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HOW MUCH CAN SMALLHOLDERS IN BANGLADESH BENEFIT FROM SUMMER TOMATO CULTIVATION? AN APPLIED AGRO-ECONOMIC ANALYSIS OF ON-FARM DATA

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ABSTRACT

Cultivating summer (monsoon season) tomatoes in Bangladesh holds promise as a profitable enterprise with which farmers can augment existing cropping patterns, since only small amounts of land are required. Using on-farm production data collected from 18farmers in Jessore District,gross margin and other economic indicators were estimated. Results indicate that, with careful management implemented early in the crop season, small farmers can earn impressive profits if they harvest summer tomatoes at least twice (two fruiting stages). With an average gross margin equivalent to US$13,737 ha^{-1}, for example, a smallholder that owns or leases only 0.028 ha (approximately 7 decimals) could earn more than US$ 350. In addition a very high rate of return over investment (5.66) was calculated for farmers harvesting four times during the seven month cultivation period. Nevertheless, additional research remains to fine-tune farmers' management of the summer tomato crop in order increase profits further by lowering the costs associated with key inputs (e.g., more efficient hormone application), or by utilizing the inputs more effectivetly (e.g., timing the spraying of hormones to coincide fruitsetting with periods of high demand). Since summer grown tomatoes are also disease and pest risk prone, the development of effective integrated pest mangement strategies are also required in order to reduce the high level of chemical use observed.

Keywords: Agronomic management, Bangladesh, economic assessment, gross margin, marginal rate of return, profitability, summer tomato, tomato production

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INTRODUCTION

Widely grown throughout the world, the tomato plant (*Solanum lycopersicum*) produces a very popular and nutritious fruit that contains high levels of a vitamins A and C, as well as the carotenoid phytochemical lycopene-one of the most potent anti-oxidants known (Milind et al., 2011). According to FAOSTAT (2015), in 2013 tomato ranked 10th worldwide in terms of production value (US$ 59.9 billion) amongst all crops and was the 11th most-produced food commodity, with 164 million tones (t) produced. China was the largest producer in 2013, followed by India and the United States. Bangladeshi farmers produced only 251,000 t in 2013 (FAOSTAT, 2015), and are often reluctant to cultivate horticultural crops during the summer monsoon season (June to October) for fear of crop damage due to strong rains and wind, and localized flooding. This is especially true for tomatoes, the majority of which are produced in the winter season; for this reason, tomato production in Bangladesh lags behind anincreasing demandthat is driven by both the expanding population and rising incomes of urban consumers. The resulting scarcity in the market drives up the price (especially during the Eid holidays), making tomatoe production attractive to farmers – if only they are able to tackle various production constraints.

A key limitation to tomato production in Bangladesh during the summer season is that the setting of the fruits is interrupted at temperatures above 26/20° C (day/night), and can becompletely arrested above 38/27°C (Stevens and Rudich, 1978; El-Ahmadi and Stevens, 1979; Kuo et al., 1979). Additionally, Charles and Harris (1972) reported that fruit-setting of tomatoes requires night temperatures of 15-20°C, which do not prevail anywhere in Bangladesh during May to September. Within this context, the Horticulture Research Center of the Bangladesh Agricultural Research Institute (BARI) developed two heat-tolerant, hybrid tomato varieties (BARI Tomato 4; BARI Tomato5) released in 1996, and two hybrid varieties (BARI Tomato10; BARI Tomato13) released in 1998 (BARI, 2008). These deveopments resulted in the potential for cultivating tomatoes in new areas of Bangladesh throughout the year, with significant economic benefits available for those able to adopt the technology (especially small-scale farmers with limited land resources).

Summer tomato cultivation requires complex agronomic management that is reliant on relatively high levels of labor and material inputs, in addition to skill and knowledge. This research examines key production practices with a view to improving both yield and overall economic performance of the enterprise through efficient input usage, best-bet practices, and the timing of management decisions. It also assesses the economics of summer tomato cultivation in Bangladesh in terms of gross margin and benefit-cost analyses, derived from actual on-farm production and sales data collected from producing households. The remainder of the article is structured as follows: the next section provides a brief description of the production system, after which the study location and methods employed for the economic assessment are summarized. Results are then presented with associated discussion, while the closing section offers some conclusions and recommendations that can guide further study as well as improve the application of the summer tomato technology in farmers' fields.

