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Sustainable Nutrient-Rich Food Production during COVID-19 Pandemic through Year-Round Vegetable Farming Using Hydroponic Technique †

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Abstract: The impact of the ongoing COVID-19 pandemic has caused disastrous food shortages and increased food prices due to the disruption of agricultural systems and activities. Less consumption of nutrient-rich foods made the people more susceptible to COVID-19 infection during the pandemic. The situation resulted in a pivot to develop technology for economic and year-round production of nutrient-rich vegetables to alleviate malnutrition and to improve the immunity of the human body. Hydroponic farming (growing plants without soil) is a resilient food production system which provides perfect conditions for better and faster growth. This study involved the estimation of the total cost of establishing a polyhouse; setting up nutrient film technique (NFT) hydroponic system, the production costs of selected five vegetables, namely, tomato, broccoli, capsicum, lettuce and cabbage; the determination of their annual production and gross income based on prevailing market prices; and the net profits from hydroponic farming techniques. An amount of BDT 18.75 million (USD 0.22 million) could be earned by growing the selected five vegetables in a polyhouse of 100 m × 75 m size following the NFT technique of hydroponic farming. By investing BDT 31.56 million with a concurrent annual addition of BDT 0.59 million from the 2nd year, an amount of BDT 1.17 million net profit per year can be achieved. If the farmer pays a loan of BDT 0.60 million per year, a profit of BDT 0.56 million can still be earned every year and all the debts can be paid within eight years.

Keywords: COVID-19 pandemic; hydroponic farming; polyhouses; profitability of hydroponic vegetables; year-round production

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1. Introduction

The burden of malnutrition from the insufficient intake of protective foods is a growing concern in Asian countries, especially during this COVID-19 pandemic. Low fruit and vegetable intake are among the top 10 selected risk factors for global mortality [1]. During the COVID-19 pandemic the issue has become more important than before. Worldwide, a low intake of fruits and vegetables is estimated to cause 19% of gastrointestinal cancer death, 31% of ischaemic heart disease and 11% of stroke deaths [2]. To contest with pathogens the body relies on various types of lymphocytes including T-cells. To fight against many infections a good T-cell response that detects and kills abnormal body cells is crucial. Research demonstrated that nutrients and bio-active food components influence γδ T cells' cytotoxicity, cytokine secretion and proliferation capacity. A recent clinical study demonstrated that ingesting fruit and vegetable juice concentrate increased the number of circulating γδ T cells [3].

Nutrient-rich vegetable production and consumption by the people of the world during the COVID-19 pandemic is, therefore, essential to improving the immunity systems

of their bodies. To sustain our economic development, we also need to produce more food in only a small area of land. Vertical agriculture following hydroponic techniques is the best alternative to addressing all these issues. Hydroponic farms are a solution to satisfy the demands for a more plant-based diet in the increasingly insecure food supply chain [4]. The utilization of all un-occupied and non-fertile land, especially in urban areas is an urgent necessity for increasing food production to mitigate the probable food crisis after the COVID-19 pandemic, as emphasized by WHO. This technique not only increases the crop harvesting frequency by 3–5 times (Figure 1) but also decreases water, pesticide and fertilizer usage from 50 to 80%. This farming technique is also environmentally friendly as there is not much use of chemicals in the form of pesticides [5].

