

SOYBEAN

Production Guide In Uganda

Phinehas Tukamuhabwa and Tonny Obua

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Preface

SOYBEAN ***(Glycine max)*** is the most nutritious crop in the world containing approximately 40% protein and 20% oil, both of which are vital in human and animal diet. With the available technology for processing soybeans at industrial and household level, soybean has become one of the most promising food crops available to improve the diets of millions of people in the world. Soybean contains at least 100% more proteins with yields of 5-10 times more protein per unit area than any other crop. The protein in soybean is also balanced with all the essential amino acids which the body cannot manufacture.

Due to its nutritional superiority, soybean flour is often blended with cereal flours such as maize to boost their nutritional value. The amount of proteins found in soybean is similar to animal proteins, which makes it the only substitute to animal and fish protein. For this reason, soybean based foods are highly recommended by nutritional specialists to children, mothers and HIV patients.

Soybean oil is 85% unsaturated, comprising linolenic acid (omega 3 fatty acid) and oleic acid which have been shown to reduce the risk of heart disease by lowering serum cholesterol by 33%. Besides it also contains isoflavones which increase artery and heart health. Studies have also shown that regular soy food consumption can reduce the risk of rectal cancer by 80%, mammary tumor by 40% and breast cancer by 50%. Daily consumption of 25 grams of soybean protein a day was recommended as a means to reduce the risk of heart disease by the US Food and Drug Administration in 1999. Countries whose diets are based on soybean such as China, Japan and Korea are known to have long life expectancy and experience minimum cases of cancers. Over the years soybean has also become a very important feed resource. Its being used as a major source of protein in animal feeds.



Forward

SOYBEAN *(Glycine max)* is increasingly becoming a cash crop in Uganda and within the region both in production and productivity. This is clearly seen by the rapid increase in the number of industries involved in processing soybean in Uganda and the neighbouring countries in the last ten years. These industries develop numerous products both for human consumption and animal feeds.

This production guide is carefully written in a comprehensible language while making no scientific compromises. I believe this production guide will become an essential source of ideas and information for any farmer, extension worker, and researcher who is interested in cultivating soybean in Uganda. The guide contains valuable scientific information about soybean management topics such as seedbed preparation, varieties, germination test, planting methods and seed rate. Soil fertility management, crop protection and post harvest technology under Ugandan conditions are also addressed. This guide addresses production aspects of the soybean value chain.

One of the mandates of Makerere University is outreach; giving back to the community. The publication of this production guide is thus very timely, and will help a broad spectrum of the soybean stakeholders (smallholder farmers, extension staff, agricultural researchers, agricultural consultants, commercial producers and policy makers) by providing vital information on the best management practices that will improve soybean production and productivity.

I sincerely appreciate all the soybean development partners for their contribution towards the production of this production guide. The management of Makerere University applauds this effort by the authors and hope that the information in this guide reaches the intended users as **"We Build for the Future"**



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Dedication

This introduction is dedicated to all soybean farmers in Uganda for their dedicated support to the soybean sub-sector in Uganda.

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Introduction

Soybean is a legume plant suited to soils with a relatively high clay content, as they do not do very well on weak sands. They are also very sensitive to soil acidity. Soybean requires reliable rainfall, particularly from flowering to pod maturity. It's a good crop to grow in rotation with cereals

Soybean production in Uganda has been steadily growing. However, production had come to a standstill because of the outbreak of soybean leaf rust disease which was devastating soybean crops throughout the country. The Soybean Breeding and Seed Systems Program with support from the Ministry of Agriculture, Animal Industry and Fisheries - Vegetable Oil Development Project (MAAIF - VODP), Alliance for a Green Revolution in Africa (AGRA) and Regional Universities Forum for Agricultural Development (RUFORUM) successfully bred, developed and released improved high yielding, early maturing and rust resistant soybean varieties between 2004 and 2013.

In chronology of their release, the varieties are Maksoy 1N and Namsoy 4M (2004), Maksoy 2N (2008), Maksoy 3N (2010), Maksoy 4N and Maksoy 5N (2013) (Table 1). These improved soybean varieties have been adopted for commercial production in Uganda, and have led to soybean yield increase of up to 2,000 - 3,000 kg per hectare, providing income and an affordable source of protein for the country's rural population.

Currently, all the soybean varieties grown in Uganda are Maksoy lines and have been adopted in Kenya, Rwanda, Mozambique, Malawi and Nigeria. These varieties grow well up to 1,500 metres above sea level wherever maize is grown, and don't demand any fungicide sprays to control rust like the older varieties. Soybean can be grown in both the first and second seasons of the year, which improves farmer's income, food security and reduced poverty at rural households.

This production guide is developed to help soybean growers make timely management decisions that contribute towards breaking the yield barrier. A section on soybean seed production practices has also been included to guide commercial seed producers, NGOs and farmers involved in soybean seed production.



Soybean varieties in Uganda

There are two basic types of soybean varieties: Determinate and Indeterminate. This refers to the way the plant grows. Determinate varieties grow vegetatively for about six weeks and then begin flowering, having put on 10 to 12 leaves. Once flowering begins, no new leaves are produced further on the main stem. Indeterminate varieties, on the other hand grow vegetatively for about 6 weeks, then begin flowering when the main stem has three weeks or so, producing another five to seven leaves. Thus, the vegetative and reproductive growth periods overlap in indeterminate varieties but not in determinate varieties. Indeterminate varieties also tend to grow taller than determinate varieties. For these reasons, determinate varieties are more suited to warm fast growing environments where irrigation is available. Under drought conditions, indeterminate may have some advantage over determinate varieties.

