A guide to soybean production in Malawi

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Foreword

Soybean is one of the most important crops in Malawi. It is a versatile grain legume because it has a variety of uses. Soybean is rich in protein, vegetable oil and essential minerals. The crop has the ability to fix atmospheric nitrogen and therefore improves soil fertility. Soybean is increasingly becoming popular and serving as an alternative food and cash crop. The area under soybean production as well as productivity is increasing in Malawi due to government policies on value addition, domestic use and crop diversification. Consequently, there is a significant expansion of the soybean industry within Malawi and with substantial demand for export market. Despite its importance and potential, the crop faces a number of major challenges which include short shelf life, poor crop production practices, diseases particularly soybean rust and effects of climate change. However, the Department of Agricultural Research Services (DARS) through the Soybean Improvement Programme in collaboration with its partners such as International Institute of Tropical Agriculture (IITA) has responded and continue to search for sustainable solutions to these challenges by developing suitable soybean varieties adaptable in most agro-ecologies in Malawi and has developed appropriate agronomic messages to address and manage some of the challenges.

This manual contains valuable information on suitable agro-ecologies for soybean production, recommended varieties, seed sources, soybean agronomical practices (land preparation, planting aspects, weeding, crop protection), seed production and post-harvest handling in Malawi. The appendix contains extra information on nutritional content of soybean listed in the catalogue of released varieties in Malawi including their botanical classifications. This manual is to be used as a reference material and as an essential source of information for farmers, field officers, and researchers on soybean production. Ultimately, use of information from this guide will assist smallholder farmers to boost soybean production and productivity in Malawi. DARS in collaboration with IITA and with financial support from INVC project developed this guide and its publication is timely because it will help a wide spectrum of stakeholders.

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Abbreviations and acronyms

ADDs	Agricultural Development Divisions
BC	Before Christ
cm	centimeters
DARS	Department of Agricultural Research Services
EC	Emulsifiable Concentrates
g	grams
ha	Hectares
IITA	International Institute of Tropical Agriculture
Kg	Kilograms
L	Liters
LEFOG	Legumes, Fibres and Oil Grains
masl	meters above sea level
ml	milliters
mm	millimeters
MoAFS	Ministry of Agriculture and Food security
MT	Metric tones
P	Phosphorous
PhD	Doctor of Philosophy
SCN	Soybean Cyst Nematode
SSU	Seed Services Unit
STAM	Seed Traders Association of Malawi
TSP	Triple Super Phosphate
UNICEF	United Nations International Children's Education Fund
USA	United States of America

1.0 Background Information

Soybean, Glycine max (L.) Merr., is a leguminous vegetable of the pea family that grows in tropical, subtropical, and temperate climates. Soybean was domesticated in the 11th century BC around north-east of China. Soybean is not a new crop in Malawi. Reports by the Ministry of Agriculture and Food Security indicate that this crop has been grown in Malawi since 1909. It was being grown as a minor in association with tung. However, when varietal and agronomic research work was conducted on the crop, some useful information was generated that made soybean to be a more important crop. The crop is well adapted for production in all agro-ecological zones in Malawi. However, soybean production is concentrate in Lilongwe, Kasungu and Mzuzu Agricultural Developement Divisions (ADDs).

1.1 Importance of Soybean

1.1.1 Soybean combats severe nutritional deficiency and enhances household food security

Soybean consists of more than 36% protein, 30% carbohydrates, and excellent amounts of dietary fiber, vitamins, and minerals. It also consists of 20% oil, which makes it the most important crop for producing edible oil. In addition to nutritious weaning foods, whole soybeans can form important ingredients in recipes for preparing adult meals. This compliments carbohydrate dominated diets such as maize. Refer to appendix on page 21.

