Food Policy 61 (2016) 132–140

Contents lists available at ScienceDirect

Food Policy

journal homepage: www.elsevier.com/locate/foodpol

# Farmer training in off-season vegetables: Effects on income and pesticide use in Bangladesh

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ARTICLE INFO

*Article history:*
Received 12 February 2015
Received in revised form 9 March 2016
Accepted 14 March 2016
Available online 22 March 2016

*Keywords:*
Agriculture
Agricultural diversification
Impact evaluation
Propensity score matching
Inverse probability weighting

ABSTRACT

The cultivation of crops outside the regular cropping calendar when supply is low and prices are high can give farmers better profits and consumers more choice. However, off-season production may increase pesticide risk if crops are more affected by pests and diseases and farmers do not handle pesticides correctly. This study quantified the effect of training in off-season tomato production on the income and pesticide use of smallholder vegetable farmers in southwestern Bangladesh. The study uses farm-level data from 94 trained and 151 non-trained farm households and applies propensity score matching and inverse probability weighting to correct for selection bias. For the average smallholder vegetable farmer, training increased net household income by about 48%. We found that 31% of the trained farm households who had initially adopted the technology continued its use in the second year, but farm households who discontinued using the technology also experienced significant income gains from the training. There was a significant increase in pesticide use (+56%) and although there was an improvement in pesticide handling practices, trained farmers may have been more exposed to pesticide health risk. The policy implication is that while off-season vegetable production can create dramatic income improvements, it is important to emphasize safe and sustainable pest management methods as part of policies promoting it.


## 1. Introduction

Fruit and vegetables taste best when eaten in season. This is also when they are cheapest. This is good for consumers, but a problem for farmers, who would prefer producing and selling vegetables in the off-season—if they could. Modern technologies such as protected cultivation and specially bred varieties increasingly allow farmers to do this. These technologies can make an important contribution to the year-round availability of nutrient-rich food to consumers, and to the income of farmers. Yet high production costs and increased risk make income gains uncertain, while intensive pesticide use may pose a risk to farmers and consumers alike.

This paper explores the effect of off-season cultivation of tomatoes (*Solanum lycopersicum*) in southwestern Bangladesh. Off-season (also called counter-season) vegetable cultivation is the growing of vegetables under adverse climatic or economic conditions. The agricultural cropping season in South Asia is generally divided into two main seasons as determined by the South Asian monsoon. The *kharif* season—often referred to as spring, summer, rainy or simply monsoon season—is characterized by high temperatures, high rainfall and high humidity. Over 85% of the annual rainfall typically falls in this period, which generally lasts from May to November. Typical summer crops are rice, soybean, mungbean, and summer vegetables such as okra, amaranth, Indian spinach and gourds. The *rabi* season—also referred to as autumn or winter—has much cooler and drier conditions and lasts from November to March. Typical *rabi* crops are wheat, maize, potatoes, mustard, and winter vegetables such as cabbage, eggplant, and tomato.

Previous studies have suggested that farmers growing tomatoes during the *kharif* season have received high profits. Zaman et al. (2006) analyzed on-station data from experimental plots and showed that every dollar (USD) invested in off-season tomato production gave revenues of 3.3 dollars (benefit cost ratio). In comparison, growing tomatoes in the *rabi* season gave only a benefit cost ratio of 1.7 (Zaman et al., 2010). Karim et al. (2009) estimated the

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http://dx.doi.org/10.1016/j.foodpol.2016.03.002
0306-9192/

benefit cost ratio for off-season tomato production from on-farm data in Jessore district and estimated it to be 4.2. These estimates are based on data from experimental plots or from adopting farmers only, and thus are probably not representative for the average vegetable farmer. Furthermore, these studies did not estimate the profitability of a similar group of non-adopting farmers. To our knowledge, there has been no ex-post evaluation of off-season tomato production in Bangladesh, or elsewhere, that uses a valid counterfactual. In fact, few studies have been conducted on the impact of off-season vegetable production on incomes and pesticide use in developing countries, despite the rapid spread of these technologies (Kang et al., 2013; Nair and Barche, 2014).

To address this gap, this study aims to quantify the effect of training in off-season cultivation of tomatoes on the income of smallholder farmers and the intensity of pesticide use in Bangladesh. It also identifies challenges to off-season tomato production.

The paper starts by describing the intervention that is being evaluated. It then describes how data were collected and how the evaluation design minimized the confounding effects of selection bias and technology spillovers. After presenting the results, we discuss the limitations of the study as well as the implications of the findings for research and development of off-season vegetable production in Bangladesh and elsewhere.

