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Cucumber under Controlled Environment Polyhouse: A Step Forward to Enhance Farmers Income

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Present study was conducted to see profitability of cucumber crop when grown under polyhouse. Controlled environment crops have greater consistency and production is more reliable than uncontrolled open field crops. Technology is used to manage and manipulate the growing conditions to reduce uncertainty and optimise crop growth. Particularly, cucumber crop was uneconomical when grown under open field conditions due to its climate sensitiveness. Present study was conducted in cucumber which was being cultivated in environment-controlled poly house. The cost return analysis showed that the total cost of cultivation per 1000 m2 area was Rs. 307746 with an output value of Rs.888960 resulted in Benefit Cost Ratio of 2.89. As the poly house involves

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initial establishment costs besides maintenance costs every year. This component was amortized to be included in Total Fixed Cost component (TFC) of cost analysis. Similarly, the bed prepared for cucumber sowing also amortized as it lasts for five years once prepared. As most of the farmers were facing initial capital issues for establishing polyhouse, majority of farming fraternity till unable tap the full benefits of cucumber crop. By utilizing the policies of government, cucumber cultivation under poly house is economically beneficial.

Keywords: Cucumber; polyhouse; BCR; amortization; income enhancement.

1. INTRODUCTION

The productivity and quality of most of the vegetable crops is very poor due to several biotic and abiotic stress conditions during their open field cultivation. Protected cultivation of vegetables provides the best way to increase the productivity and quality of vegetables, especially cucurbits. The yield of some cucurbits like cucumber can be increased manifold compared to their open field cultivation. Normally the economics of protected cultivation directly depends upon the initial cost of fabrication of the protected structure, its running cost and the available market for high quality produce. Therefore, low-cost protected structures, which can generally be fabricated with low cost and the running cost of such structures is also very low, just like naturally ventilated greenhouses, walk-in-tunnels and plastic low tunnels. These are highly suitable for off-season cultivation of cucurbits and are also highly economical for peri-urban areas of northern plains of India. Naturally ventilated greenhouses are highly suitable for year-round parthenocarpic cucumber cultivation, whereas, walk-in-tunnels are suitable for off-season cultivation of melons. Plastic low tunnels are highly suitable and profitable for off-season cultivation of cucurbits like summer squash, bottle gourd, bitter gourd, muskmelon, watermelon, round melon and long melon in peri-urban areas of northern plains of India.

"Cucumber (*Cucumis sativus* L.) is popularly known as 'khira' in India which belongs to the Cucurbitaceae family. Cucumber is an annual herbaceous climbing fruit vegetable that is used as a summer vegetable in India. Cucumber is cultivated for its tender fruits, which are consumed either raw as salad, cooked as vegetable or pickled in its immature stage" [1]. "For fresh consumption, cucumber fruits are picked at their full growth stage before attainment of physiological maturity" [2]. "Cucumber is very special of summer in maintaining the quantity of water in our body as the fruit is containing 96% water. Cucumber is a good source of molybdenum (Mo) and vitamins. Cucumber is used to treat skin, kidney and heart problems and as an alkalizer, it has a cooling effect, prevents constipation, useful in jaundice treatment and its seeds have number of ayurvedic uses" [3].

"Cucumber is monoecious herb with trailing or climbing, 4-5 angled stems up to 5 m long, sparsely branching with simple tendrils up to 30 cm long. The plant is covered with scaberulous hairs and root system is extensive superficial. Leaves are alternate, simple and borne on petiole 5-20 cm long. Cucumber plants have male, female, and bisexual flowers, and could be classified by their flower position and appearance on the stem as gynoecious, monoecious, andromonoecious, trimonoecious, hermaphroditic, or androecious" [4].

"The cucumber plant is a typical semitropical plant, growing well under stable, warm and humid conditions with high levels of light. It is a thermophilic and frost-susceptible horticultural crop usually cultivated in fields during spring-summer period or in greenhouse in different seasons" [5]. It requires a continuous supply of water and nutrients. It has a medium tolerance to salt levels. In the wild, the plant is extremely variable in both vegetative and fruit characteristics. Cucumber has special importance among the vegetables grown in protected environment because cucumber is the only crop among the popular vegetables grown in poly house which gives good income by getting ready in less time.