Apart from the growth habits, farmers must choose varieties that have a high yield potential, do not lodge, have a high clearance of pods from the ground, good resistance to pests and diseases and take a long time from maturity to pod shattering.

New varieties are continuously being produced and therefore it is important to keep up to date with these, as the new ones always have an advantage over the old varieties.

The first requisite for producing good quality seed or grain is to start with varietal pure seed at planting; which may be a traditional or an improved variety. Farmers have several options of choosing the most suitable soybean variety based on seed size, stature, maturity, yield potential, protein and oil content, and resistance to soybean rust disease. Table 1 presents the comparative characteristics of released soybean varieties currently being grown by farmers in Uganda. Soybean maturity and yield potential should be considered first when deciding suitability to a given agro-ecological zone. Early maturing soybean varieties are recommended for short term rainfall areas. However, late maturing varieties tend to yield more than early maturing varieties under standard rainfall conditions.

Table 1: Characteristics of commercial and recommended soybean varieties in Uganda

Attributes	Maksoy 1N	Namsoy 4M	Maksoy 2N	Maksoy 3N	Maksoy 4N	Maksoy 5N
Year of release	2004	2004	2008	2010	2013	2013
Soybean rust resistance	Resistant	Resistant	Tolerant	Very Resistant	Resistant	Resistant
Stature	Short	Tall	Tall	Tall	Tall	Tall
Lodging	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant
Maturity (days)	90	100	105	100	103	96
Pod shattering	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant
Seed-size	Small	Large	Large	Large	Large	Large
Seed/hilum colour	Cream/ brown	Cream/black	Cream/cream	Cream/light brown	Cream/Grey	Cream/Black with white slit
Seed storability	Very good	Good	Fair	Good	Good	Good
Yield (tons/ha)	2 – 3	2 – 3	2 – 3	2 – 3.5	2 – 3.5	2 – 3.5
Protein content (%)	41	43	38	36	38	38
Oil content (%)	17	20	20	22	21	19

Pre-planting

Different pre-planting factors should be taken into account because they influence eventual soybean establishment, quality and quantity of seed/grain. Growers must make a plan on when and where to purchase inputs, timing of applications and scouting for pests and diseases. They can engage in the following pre-planting activities:

SEEDBED PREPARATION

Before seedbed preparation it is advisable to clear all forms of vegetation from the field. Land may be prepared by hand hoe or animal-drawn ploughs or tractor. Single ploughing and harrowing is recommended for preparing a suitable soybean garden. An ideal soybean seedbed should comprise fertile loam soils that are loose and well aerated to ensure rapid germination and seedling emergence which reduces weed pressure. A fine seed bed also provides adequate moisture and optimum temperature (above 21°C).

Farmers must avoid tight, high clay soils since these soils are generally low in humus, are imbalanced in nutrients and act as barriers to seedling emergence.

FIELD DRAINAGE

Close attention should be given to field drainage. Well drained soil enhances soybean yields. Loose, aerated soil allows for air to reach roots and nitrogen-fixing nodules, increases water-holding capacity and ultimately reduces erosion.

SOIL FERTILITY ASSESSMENT

If possible farmers can take soil samples for nutrient and pH analysis. Nutritional limitations of Phosphorus and Potassium should be optimized since these nutrients are critical for good plant growth and development and achieving higher soybean yields.

Harvesting Maturity	Seed Type	Name of variety
		**Namsoy 4M**
		**Maksoy 1N**
		**Maksoy 2N**
		**Maksoy 3N**
		**Maksoy 4N**
		**Maksoy 5N**

VARIETAL SELECTION

Successful and efficient soybean production requires farmers to select varieties with maturities that make the best use of the growing season in their areas. One can select for good yields and important characteristics such as oil and protein content. Depending on the fields' pest and disease histories, its recommended to choose varieties with genetic resistance to those pests and diseases. Where the farmer has several soybean fields, multiple soybean varieties may be planted to ensure genetic diversification across fields.

GERMINATION TEST

Like many oil crops, soybean seed rapidly loses viability under ambient conditions. This results in poor plant stand, leading to considerable reduced productivity. It is therefore recommended to always use seed from credible sources and or seed harvested in the previous season to avoid poor germination.

Before planting, growers have only one chance to establish the potential optimum stand by carrying out a germination test. Knowing the potential germination rate helps farmers to know what proportion of seeds to be planted are viable. The germination experiment is simple and can be done by farmers as follows:

- Count out 100 whole soybean seeds and place them on one half of paper towel.
- Wet the paper towel and allow free water to drip off for a minute.
- Lay the wet towel on a clean surface and fold the towel over and roll it into a moderately tight tube.
- Position the rolled towel so the tube is upright so that roots will grow downwards while shoots will grow upwards, for ease in removing seedlings during counting.
- Keep the rolled towel in a warm place (between 23° and 30°C). Count the first germinated seeds after three days by opening the towel. Fold and roll back into a tube.
- Repeat counting after another three to four days. Good viable seeds are expected to have a germination rate of over 90 percent, notably because germination time for most legumes is between 5 - 7 days.



Figure 1: *Petri dish Germination test*

Note: Germination test can be carried out on moist filter paper on a petri dish or directly in the soil by the farmer if the other materials are not available.

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 – March for the first season and (ii) August – September for second season. Farmers should plant soybean the moment the rains are stable.

SEED RATE AND PLANT POPULATION

Depending on seed size, seed rate may vary between 50 - 60 Kg per hectare for a recommended plant population of over 300,000 plants per hectare. 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.

The desirable plant population is around 350,000 plants per ha, but soyabean is capable of adapting to a wide range of plant populations. A minimum plant population is 200,000 plants per hectare, while a maximum is 500,000 plants per hectare. The higher the plant population, the greater is the danger of lodging, but the higher is the pod clearance.