1.1.2 Soybean helps to halt the precipitous decline in soil fertility

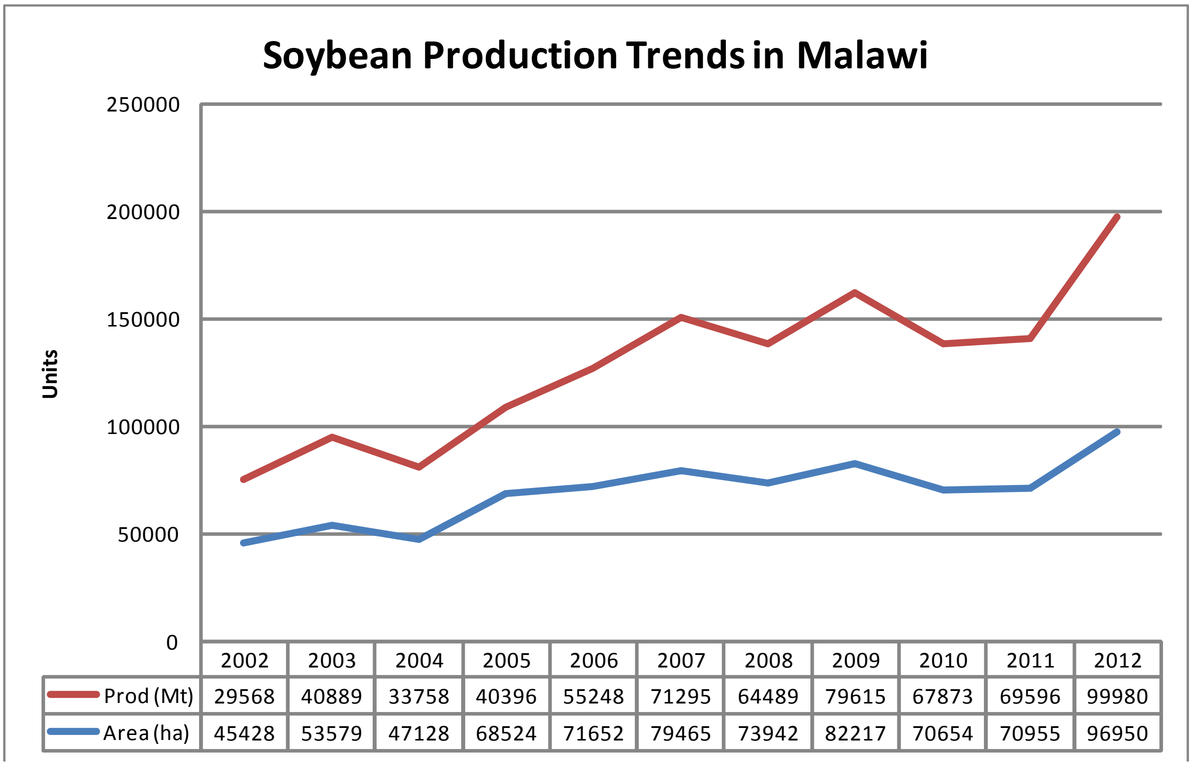
In Malawi, the declining agricultural productivity especially of crops like maize is largely due to soil fertility depletion, among other reasons. The benefits of including grain legumes such as soybeans, in rotation with maize, have been verified. Promiscuous soybean varieties remain green for an extended period of time enabling the crop to fix more nitrogen in the soil. Self-nodulating soybean varieties reportedly add approximately 20 kg nitrogen per hectare per season. This is added benefit to the farmer considering that inorganic fertilizers are very expensive. In Malawi, Tikolore, released in 2011 is a an example of a promiscuous variety and replaced Magoye because it was low yielding and small seeded.

1.2.3 Soybean helps to mitigate worsening rural poverty

Apart from gains in improving soil fertility, soybean also provides a supplementary source of income to smallholder farmers especially rural women. Domestic demand for soybean by the processing agro-industries (growing poultry and fish industries), is high. Thus soybean has a ready domestic and export market that is not fully exploited.

1.2 Soybean production trends in Malawi

Agronomic studies on soybean have shown that the crop is well adapted for production in all agro-ecological zones in Malawi. However, soybean yields are still low as farmers obtain 800 kg/ha on average against the potential yield of 2000-2500 kg/ha. Development and promotion of new high yielding soybean varieties currently grown by farmers in Malawi over the last 6 years, has significantly enhanced productivity from 600kg/ha to 800kg/ha (See Figure 1).



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Prod (Mt)	29568	40889	33758	40396	55248	71295	64489	79615	67873	69596	99980
Area (ha)	45428	53579	47128	68524	71652	79465	73942	82217	70654	70955	96950

Source: MOA (2011)

Figure 1, Soybean production trends in Malawi for the past 10 years

The national production over 10 years has been growing at about at 4.6 % per year. The national demand was at 111,000 metric tons which caused the farmers to increase their production areas.

1.3 Challenges to Soybean production

The challenges faced by farmers growing soybeans in Malawi includes:

- Diseases such as soybean rust are important in soybean producing areas which results in yield losses up to 80%.
- Pest such as leaf eating caterpillars and leaf rollers.
- Low farm gate prices and unpredictable demand.
- Terminal drought that affect pod filling, seed sizes and overall seed quality.
- Poor soil fertility (low P) which affects yield, seed size among other.
- Limited access to seed of improved varieties that results in farmers continue using recycled seed.

- Poor market infrastructure, price volatility and unpredictable demand.
- Low access to extension services
- Lack of knowledge on soybean crop management, practices processing and utilization.

1.4 Opportunities for increased Soybean production in Malawi

Soybean Industry have lots of opportunities to expand as below:

- High demand for soybean to produce feed due to expansion of the poultry and fish industries in Malawi.
- Private sector interest, especially processors to support and enhance soybean production to meet local demand.
- Availability of suitable varieties adaptable to almost all agro-ecological zones.
- Formation of the Soybean Association of Malawi that is equipped to drive the soybean industry and establishment of Legumes Development Trust (LTD) to support partnership and promote market.
- Political will and government initiatives in place to enhance soybean production.

Figure 2, Well graded soybean ready for the market

2.0 Agronomic Practices

Improved agronomic and management practices for soybeans are critical since they influence soybean growth, development and yield. Soybean is is very sensitive to various stresses.