During summer and winter season in Telangana, it is extremely difficult to grow vegetables in open field conditions; however, with creation of false micro-climate through modified protected structures, some high-value crops and vegetables could easily be grown continuously. In semi-arid region of Telangana, the summer (April to July), the rainy (July to October) and the winter (November to February) are the major hotspot seasons. However, in protected

cultivation, growing season can easily be extended and one or two more short duration crops could easily be taken which further adds to increased crop yield per unit per day as compared to open field conditions. Moreover, the cultivation of high value crops/vegetables in protected conditions can play a better role in improving quality and advancing maturity as well as increasing fruiting span. In Telangana, at poor resourced farmers' level, the popularity of protected cultivation has not been encouraging. This could be due to unawareness about its significance, unavailability of working capital for developing infrastructure, illiteracy of farmers', deprived communication channels and tormented glitches in transportation and lack of sound resources. Telangana with its wide variability of climate and soil type, is highly favourable for growing a large number of vegetables crops. The economy of Telangana is primarily and largely dependent on agriculture and its allied sectors owing to its predominance in rural inhabitants.

"Simultaneously, BUAT Banda organizes trainings, conducts field day on low cost protected cultivation, and creates awareness among the farmers to adopt low cost protected cultivation technology at their fields and gradually progressive farmers of the Banda district have been showing their interest and started creating low cost protected infrastructure at their field for commercial cultivation and large dissemination. With this limited effort, some of the farmers are ensuring better yields, greater price and are saving their input resources (water, labour and fertilizer costs) year after year that helped them to uplift their socio-economic livelihood in the region. Cucumbers grown in protected areas gives a higher yield and higher quality than those grown in an open field" [6].

"Now-a-days, polyhouse is most effective against adverse climatic conditions. Vegetable production under polyhouse by using advanced technology to make control over the environment pertaining to crop productivity per unit area and produced the quality vegetables and it is further protecting the crops from adverse conditions like extra solar radiation, high temperature, rain, pest and disease. It not only improves the productivity but also quality of the vegetables. Poly houses also helps to increase photosynthetic rate which results in increased productivity and improved quality of produce under better management. The protected cultivation of cucumber presents a lot of opportunities in term of better economic gain in shorter span of cropping period" [7].

However, the quality and production of cucumber is now in threat under changing climatic scenarios, growing media (occurrence of soil-borne diseases on global basis) and the microclimate within plant community. In this scenario, present study was conducted to see whether cucumber cultivation under polyhouse is economical or not with the following objectives.

1. To study the economics of cucumber cultivation in poly house
2. To assess the sensitivity analysis of cucumber under poly house

2. MATERIALS AND METHODS

Cucumber cultivation of under naturally ventilated polyhouse was carried out at Agricultural college, Jagtial, PJTSAU, Telangana during 2020. The experiment was laid out by following randomized block design (RBD) with three replications. The cucumber is a warm season crop and grows best at a temperature between 18^0C and 24^0C. Suitable temperature and humidity management right from sowing to harvest done under poly house.

Propagation and transplanting: A parthenocarpic cucumber cv. Multistar was selected for cucumber farming. Multistar (dark green colour fruit) variety was used which is very popular for cultivation under greenhouse. In the polyhouse, a protray is used for growing cucumbers. Growing Mixtures such as coco peat and vermicompost are used to fill the pro tray. Then one seed was sown in each hole. Only used strong, healthy, uniform seedlings to ensure crop is progressive and productive. Transplanting was done after 4 to 5 weeks of sowing in plug trays. Emerged seedlings are planted on raised beds having dimensions of 100 x 40 x 50 cm (width, height and path) at a spacing of 60 x 45 cm^2 in a double row system.