The row spacing may be from 25 to 90 cm, the closer the row spacing, the higher the yield, but the yield advantage is not great (about 5 to 10 %). The wider the row the closer are the seeds placed in the row.

How to determine seed rate

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.

EXAMPLE

Assuming a farmer's target is a density of 375,000 plants in the field with a minimum of 10% percent stand loss. However, seed intended for planting has germination rate of 95%. Therefore, SR will be:

= 375,000 * [100 / (95)] * [100 / (100-10)]
= 375, 000 * 1.053 * 1.111
= **438,290 seeds per hectare.**

Assuming that 1,000 grain weight is approximately 0.151 kg, this means that the actual amount of seed planted will be:

= (438,290 *0.151)/1,000
= 66,181.790/1000
= 66.18179 ~ **66 kg per hectare.**

LAND PREPARATION

This is one of the most important practices in soybean production. Land preparation serves a duo purpose of eradicating weeds and having a fine tilth. This operation includes 1st and 2nd ploughing.

For farmers practicing conservation agriculture, the land can be sprayed with an appropriate herbicide (weed killer) and later planted. However, care should be taken to ensure that all the weeds are killed.

Planting

Actual planting is a critical period for managing soybeans because it's during this stage that growers have to successfully implement or apply all the decisions made during the pre-planting stage. This section will provide agronomic recommendations and tips to consider during the planting stage. In fields where inoculated soybean has never been grown, seed should be inoculated with ***Rhizobium japonicum*** which can be purchased at Makerere University, School of Agricultural Sciences.

INOCULATION OF SOYBEAN

During planting it's recommended that the farmer dresses/ mixes the soybean seed with an inoculum Rhizobium Japonicum. This is a nitrogen fixing bacteria that improves on nodulation capacity and subsequently yield of soybean.

Inoculation is most important in the field where soybean has never been grown.

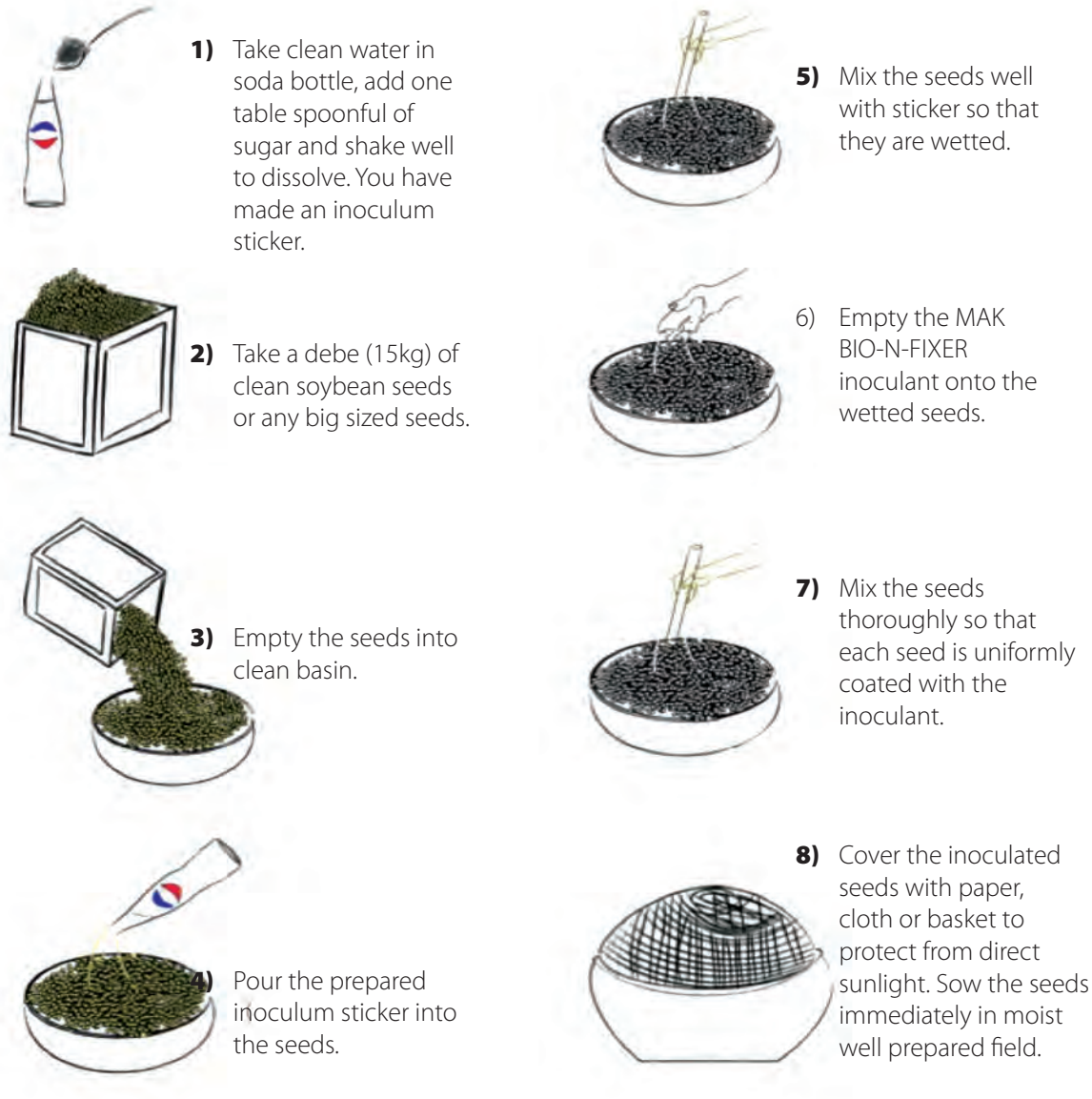


Figure 2: *Soybean inoculation procedures.*

PLANT SPACING

Spacing for soybean is dependent on the method of planting i.e. planters, hand dibble or drill. When planters are used, one seed per hole should be planted at spacing of 60-cm between rows and 5-cm between plants within the rows. For dibble planting by hand hoe, three seeds per hole are planted at the spacing of 50-cm between rows and 25 cm between plants (Fig. 2). Meanwhile, drill by hand requires 60-cm between rows and 5-cm between plants which is best carried out by making shallow trenches and covering slightly (Fig. 3). If you are using 50 cm x 25 cm, dig holes in the usual way and always maintain 25 cm between holes.

