SUSTAINABLE SOYBEAN PRODUCTION IN SOUTHERN HIGHLANDS OF TANZANIA (TSSI PROJECT)

Training Manual on GAPs for Sustainable Intensification of Soybean Production for Agriculture Extension Agents

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Transforming African Agriculture

Contents

Introduction

- Soybean is a nutritious grain legume which contains on average 40% protein.
- Soybean can be used directly for food in the household, or processed for soy milk, cooking oil and ranges of other products including infant weaning food.
- Poultry industry uses soybean for feed production.
- Soybean crop residues are also rich in protein and are good feed for livestock or form a good basis for soil organic matter.
- Soybean forms nodules which contain bacteria called rhizobia. The bacteria can fix nitrogen from the air into a form that soybean can use for growth.
- Soybean has become a cash crop with demand for grains more than the supply.
- Unfortunately, farmers are unable to utilize this opportunity to increase their incomes as the grain yields are low (about 750 kg/ha or 300 kg/acre or less).
- The goal of every soybean farmer is to increase grain yield for increased income.
- With good practices and the right varieties farmers can increase their yield up to 2,000 kg/ha or 800 kg/acre (= eight 100 kg bags/acre) or more – note that the potential yield is 2,800 kg/ha (1,100 kg/acre).
- It becomes demoralizing for farmers when they are unable to achieve such goals.
- Some farmers only plant the soybean and do not do anything else in terms of applying improved inputs or management, and still expect to achieve higher yields.

Usually, what most farmers do is just:

- *Plough without harrowing or levelling to make the soil ready for best sowing technique*
- *Sow without following the recommended time of sowing*
- *Sow without following any proper pattern or technique*
- *Expect higher yields with no inoculant or legume fertilizer application and low plant population*
- *Untimely weeding without any proper plan or no weeding at all*
- *Harvest without proper plan or timing of harvest and post-harvest handling*

To increase yields and income, soybean farmers need to do things differently – embrace new technologies and/or improved agronomic practices.

So, what can farmers do differently to increase their soybean yields?

Farmers must consider the following factors/practices:

- Ensure early planting, **between 1st to 21st February depending** on rainfall.
- Use non-shattering soybean varieties to avoid grain loss at harvest.
- Ensure that the recommended plant population is achieved – 400,000 plants/ha or about 160,000 plants/acre at harvest (spacing of 50x5cm)
- Use recommended inputs – certified seeds, inoculant and legume fertilizer at recommended rates.
- Ensure timely application of inputs and use appropriate methods to apply.
- Manage crop stress adequately – timely and thorough weeding, effective pests, and diseases control.
- Adequately plan your harvest, do it on time to avoid shattering and grain loss.

- Majority of soybean farmers, especially the smallholders, need more knowledge on such GAPs/productivity enhancing technologies or proven practices to enable them to achieve their goal of increasing soybean grain yields for increased income.
- The **purpose of this training manual,** therefore, is to provide such knowledge/information or share experiences on proven/emerging technologies and/or agronomic practices that can be adopted by farmers to enable them to increase their soybean grain yields.
- The manual is structured into **four Modules** based on the productivity enhancing technologies/practices/factors that help to intensify and increase soybean grain yields:

Module 1 – Achieving optimum plant population

Module 2 – Harnessing the power of improved inputs

Module 3 – Adequate crop stress management

Module 4 – Proper harvest planning

Module 1

Model 1: Achieving optimum plant population

Learning objective	▪ Show in a sequential manner, the various factors or proven practices that combine to facilitate achieving optimum or recommended soybean plant population for increased grain yield.
Learning outcomes	▪ Trainees can identify sequentially the main factors/proven practices that can help farmers to increase soybean plant population. ▪ Trainees have acquired enhanced knowledge on each factor or proven practice that can contribute to achieving optimum or recommended soybean plant population for increased yield.

Training materials	Delivery methods	Training duration
Training manual, flip chart, relevant pictures/illustrations, permanent marker, color cards, stick note,	Presentation, videos, image viewing, group discussions, role play	2 hours

Factors or proven practices to achieve optimum plant population

- Several factors or proven practices play crucial roles in helping to achieve optimum/recommended soybean plant population per hectare or acre by enhancing good germination and survival of plants as required, to increase grain yield.
- These factors/practices include but not limited to the following:
    - Proper site selection
    - Adequate land preparation
    - Use of improved/certified seeds
    - Conducting germination test to determine viability of seeds before sowing
    - Use of appropriate sowing technique
    - Field guarding after sowing

1.1 Site selection

- Soybean can be grown on a wide range of soils with a pH between 4.5 and 8.5
- Land for soybean production should have a well-drained soil, preferably sandy-loam soil, avoid waterlogged, or very sandy, gravelly soils.
- The soil should have no hardpan to enhance water percolation and prevent flooding during heavy downpour.
- If possible, use a flat land or a land with a gentle slope to avoid erosion of topsoil.
- If the land selected has a steep slope, then create ridges across the slope (if ridging is a normal practice) to prevent surface runoff.
- Think about the rotation scheme for the field you want to plant. Do not plant soybean in the same field for two succeeding seasons, as this increases the chance for disease.
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1.2 Adequate land preparation

Land for soybean production can be prepared in various ways based on multiple factors including:

- farmer's preference,
- farmer's available resources,
- access to mechanization services,
- site/soil conditions.

