SOYBEAN

UG244 TRAINING GUIDE

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Introduction

SOYBEAN (*Glycine max* (L.) Merr.) has a great potential to drive the growth of Uganda's Industrial Development Goals through value addition and investment in processing. Soybean has become a very attractive crop to grow by smallholder farmers in Uganda as short cycle crops (grown twice a year) and requires minimal inputs in their production. A large number of farmers with limited means (in close to 480,000 households) are dependent on growing soybeans as a source of livelihood (VODP, 2018). Soybean is an important crop with potential to improve household food and nutrition security and income. The crop is very nutritious containing approximately 40% protein and 20% oil, vital in human and animal diet. The soybean processing technology at industrial or household level in Uganda has made the crop, one of the main tradable commodities in the farming communities of Uganda.

Recently, soybean production in Uganda had come to a decline due to the outbreak of soybean leaf rust disease. The disease was devastating to soybean crops throughout the country (soybean production guide in Uganda, 2015). However, breeding programs released resistant soybean varieties that allowed an increase in their production. To date, up to 350,000 metric tons of soybean grains are produced annually with an expected value of 500 billion Uganda shillings.

Although production area increased from 39,000 hectares in 1998 to 437,500 hectares in 2018, yields remained relatively low over the same period (0.6 - 0.8mt/ha). Researches in Uganda indicates a potential soybean yield of 2.5 – 3.0mt/ha (Soybean research and development, 2002-2015)

The purpose of this handbook is to fill the urgent need in so far as soybean agronomy, post-harvest handling, disease and pest control, knowledge and skills are concerned. The book also gives the farmers the expected economic benefit of growing soybean crops. The content of this guide was compiled to be practical to assist extension workers in their training of farmers on soybean production.

1.1 Pre-planting activities

Pre-planting factors should be taken into account because of their influence on soybean establishment, quality and quantity. Therefore, growers must consider the following pre-planting activities:

-1.1.0 Site Selection: chose well drained soils that are loose and well aerated allowing air to reach the root system and nitrogen fixing nodules. Soils should have a good water-holding capacity and not be exposed to erosion. Potential sites for soybean production should be under crop rotation to reduce disease incidence and soil nutrient depletion.

-1.1.1 Seedbed preparation: typically involves plowing, tilling, mixing and overturning the soil. It also involves breaking the soil into smaller pieces, incorporating plant residue and leveling the field for crop production. Land may be prepared by hand hoe, animal-drawn ploughs, tractor and herbicides. Land preparation serves two main purposes of eradicating weeds and having a fine tilth suitable for the emergence of seedlings. When using the traditional way of land preparation, first and second ploughing/harrowing is usually recommended for preparing a suitable soybean garden.

Avoid bad practices such as indiscriminate cutting down of trees and uncontrolled burning of forests to clear land. This can lead to loss of soil fertility, soil erosion and contribute to environmental degradation.

An ideal soybean seedbed comprises fertile loam soils loose and well aerated to ensure rapid germination and seedling emergence. Rapid emergence will help reduce the weed pressure on soybeans. A fine seed bed also provides adequate moisture and optimum temperature (above 21oC).

Figure 1: *Well prepared seedbed*

Farmers practicing conservation agriculture can prepare their lands by spraying them with herbicides like Round up before seeding. The use of herbicides has several advantages:

• It kills any plant (both weeds and crops), down to the roots so that weeds do not emerge, unlike digging
• It is not time consuming

- It makes minimal disturbance to the soil, hence preserving soil nutrients
- It is less costly compared to tilling
- It requires less labor

To benefit from the practice, farmers need to follow the right procedures and the safety precautions as indicated below:

i). have the correct item to start spraying

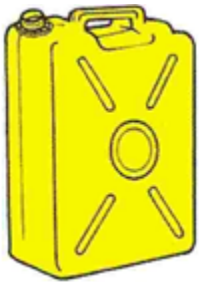
- A spray pump
- Flat nozzle
- Protective gear (garden gloves and face mask) to handle glyphosate
- Glyphosate (Roundup)
- Water

Spray pump

Flat nozzle

glyphosate

protective Gear



Jerrican of water

Figure 2: items needed when applying glyphosate (Roundup); *adopted from Soybean Production Trainer's guide*, IFDC

ii). Follow the right procedure to apply Roundup (glyphosate)

- It must be applied to living, growing weeds.
- For overgrown weeds, first properly slash all the tall weeds close to ground level.
- After the slashed weeds have regrown for at least 2 weeks, spray with glyphosate.
- Only spray when no rain is anticipated for at least 6 hours.
- Spray when the soil is moist, but not flooded, and weeds are actively growing.
- For swampy areas, drain all the water and leave it at least 2 days before spraying.
- Glyphosate takes two weeks to kill weeds, but you can plant a week after application.

iii) Follow safety precautions:

- Wear long sleeved pants and shirts
- Wear gloves
- Wear boots
- Wear a hat to protect your hair and scalp
- Wear a mask to protect your eyes, face and nose
- Immediately wash parts of your body where the herbicide spilled with a lot of running water and soap to avoid skin irritation.
- Bathe after applying herbicides and change into clean clothing.
- Wash herbicide-contaminated clothing separately from other clothing after applying.
- Clean the pump before you use it to spray any other herbicide.
- Protect herbicides from extreme cold or extreme heat.
- Keep herbicides in a place which cannot be accessed by children or animals.