2.1 Agro-ecologies

Soybeans are well adapted for production in all agro-ecological zones in Malawi. Malawi is agro-ecologically divided into 8 agricultural development divi-sions (ADDs). Five main landforms are evident in most of these agro-ecologies namely: Highlands, Escarpments, Plateau, Lakeshore, Upper Shire Valley and the Lower Shire Valley. The Plateau represents three quarters of Malawi at elevations of 750-1300 masl. Although the major soybean production districts are concentrated in the plateau, soybean virtually grows well in all agricultural development divisions. Soybean also grows well in warm, moist conditions with rainfall of 550-850 mm, well distributed over the growing season. Soybeans can also be grown under irrigation. If grown under irrigation planting should be done between May to June in low lying dry areas. It should be noted that soybean yields are reducedwhen grown off season due to photoperiod sensetivityness of the crop. Yields are adversely affected by temperatures rising above 30^{o}C or falling below 13^{o}C for long period during flowering stage. This is detrimental to the formation of flowers and seed.

2.2 Soybean varieties

There are more than eight soybean varieties currently grown in Malawi and have their recommended agro-ecologies based on their maturity period (Table 1 on page 5). These varieties were released in Malawi by the Agricultural Technology and clearing Committee (ATCC). Farmers must select varieties that are adaptable and recommended in their respective agro-ecological areas. Maturity period and yield are important considerations when choosing a variety suited to a specific agro-ecology. Consider varieties that are early maturing rather than late maturing in areas with low rainfall like Salima and Shire valley. Although late maturing varieties have the capacity to give increased yields, it is risky to grow late-maturing varieties in drier environments because of late-season dry spells.

Figure 3a and 3b,Some of recommended soybean varieties in Malawi

Table 1. List of recommended soybean varieties grown in Malawi.

Variety	Source of material	Year of release	Maturity period	Recommended agro-ecologies	Special varietal attributes
Ocepara-4	DARS	1993	Medium to late maturity (120-140 days)	Medium altitude areas	Large seeded with brown helum, produce white flowers and grey hair, exhibits indeterminate growth, resistant to root-knot nematodes and yields up to 2500kg/ha,
Nasoko	DARS	2002	Medium to late maturity (120-140 days)	Medium to high altitude areas	Large seeded with cream colour, white helum, produce white flower and grey hairs, exhibit indeterminate growth and yields up to 3000kg/ha
Makwacha	DARS	2003	Medium to late maturity (120-140 days)	Medium to high altitude areas	Large seeded with light cream colour, white helium, produce white flowers and grey hairs, exhibits indeterminate growth and yields up to 3000kg/ha
Solitaire	SeedCo/ DARS	2003	Medium to late maturity (120 days)	Widely adapted to most agroecological zones	Large seeded, tolerant to frogeye disease and yields up to 3000kg/ha
Soprano	SeedCo/ DARS	2003	Medium to late mature (120-140 days)	Medium to high altitude areas	Large seeded, tolerant to frogeye disease and yields up to 3000kg/ha
Tikolore	DARS /IITA	2011	Medium to late maturity (120-140 days)	Low, medium to high altitude areas	Small seeded, brown helum, promiscuous (may not require inoculation), tolerant to frogeye disease, susceptible to rust and yields up to 2500kg/ha
Serenade	SeedCo/ DARS	2012	Early maturing (120 days)	Medium to high altitude areas	Large seeded, exhibits indeterminate growth and yields up to 3000kg/ha
PAN 1867	Pannar/ DARS	2012	Early Maturing (120 days)	Medium to high altitude areas	Large seeded, exhibit indeterminate growth, yields up to 2500kg/ha

Source: DARS (2011)

2.3 Source of seed

The seed source should be known and reliable such as research institutions, registered agro-dealers, and registered seed producers with Seed Trade Association of Malawi (STAM). The seed should not be broken, shrivelled, diseased, not purple stained and should not contain off-types. Use high quality seed of the selected variety. It is common for soybean, even when stored properly, not to germinate after 12–15 months in storage since it loses viability. Therefore, use seeds that are not more than 12 months old to ensure good germination.

Sort out good seed for planting to ensure clean planting materials that are free from insect pest damage, disease infestation and weed seeds. Always buy soybean seeds from accredited seed companies or agro-dealers. Do not purchase seeds from open market the germination potential is not guaranteed. Poor quality seeds will not produce good yield.

2.4 Site selection

Soybean can be planted in any soil that is suitable for growing maize but performs badly in a poor sandy soils with low content of organic matter. Generally soybean is better suited to heavier soils than most other crops. Soils that easily compact and form a crust must be avoided for growing soybean because the protruding soybean seedling (hypocotyl) breaks easily under pressure. A fertile soil ensures that nutrients are available for the soybean crop and therefore minimizes the need for inorganic fertilizer inputs.

Therefore avoid :

- Land laying on a steep slope
- Land which is near a swamp or likely to have water logging conditions
- Very sandy soil and areas with shallow surface soil to avoid drought stress
- Areas with a lot of couch grass.
- Areas with a lot of shade to the soybean crop like under the trees

2.5 Land preparation

A good contact between the seed and soil enhances rapid germination therefore proper land preparation is vital to ensure good germination and reduces weed infestation. A well prepared land should ensure that weeds, shrubs and bushes are cleared.