MATERIALS AND METHODS

Basic details of the production system

The typical size of a summer tomato plot in the greater Jessore area is only about 10 decimals, or 0.04 hectare (ha). Farmers generally plant summer tomato seedbeds in mid-May before the advent of the monsoon rains, although some may plant up to mid-June; seedlings are typically transplanted into the field after one month of age. Raised beds are formed upon which farmers transplant the seedlings because the moisture level in the soil must be moderated to avoid water logging. The cultivation period can potentially last into February of the following year, but doing so prevents an alternative Rabi (winter) season crop to be grown. Therefore, many farmers tend to cultivate summer tomato up to December (six to seven months duration), during which time as many as four distinct fruiting periods may be realized.

In order to protect tomato plants from damage caused by intense precipitation events, farmers construct a framework made of bamboo poles and slats onto which a hoop-shaped roof of polyethylene is attached (at about 2 metres height). When the rainy season passes in late September, farmers remove the polythene roof to allow the tomato plants to continue trellising past the top of the structure. To provide support to the plants, and to avoid direct contactof fruit and foliage with the soil, a smaller bamboo trellis structure is placed within the larger superstructure. Staking can increase fruit yield and size; it also reduces the incidence of soil-borne diseases and makes pest control and harvesting easier.

Cultivation of tomato in the Bangladeshi summer faces several difficulties besides the risk of storm damage and extreme temperatures. Because of the unique climactic and soil conditions under which summer tomato is grown, the crop is more susceptible to pest and disease infestation than tomato grown during the cooler, dryer winter season. Key insect pests encountered include white flies (*Bemisia* spp.), which are capable of vectoring yellow tomato leaf-curl virus and which can be particularly problematic for the crop. Less significant, yet present, is a complex of Lepidopteran tomato fruit borer species including *Spodopera* spp.and *Helicoveroa* spp. The perception of farmers in terms of yield-loss risk is particulatly stronggiven their investment in the crop, however, and they therefore frequently resort to the use of insecticides to control pests. The problem is that the agro-chemicals employed, and their rates and frequency of application, are typically based on improper recommendations from dealers (Rashid et al., 2003), as well as calendar-based spraying intervals regardless of actual need. As such, one objective of this study is to assess the economic consequences of insecticide use in summer tomato production as as tarting point for building an appropriate and responsive framework for improved management in the future, one which optimizes cultural (rather than chemical) control, as with integrated pest management (IPM) principles.

Growth hormones are employed to ensure fruit setting under excessive temperatures. This is a key component of the production process and helps the farmer obtain larger fruit and higher yields; even under favorable growing conditions (15–25°C), hormone spraying can increase crop yields (Chen and Hanson, 2001). While insecticides can pose serious environmental and human health risks when used improperly, hormone application is relatively benign although it is potentially costly for farmers if not applied efficiently.

Study Area / Evaluation Metrics Employed

During 2011, the Cereal Systems Initiative for South Asia in Bangladesh project provided basic training to farmers in Jessore Sadar and Monirampur upazilas (i.e., subdistricts of Jessore District) in an attempt to scale-out, learn from, and refine summer tomato production. Subsequently, 18 of these farmers established summer tomato plots in the Arabpur union under Jessore Sardar upazila. These farmers agreed to provide detailed production information in order to analyse the constraints and opportunities presented by summer tomato; as such, the agro-economic data analyzed herein allow estimation of the economic profitability of summer tomato cultivation under actual field conditions. For the purposes of this study, the 18 farmers are stratified by the number of fruiting periods (flowering events) from which they harvested tomatoes during the course of the year: 7 farmers harvested fruits from all four flowering events possible; while 4, 5, and 2 farmers harvested respectively from 3, 2, and 1 fruit flowerings.

