DOI : 10.5958/0974-0112.2022.00064.0

Indian J. Hortic. 79(4), December 2022: 458-463

Economic feasibility of grow bag based cucumber and capsicum cultivation under greenhouse

R. D. Randhe*, Murtaza Hasan, D. K. Singh, Pramod Kumar*** and Prakash, P.******

Centre for Protected Cultivation Technology, ICAR-Indian Agricultural Research Institute, New Delhi-110012, NCT Delhi, India.

ABSTRACT

Soilless farming inside a protected structure is one of the promising technologies to produce nutritional food for an ever growing population and to increase water use efficiency where water is rare or unavailable. In order to increase the adoption of soilless cultivation inside greenhouses, economic analysis needs to be studied for growers' budgetary planning. This study aimed to determine the costs and returns of capsicum and cucumber crops grown in soilless grow bag system with developed automatic fertigation controller inside the semi-climate greenhouse. And to develop a financial statement for small greenhouse growers. The economics of soilless cucumber and capsicum production in greenhouses was examined in this study. The yield and returns from the cucumber and capsicum grown in 500, 1000, and 2000 m² soilless greenhouses with developed controller were calculated. In a 2000 m² greenhouse, it was found that the net returns for cucumber and for capsicum were Rs. 480858.1/- and Rs. 691286.2/- respectively. Techno-economic feasibility was carried out with combinations of the crop under various sizes of greenhouses. Higher net present value, internal rate of return, B:C ratio (1.62-2.56) and lower payback period (less than two years) were obtained under the automated fertigation system in combinations of crops throughout the year under various sizes of greenhouse. Thus, investment in coco-peat grow bag based soilless cultivation with an automatic fertigation controller system was found to be profitable and economically feasible.

Key words: *Cucumis sativus*, *Capsicum annuum*, soilless cultivation, economic feasibility.

INTRODUCTION

Soilless cultivation is widely used in protected cultivation for intensive horticultural production of vegetables in a climate change environment with limited land and water resources. In addition, many greenhouse growers have shifted to soilless based farming because the soil-borne diseases and root-knot nematodes create serious problems for growing the high value horticultural crop inside greenhouse. Soilless cultivation is one of the components of sustainable protected cultivation technology (Savvas and Gruda, 11). In India, the soilless cultivation technology under the greenhouse is in its nascent stage and needs to be fully developed, standardized, and indigenized for adoption in different agro-ecological regions of the country. For large adoption of soilless cultivation, an automatic fertigation system needs to be developed as fertigation scheduling is the most important, critical, and continuous activity which is affected by a number of factors, including crop parameters, climatic conditions, and substrate culture. Numerous research studies on soilless cultivation in greenhouses have been carried out recently (Singh *et al.,* 12; Singh *et al.,* 13).

Further, one of the most important factors in the adoption of soilless cultivation in greenhouses is its economic feasibility and very few studies have reported (Grafiadellis *et al.,* 3; Engindeniz and Gul, 1; Sreedhara *et al.,* 16; Gill, 2; Singh *et al.,* 14). Many studies revealed that the production of horticultural crops inside protected structures ranging from 500 m² onward were more profitable and feasible (Murthy *et al.,* 7; Spehia, 15). Still, there is no study, especially on the economic feasibility of crop combinations cultivated under soilless grow bag system with or without automation under Indian conditions. Hence, such economic analysis would serve as a base for the establishment of soilless cultivation inside greenhouse. Growers can utilize cost and returns budget to analyze total production costs and revenue within diverse grower type, production time, geographic region, operation area, and cost base (Engindeniz and Gul, 1).

The present study aimed to determine the costs and returns of capsicum and cucumber crops grown in soilless grow bag cultivation inside the semi-climate greenhouse and also help to develop a

*Corresponding author: ravindrardr@gmail.com, Irrigation and Drainage Engineering Division, ICAR-CIAE, Bhopal-462038, Madhya Pradesh, India
**Division of Agricultural Engineering, ICAR- IARI, New Delhi, 110012, India
***Division of Agricultural Economics, ICAR-IARI, New Delhi-110 012, India
****ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala -695017

financial statement for small greenhouse growers who are going to use this soilless grow bag technique. Furthermore, a feasibility study of possible soilless cucumber and capsicum crop combinations in various sizes of greenhouse with or without a developed controller was conducted for sustainable adoption of grow bag based soilless cultivation in India.

