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Chemical Free Vegetable Cultivation and Outcomes in Winter Season in Bangladesh : A case study on BOP farmers in five districts

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In Bangladesh the demand of chemical free vegetables is increasing due to health hazards of conventional vegetables. However, the awareness of the farmers and supply of such vegetables are not sufficient. In this research, therefore, we focused on why agrochemical free vegetable production including marketing has been underdeveloped in Bangladesh as a growing business compared to conventional vegetable production. In order to collect the information, which can argue these reality of chemical free vegetable production, distribution and marketing in Bangladesh, we especially focused on widely cultivated winter vegetables such as cabbage, cauliflower and tomato. Data were collected targeting the activities of SENSE (Support to establish a new society of BOP farmers by using the power of ICT) project regarding production and marketing. The results indicated that the production of chemical free cauliflower and tomato were substandard compare to the cabbage. The reasons for getting substandard production were unavailability of proper production inputs such as appropriate organic pesticides, quality compost and lack of timely execution of the farming activities. Moreover, the selling results indicated that farmers got higher income from tomato compare to cabbage and cauliflower. Additionally, revenue (per kg) of the products sold in Dhaka market was more than the local markets. The differences of revenue (per kg) between Dhaka and locally sold cabbage, cauliflower and tomato were BDT 6.02, BDT 6.63 and BDT 10.22, respectively. However, the average selling percentage of cabbage, cauliflower and tomato in Dhaka market (10.06%) and local market (89.94%) indicated that chemical free vegetable production had high potential by selling more products in Dhaka market for high income generation of the resource poor farmers.

Key words: Chemical Free Vegetables, Winter Vegetables, Income Generation, Cost of Production

INTRODUCTION

Bangladesh is largely an agricultural country where most of the rural inhabitants (85%) are directly or indirectly engaged with agricultural activities and their economic condition is not satisfactory (Islam *et al.*, 2016). Agriculture plays a vital role in the economy in terms of sustainable land utilization, food security, value addition, employment and export of agricultural products. Agricultural sector in 2009–10 fiscal years, earned US\$ 687.53 million by exporting agricultural products which is 4.24% of total export earnings (Sharmeen, K. and S. T. Chowdhury, 2013). Agriculture, including crops and vegetables, is the largest single sub-sector of the economy, accounting for about 12% of the country's gross domestic product (GDP) for the fiscal year 2009–2010 (Sikder, R. and J. Xiaoying, 2014). In fiscal year 2009–2010, the government of Bangladesh allocated US\$ 941.59 million to the Ministry of Agriculture for the purpose of increasing agricultural production, ensuring food security and poverty alleviation (Sharmeen, K. and S. T. Chowdhury, 2013).

The farmers in Bangladesh have been producing vegetables by following the conventional cultivation

methods using injudicious chemical fertilizers and pesticides to boost the production. However, this increases the health risk of people. Moreover, the consequences of overuse of insecticides lead to ecological imbalance and environmental degradation. Farmers are exposed to pesticides by different routes of exposure such as inhalation, ingestion and dermal contact. Acute and chronic health effects are reported due to exposure of pesticides (Chitra *et al.*, 2006). The World Health Organization (WHO) and the United Nations Environment Program (UNEP) estimated that about 4.0 million people suffer from severe pesticide poisoning. It's rate is 2–3 per minute, with approximately 20,000 workers dying from exposure every year, and majority belongs to developing countries (Miah *et al.*, 2014).

Farmers of Bangladesh mostly apply insecticides, herbicides, fungicides, acaricides and rodenticides in the vegetable field in the form of granules, liquid and powder to control pests. Most of the farmers particularly in the developing countries like Bangladesh apply pesticide without knowing their requirements and mode of action. More than 90% of Bangladesh farmers use pesticides unnecessarily, indiscriminately and excessively due to lack of knowledge and awareness of proper pesticides uses (Miah *et al.*, 2014). In Bangladesh, the use of pesticides, which averaged 3,850 metric tons annually in 1973–1990, has gradually increased to a record use of 37,712 metric tons in 2008 (Islam *et al.*, 2015). Pesticide poisoning is a major global health problem, and it is more problematic in Bangladesh.

