Simple and effective management methods that can improve soybean production in Bangladesh

Kh. Shafiqul Islam, Md. Mubarak Ali, Sumona Shahrin, Stephanie Cheesman, Syed Nurul Alam and Timothy J. Krupnik
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¹ International Maize and Wheat Improvement Center (CIMMYT), House 10/B, Road 53, Gulshan-2, Dhaka 1212, Bangladesh
² Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur-1701, Bangladesh
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Tel (landline/fax): +880 2 989 6676, +880 2 989 4278
Postal address: PO Box 6057, Gulshan, Dhaka 1212, Bangladesh
For more information by email: t.krupnik@cgiar.org

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CSISA was established in 2009 with the goal of benefiting more than eight million farmers by the end of 2020. The project is led by the International Maize and Wheat Improvement Center (CIMMYT) and implemented jointly with the International Food Policy Research Institute (IFPRI), the International Water Management Institute, and the International Rice Research Institute (IRRI). Operating in rural ‘innovation hubs’ in Bangladesh, India and Nepal, CSISA works to increase the adoption of various resource-conserving and climate-resilient technologies, and improve farmer access to market information and enterprise development. CSISA supports women farmers by improving their access and exposure to modern and improved technological innovations, knowledge and entrepreneurial skills. CSISA works in synergy with regional and national efforts, collaborating with myriad public, civil society and private sector partners.

CSISA’s goals are to:

- Facilitate widespread adoption of resource-conserving practices, technologies and services which increase yields with lower water, labor and input costs.
- Support mainstreaming innovations in national-, state- and district-level government programs to improve long-term impacts achieved through investments in the agricultural sector.
- Generate and disseminate new knowledge on cropping system management practices that can withstand the impacts of climate change in South Asia.
- Improve the policy environment to facilitate the adoption of sustainable intensification technologies.
- Build strategic partnerships that can sustain and enhance the scale of benefits accrued through improving cereal system productivity.

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The significance of soybean

Soybean (*Glycine max* (L.) Merrill) accounts for approximately fifty percent of the total production of global oilseed crops. It has exceptional nutritional value, provides the richest source of protein of any crop (similar to levels found in cow’s milk and meat, fish or poultry) and is able to serve as the core protein supplement to human diets. Soybean, including processed soybean products like tofu, constitutes good nutritional quality for adult humans, containing a high amount of protein (40%–50%), lipids (20%–30%) and carbohydrates (26%–30%), with more than eighty-five percent of its protein content made up of β-conglycinin and glycinin. The USDA reports much lower levels of protein (13%), lipids (6.8%), carbohydrates (11%) and dietary fiber (4%) in raw green soybeans but higher levels in mature raw soybean seed (36.5%, 20%, 30% and 9% respectively). Soybean is abundant in essential fatty acids, including saturated, monounsaturated and polyunsaturated fatty acids, and contains beneficial secondary metabolites such as isoflavones, phenolic components and saponins. A good source of low-cost protein and other nutritive factors for humans as well as for use in poultry feed, soybean is thus a valuable crop for both developed and developing nations. In addition, it is rich in phosphorous and calcium, while its oil component contains vitamins (in particular A and D) and lecithin, a crucial fatty acid.

Soybean oil has gained popularity in modern day cooking in Bangladesh. However, as its extraction from soybean seed is not yet possible using traditional methodologies, most of the soybean that the country produces is used predominantly in the feed industries, and any soybean oil in the market is imported.

Worldwide, the total annual production of soybean is 365.79 million tons from an area of land totaling 130.90 million hectares. In Bangladesh, total annual production is 96,921 tons from a cultivated area of 62,870 hectares – at 1.54 tons/ha, this is much lower than the world average of 2.79 tons/ha. Much neglected until just a couple of years ago, soybean is gradually gaining popularity as a cash crop, especially among farming households in the country’s southern belt (Noakhali, Lakshmipur and Bhola districts). The socio-economic condition of these farming communities could be potentially enhanced through the establishment of small soy-based food manufacturing industries, producing milk, curd (yoghurt), flour/breads, meat, *halwa*, biscuits and assorted snacks, all from soybean.

In Bangladesh, there are ample opportunities to increase both the area and productivity of oilseed crops such as soybean because of the availability of short-duration improved varieties and suitable agro-climatic conditions. At the same time, at the production and post-harvest processing levels there is some potential for mechanical interventions. These might enhance current oilseed production and processes and allow farmers to earn more from soybean cultivation.
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Table 1: Soybean varieties currently cultivated in Bangladesh and their salient features\(^9,10\). Source: [http://dhcrop.bsmrau.net/soybean/](http://dhcrop.bsmrau.net/soybean/); [http://www.bina.gov.bd/](http://www.bina.gov.bd/).