1.2.1 Ploughing

- Ploughing can be done using a tractor or bullock depending on which one the farmer can access/afford.
- If the land has a slope, ploughing should be done across the slope.
- Ploughing is essential as it helps to loosen the soil, bring up nutrients from deeper soil layers and burry weeds. Loosening the soil is important for:
    - enhanced air circulation which is vital for soil micro-organisms that help to decompose organic materials to release nutrients for uptake by soybean plants,
    - improving water infiltration, and penetration of plant roots into deeper layers to take up nutrients for better growth.
- Please, note that ploughing usually leaves the soil surface uneven (with soil clods/lumps and furrows/trenches/gutters).
- Well prepared land ensures good germination and reduces weed infestation. Therefore, it is necessary to harrow/level the soil surface either mechanically or manually before sowing to enhance seed germination.

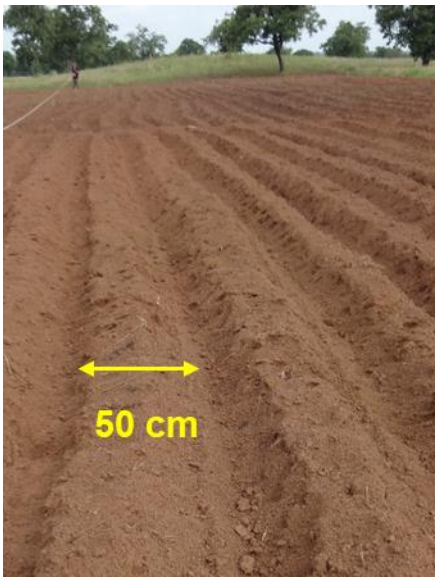
1.2.2 Harrowing

- Harrowing is done to level the soil surface after ploughing to make the soil surface even, break up lumps of soil and provide a good soil tilth to enhance seed germination.
- It is mostly done mechanically, but if this is not possible, the farmer can use hand hoe to level the soil surface and make it ready for sowing.
- Please, allow some days (up to a week) after ploughing for the soil to dry before harrowing to obtain a level surface.
- Harrowing/leveling of soil surface before sowing helps to:
    - break soil clods that form on the surface after ploughing as they will prevent the seeds from germinating.
    - prevent water from collecting in holes/furrows left after ploughing which can make seeds rot or germinated seeds die for being soaked in water.
    - further destroy weeds and loosen the topsoil for the young roots of germinated seeds to develop well and the plants to grow better.

1.2.3 Ridging

- Ridging can be done with tractor, bullocks or using hoes.
- It is vital for shallow soils or soils with a hardpan that could easily get flooded. In such cases, ridging allows water to collect in the furrows between the ridges, helps to improve drainage and keep the plants safe.

- Ridging increases the depth of the topsoil which allows the roots of plants to have more soil room to exploit nutrients and water for better growth.
- Ensure that the distance between the apex (tips) of any two ridges is 50 cm in accordance with the recommended row spacing.
- If the farmer prefers to sow on both edges of the ridge, then the ridges should be made 50 cm wide such that the distance between the edges is 50 cm.
- Ridging with tractor/bullocks does not automatically give the required spacing since the discs/ridgers are not usually adjustable. So, it is vital for the farmer to do adjustments after mechanical ridging to achieve the require row spacing.
- The ridges should be as high as practicable to improve water infiltration.



1.2.4 Minimum/zero tillage

- Some farmers prefer to prepare their lands with minimum or no soil disturbance, especially those that are engaged in conservation agriculture.
- With this tillage practice, the vegetation on the land is not cleared. Instead, planting holes are made, and the seeds are sown directly into the weeds/residues.
- The farmer takes care of the weeds by spraying herbicides to kill the weeds and allow the seeds to germinate and grow without competing with weeds.
- This type of land preparation is most suited to land/soil with the following conditions:
  - areas susceptible to drought and high soil temperatures.
  - land with steep slopes and land prone to erosion to prevent water loss through ruff off.

- soils with low water holding capacity to allow water conservation.

1.3 Seed selection

- Use only certified seeds obtained from certified agro-dealers for sowing.
- If you receive the seeds from a nucleus farmer/aggregator, please verify that they are certified seeds and originally sourced from a certified seeds dealer.
- If required, conduct seed treatment by applying fungicides.
- Clean the seeds by removing damaged/broken seeds
- and debris.

1.4 Germination test

Conduct germination test between **10 – 14 days before sowing** to determine if the seeds are good enough for sowing. Plant 50 seeds. If at least 40 emerge, the seed is good for planting. If 30-40 emerge, plant more seed than recommended. Get new seeds if less than 30 seeds emerge. Germination test can be conducted in a variety of ways. These have been described below:

1) **Seedbed method**
   - Prepare a small seedbed and water it to make it moist but not wet or soaked.
   - Make one 100 holes in the seedbed.
   - Select one 100 seeds randomly from the seed pack and sow one seed in each hole.

2) **Bowl method**
   - Fill a large bowl with soil and moisten the soil.
   - Make one 100 holes in the seedbed.
   - Select one 100 seeds randomly from the seed pack and sow one seed in each hole.
   - Count the number of seeds that have emerged by one week time.

