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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 ongoing Covid-19 pandemic caused disastrous food shortages and increased food prices due to 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 immunity of 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 estimation of total cost of establishing a polyhouse, setting up nutrient film technique (NFT) hydroponic systems, production costs of selected five vegetables namely, tomato, broccoli, capsicum, lettuce and cabbage, determination of their annual production, gross income based on prevailing market prices, and the net profits following hydroponic farming technique. An amount of BDT 18.75 million (USD 0.22 million) can be earned by growing selected five vegetables in a polyhouse of 100 m X 75 m size following 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 loan of BDT 0.60 million per year still BDT 0.56 million profit can be earned every year and all the debts will 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 intake of insufficient 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 this covid-19 pandemic the issue is more important than before. Worldwide, low intake of fruits and vegetables is estimated to cause 19% of gastrointestinal cancer death, 31% of ischaemic heart disease and 11% of stroke death. [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 is crucial that detects and kills abnormal body cells. 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 a fruit and vegetable juice concentrate increased the number of circulating γδ T cells [3].

Nutrient-rich vegetable production and consumption by the people of elsewhere under this COVID-19 pandemic is, therefore, essential to improve the immunity systems of their bodies. To sustain our economic development, we also need to produce more food in a small area of land. Vertical agriculture following hydroponic technique is a best alternative to address all these issues. Hydroponic farms are a solution in satisfying the demands for a more plant-based diet in the growingly insecure food supply chain [4]. Utilization of all un-occupied and non-fertile land, especially at urban area is an urgent need to increase food production to mitigate the probable food crisis after covid-19 pandemic as emphasized by WHO. This technique not only increases the crop harvesting frequency by 3-5 times (Figure 1) but also decrease water, pesticides, fertilizers usage from 50 to 80%. The farming technique is also environmentally friendly as there is not much use of chemicals in the form of pesticides [5].

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 done throughout the year and therefore, can avoid effect of climate change. Moreover, there is no water loss by evaporation or runoff in HF and efficient use of nutrients take place.

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

2. Methodology followed

The estimate is based on the production of five vegetables namely, tomato, broccoli, capsicum, lettuce, and cabbage growing under nutrient film technique (NFT) in a polyhouse of 100 m X 75 m size under Bangladesh socio-economic conditions during January to December 2020. The cost of production included both the fixed costs and variable costs e.g., establishing and maintenance of the polyhouse and equipment, setting up the hydroponic systems, raising of seedling, transplanting of 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 profit has also been outlined.

3. Results and Discussion

3.1. *Estimation of Costs and Gross Income*

The establishment of polyhouses is a bit expensive task and needs to invest more money initially. However, after completion of loan payment the whole system will be paying multi-fold benefits. Table 1 shows the estimation of cost of production including 10% maintenance cost. It can be noted that this amount of cost (BDT 31.56 million) is not required to spend in every year. The concurrent cost from the second year is the actual year-wise cost which is shown in the Table 2.

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

No	Cost item	Description	Cost (BDT)	Cost (USD)
1	Fixed costs	a) Polyhouse building & maintenance (10%) (Size: 100 m X 75 m)	1,56,00,000	1,82,456
		b) Other fixed cost (Covered Trucks, Nursery house, Product processing room, Office-cum-training room, Covered vehicle parking area etc.), and their maintenance (10%)	93,28,000	1,09,099
		c) Equipment cost (Hydroponic settings, Cooling devices, Fans, Solar panel, Generator, Nutrient Tanks etc.) & maintenance (10%)	33,11,000	38,725
Total fixed cost			2,82,39,000	3,30,281
2	Variable cost	Research materials, Utility costs, Salary of Personnel, Labour wages etc.	32,20,000	37,661
3	Misc. costs	Advertisement, Internet, Stationeries etc.	1,00,000	1,170
4	Total cost of production		3,15,59,000	3,69,111

Table 2. Concurrent costs needed from the second year

No.	Item of cost	Amount (BDT)
1.	Variable/Operational costs for the polyhouse	32,20,000
2.	Polyhouse maintenance cost	14,28,000
3.	Equipment maintenance cost	3,01,000
4.	Maintenance cost of other establishments & vehicles	8,48,000
5.	Misc. cost. (Advertisement, Stationery, Gifts, Donation etc.)	1,00,000
Total concurrent cost		58,97,000

Hydroponic vegetables secure more production per year since it provides with multiple harvests in a year (Figure 1) in comparison to a single harvest in the 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 selected five vegetables in a polyhouse of 100 m X 75 m size following NFT technique of hydroponic farming.

3.2. Estimation of Profit Per Year

The profits have been estimated based on 5% increase in production from the 2nd year. The net profits from 1st year to 8th year are shown in the Table 4. It can 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&5). On the other hands, the profits in the first year of operation is comparatively low since the 5% increase in production is not considered.