<table>
<thead>
<tr>
<th>Name of variety</th>
<th>Year of release</th>
<th>Yield (tons/ha)</th>
<th>Days to maturity</th>
<th>Reaction to disease</th>
<th>Released by (organization)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sohag (PB-1)</td>
<td>1990</td>
<td>1.6–1.8</td>
<td></td>
<td>(1^r: 100–110 ) (2^k: 90–100)</td>
<td>BARI, BAU and MCC (joint collaboration)</td>
<td>Large seed size, bright yellow colour</td>
</tr>
<tr>
<td>BARI Soybean-4(G-2)</td>
<td>1994</td>
<td>1.6–2.5</td>
<td>(1^r: 105–120)</td>
<td>(2^k: 85–90)</td>
<td></td>
<td>Small seed size, greenish yellow colour</td>
</tr>
<tr>
<td>BARI Soybean-5</td>
<td>2002</td>
<td>1.8–2.0</td>
<td>90–100</td>
<td>n.a.</td>
<td>BARI</td>
<td>Semi-dwarf plant, large seed size, cream colour; grown across the country in both seasons (kharif-2 and rabi)</td>
</tr>
<tr>
<td>BARI Soybean-6</td>
<td>2009</td>
<td>2.0–2.2</td>
<td>100–110</td>
<td>YMV-tolerant</td>
<td></td>
<td>Large seed size, cream colour</td>
</tr>
<tr>
<td>Binasoybean-1</td>
<td>2011</td>
<td>2.4–3.0</td>
<td>(1^r: 105–110)</td>
<td>(2^k: 95–105)</td>
<td>BINA</td>
<td>Shorter in height; light yellow seed coat; appropriate for growing in both kharif-2 and rabi seasons</td>
</tr>
<tr>
<td>Binasoybean-2</td>
<td>2011</td>
<td>2.4–3.3</td>
<td>(1^r: 105–115)</td>
<td>(2^k: 95–105)</td>
<td></td>
<td>Shorter in height; light yellow seed coat; suitable for high and char land of South and South-western regions of Bangladesh, during both kharif-2 and rabi seasons</td>
</tr>
<tr>
<td>Binasoybean-3</td>
<td>2013</td>
<td>2.5–3.2</td>
<td>(1^r: 110–115)</td>
<td>(2^k: 105–110)</td>
<td></td>
<td>Plant height 71.6–71.8 cm; brighter yellow seed coat</td>
</tr>
<tr>
<td>Binasoybean-4</td>
<td>2013</td>
<td>2.4–3.0</td>
<td>(1^r: 115–120)</td>
<td>(2^k: 110–115)</td>
<td></td>
<td>Plant shorter in height; brighter yellow seed coat; salt tolerant up to 6 dS/m</td>
</tr>
<tr>
<td>Binasoybean-5</td>
<td>n.a.</td>
<td>2.5–3.3</td>
<td>(1^r: 106–115)</td>
<td>(2^k: 95–106)</td>
<td></td>
<td>Salt tolerant up to 6 dS/m</td>
</tr>
<tr>
<td>Binasoybean-6</td>
<td>n.a.</td>
<td>2.5–3.2</td>
<td>(1^r: 110–115)</td>
<td>(2^k: 95–105)</td>
<td></td>
<td>Salt tolerant up to 12 dS/m</td>
</tr>
<tr>
<td>BU soybean 1</td>
<td>2014</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>Department of Agronomy, BSMRAU</td>
<td>Early, high yielding, high protein content</td>
</tr>
<tr>
<td>BU soybean 2</td>
<td>2020</td>
<td>3.5–4.5</td>
<td>90–100</td>
<td>n.a.</td>
<td></td>
<td>n.a.</td>
</tr>
</tbody>
</table>

\(^1\) \(r = \text{rabi}. \(^2\) \(k = \text{kharif-2}.\)
How was the soybean crop introduced into Bangladesh?

The domestication of soybean appears to have begun in China 6000–9000 years ago. In Bangladesh, soybean was introduced around 1942, although no particular attempts were made to popularize the crop or to conduct research on it until 1960–61. In 1961, the pulses and oilseeds division of Bangladesh Agricultural Research Institute (BARI) selected two varieties of soybean (Pelican and Barnali) for the purposes of increasing fallow land cultivation in the kharif-2 season. However, by the following year these were found to be susceptible to the yellow mosaic virus and production ceased.

Soybean was reintroduced into Bangladesh by the Mennonite Central Committee (MCC) in 1972–73. In 1975, Bangladesh Agricultural Research Council (BARC) in collaboration with BARI, Bangladesh Agricultural University (BAU), Bangladesh Institute of Nuclear Agriculture (BINA), Bangladesh Council of Science and Industrial Research (BCSIR) and MCC initiated the ‘Bangladesh Coordinated Soybean Research Project’ to investigate soybean’s potential as a food crop. In 1981, this culminated in the release of the Bragg and Davis varieties of soybean. However, these were also afflicted by the yellow mosaic virus and are no longer recommended for cultivation.

How many improved soybean varieties are currently cultivated in Bangladesh?

Between 1991 and 2021 ten high-yielding varieties (HYVs) of soybean were released by BARI, BAU and MCC. These improved varieties are presented in Table 1 (see previous page) along with their key features.

Which cropping patterns are suitable for soybean cultivation?

In Bangladesh, soybean is mainly cultivated in the districts of Noakhali, Lakshmipur and Bhola by farmers following one of two cropping patterns: T. Aman rice – soybean – fallow, or spring Aus rice/jute – soybean – fallow/wheat/mustard/lentil/chickpea (Figure 1). No research findings on cropping patterns exist for other areas of Bangladesh.
Some constraints to soybean cultivation exist in Bangladesh, including climate variability, soil condition, competition with other crops for scarce resources, and high infestation rates of pest and disease. Other challenges include:

- lack of quality seed/poor seed germination;
- no guarantee of timely availability of quality seed or its supply to farmers;
- soil salinity, particularly in the coastal belt;
- lack of advanced agronomic management knowledge needed for crop production;
- lack of knowledge among the general population of soybean’s nutritional advantages;
- tendency to pod shattering (resulting in 10%–70% yield loss);
- over-reliance by farmer on manual planting, weeding, harvesting, threshing, drying and storing;
- a marketing system and supply chain are not strongly established.