The economic analyses presented in this article are based upon the calculation of average returns from the yield and sales of tomatoes, and average cost values for all labour and material inputs, for all 18 farmers collectively and asstratified by the number of flowerings. Concurrent input-output market prices reported by the farmers were considered as the basis for the cost and return analysis; all monetary values presented in the article are converted to US dollars at an exchange rate of US$ 1 = 80 Bagladeshi Taka (BDT). All empirical data are presented on a per hectare basis, although it should be noted that the land area employed for cultivating summer tomatoes is typically very small (often 0.04 ha or less).

Benefit-cost ratios were calculated for each of the flowering stages, and collectively for all 18 farmers. Salvage values were considered for the material costs incurred for the construction of the bamboo infrastructure by assuming two years longevity of the basic inputs (e.g., polyethylene plastic sheeting, bamboo). Profitability was also estimated by calculating the gross margin (i.e., total revenue over variable cost) and the marginal rate of return. Data were analyzed using marginal analysis (MA) under a partial budgeting system. MA is the process of calculating marginal rates of return between treatments options (or different tillage options for machinery studies) by proceeding in steps from a lower cost treatment to that of the next higher cost, and comparing those rates of return to the minimum rate of return acceptable to farmers. The marginal rate of return (MRR) is the ratio of marginal gross margin (i.e., the change in net benefits) and the marginal cost (i.e., the change in net costs) expressed as a percentage. The MRR can easily be interpreted as the percent return to invested capital, after the capital has been repaid. Additionally, a comparative profitability assessment was made with respect to transplanted rainy season'*Aman*'rice (*T.Aman*), which is the primary crop grownduringthe late-summer/autumn cropping season during which summer tomato is cultivated.

RESULTS AND DISCUSSION

Cultivated area and input usage

Farmers planted seedlings during the period 17 May to 10 June 2011, using the BARI Tomato 4 variety on land that was 0.025 ha in size, on average (see Table 1); the range was 0.008-0.162 ha. Note that the average cultivated area was double (0.05 ha) for the seven farmers who continued harvesting through the fourth flowering; the average area was much less for the other 11 farmers.

The addition of compost at rates between 10-15 t ha^{-1} are typically recommended for summer tomato production. However, the farmers studiedapplied much lower rates, averaging 3.69 t ha^{-1}. Only three farmers approached or exceeded the minimum recommendation, while all others applied less than 4 t ha^{-1}. Urea, triple super phosphate (TSP), and murate of potash (MoP) were applied at the rates of 235, 536, 181 kg ha^{-1}, respectively, compared to the recommended doses of 550, 450, and 250 kg ha^{-1} for winter tomato production. Since no standard recommendations currently exist for fertility management for summer tomato, these results must therefore be interpreted with caution. Indeed, because the yield potential of summer tomato is typically lower than winter grown tomato, this adaptation is likely sensible to hedge against production risk given anticipated lower yields. There is clearly an urgent need for research to establish best-bet summer tomato soil fertility management practices across the gradient of soil types and environments in which it is currently being grown.

To control insects, viruses, and diseases, farmers frequently applied different types of insecticides and fungicides. The average number of sprayings for insecticides and fungicides were 19.1 and 21.9, respectively, which equals five and six times per month (respectively) during the fruit bearing period. In total, farmers applied six different types of insecticides- although Imidacloprid (10ml 200^{-1} *)*[trade name: Premier SL] was by far the most used in terms of quantity. Whereas 10 different kinds of fungicides are applied, Metalaxyl-M (4%) +Mancozeb (64%) [Ridomil Gold MZ 68 WG], Mancozeb (80%) [DithaneM-45], Quinalphos [Corolux 25 EC], and Propineb (600g kg^{-1})+Iprovalicarb (90g kg-^{1}) [Melody Duo 69 WP] were the most widely used.