iv) Follow correct steps during mixing glyphosate:

- Read and follow the instructions on the label exactly and mix only the needed amount of herbicides for the job.
- Take precautions to prevent spills of the herbicides, close containers tightly after each use, even if you plan to reopen them again.
- Use 20mls of glyphosate in 1 liter of water as your starting point. This will help you determine how much glyphosate you need for the size of spray pump you intend to use.
- For example, in a 20 liter spray pump:
- Fill the spray pump halfway with water.
- Add 400mls of glyphosate for easily killed weeds or 800mls of glyphosate for difficult weeds in a half-filled, 20 liter spray pump.
- Shake 10 times.
- Top up water to fill the 20liter spray pump.
- Shake again.

v) Do the following after completing the spraying:

- Be sure to triple-rinse all empty containers used to prepare herbicides to allow the concentrate to drain from the empty container.
- Rinse water must be collected and applied to a compatible site.
- Keep herbicides and other pesticides in their original containers. This helps you know what they are and how to use them.
- Mark the date of purchase on each container and use older chemicals first.
- If possible, store pesticides and herbicides indoor in a clearly marked area, designated as a secondary containment.

-1.1.2 Varietal and seed Selection: It is important that farmers use quality soybean seeds when planting. This can help to improve their yields significantly. Quality seeds exhibit certain characteristics: they are high yielding, fast maturing, resistant to pod shattering, disease and pest, and have high oil and protein contents.

Figure 2: Soybean harvest maturity sign, seed type and variety name, *adopted from soybean production guide in Uganda, 2015*

-1.1.3 Seed selection

Most farmers use seeds they have stored for a long time, from open markets, or from grain traders. This is a problem because seeds from fields inflicted with diseases can be replanted in the process. Soybean seeds like many oil seeds are delicate seeds that tend to easily lose viability if not properly handled (Soybean Production Guide in Uganda, 2015). The conditions of seed conservation and handling at open markets, in homes and at stores of grain traders are often substandard thus such seeds do not germinate properly. Farmers therefore should always use improved quality soybean seeds from accredited sources.

Table 2: Attributes of soybean varieties in Uganda

Variety	Year of release	owner	Seed source	Days to maturity	Yield/ha	% oil content	Characteristic (special attribute)
Bukalasa 4	1967	NARO	NARO	100	1.0	15	Susceptible to bacterial pustule and rust, shatters, lodges
S 38	1968	NARO	NARO	100	0.8	-	Susceptible to bacterial pustule and rust, shatters, lodges
.Congo 72	1969	NARO	NARO	100	0.5	-	Resistant to rust, Resistant to shattering
.Kabanyolo 1	1971	NARO	NARO	100	2.0-3.0	-	Susceptible to bacterial pustule, rust, shattering and lodging
Nam 1 (CAL 131)	1989	NARO	NARO	115	2.5-3.5	-	Resistant to bacterial pustule, susceptible to rust, resistant to shattering
Nam II (L73)	1994	NARO	NARO	120	2.5-3. 5	15	Resistant to bacterial pustule, susceptible to rust, big seeded with black hilum, resistant to shattering
7. Namsoy 3 (NG7-3	) 2000	NARO	NARO	100	1.5-2.0		Resistant to bacterial pustule shattering, improved nodulation, early maturity
8. Maksoy 1N	2004	MAK	MAK	95	2.0 – 2.5	17	Resistant to soybean rust, very resistant to pod shattering, 41%.protein content
Namsoy 4M	2004	MAK	MAK	100	2.0 – 3.5	20	Resistant to soybean rust, resistant to pod shattering has 43%.protein content
Maksoy 2 N	2008	MAK	MAK	105	2 – 3.0	20	Tall variety reaching 1 meter, resistant to shattering and bacterial pustule
Maksoy 3 N	2010	MAK	MAK	100	2 – 3.5	22	Resistant to Soybean rust has 48%, protein content
Maksoy 4 N	2013	MAK	MAK	103	2 – 3.5	21	Tolerant to Soybean rust, early maturing
Maksoy 5 N	2013	MAK	MAK	96	2 – 3.5	19	Tolerant to Soybean rust, early maturing

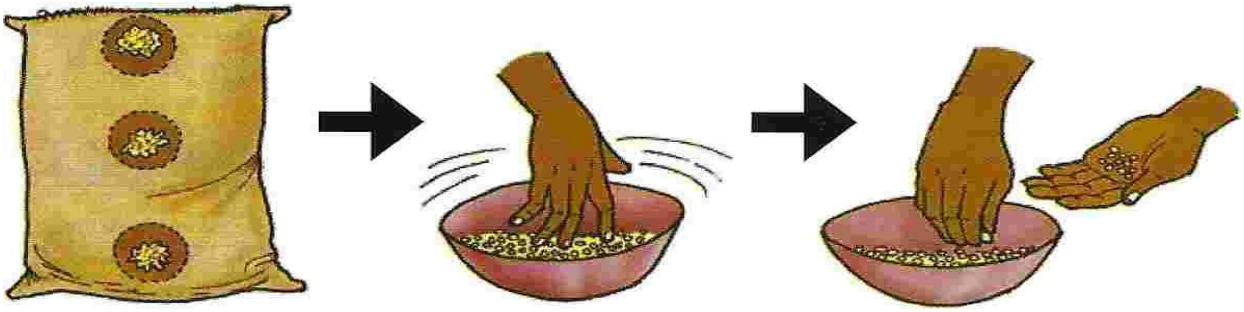
Source; National crop variety list for Uganda, 2015