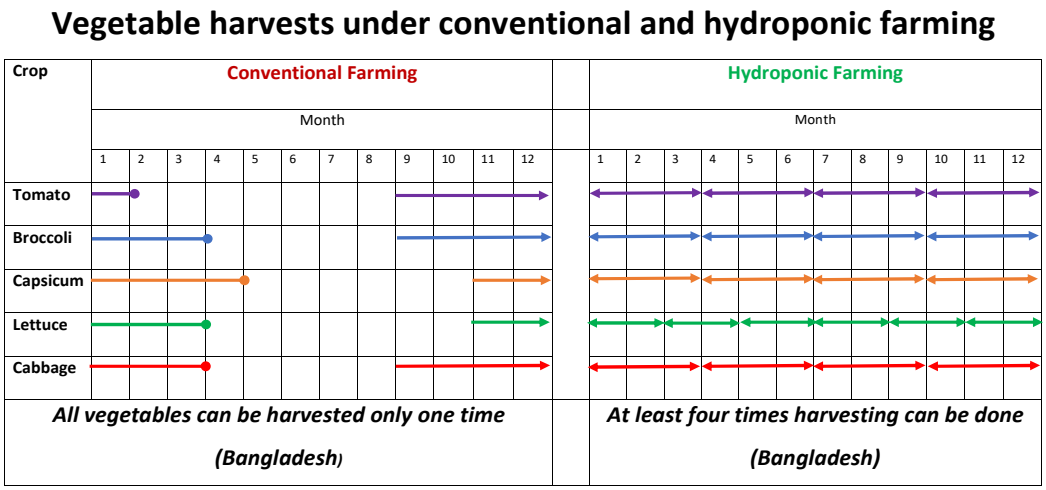

Figure 1. Frequency of harvests of five selected vegetables using hydroponic farming and conventional farming.

Hydroponic farming is a method of growing plants without soil by using mineral nutrient solutions in a water solvent. It is a resilient food production system. It always provides perfect conditions for better and faster growth. Conventional farming (CF) is season-based, but hydroponic farming (HF) can be undertaken throughout the year and, therefore, can avoid effects of climate change. Moreover, there is no water loss by evaporation or runoff in HF and the efficient use of nutrients take place.

With these ends in view an attempt was therefore undertaken to estimate the profitability of vegetable farming using the hydroponic technique.

2. Methodology Followed

The estimate is based on the production of five vegetables, namely, tomato, broccoli, capsicum, lettuce, and cabbage, grown using nutrient film technique (NFT) in a polyhouse of 100 m × 75 m size under the socio-economic conditions of Bangladesh from January to December 2020. The cost of production included both the fixed costs and variable costs, e.g., the establishment and maintenance of the polyhouse and equipment, setting up the hydroponic systems, the raising of the seedlings, the transplanting of the seedlings, post planting cares, harvesting, etc. The net income has been calculated by subtracting the cost of production from the gross income (total produce multiplied by sale price) and the profits have been estimated by subtracting general and administration costs from the net income. A plan for loan payment using the money from the net profits has also been outlined.

3. Results and Discussion

3.1. Estimation of Costs and Gross Income

The establishment of polyhouses is a somewhat expensive task and needs the investment of more money initially. However, after the completion of loan payment the whole system will be gaining multifold benefits. Table 1 shows the estimation of the cost of production, including 10% maintenance cost. It should be noted that this amount of cost (BDT 31.56 million) is not required to be spent every year. The concurrent cost from the second year is the actual yearly cost, as is shown in the Table 2.

Table 1. Estimation of the cost of production of the selected vegetables.

No.	Cost Item	Description	Cost (BDT)	Cost (USD)
1	Fixed costs	(a) Polyhouse building and maintenance (10%) (Size: 100 m × 75 m)	15,600,000	182,456
		(b) Other fixed costs (covered trucks, nursery house, product processing room, office-cum-training room, covered vehicle parking area, etc.) and their maintenance (10%)	9,328,000	109,099
		(c) Equipment costs (hydroponic settings, cooling devices, fans, solar panels, generator, nutrient tanks, etc.) and maintenance (10%)	3,311,000	38,725
Total fixed cost			28,239,000	330,281
2	Variable cost	Research materials, utility costs, salary of personnel, labour wages, etc.	3,220,000	37,661
3	Misc. costs	Advertisement, internet, stationery, etc.	100,000	1170
4	Total cost of production		31,559,000	369,111

Table 2. Concurrent costs needed from the second year.

No.	Item of Cost	Amount (BDT)
1.	Variable/operational costs for the polyhouse	3,220,000
2.	Polyhouse maintenance cost	1,428,000
3.	Equipment maintenance cost	301,000
4.	Maintenance cost of other establishments and vehicles	848,000
5.	Misc. cost. (Advertisement, stationery, gifts, donations, etc.)	100,000
Total concurrent cost		5,897,000

Hydroponic vegetables secure more production per year since they provide multiple harvests in a year (Figure 1) in comparison to a single harvest in conventional soil-based farming. Table 3 shows the total production and gross income of hydroponically grown vegetables. Therefore, an amount of BDT 18.75 million (USD 0.22 million) can be earned by growing the selected five vegetables in a polyhouse of 100 m × 75 m size following NFT technique of hydroponic farming.