MATERIALS AND METHODS

The present study was conducted on yellow-coloured capsicum and cucumber crops which were selected based on their short and long duration of growth inside a 200 m^2 climate-controlled greenhouse at the Centre for Protected Cultivation Technology (CPCT) in the Indian Agricultural Research Institute, New Delhi, during 2019–2021. In this experiment, developed weight and timer based automatic fertigation controller system was used for fertigation scheduling of cucumber and capsicum grown in coco-peat grow bags inside a greenhouse. This automatic fertigation system maintained the adequate amount of water and optimize dose of nutrient in each irrigation events during the production of cucumber and capsicum. Other details of soilless cucumber and capsicum cultivation and production with automatic fertigation controller system can be found out in Randhe *et al.* (9) and Randhe *et al.* (10) prequel of this paper.

From the experiment, yield data and other parameters of cucumber and capsicum grown in a greenhouse were taken for costs and returns analysis. Thus, profits and expenditure data were collected, for instance, and a financial statement for growers was developed. Then, the techno-economic feasibility of the developed fertigation controller was carried out by evaluating the capsicum and cucumber crops with and without the controller under different sizes of greenhouse. For selection of greenhouse size, it was considered that the developed controller was suitable for fertigation scheduling up to 2000 m^2 greenhouse. Therefore, greenhouses were selected and divided into three groups according to the standard sizes, i.e. 500 m^2, 1000 m^2 and 2000 m^2. Data related to the cost of fan pad greenhouse components and management was taken as per the cost norms of various components of the National Horticulture Board. Then the data was statistically analyzed and converted into an economic outline of a typical greenhouse unit.

Costs and profits analysis was done to estimate the costs and returns of capsicum and cucumber crops grown in coco-peat grow bag with an automatic fertigation controller inside the protected structure. The costs were divided into fixed and variable costs. Fixed costs included land rental value, interest on fixed capital, the amortized cost of crop setup and depreciation. The variable costs associated with crop production were all inputs that directly related to the production of cucumber and capsicum, and it includes interest on working capital, planting materials, plant protection chemicals, fertilizers, labour, electricity charges (including electricity units consumed by fertigation pump and fan), and packaging and transportation costs (approx. cost per kg is considered for this activity).

Gross and net returns were calculated to determine the profitability level of soilless capsicum and cucumber grown with the developed automatic fertigation controller in a semi-climate greenhouse. The gross income was calculated by multiplying the total quantity of capsicum and cucumber produced with the price of the produce, which is fixed by the institute price fixation committee representing real market situation. While all production costs were subtracted from gross income to get to their net income.

Feasibility analysis of soilless cultivation was carried out by assuming the project life of the soilless vegetable-based greenhouse is to be 12 years. Additionally, it was considered that capsicum could only be grown once a year while cucumber could be grown three times every year in a greenhouse. The project evaluation technique, namely net present value (NPV), benefit cost ratio (BCR), internal rate of return (IRR), and payback period, were employed to evaluate the feasibility of the soilless capsicum and cucumber cultivation with or without a developed controller under the subsidized greenhouse (Kothari *et al.,* 5; Jain *et al.,* 4; Kothari *et al.,* 6).

RESULTS AND DISCUSSION

The establishment cost of soilless cucumber and capsicum under GI-framed polyhouse structures as practiced in India in coco-peat grow bags is presented in Table 1. The highest proportion of this cost is accounted by the polyhouse structure, which accounts for approx. 76-77% of the total establishment cost for all sizes of structure. While the cost of irrigation and fertigation system accounts about 10-13% and crop establishment cost accounts approx. 9-12% of the total establishment cost. The total establishment cost of soilless cucumber and capsicum under the greenhouse with subsidy is Rs. 6.16 lakhs, Rs. 10.54 lakhs, and Rs. 19.50 lakhs for the greenhouse of the sizes 500 m^2, 1000 m^2, and 2000 m^2, respectively. The cost of the fertigation controller is Rs. 50,000/- for all sizes of greenhouse. It was considered that the developed controller is suitable for fertigation scheduling up to 2000 m^2 greenhouse. The cost of the controller was removed,

Table 1. Establishment cost of soilless cucumber and capsicum under greenhouse.