-1.1.4 Germination test: soybean seed rapidly loses viability when not handled well during processing and storage. Quality seeds tend to be expensive but, will give high crop yields. It is therefore important that you assure the seed germination before planting. The germination test is simple and easy to conduct.

- Take samples of seeds from different parts of the bag and mix them thoroughly
- Count out 100 whole soybean seeds and place them on one half of cotton cloth.
- Soak the seeds for twenty four hours
- Wrap the soaked seeds in a moist cotton cloth or paper towel
- Position the moist wrapped cotton cloth upright so that roots will grow downwards while shoots grow upwards.
- Keep the rolled cotton cloth in a warm place (between 23° and 30°C).
- Count the first germinated seeds after three days by opening the cloth
- Fold and roll back into a tube.
- Repeat counting after another three to four days, germination time for most legumes is between 5 - 7 days.

- Good viable seeds are expected to have a germination rate of over 90 percent,

Seed germination testing procedure

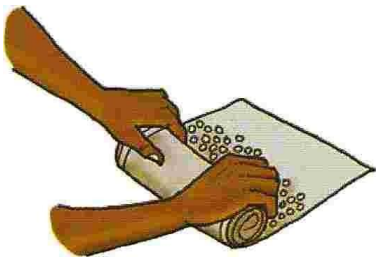


Pick sample from 3 different spots

mix the 3 samples thoroughly

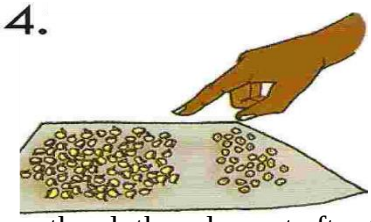
count randomly 100 seeds

Soak the seeds in water for one day (24hrs).



place the soaked seed in moist cotton cloth

moist cloth and seeds and place in warm place



Open the cloth and count after three days and repeat after 5 days

Figure 3: seed germination test: *adopted from Soybean Production Trainer's guide,* IFDC

-1.1.5 Inoculation of soybean: to further boost soybean yields, farmers are encouraged to dress soybean seeds with rhizobia before planting. The process of dressing soybeans with rhizobia is called inoculation. The inoculum-*Rhizobium japonicum* is a nitrogen fixing bacteria that forms nodules on roots. This allows the capture of air nitrogen by the crop and subsequently, a soybean yield increase.

-1.1.6 Procedure of inoculation

1. Make an inoculum sticker by dissolving one cup of sugar and 2 cups of clean water.
2. Mix the seeds well with inoculum sticker so, that they are wetted.
3. Empty 250gm of MAK BIO-N-FIXER inoculant onto 25kgs of seeds (10grams of inoculum mixes 1kg of soybean seeds).
4. Mix the seeds thoroughly so that each seed is uniformly coated with the inoculant.
5. Cover the inoculated seeds with paper, cloth or basket to protect from direct sunshine.
6. Plant the seeds immediately after inoculation

1.2 Soybean Planting:

-1.2.0 Planting date: Climate variability has made it generally difficult for smallholder farmers to predict the exact planting dates. Researchers recommend that planting soybean should be done as early as possible. In Uganda, recommended planting dates for soybean are: (i) February – April for the first rainy season and (ii) August to September for second rainy season. However, farmers should plant soybean at onset of stable rains.

Table 2: Possible planting and harvesting period for soybeans in Uganda

First crop		**P**	**P**	**P**									
Harvest						**H**	**H**	**H**					
Second crop								**P**	**P**				
Harvest											**H**	**H**	
Months	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**

Source; Uganda soybean research and development: Key: P- planting, H – Harvesting:

First rains give farmers more opportunity to plant soybeans, which could be the reason why more soybeans are planted in the first rainy season than second rainy season (UOSPA monitoring field report, 2017)

-1.2.1. Seed rate and plant density determination: depending on seed size, soybean seed rate may vary between 20kg - 25Kg per acre for a recommended plant population of 120,000 plants per acre. Note that, lower plant population may contribute to erratic stand, excessive branching, weed competition and reduced yield. In contrast, high population may cause competition for resources, shading and lodging of soybean crops in the field. Therefore, farmers should try to achieve optimum plant populations able to suppress weeds during early crop growth and result in higher yields per hectare.