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The per capita vegetable consumption is only 166.1 gram as compared to the daily requirement of 200 gram (Sadika *et al.*, 2013). Therefore, intake of less amount of vegetables is bad for health along with vegetables cultivated using chemicals definitely increases the health risk of Bangladeshi peoples. For reducing the health risk of the people, farmers are being encouraged to cultivate chemical free vegetables by using compost and organic pesticides.

This research, therefore, prioritizes the production of chemical free vegetables and regular supply of fresh vegetables in the market of Bangladesh. The main research question is, does production of chemical free quality vegetables performs better in relation to generating income for BOP (Bottom of Pyramid) farmers in Bangladesh.

A Grassroots Technical Cooperation Project named “SENSE (Support to establish a new society of BOP farmers by using the power of ICT)” by using power of ICT funded by the Japan International Cooperation Agency (JICA) has been implemented which was considered for the case study. The main objectives of this research were to analyze the real-time status of chemical free vegetables in terms of area, production and yield and to discover the major constrains of production and marketing to generate income for BOP farmers in Bangladesh.

METHODS

About SENSE project

SENSE project was proposed by Kyushu University, Japan and funded by JICA. The project duration was from January 2014 to January 2017. The project aimed at income generation of BOP farmers by producing chemical free vegetables. The project collaborated with four local partners; WIN-incorporate for development of ICT contents, Grameen Communications (GC) for construction of ICT environment, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) for provision and teaching of agricultural techniques and Bangladesh Agricultural Research Institute (BARI) for providing soil and product testing. The project was started its activities in five locations namely Ekhlaspur village at Chandpur district, Kapasia sub-district at Gazipur district, Basundia village at Jessore district, Mirzapur sub-district at Tangail district and Manohardi sub-district of Narsingdi district. Information of these model villages is shown in Fig. 1. In order to achieve the goal of the project, the selected farmers were asked not to use chemical fertilizer and pesticides during cultivation of vegetables. The selected farmers were trained to produce chemical free vegetables such as preparation of seedling, composts and organic pesticides.

To support the farmers, the project established Quality Vegetable Management Center (QVMC) as central station for farming and marketing activities. The QVMC was gathering place for the farmers and installed with ICT devices such as computer, digital camera, digital weight machine, hygrometer etc. All the devices were installed by the project and monitored by the pro-

ject personel. By using ICT devices in QVMC, farmer could get proper information for their farming. Farmers sold their vegetables at QVMC in the presence of a Quality Vegetable Entrepreneur (QVE) who helped the farmers in farming activities as well. By following the methods of the project, farmer were able to produce chemical free vegetables.

In order to distribute the high quality vegetables, the project established a supply chain system, which was unique in Bangladesh. Farmers brought their products in the QVMC after harvesting with an initial grading at their fields. The second grading was done in the QVMC by the farmer in presence of QVE. The products were packaged by farmers and sending the products to Dhaka by QVE through local transports like van (van is a type of pedal-driven three-wheeled vehicle used for goods transportation in Bangladesh), rickshaw (rickshaw is a type of pedal-driven three-wheeled vehicle used for goods or passengers transportation in Bangladesh), bus, boat etc. The project governed with its main office in Dhaka and local offices in each model village. There were six regular employees: one coordinator (a role of a general manager and to coordinate with the partnering organizations), one marketing manager (to create marketplace for farming products), two marketing officers (to assist the marketing manager), one technical manager (to answer the farmer's queries by using ICT) and one technical administrator (to maintain the ICT setup in main office and local quality vegetable management center) in Dhaka office (Ahmed *et al.*, 2016). The fresh products were received by Dhaka marketing team and distributed among customers after final grading and packaging with proper leveling of the farmer information