**Figure 1: How soybean fits into the cropping patterns for (a) the *rabi* season: *T. Aman* rice–soybean–fallow, and (b) the *kharif-2* season: *Aus* rice/jute–soybean–*.  
* indicates possible crops in the *kharif-2* cropping pattern, these are wheat, mustard, lentil, chickpea or fallow.
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Figure 2: Season-based soybean production working calendar, showing a timeline for *rabi* (left) and *kharif-2* (right).
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Figure 3: Growth stages of the soybean plant. Source: https://prairiecalifornian.com/soybean-growth-stages/
**Vegetative growth stages:**

VE = emergence (cotyledons emerge through the surface of the soil)
VC = unrolled vegetative (unfolding of the unifoliate leaves)
V1 = first trifoliate (one set of unfolded trifoliate leaves)
V2 = second trifoliate (two sets of unfolded trifoliate leaves)
V3-Vn = third trifoliate (three unfolded trifoliate leaves) - “n”-th trifoliate

**Reproductive/flowering and pod formation stages:**

R1 = start of flowering (plants have at least one flower on any node)
R2 = full flowering (an open flower appears on one of the two uppermost nodes)
R3 = pod formation starts (\(\frac{3}{16}\) inch [5 mm] pods appear on one of the four uppermost nodes)
R6 = seeds are complete (a pod containing a green seed which fills the pod to capacity appears on one of the four uppermost nodes on the main stem.

**Maturity stages:**

R7 = start of maturity (one healthy pod on the main stem reaches mature-pod color)
R8 = full maturity (95 percent of the pods reach full mature color)

What is soybean crop phenology typically like?

<table>
<thead>
<tr>
<th>Life cycle:</th>
<th>90-120 days from seed sowing to harvesting.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germination:</td>
<td>Seed emergence takes 3-5 days under moist conditions. Cotyledons emerge from the soil, unifoliate leaves unroll.</td>
</tr>
<tr>
<td>Flowering stage:</td>
<td>Flowering starts at 25-30 days, ending with full flowering up to 60 days after germination.</td>
</tr>
<tr>
<td>Pod formation:</td>
<td>Starts 50-60 days after germination.</td>
</tr>
<tr>
<td>Green bean stage:</td>
<td>After pod formation, seeds develop inside the pod and gradually start to harden.</td>
</tr>
<tr>
<td>Maturity stage:</td>
<td>Pod and seeds begin to turn yellow; full maturity is reached when 95 percent of the pods have turned from yellow to gray.</td>
</tr>
</tbody>
</table>
How can I produce soybean as an intercrop?

Soybean can be cultivated as an intercrop with maize by sowing a row of soybeans between two rows of maize which are 60 cm apart, with 30 cm between individual soybean and maize rows. There are benefits to producing soybean as a supplemental crop to maize – for example, and most significantly, soybean adds nitrogen to the soil content through the formation of nodules which contain \textit{Rhizobium} spp. bacteria, which help to improve soil health over time. Another intercrop combination can be soybean with sunflower. Or, as displayed in the pictures below, soybean can be grown as intercrop in the initial stages of mahogany woodlots or fruit tree gardens.

Figure 4: Soybean-Mahogany intercrop.

Figure 5: Soybean-Multa tree intercrop.
Which soil and climate types are conducive for soybean cultivation?

Soybean can be cultivated in loam, sandy loam and clay loam soils. Medium-high to low-lying land works best for the *rabi* season crop, and high land with good drainage for the *kharif-2* season. Optimal temperatures of 20°–25°C and 15°–22°C have been found to be suitable for flowering and maturity respectively. However, yield decreases when day temperatures are above 26°C¹⁵. In Bangladesh, because of their climate, the districts of Noakhali, Bhola and Lakshmipur are the most suitable regions for soybean cultivation. In the *kharif-2* season of 2021, DAE introduced soybean at Chuadanga district.

What seed rate is suitable for soybean cultivation?

Although general advice can be given on the seed rate for soybean, in practice the actual seed rate should be modified slightly depending on seed quality, with the specific germination percentage and the moisture content of the soil helping to determine the rate used. Quality seed should have a germination percentage of over 80 percent. The ideal seed rates of Sohag (PB-1), BARI Soybean-5 and BARI Soybean-6 are 8.0–9.5 kg/bigha (33 decimals) or 60–70 kg/ha. Due to its small seed size, seeding rate for the variety Bangladesh Soybean-4 is 5–6 kg/bigha or 40–45 kg/ha. Row-to-row spacing is usually 30–40 cm, depending on the season (see “What is the ideal number of soybean plants in a given land area?”, below). If germination rates are <80 percent, these rates may be increased to ensure adequate crop establishment.

What are the characteristics of quality seed?

To maintain genetic purity, seed should be collected from breeder seed (which has a 99%–100% germination rate), foundation seed (90%–95% germination rate) and/or certified/truthfully labelled seed (>80% germination). The seed should be viable (that is, no more than one year old) and must be stored in cool, dry conditions. Their shape and size should be uniform, and they should bear a bright brownish tinge, indicating proper maturity; they must also be unbroken, and free from disease and insects. Finally, they should be clean, and free from non-seed and weed seed.

How do I conduct a germination test?

It is advisable to conduct a germination test one week prior to sowing in the field, following the procedure described below.