Ridge or flat spacing: Farmers can plant soybean either on ridges or flat seedbed. If the farmer decides to make ridges, the ridges should be spaced at 75cm apart and make two grooves (20-30 cm apart) on a single ridge where the seed will be placed. If planting is on the flat, the recommended row spacing is 45 cm between rows.

2.6 Planting

Time of planting: In Soybean production, early planting does not have the same positive effect on yield as is the case with crops such as maize. However, soybean requires enough soil moisture at planting. This is because soybean needs to absorb a minimum of 50% of their own mass in moisture (compared to 30% in the case of maize) before they begin to germinate. Sufficient soil moisture is thus necessary at planting. In Malawi, soybean can be planted in summer (December–April) and/or during winter (off-season) i.e. May/June and harvest around October) with irrigation or in dimbas under residual moisture. For the summer crop planting should be done with effective planting rains or soon rains are well established i.e. 30 mm of cumulative effective rains. Soybean should not be dry planted and should not be planted until it is clear that the rains have properly started. In winter season, planting to be done during May or June period but not later than July end. Timely planting helps in:

- Greater number of main stem nodes and increased biomass
- More rapid growth rate during pod setting
- Potential for earlier flowering and therefore, a longer reproductive period
- Greater grain filling rate, hence high yield

2.6.1 Use of inoculants

Soybean production requires good supply of nitrogen for high grain yield. However, like many other annual legumes, the crop has the ability to meet most of its own N requirement through biological nitrogen fixation after successful nodulation. Inoculants or rhizobia form a relationship with the soybean plant to form nodules or swellings that act as small factories for producing nitrogen. The decision to use inoculants on soybean before planting depends on the following:

- The variety of soybean you have chosen to plant
- The land cropping history

There are two kinds of soybean varieties; specific varieties and promiscuous varieties. Specific soybean varieties require inoculants for them to perform well in the field where soybean has not been planted over the last three years. These varieties require specific rhizobia strain in the soil for them to form adequate nodules whilst promiscuous soybean varieties can easily associate with a number of rhizobia in the soil. If your field was planted with soybean in the last 3 years, then inoculation might not be necessary since the soybean will utilise the indigenous rhizobia left by the previous soybean crop. Currently, Tikolore is the only promiscuous soybean variety released for cultivation in Malawi.

The inoculant that is recommended is SOY inoculant. This inoculant is being produced and sold at Chitedze Research Station and Bvumbwe Research Stations. It can also be available in other research stations such as Lunyangwa, Chitala or Makoka if demanded. Arrangements can also be made to distribute inoculant to various ADDs. It is packaged in 50 g packets which is enough for 10-15 kg of seed. When inoculating the seed, the following procedure should be used:

1. Put soybean seed into a plastic pail.
2. Using a match inner box, weigh 5-10g sugar. The sugar acts as a sticker.
3. Mix sugar thoroughly with 200 ml of water. You can use a 300ml bottle to get the 200ml of water i.e. ¾ of 300ml bottle.
4. Then put the sugary water in a plastic pail with the soybean seed where the inoculant is then mixed with the seed until the seed is coated with the inoculum mixture. The sugary water helps the seed to be stacked with the inoculant. 50g pack of inoculant can cater for 10-15kg of soybean seed.
5. After thorough mixture of the seed with the inoculant, spread the inoculated seed on a tarpaulin or other clean surface under a shade (a tree) and leave for about 30 minutes to dry. The inoculated seed should be planted within 24 hours of inoculation in order to avoid killing the rhizobia.