Farmers can learn how to calculate their own seeding rate (SR), expressed as number of seeds per hectare from the following equation:

SR = DPD * [100 / GP] * [100 / (100-APSL)] where:
DPD - desired plant density per hectare,
GP - germination percent and
APSL - average percent stand loss.
Take for example that farmer's target desired plant density is 120,000 plants in one acre with a minimum of 10% percent stand loss. However, seed intended for planting has germination percentage of 95%. Therefore, Seed Rate (SR) will be:

= 120,000 x [100 / (95)] x [100 / (100-10)] = 120,000 x 1.053 x 1.111 = 140,386 seeds acre.
Assuming that 1,000 soybean seeds weighs approximately 0.151 kg, the actual amount of seed planted will be: = (140,386 x 0.151)/1,000 = 21,198.286/1000 = 21.198 ~ 21 kg per acre.

-1.2.2 Recommended spacing and planting depth: before planting soybean, sort out the good seeds, make sure that the seeds are free from insects, diseases and weed seeds. When planting soybeans, leave 45cm between rows and 20cm spacing between plants along the row if 2 seeds are to be planted per hole or space at 50cm x 25 cm when 3 seeds are to be planted per hole. It is advisable to mark the planting string to maintain correct spacing between plants,

Figure 4: Planting soybean at recommended spacing and in lines

The planting hole depth should be 2-5cm deep to allow easy emergence of planted seeds
Plant 2 or 3 seeds in each hole and cover slightly with soil
Use 20-25kg of seeds to plan optimally one acre
Avoid repeated planting of soybean in same piece of land season after season (planting soybean after soybean). This will cause soil nutrient depleting and pest and disease spreading.

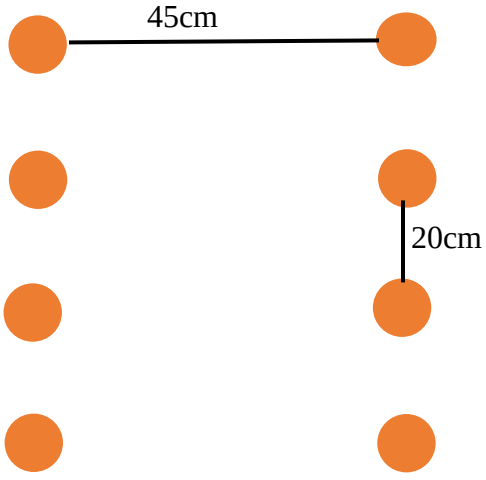


Figure 5: Recommended soybean spacing

Seed planted at recommended depth, in soil with a temperature above 21oC and adequate moisture, rapidly absorbs water and germinates within 2 - 3 days after planting. However, if the depth of sowing is deeper than 5 cm and soil temperatures are below 21oC, germination may slow down and emergence delayed up to 6th day after planting. Avoid deep planting because the germinating seedlings may deplete their nutrient reserves stored in the seeds before they have developed primary roots capable of water and nutrient uptake. In such situations, the seedlings may die.

-1.2.3 Growth stages and phases of soybean development

As with most crops, soybean management is tied to the crop growth and development. Knowledge of soybean growth is important in managing soybeans. Soybean development is characterized by two distinct growth stages - vegetative and reproductive.

The vegetative (V) growth stage starts from emergence (VE) until when the last node with fully developed leaf is formed (Vn). During this period plant develops the basic structure to support seed production. It is also during this stage that bacteria containing nodules form on the roots. During the early vegetative stage, soybean plants are extremely sensitive to weed competition.

The reproductive (R) stage commences immediately soybean starts flowering (R1) through to maturation (R8). Once flowering starts, soybeans enter the reproductive phase. Flowering continues for a period of up to 25 days, with flowers opening progressively up the stem and branches.

The pods and seeds begin to develop about 15 days after the start of flowering. Once the seed begins to fill in the pods, the plant becomes extremely sensitive to water deficit stress and leaf loss due to pest and disease infections.

Summary of stages and phases of soybean development

A) Vegetative stage;

VE Emergence 5 to 6-days after sowing the cotyledons break through the soil surface and gradually turn green. Nodule formation typically begins at this growth stage.

VC Cotyledon 7-days after emergence the cotyledons fully expanded so that the unifoliate leaves sufficiently unfolded so that the leaf edges are not touching.

V1 First node and first trifoliate leaf developed. Control any new emerging weed. Start scouting for caterpillars and observing symptoms of rust disease.

Vn- last node develops and full development of trifoliate leaves occurs. Control any new emerging weed. Start scouting for caterpillars and observing symptoms of rust disease.

B) Reproductive

R1 Begin bloom Appearance of one open flower at any four of the nodes on the main stem. At this stage ensure good control of rust disease and caterpillars

R2 Full bloom One open flower on one of the two uppermost nodes on the main stem with a fully developed leaf.

R3 Begin pod - Pod 0.5 cm long at one of the four uppermost nodes on the main stem with a fully developed leaf.

R4 Full pod-pod 2 cm at one of the four uppermost nodes on the main stem with a fully developed leaf. Rapid pod growth and initiation of seed development.

R5 Seed 0.3 cm developed seeds in pod at one of the four uppermost nodes. Rapid seed growth, with nutrient accumulation and dry matter distribution shifting from vegetative development toward the growing seed. Need for adequate water for the plant at this time.

R6 - Green seeds filling pod's cavity. Leaves begin to appear older (lower) nodes first, with the possibility of 3 to 6 trifoliate leaves falling off before leaf yellowing begins.