Method of irrigation coupled fertigation: "The drip irrigation system was used for the cucumber crops, in which water and fertilizer balance is maintained according to plant growth. It is considered as a tool for increasing water and nutrient use efficiency (NUE) of the crop grown when managed carefully. It maximizes yield with a significant reduction in input water and environmental pollution by improving the photosynthetic capacity of the plants. It minimizes the leaching of nutrients or chemicals from root-zone system of the plants" [8]. "Numerous studies reported the positive effect of

drip irrigation in improving yield of the crop grown" [9].

Nutrition: Provided a balanced and appropriate supply of nutrients to maintain crop vigour, balanced growth and health.

Culture practices in cucumber: Different cultural practices are followed in cucumber for period of 5 month of duration. The details of different cultural practices were given below

Training: Training is nothing but managing the crop growth to produce balanced, healthy plants. Training is the method of guiding plant growth so that plants make the best use of the available light and space. Cucumber is a creeping vine, grows on trellises, wrapping around supports with thin spiralling tendril. Plants are trained upwards around a length of string (a cordon) so that the main stem climbs to an overhead wire. Single rows are evenly spaced approximately 1.5 m apart and plants are distanced approximately 30 cm apart within each row, and the 2 overhead wires are spaced approximately 75cm apart from each other. Plants can be trained on plastic twine supported from horizontal support wires running along the length of the bed (3mt above top of the bed). The base of the string can be anchored loosely to the base of the plant with non-slip noose.

Pruning: The main stem was allowed to grow vertically following a string and the growing point of the main stem is removed when one or two leaves have developed above the wire. Two lateral branches near the top of the plant are allowed to grow and are trained over the overhead wire, in downward direction. The growing point of each lateral is removed when they are approaching to the ground. Pruning also improved the uniformity of the crop and way to regulate fruit per square metre to meet seasonal variations. Pruning used to manage plant balance and ensure that the plant produces good quality fruit.

Harvesting: Cucumber was planted in February and harvested up to April-May. Harvesting usually started 50 to 65 days after planting. Cucumbers grow fast, so they are harvested every 2 to 4 days.

The total costs incurred and returns were calculated based on CACP (Commission on Agricultural Costs and Prices) methodology of estimation of cost of cultivation. In general, perennial vegetable crops have two types of costs *viz.,* establishment costs and maintenance costs. Establishment costs include all the expenses incurred during pre-sowing period such as polyhouse construction, seed bed preparation, soil sterilization, Farm Yard Manure (FYM) application etc. Maintenance costs include expenses incurred on human labour, irrigation, fertigation, fertilizers, plant protection chemicals etc during process of cultivation. Amortization method was used to include establishment costs of polyhouse with an economic life span of 10 years and planting material cum seed bed preparation with life span of 5 years. The amortized cost was included in fixed cost items. Variable costs or working capital were taken for every year.

Total Fixed Costs (TFC): It includes costs incurred on construction of sheds, interiors, implements, permanent seed bed and amortized costs on establishment capital.

Total Variable Costs (TVC): It includes costs incurred on seeds, fertilizers, plant protection chemicals and labour wages of various operations etc.

Amortization: Crops like cucumber which need to be grown in controlled environments like polyhouses for better returns needs an initial establishment cost for construction of polyhouse. The initial establishment costs are included in cost of cultivation and such costs are amortized by using the following formula and included every year till the completion of its life span [10].

$$A = \frac{P \times i\ (1+i)^n}{(1+i)^n - 1}$$

Where

A = Amortized cost
P = Initial investment made on establishment
i = Rate of interest
n = Economic life span of establishment

Rate of interest was taken at 10 percent for calculation of amortization.

Financial feasibility analysis: The life of polyhouse is assumed to be 10 years. The cost taken into account was establishment cost of polyhouse, input cost, labour cost and maintenance cost. Establishment cost incurred during the first year of planting includes cleaning and preparation of land, cost of seedling and cost of planting *i.e.* ploughing, digging, filling soil,

planting and irrigation structure *etc*. The input costs included fertilizer cost and pesticide chemicals cost, *etc*. and labour cost includes cost on manuring, harvesting, packing *etc* [11].