- Pick out seeds from multiple different parts of the storage container.
- Randomly select 100 seeds, discarding any that are broken.
• Take an earthen pot and fill it with sandy soil (a banana/aroid leaf or jute bag/cloth can also be used). It should be big enough to hold 100 seeds planted 1 cm deep in rows 1 cm apart.
• Plant the seeds and level off the top with soil.
• Maintain optimal soil moisture (50 percent) and store in a shady location¹⁶.
• After 5–6 days, count the number of seeds which have germinated with good/healthy roots and shoots, and use the following formula to calculate the germination percentage:

\[
\text{Germination percentage} = \frac{\text{seeds germinated}}{\text{total seeds}} \times 100
\]

Note: applying additional water after planting the seeds can result in rotting and a reduced germination percentage.

**How do I adjust the seed rate?**

Seed rate is conditional on germination percentage and seed size, and should be adjusted if the germination percentage is low (<80 percent). To obtain an optimum seed rate when germination is 75%–80%, add about an extra 5 percent of seed; add about an extra 10 percent of seed when germination is 70%–75%.

**Table 2: Recommended seed rate and germination percentage of different soybean varieties.**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Seed requirements for different germination percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&gt;80%</td>
</tr>
<tr>
<td>Optimum seed rate</td>
<td></td>
</tr>
<tr>
<td>Optimum seed rate + 5% addition</td>
<td></td>
</tr>
<tr>
<td>Optimum seed rate + 10% addition</td>
<td></td>
</tr>
<tr>
<td>Not wise to use as seed</td>
<td></td>
</tr>
<tr>
<td>Sohag (PB-1)</td>
<td>60–70 kg/ha</td>
</tr>
<tr>
<td>BARI Soybean-5</td>
<td></td>
</tr>
<tr>
<td>BARI Soybean-6</td>
<td></td>
</tr>
<tr>
<td>Bangladesh Soybean-4</td>
<td>40–45 kg/ha</td>
</tr>
<tr>
<td>(small seed size)</td>
<td></td>
</tr>
</tbody>
</table>
What land preparation and seed sowing techniques should I use?

Depending on the soil type, four to five ploughing cycles followed by laddering are required to prepare the land. Soil should be free from weeds, and leveled to facilitate irrigation, drainage and intercultural operations.

Soybean seed can be sown in a line formation using jab/dibble planting, or broadcasted like black gram or mung bean. An iron tine or small wooden plough can be used to form the rows. During the *rabi* (winter/dry) and *kharif*-2 (summer/frequent rain) seasons, the distance between individual rows should be 30 cm and 40 cm respectively. Seed should be inserted into the soil to a depth of 3–4 cm with 4–5 cm between plants, and then covered with loose soil.

Can I use conservation agriculture methods to cultivate soybean?

Soybean seed can be sown using a conservation agriculture system. Seeder machines (either inclined plate- or fluted roller-type) are used for strip-tillage, and retaining 30 cm of residue in the field from the previous *Aus/T. Aman* rice crop maintains moisture in the soil. The farmer can also use a 16-teeth seeder machine to sow seed and apply fertilizer simultaneously. Strip-till (or zero tillage) methods can thus be employed effectively for soybean cultivation.

Bed-planting – a new technology for soybean production in Bangladesh – enables the farmer to sow seeds in line with a raised bed and automatically develops drainage, improving irrigation. Note: it is essential to apply a non-selective and an appropriate pre-emergence herbicide prior to strip/zero tillage or bed-planting, to ensure all weeds are removed. Consult with the Department of Agricultural Extension for advice on appropriate, low-toxicity weed control products.

When is the optimum time to sow soybean seed?

Soybean can be cultivated in two seasons each year: *rabi* (15 December to 15 April) and *kharif*-2 (15 July to 15 November). Soybean production occurs predominantly during the *rabi* season; production of soybean seed for use the next year takes place mostly during the *kharif*-2 season.
What fertilizers are required and how do I apply them?

Given that soybean is a leguminous crop, its cultivation requires less fertilizer than cereal crops. Also, fertilizer rates vary from one location to another according to soil type. Although site-specific fertilizer trials for soybean have yet to be conducted in Bangladesh, BARI makes the following recommendations for its use in soybean cultivation:

Cow dung/compost should be applied before final plowing. Half of the urea and all other inorganic fertilizers should be applied as basal dose at the time of final plowing. The remaining half of the urea should be applied later – before the flowering stage – and when conditions are damp.

A basal dose of urea is required for initial plant development. Note, however, that applying nitrogen (which urea contains) may also reduce nitrogen fixation in the root, achieved through the action of *Rhizobium spp* bacteria. Conversely, inoculum will encourage nodulation, and its application is described below.

### Table 3: Recommended fertilizer application rates for soybean cultivation.

<table>
<thead>
<tr>
<th>Fertilizer type</th>
<th>Application time</th>
<th>kg/bigha</th>
<th>kg/acre</th>
<th>kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea</td>
<td>basal dose</td>
<td>3-4</td>
<td>10-12</td>
<td>25-30</td>
</tr>
<tr>
<td></td>
<td>top dressing (before flowering stage)</td>
<td>3-4</td>
<td>10-12</td>
<td>25-30</td>
</tr>
<tr>
<td>TSP</td>
<td>basal dose</td>
<td>20-23</td>
<td>60-70</td>
<td>150-175</td>
</tr>
<tr>
<td>MoP</td>
<td>basal dose</td>
<td>13-16</td>
<td>40-48</td>
<td>100-120</td>
</tr>
<tr>
<td>Gypsum</td>
<td>basal dose</td>
<td>11-15</td>
<td>32-45</td>
<td>80-115</td>
</tr>
<tr>
<td>Boron</td>
<td>basal dose</td>
<td>1.25</td>
<td>3.25-4</td>
<td>8-10</td>
</tr>
<tr>
<td>Cow dung/compost</td>
<td>basal dose (before final plowing)</td>
<td>1.3 tons</td>
<td>4 tons</td>
<td>10 tons</td>
</tr>
</tbody>
</table>

Is inoculum beneficial, and how do I apply it?