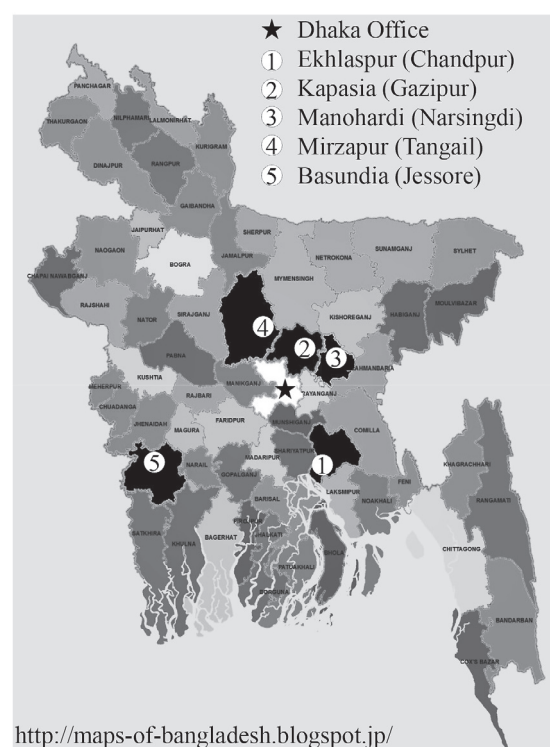


Fig. 1. Model village of SENSE Project.

at Dhaka office.

Information on chemical free vegetables selling in local market and Dhaka market were collected through regular visit by QVE. Since marketing of the chemical free vegetables through QVMC is a newly established concept in Bangladesh, the consumers of the vegetables is limited. Additionally chemical free vegetables in Bangladesh are consumed mostly by high-end people in Bangladesh, the project aim to sell the farmers products in markets of Capital (Dhaka) and regularity of the supply of vegetables in the market. All data collection for this research was conducted in October 2014 to March 2015 in five project sites.

Vegetable and farmer selection

Among different winter vegetables, cabbage, cauliflower and tomato are very popular among the farmers for its availability in all areas of Bangladesh and high return. In addition these three vegetables are better for the farmer since the farmer can get better seeds in their local markets. Therefore, we selected these three vegetables to know the status of chemical free cultivation. We approached 20 farmers of each local site namely Kapasia, Basundia and Mirzapur, 17 farmers of Ekhlapur and 11 farmers of Manohardi to know the interest of companion cultivation of cabbage, cauliflower and tomato without use of any chemical fertilizer and chemical pesticides.

Farming activities

The quality vegetable production is depended on appropriate farming activities on time (Saikou *et al.*, 2009). The selected farmers followed the guideline, which was provided by the project. The common farming practices which were followed by the farmers are shown in Table 1. The farmers followed the companion cultivation methods such as cabbage-cauliflower-tomato, cabbage-cauliflower, cabbage-tomato, and cauliflower-tomato. Fig. 2 shows different cultivation activities.

Compost preparation and its use as nutrient source

Compost is the main source of nutrients for producing chemical free vegetables. The farmers were given training related to compost preparation from the project.

The main compost materials, which were used during preparation, namely shoot of bamboo, water hyacinth (*Eichhornia crassipes*) and cowdung. The composition of materials in compost was half of plant materials and half of cowdung. The compost was prepared using pile compost technique on soil surface.

Pest control methods

Insect pest control is the most critical part of chemical free vegetable cultivation compared to conventional practices. Early application of organic pesticide is more important in chemical free vegetable cultivation to reduce pest attack. The project arranged training sessions to teach the farmers about organic pesticide preparation. The farmers used self-produced pesticides in the fields to control different types pests of cabbage, cauliflower and tomato. They mainly used neem (*Azadirachta indica*) extract, tobacco (*Nicotiana tab-*

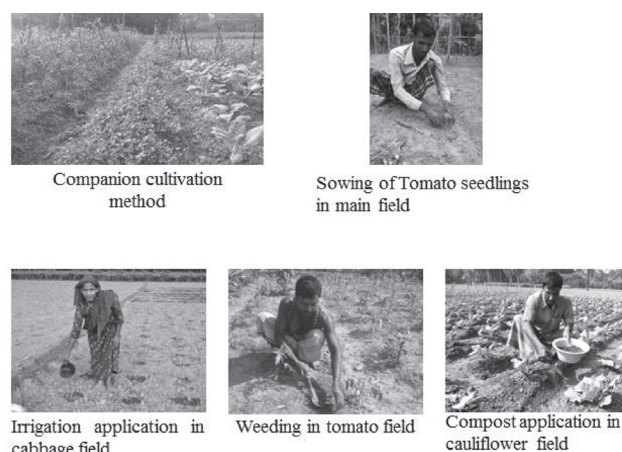


Fig. 2. Cultivation activities.



