Reducing Imbalanced Fertilizer Use Through Rule-Of-Thumb Instructions in Bangladesh

Researchers:

Sabrin Beg

Mahnaz Islam

Sector(s): Agriculture

J-PAL office: J-PAL South Asia

Fieldwork: Centre for Development Innovation and Practice (CDIP)

Sample: 1440 households

Initiative(s): Agricultural Technology Adoption Initiative (ATAI)

Target group: Farmers

Outcome of interest: Pollution Technology adoption

Intervention type: Extension services Fertilizer and agricultural inputs Information Training

AEA RCT registration number: AEARCTR-0002062

Dados: Dataverse

Research Papers: 'Rule-of-Thumb' Instructions to Improve Fertilizer Management: Experimental Evi...

Partner organization(s): USAID Development Innovation Ventures, Gates Foundation, Bangladesh Department of Agricultural Extension, UK International Development, mPower Social Enterprises, Pathways in Bangladesh

Fertilizer use has been promoted to boost agricultural productivity and increase farmers' yields and income. However, the incorrect use of chemical fertilizers can negatively affect yields and harm the environment. Researchers conducted a randomized evaluation among rice farmers in Bangladesh to evaluate the impact of providing leaf color charts and basic training on the quantity and timing of fertilizer use and crop yields. Researchers found that fertilizer use declined while yield moderately increased for farmers. They suggest that these results were driven mainly by farmers' decision to delay the application of fertilizer until later in production because returns to urea application are lower earlier in the planting cycle.

Policy issue

Fertilizer use has been promoted to boost agricultural productivity and increase farmers' yields and income. However, the incorrect use of chemical fertilizers can negatively affect yields and harm the environment. Fertilizer that is overused or applied at the wrong time cannot be absorbed by the plants and can leach from soil to surface or ground water raising toxicity levels in water supplies or deposing into nitrous oxide and carbon dioxide, common greenhouse gases. On the other hand, failure to apply adequate amounts of fertilizer at the right times deprives crops of necessary nutrients and can negatively affect yields.

Effective fertilizer management through optimal quantity and timing of fertilizer application can minimize waste, lowering direct fertilizer expense and the associated environmental costs, and can also improve productivity by ensuring nitrogen is available when it is most beneficial for plant growth. Innovative technologies, which provide farmers with plot-specific information on when

to apply nitrogen fertilizers, offer a simple solution to fertilizer overuse, but many farmers have not adopted them yet. Can providing farmers with an innovative tool and information on the crop's need for fertilizer help them to adopt improved farming practices and apply fertilizer in a more targeted way?

Context of the evaluation

Bangladesh has a large agricultural sector which contributes to 21 percent to its GDP and employs about 50 percent of the country's labor force. Rice is the dominant crop, accounting for about 70 percent of direct caloric intake in the country and employing about 13 million agricultural households in its cultivation. As a result, improving yields has been a constant priority. Average rice yields in Bangladesh have grown from 0.76 tons per acre in 1970 to 1.9 tons per acre in 2012. The increase occurred mainly due to the use of high-yielding varieties that require higher levels of fertilizers and a considerable increase in irrigation. Fertilizer usage has thus increased by 400 percent in the last 30 years. Heavy government subsidies to induce fertilizer adoption and stimulate agricultural output have also led to inefficient application and overuse of fertilizer in Bangladesh, resulting in higher than necessary costs to farmers and negative consequences for the environment.

Urea, a nitrogen-based fertilizer, is the most widespread fertilizer in Bangladesh. Compared to other fertilizers, urea is particularly challenging to use, as the timing of the applications is crucial to respond to nitrogen deficiencies at critical times in the production process. At this time, farmers can identify the crop's nitrogen requirements by the color of its leaves. Rice farmers from the eight districts of Bangladesh (Brahmanbaria, Chandpur, Comilla, Gazipur, Lakhipur, Munshiganj, Naranganj, and Noakhali) that were included in this study reported using urea fertilizer in their production prior to the intervention. Farmers on average used about 1.01 kilograms of urea and harvested between 25 and 26 kilograms of rice for every forty square meters of land. Farmers also cultivated 2.4 plots of land and had just below six years of schooling.