The financial feasibility analysis was done by adopting the methodology like discounted cash flow techniques used by Satish Kumar et al., 2020. The financial measures such as NPV, BC Ratio, IRR were used by considering the investment period of 10 years and using discount rate at 10 per cent.

Net Present Value (NPV): Net present value is the present worth of the net benefits or cash flow stream.

Mathematically, the Net Present Value is estimated as follows:

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t}$$

Where

B_t denotes Benefit (Cash inflow) in year t,
C_t denotes cost (Cash outflow) in year t,
'n' denotes investment lifespan,
'i' denotes cost of capital and
't' denotes time measured in years.

If the calculated NPV is positive it implies the investment is viable, and where the NPV is equal to zero implies that the investment breaks even. The rule with NPV is to accept all mutually exclusive investments with a zero or greater NPV.

Benefit cost ratio (BCR): It is the ratio of discounted cash inflows and cash out flows which must be unity or more for an enterprise to be considered worthwhile. The minimum ratio required is 1:1, which indicates the coverage of costs without any surplus benefits. But, usually the ratio should be more than unity in order to provide some additional returns over the costs for clear decision.

Its formula for estimation is as follows:

$$BCR = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+i)^t}}$$

B_t, C_t, n, t, i as defined for NPV

Fig. 1. Field view of cucumber after transplanting inside the polyhouse

Fig. 2. Plants were supported with trellising technique

Internal rate of return (IRR): This is the discount rate at which the NPV of an investment equal to zero, i.e.

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+IRR)^t} = 0$$

The internal rate of return is arrived by interpolation technique using different discount rates so as to see that the net present worth is equated to zero. The interpolation formula employed in this study is as follows

$$IRR = LDR + D\left(\frac{NPV_{LDR}}{NPV_{HDR}+NPV_{LDR}}\right)$$

Where,

LDR denotes lower discount rate
HDR denotes higher discount rate
NPV_{HDR} denotes NPV calculated using higher discount rate
NPV_{LDR} denotes NPV calculated using lower discount rate
D denotes difference between lower and higher discount rates

The decision rule is to accept all independent projects having an Internal Rate of Return equal to or greater than the cost or opportunity cost of capital. The internal rate of returns also ranks the different investment proposals for preference in the order of the magnitude. The IRR should be more than the discount rate to be considered for viable investment and financial soundness.

3. RESULTS AND DISCUSSION

From the Table 1, it was clearly indicated that the total cost of the establishment of polyhouse with in an area of 1000 m2 was Rs. 975000 as the cucumber crop should be grown under controlled environment for better yields and profits than open fields. The land value was taken hypothetically as Rs. 100000 and it varies based on the market value of the location of construction. Generally, the economic life span of polyhouse was about 10 years. Construction of polyhouse along with shades, irrigation systems etc needs initial investment only and thereafter maintenance costs are prevailing. Hence, this establishment amount should be amortized to be included in the total cost of cultivation of cucumber [12]. The amortized cost was Rs. 154974 when calculated at 10 per rate of interest. Similarly, cucumber cultivation needs seed material and seed bed which could be used continuously for about five years. The establishment cost of both planting material and seed bed materials was Rs. 287000. This amount also needs to be amortized and that cost was Rs. 75774. The total amortized costs of establishment of polyhouse, seed bed, planting

material were Rs. 230748. The management costs of cucumber were Rs. 77000, out of which most of the amount was spent on production and protection (Rs. 30000) followed by harvesting and transport (Rs. 25000). Thus, the total cost of cultivation of cucumber per year was Rs. 307746. The number of plants that could be grown in a 1000 m2 area were 3704 plants when the spacing was 60×45 cm. The average production of flowers per plant per year was 8 kgs. A total of 29.63 tons of cucumbers were produced from 1000 m2 area of polyhouse. The average price per kg of cucumber was Rs. 8 which gave an income Rs. 888960. The benefit cost ratio worked out to be 2.89. The BCR reflected that per rupee investment on cucumber cultivation, the net returns were about Rs. 1.89, which was more than double. The same results were obtained by Prakash et al., [13] and Kumar et al., [14]. Hence, we could say the cucumber cultivation under polyhouse is economically viable and gives profits to the farmers.