Fig. 3. Methods for pest control.

Table 1. Information of farming activities in winter season

Vegetable	Cabbage	Cauliflower	Tomato
Variety	K-K Cross	Shira Giku	Mintu Super F1
Seed Rate	0.05g/m ²	0.05g/m ²	0.025g/m ²
Spacing	Line to line: 60 cm Plant to plant: 45 cm		Line to line: 60 cm Plant to plant: 40 cm
Compost Application	Before sowing: 1 kg/m ² , 25 days after sowing: 0.5 kg/m ² , 40 days after sowing: 0.5 kg/m ²		
Pesticide Application	When infestation symptoms are seen in the field		
Border Crop	Coriander		
Weeding	2 times weeding after sowing		
Irrigation	Irrigation is applied based on field conditions		

acum) extract, garlic (*Allium sativum*) extract, dry ash and hand picking the insects in controlling pests. Fig. 3 shows different pest control methods.

RESULTS AND DISCUSSION

Farmers' interest and demographic characteristics

Number of farmers agreed to cultivate agrochemical free cabbage, cauliflower and tomato are shown in Table 2. Regarding the companion vegetable cultivation without chemicals all of the farmers were interested at Basundia, more than half of the farmers were interested at Kapasia and Ekhlaspur, however, the farmers in Manohardi and Mirzapur were not interested. Disagreed farmers in chemical free vegetable cultivation believed that companion cultivation without chemicals would requires more time and labor compare to its return. In addition, they felt that the production might be less

compare to conventional cultivation. However, the positive farmers especially in Basundia had some previous experience on agrochemical free cultivation with the support of several non-governmental organizations (NGO) and they would know the advantages of producing chemical free vegetables.

Table 3 shows demographic characteristics of total of 47 respondent farmers, where 87% were male and 13% were female. Many of the farmers were middle aged (belongs to 41– 50 category) and their main occupation was full-time farmer (94%). The farming experience of the farmers ranged between 11 and 40 years. About 66% of the farmers had primary education (Class 1 to Class 8 in Bangladesh called "Primary education" The Daily Star (2016)), while 11% farmers had no formal education (did not attended school, can only write name). From the above results, it is indicated that the educated and experienced farmers were agreed to culti-

Table 2. Farmers agree to cultivate artificial agro-chemicals free cabbage, cauliflower and tomato

Kapasia N=20		Ekhlaspur N=17		Basundia N=20		Manohardi N=11		Mirzapur N=20	
Number of Agreed	Agreed Percentage	Number of Agreed	Agreed Percentage	Number of Agreed	Agreed Percentage	Number of Agreed	Agreed Percentage	Number of Agreed	Agreed Percentage
11	55.0	10	58.8	20	100.0	1	9.1	5	25.0

Table 3. Demographic characteristics of agreed farmer to cultivate quality vegetables

Socio-economic Characteristics	Agreed	
	Number N=47	%
Gender Distribution		
Male	41	87
Female	6	13
Age distribution		
21–30	8	17
31–40	6	13
41–50	21	45
51–60	9	19
>60	3	6
Occupational Distribution		
Full-time farmer	44	94
Trading/Business	2	4
Service (Govt. and Private)	1	2
Farming Experience		
<10Years	7	15
11–20	24	51
21–30	8	17
31–40	8	17
Educational Background		
No formal education	5	11
Primary Education	31	66
Secondary Education	10	21
Above Secondary	1	2

vate veeteables without chmicals. Additionally, full-time farmer and middle aged farmers were agreed mostly to cultivate chemical free vegetables.

Production status

The vegetable cultivation in Bangladesh mainly depend on agricultural chemicals (Ahmed *et al.*, 2016). The yield of chemical free vegetables in five locations are shown in Table 4. In case of cabbage, the yields obtained in Manohardi, Mirzapur, Ekhlaspur and Kapasia were higher than conventional yield in Dhaka district reported by Zaman *et al.* (2010), while it was lower in Basundia. In case of cauliflower, the best yield was noted in Basundia followed by Manohardi, Ekhlaspur, Kapasia and Mirzapur, which was also higher compare to the yield in Dhaka district reported by Zaman *et al.* (2010). In case of tomato, the best yield was achieved in Ekhlaspur followed by Kapasia and Manohardi, Mirzapur, and Basundia. The yield of tomato achieved in Ekhlaspur was also higher compare to the yield in Dhaka district reported by Zaman *et al.* (2010). From the above comparison with conventional vegetables, it is indicated that the yield of cabbage was satisfactory compare to cauliflower and tomato. The yield of cabbage was better because the pest infestation is less in mature stage of cabbage while cauliflower and tomato suffer more pest infestation in mature stage especially after flowering (Ric B. 2011a, 2011b).