Germination tests can be conducted using other methods as well, and the number of seeds to be used for the test can be 100 or 1,000.

Below is a guide on the required number of seeds that should be sown based on the outcome of the germination test

Germination test result (number of seeds that emerged)	Number of seeds to be sown per hole or stand
85 or more	2
80 – 84	2–3
70 – 79	3 or more
Below 70	**Discard** (do not use for sowing)

Irrespective of the sowing method, if birds/rodents may be too much of a problem, then sow at 3 seeds per hole or stand and thin to 2 plants two weeks after sowing

1.5 Appropriate sowing technique

- soybean can be planted close together because the roots do not spread much widely in the soil like other crops such as maize.
- soybean, being a legume crop, rely more on nitrogen in the air for growth. Therefore, close planting does not result in intense competition for nutrients nitrogen like maize and other crops.
- However, at an early stage of growth, especially before nodulation, soybean rely on soil nitrogen. Therefore, if the soil is deficient in nitrogen, it is important that a starter dose (a small amount of nitrogen, about 15 – 20 kg N/ha or 6 – 8 kg N/acre) can be applied to stimulate growth until nodulation.
- Ensure there is good soil moisture prior to sowing, usually after a good rainfall but soil should not be soaked with water as the seeds will rot and not germinate.
- **Do not broadcast** the soybean seeds.
- **Plant in rows.** This will allow the recommended spacing of **50 cm** between rows and **10 cm** between plants within the rows to be applied and to achieve the required plant population.
- Avoid deeper sowing (recommended depth = 3 cm; **not deeper than 5 cm)** as this may result in loss of seed vigor and poor germination or failure to germinate.

Below are some good examples of sowing techniques

1.5.1 Dibbling (include the use of dibber, hoe or cutlass):

- On each row, make 2 adjacent holes about **5 cm** apart and **3 cm** deep as below.
- Each pair of adjacent holes should be **10 cm part** from within the row.
- Sow **2 seeds in one hole.** The other hole is for fertilizer and will be discussed in later section. Remember, the number of seeds to put in one hole depends on the results of your germination test ***(please refer)***.

- Do not step on the planting hole after sowing to allow seeds to emerge.

1.5.2 Drilling:

- On each row, make a furrow using a dibber with a flat edge of about **5 cm width.**
- Sow the seeds at one side of the furrow with 2 seeds per stand and **10 cm between plant stands** within the row and cover after sowing. The opposite side of the furrow is meant for the drilling of the fertilizer at sowing (see details under fertilizer application).
- Do not step on the covered seeds after sowing to allow seeds to emerge.
- Again, remember the number of seeds to put per stand depends on the results of your germination test *(**please refer**).*

This method of sowing requires the land to be well prepared – ploughed to properly loosen the topsoil and harrowed/leveled (or double ploughed) to provide an even surface for sowing.

1.5.3 Intercropping

In areas **where** soybean is commonly intercropped with maize or other cereals, the following sowing technique should be used:

The planting rows should be spaced 75 cm apart.

Sow the maize at 50 cm within the row and plant 4 soybean seeds between 2 maize plants on the same row as seen in the picture. Make sure the 4 soybean seeds are evenly spaced between the 2 maize plants. Do not put all 4 seeds in one hole.

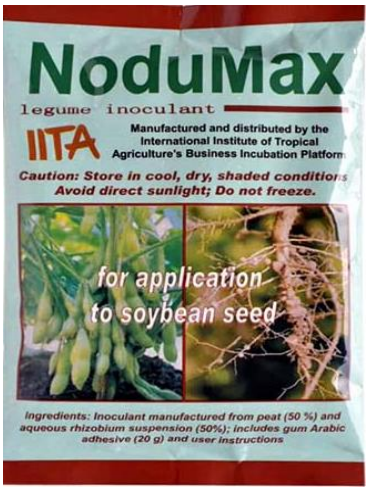
1.6 Field guarding after sowing

- There are several animals (birds and rodents especially) that usually disturb the germination of seeds.
- Therefore, after sowing, the field should be guarded to protect the seeds and ensure good germination.
- Guarding of the field can be done in multiple ways:

- The farmer or someone appointed need to watch over the field to scare away birds and rodents and prevent them from digging up the seeds or eating them when they emerge from the soil.
- Alternatively, the farmer can put up some scare crows to steer away birds and rodents or free roaming livestock from stepping on the seeds sown.
- The field guarding should be done until germination is completed, and the resulting seedlings have attained at least 2 – 4 leaves.

Module 2

Model 2: Harnessing the power of improved inputs



Learning objectives	▪ Showcase a host of recommended inputs that can help to increase soybean grain yield.
Learning outcomes	▪ Trainees are aware of some recommended inputs to increase soybean yield. ▪ Full understanding of the application rates, times, and methods of each of the recommended inputs.