SEEDING DEPTH AND GERMINATION

Depending on soil texture, it is recommended for seeding to be done at an optimum depth of 2 - 5 cm, thereafter seeds should be covered slightly with soil. Seed sown at the right depth (2 cm) in soil with a temperature above 21°C and adequate moisture, rapidly absorbs water and germinates within 2 - 3 days after sowing. However, if the depth of sowing is deeper than 5 cm and soil temperatures are below 21°C, germination may slow down and emergence delayed for more than 6 days. After germination, it is recommended to thin the seedlings to the required within row spacing of 5 cm. The germinated seedling utilizes the nutrients reserves stored in the seed for the first week until it develops primary roots capable of water and nutrient uptake.

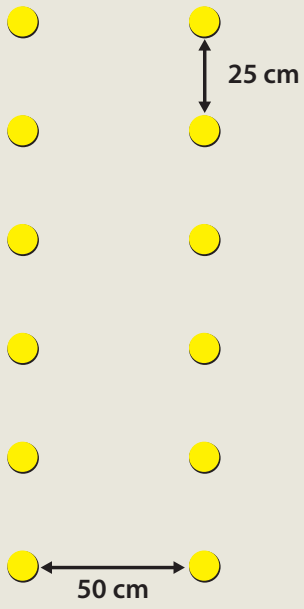


Figure 3: Dibble planting

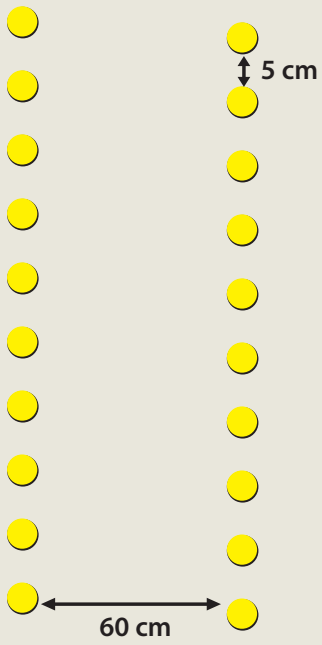


Figure 4: Drill planting

SCARING BIRDS AT GERMINATION

When seedlings are emerging, it is necessary to scare birds early in the morning and later in the evening. Birds can only damage soybeans during the first 2-weeks after onset of germination.

Growth stages of soybean

GROWTH OF SOYBEAN

As with most crops, soybean management is tied to growth and development of the crop. Table 2 is an aid to managing soybeans for high yields.

Development of soybean is characterized by two distinct growth stages and different growth phases that are determined by identifying and classifying leaf, node, flower, pod and seed development (Table 2). The vegetative (V) growth stage starts from emergence (VE) until when the last node with fully developed leaf is formed (Vn). During this period (about 50 days depending on variety, temperature and day length) plants develop the basic structure to support seed production. It is also during this stage that bacteria containing nodules form on the roots. In contrast, the reproductive (R) stage commences immediately soybean starts flowering (R1) through to maturation (R8).

The vegetative period lasts about 50 days, depending on variety, air temperatures and day length. During the early vegetative stage, soybean plants are extremely sensitive to weed completion. It is also during this vegetative stage that the nodules of bacteria form on the roots to provide the plant with nitrogen from the atmosphere.

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 pests and disease infection. The plants are considered mature when at least one pod on the plant is dry, but it still may take a further 14 days before the crop is ready for harvest. Maturity period of Ugandan soybean varieties ranges between 90 to 120 days after planting.

Table 2: Growth stages and phases of soybean (see page 28 for illustrations)

Growth stage	Growth phases		Descriptors	Management Practice
Vegetative	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.	Apply fertilizer as necessary, use best variety, and appropriate plant population
	VC	Cotyledon	7-days after emergence the cotyledons fully expanded so that the unifoliolate leaves sufficiently unfolded so that the leaf edges are not touching.	
	V1	First node	First trifoliate leaf develops. Fully developed trifoliate when the leaflets at the third true node are unfolded.	Control any new weed growth. Start scouting for caterpillars and rust
	Vn	Last node	Total nodes on the main stem with fully developed leaves beginning with the unifoliolate leaves.	
Reproductive	R1	Begin bloom	Appearance of one open flower at any four of the uppermost nodes on the main stem.	Ensure good control of rust and caterpillars
	R2	Full bloom	Open flower at one of the two uppermost nodes on the main stem with a fully developed leaf. Plant attained about 50% mature height and total mature nodes.	
	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 in pod at one of the four uppermost nodes on the main stem with a fully developed leaf. Rapid seed growth, with nutrient accumulation and dry matter distribution shifting from vegetative development toward the growing seed.	Irrigate if possible when there is a dry spell longer than 5 days
	R6		Green seeds fill cavity of pod at one of the four uppermost nodes on the main stem with a fully developed leaf. Leaf senescence begins on the 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. 5 – 10 days of drying weather needed to have less than 15% moisture. Ideal moisture for harvest and storage is 13%.	