Figure 4: Soybean Inoculant

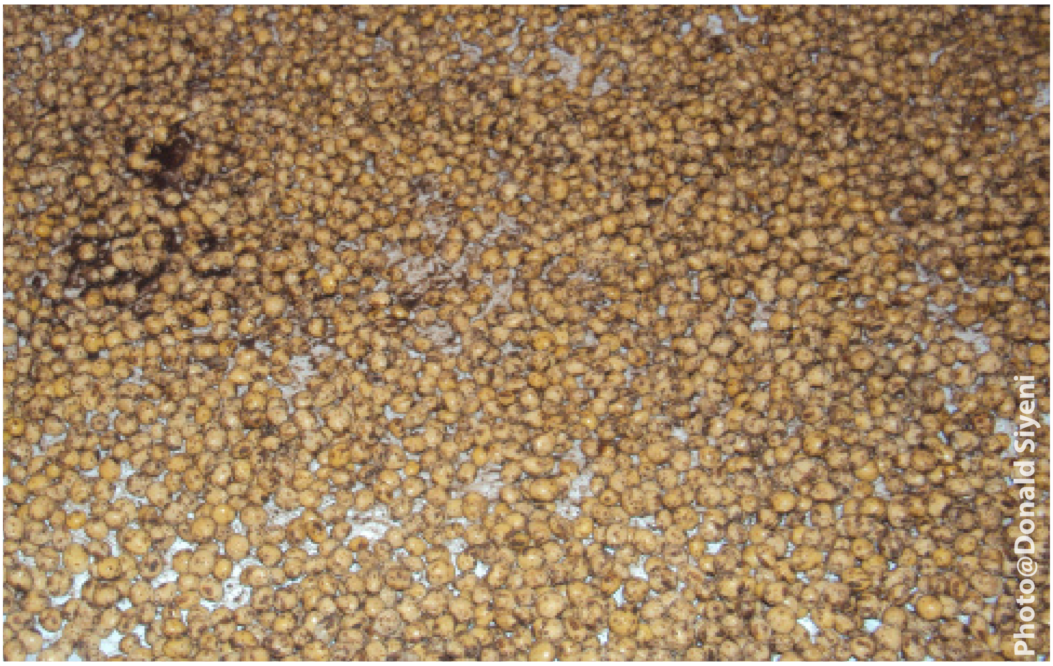


Figure 5: Inoculated soybean spread before planting on a matt before planting

Figure 6: Inoculated and uninoculated soybean in the field

NOTE:
Soybean inoculants require careful handling and storage. When you have inoculated your soybean seeds, planting should be done the same day (within 24 hours). The inoculant should be stored in cool dry place where the rhizobia cannot be killed. It is recommended that the inoculant be stored in a fridge, however, avoiding the deep freezer section of the fridge. Locally, farmers can keep the inoculant in a cool place for a short period of two to three weeks.

2.6.2 Planting

Planting soybean should be done on ridges or on flat land seed beds. Ridge planting should be done at 20-30 cm apart. Place one seed per planting station 5 cm apart to a depth of 2.5 cm. Flat planting should be done on rows spaced at 45 cm apart and 5 cm between plant stations.

2.6.3 Seed rate

The required seed rate is 80 kg/ha for large seeded soybean varieties and 60-65 kg/ha for small seeded soybean varieties such as Tikolore.

2.6.4 Fertilizer use

Most soils in Malawi are highly weathered and thus there is a very high variability of soil fertility and types among different sites. This means that not all soils in Malawi can sustain soybean growth and development and depending on their history, these soils have different rhizobial populations in them. As such, a good fertilizer recommendation for soybean production depends on a good soil test. Under normal conditions, soybean as a legume should provide itself with nitrogen through biological nitrogen fixation. Until nodulation occurs, the soybean plant depends on soil nitrogen for growth. Phosphorus is often the most deficient nutrient; therefore, apply optimum phosphorous fertilizer for good yield. Apply phosphorus using 2×50 kg bags for hectare of 23:21:0 +4S compound fertilizer available in Malawi. At planting or one week after planting, incorporate 18g fertilizer per meter length of the ridge/row into the made groove in the middle or between the two soybean rows in the ridge. If fertilizer application is delayed, it makes the crop grow vegetatively without making pods.

2.6.5 Plant configurations in intercropping

Soybean grows best when planted as a monocrop. However, when intercropped, plant component crops should be planted on alternate 4-5 rows. Farmers can also plant soybean in between maize planting stations, if the maize planting stations are spaced at 90 cm apart not at the current planting pattern of 25 cm in between planting stations of maize crop because soybean is sensitive to shading.

Intercropping two legumes that have different growth habits is a relatively new practice. It is an approach that takes advantage of beneficial interactions between the 2 legume crops. Successful doubled-up legume intercropping systems mostly involve pigeon pea. It has been established that pigeon pea grows very slowly for the first 2 months after planting. It follows that pigeonpea can be intercropped with either groundnuts or soybeans, without too much competition for water, nutrients and sunlight. Pigeonpea only starts rapid growth when either soybean or groundnuts are approaching maturity. When the groundnut or soybean matures in about 4 months and harvested earlier, pigeon pea continues to grow on its own in the field, forms pods, and will be harvested later. This way we ‘double’ crops and ‘double’ soil fertility benefits as both legume crops add soil fertility to the soil through biological nitrogen fixation and crop residues.

Establishment of soybean-pigeonpea (doubled-up) cropping

Doubled-up legumes technology involves intercropping of herbaceous legumes such as ground-nuts followed subsequently by a cereal crop such as maize in the second year. The following are details of the cropping pattern involved with the technology in year 1 and 2 (successively) in cases where legumes are grown in rotation with cereals, mostly maize in Malawi:

- Year 1: Intercropping of one legume crop with a different legume crop
- Year 2: Growing maize

All recommended practices in maize production should be followed to make sure farmer attain bumper yields. It is estimated that you can plant 1 kg of pigeonpea seed on 30 x 40 field.

Figure 7, Field where double up was followed

2.7 Weed management

Perennial and most annual weeds are a problem in soybean especially during the early growth stages. A properly timed weed management program can minimize the effects of weeds on growth, development and yield of soybean. Weed control in soybean could be manual or chemical or both. Manual weed control: Carry out the first weeding at 2 weeks after planting and subsequent weeding operations can be done when deemed necessary upon looking at the nature and their infestation in the field. Avoid weeding immediately after rains as this would lead to transplanting the weeds. Poor hoe weeding or delay in weeding could cause significant reductions in soybean yields.