## 2. Background

Agricultural production in Bangladesh is changing from a single focus on rice for food security to diversification with higher-value crops (FAO, 2011). According to Rahman (2009), crop diversification is the desired strategy for agricultural growth in Bangladesh. Many international donors have invested in crop diversification programs. Vegetables play a key role in these efforts, particularly for smallholder farmers, as average farm size has declined over time and higher returns per hectare are needed to improve the living standards of a growing population. Previous studies have shown that the adoption of improved vegetable technologies can lead to dramatic improvements in economic well-being (e.g. Weinberger and Genova II, 2005). Yet, Mahmoud and Shively (2004) noted that some have questioned the promotion of vegetables because of the environmental and health effects of high pesticide use. Tomatoes are the most important vegetable in Bangladesh after eggplant and potato (which is considered a vegetable in Bangladesh).

Most tomato varieties are not well adapted to hot and humid tropical conditions that characterize the *kharif* season. Flowers tend to drop under heat stress, thereby reducing fruit set and yield. High humidity and heavy rainfall can lead to more problems with pests and diseases, particularly fungal diseases and physiological disorders.

Since the early 1990s, the Bangladesh Agricultural Research Institute (BARI) in collaboration with AVRDC – The World Vegetable Center developed a technology package that includes heat tolerant tomato varieties (BARI Hybrid Tomato-4 being the most popular one), raised planting beds, low-cost rain shelters, hormone sprays to improve fruit set, and integrated crop management (pruning, staking, field sanitation, disease and pest management).[1] Unfortunately, BARI Hybrid Tomato-4 is susceptible to the whitefly-transmitted tomato yellow leaf curl virus. Farmers apply insecticides frequently in often-futile attempts to kill whiteflies and reduce tomato yellow leaf curl incidence. Various other insect pests are also abundant during the *kharif* season and motivate farmers to spray.

[1] BARI Hybrid Tomato-4 is a cross of AVRDC heat tolerant tomato lines CLN1621E and CL9-0-0-1-3 and was released in 2002.

In 2012, AVRDC selected 104 farmers (50 from Jessore district and 54 from Barisal district) and gave them two days of intensive training in off-season tomato production. Off-season tomato production is a complicated innovation because it requires a range of parallel changes to farmers' usual practices. The project implementers therefore targeted relatively progressive farmers who already had experience planting vegetables and an interest in off-season tomato, but who had not grown it before. It was expected that other farmers could observe and learn from them and adopt later on. The project targeted smallholder farmers with less than 2.5 acres (1 ha) of farmland.

Training topics included healthy seedling production (preparation of potting mixtures for raising seedlings, double transplanting, and use of plastic plug trays), cultivation techniques (field preparation, rain shelter construction and crop management), and pest and disease management through integrated pest management (IPM). Nearly all topics included hands-on practice sessions. Trainees visited existing off-season tomato farmers and tomato nurseries. After the training, farmers received 3 g of quality seed (BARI Hybrid Tomato-4) and partial input support for the purchase of plastic sheets, bamboo, jute and nylon ropes, plant growth regulators (hormones), nets, fertilizers and pesticides to an equivalent of 10,000 Taka (USD 130). These inputs were enough for growing 2 decimals (81 $m^2$) of off-season tomato, though farmers were free to plant a larger acreage if they wanted. Farmers received no regular support in the second year; data from that year were therefore used for this study.

After the training, project staff visited most farmers nearly every week during the *kharif* season to provide technical assistance. When farmers had problems with pests and diseases, the project staff would come and advise them how to deal with it. Most farmers had cellphones and could easily contact project staff for advice. Trained farmers were encouraged to share their knowledge and skills with their peers.

## 3. Material and methods

### 3.1. Selection bias

This study evaluates impact using observational data for trained and non-trained farmers. Selection bias is the main concern when using observational data. There are two sources of selection bias. The first is self-selection bias, which occurs when farmers with favorable characteristics self-select into the training program. This was not an issue in our study because the project implementers, not the individual farmers, decided whom to invite for the training. The second source of selection bias is program placement bias. This is a potential source of bias in our study because project implementers purposively selected relatively progressive farmers with experience in planting vegetables and an interest in off-season tomato. Farmers selected for the training are therefore likely to have characteristics that could allow them to be more successful in using the technology than the average vegetable farmer. It would therefore be incorrect to directly compare trained farmers to a randomly selected group of non-trained farmers. We minimized the effect of program placement bias through the control group selection procedure and the use of propensity score estimators.

The first was achieved by applying exactly the same criteria to select control farmers as had been used to select training participants. The enumerators did a random walk in each of the ten villages to select 4–5 farmers from each quarter of the village. These farmers were asked for their help in making a list of other farmers who met the selection criteria of being vegetable growers, having no previous experience in off-season tomato, and having