A farmer uses fertilizer on a rice paddy field in Bangladesh.

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Details of the intervention

Researchers partnered with the Centre for Development Innovation and Practices (CDIP) to test the impact of leaf color charts (LCCs) on farmers' fertilizer use and crop yields. The sample consisted of 1,440 farming households across 105 villages, with one-third of participants being CDIP microfinance clients and the remaining two-thirds drawn from households residing in villages with a CDIP school. Half of the households in the sample were randomly assigned to participate in the program, while the remaining farming households served as the comparison group.

At the beginning of the 2013 planting season, the primary farmer from program households was invited to participate in a training session organized and conducted by CDIP staff and extension agents from the Ministry of Agriculture's Department of Extension. During the session, each farmer received a leaf color chart (LCC), a tool to indicate whether and at what times fertilizer should be applied to rice plants, and instructions on how to use it. An LCC is a plastic, ruler-shaped strip containing four panels that range in color from yellowish green (nitrogen deficient) to dark green (nitrogen sufficient). By comparing the leaf color with the chart, a farmer can determine whether a plant is nitrogen deficient and whether he needs to apply nitrogen-based fertilizer. At the time of the study, each LCC cost about US$1 and was expected to last for multiple seasons.

The training session focused on basic 'rules-of-thumb' on when to check leaf colors, when to apply fertilizer, and how much to use at each application. Specifically, farmers were instructed to begin fertilizer application 21 days after planting when the crop benefits the most from urea fertilizer and to stop applying fertilizer once the crops have flowered. CDIP staff also conducted home visits to provide the LCC and instructions to farmers who did not attend the in-person training.

Researchers conducted baseline surveys with rice farmers prior to the intervention in September and October 2012 and final surveys between June and August 2013 after the intervention was completed. Researchers collected data on whether farmers waited for the recommended 21 days to apply urea, whether they stopped applying urea after the crops had flowered, and any changes in the frequency of application and quantity of fertilizer in addition to crop yields.

Results and policy lessons

Farmers who were offered the training and received an LCC applied less fertilizer and waited longer to apply fertilizer than farmers in the comparison group. Program farmers were therefore more likely to follow the general recommendations for fertilizer applications, reducing the potential for fertilizer overuse.

Timing: Program farmers were more likely to have waited until 21 days after planting to start fertilizer application: About 15.9 percent of program farmers waited 21 days, compared to 11.9 percent of farmers in the comparison group. Results suggest that program farmers were less likely to apply fertilizer at this period, therefore not wasting resources.

Quantity: Program farmers decreased the amount of fertilizer used per application by 0.03 kilograms per forty square meters of land. On average, farmers reduced the amount of fertilizer used by 8 percent relative to the comparison group. Considering that farmers cultivated around 2.4 plots of land each, program farmers saved about 5.2 kilograms of fertilizer on average.

Yield: Program farmers increased their rice yield by about 1.8 kilograms per forty square meters of land. For farmers with an average plot holding, this meant an increase in revenue of about US$ 22.30. Researchers interpret the increases in yields as suggestive evidence that overall productivity improved. A possible explanation could be that farmers shifted fertilizer application to a period in the planting cycle where applying fertilizer had a high return, which allowed them to use less fertilizer overall.

Cost-effectiveness: Researchers found that the program was cost-effective when applied over two or more seasons. Based on researchers' estimates, assuming no change in yield, every US$1 spent on the intervention would generate a return of US$1.80

through urea savings over two seasons and US$2.80 over three seasons.

Overall, results suggest that overuse of urea can occur, and urea savings can be achieved without compromising productivity. Quantity and timing need to be considered in fertilizer use, challenging traditional notions that quantity is the sole determinant.