Chemical weed control: Herbicides, if used properly, are safe and effective in controlling weeds in soybean. The choice of herbicide, however, depends on the pre dominant weed species and the availability of the herbicide. Herbicides are available for pre-emergence (dual magnum) and post-emergence weed control in soybean. If herbicide is applied at planting, one weeding may be required at 5–6 weeks after planting. Knowledge of the weed problems in a field and proper weed identification are essential when making herbicide decisions. Most herbicides selectively control certain weeds when applied as directed on the herbicide label. Weeds not listed on the label probably will not be controlled. Always read the label carefully and follow directions concerning application rates, timing, spray additives, application technique, personal protective equipment, and any restrictions when using chemicals.

Figure 8: Use of chemical weed control

Cultural practices: Cultural practices can have a tremendous influence on the type and severity of weed problems. Crop rotation, tillage system, livestock wintering, and other field-management practices affect weed populations and competition in soybeans. Production practices that encourage quick soybean emergence and canopy development can give the crop a competitive advantage over many weeds. Proper seed placement, fertility management, planting date, and seeding rates can help establish a healthy, competitive soybean crop. Removing weeds in the field before they have reached physiological maturity (formed seeds) is an important weed control strategy for the next crop in the following cropping season even if you have already harvested your crop. This prevents the weeds from producing seeds that would have germinated in the next cropping season.

2.8 Soybean insect pests and their control

Several insects occur in soybean fields but few are of economic importance, and the species that cause damage are usually not abundant enough to warrant control measures. However, during vegetative stage, the crop can be attacked by caterpillars commonly soybean lopper, leaf miners and leaf rollers insects that feed on the foliage make up the majority of the insects that attack soybeans and if not controlled may affect final yield because they reduce the plant photosynthetic area.

Figure 9a and 9b Some of the leaf eaters in Soybean production

Termite may also attack soybean plants and cause significant yield losses. Termites can attack soybean plants at any stage of development from the seed to the mature soybean plant particularly when there is prolonged dry spells. The first sign of termite attacking roots on seedlings or older plants is wilting. Eventually some plants die or fall over. Pulling out the affected plants and examining the roots and lower stem for live termites and tunnelling will confirm the presence of termites. Plant roots and stems may be completely hollowed out and soil-filled. In general, damage by termites is greater in rain-fed than irrigated crops, during dry periods than periods of regular rainfall, in lowland rather than highland areas, and in plants under stress (lack of moisture, disease or physical damage), rather than in healthy and vigorous plants. Weeds competing with crops for nutrients, light and water may lead to stress and hence increased susceptibility to termite attack. Crop rotation may be useful in reducing the build-up of termites since intensive monoculture for long periods makes plants more susceptible to termite attack. The removal of residues and other debris from the field may reduce potential termite food supplies and hence lead to a reduction in termite numbers and subsequent attack. However, the extent to which termites are a problem to agricultural crops, the nature of loss they cause and the plant species they infest are very much related to the geographic region concerned.

From flowering onwards, soybean becomes attractive to pod-sucking bugs that can seriously reduce seed quality. Insect pests can be controlled with a single spray of Cypermethrin + Dimethoate 10 EC; read the chemical label for application rates and conditions.

2.9 Soybean Diseases and their control

For Malawi, just like many other countries within the region where soybean is grown, Soybean rust, is the only disease of economic importance. Other diseases such as frogeye, bacterial pas-tule, soybean rust and red leaf blotch also occur but are relative less important economically. Except for soybean rust and soybean cyst nematode, soybean diseases normally do not result in major yield losses under Malawian growing conditions. From time to time however, weather and growing conditions can combine to produce significant losses from diseases such as *Phytophthora* root rot, seed-ling blights, and *Phomopsis* pod and stem blight. These diseases can be caused by fungi, bacteria and viruses.

Soybean rust: Asian soybean rust, caused by *Phakopsora pachyrhizi*, is one of the most important foliar diseases for soybean in Malawi. The infected leaves have small tan to dark brown or reddish brown lesions on which small raised pustules (or 'bumps') occur on the lower surface of the leaves (Fig. 10). Pustules produce a large number of spores. Brown or rust-coloured powder falls when severely infected leaves are tapped over a white paper or cloth. Severe infection leads to premature defoliation and yield losses up to 80%. The disease is of great economic importance in the areas where rainfall and humidity are high. Late planted soybean is prone to soybean rust infection. It is therefore recommended that planting should be timely atleast before end December.

Figure 10, Rust infested soybean field

Soybean cyst nematode: The soybean cyst nematode (SCN), *Heterodera glycines*, is important in soybean . It can be present in the field without causing obvious above-ground symptoms and yield losses caused by SCN are often under-estimated. In heavily infested fields, SCN can cause yield losses of more than 30%. "Yellow dwarf" is an appropriate description for symptoms that are commonly caused by SCN. Root galls (swellings) are diagnostic and quite different from nodules produced by the N-fixing bacteria. When soybean plants are severely infested, they become stunted, canopy closure doesn't occur, and leaves may become chlorotic. Unfortunately, these symptoms are not unique to the disease caused by SCN and may be confused with symptoms caused by other crop stresses such as nutrient deficiencies, injury from agricultural chemicals, feeding of the soybean aphid, and infection by other plant pathogens. SCN infection may limit nodulation by nitrogen-fixing bacteria. Severely infected plants may die before flowering, especially during dry periods where soils have poor water holding capacity.