Economic performance of chemical free vegetable cultivation

The cost of production is the indicator of economically profitable vegetables and its technology of the culti-

Table 4. Area, Production of five areas with vegetables

Vegetable	Area (m ²)					Production (Kg)					Yield (Kg/m ²)					cf.Zaman et al. (2010) (Conventional)
	Kapasia	Ekhlaspur	Basundia	Manohardi	Mirzapur	Kapasia	Ekhlaspur	Basundia	Manohardi	Mirzapur	Kapasia	Ekhlaspur	Basundia	Manohardi	Mirzapur	
Cabbage	869.89	667.59	384.37	68.78	121.38	3,340	2,778	861	338	591	3.84	4.16	2.24	4.91	4.87	3.71
Cauliflower	869.89	647.36	1,476.79	68.78	1,092.42	2,082	1,744	6,057	200	2,284	2.39	2.69	4.10	2.91	2.09	2.97
Tomato	728.28	910.35	1,942.08	80.92	141.61	1,080	3,109	1,760	120	205	1.48	3.42	0.91	1.48	1.45	2.47

Table 5. Allocation of total production cost in percentages

Items	Cabbage					Cauliflower					Tomato				
	Kapasia	Ekhlaspur	Basundia	Manohardi	Mirzapur	Kapasia	Ekhlaspur	Basundia	Manohardi	Mirzapur	Kapasia	Ekhlaspur	Basundia	Manohardi	Mirzapur
Land Preparation (%)	2.49	10.40	6.65	2.80	6.02	2.52	3.44	2.77	2.78	6.24	2.33	10.91	5.00	2.23	3.69
Seeds/Seedlings (%)	2.38	4.62	7.99	10.50	7.53	2.41	5.89	19.51	9.25	6.55	2.33	5.09	7.61	5.36	6.14
Manure (%)	8.54	4.86	10.82	23.33	16.87	7.45	7.22	7.92	23.20	8.58	9.30	3.82	7.98	17.86	11.55
Irrigation (%)	2.38	11.10	3.33	4.67	4.52	2.41	6.88	2.83	4.64	2.06	2.33	10.9	2.50	6.70	2.46
Organic Pesticide (%)	3.82	1.16	3.99	3.73	0.90	3.86	1.72	2.84	3.71	0.78	4.65	0.91	2.50	3.57	1.23
Labor (%)	56.99	63.24	53.91	45.26	49.10	57.66	67.97	41.71	45.01	43.36	55.81	64.73	49.92	50.00	50.37
Land Lease (%)	23.40	4.62	13.31	9.72	15.06	23.68	6.88	22.43	11.37	32.44	23.26	3.64	24.49	14.29	24.57

Table 6. Production and total production cost of conventional vegetables in percentages (Zaman *et al.*, 2010)

Items	Yield (Kg/m ²)	Land Preparation (%)	Seeds/Seedlings (%)	Fertilizer (%)	Irrigation (%)	Pesticide (%)	Labor (%)	Land Lease (%)	Interest on Capital (%)
Cabbage	3.71	8.87	1.86	22.90	3.00	1.77	44.35	13.31	3.94
Cauliflower	2.97	7.06	10.59	29.16	3.53	3.53	35.29	7.06	3.78
Tomato	2.47	5.98	0.45	48.27	2.99	2.99	29.90	5.98	3.44

vation. Crop, varieties, time, place, and production technology have a great influence on cost of production. The cost of production of chemical free vegetables was categorized into seven major categories namely land preparation, seeds/seedlings, manure, irrigation, organic pesticides, labor, and land lease. Table 5 shows the allocation of total cost of production in five locations for cabbage, cauliflower and tomato. In addition Table 6 shows general total cost of production in Dhaka district which was reported by Zaman *et al.* (2010).