R7 - One normal pod on the main stem attained mature pod color. Plant at physiological maturity with very little additional accumulation of dry weight. Harvest early to avoid pod shattering losses.

R8- approximately 95% pods have mature pod color, leaves have fallen and seeds have less than 15% moisture content.

-1.2.4 Diagrammatic representation of soybean growth stages

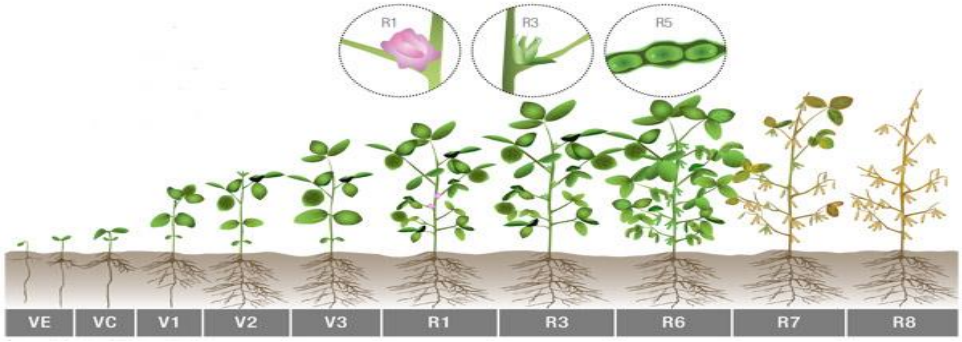


Figure 6: soybean stages, adopted from Production guide in Uganda

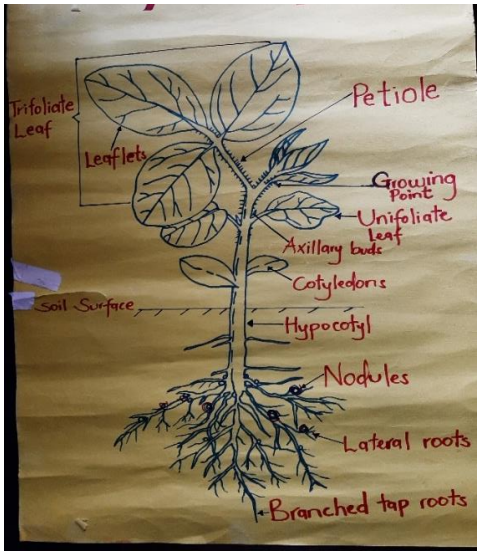


Figure 7: Different parts of soybean *crop*

Leaves – food manufacturing

Stem - food manufacturing and transport of nutrients to different plant parts

Buds- develop into flowers, pods and seeds

Nodules – nitrogen fixing bacteria

Roots – absorb water and nutrients needed by the plants

1.3.0 Crop management

1.3.1 Soil fertility management

To get high yields from soybean ensure that the soil on which soybean is planted is fertile. If it is not fertile enough, you are encourage to use fertilizers. You can use organic fertilizers such as well matured animal and plant composts. You can also use essential chemical fertilizers such as N, P and K that are required relatively in large amounts.

Nitrogen (N) is the number one crop nutrient because it is essential for enzymatic function, protein synthesis and cellular metabolism. However, being a legume, soybean does not require N fertilizers since the crop is capable of biological nitrogen fixation through root nodules.

Phosphorous (P) has very short range of movement in soil, therefore it is required in relatively large amounts. P is required for enhanced shoot and root growth, early maturity and stress tolerance. In soybeans, demand for P is greatest during pod and seed development. Therefore, it is recommended to incorporate 100 Kg/ha of triple super phosphate (TSP) into the soil before planting.

Potassium (K) is associated with movement of water and carbohydrates within the plant. Particularly, K plays a major role in signaling mechanisms intended to conserve water and reduce moisture stress. Adequate K levels are important to maximize soybean yield potential. Peak absorption of K is greatest from flowering through to early pod development. Therefore, it is recommended that soybean farmers apply 20 Kg/ha of Muriate of Potash (MOP).

The advantages and disadvantages of organic and inorganic fertilizers

Organic fertilizers	Chemical fertilizers
Advantages	**Advantages**
It is cheap to acquire	They contain more nutrients and therefore guarantee increase productivity
It protects the natural balance of the soil	When applied the nutrients are readily available to crops
It is sustainable since it can be made right on the farm	They are not as bulky as the organic fertilizer
Disadvantages	**Disadvantages**
It is bulky to transport.	They are expensive.
It has less nutrients compared to the inorganic fertilizers.	They can lead to crop damage if not used in the right amounts
Can lead to disease and pest infections if not well decomposed	They can lead to poisoning if swallowed by children and animals
takes long time to decompose	
The nutrients may not be readily available for crops	

Source; soybean training plan 2020

1.3.2 Weed Management

Weeding: Weeds are a major threat to soybean production, because they deprive the plants of essential growth resources like water, nutrients and light. Plants do not give good yields with less nutrients. Therefore, it is important to control weeds in soybeans during the first weeks of growth to:

- allow crops to grow strong and healthy.
- give crops space to grow.
- prevent interference with harvest operations and reduction in quality and price of grains
- reduce competition for water and nutrients between crops and weeds.
- reduce pest and disease incidences.