Soybean crop management

SOIL FERTILITY MANAGEMENT

In order for soybean to grow well, the following 14 essential nutrients i.e. nitrogen (N), phosphorus (P), potassium (K), sulfur (S), calcium (Ca), magnesium (Mg), zinc (Zn), manganese (Mn), copper (Cu), iron (Fe), boron (B), chloride (Cl), nickel (Ni) and molybdenum (Mo) must be supplied in their correct quantities. Soil analysis should be done in order to identify possible problems caused by mineral deficiency or excess. This permits making precise recommendations on the use of fertilizers. Unfortunately, most soils either have deficiencies or imbalances in the amounts of nutrients available for plant growth. In case of nutrient deficiencies, it is recommended to apply artificial fertilizers. In this guide our focus is on the essential nutrients N, P and K because they are required in relatively large amounts compared to other nutrients.

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. The crop is capable of fixing up to 110 kg nitrogen per acre and does not respond to N fertilizers.

Biological nitrogen fixation (BNF)

The biological process responsible for reduction of molecular nitrogen into ammonia is carried out by specialized groups of bacteria that form symbiotic association with vascular plants. Many leguminous plant species can enter into symbiotic relationship with root-nodule bacteria, ***Bradyrhizobium japonicum***. This leads to a more robust root structure, better nitrogen fixation and greater yield potential. Hence it is essential to apply rhizobium inoculants to the seed at planting.



Figure 5: Soybean root-nodules

The efficacy of ***Bradyrhizobium*** depends on handling and application by farmers hence the inoculant must be stored in a cool, dry and dark place; avoid storage under hot conditions or direct sunlight.

Phosphorous (P) has very short range of movement in soil, therefore it is required in relatively large amounts. Adequate P levels are 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.

It is very important to note that dry soil conditions negatively affect P uptake by the plant's root system. Farmers also need to maintain adequate P levels through addition of humus or organic materials that decompose to release nutrients to plants.

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. Moreover, this important nutrient is not readily available for plant growth and development. 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). However, this amount may vary depending on the amounts supplied by soils.

IRRIGATION MANAGEMENT

Soybean is very susceptible to drought during the pod-filling stage. This occurs in the last third of the crop's life, and the beginning of this stage is identified when the pods on the upper nodes of the main stem are 2cm long and the small seeds are visible in the pods. If supplementary irrigation is available, this is the time to apply water, as it can produce large yield increases

Irrigation is not a common practice in Uganda except in irrigation schemes, such as Mubuku in Kasese district, which are characterized by high temperatures and low rainfall dictating the need for irrigation of soybean. However, irrigation must be used in conjunction with knowledge of soil texture and available water and development stages. Irrigation helps to alleviate yield reductions each time drought occurs, especially before the reproductive growth stage. Water deficits in the vegetative stage can prevent canopy development and reduce the maximum potential seed number in soybeans.



Figure 6: Irrigation at planting

Growth of pods and seeds occurs later in the season when soil moisture and rainfall are at the lowest seasonal levels. Therefore, potential for significant reduction in pod and seed development by drought is critical during the beginning of bloom and mid-filling period (R1 – R5.5). Besides, soybeans growing on coarse-textured soils have very little water available for plants due to gravitational loss from the low surface area of the large sand particles. Thus, crops growing on sandy soils must be monitored for pre-flowering drought stress that may limit vegetative growth to support maximum reproductive development.

In contrast, medium-textured loam soils have the most water available to plants because they have intermediate-sized particles and pores that are only moderately affected by gravitational water loss. Properly managed irrigation will ensure profitable soybean production. Irrigation of soybean seed plots should be done by gravity or drip irrigation. Sprinkle irrigation is not recommended because it creates a very damp environment, which is favorable for disease development such as soybean rust.

WEED MANAGEMENT

Soybeans are particularly sensitive to weed competition during the first weeks of the season. Weeds are a major threat to production of most crops, because they deprive plants of essential growth resources like water, nutrients and light. Besides, seeds from certain weed species not only interfere with harvest operations but also reduce quality and price of grains. In soybean, annual and perennial weeds are problematic at early vegetative stage. Weed control is very important because it reduces competition for nutrients, water, and light and prevents mixing of weed and soybean seed during harvesting.



Figure 7: Poorly weeded Soybean

HAND WEEDING

Later after the crop has fully established, hand weeding can be conducted twice in a cropping season at 2 and 5 weeks after planting, respectively. Unfortunately, hand weeding though cost-effective can facilitate the spread and propagation of perennial weeds with underground tubers and rhizomes.

CHEMICAL HERBICIDES

Herbicide control when cautiously applied can effectively control weeds in soybean. Choice of herbicide is influenced by weed species characteristics i.e. life cycle, nutrient requirements and modes of reproduction. Applying roundup (glyphosate) to soybean fields before planting is highly recommended. It significantly reduces the time before emergency of weed seed after planting, leading to reduction in the number of weeding and subsequently total cost associated with hand weeding. Deployment of integrated approaches for weed management are particularly important to prevent weeds from producing seed throughout the cropping cycle. This can be achieved by farmers ensuring that soybean seeds they intend to sow are not contaminated with weed seeds and have over 85% germination percentage, since vigorous seedlings are capable of suppressing weeds.

GUIDELINES FOR HERBICIDE USE

- Herbicides should be stored out of reach of unauthorized people, children and animals, and away from food or feed, stoves or lamps or fires.
- Carefully read the label on the immediate container of any herbicide product concerning the safe and effective use.
- Use proper equipment and containers and ensure proper mixing procedures depending on the herbicide formulation.
- Wear appropriate protective clothing (gum boots, hat, face mask, and an overall attire). Never eat, drink or smoke while applying herbicides.
- Do not spray in presence of or against strong winds to avoid inhalation of spray droplets. Keep animals and people away.

