Research protocol: On farm field trials to improve mungbean productivity through fertilizer management

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Background

Mungbean is an important pulse crop in Bangladesh, where it is primarily grown in the south by small and marginal farming households who produce two-thirds of the total national mungbean crop. Mungbean is a short-duration crop which requires only 60-65 days from planting to harvest. It is typically grown between February and May with few inputs or intensive management, and is thus growing in popularity in southern Bangladesh.

Yields of mungbean grown in farm fields are typically lower than those observed in research trials, largely because farmers apply little or no chemical fertilizer (certainly less than is recommended by government agencies). This reflects farmers' general risk aversion, difficulty accessing appropriate fertilizers, and also increases in fertilizer prices as a result of international challenges in supply. Another potential option to improve mungbean yields is the inoculation of seed with rhizobium prior to sowing. This practice has been shown by the Bangladesh Agricultural Research Council (BARC) to produce high mungbean yields in Bangladesh without the addition of nitrogen fertilizer by accelerating biological nitrogen fixation (the addition of recommended doses of non-nitrogen fertilizers are still recommended). However farmers' use of rhizobium has so far been limited due to lack of awareness of the benefits of its use, and ability to store it suitably prior to use. Additionally, there has been little work in Bangladesh on the response of rhizobium inoculum in mungbean cultivars.

Mungbean is typically grown following wet-season (kharif II) rice cultivation and, over a number of years, mungbean may help to improve soil quality by fixing nitrogen within the soil and improving a soil's physical, chemical and biological properties. Nevertheless it is likely that additions of fertilizer and/or rhizobium in mungbean crops will improve farmers' overall cropping system yields, and potentially, profits.

Under Work Package 1 of the CGIAR Asian Mega Deltas Initiative, CIMMYT is conducting on-farm trials in southern Bangladesh over two years to improve mungbean yields through improved fertilizer management practices and thus to improve the productivity and profitability of rice-mungbean cropping systems. This protocol describes the field trials which are being conducted.

Objectives

To undertake on-farm research to quantity differences in yield, costs of production, and gross margins between four different treatments comparing farmer fertilizer rates with and without the addition of rhizobium inoculation, and BARC-recommended fertilizer rates with and without the addition of rhizobium inoculation.

Research Questions

Research questions asked in this study are:

1. **Is there a significant change in farmers' mungbean yields between current farmer practice and BARC-recommended fertilizer?**
2. **Is it profitable for farmers to use BARC-recommended fertilizer rates in mungbean cultivation?**
3. **Is rhizobium inoculation of mungbean seed an effective method of increasing yields?**
4. **Is it profitable for farmers to inoculate mungbean seed with rhizobium?**
5. **Is it practical for farmers to inoculate mungbean seed with rhizobium?**
6. **What are the limiting and/or enabling factors affecting the wider adoption of either BARC-recommended fertilizer rates or rhizobium seed inoculation in southern Bangladesh?**

Methodology

Location

Field trials were conducted in two upazillas, Kazirhat and Adabaria, of the Patuakhali district of Barishal in southern Bangladesh. Mungbean cultivation is relatively intensive in these upazillas and the rice-mungbean cropping system is the most widespread in the farming community. Fifteen farmers were selected from each upazila, for a total of 30 farmers participating in the trial.

Mungbean variety

The BARI mungbean 6 variety is widely grown in southern Bangladesh and has been used in this trial. The seed rate is calculated following advice provided by the Bangladesh Agricultural Research Institute.

Experimental treatments

Four experimental treatments have been identified as follows:

T1: Farmers' fertilizer practice with no rhizobium inoculation of mungbean seed (control)

T2: Farmers' fertilizer practice with rhizobium inoculation of mungbean seed

T3: BARC-recommended fertilizer with no rhizobium inoculation of mungbean seed

T4: BARC-recommended fertilizer with rhizobium inoculation of mungbean seed

T4 differs from T3 as BARC recommends no synthetic nitrogen fertilizer be applied when seed is inoculated with rhizobium. In this instance BARC further recommends the addition of non-nitrogenous fertilizers.

Experimental layout

Each farmer is considered as an experimental replicate, testing the four fertilizer and management treatments identified above.

Each treatment occupies approximately 10 decimals (400 m^2) land, with spacing of at least 50 cm between treatment plots. Each experimental replicate (i.e. land required from each farmer) occupies at least 40 decimals (just over 1,600 m^2) land (Figure 1).

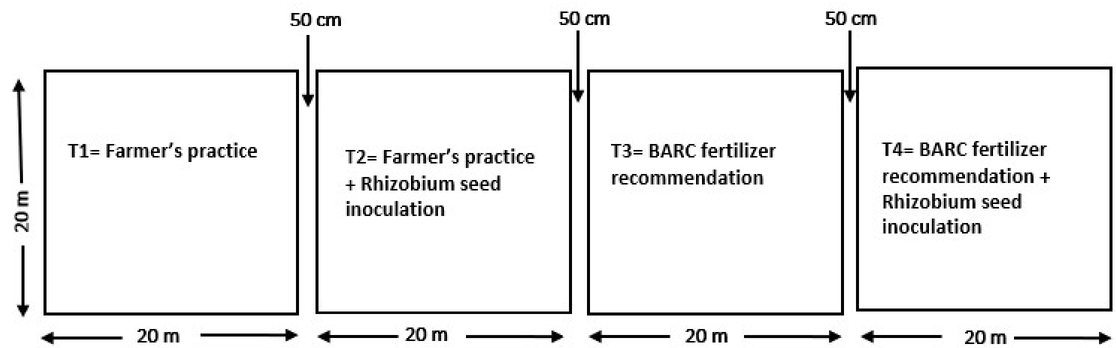

Figure 1. Experimental layout

Fertilizer

Fertilizer rates for experimental treatments T3 and T4 are calculated using BARC fertilizer recommendations for southern Bangladesh. Fertilizer is applied as shown in Table 1.