*Rhizobium spp* are bacteria that serve as inoculum and help formation of nodules on the root system of the soybean plant. These bacteria ‘fix’ atmospheric nitrogen to the root, which as a result develops nodules which facilitate access to this nitrogen, improving the plant’s growth. Before sowing, soybean seed should be mixed with inoculum to enhance nodule formation in the root system.
As a rule of thumb, inoculum is not needed for the same plot of land following the first year’s application; however, annual additions of inoculum will enhance nodulation in the root zone and ensure proper growth of the soybean. Unavailability of inoculum is a primary limiting factor in areas where soybean is being cultivated for the first time. Inoculated seed produces seedlings at impressive rates — inoculum also promotes healthy growth throughout the growth cycle, while maintaining a steady supply of nitrogen. According to the Government of Bangladesh’s Department of Agricultural Extension, applying biofertilizer can lead to a potential 75%-150% increase in soybean yield. Application of inoculum can therefore be a cost-effective way of boosting soybean productivity where farmers may not have enough money or access to nitrogen fertilizer.

**Inoculum-mixing procedure**

Wearing a pair of protective gloves, mix soybean seed with a small quantity of water (just enough to coat the seeds) and add *Rhizobium spp.* inoculum (2 g for each 1 kg of seed) and mix for 3–5 minutes (depending on the quantity of seed). To prevent deterioration of the bacterial strains, the inoculum-mixed seeds should be planted within 2–3 hours, during which time the seed should not be exposed to sunlight.

Figure 6: Inoculum (*Rhizobium spp.*) mixing procedure.

**How do weeds hamper soybean production?**

Weeds reduce soybean yield by competing with the plant for sunlight, moisture and soil nutrients. In general, they can negatively affect farming in several ways, including compromising the effective application of fertilizer in weed-impacted fields (because weeds absorb fertilizer more effectively than the soybean plants). They can also act as alternative hosts for disease and pests which affect rice (and which might therefore damage the rice crop in a neighboring field) and provide shelter for rats.

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5 Inoculum can be sourced from the Bangladesh Institute of Nuclear Agriculture (BINA), Department of Soil Science, Mymensingh. Commercial production of the inoculum is carried out by ACI Limited.
Weeds tend to be more prevalent on dry land and rain-fed lowlands. The most common weeds found in the soybean field are mutha (nut grass; *Cyperus rotundus* L.), durba (scutch grass; *Cynodon dactylon* (L.) Pers.), foshka begun (clammy groundcherry; *Physalis heterophylla* Nees), kantanotae (spiny pigweed; *Amaranthus spinosus* L.), shyma (cockspur grass; *Echinochloa crusgalli* (L.) Beauv), anguli (hairy crabgrass; *Digitaria sanguinalis* (L.) Scop.), badla (hairy sickle grass; *Parapholis strigosa* (Dumort.) C.E. Hubb.) and bagajoga (swampweeds; *Hygrophila* spp.).

Figure 7: Common weeds found in soybean fields in Bangladesh.
What are the most useful weed control techniques?

To obtain a desirable yield (that is, an average of 2 tons/ha during the rabbi season and 1-1.5 tons/ha during the kharif-2 season), weeding should be carried out within 15-20 days of seed sowing. This is the most critical time of crop-weed competition, during which seedlings and weeds compete for nutrients, moisture and light. Manual weeding or a dry-land mechanical weeder are good options for controlling weeds. Ideally, the crop should be weed-free after seed germination for the first five weeks during the kharif-2 season or three weeks during the rabbi season. To achieve optimum weed control while at the same time practicing conservation agriculture, spray a pre-emergence herbicide prior to seed sowing.

What is the ideal number of soybean plants in a given land area?

Excess soy seedlings should be thinned out, keeping an average of 25-35 plants per m². During the rabbi season, maintain a line-to-line distance of 30 cm and plant-to-plant distance of 10 cm; for the kharif-2 season crop, the line-to-line distance should be 40 cm and plant-to-plant distance 10 cm (Figure 8). These planting systems (line-to-line and plant-to-plant) can be established manually or through machine-assisted sowing.

How many irrigation cycles should I apply? What is the best method of draining off surplus water?

Correct irrigation is essential for any crop to obtain the optimum yield. Keep in mind that soybean is a somewhat water-stress tolerant crop and therefore requires minimum irrigation, with the amount depending on soil type and level of moisture already in the soil.

During the rabbi season, irrigation may be required once before sowing the seed to obtain moist soil conditions. Farmers sometimes also irrigate again immediately after seeding to obtain a good germination rate.

Also during rabbi cultivation, where the soil is sandy, irrigating a total of 2-3 times may be needed. The water-holding capacity of sandy soil is minimal, while that of loamy soil is better, meaning it requires irrigating a maximum of two times. In the kharif-2 season, all types of soil will probably only need irrigating once, as frequent rainfall generally occurs at this time of year.