Good soil fertility and adequate moisture increase tolerance of soybean plants to SCN and reduce the severity of above ground symptoms in fields. Good crop production practices can also help reduce severity of nematode infestation. For example, a 1 to 2 year rotation with maize or cotton (non-hosts) has proven effective for many soybean growers. In addition, soybean resistant varieties such Ocepara 4 are being successfully used in SCN management.

Virus diseases: They are commonly transmitted by insects such as whitefly. Depending on genotype and age of infection symptoms range from mosaic and mottling, leaf curling, green vein banding, and stunting (Fig 8) . Most severe symptoms are observed in plants infected at early stages of growth (pre-flowering) and significant reduction in pods.

Soybean is also susceptible to several viruses transmitted by aphids and beetles prevailing in Malawi. Most of the virus infection results in foliar symptoms such as mosaic and mottling, thickening or brittling of older leaves, puckering, leaf distortion, severe reduction in leaf size, and stunting of plants (Fig11). Infected plants should be rouged and burnt.

Figure 11, Symptoms of mosaic viral disease in soybean

In general, soybean diseases can be controlled by:

- Use of certified seed to avoid seed-borne infection or use seed that are produced away from the infection sources.
- Use of resistant varieties to prevailing diseases in the area.
- Early planting may also escape diseases that can late in the season but also encourage good establishment of soybean plants to enable them withstand disease attack
- Avoid planting seeds obtained from mosaic-affected plants
- Roguing (uprooting and destruction) symptomatic plants. This can reduce the incidence of insect-transmitted viruses.
- Do not use seed that is cracked or broken as it is easily invaded by seedling disease organisms. Care should be taken in harvesting and handling to reduce mechanical damage.
- Since many soybean diseases such as pod and stem blight, brown spot, and bacte rial blight can infest crop debris, rotating soybeans with non host crops such as maize or sorghum is good control practice.
- Eradicate the weeds and voluntary plants in the vicinity of the soybeans farms as these act as host agents of soybean diseases.

3.0 Harvesting Management Practices

3.1 Harvesting of Soybean

Depending on the variety, soybeans can be harvested between 100 and 150 days after planting. If a farmer harvests before the crop is mature, it can mold and eventually rot due high moisture presence; the quality will thus be low. When soybeans are fully mature their leaves will turn yellow then brown and fall to the ground. Harvest when 90-100% of pods are brown and dry, but before they are brittle and shatter. Some soybean varieties will shatter when they are ready for harvesting while others do not shatter. Shattering may reduce grain quality and quantity if soybean is harvested late. Timely harvesting helps maintain seed quality and avoids infestation by insects.

Harvesting should be done in the morning hours when temperatures are low to avoid shattering. Do not harvest on a rainy day. Wait for the rains to stop to avoid drying problems which can lead to some losses.

During harvesting, cut the mature plants just above ground level. Do not mix varieties when harvesting especially when heaping the crop. It is recommended not to pull the plants out by the roots. The roots of soybean plants have nodules of nitrogen fixing bacteria, which may help establish a colony of these bacteria in your soil to aid future planting

3.2 Post-harvest operations for soybean grain

Post-harvest options are generally all the activities that can be carried out after the harvesting of crops in order to convert it to use by man and animal. It can be classified into primary and secondary processing. Primary processing includes threshing, winnowing, cleaning, separation, grading, sorting, packaging, transportation, marketing, storage and so on whilst secondary crop processing involves processing of food for direct consumption.

3.2.1 Threshing soybean

Thresh manually or mechanically when the plants are properly dry and as soon as possible. Manual threshing is mainly recommended for small-scale production. It involves piling soybean plants on tarpaulin or putting dry soybean pods in sacks and beating them with a stick. Beating the plants should be gentle to avoid destroying the embryo which eventually may affect germination and overall seed quality. The soybean plants can then be winnowed to remove the grain from the soybean debris.

Figure 12, Soybean threshing process

3.2.2 Grading

The purpose of grading is to ensure that discoloured grain, diseased grain, cracked, insect-damaged, shrivelled, any debris and foreign matters are removed. This attracts buyers and fetches premium prices on the market.

3.2.3 Storage

Seed storage becomes necessary if the processed seeds cannot be sold immediately or when there are surplus seeds carried over to the next season. The conditions under which the grains are stored greatly influence the quality of the processed product. At harvest, the grains usually contain about 14% moisture. However, soybean should be stored at a moisture content of less than 10%. A soybean seed is sufficiently dry when it cannot be dented with the teeth or fingernails. High moisture content in stored soybean encourages the development of various agents of deterioration, such as insects and microorganisms. Good storage management can greatly influence the storability of soybean and subsequent germination when planted in the field. Do not leave soybean exposed to high temperatures to avoid seed quality deterioration.

Figure 13, Well packed soybean stacks in a warehouse

4.0 Soybean Seed Production and Certification

Only released and approved varieties that have gone through the Seed Certification procedure will be done by Seed Services Unit (SSU). The seed crop has to be registered, inspected in the field and tested in the laboratory.