Training materials	Delivery methods	Training duration
Training manual, flip chart, relevant pictures/illustrations, samples of inputs	Presentation, field visit, physical observations, inoculation demonstration, videos, image viewing, group work & discussions.	2 hours, 30 minutes

Introduction

- A host of improved inputs are available that farmers can use to assist them increase their soybean yields.
- Each of these inputs can be used alone or combined to better enhance the prospect of increasing soybean grain yield.
- These include the following:
    - **Improved variety**
    - **Certified seeds**
    - **Rhizobia inoculant**
    - **Legume fertilizer**

1.7 Appropriate variety

- Before buying certified seeds for planting, a farmer should first decide on which variety to use. Select a good soybean variety which suits your agro ecological zone.
- Generally, a farmer must always choose a variety with the following attributes:
- high yielding,
- resistant to pod shattering,
- resistant to drought, and tolerant to pests/diseases.
- Farmer also required to pay attention to the maturity period, some varieties have a relatively short maturity period and are suitable for areas with low rainfall, or when planted late in the season
- Late maturity varieties are less suitable for dried environments, but often produce higher grain and biomass yields, fix more nitrogen, and contribute more to soil fertility than early maturing varieties.
- In addition, a farmer may also consider the type of contract or market he/she is targeting to sell his/her soybean grains when deciding on which variety to use for planting – e.g., if the farmer is targeting/has a contract to sell the grains to a processor for oil, then a variety with seeds high in oil should be used. But the variety must conform to the traits indicated above.

- **Below are some improved varieties recommended by the SSPiNG project**

Name of variety	**Grain characteristics**	**Maturity** (days)	**Potential yield** (kg/ha)	**Pod shattering**	**Pests and diseases**
Bossier	Colour: Cream size: Medium Oil: 30%-40%	90-100	1.0 – 2.0	Resistant, up to 3% shattering	Moderately resistant to leaf rust, tolerant to other diseases
Uyole soya 2	Colour: Cream size: Large Oil: 35%-40%	110 – 120	1.0 – 2.5	Resistant, up to 8% shattering	Moderately resistant to other disease, susceptible to soybean rust

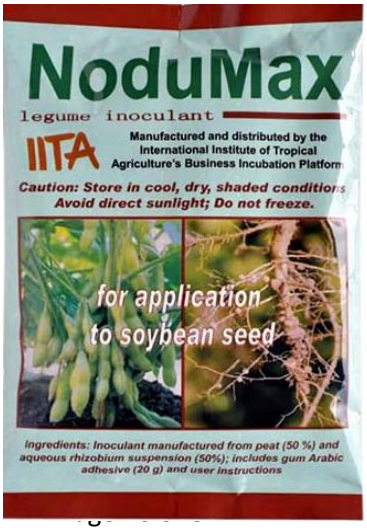
Uyole Soya 4		110 - 120	1..5 – 2.5	Resistant, up to 5% shattering	Moderately resistant, susceptible to soybean rust

1.8 Certified seeds

- It is important to always use certified seeds from a certified agro-dealer. Such seeds mostly give better germination for high plant population and higher grain yields.
- Make sure seed is not more than 12 months old. Always verify that the seeds were from a season prior to the present one and not kept in storage for multiple seasons (seeds likely to lose vigor, not germinate and give low yield).
- About, and 40 – 45 kg to for one hectare. These are targeted at achieving the optimum population **16 – 18 kg of soybean seeds are required to plant one acre** of about **160,000 plants per acre**
- It is not advisable to reserve some of the soybean grains from the previous season's harvest and use for planting in the current season because:
  - soybean seeds tend to lose their viability and vigor when poorly stored leading to poor germination and low yields.
  - the ability of seeds from previous harvest to give higher yields when re-used for planting generally tend to decline season after season.

1.9 Rhizobium inoculant

Introduction (Facts/important notes)



- Rhizobium inoculants are commercially produced rhizobia applied to legume seeds before sowing to enhance nodulation, nitrogen fixation and better yield. There are several quality inoculants available for use on soybean.
- It is important to inoculate soybean seeds because the rhizobia that normally cause soybean to form nodules and fix nitrogen are naturally found in low amounts in most soils in the Southern highlands
- Most essentially, on newly cleared lands or lands that have not been cultivated to soybean before, the amount of the right rhizobia for soybean is more likely to be even less or

lacking. Hence, a farmer must always apply inoculant when growing soybean on such lands/soils.

- To ensure that adequate amounts of the required rhizobia is available in the soil, it is necessary to inoculate soybean seeds. This will enable the plants to form more nodules, fix more nitrogen, produce more biomass/residues and grains.
- When the soybean is able to fix more nitrogen, it uses part for its own growth and leave some in the soil to improve the fertility which will then benefit a subsequent crop like maize grown in rotation with the soybean.
- Always check that the inoculant is the right one for soybean before buying because some inoculants may not work on soybean as each legume needs a specific rhizobium to infect its roots to be able to form nodules.
- The inoculant packet always shows the legume types it should be applied to.
- Also check the specific rate to be applied because it differs for each inoculant as manufacturers use different formulations and carriers in developing inoculant.
- Ensure that the inoculated seeds do not get in contact with fertilizers when sowing.

Application rates and methods

Due to the different formulations/carriers used in developing inoculants, the method and rate of application also differs for each inoculant. Always check the instructions that come with the inoculant for the right method and rate.

Application rate: (Nodumax)????

- 10 g per kg of soybean seeds **OR** 100 g (one sachet) per 10 kg of seeds.