There are possible alternatives to these chemicals that warrant further exploration by agricultural researchers in Bangladesh. White flies, and the transmission of yellow tomato leaf curl virus, are the most problematic issues for tomatoes early in the season. As such, some of the pesticides applied can be avoided entirely with the use of fine-mesh netting that can completely exclude arthropods from tomato seedbeds. The use of Neem *(Azadirachta indica)* extract to make less toxic alternatives to conventional insecticides may also be promising. Neem can be produced locally by farmers, but rarely at the volumes and concentrations needed to make such efforts profitable; commercial neem extracts may therefore be necessary. Work conducted by the Asian Vegetable Research and Development Centre (AVRDC) in similar regions of the tropics indicates that *Spodoptera spp.* and *Helicovera spp*. are effectively controlled by rotating neem application with conventional insecticides, in order to achieve dramatic reductions in the latter without a consequent impact on yield (Ramasamy, personal communication). However, commercial neem extracts are not currently available in southern Bangladesh, which creates a barrier for adoption unless research blended with advocacy and public-private partnerships can secure low-cost markets for this and similar biopesticide products.

The application of growth hormones is importantfor summer tomato production to ensure improved fruit set despite high temperature, sub-optimal growing conditions. Thus, hormones with trade names such as PGR King areutilized to promote and/or enhance fruit setting. All of the farmers applied PGR King, followed by Zoar, which was applied by approximately 55% of the farmers. Growth hormones account for 29% of the total cost of production, the largest share of all inputs (Figure 1). In comparison, Karim et al. (2009) found that summer tomato farmers in the Bagherpara area of Jessore District reported hormone use to be only approximately 10% of total costs. The difference is due to improper spraying techniques because the study farmers employed blanket-spraying of the plants instead of targeting individual flower buds, and suggests that, like the use of pesticides/fungicides, the study farmers are applying excessive amounts of hormones.

Harvesting and yield

Two months after tranplanting, farmers began harvesting the first flush of fruit from mid-July to early-August. Farmers collecting multiple flushes of fruit (FF) continued harvesting until the final days of December 2011. As shown in table 1, the average yield obtained was equivalent to 35.2 t ha^{-1}. The range varied from 2.7 t ha^{-1}, from a farmer that cultivated until August (with only one FF) because his crop was severely damaged due to disease infestation, to 66.5 t ha^{-1} obtained by one farmer who harvested four FF.

Economic performance

The average variable cost for summer tomato cultivation is equivalent to US$ 3,491ha^{-1}. Costs are relatively high for the hormone use in particular, as mentioned above, accounting for nearly a third of the total variable cost of production. There is thus an opportunity to reduce this cost by improving the application method; rather than spraying indiscriminantly, targeted application using locally-made equipment to direct the hormone can be implemented. Farmers can also be trained on the optimal timing of hormone applications. For example, they are best applied late in the day (Chen and Hanson, 2001), although most farmers were unaware of this. Additionally, sprayings can be timed to coincide fruit setting with major holidays and relegious festivals in Bangladesh, during which the price for tomatoes and other agricultural produce usually rises.

Insecticide (13%) and fungicides (13%) together comprise more than a quarter of all variable costs. As such, the integration of cultural control for insect pests, IPM, and knowing when it is profitable to intervene in pest control and when it is not, will likely reduce these costs substatially and increase net returns as a result. Labour comprised 12% of total costs, which is equivalent to 102 person-days per hectare, on average. The construction of bamboo sheds and internal staking (11%), seedling raising and transplanting (10%), and chemical fertilizers (8%) are the other significant variable cost components. Figure 1 illustrates the relative shares of the items comprising the total variable cost of production, while table 2 presents the underlying data in more detail.

The average gross margin was equivalent to US$ 13,737 ha^{-1} (Table 2). The range was US$ 936 ha^{-1}, on the low end (which was impacted by disease), to US$ 24,695 ha^{-1} for the most profitable farmer. The two farmers that harvested only one FF had proportionately much lower yields and lower gross margins than the rest of the farmers who continued harvesting multiple times (Figure 2). The average benefit-cost ratio (BCR) for all 18 farmers was calculated as 4.63, which indicates that the cultivation of summer tomatoes is highly profitable. Table 2 also reveals one of the key findings of this research: small farmers can earn impressive profits if they harvest summer tomatoes at least twice (two fruiting stages), which should be possible if careful management is implemented early in the crop season. Moreover, there isample scope to increase profit further by lowering the costs associated with some key inputs (e.g., more efficient hormone application), or by making better use of the inputs (e.g., spraying hormones at the right time to ensure fruits set at periods of high market demand and price).