DISEASE AND PEST MANAGEMENT

The requisite for the production of good quality seed and grain is that the pure varietal seed should be free of pests and seed-borne diseases. Pests and diseases reduce seed quality, so should be controlled with recommended agrochemicals once observed in the field. Soybean suffers from several pests and diseases that occur over a wide range of conditions and plant growth stages. It is very important for growers and extension agents to have an enhanced capacity to detect and identify soybean diseases especially in scenarios where symptoms of several diseases coexist in the same field. Moreover, accurate identification of pathogen species is very difficult if the infected plants are already dead. When this happens, it is advisable to submit samples to a credible plant pathology laboratory.

SEEDLING DISEASES

Although not a major problem, seedling diseases are typically caused by combinations of pathogen species, notably ***(a) Phytophthora sp., (b) Pythium sp., (c) Rhizoctonia solani*** and ***(d) Fusarium sp.***
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.



Figure 8: Some features of seedling diseases.

LEAF DISEASES

a) Soybean rust

Caused by the fungus ***Phakopsora pachyrhizi*** Sydow. Symptoms include small-water soaked lesions on underside of leaves, blister-like uredia with a central pore with extruding uredinospores on the abaxial (lower) side of the leaf. Lesions gradually increase in size and later turn from gray to tan, reddish-brown or dark brown and assume a polygonal shape restricted by leaf veins.



Figure 8: soybean rust

b) Bacterial blight

Pseudomonas syringae pv. glycinea. Characterized by small, angular, water-soaked lesions. As infected tissues die, the centers of the lesions soon turn dark reddish brown to black, surrounded by a water-soaked margin bordered by a yellowish green halo and fall out so that leaves appear tattered or shot-holed. Infected young leaves frequently are distorted, stunted, and yellowish (chlorotic).



Figure 9: bacterial blight

c) Bacterial pustule

Xanthomonas campestris pv. glycines. Infected plants display small, pale, yellowish green lesions with dark reddish brown centers which are mostly conspicuous on the upper leaf surfaces. The central part of each lesion develops into a minute, raised, light-colored pustule on the abaxial (lower) leaf surface.



Figure 10: bacterial pustule

DISEASE MANAGEMENT

Although soybean diseases have increased in Uganda, the available varieties are resistant to most of them. Soybean rust disease is the most devastating and prevalent in Uganda. However, resistant varieties have been bred and developed by School of Agricultural Sciences of Makerere University in collaboration with National Agricultural Research Organization (NARO). Therefore, the most recommended control measure of soybean diseases is the use of resistant varieties like Namsoy 4M, Maksoy 1N, Maksoy 2N, Maksoy 3N, Maksoy 4N and Maksoy 5N. However, fungicides can be used to control soybean rust if susceptible varieties (NAM 1 and NAM 2) have been planted. The readily available fungicides include:

Diathane M45

Mode of action is protectant and active ingredient is Mancozeb. Rate of application: 2 Kg/ha (2.5 g/liter) or 1 leveled teaspoon in two liters of water. Best results are obtained when applied at 2 weeks intervals from disease onset i.e when rust spots first appear on lower leaves.

Saprol

Mode of action is systemic and active ingredient is ***Triforine***. Rate of application: 1.6 Kg/ha (2 ml / liter). Should be sprayed at 2 week intervals from disease onset i.e when rust spots first appear on lower leaves.

Folicur

Active ingredient is ***Tebuconazole.*** Rate of application: 830 mls / ha (1 ml /liter). Should be sprayed at 3 weeks intervals from disease onset i.e. when rust spots first appear on lower leaves.

PESTS

Groundnut leaf miners (Webworms)

Groundnut leaf miners ***(Aproacrema modicella)*** commonly known as webworms cause blister like mines on leaves (midrib) cutting water and nutrient flow to and from the leaves. The damaged leaves become



Figure 11: Webworm



Figure 12: Beetle damage



Figure 13: Soybean mottle mosaic virus



Figure 14: Caterpillars



Figure 15: Stink bugs



Figure 16: Stink bug pod damage

brownish, rolled and dessicated and eventually dry up leading to early defoliation which reduces effective leaf area for photosynthesis. Webworms are controlled using the contact liquid insecticide Cypercal P720 EC® (a.i. 120 g/l cypermethrin and 600 g/l profenofos), applied at 2 and 4 weeks after emergence. Alternatively, Dimethoate (Rogor 40L EC® (a.i. 400 g/l perfekthion) starting from 20 days after emergence and repeating 4 times at 10 days interval.

b) Bean leaf beetles

The bean leaf beetle can be confused with some other spotted beetles found in soybean e.g. the lady bud beetle. This pest can be found in most soybean field every year. The beetles are important immediately from seedling emergence until the first trifoliate leaf has unrolled and later during pod fill. Damage is characterized by leaf defoliation and stand reduction. Greatest economic damage occurs when the beetles feed on the developing pods. It can also transmit the soybean mottle mosaic virus (Fig. 12). Depending on the severity of attack, the beetles may be controlled by available pesticides on the market. Always follow manufacturer's instructions.

c) Green cloverworm (caterpillars)

Although generally minor economic importance in other crops, caterpillars may cause considerable damage in soybeans. Examples: leafworm (Spodoptera littoralis), armyworm (Spodoptera exigua) and the looper (Chrysodeixis chalcites). S. littoralis often causes extensive damage to soybeans. Management is through conservation of natural enemies i.e. parasitic wasps, predators and pathogens that are important in their natural control. Monitor the crop regularly and use available pestcides. Use botanicals like neem extracts depending on the magnitude of damage.

d) Stink bug

Stink bugs are important soybean pests in Uganda which pierce the pod pericarp and suck the milk sap from the developing seeds. This causes seeds not to develop and at times the dropping of pods. The plant compensates for lost pods by setting new ones but infested pods have fewer and smaller seeds. When pods are damaged severely by stink bugs, the soybean plants retain their leaves, while stems remain green long after normal maturity period. Green stems among mature plants ready for harvest make harvesting difficult.