Method of weed control; there are basically two methods of weed control in soybean

i) Hand weeding: after the crop is fully established, hand weeding can be conducted twice. The first weeding is done two (2) weeks after crop emergence and the second weeding follows four (4) weeks later.

ii) Chemical weeding: Herbicide control when cautiously applied can effectively control weeds in soybean. Applying roundup (glyphosate) to soybean fields before planting is highly recommended. It significantly reduces the time before weed emergence. This herbicide application leads to reductions in the weeding numbers and, in the total cost associated with hand weeding.

1.3.3 Diseases and Pest management

Pest and disease agents reduce grain quality, so it is very important for growers and extension agents to have an enhanced capacity to detect and identify soybean diseases and pests and acquire knowledge of their control.

1.3.4 Diseases

Seedling disease: Although not a major problem, seedling diseases can be caused by a combination of pathogens.

Pythium sp *Fusarium sp* *Rhizoctonia solani*

Figure 8: common soybean seedling diseases; *adopted from soybean production guide in Uganda*

However, depending on moisture and temperature conditions, seedlings are particularly susceptible to three major diseases i) seed rots prior to germination, ii) seedling decays between germination and emergence, and iii) damping off during the first 2- to 3-weeks after emergence.

Management: plant disease free seeds, seeds that are resistant to common seedling diseases.

Bacterial blight *Pseudomonas syringae*

Figure 9: Soybean infected with bacterial blight

Symptoms

Water-soaked spots on leaves which enlarge and become necrotic; spots may be surrounded by a zone of yellow discoloration; lesions coalesce and give plant a burned appearance; leaves that die remain attached to plant; circular, sunken, red-brown lesion may be present on pods; pod lesions may ooze in humid conditions

Caused by bacteria and can be transmitted by contaminated seed; bacteria stay in crop debris; disease emergence is favored by warm temperatures; spread is greatest during humid, wet weather conditions.

Management

Plant only certified seed; plant resistant varieties; treat seeds with an appropriate bactericide prior to planting; spray plants with an appropriate protective copper-based bactericide before the appearance of symptoms.

Bacterial pustule *Xanthomonas campestris*

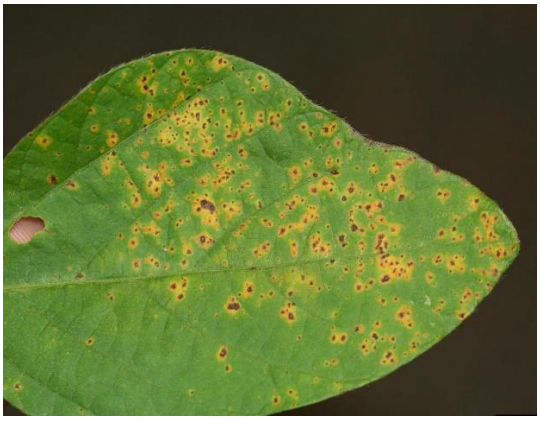


Figure 10: Bacterial pustule symptoms on soybean

Symptoms

Tiny pale-yellow spots with raised centers on both upper and lower leaf surfaces which develop raised pustules in lesion centers; pustules usually form in lesions on lower leaf surface; mottled brown areas may develop on leaves if lesions coalesce; small red-brown spots may develop on pods of some varieties.

Causes: The disease is caused by bacteria, and is prevalent in soybean growing regions with warm temperatures and frequent rainfalls.

Management

Plant resistant soybean varieties to bacterial pustule; spray plants with an appropriate protective copper-based bactericide before appearance of symptoms

Rust *Phakopsora pachyrhizi*

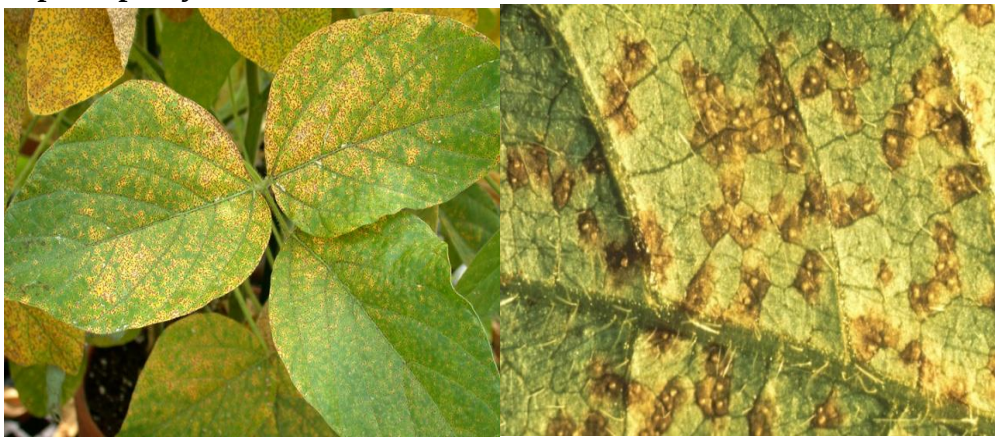


Figure 11: Rust disease on soybean

Symptoms
Gray or red-brown water-soaked spots on leaves which turn to dark reddish brown in color lesions may also be present on stems, petioles and pods; volcano spore producing structures are present within the lesions; plants drop leaves and mature prematurely.

