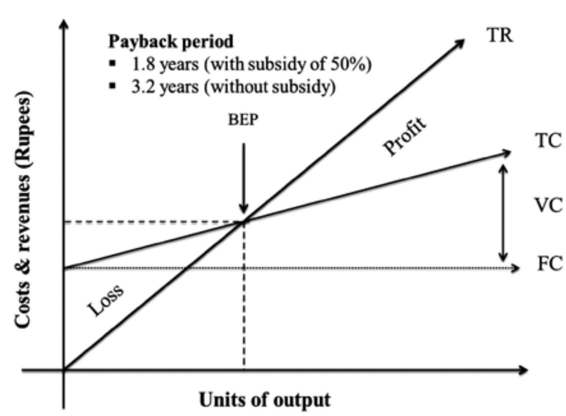

Fig. 1: Break-even point curve

Table 6. Treatment wise benefit cost ratio for season 1 and 2.

Fertigation level	Variety	B:C			
		Season 1		Season 1	
		Without subsidy	With subsidy (50.0%)	Without subsidy	With subsidy (50.0%)
100% (F1)	Kafka	1.35	1.69	1.29	1.58
	Multistar	1.39	1.74	1.38	1.69
	PBRK-4	1.31	1.64	1.19	1.47
85% (F2)	Kafka	1.15	1.43	1.17	1.44
	Multistar	1.26	1.58	1.23	1.51
	PBRK-4	1.10	1.37	1.09	1.34
70% (F3)	Kafka	1.01	1.26	1.06	1.30
	Multistar	1.13	1.41	1.11	1.36
	PBRK-4	0.98	1.23	0.95	1.16
	Average	1.19	1.48	1.16	1.43

The benefits can further be improved through year-round cultivation of soilless parthenocarpic cucumbers under a greenhouse supported with optimal operating microclimatic conditions.

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