Harvest and post-harvest

HARVESTING

Harvesting is the last important operation to be considered for the production of good quality seed and grain. Most soybean varieties are harvested within a period of 90 - 120 days after planting. Timely harvesting of seed minimizes seed deterioration in the field, infestation by insects and losses from physical damage. Delayed harvesting may cause the pods to start shattering in susceptible varieties leading to yield loss.

Soybeans should be harvested as soon as the plants have dried. The crop is ready for harvesting when pods dry and give a rattling sound when shaken. If the harvesting is delayed, the pods may shatter with a consequential loss of seed.

a) Hand harvesting; this method is suitable for small areas, where a large labour force is readily available. The advantage of this method is that losses are kept at a minimum, soybeans of a high quality are produced and the beans are normally of a high viability. Therefore the hand harvesting is suitable for seed production. The usual system of hand harvesting is to allow labourers to cut or pull as much plant material as they are able to thresh in a day.

THRESHING

Can be done manually or mechanically. At threshing, the seed should have a moisture content of 14-15%. It is important that seed of different varieties are threshed on different days to avoid admixing of the varieties. The seed should be dried on clean tarpaulins to avoid soiling and contamination. Drying of seed should not be done at high temperatures because this adversely affects the quality. Proper drying of seed reduces storage losses.

DRYING

Can be natural or artificial. Natural drying is done by the normal movement of ambient air around the moist seed spread on trays, canvas or directly on paved floors. Artificial drying is done with heated air blown mechanically through the seed; the temperature of this air should not be above 35 to 37°C. Total drying time is determined by the initial and final moisture content of the seed, the depth of the seed, the air velocity and temperature, and the relative humidity of the atmosphere.

STORAGE

During this exercise, seed should be graded according to variety and quality. Also remove all impurities, including inert matter and weed seeds. After the seed has been cleaned, it should be weighed and packed. Seed should be dry before storage so that its viability can be maintained during the storage period. Soybean should be stored at a moisture content of 10 - 12% or less. Seed is sufficiently dry when it cannot be dented with the teeth or fingernails. Dry to 12% moisture for storage of 6–12 months and to 10–11% for longer storage. If seed is stored with high moisture, it will accumulate heat and rapidly deteriorate. The seed should be stored on raised platforms, in a dry cool place (Fig 19).



Figure 17: Harvesting



Figure 18: Drying



Figure 19: Cleaning



Figure 20: Proper storage

Gross Margin Analysis for soybean production

Gross Margin Analysis for soybean production with fertilizer and improved seed (Per Acre)

Revenue and Costs	**Total (Shs)**
a) Costs	
First ploughing (UShs/Acre)	80,000/=
Second ploughing (UShs/Acre)	80,000/=
Fertiliser/Rhizobia (2 sachets each 5,000/=)	10,000/=
Seed (UShs/Acre)	75,000/=
Rhizobia application (UShs/Acre)	5,000/=
Planting (UShs/Acre)	20,000/=
Weeding (UShs/Acre)	80,000/=
Harvesting (UShs/Acre)	30,000/=
Threshing	20,000/=
Post Harvest drying and cleaning (UShs/Acre)	40,000/=
Bags and Bagging (UShs/Acre)	30,000/=
Transportation (UShs)	10,000/=
Total Variation Costs (UShs/Acre)	**480,000/=**
b) Revenue	
Output (Bags/Acre)	800
Price (UShs/Acre)	1,200/=
Total Revenue	**960,000/=**
Gross Margin (UShs/Acre)	**480,000/=**

Soybean seed production

The objective of this section is to provide useful information related to production practices, quality control and processing of soybean seed. After reading this section, one should be in position to produce good quality soybean seed. The Seeds and Plant Act of 2007 of Uganda, recognizes three classes of seed; breeders seed, basic seed and certified seed as summarized below:

BREEDER'S SEED

Seed of a particular variety, produced by the breeder (owner) of the variety or his or her agent, under the plant breeder's supervision. This seed type posses the highest quality of all seed grades and is usually in very small quantities, and is the most expensive.

BASIC SEED /FOUNDATION SEED

Seed produced from breeders seed under the control of the plant breeder or his or her agent.

CERTIFIED SEED

Class of seed produced under a certification programme of the Ministry of Agriculture. This seed is the offspring of basic seed and is meant for distribution to seed agents. This seed can be produced over two generations to allow adequate seed increase for sale.



Figure 21: Foundation seed field at MUARIK

Good quality seed

Successful and efficient soybean production requires farmers to plant good quality seed with high varietal and physical purity. (i) The seed should reproduce true to the variety type transmitting all its genotypic as well as phenotypic characteristics. (ii) It should be free of weeds, inert matter, seeds of other crops, and have a uniform appearance. Care must be taken to ensure that the seeds are free of pests and pathogenic organisms as this can be a dissemination medium of pests and diseases to the next crop.

Good germination is one of the first indicators of good quality seed with the ability to produce vigorous seedlings that grow fast and are generally tolerant to adverse conditions. Excessive physical mishandling of soybean seed plants at threshing and processing may lead to most of the seed developing cracks, affecting the embryo which will reduce the germination potential of such seed. It is recommended that farmers do not purchase seeds from the open market. Certified seeds should be purchased from credible seed companies or seed producers.