Cause by fungus. Disease development is favored by warm temperatures and periods of high humidity.

Management
Plant resistant soybean varieties to rust; applications of appropriate foliar fungicides can help to control the disease

Sclerotinia stem rot *Sclerotinia sclerotiorum disease*

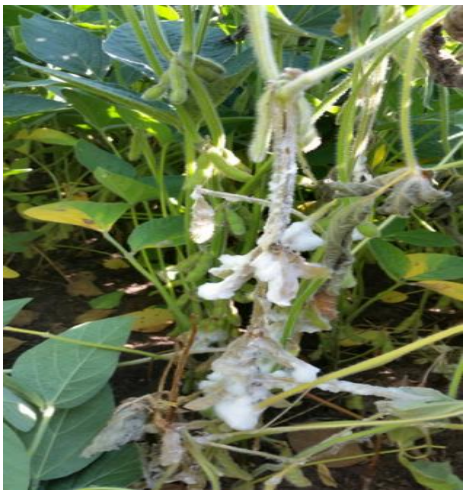


Figure 12: Sclerotinia stem rot

Symptoms
Upper leaves of plant become wilted and die; leaves turn to gray-green color and dry out; water-soaked lesions on stem nodes change color from tan to white; lesions may cord the stem and cottony white mycelial growths occur on infected plant parts as on the picture of sunflower stem above.

Cause by fungus. Disease emergence is favored by cool, wet weather; pathogen is resistant to many fungicides.

Management
Do not plant soybeans in fields where common bean, sunflowers or other susceptible crops have been grown the previous season; space plants in narrow rows; plant soybean varieties that are less susceptible to the disease.

1.3.5 Pests: The major soybean pests in Uganda are the armyworms and the birds.

i) Armyworms; larvae damage soybean leaves affecting food manufacturing (photosynthesis function).
Symptom: singular, or closely grouped circular to irregularly shaped holes in foliage. Crop has skeletonized leaves; shallow, dry wounds on fruits; clusters of 50-150 eggs present on the leaves covered in a whitish scale which gives the cluster, a cottony appearance. Young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside.


Figure13: armyworms larvae feeding on soybean leaves

Management
Organic methods of controlling armyworms include biological control by natural enemies which parasitize on the larvae.

ii).Birds

Birds damage soybeans during the first 2-weeks after the onset of germination.

Management

Scare birds at germination when seedlings are emerging. It is most effective to scare birds early in the morning and later in the evening.

1.4.0 Harvest and post-harvest handling of soybean

1.4.1 Harvesting: Most soybean varieties in Uganda are harvested within a period of 90 - 100 days after planting. Timely harvesting of seeds minimizes their deterioration in the field, insect infestation and losses from physical damage. Delayed harvesting may cause the pods to start shattering in susceptible varieties leading to yield loss. The crop is ready for harvesting when pods become dry and give a rattling sound when shaken.

Figure 14: harvesting of soybean by uprooting

The common method of harvesting is by hand where the crop is pulled or cut. This method is suitable for small areas, where an available large labor force. The advantage of this method is that losses are kept at a minimum and soybeans of a higher quality are produced.

1.5.2 Drying and threshing- The harvested soybeans are dried under the sun and threshed manually by beating the soybean crop with stick. The seeds obtained after threshing should be dried on clean tarpaulins to avoid soiling and contamination. Proper drying of seeds reduces storage losses. Dry the seeds until it cannot be dented with the teeth or fingernails. The dried soybean seeds is cleaned to remove all impurities, including inert matter and weed seeds,

Figure 15: Drying and cleaning of soybean

Advantages of proper drying and cleaning

1. The grain fetches better price
2. The grain can be stored for long time without getting molded or infested by insects
3. Well dried soybean is easy to process by oil milers
4. Results into production of good quality products (oil and cake).

1.4.3 Storage: Soybean seeds should be dried to 10-12% moisture for quality and longer storage. If soybean grains are stored at high percent moisture content, it will accumulate heat and rapidly deteriorate. The seed should be stored on raised platforms, in a dry cool place and away from the wall.

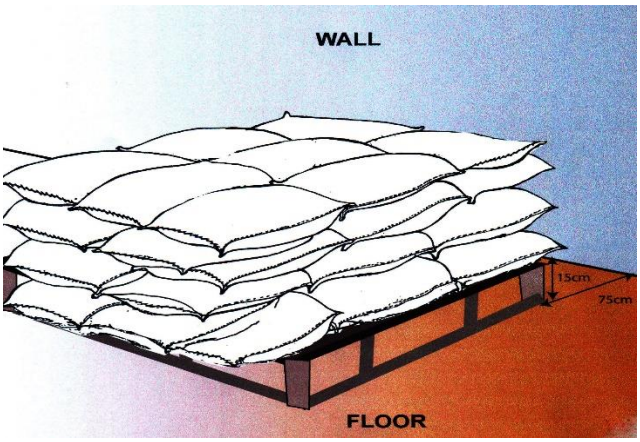


Figure 16: Proper storage method of soybean grains

Advantages of proper stacking as above;

- Prevent damp (moisture) from floor and wall being absorbed by grains in store.
- Ease of cleaning the floor and the walls
- Ease of counting of the bags in the store
- Ease of inspection of produce attack by pests (insects or rodents).