Data were also analyzed using marginal analysis (MA) under a partial budgeting system, the results of which are presented in table 3. The FF Stage 2 gave the highest MRR on investment (3,359%), followed by FF Stage 4 (1,249%); MRR FF Stage 3 (245%) was the lowest. This analysis confirms the key finding mentioned in the previous paragraph (i.e.farmers will maximize the rate of return to their capitalif they harvest twice), and even adds a further dimension: if farmers decide to harvest more than twice, they would be better off harvesting four times instead of thrice. Note that such conclusions require further study to establish their validity and wider applicability, however, given the small sample size and the fact that the results are based on data fromonly one year (2011).

Since the main cropping pattern in the study area is *T. Aman* rice, followed by dryseason *Boro* rice (followed by a brief fallow period), a comparison with the principal competing crop during the rainy season, *T. Aman* rice, is justified. The estimated results are also presented in table 3, and show that the gross margin of summer tomato is 1,571% higher than *T. Aman* rice clearly demonstrating that summer tomato cultivation is much more profitable than growing the principal crop that it replaces (Razzaque and Rafiquzzaman, 2007). One does not expect farmers to convert all of their *T. Aman* area into summer tomato, however, because rice is the staple crop in Bangladesh and South Asia, and as such will always be important for maintaining food security. Nevertheless, the introduction of summer tomato on a small proportion of a farmer's field can provide an effective income generating crop for farmers having the proper land, knowledge, technical ability, and financial capital to adopt this cropping option.

CONCLUSIONS AND RECOMMENDATIONS

The results suggest that small holders who cultivate summer tomatoes can earn (on average) a profit equivalent to US$ 13,737 ha^{-1}, which indicates that devoting only 0.028 ha to summer tomato cultivation would allow adopting farmers to earn more than US$ 350 per year. While not every farmer is in a position to grow summer tomatoes (e.g. low-lying land is not suitable, start-upcostscan be prohibitive), this intesive cropping alternative remains within the reach of even very small holders that own 0.2 ha or less provided they receive the requisite training and the *sine qua non* investment capital, which will likely have to be supplied through micro-credit financing (e.g. from local NGOs) for farmers who are unable to cover initial costs themselves. For those that do adopt summer tomato cultivation, however, this income generating crop can help to diversify farm production and generate additional income for households otherwise reliant upon *T. Aman* rice in the rainy season; it thus appears to hold promise for large numbers of farmers, given suitable soil conditions, elevation, and access to inputs.

Much work still needs to be done to improve both the agronomic best practices and the economic efficiency of this crop, however. For example, in order to control insects and viruses, farmers had to frequently apply 16 different insecticides/fungicides 41 times in a season, which constituted approximately 26% of the total cost of production. This not only has an impact on the profitability of the enterprise, but it exemplifies the heavy reliance on pesticides for which the vegetable farmers of Bangladesh are known (Rashid et al., 2003). For the sake of farmer, consumer,and environmental health, summer tomato cultivators require IPM options that can offer alternative methods of insect control balanced with judicial use of insecticides and fungicides. Thus, an urgent need exists for research to develop economically viable IPM programs to overcome farmers' reliance on heavy pesticide use and adopt other pest control options. To develop approproate IPM recommendations, locally specific research solutions are required to integreate cultural control with biopesticides that are available in the country.

Finally, economic performance can be improved by simply utilizing a focused approach in terms of the application of growth-inducing hormones. With proper materials and attention to detail, farmers can reduce costs by applying hormones to individual tomato flowers through targeted spraying (with proper low-cost equipment) instead of the blanket spraying that they employed, which wasted much of the hormone. Simply changing to this technique, as well astraining farmers to produce their own hormones, provides another avenuefor these farmers to increase profits by reducing the amount of growth hormones used.