Financial feasibility analysis: Cash out flow means all the cash that spent in the farm business which includes structure costs, land preparation costs, annual maintenance costs, fixed costs, variable costs, *etc*. Cash inflows include all the cash that comes in to the farm business from sale of the produce. The cash flows were projected for a period of 10 years as the average life span of polyhouse structure was assumed to be 10 years. The life span of plants and seed bed was 5 years and they need to be replaced after 5 years of establishment.

The sum of polyhouse structural cost, land preparation and annual maintenance costs were considered as the cash out flow for the first year. For the subsequent years' annual maintenance costs along with the interest were considered as cash out flow. The costs and returns were calculated for the first year and for the remaining nine years they were assumed to inflate at the rate of 5 per cent per annum.

Table 1. Cost return components of cucumber under poly house (1000 m^2)

Item of Expenditure	Amount spent (Rs.)
Fixed Cost Rs	
Land	1,00,000
Polyhouse @ 1000m^2	7,50,000
Irrigation system	1,00,000
I. Amortized cost	**154972**
Recurring cost	
A. Seed cost	20000
B. Bed preparation	
FYM	50000
Sand	30000
Soil	1,50,000
Husk	5000
Labour cost	22,000
Fertilizers	10,000
Total B	267000
Total A+B	287000
II. Amortized cost of A & B	**75774**
Working capital	
Soil sterilization	22000
Management cost	
Harvesting & Transport	25,000
Fertilization & Pesticides	30,000
III. Total of Working capital (C+D+E)	**77000**
Total Cost of Cultivation (I+II+III)	**307746**
IV. Output	
Cucumber production (8kg/plant/year)	240
V. Income or Gross Returns	
Income from sale (Rs 30/- per 1kg fruits from 3704 plants)	**8,88,960**
BCR	**2.89**

Table 2. Financial feasibility of cucumber under polyhouse

S. No	Particulars	Cost of capital @10% (Rs.)
1	NPV	Rs. 3348653
2	BCR	2.58
3	IRR	60.58%

The cost and returns are not the perfect measures to assess the profitability from investment made on cucumber. Before making a choice on any enterprise, it becomes necessary to examine the economic feasibility of that enterprise. Several techniques are available for evaluating the economic viability of cucumber plantation under polyhouse. NPW, BCR, and IRR were employed to examine the economic feasibility of investment on cucumber plantation under polyhouse.

To evaluate the financial performance of cucumber plantation under polyhouse, a spread sheet model was constructed to describe the revenue and costs associated with cucumber over 10 years [10]. It was considered suitable to determine the cash flow. In the present study the cost and returns had been discounted at 10% to estimate the net present value of future returns. The results of NPV, BCR and IRR values calculated per hectare are presented in Table 2.

It can be observed from the table 2, that the NPV was highly positive with Rs. 3348653 per 1000 m^2 area of polyhouse at 10 per cent discount rate. This indicates that the investment in cucumber plantation under polyhouse was economically feasible and financially sound. Benefit cost ratio of 2.58 at 10 per cent opportunity cost of capital, indicates that the investment on cucumber plantation was profitable with a return of Rs. 2.58 for an investment of Rs. 1. Internal Rate of Return (IRR) was 60.58 %, which was nearly six times higher as compared to the present cost of capital. This indicates the investment on cucumber crop was profitable when cultivated under polyhouse conditions.

4. CONCLUSION

Protected conditions provide a favourable environment and microclimate for growth and development, and the physiological functioning of cucumber plants inside a naturally ventilated polyhouse as compared to the open condition is very good. The low-cost naturally ventilated greenhouses are more suitable and economical for year-round cucumber cultivation. The cost return analysis of cucumber under poly house was highly profitable. The financial feasibility analysis also proved to be economically feasible and financially viable if the cucumber grown under poly house. The initial establishment seems to be mounting for small and marginal farmers. hence, they hesitated to taken up cucumber under poly house. However, several government policies provide financial assistance, through which farmers can establish poly house and grow cucumber.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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