Particulars	Life (years)	500 m²		1000 m²		2000 m²	
		Amount (Rs.)	% to total	Amount (Rs.)	% to total	Amount (Rs.)	% to total
1 Polyhouse structure							
Structural frame (GI pipe)	12	263418	26.8	552530	33.7	1074166	35.9
Polythene sheet	6	95223	9.7	107785	6.6	193894	6.5
Shade net	6	28822	2.9	39008	2.4	74663	2.5
Fan and pad system	12	170000	17.3	230000	14.0	325000	10.9
Packaging machines	12	50000	5.1	50000	3.1	50000	1.7
HDPE sheet flooring	12	70000	7.1	140000	8.5	280000	9.4
Miscellaneous	12	78592	8.0	150000	9.2	310569	10.4
Sub total		756055	76.8	1319322	77.5	2358291	77.2
2							
Irrigation system	6	79000	8.0	129000	7.9	258000	8.6
Fertigation controller	5	50000	5.1	50000	3.1	50000	1.7
Sprayers	5	6000	0.6	6000	0.4	6000	0.2
Sub total		135000	13.7	185000	11.3	364000	10.5
3 Crop establishment							
Grow bags(Rs 180/bags)	3	90000	9.1	180000	11.0	360000	12.0
Miscellaneous	3	1500	0.2	2000	0.1	4000	0.1
Labour	3	1800	0.2	2400	0.1	3000	0.1
Sub total		93300	9.5	184400	11.3	367000	12.3
4 Total establishment cost		984355	100.0	1638722	100.0	2989291	100.0
5 Subsidy		368028		609661		1114145	
6 Establishment cost with subsidy and controller		616328		1054061		1950146	
7 Establishment cost with Subsidy & without controller		566328		979061		1825146	

and the cost of labour was calculated to estimate the establishment cost with subsidy for conventional fertigation.

The details of the cost of cultivation of cucumber and capsicum are depicted in Table 2. The cost of cultivation of soilless cucumber and capsicum under the semi-climate greenhouse is divided into two groups: fixed costs and variable costs. The total cost of cultivation of soilless cucumber was found higher as compared to soilless capsicum with and without a controller for the different greenhouse sizes of 500 m², 1000 m², and 2000 m² respectively.

The gross and net return from the soilless cucumber and capsicum grown under greenhouses is presented in Table 3. The price per kg of yellow-coloured capsicum and seedless cucumber was fixed at Rs. 100.00 and Rs. 40.00, respectively, by the institute price fixation committee, and accordingly it was taken for gross and net return calculation. The yield of cucumber was 5000 kg, 10000 kg, and 20000 kg, and the gross returns were Rs. 2 lakhs, Rs. 4 lakhs, and Rs. 8 lakhs from cucumber crops grown in four months in greenhouse sizes of 500 m², 1000 m², and 2000 m², respectively. For the calculation of returns, the fixed cost was taken in proportion to the crop duration (4 months). For four months, the net returns of cucumber crop with controller were found Rs. 103862.4/-, Rs. 230444.6/- and Rs. 480858.1/- for 500 m², 1000 m² and 2000 m² greenhouses, respectively, after meeting the total cost of crop duration (4 months). The yield of soilless capsicum was achieved 3000 kg, 6000 kg, and 12000 kg per eight months, for greenhouse sizes of 500 m², 1000 m², and 2000 m², respectively. Average gross returns for a capsicum crop in eight months were obtained Rs. 3 lakhs, Rs. 6 lakhs, and Rs. 12 lakhs for greenhouse sizes of 500 m², 1000 m², and 2000 m², respectively. For the calculation of returns, the fixed

Table 2. Cost of cultivation of soilless cucumber and capsicum.