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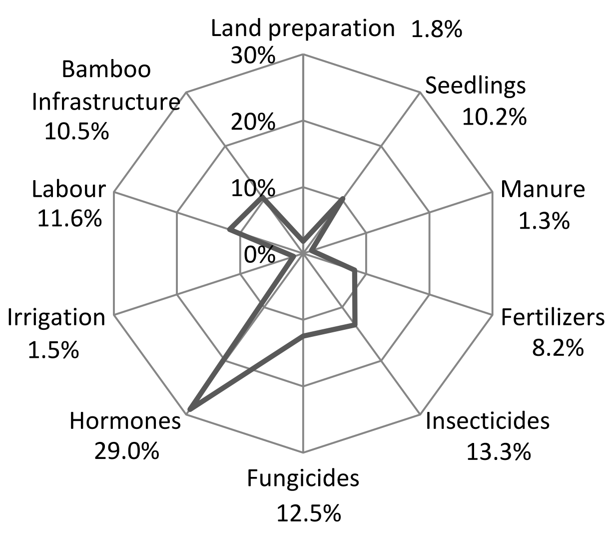

Figure 1. Share of different variable input costs for summer tomato cultivation.

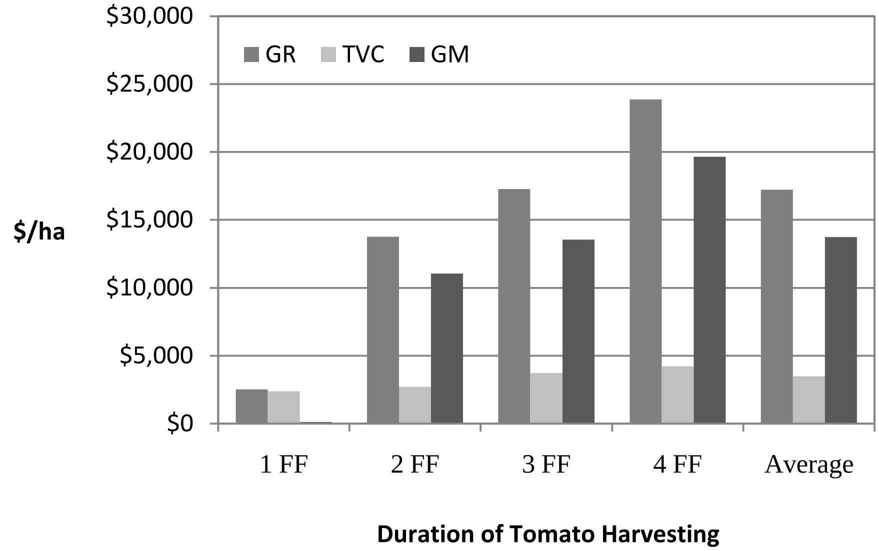

Figure 2. Gross revenue (GR), total variable costs (TVC), and gross margin (GM) of summer tomato cultivation by the number of fruit flowering (FF) events.

Table 1. Summer tomato agronomic data fromArabpur union, Jessore District (n=18)

Agronomic Practice / Information	Crop Duration				All (average)
	1 fruiting	2 fruitings	3 fruitings	4 fruitings	
Number (no.) of farmers	2	5	4	7	18
Avg. plot size (ha)	0.008	0.008	0.011	0.049	0.025
Avg. no. of plowings	3.0	3.0	3.3	3.4	3.2
Avg. no. of seedling used	49,400	48,412	48,165	47,727	48,201
Transplanting period	1-4 June	1-8 June	27 May-7 June	17 May-10 June	17 May-10 June
Avg. manure use (t ha^{-1})	2.16	3.73	4.23	3.79	3.69
Avg. basal fertilizer (kg ha^{-1}):					
Urea	124	136	142	105	124
TSP	247	346	367	309	325
MoP	124	222	235	137	181
Gypsum	247	296	337	296	300
Zinc sulphat	9.26	4.94	9.26	4.41	6.18
Boron	0	0	1.54	0	0.34
Furadan (kg ha^{-1})	0	0	0	11	4.27
Avg. top dress fertilizer, Urea	62	86	91	154	111
Avg. top dress fertilizer, TSP	93	173	259	245	211
Avg. no. of sprayings (Insecticide)	12.5	13.8	18.8	25.0	19.1
Avg. no. of sprayings (Fungicide)	12.5	16.0	18.0	31.1	21.9
Avg. no. of irrigations	2	3	5	9	5.6
Avg. no. of weedings	2	4	5	6	4.67
Human labour use (man-day)	85	80	86.5	124.5	101.6
Harvesting period	2 Aug.-29 Sept.	2 Aug.-15 Oct.	25 July-7 Nov.	15 July-30 Dec.	15 July-30 Dec.
Yield (t ha^{-1})	4.45	24.9	36.7	50.5	35.2