Among the categories the labor cost was highest, which consisted about 50% of the total cost of production of a single crop. According to Zaman *et al.* (2010), the labor cost of conventionally cultivated cabbage, cauliflower and tomato were 44.35%, 35.29% and 29.90%, respectively. The range of labor cost of cabbage (45.26–63.24%), cauliflower (41.71–67.97%) and tomato (49.92–64.73%) in five sites were higher compare to the labor cost reported by Zaman *et al.* (2010). The reason for higher labor cost in chemical free cultivation was the frequent application of chemical free pest control measures. The action of chemical free pest control measures are not long lasting as compare to chemical pesticides. Therefore, the control measures of pests in chemical free production were more labor intensive. This is the main reason to increase the cost of production in chemi-

cal free vegetable cultivation.

The price of agricultural products are largely depended on location, appearance and time of production. The chemical free vegetables were produced in the best suitable time of the winter season for minimizing the pest infestation. In case of conventional vegetables, farmers produced early vegetables to obtain better price. The appearance (shape, size, color, etc.) of the chemical free vegetables is ordinary compare to conventional vegetables. However, the income varied due to this price difference between chemical free vegetables and conventional vegetables. The people of Bangladesh is not yet ready to give more price for chemical free vegetables compared to that produced with artificial agricultural chemicals. Because there are no established certification process for raw vegetables which are produced without agricultural chemicals. Additionally, there is lack of awareness among people of Bangladesh about benefits of chemical free vegetables and consequences of consuming conventional vegetables.

The produced product under the project was 100% sold in the market of Dhaka and local market of five locations. The unit price difference in retail market of Dhaka and local market is significant which is important to get more income shown in Table 7. The majority percentage of the sale was done in local market which leads getting

Table 7. Per kg selling cost in Dhaka and local market

Vegetable	Total Sold in Dhaka Market (Kg)	Total Sold in Local Market (Kg)	Ratio of Dhaka Market Sales (%)	Ratio of Local Market Sales (%)	Total Revenue from Dhaka Market (Tk.)	Total Revenue from Local Market (Tk.)	Per Kg Revenue from Dhaka Market (Tk./Kg)	Per Kg Revenue from Local Market (Tk./Kg)
Cabbage	721	5,125	12.3	87.7	10,896	46,564	15.11	9.09
Cauliflower	562	11,605	4.6	95.4	7,703	82,221	13.71	7.08
Tomato	787	5,162	13.2	86.8	23,219	99,513	29.50	19.28

Table 8. Benefit–cost analysis of cabbage, cauliflower and tomato for chemical free vegetables

Location	Cabbage				Cauliflower				Tomato			
	Revenue (Tk./m ²)	Cost (Tk./m ²)	Benefit (Tk./m ²)	Ratio	Revenue (Tk./m ²)	Cost (Tk./m ²)	Benefit	Ratio	Revenue (Tk./m ²)	Cost (Tk./m ²)	Benefit	Ratio
Kapasia	26.14	26.18	−0.05	0.998	25.50	26.22	−0.72	0.973	31.88	29.52	2.36	1.080
Ekhlaspur	32.34	32.39	−0.05	0.999	28.40	20.21	8.19	1.405	65.47	30.21	35.26	2.167
Basundia	17.62	37.14	−19.52	0.474	20.48	23.25	−2.77	0.881	16.54	19.56	−3.01	0.846
Manohardi	33.56	31.70	1.86	1.059	30.24	31.33	−1.09	0.965	29.66	27.68	1.98	1.071
Mirzapur	33.38	82.06	−48.67	0.407	15.60	29.35	−13.75	0.532	37.99	57.48	−19.49	0.661

the less revenue (total selling amount without deducting cost) from cultivation of chemical free vegetables.

A cost–benefit analysis of agreed farmers (contracted farmer with the project) is displayed in Table 8. In case of cabbage, only Manohardi farmers were benefitted more among five locations. In case of cauliflower, only Ekhlaspur farmers were benefitted among five locations. However, in case of tomato, Kapasia, Ekhlaspur and Manohardi farmers were benefitted. Therefore, it is found that tomato cultivation might be positive for farmers to obtain more income by following cultivation method without artificial agricultural chemicals.