Table 1: Fertilizers applied in each experimental treatment

Treatment	Nitrogen ($kg\ ha^{-1}$)	Phosphorus ($kg\ ha^{-1}$)	Potassium ($kg\ ha^{-1}$)	Sulfur ($kg\ ha^{-1}$)	Zinc ($kg\ ha^{-1}$)	Boron ($kg\ ha^{-1}$)	Rhizobium ($g\ kg\ seed^{-1}$)
T1	FP[1]	FP[1]	FP[1]	FP[1]	FP[1]	FP[1]	0.0
T2	FP[1]	FP[1]	FP[1]	FP[1]	FP[1]	FP[1]	50.0
T3	15.0	15.0	20.0	10.0	1.5	1.0	0.0
T4	0.0	15.0	20.0	10.0	1.5	1.0	50.0

[1] FP: farmer practice

Fertilizers in T1 and T2 are applied according to farmers' standard practice for amounts and timing. These are recorded as part of experimental data collection.

All fertilizers in T3 and T4 are applied basally during final land preparation.

Weed data collection

Information on weeds is collected from two 0.5 m × 0.5 m = 0.25 m^2 subplots within each treatment at 35 days after sowing (Figure 2). In each treatment, sampled weeds are separated into grasses, sedges and broad leaves, and the fresh biomass weight is recorded.

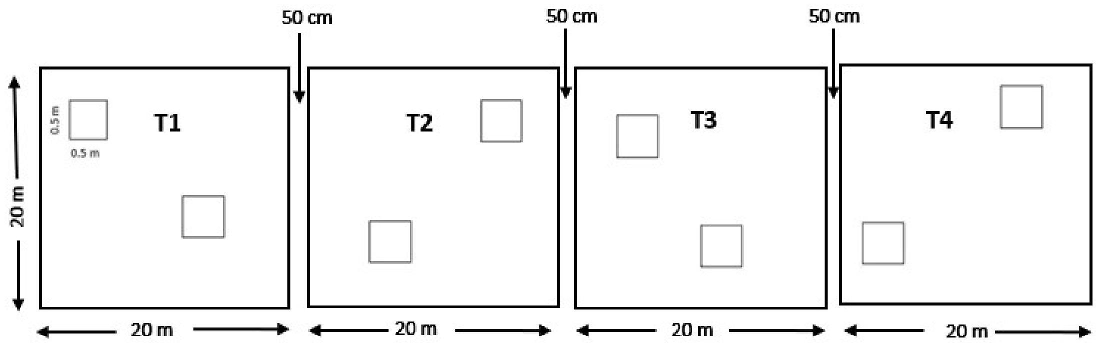

Figure 2. Weed data collection sampling layout

Management practices

Management practices are common across all treatments, except fertilizer application, and are as recommended by BARC.

Survey data collection

Farmers are surveyed to record fertilizer information in T1 and T2, and initial economic data in order to calculate cost of production and gross margins. The following data are recorded:

- Farmers' personal information (name, mobile number, address)
- Field GPS location
- Mungbean seeding rate
- Mungbean seed cost
- Date of sowing
- Number of tillage events
- Total cost of tillage events
- Amount of fertilizer used in T1 and T2 treatments
- Price of all fertilizers
- Number of weeding events
- Cost (if any) of weeding
- Pesticides applied (if any)
- Cost (if any) of pesticides

Crop cuts

Mungbean crops are harvested when pods begin to darken from bright green. They are mostly hand-picked at weekly intervals. Between one and three pickings are achieved, largely depending on weather conditions and, to a lesser extent, available labor. To estimate crop yield three sub-samples are collected from each treatment, from sub-sample crop cut areas of $1m^2$ (Figure 3). Yield samples from all plots are collected away from treatment borders, with two samples nearer to opposite sides of the treatment plot and one from approximately the middle of the plot.

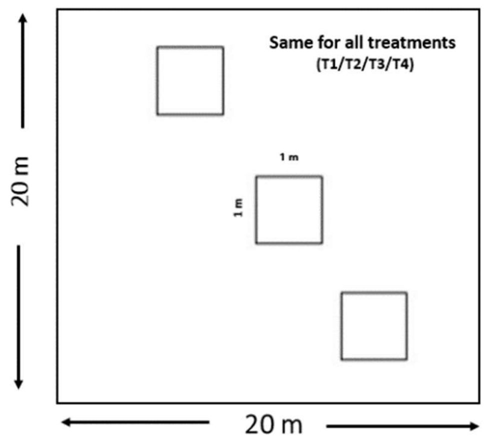

Figure 3: Crop-cut sampling and sub-sampling layout

Crop cut data collection

The following data will be collected from each treatment:

- **Plant stand count**
- **Fresh weed biomass**
- **Plant height**
- **Date of first, second, third pickings (as appropriate)**
- **Farmers' estimate of harvest loss due to adverse climatic conditions**
- **Grain yield**
- **1000 grain weight**
- **Fresh weight of plant biomass**
- **Mungbean market price at harvest**

Expected outputs

These field trials will provide replicated agronomic and economic data over two years on mungbean productivity under three experimental treatments relative to the farmer practice control. The replicated experimental data from two experimental seasons will be analyzed to assess if there are significant differences in mungbean productivity and profitability between treatments

Expected Outcomes

Analyses will be used to inform farmers, government agencies and donors of the benefits, trade-offs and risks of mungbean cultivation in southern Bangladesh, and to identify ways in which smallholder farmers can be supported at scale to increase household food, nutrition and economic security.

Experimental research results will be published in an international, peer-reviewed journal paper.

Proper citation:
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