Figure 22: Poor quality seed



Figure 23: Good quality seed

CHOOSING AN APPROPRIATE FIELD

A field suitable for producing good quality soybean seed is one where soybean was not planted during the previous season. This is to prevent possible varietal mixing as a result of germination of seeds of the previous crop leading to volunteer plants. In addition the field should be separated from any other soybean crop by a distance that prevents possible contamination by mechanical means.

ROUGING OF OFF-TYPES

Off-types are plants or seeds that do not conform to the characteristics of a variety as described by the breeder. These should be removed whenever they are observed during seed inspection in the field. The process of removing these off types is called rouging. It consists of systematically examining the seed production field and manually removing all off-types and diseased plants in order to ensure that the field produces seed with the desired genetic and physical purity. This practice also contributes to a better sanitary control of the seed lot and prevents mixing of foreign or off-type seed with the desired seed. It is therefore very important to accurately identify the major morphological characteristics of a soybean plant in order to differentiate it from other plant species as well as special characteristics of individual soybean varieties.



Figure 24: Early and late maturing varieties growing in the same field



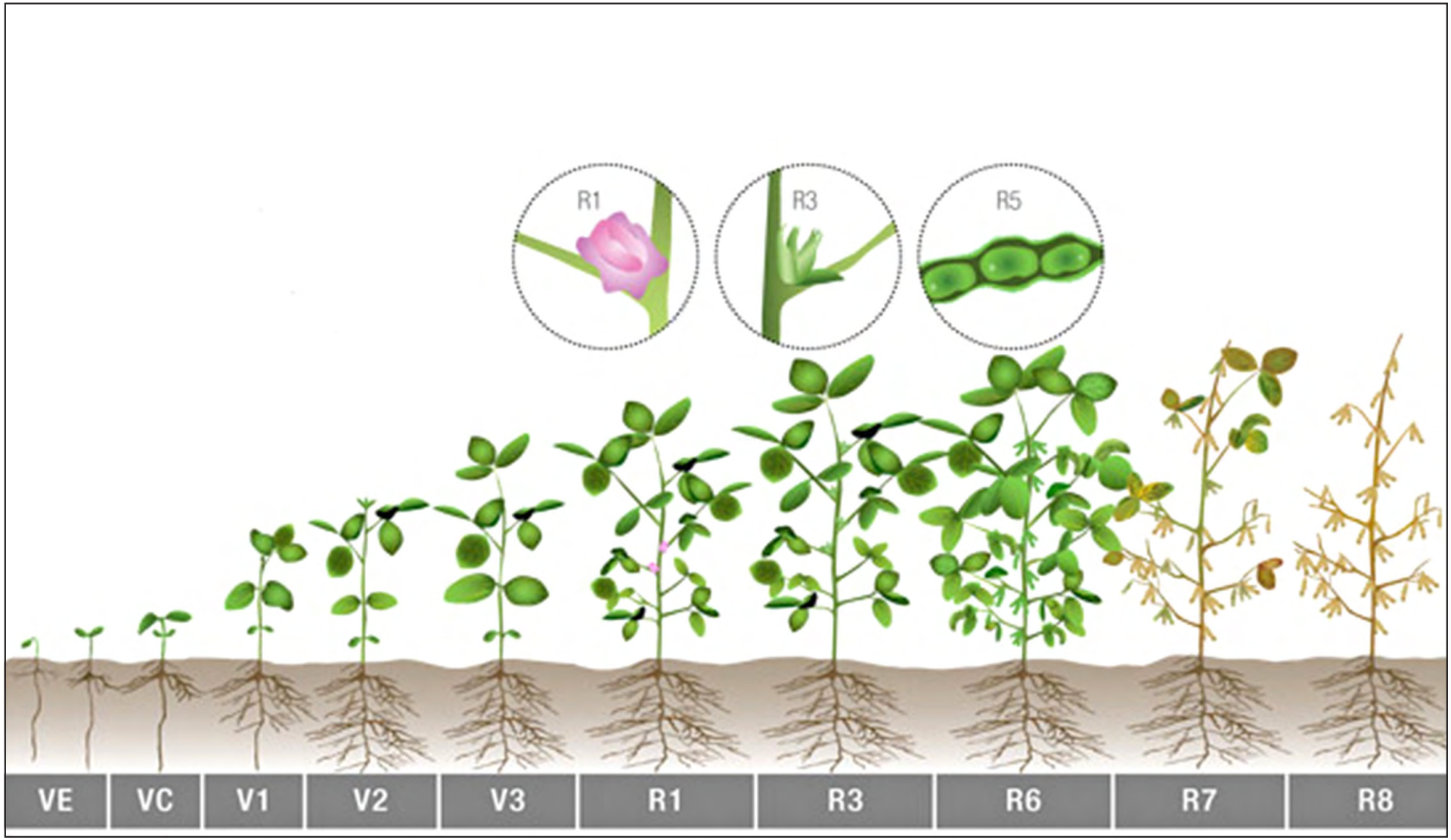
Figure 25: Mature off-type (arrow) growing side by side with desired variety

REPLENISHMENT WITH NEW SEED STOCK

After repeated use of good seed, it starts declining in quality due to accumulation of seed borne diseases and physical admixtures with other varieties which may be difficult to control at farm level. For this reason, regular replenishment with certified seed from a reputable seed Company and seeking new variety releases from the Breeder are highly recommended.

Soybean development stages

(See page 17 for text)



Soybean plant population



Adequate plant population (300,000 Plants per Hectare):
Supresses the weeds during crop development and results in high yeilds per hectare.

Soybean intercropping

Soybean may be intercroped with maize or soghum with wide inter-row spacing of the cereals.







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