After crop establishment, the first irrigation should be applied 25-30 days after emergence; if there is no rain, apply a second irrigation 50-55 days after emergence. However, before any irrigation, farmers should observe the crop phenology and the stage of the crop. For example, during the flower initiation and pod formation stages,
Simple and effective management methods that can improve soybean production in Bangladesh.

Figure 8: Soybean plant spacing in (a) the *rabi* season, and (b) the *kharif*-2 season.
irrigation is necessary if the land has insufficient moisture. Before any irrigation, however, refer to online weather data or weather news broadcast on the television or radio and irrigate only if there is no possibility of rain.

Farmers in Bangladesh generally use flood irrigation. However, to cultivate soybean, using the bed-planting method is the best way to ensure proper irrigation through optimum water use. This conservation agriculture approach plants seed and establishes drainage simultaneously, enabling irrigation water to move freely and the root system to access moisture correctly, avoiding water stagnation and facilitating the drainage of excess water/rainwater.

Which harmful pests and diseases constrain soybean production and what techniques should I use to manage them?

Many of the pests and diseases with the potential to affect soybean will be familiar to the farmer and can be dealt with using rational pest management. The key to keeping the upper hand is vigilance, up-to-date information, prevention (when this is possible) and swift action. In general, pesticides should only be used as a last resort after other management methods and biological control have been tried.

Various kinds of insects are considered pests and are harmful to the soybean crop. In Bangladesh, major pests include the hairy caterpillar *Diacrisia oblique* Wlk., common cutworm *Spodoptera exigua* Hb., leaf roller *Lamprosema indicate* F. and stem fly *Melanagromyza sojae* (Zehntner). In a humid climate like Bangladesh, soybean can also be affected by plant diseases which can reduce yield. It is important to employ different techniques for managing pest and disease, as an integrated approach provides the best protection.

Note: only apply pesticides after receiving proper training and never without first consulting a qualified extension agent or trained agriculturist. Always wear protective clothing. Figure 9 presents an example of full protective clothing, which should be worn when applying pesticides (e.g. fungicides, insecticides) and herbicides.

What are the common safety measures to follow when using pesticides?

Pesticide is a poison. When purchasing or spraying it, always follow these safety measures to the letter:

- Wear protective clothing (a plastic, non-porous coverall, protective headgear including goggles and respirator, gloves and gumboots) while spraying.
- NEVER attempt to clean the nozzle by blowing into it.
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Figure 9: Full safety protection to be used when spraying pesticides and herbicides.

- NEVER smoke or eat while spraying.
- NEVER put any food materials in empty pesticide containers (e.g. a drum, bottle or mug).
- NEVER wash a pesticide sprayer in a pond or other waterbody.
- Keep pesticides in a cool, dry place and out of the reach of children.
- Keep pesticides away from food to avoid contamination and volatilization.
- ALWAYS wash any exposed skin (e.g. face, hands/arms, feet/legs) thoroughly after using any pesticide.
- Don’t spray into the wind, or when the weather is rainy or cloudy.
- To avoid over-application of the pesticide, never let the machine leak.
- Do not touch anyone else, particularly children, after using pesticides and before washing.
- Contact a doctor immediately if you become sick after using pesticides. This could be because you have followed the incorrect method of use.
How do I identify and manage common pests and diseases?

Hairy caterpillar

The hairy caterpillar (Diacrisia oblique) is a major and serious pest affecting jute and is also one of the main pests of soybean. It also frequently causes damage to other oil crops, including sesame and pulses.

What are the early signs of infestation?

- The pink hairy caterpillar moth lays egg masses of 500-1500 eggs on the underside of the plant’s leaves. After hatching, larvae remain together in a cluster.
- Adult larvae cause serious damage to plants, attacking the soybean leaves at the initial stage. Affected leaves are easily identified by their net-like structure.

How can I manage this pest?

- Use light traps (1 trap per hectare) to attract and kill the insect moths at night. Place a pot containing water mixed with kerosene under each trap to catch and drown the moths, reducing the population.
- Pick the leaves supporting the egg mass, and the first and second instar larvae, and destroy them by crushing, burying or burning.
- Put bamboo sticks into the ground (about 8-10 per bigha). This will encourage predatory birds (e.g. the borer bird) to land in the field, roost on the sticks, surveil the field for prey, and find and eat the caterpillars.
- Infestation is reduced by spraying neem oil (10 percent) mixed with 2-3 g detergent/L of water twice, at a 10-day interval.

Figure 10: (a) Leaf attacked by the adult larvae; (b) and (c) larvae clustered on the plant; (d) the female hairy caterpillar moth.
Common cutworm

The common cutworm (*Spodoptera litura*) is a very destructive pest affecting many important agricultural crops. Besides soybean, it can infest tobacco, cotton, beet, cabbage, chickpea, mungbean, mustard, sunflower, and many more.

**What are the early signs of infestation?**

- The black cutworm moth lays an egg mass of 500-2000 eggs on the upper side of the leaves.
- Black-spotted light green larvae emerge from the eggs and start eating the leaves.
- The adult larvae damage the plant by feeding heavily on it, eating half of the leaf and reducing it to a net-like structure.
- The larvae spread throughout the field and cause damage to the crop right up until harvest-time.

**How can I manage this pest?**

- Install pheromone traps, 50 m apart, from the seeding stage of the plants onwards.
- Hundreds of larvae remain together in a cluster. This contributes to them being easy to destroy, by picking the leaves holding the egg mass and neonate larvae, and crushing, burying or burning them.