LIMITATIONS OF CHEMICAL FREE VEGETABLE CULTIVATION

Soil status of five locations

The land of Bangladesh are gradually losing soil fertility due to extensive use chemical fertilizer and insufficient use soil amendment for improving the soil. In Bangladesh, most of the cultivated soils have less than 1.5% organic matter, while a good agricultural soil should contain at least 2% organic matter. Moreover, this important component of soils is declining with time due to intensive cropping and use of higher doses of nitrogenous fertilizers with little or no addition of organic manure (Ali *et al.*, 2009). Soil organic matter is

decreased by chemical fertilizer application but increased with all types of organic manure (Ullah *et al.*, 2008). Soil nutrient conditions are much related to the production of the vegetables. The negative soil nutrient balance have found in the country and the net removal of major nutrients (N, P, K, S) are as high as ranges between 180 and 250 kg/ha/yr. (Hasan, M. K. and A. K. M. A. Alam, 2006). The chemical components of soil of the five locations showed that the nutrient amount is extremely low. Table 9 shows the results of the nutrient status.

In soils of project sites, the organic matter content (%) ranged from 0.61 to 1.41%. The highest organic matter content in soil was found 1.41% in Ekhlaspur and Basundia which is low compare to an ideal minimum value of organic matter (3%) (Akter *et al.*, 2012). The total nitrogen content (%) ranged from 0.031 to 0.071% in five project sites. The total nitrogen content (%) of different soil of Bangladesh ranged from 0.05 to 0.22% (Akter *et al.*, 2012). The highest total nitrogen content (%) in soil (0.071%) was found in Ekhlaspur and Basundia which is very low. The potassium content in different soil of Bangladesh ranged from 0.078 to 0.952 meq/100gram (Akter *et al.*, 2012). The potassium content ranged from 0.12–0.25 meq/100gram in five project sites, which was highest in Basundia (0.25 meq/100gram). The available Phosphorus in different soil of

Table 9. Soil nutrients status of five locations

Location	pH	Organic Matter (%)	Total Nitrogen (%)	Potassium (meq/100g soil)	Phosphorus (μg/g)	Sulphur (μg/g)
Ekhlaspur	6.8	1.41	0.071	0.12	65.58	0.99
Manohardi	5.5	1.34	0.067	0.18	41.08	0.49
Mirzapur	6.3	0.61	0.031	0.12	9.13	1.6
Kapasia	5.8	1.01	0.051	0.13	52.98	1.13
Basundia	6.8	1.41	0.071	0.25	92.82	25.89

Bangladesh ranged from 2.2 to 140 $\mu\text{g/g}$ (Akter *et al.*, 2012). The Phosphorus content ranged from 9.13–92.82 $\mu\text{g/g}$ in five project sites. The highest Phosphorus content was found 92.82% in Basundia. The sulphur content found ranged from 13.40 to 420.32 $\mu\text{g/g}$ in different soil of Bangladesh (Akter *et al.*, 2012). The range of sulphur content in five project sites is 0.49 to 25.8 $\mu\text{g/g}$ which is very low compare to the results of Akter *et al.*, 2012. From the above results, it is indicated that the soil nutrient status of five project sites is very low which affect the production of cabbage, cauliflower and tomato.

Nutrients supply during cultivation

The substandard soil conditions can be improved by using nutrient rich compost. However, the compost which was using by farmers of this project were inferior in nutrients compare to the standard compost mentioned by Roy *et al.* (2013). The nutrient concentrations of major organic materials used for the compost are shown in Table 10. The results indicated that there are differences in nutrient composition of the compost. The nutrient content of the compost materials is quite low as compared to the standard mentioned by Roy *et al.* (2013). This is evident in the growth response obtained in this winter season where compost applied in fields performed moderate than the conventional farming. The reason of limited nutrient composition of compost was the scarcity of composting materials.