4.1 Classes of seed

In seed production there are three classes of seed that are used. Breeders' seed: This is a generation which is handled by breeders and usually is in small quantities. The breeder tries to ensure that the genetic make up is maintained in order to have the purity at the recommended standard. Basic seed is produced from breeder seed with more quantities and is given to farmers with appreciable experience so that the seed is not wasted because this is meant for further production. Certified seeds which is marketed for production of grain is produced from basic seed.

4.2 Registration of seed producers

Registration can be done in all the seed services offices in the research centers as follows: Bvumbwe in the Southern region, Chitedze and Lifuwu in the Central region and Lunyangwa in the North upon payment of a prescribed fee. The importance of registration is to record all necessary details about farmer including location of the field. Registration is only done once.

Figure 14, Registering seed samples at Seed Services Unit (SSU)

4.3 Site selection

Characteristics of a good site: Soybean seed can only be produced on a piece of land where previously no soybean was grown. This is important because it takes care of disease incidents and issues of admixtures. For basic seed it requires 2 years before any soybean seed can be planted on that land and for certified seed it requires one year before any soybean seed can be planted on that land. If the land was planted to tobacco then soybean seed cannot be planted on that piece of land for two years.

4.4 Isolation distance

Soybean is a self-pollinator. However isolation distance is applied because of the possible physical admixtures from one field to the other. For basic seed it requires 10m while certified seed requires 5m of isolation distance.

4.5 Source of seed

Only the approved source by Seed Services Unit will be accepted for registration. This means that the unit is aware of the class of seed, when and where it was grown through previous registrations and field inspections.

4.6 Crop and field management

Land preparation, Planting (seed rate and plant spacing), inoculant application, and weeding are the same as for production of grain. But for fertilizer it is recommended that the farmer applies 50kg of 23:21:0 + 4S per ha. Control of Common Pests and Diseases is very crucial.

4.7 Rogueing

General good crop management is recommended to allow the seed crop to show all its growth characteristics. This helps in identifying off-types at vegetative, flowering and harvesting stages. The seed crop which is true to type should display same hair colours, branching, same flowers and leaves throughout the vegetative growth up to the time of harvest. A farmer is advised to remove all off types and diseased plants (rogueing). The seed field should be free from weeds all the time. Disease and pest control is important in order to achieve quality seed (see figure 15).

Figure 15, Roguing off-types in soybean seed production

4.8 Post harvest handling: Harvesting, Processing, Grading & Packaging

After harvesting the Seed Services Unit expects the farmer to process the seed according to the required standards, so the sampling and testing results of that seed do not require the farmer to rehandle or regrade the seed. Soybeans require harvesting as soon as the crop is dry preferably around morning hours when the temperatures are low to avoid splitting. Slow drying helps the soybean seed to complete its drying process and maintain the viability. Use a tiny stick to process the crop because this will reduce any breakages that can affect the physical purity and germination test. Ensure that all the broken, weevilled, shriveled, rotten, termite damaged and other variety seed are removed during grading. Pack in good clean sacks ready for sampling and label.

Transportation of Harvested Seed: When transporting seed from the farm or any location to the processing facility a farmer is supposed to seek permission on the movement of the seed. This is important so that the seed can be traced back and no other variety seed is added in the process.

4.9 Labelling

All the bags should be labeled for identity as follows: Crop, variety, lot number, quantity, name and address of the producer. This helps to identify the seed lot among so many others from different farmers.

4.10 Seed sampling and testing

A representative sample of the seed lot is collected by the samplers for for various quality tests like physical purity, defects, moisture content and germination. The recommended sample size is submitted to the seed testing laboratory for the analysis. A certificate or analysis of results is issued based on the findings.

4.11 Storage of Seed

In seed production the demand for seed comes later in the season so the farmer is supposed to keep the seed in well ventilated, cool and dry conditions. The containers should be well labelled. Pallets are recommended for stacking but the farmer can also use ordinary poles so that the seed is kept raised from the ground. Seed is a living material. Therefore any remaining seed after sales should be re-sampled for re-testing.

Figure 16, Seed testing vital to quality control

4.11 Marketing of Seed

Marketing of seed depends on the class of seed but also market forces. The advantage of seed over grain is that the prices are significantly higher than those of grain.

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6.0 Appendix: Nutritional values of various food sources

Food type	Water	Energy	Protein	Oil	Calcium	Iron
Common beans	10	334	25.0	1.7	110	8.0
Peas	10	337	25.0	1.0	70	5.0
Pigeonpea	10	328	26.0	2.0	100	5.0
Soybean	8	382	40.0	20.0	200	7.0
Meat	66	202	20.0	14.0	10	3.0
Milk	74	140	7.0	8.0	260	0.2
Egg	74	158	13.0	11.5	55	2.0
Groundnut	6	579	27.0	45.0	50	2.5
Wheat flour	13	346	11.0	1.6	20	2.5
Finger millet flour	12	332	5.5	0.8	350	5.0
Maize flour	12	362	9.5	4.0	12	2.5
Cassava flour	12	342	1.5	0.0	55	2.0
Plantain (banana)	67	128	1.5	0.2	7	0.5
Round potatoes	80	75	2.0	0.0	10	0.7
Sweet potatoes	70	114	1.5	0.0	25	1.0

Source: Marealle, 1974 (Tanzania Food Tables)

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