![Figure 11: Common cutworm: (a) affected leaf, (b) larva eating a soybean leaf, and (c) female moth.](image-url)
• Put bamboo sticks into the ground (about 8-10 per bigha). This will encourage predatory birds (e.g. the borer bird) to land in the field, roost on the sticks, surveil the field for prey, and find and eat the caterpillars.

• Apply the microbial pesticide Spodoptera nuclear polyhedrosis virus (SNPV) at the rate of 0.2 g/L of water after the initial visible symptoms of pest attack. SNPV should be sprayed during the afternoon.

• Arrange the inundative release of the egg parasitoid Trichogramma chilonis at the rate of 1 g parasitized eggs (40,000 live adults) per hectare and fortnight as well as larval Bracon hebetor at the rate of 1 bucket (800–1000 live adults) per hectare each fortnight.

• Use chemical pesticides – but only after trying other methods first. Because cutworm attacks several important crops, many farmers regularly apply chemical pesticides throughout the year, resulting in the rapid growth of pest resistance. Care should therefore be taken only to use chemical means of pest control as a last resort. If infestation is severe and chemical treatment unavoidable, at the start of visible plant infestation use either two applications (at a 15-day interval) of chlorantraniliprole (Coragen 18.5 SC) at the rate of 0.5 ml/L of water, or a single spraying of spinosad (Tracer 45 SC) at the rate of 0.4 ml/L of water.

**Leaf roller**

As well as soybean, the leaf roller (*Lamprosema indicata* Fab.) also infests beans, cowpea, green gram, black gram and red gram. The adult moth is creamy yellow to light brown with oblique wavy black lines on both pairs of wings.

**What are the early signs of infestation?**

• The leaf roller moth lays a mass of 300–400 eggs on the underside of the leaves. Larvae emerge from the eggs and eat the soft green part of the leaves.

• The yellowish-greenish larvae curl the leaves at the tip of the plant. Growth is retarded, reducing seed yield by 15%-20%.

• Each plant hosts 4-5 insects.

• Most infestation occurs between February and April during the vegetative growth stage of soybean.
How can I manage this pest?

- Reduce infestation by cultivating stress-tolerant varieties such as Sohag PB-1 and BARI Soybean-519.
- Use a light trap to attract and kill the insect moths at night. Put a pot containing water mixed with kerosene under the trap to catch and drown them.
- Destroy the curled leaf and the insects on it by stamping on them together.
- Put bamboo sticks into the ground (about 8–10 per bigha). This will encourage predatory birds (e.g. the borer bird) to land in the field, roost on the sticks, surveil the field for prey, and find and eat the caterpillars.
- Arrange the inundative release of egg parasitoid Trichograma chilonis at the rate of 1 g of parasitized eggs (40,000 live adults) per hectare at 15 days interval, and larval Bracon hebetor at the rate of 1 bucket (800-1000 live adults) per hectare each fortnight.
- If no other method has worked and infestation is severe, spray carbaryl (Sevin 85 wp or another trade name) at the rate of 2 gm/L of water, or dimethoate (Perfekthion 40 EC or other trade name) at the rate of 2 ml/L, twice at a 10-day interval to control the insect effectively.

**Stem fly**

The soybean stem fly Melanagromyza sojae (Zehntner) is a common pest of soybean in Asia. It is favoured by warm temperatures, high rainfall, and high humidity²⁰.
What are the early signs of infestation?

- Adult stem flies are shiny black and about 2 mm long. The damaging stage is the white larvae which feeds inside the stem.
- The soybean stem fly lays eggs on the underside of young leaves. After hatching, the yellowish larva mines through the leaf tissue to the nearest vein of the leaf, then continues down the leaf petiole into the stem, where it feeds on the pith.
- If the infected stem splits open, a distinct zigzag reddish tunnel can be seen inside it, with a larva or pupae inside that. Before pupation, the larva makes an exit hole in the stem for the adult.
- Apart from the exit holes, the soybean plants will initially appear healthy on the outside. Large infestations (3 or more larvae per plant) may cause wilting and even plant death, especially in younger plants.
- The larval stage lasts 8–11 days and the pupal stage 6-12 days (depending on temperature). Several generations can develop in the soybean crop throughout the season, worsening and spreading the infestation in the field.

How can I manage this pest?

- Put out sticky traps to monitor the presence of stem flies in the field.
- Do not cultivate soybean on the same land every year – crop rotation with dissimilar crops is better.
- Reduce infestation by clearing the field of weeds, dead leaves and debris – these are where the attacking insect tends to shelter.
- Remove and destroy any damaged plant parts.
- Minimize insect attack by treating seed with Fortenza 60 FS at the rate of 2.5 ml/kg seed.
• If infestation is severe, spray diazinon 60 EC or chlorpyrifos (Dursban 20 EC) at the rate of 2 ml/L of water) twice at a 10-day interval. N.B.: The pesticide must be sprayed with proper personal protection and by registered personnel only.

**Yellow mosaic virus**

Yellow mosaic virus is transmitted from diseased to healthy plants by aphids.

**What are the early signs of infestation?**

- At first, yellow mosaic virus will be found in very few plants in the soybean field but will then gradually spread out.
- Bright or golden yellow areas develop on the plant, along with dark or light green patches, scattered primarily across the leaf surface.
- The affected leaves curl up and the plant remains a dwarf (or smaller in size).
- When infestation is severe, the disease is also transmitted to the soybean seed.