Application method:

- Measure and place **10 kg** of soybean seeds in a container large enough to accommodate all the seeds.
- Dissolve the gum Arabic enclosed with the inoculant packet in 200 ml of warm water (about half of the small Voltic bottle) if preparing it for 10 kg seeds. This is the sticker. For 1 kg of soybean seeds, use 20 ml of water to prepare the sticker.
- Add the gum Arabic solution to the seeds, mix until all seeds are uniformly covered.
- Add **100 g** (one sachet) of inoculant to the seeds already covered in gum Arabic solution and mix thoroughly until all the seeds are uniformly covered and/or coated with the inoculant.
- Avoid exposure of the inoculated seeds to sunlight by covering with a paper, cloth, etc. Exposure to sunlight will kill the rhizobia bacteria.

- Put the inoculated seeds under a shade to allow them to **coolly dry for about 15-30 minutes** (note that the time depends on the quantity of seeds inoculated) before sowing.
- Ensure that you sow the inoculated seeds as soon as possible, especially about 30 minutes after inoculation. In an extreme case, ensure you sow the inoculated seeds on the same day they are inoculated.

Application rate: (Legume fix)

- 4 g per kg of soybean seeds **OR** 250 g (one sachet) per 60 kg of seeds.

Application method:

- Measure 15 kg of soybean. Place in any containers that will accommodate the seed
- When seed is a bit dusty, a small amount of water (30ml, 6 teaspoons or soda bottle -tops) can be mixed with the seeds.
- Add 75 gram (7 tablespoons) of inoculants to the seeds.
- Mix the seeds and the inoculant thoroughly until all the seeds are uniformly covered.
- Protect the inoculated seed from direct sunlight by covering the container with paper, cloth or gunny bag and keep under shade until planted.
- Plant the seed on the same day you inoculate them.
- You can adjust the volumes above to any quantity of soybean of seed. Per kg seed, use 4 gram (1 heaped teaspoons or soda bottle -tops) inoculant.

Application rate: (Biofix)

- 4 g per kg of soybean seeds **OR** 250 g (one sachet) per 60 kg of seeds.

Application method:

- Measure 15 kg of soybean. Place in any containers that will accommodate the seeds
- Measure one soda bottle (300ml) of clean lukewarm water
- Add the 30g of gum Arabic contained in the Biofix pack (the whitish material) or 2 tablespoons of sugar to the water.
- Mix thoroughly to get an even solution of gum arabic (or sugar). This solution is called the sticker. Add the sticker to the seed and mix until all the seeds are evenly coated with the sticker.
- Add the rhizobium inoculant onto the seeds and sticker. The inoculant is the 100g (10 tablespoons) black powder contained in the Biofix pack.
- Mix the seeds and the inoculant thoroughly but gently until all seeds are uniformly covered with the inoculant.

- Protect the inoculated seed from direct sunlight by covering the container with paper, cloth or gunny bag and keep under shade until planted.
- Plant the seeds on the same day you inoculate them.
- You can adjust the volumes above to any quantity of soybean seeds. Per kg seed, use 4 teaspoons or soda bottle -tops (20ml) of the sticker solution, and 2 heaped teaspoons or soda bottle-tops (10g) of inoculant.

Handling and storage of inoculant

- Inoculants lose their effectiveness when stored in an open package. Therefore, keep the inoculant package sealed until you are ready to use.
- Store the inoculant in a cool, dark and dry place away from heat, direct sunlight and moisture.
- Do not store the inoculant in a freezer as this will kill the rhizobium bacteria.
- Always follow the recommended storage instructions that came with the inoculant.

Facts about inoculants

- The roots of legumes and rhizobium bacteria work together to biologically fix nitrogen. Inoculants contain the bacteria that help the soybean to make nitrogen.
- Inoculants are much cheaper than nitrogen fertilizer
- Each legume crop needs a different type of rhizobium bacteria, so always check you have the right inoculant for the crop you want to sow
- Directions for using inoculants can be found on the package. How to inoculate depends on the type of inoculant you use. Therefore, always check the instructions on the package or ask an agrodealer or extension worker

2.4 Legume fertilizer

Important points

- Soybean can fix its own nitrogen, and therefore you do not need to apply nitrogen fertilizer like urea or CAN. Soybean cannot fix other nutrients, and therefore you do need to apply other nutrients such as phosphorous at planting. Good fertilizer types for soybean that supply phosphorous are TSP, DAP or Minjingu phosphate 9. However, SSP and TSP are not readily available in Tanzania. Choose Minjingu phosphate when the pH of the soil is below 5.6.

Benefits of the legume fertilizer

- Rapid growth and development of the soybean plants.
- Reduction in flower abortion or loss of flowers.
- Increased number of pods per plant and pod filling (3-4 seeds per pod).

- Larger grain size and increased grain weight.
- Increased grain yield.
- Improved grain quality.
- Increased economic returns.

Application rate and methods

Application rate:

- 100 – 160 kg/acre equivalent to 250 kg/ha, which should be applied at sowing **(recommended).**

Application time:

- The fertilizer should be applied at sowing (**preferred**).
- If for any reason the fertilizer cannot be applied at sowing, ensure that it is applied within **one (1) week** after sowing and **NOT** later than **two (2) weeks** after sowing.