Particulars		Cucumber			Capsicum		
		500 m^2	1000 m^2	2000 m^2	500 m^2	1000 m^2	2000 m^2
		Amount (Rs.)	Amount (Rs.)	Amount (Rs.)	Amount (Rs.)	Amount (Rs.)	Amount (Rs.)
A.	Fixed cost						
	Rental value of land	5000	10000	20000	5000	10000	20000
	Land revenue	8	15	30	8	15	30
	Interest on fixed capital @ 12% p.a	73959	126487	234017	73959	123487	225017
	Amortization of crop establishment	22691	44846	89254	22691	44846	89254
	Depreciation	59339	88674	162115	59339	87007	151448
	Total fixed cost	160996	270022.5	505417	160996	265355.8	485750
B.	Variable cost						
	Planting material (Cucumber seeds)	16000	32000	64000	4000	8000	16000
	Plant protection	2894	5787	11574	3308	6617	13234
	Fertilizer	10173	20346	40691	14002	28005	56010
	Labour cost (With Controller)	9275	21000	34125	12075	26600	29400
	Labour cost (Without Controller)	84000	91000	101062.5	140000	148866.7	154700
	Electricity charges	11306	15118	30235	18547	24657	49095
	Packaging and transportation	5000	10000	20000	6000	12000	24000
	Interest on working capital @ 7% p.a	3825	7298	14044	4055	7411	13142
B(i)	Total variable cost with controller	42472	79548	150670	57988	105290	184881
B(ii)	Total variable cost without controller	117197	149548	217607	185913	227556	310181
Total cost with controller [A+B(i)]		203468	349570	656086	218984	370646	670631
Total cost without controller [A+B(ii)]		278193	419570	723024	346908.8	492912.2	795930.5

cost was taken in proportion to the crop duration. For eight months, the net returns of the capsicum crop with controller were Rs. 1.34 lakhs, Rs. 3.17 lakhs, and Rs. 6.91 lakhs for 500 m^2, 1000 m^2, and 2000 m^2 greenhouses, respectively, after meeting the total cost of the crop duration (8 months).

The feasibility analysis of crop combinations cultivated under soilless greenhouse with or without a developed controller is depicted in Table 4. The various sizes of greenhouses with subsidies were considered for analysis of the feasibility of the developed controller in soilless cultivation. In case of automatic fertigation with controller at 12% discount rate, the IRR ranged from 57% for capsicum to 2334% for cucumber-cucumber-cucumber depending on the crops raised and various sizes of greenhouse. The NPV ranged from Rs. 7.28 lakhs for capsicum to Rs. 87.72 lakhs for cucumber-cucumber-cucumber. The benefit-cost ratio ranged from 1.62 for capsicum to 2.56 for capsicum with cucumber. The payback period for the cultivation of soilless cucumber and capsicum with controller was found to be lowest at 1.03 for cucumber-cucumber-cucumber and highest at 2.44 years for capsicum depending on the sizes of greenhouse. Thus, the greenhouse soilless cultivation of capsicum and cucumber was sustainable, feasible, and profitable with the developed fertigation controller. Under conventional fertigation system at 12% discount rate, the IRR varies from 12% for capsicum to 699% for cucumber-cucumber-cucumber. The NPV ranged from Rs. 0.07 lakhs for capsicum to Rs. 75.99 lakhs for cucumber-cucumber-cucumber. The benefit-cost ratio ranged from 1.0 for capsicum to 2.09 for capsicum with cucumber. Thus, it is revealed that the cultivation crops under conventional fertigation system is found only few crop combinations appear to be rewarding under 500 m^2 area and quite rewarding with 1000 m^2 and 2000 m^2 areas. Previous research studies also reported that growing horticultural crops in polyhouses and soilless systems was profitable (Grafiadellis *et al.,* 3; Murthy *et al.,* 7; Engindeniz

Table 3. Returns from soilless cucumber and capsicum with controller.