1.4.4 Post-Harvest Loss (PHL) in soybean:

This is a loss of both quality and quantity of soybean grains due to;

- Harvesting soybean before it has mature giving poor seed quality or late harvest when most seeds have shattered - susceptible varieties
- Insect attack at storage due to poor store management
- Poor drying of grains resulting to seeds getting molded/rotten at storage
- Poor threshing method-spillage of seeds or breakage of seed
- Poor storage structure eaten by rodents, termites. Roofs have holes allowing water leakage
- Poor packaging during transport to market leading to leakage.

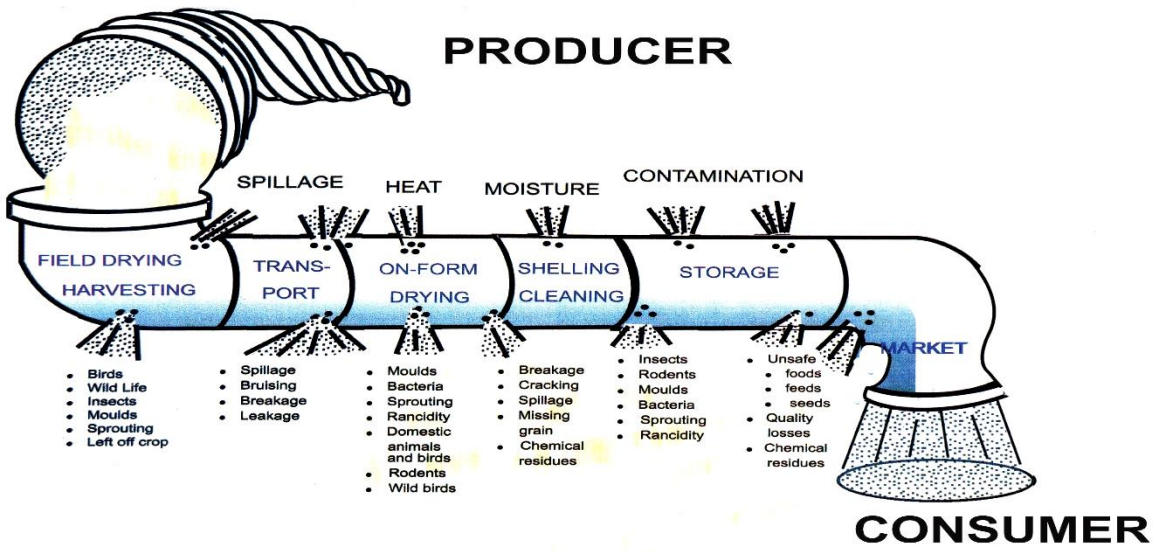


Figure 17: Schematic summary of causes of post-harvest grain loss in soybean

In Uganda PHL is still very high at 15-20 percent due to poor storage, limited access to postharvest handling equipment and material by farmers, (NARO, 2008). What does this mean to soybean growers (farmers)? It means that at soybean yield of 600kg/acre, a farmer would incur loss of 90-120kg per acre due to poor post-harvest handling.

This loss when converted to monetary value at average farm gate price of 900Ugx per kilogram, would translate to economic loss of 81,000 to 108,000 Uganda shilling (Ushs) from one acre by farmer due to poor post- harvest handling.

Farmers are therefore advised to reduce these losses by harvesting soybean at correct maturity, dry soybean to recommended percent moisture content on tarpaulins or cemented floor, follow quality storage method, use good packaging material and transport system to market.

Table 3: Economic returns to soybean production

	Local seed (home save seed)			Improved seeds		
Item	Qty	**Unit cost (Ugx)**	**Total cost (Ugx)**	**Quantity**	**Unit cost (Ugx)**	**Total cost (Ugx)**
First ploughing	50 *atala*	2000	100,000	50 atala	100,000	100,000
Second ploughing	50 *atala*	1500	75000	50 *atala*	75000	75,000
Planting seeds	25kg	-	-	25kg	6000	150,000
Planting string	1	5000	5,000	1	5000	5000
Labor for planting	1	50000	50000	1	50,000	50,000
Weeding & thinning	2	75000	150,000	2	75000	150,00
Harvesting	1	25,000	25,000	1	25,000	25,000
Transporting of crop home	1	35,000	35,000	1	35,000	35,000
Dry and threshing	1	30,000	30,000	1	30,000	30,000
Cleaning and sorting	1	10,000	10,000	1	10,000	10,000
Bagging (Estimated)	6	1200	7200	10	1200	12000
Transport to market	6	1000	6000	10	1000	10,000
Total Production cost			**493,200**			**652,000**
Average crop yield	600kg			1200kg		
Unit farm gate price	900 Ugx			900Ugx		
Gross profit			540,000		1,080,000	
Net profit			**46,800**		**428,000**	

Source; Farmer group training, 2020

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