Application methods

a) Drilling method:

- With this method, the fertilizer is applied at sowing time.
- The method requires the land to be well prepared – ploughed to properly loosen the topsoil and harrowed/leveled to provide an even surface.
- At planting, make a furrow using a dibber with a flat edge of about **5 cm width.**
- Sow the seeds at one side of the furrow and cover seeds *(please refer to sowing techniques)* and then drill the fertilizer at the other side of the furrow opposite the side where the seeds were sown. Cover the fertilizer after application.

b) Band placement method:

- This method also requires the land to be well prepared – ploughed and harrowed/leveled.
- The method can be used to apply fertilizer both at sowing and after the seeds have germinated.
- If applying at sowing,
  - make 2 adjacent holes about **5 cm** apart and **3 cm** deep *(refer to the picture under sowing technique)*.
  - Sow the seeds in one hole and place the fertilizer in the other hole and cover after application.
- If applying after germination, place the fertilizer **5 cm away** from the base of the plant in a **3-5 cm deep trench** and cover after application.

▪

Module 3

Module 3: Adequate crop stress management

Learning objectives	▪ Know when soybean plants are stressed. ▪ Identify the major sources or factors that cause stress in soybean. ▪ Understand damages caused by each source/factor of crop stress. ▪ Understand the different mitigation and/or management measures for the various crop stress factors.
Learning outcomes	▪ Enhanced understanding of weeds management practices. ▪ Ability to identify the major pests and diseases of soybean and their control/management measures. ▪ Increased awareness of the right PPEs to use when handling agro-chemicals (herbicides and pesticides).

Training materials	Delivery methods	Training duration
Training manual, flip chart, relevant pictures/illustrations, samples of agro-chemicals,	Presentation, field visit, physical observations, videos, image viewing, group discussions. role play	2 hours

permanent marker, stick note, color card		

When is a crop stressed?

A crop is stressed when an external factor/condition causes it to suffer and grow poorly and ultimately decreases the yield. Crop stress could result in very low yields or even a total crop failure.

Impact of crop stress

If crop stress is not sufficiently managed, it can lead to:

- Reduced number of soybean plants per acre or hectare as it could affect the survival of the plants. In the end, optimum plant population cannot be achieved.
- Stunted plant growth.
- Limited production of biomass.
- Poor nodulation and nitrogen fixation.
- Low number of pods per plant.
- Poor pod filling leading to low number of seeds or grains per pod.
- Small seed or grain weight/size.

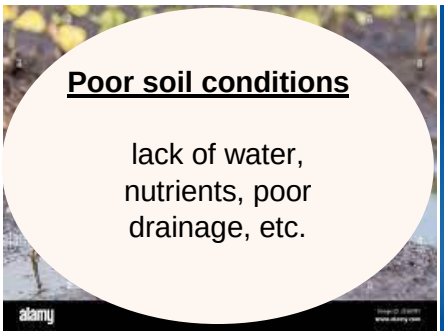
3.1 Sources of crop stress

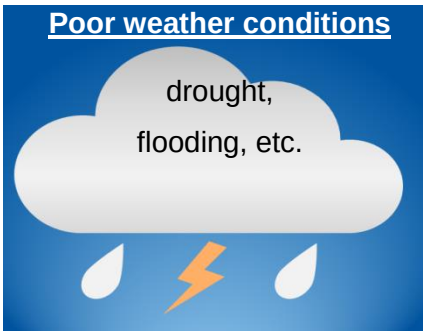
Crop stress emanate from multiple external factors/conditions, which can be living organisms or non-living things. Prominent among these include:

Pests

Diseases

Weeds





3.1.1 Weeds

- Weeds compete with the soybean plants for nutrients, water, light and space, depriving the plants of these essential growth elements and decreasing the yield.
- Weeds serve as host for some diseases and pests that attack soybean plants.
- Weed seeds/residues can be mixed with soybean grains and reduce the quality.
- Timely and thorough weeding is important for better growth, canopy closure, better weed suppression and higher yield.
- The number of weeding depends on the time and severity of weed infestation.

Manual weed control

- Hand weeding (with hoe) is preferred though labor intensive.
- Generally, 2–3 weeding should be done for better growth of soybean.
- First weeding should be done at 2–3 weeks after planting and second weeding at 4–6 weeks after planting based on level of weed infestation.
- The second weeding should be done before flowering to prevent loss of flowers.
- Avoid weeding immediately after rain to prevent weed seed transport in the field

Chemical weed control

- Weeds can also be controlled with herbicides / weedicides.
- The choice of herbicide depends on the predominant weed species in the field and the availability of herbicides.
- Chemical weed control can be performed at pre-emergence stage (before the soybean seeds germinate, usually, same or next day after sowing) or at post-emergence stage.
- A post-emergence herbicide can be applied when the soybean plants are at about 4–6 leaf growth stage or as early as weed infestation warrants it.

Recommended herbicides that can be used for chemical weed management in soybean

1) Dual Gold 960EC

A **pre-emergent** herbicide for the control of annual grasses and broadleaf weeds.

Application rate:

Water volume	Recommended rate
80-160 litres	400 – 600 ml/acre
200-400 litres	1– 1.5 L/ha
15 liters	38 - 40ml/15L Knapsack
20 litres	50 -60ml/20L Knapsack

Method of application:

Fill the Knapsack with half the required amount of water. Add the recommended amount of chemical and mix thoroughly. Top up the tank with water to the required level and shake well to ensure thorough mixture and then spray.