Returns components	Cucumber			Capsicum		
	500 m^2	1000 m^2	2000 m^2	500 m^2	1000 m^2	2000 m^2
Number of plants in greenhouse (No.)	2000	4000	8000	2000.0	4000.0	8000
Yield per plant (kg)	2.5	2.5	2.5	1.5	1.5	1.5
Total Production (kg)	5000.0	10000.0	20000.0	3000.0	6000.0	12000.0
Average sale price per kg (Rs./kg)	40.0	40.0	40.0	100.0	100.0	100.0
Gross return (Rs.)	200000.0	400000.0	800000.0	300000.0	600000.0	1200000.0
Total cost(Rs.)*	96137.6	169555.4	319141.9	165318.5	282193.6	508713.8
Net return (Rs.)	103862.4	230444.6	480858.1	134681.5	317806.4	691286.2

Note: Fixed cost was taken in proportion to crop duration (4 months for cucumber and 8 months for capsicum)

Table 4. Feasibility analysis of crop combinations cultivated under soilless cultivation for developed controller.

Crop combinations	Feasibility criteria	With controller			With conventional system		
		500 m^2	1000 m^2	2000 m^2	500 m^2	1000 m^2	2000 m^2
Cucumber-cucumber	NPV (Lakh Rs.)	10.70	23.44	49.78	1.55	15.47	42.21
	IRR (%)	84	130	172	21	78	134
	B:C ratio	1.75	1.89	2.01	1.07	1.45	1.74
	PBP (years)	2.08	1.55	1.42	4.24	2.1	1.48
Capsicum	NPV (Lakh Rs.)	7.28	17.78	39.04	0.07	10.91	31.99
	IRR (%)	57	86	111	12	53	87
	B:C ratio	1.62	1.89	2.08	1.0	1.41	1.74
	PBP (years)	2.44	2.07	1.72	8.09	2.39	2.04
Cucumber-cucumber-cucumber	NPV (Lakh Rs.)	19.30	42.13	87.72	6.13	29.84	75.99
	IRR (%)	238	623	2334	52	220	699
	B:C ratio	2.06	2.29	2.45	1.2	1.66	2.032
	PBP (years)	1.30	1.12	1.03	2.24	1.25	1.09
Capsicum-cucumber	NPV (Lakh Rs.)	16.28	36.10	76.17	4.45	24.90	64.97
	IRR (%)	165	327	609	39	151	346
	B:C ratio	2.08	2.37	2.56	1.17	1.66	2.09
	PBP (years)	1.46	1.24	1.13	3.02	1.38	1.20

and Gul, 1; Spehia, 15; Punera *et al.,* 8; Singh *et al.,* 14).

The overall results revealed that the highest net present value, internal rate of return, B:C ratio, and lowest payback period were obtained under the automated fertigation system in combinations of crops (capsicum and cucumber) throughout the year, followed by the manual control fertigation system in all combinations of crops. The benefit-to-cost ratio was highest in the combinations of cucumber-cucumber-cucumber and capsicum-cucumber throughout the year, varying in the range of 2.06-2.08 (for 500 m^2) to 2.45-2.56 (for 2000 m^2), indicating that the growing of capsicum and cucumber crops in combination for greenhouse soilless system was economically viable. Also, a payback period of less than two years was observed for combinations of soilless cucumber-cucumber-cucumber and capsicum-cucumber cultivation in various sizes of greenhouses, varying from 500 to 2000 m^2. Thus, investment in soilless cultivation with combinations of cucumber-cucumber-cucumber and capsicum-cucumber crops under an automated fertigation controller system was found profitable and economically feasible on a long-term basis. Therefore, growers are advised to adopt soilless cultivation with the use of a developed indigenous conditional controller for fertigation scheduling to get maximum production and returns

even though the initial capital investment for soilless cultivation is high.

AUTHORS' CONTRIBUTION

Conceptualization of research (RDR, MH, DKS); Execution of experiments and data collection (RDR, MH, PK); Analysis of data and interpretation (RDR, PK, PP); Preparation of the manuscript (RDR, MH, DKS, PK, PP).