Table 3. Total production and gross income from the five selected hydroponic vegetables.

Name of Vegetable	Plants/ Unit Area [1] (No)	Product/ Plant (kg)	Product/ Harvest (kg)	No. of Harvest/ Year	Product/ Year (kg)	Sale Price (BDT/kg) [2]	Income/ Year (BDT)	Income/ Year (USD)
Tomato	2500	12	30,000	4	120,000	25	3,000,000	
Broccoli	2500	5	12,500	4	50,000	30	1,500,000	
Cabbage	2500	5	12,500	4	50,000	25	1,250,000	
Capsicum	2500	10	25,000	4	100,000	80	8,000,000	
Lettuce	10,000	4	40,000	5	200,000	25	5,000,000	
Total income per year							18,750,000	219,298

[1] The unit area = 10 rows of 100 m length and 1.30 m width, i.e., every crop has 10 rows. [2] The sale price as per the prevailing market value of the produce in the year 2020 in Bangladesh.

3.2. Estimation of Profit per Year

The profits were estimated based on a 5% increase in production from the 2nd year. The net profits from the 1st year to 8th year are shown in the Table 4. It should be noted that in the 8th year the profits are much higher than other years as the loan payment on that particular year is less (Tables 4 and 5). On the other hand, the profits in the first year of operation are comparatively low since the 5% increase in production is not considered.

Table 4. Estimation of gross profits, net profits, benefit–cost ratio and loan payment plan (Figures in BDT).

Particulars	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Sales revenue	18,750,000	18,750,000	18,750,000	18,750,000	18,750,000	18,750,000	18,750,000	18,750,000
Production increase	–	5%	5%	5%	5%	5%	5%	5%
Actual sales revenue	18,750,000	19,687,500	19,687,500	19,687,500	19,687,500	19,687,500	19,687,500	19,687,500
Cost of production	5,897,000	5,897,000	5,897,000	5,897,000	5,897,000	5,897,000	5,897,000	5,897,000
Gross profits	12,853,000	13,790,500	13,790,500	1,37,90,500	13,790,500	13,790,500	13,790,500	13,790,500
General and admin costs	2,100,000	2,100,000	2,100,000	2,100,000	2,100,000	2,100,000	2,100,000	2,100,000
Net profit	10,753,000	1,16,90,500	11,690,500	11,690,500	11,690,500	11,690,500	11,690,500	11,690,500
Benefit–cost ratio	3.179	3.338	3.338	3.338	3.338	3.338	3.338	3.338
Loan payment	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	4,720,945
Net profits	4,753,000	5,690,500	5,690,500	5,690,500	5,690,500	5,690,500	5,690,500	6,969,555

Table 5. The calculation of bank debts and the successful payment of the debts in time. (Figures in BDT).

Particulars	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Principal amount	32,567,000	29,498,030	26,152,853	22,506,610	18,532,205	14,200,103	9,478,112	4,331,142
9% interest	2,931,030	2,654,823	2,353,757	2,025,595	1,667,898	1,278,009	853,030	389,803
Amount with interest	35,498,030	32,152,853	28,506,610	24,532,205	20,200,103	15,478,112	10,331,142	4,720,945
Yearly installment	6,000,000	6,000,000	6,000,000	60,00,000	6,000,000	6,000,000	6,000,000	4,720,945
Amount remaining	29,498,030	26,152,853	22,506,610	1,85,32,205	14,200,103	9,478,112	4,331,142	Nil

3.3. Project Financing and Debt Payment

The estimation of bank debt with 9% interest and a plan for the payment of the dept with an annual installment of BDT 6,000,000 is given here. The principal amount is BDT 32,567,000 for a period of eight years. It is clear here that by the 8th year no bank loan will be remaining (Table 5).

4. Conclusions

Hydroponic farming is an advanced technology and a truly revolutionary approach for the sustainable year-round production of vegetables. Therefore, hydroponic vegetable farms should be established, especially in low- and medium-income countries (LMICs), and thereby, higher production and the supply of the products to the local markets would be ensured, and the market availability of fresh and locally produced vegetables would be guaranteed. It is suggested that more peoples should be trained in this farming technique and make themselves entrepreneurs in farming systems. Finally, people will consume more vegetables, improve their immunity, and thus, hopefully, will be able to fight effectively against COVID-19.

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