Table 2. Economic data and assessment of summer tomato cultivation (n=18)

Cost items	Crop duration				All (average)
	1 fruiting	2 fruiting	3 fruiting	4 fruiting	
Number offarmers	2	5	4	7	18
Land preparation (Tk ha^{-1})	4,298	4,950	5,131	5,378	5,084
Seedling cost (Tk ha^{-1})	29,023	29,023	28,559	27,791	28,441
Manure use cost (Tk ha^{-1})	2,161	3,730	4,230	3,787	3,689
Fertilizer use cost (Tk ha^{-1}):					
Urea	3,705	4,446	4,663	5,169	4,693
TSP	8,491	12,968	15,669	13,831	13,406
MoP	1,482	2,668	2,816	1,642	2,170
Gypsum	1,359	1,630	1,834	1,628	1,644
Zinc sulphate	1,389	741	1,389	662	926
Boron	0	0	278	0	62
Total fertilizer cost (Tk ha^{-1})	16,426	22,453	26,649	22,932	22,901
Insecticide (Tk ha^{-1})	37,050	37,066	30,011	41,495	37,218
Fungicide (Tk ha^{-1})	17,908	30,120	33,623	43,649	34,803
Hormone (Tk ha^{-1})	24,700	25,046	101,702	125,563	81,132
Irrigation cost (Tk ha^{-1})	1,482	2,865	3,952	6,251	4,270
Human labour cost (Tk ha^{-1})	27,170	25,688	30,875	39,843	32,510
Infrastructure cost (Tk ha^{-1}) [a]	30,875	36,144	33,963	21,169	29,250
Total variable cost (Tk ha^{-1})	191,093	217,085	298,695	337,858	279,299
Farmgate price (Tk kg^{-1})	45.9	41.9	40.3	32.7	40.2
Gross return (Tk ha^{-1})	201,429	1,100,385	1,382,274	1,910,700	1,378,265
Gross margin (Tk ha^{-1})	10,336	883,300	1,083,579	1,572,842	1,098,966
Total variable cost (US$ ha^{-1})	2,389	2,714	3,734	4,223	3,491
Gross return (US$ ha^{-1})	2,518	13,755	17,278	23,884	17,228
Gross margin (US$ ha^{-1})	129	11,041	13,545	19,661	13,737
Benefit-cost ratio	1.05	5.07	4.63	5.66	4.63

[a] Considers the salvage value

Table 3. Marginal analysis of summer tomato cultivation by number of fruit flushes, and profitability comparison of summer tomato (n=18) vs. *T. Aman* rice

Fruit Flushes (FF); No. of Farmers	**Gross Margin (US$ ha^{-1})**	**TVC (US$ ha^{-1})**	**MGM (US$ ha^{-1})**	**MVC (US$ ha^{-1})**	**MRR (%)**
1 FF; n = 2	129	2,389	--	--	--
2 FF; n = 5	11,041	2,714	10,912	325	3,359
3 FF; n = 4	13,545	3,734	2,503	1,020	245
4 FF; n = 7	19,661	4,223	6,116	490	1,249
Crop Comparison	**Gross Margin (US$ ha^{-1})**	**TVC (US$ ha^{-1})**	**Gross Return (US$ ha^{-1})**		
ST; n = 18	13,737	3,491	17,228		
T.Aman rice	581	450	1,031		
% Difference	2,264	676	1,571		

Note: TVC = variable costs; MGM = marginal gross margin; MVC = marginal variable costs; MRR = marginal rate of return. Source of T. Aman data (data year 2000) is Razzaqueand Rafiquzzaman (2007), which describes on-farm demonstration results of BR-23 plots at Borguna district in 2000; the data were adjusted for inflation to 2011 dollars by the authors of the present study.