**How can I manage this pest?**

- Cultivate disease tolerant varieties, such as Bangladesh Soybean-4, BARI Soybean-5 or BARI Soybean-6.
- As soon as one or two plants are found to be affected, remove them from the field and burn them.
- If necessary apply recommended insecticides, preferably bio-pesticides, to control aphids (the insect which carries the virus).

![Figure 14: Leaves (a) and (b), and (c) seed affected by yellow mosaic virus.](image)
How do I check crop maturity? What is the best time and method of harvesting and threshing?

- Keep a close eye on the maturing of the plant, so as to harvest at the right time and obtain the optimum yield. As the plant approaches maturity, the leaves turn yellow and start to fall, and the pods appear dry and yellow.
- Harvest the plant when it reaches full maturity (about 90–120 days from sowing).
- Laborers usually harvest the mature plants using a home-made (kachte) knife.
- Harvesting should not be done at noon or in the evening.
- Transport the harvested pods from the field to the threshing floor to be dried.
- Dry the pods in the sun for 2–3 days after harvesting. When the seeds inside the pod are hard (understood by shaking the pod and listening), start threshing.
- Mechanical threshing breaks the pods, exposing the seeds. Use an air-blower to remove the husk and any dust, and to clean the seeds. Sieve the seeds and put them into sacks.
- During manual threshing, pods are generally beaten with a wooden stick, separating the seed and husk. Winnow and clean the seed, and put it into sacks.

What are the best methods of preparing soybean seed for storage?

About two to three months after harvesting, seeds in general gradually start to lose their ability to germinate. Soybean seeds in particular lose viability very quickly under ordinary storage conditions and so special post-harvest care needs to be taken:

- After harvesting, clean the seeds thoroughly, removing any which are rotten and affected by damp, pests or mold. Dry them very carefully. This should be done as soon as possible after harvesting – ideally immediately.
- Do not leave the seeds in strong, continuous sunshine for more than three to four hours.
- Store the seeds in an airtight container, such as a polyethylene bag, metal drum, black matka (a pitcher made from clay) or metal biscuit tin.
- Keep this container in a cool, dry place on a wooden-based platform: make sure it does not touch the floor directly.
- Check the seed moisture regularly and take steps to dry out the seeds every month if moisture content increases to above 12 percent.
- Always carry out a germination test before planting and adjust the seed rate accordingly (see “How do I conduct a germination test?”, above).
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Farmers generally use soya to prepare foodstuffs, including soya milk, soya halua (a dessert), soya curd (a type of yoghurt), soya piazu (a deep-fried snack with a base of flour mixed with onions and spices), soya flour (which can be mixed with wheat flour to make thick roti) and soya vorta (various combinations of mashed herbs, vegetables, or fish).

When the soybeans are for household consumption, they need to be cleaned, dried in the sun and put into an airtight sack or drum. Every two to three months they should be taken out of the container for half an hour and placed in the sun again. When using the beans, the farmer should take the required amount out of the container, close it immediately, ensure it is airtight and return it to its shaded platform.

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4 Farmers generally use soya to prepare foodstuffs, including soya milk, soya halua (a dessert), soya curd (a type of yoghurt), soya piazu (a deep-fried snack with a base of flour mixed with onions and spices), soya flour (which can be mixed with wheat flour to make thick roti) and soya vorta (various combinations of mashed herbs, vegetables, or fish).
What is the best way to prepare the harvested soybean for marketing and distribution?

After drying thoroughly in the sun for three to four hours, the cleaned beans should be cooled in a shady place. The farmer then weighs the beans and puts them into 50 kg sacks to sell. Small farmers take these weighed sacks to a local *haat* (small local market) to sell to a buyer and get a good profit. First, a *foria* (local business person) purchases the beans from the farmers, for around BDT 900–1150 per *maund* (40 kg) and sells them to an *arotdar* (local dealer/wholesaler). The *arotdar* then takes 2%–3% commission and either sells the beans on to companies – such as biscuit factories, and poultry and fish feed mills – or stores the soybean before selling them to a similar type of customer at a 10%–15% higher price. As well as this, company people come to buy the beans at district level markets in Noakhali, Lakshmipur and Bhola, and take them back to their factories to use in the manufacture of products such as condensed milk, poultry and fish feed, and biscuits.

As a farmer, what can I do next?

- Organize neighboring farmers into several groups, prepare bulk production, and draw up a business plan which identifies and addresses the constraints of the value chain.
- To facilitate this, create links with poultry and fish feed mills, local *forias*, *arotdars*/dealers and wholesalers.
- Explore the markets and share any relevant information with farmer groups regularly.
- Identify lead private companies interested in providing training in business development planning and marketing, and in helping to establish a supply chain.
- Start communication with BARI and DAE officers at the local, *upazila* and district levels, to pursue access to quality seed, and receive technical training and updated information.
- Share all of this information with members of the group.
Simple and effective management methods that can improve soybean production in Bangladesh

**Bibliography**


19 Sohag PB-1 and BARI soybean leaflet, published by the Oilseed Research Centre, BARI, Gazipur.

This manual is for anyone interested in cultivating soybean, particularly in the Noakhali, Lakshmipur Bhola and Chuadanga districts of Bangladesh. It is intended to motivate farmers to consider the advantages of a new crop and how to get started. It explains the conditions needed for cultivating and processing soybean, the conservation agriculture approach which produces the best results, and how to tackle common problems that might arise. It provides a financially and environmentally sound approach to modern agriculture, and indicates the professional satisfaction which is likely to accrue as a result of taking this step forward.