2) Fusilade Forte 150EC

A superior post emergence herbicide for the control of grass weed

.

Application rate:

- 150ml/20L Knapsack (112.5ml/15L Knapsack)
- 600ml per 80L water per acre
- 1500ml per 200L water per hectare

Method of application:

Fill the Knapsack with half the required amount of water. Add the recommended amount of chemical and mix thoroughly. Top up the tank with water to the required level and shake well to ensure thorough mixture and then spray.

3) Gallant super 108 EC – (Haloxyfop-R Methyl Ester 108g/l)

A selective systemic post-emergence herbicide for the control of annual and perennial grasses in broad-leaved crops.

Application rate:

- 66.7ml/20L Knapsack

  (50ml/15L Knapsack)
- 1L per 500L water per hectare
- 200ml per 400L water per acre

Method of application:

Fill the Knapsack with half the required amount of water. Add the recommended amount of chemical and mix thoroughly. Top up the tank with water to the required level and shake well to ensure thorough mixture and then spray.

4) Bentazone 480EC (bentazone 480g/L)

A water-soluble concentrate, selective contact herbicide for use as a post-e

on annual and perennial weeds.

Application rate:

- 2L/ha
- 800ml/acre

Method of application:

Fill the Knapsack with half the required amount of water. Add the recommended amount of chemical and mix thoroughly. Top up the tank with water to the required level, shake well to ensure thorough mixture and spray.

3.1.2 Pests

- Pests attack plants at different stages of growth – seeds, young plants, flowering, podding and pod-filling stages. Control should be targeted at these stages.
- Most importantly, pests and diseases must be controlled between flowering, podding and pod-filling stages for better grain yield.

Identification of soybean important pests

1) soybean stink bugs

- These pests feed on the soybean seeds in the pods when they are still developing.
- They penetrate the pods, suck nutrients and fluids and eventually cause the seeds to be shriveled.

2) soybean aphids

- These pests are normally found on the undersides of soybean leaves and stems.
- They suck fluids and nutrients, and cause the plants to be stunted, abort flowers and ultimately reduce pod and grain yield.

3) Silverleaf whitefly

- This is one of the most common pests of soybean that reproduces faster under hot and dry weather conditions.
- They are small insects that suck fluids and nutrients from soybean plants, like the aphids and causing serious yield reduction.

4) Two-spotted spider mites

These are small and rarely visible to the naked eye.

Usually found on the underside of leaves, feed on the cell contents and the infested leaves turn brown and drop down.

5) Pod bug

These pests suck the pods of soybean, causing poor pod filling and reduced grain yield.

6) Bean leaf beetle

- These pests vary in color ranging from yellow, green, tan or red with a small triangle behind the head.
- They cause much damage on young soybean plants by causing defoliation.

7) Ants

- Ants do not directly attack soybean plants like the other pests.
- However, in the process of building their nests or mounds, soils brought to the surface by colonies of ants can
  - bury smaller soybean plants.
  - affect the roots of soybean plants, cause loss of soil moisture around the root zone and deprive the plants of the needed water and eventually negatively impact on the survival of soybean plants.
  - These can lead to low plant population and contribute to yield reduction.
- These ant colonies can be controlled with chemicals such as **Furadan and Dursban.**

Pest management measures

- Use clean or certified seeds for sowing.
- Use soybean varieties resistant to pests.

- Practice adequate land preparation – ploughing and harrowing to kill weeds that could serve as hosts for pests.
- Practice crop rotation to break pest cycles.
- Use recommended insecticides to control pests.
    - Usually, one or two sprayings of these insecticides is adequate to control pests.
    - However, the level of pest infestation will determine the number of sprayings needed.
    - When to first spray soybean plants depends on the time pest infestation is noticed and the level of pest incidence – but usually first at flowering and then another one spraying may be enough based on pest incidence – normally 21 days after the first spraying.
    - Spraying should be done early in the morning or late in the afternoon.

Below are some recommended insecticides that can be used to control pests in soybean.

Dursban 4E (Chlorpyrifos 480g/L)

- 50-75ml/20L knapsack
- 1.25-1.5L/ha
- 500-600ml/acre

Karate 5%EC (50g/L Lamda-cyhalothrin)

- 40ml/20L knapsack
- 30ml/15L knapsack
- 400ml/ha
- 160ml/acre
- 200L of water/ha
- 80L of water/acre

Selecron 720 EC (Profenofos 720g/l)

- 27-53ml/20L knapsack
- 20-40ml/15L knapsack
- 500-800ml/ha
- 200-320ml/acre

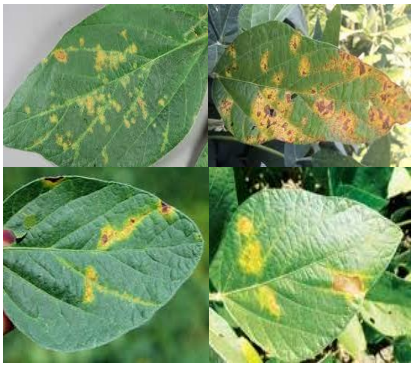
3.1.3 Diseases

Identification of soybean diseases

There are several diseases that affect soybean plants at different stages to growth and reduce the yield. **Below are some of the most common diseases that affect soybean:**