Efficacy of homemade pest control measures

Homemade pest control measures means the preparation of different extracts or activities based on resources availability in farmers household. Homemade pest control measures are perfect to a limited extent to

Table 10. Compost status

Items	QVegic Compost Amount	Standard Compost Amount Roy <i>et al.</i> (2013)
Colour	Dark gray	Dark gray to black
Physical Conditions	Non granular form	Non granular form
Odour	Absence of foul odour	Absence of foul odour
Moisture	35.00%	15–20%
pH	5.5	6.0–8.5
Organic Carbon	6.89%	10–25%
Total Nitrogen (N)	0.92%	0.5–4.0%
C:N	7.5:1.0	20.0:1.0 (maximum)
Phosphorus (P)	0.49%	0.5–3.0%
Potassium (K)	0.70%	0.5–3.0%
Sulphur (S)	0.04%	0.1–0.5%
Zinc (Zn)	0.01%	0.1% (maximum)
Copper (Cu)	0.002%	0.05% (maximum)
Chromium (Cr)	24.22ppm	50ppm (maximum)
Cadmium (Cd)	2.59ppm	5ppm (maximum)
Lead (Pb)	3.56ppm	30ppm (maximum)
Nickel (Ni)	20.77ppm	30ppm (maximum)
Intert material	<1%	1% (maximum)

reduce pest populations significantly. Additionally, the effectiveness of pest control measures is varied from pests to pests. The control measures which were used in the farming were insufficient to control different types of pests. The production was moderate in winter season and that was the another major reason except substand-

Table 11. List of diseases infested in winter season

Vegetable	Diseases	Control
Cabbage & Cauliflower	Foot Rot	Remove infested plant, well drainage needed & seed treatment by garlic extract
	Leaf Spot	Garlic & neem extract spray
Tomato	Tomato Leaf Curl Virus	Rouge out infested plant, ashes application
	Yellow Mosaic Virus	Rouge out infested plant, ashes application
	Late Blight	Destroy infested plant, garlic & neem extract spray
	Early Blight	Destroy infested plant, garlic & neem extract spray
	Anthraco nose	Destroy infested plant or fruits, neem extract spray
	Wilting	Resistant variety, destroy infested plants

Table 12. List of insects infested in winter season

Vegetable	Insect	Control
Cabbage & Cauliflower	Diamond Back Moth	Hand picking, tobacco & neem extract spray
	Cut Worm	Hand picking
	Prodenia Caterpillar	Hand picking, garlic and tobacco extract spray
	Aphid	Garlic and neem spray
Tomato	Leaf Miner	Garlic, tobacco & neem extract spray
	White Fly	Yellow sticky trap using, garlic with soap solution spray
	Fruit Borer	Garlic and tobacco extract apply

ard soil and compost status. Table 11 and Table 12 show the list of diseases and insects infested during winter season.

Lack of awareness among consumers

Farmers got moderate price although they produced chemical free vegetables. The awareness among the consumers were inadequate about agricultural chemicals free vegetables. Besides, the majority of the population of Bangladesh has low income, so they are not willing to pay extra money for vegetables. Therefore, the market of Bangladesh is unready to accept chemical free vegetables.

Lack of continuous supply and established supply chain

Consumers aware about health and want to consume chemical free vegetables. However, it is extremely difficult to provide continuous supply because farming is mainly done by BOP farmer in limited land area. In addition, Bangladesh has limited supply chain for raw and perishable vegetables which are extremely expensive. Large scale commercial production may have a possibility to increase the opportunity of continuous supply and development of supply chain.

CONCLUSION

The cultivation of vegetables without use of agricultural chemical has positive prospect for generating income of BOP farmers in Bangladesh. A wide variety of vegetables can be grown to meet the increasing demands of the consumers. It is suitable for generating more income than conventional vegetable cultivation as the market competition among conventional vegetable producer is more challenging. Cost-benefit analysis of cabbage, cauliflower and tomato suggested that, the production of these vegetables is economically viable for the farmers. So successful business can be established by producing and marketing chemical free vegetables in Bangladesh. In the winter season, farmers can produce vegetables on a large scale in Bangladesh. Although, the supply chain of fresh vegetables is extremely limited in Bangladesh. The most challenging factor is that farmers are unwilling to produce chemical free vegetables due to uncertainty of returns from selling the products in Bangladesh. The findings from our research revealed that chemical free vegetable farming can be popular by using appropriate soil amendments, quality compost and organic matter. Results of this research based on only five different locations but the findings might be varied if the number of research locations would increase.

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