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

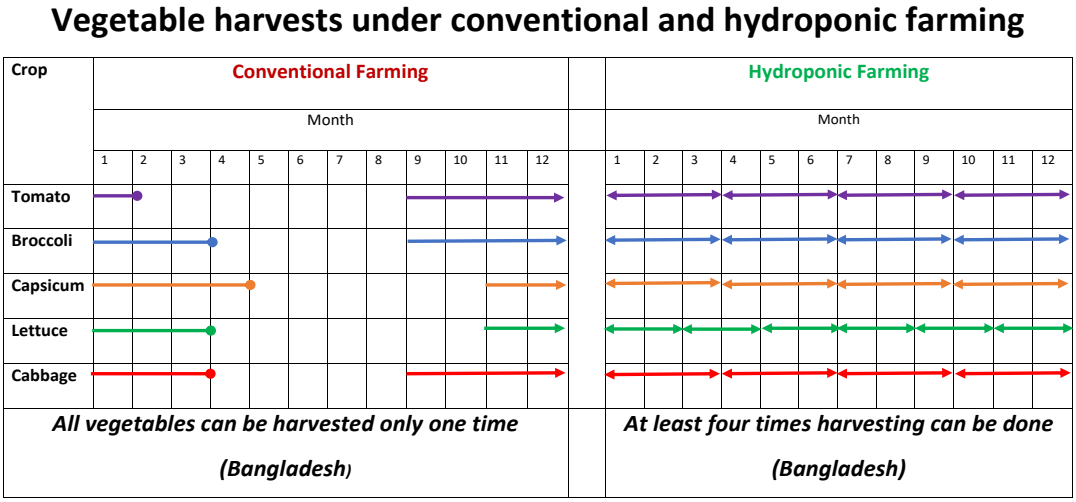

Table 3. Total production and gross income from five selected hydroponic vegetables.

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/ Yr. (BDT)*	*Income/ Yr.(USD)*
Tomato	2500	12	30000	4	120000	25	30,00,000	
Broccoli	2500	5	12500	4	50000	30	15,00,000	
Cabbage	2500	5	12500	4	50000	25	12,50,000	
Capsicum	2500	10	25000	4	100000	80	80,00,000	
Lettuce	10000	4	40000	5	200000	25	50,00,000	
Total income per year							1,87,50,000	2,19,298

[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 is as per prevailing market value of the produce in the year 2020 in Bangladesh.

Table 4. Estimation of gross profits, net profits, benefit-cost ratio and loan payment plan.

(BDT)

Particulars	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Sales revenue	1,87,50,000	1,87,50,000	1,87,50,000	1,87,50,000	1,87,50,000	1,87,50,000	1,87,50,000	1,87,50,000
Production increase	--	5%	5%	5%	5%	5%	5%	5%
Actual sales revenue	1,87,50,000	1,96,87,500	1,96,87,500	1,96,87,500	1,96,87,500	1,96,87,500	1,96,87,500	1,96,87,500
Cost of production	58,97,000	58,97,000	58,97,000	58,97,000	58,97,000	58,97,000	58,97,000	58,97,000
Gross Profits	1,28,53,000	1,37,90,500	1,37,90,500	1,37,90,500	1,37,90,500	1,37,90,500	1,37,90,500	1,37,90,500
Gen. & Admin cost	21,00,000	21,00,000	21,00,000	21,00,000	21,00,000	21,00,000	21,00,000	21,00,000
Net profit	1,07,53,000	1,16,90,500	1,16,90,500	1,16,90,500	1,16,90,500	1,16,90,500	1,16,90,500	1,16,90,500
Benefit-Cost Ratio	3.179	3.338	3.338	3.338	3.338	3.338	3.338	3.338
Loan payment	60,00,000	60,00,000	60,00,000	60,00,000	60,00,000	60,00,000	60,00,000	47,20,945
Net profits	47,53,000	56,90,500	56,90,500	56,90,500	56,90,500	56,90,500	56,90,500	69,69,555

3.3. Project Financing and Debt Payment

Estimation of bank debt with 9% interest and a plan for payment of the dept with an annual installment of BDT 60,00,000 is given here. The principal amount is BDT 3,25,67,000 for a period of eight years. It is clear here that at the 8th year no bank loan will be remaining (Table 5).

Table 5. Calculation of bank debts and successful payment of the debts in time.

(BDT)

Particulars	*Year 1*	*Year 2*	*Year 3*	*Year 4*	*Year 5*	*Year 6*	Year 7	Year 8
Principal amount	3,25,67,000	2,94,98,030	2,61,52,853	2,25,06,610	1,85,32,205	1,42,00,103	94,78,112	43,31,142
9% interest	29,31,030	26,54,823	23,53,757	20,25,595	16,67,898	12,78,009	8,53,030	3,89,803
Amount with interest	3,54,98,030	3,21,52,853	2,85,06,610	2,45,32,205	2,02,00,103	1,54,78,112	1,03,31,142	47,20,945
Yearly installment	60,00,000	60,00,000	60,00,000	60,00,000	60,00,000	60,00,000	60,00,000	47,20,945
Amount left	2,94,98,030	2,61,52,853	2,25,06,610	1,85,32,205	1,42,00,103	94,78,112	43,31,142	Nil

4. Conclusion

Hydroponic farming is an advanced technology and a truly revolutionary approach for sustainable year-round production of vegetables. Therefore, hydroponic vegetable farms should be established especially in every low- and medium-income countries (LMICs) and thereby - more production and supply of the products to the local markets would be ensured, and 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 them self-entrepreneurs in the farming system. Finally, the peoples will consume more vegetables, improve their immunity, and will fight against covid-19 hopefully.

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