Viral diseases

soybean mosaic



soybean vein necrosis

Bean pod mottle

Bacterial diseases

Bacterial pustule

Bacterial blight

Fungal diseases

Frog eye leaf spot

soybean rust

soybean stem rot

Fusarium root rot

Control measures for soybean diseases

- Use clean or quality/certified seeds for sowing.
- Treat seeds with fungicide **(e.g., Captan, Apron Plus or Thiram)** at the rate of one sachet per 8 kg seeds to control soil-borne pathogens or fungal diseases before planting.
- Use soybean varieties resistant to diseases.
- For viral diseases, uproot and bury the infected plants.
- Practice adequate land preparation – ploughing and harrowing or double ploughing or apply fungicide to contaminated soils to destroy pathogens.

3.1.4 Protective equipment for chemical usage

Face protection

- For eyes, wear goggles and protective glasses
- Wear mask for nose and lungs protection

Hands and arm protection

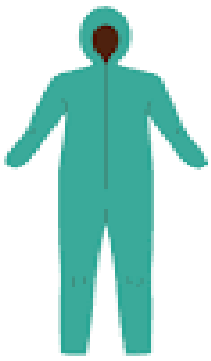
- Wear arm guards and gloves

Feet and legs

- Wear boots with protective soles such as Wellington boots

Whole body

- Wear the above PPEs including a protective clothing to cover whole body



Safe use of chemicals

- Seek advice if you are not sure of what chemical to use.
- Always read the instructions on the chemical container to fully understand the precautionary or safety measures before use.
- Always keep record of the type, date and name of chemical used.
- Do not taste or smell pesticides as they are toxic and avoid contact while spraying.
- Do not mix different chemicals together to spray.
- Do not drink or eat while mixing or when spraying any chemical.
- Always use a stick to stir when mixing chemicals. Do not use your hand to stir.
- Do not use knapsack sprayers that leak.
- Use high pressure nozzles to apply pesticides (this ensures release of smaller droplets targeted at pests) and low-pressure nozzles to apply herbicides (for release of larger droplets targeted at weeds).
- Always spray along the direction of the wind to avoid droplets of the chemical drifting towards you.
- Safely dispose of any empty chemical containers by piercing and then burying them.
- Use only herbicides, pesticides and fungicides that are recommended to soybean to avoid damage to the plant.

Module 4

Module 4: Proper harvest planning

Learning objectives	▪ Identify the best time for harvesting of soybean to avoid yield loss. ▪ Understand the different harvesting methods and benefits.
Learning outcomes	▪ Enhanced understanding of the best time to harvest soybean to avoid shattering and yield losses. ▪ Increased awareness of the different harvesting methods and the associated benefits.

Training materials	Delivery methods	Training duration
Training manual, flip chart, relevant pictures	Presentation, field visit, physical observations,	45 minutes

	videos, image viewing, group discussions.	

4.1 Harvest timing

- Most of the recommended soybean varieties are medium maturing, taking between 110 – 120 days (i.e., 3-4 months) after planting to mature.
- Harvesting must be properly timed to avoid pod shattering and yield losses. Therefore it is better to harvest early in the morning to avoid shattering.
- soybean pods are ready for harvest when about 85% of the pods have turned brown for a non-shattering variety.
- For a shattering variety, harvest when 80% of the pods have turned brown.

You can test the readiness of the pods for harvest by shaking them. If you hear the seeds / grains making rattling noise within the pods, then they are ready for harvest. At this stage, any further delay in harvesting may result in pod shattering.

4.2 Harvesting methods

- Always harvest soybean under dry weather conditions for better grain quality.
- Harvesting is commonly done by uprooting the whole soybean plants, heaping and allowing them to further dry before threshing – manual or mechanical.
- soybean can also be harvested by using hoes to cut the plants at soil level. This method allows the roots of the soybean plants to be left in the soil so that they can decompose and add nitrogen to the soil to improve its fertility.
- After harvesting and heaping the dry soybean plants, it is important to turn over the heap at a regular interval for faster, proper and uniform drying before threshing, and to avoid discoloring of the grains.
- Always protect the pods being dried from possible rainfall.

4.3 Post-harvest handling

- After threshing, clean the grains by removing weed seeds, debris and other foreign materials. This helps to ensure quality grains to meet recommended quality standards and for better grain price.
- Store the clean and well dried grains in clean and uncontaminated bags.
- Do not use recycled fertilizer or chemical bags to store soybean grains.
- Store the soybean grains in a cool, dry and ventilated room or hut.
- Place the bagged soybean grains on a wooden board such that the bags do not lie or touch the ground.
- Jute bags are usually preferable because they do not conserve heat and allow soybean grains to be stored for a longer time.
- Ensure that the storage room is well ventilated.
- You can also use PICS (Purdue Improved Cowpea Storage) triple bags to store grain under air-tight conditions and keep away insects from the grain. Place grain in the innermost bag and tie this bag tightly, then tie the middle bag, and finally tie the

outermost bag. When all the bags are tied, any insects in the grain die from lack of oxygen. It is not necessary to treat seeds against storage pests when using PICS bag.

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