DECLARATION

Authors declare no conflict of interest.

ACKNOWLEDGEMENT

The authors acknowledge the ICAR-IARI, New Delhi for financial assistance in the form of IARI Ph.D. fellowship and extend their sincere gratitude to ICAR-CIAE, Bhopal for granting study leave.

REFERENCES

1. Engindeniz, S. and Gul, A. 2009. Economic analysis of soilless and soil-basedgreenhouse cucumber production in Turkey. *Sci. Agric. (Piracicaba, Braz.)* **66** : 606-14

2. Gill, D.S. 2018. Performance of sweet pepper (*Capsicum annuum* L.) cultivars and economics under protected structures in Punjab. *Ph.D. Thesis,* Lovely Professional University, Punjab, India.

3. Grafiadellis, I., Mattas, K., Maloupa, E., Tzouramani, I. and Galanopoulos, K. 2000. An economic analysis of soilless culture in Gerbera production. *HortSci.* **35**: 300–03.

4. Jain, N.K., Kothari, S. and Mathur, A.N. 2004. Techno-economic evaluation of a forced convection solar dryer. *J. Agric. Engg.* **41**: 6-12.

5. Kothari, S., Kaushick, S.C. and Mathur, A.N. 2006. *Greenhouse Technology for Protected Cultivation a text book*. Khana Publication, Udaipur.

6. Kothari, S., Rathore, N.S. and Panwar, N.L. 2001. Techno economics of greenhouse for Cultivation of aswagandha under composite climate of Udaipur. *Agric. Engg. Today* **25**: 36-40.

7. Murthy, D.S., Prabhakar, B.S., Hebbar, S.S., Sriniva, V. and Prabhakar, M. 2009. Economic viability of vegetable production under polyhouse: A case study of capsicum and tomato. *J. Horic. Sci.* **4**: 148-52.

8. Punera, B., Pal, S., Jha, G.K. and Kumar, P. 2017. Economics and institutional aspects of protected cultivation of carnation in Himachal Pradesh. *Agric. Econ. Res. Rev.* **30**: 73-80.

9. Randhe, R.D., Hasan, M., Singh, D.K., Naresh Kumar, S., Kumar, P. and Alam, W. 2022a. Response of soilless coloured capsicum under different irrigation strategies in greenhouse. *Eco. Env. Cons.* **28**: 214-18.

10. Randhe, R.D., Hasan, M., Singh, D.K., Naresh Kumar, S., Kumar, P., Alam, W. and Pandey, R. 2022b. Effect of fertigation strategies on growth and production of soilless cucumber (*Cucumis sativus*). *Indian J. Agric. Sci.* **92** : 541–4

11. Savvas, D. and Gruda, N. 2018. Application of soilless culture technologies in the modern greenhouse industry- A review. *Eur. J. Hort. Sci.* **83**: 280-93.

12. Singh, M.C, Singh, K.G. and Singh, J.P. 2018. Yield of soilless cucumbers planted under partially controlled greenhouse environment in relation to deficit fertigation. *Indian J. Hort.* **75**: 259-64.

13. Singh, M.C., Singh, K.G., Singh, J.P. and Mahal, A.K. 2019. Performance of soilless cucumbers in relation to differential fertigation under naturally ventilated greenhouse conditions. *J. Plant Nutr.* **42**: 1316–32.

14. Singh, M.C, Singh, A., Singh, J.P. and Singh, K.G. 2020. Economic viability of soilless cucumber cultivation under naturally ventilated greenhouse conditions. *Indian J. Hortic.* **77**: 315-21

15. Spehia, R.S. 2015. Status and impact of protected cultivation in Himachal Pradesh, India. *Curr. Sci.* **108**: 2254-57.

16. Sreedhara, D.S., Kerutagi, M.G., Basavaraja, H., Kunnal, L.B. and Dodamani, M.T. 2013. Economics of capsicum production under protected conditions in Northern Karnataka. *Karnataka J. Agric. Sci.* **26**: 217-19.

Received : August, 2022; Revised : October, 2022; Accepted : November, 2022