MINISTRY OF AGRICULTURE ANIMAL INDUSTRY AND FISHERIES

Beans Training Manual for Extension workers in Uganda

Partners

Ministry of Agriculture Animal Industry and Fisheries (MAAIF)

Feed the Future Uganda Enabling Environment for Agriculture (FTF/ EEA)

Ministry of Trade Industry and Cooperatives (MTIC)

Makerere University College of Agriculture and Environment Sciences

International Institute of Tropical Agriculture

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Foreword & Acknowledgement

Agriculture is as one of the key drivers of Uganda's economy where over 70% of the population derives their livelihood. The Ministry of Agriculture Animal Industry and Fisheries has put in place interventions to boost production and productivity of key priority and strategic commodities in medium term. Beans is one of the commodities prioritized under ASSP (2015/16-2019/20). They are mainly grown by smallholder farmers who are the majority in Uganda. It is therefore envisaged that promoting this enterprise will result in improving the living conditions of smallholder farmers.

The beans production system is predominantly small-scale accounting between 60–90% (on less than 2 acres) with average production of 0.25 tons (250kg) per acre. This is very low compared to potential yield of 700 to 1500kg/acre depending on the variety. The system is characterised by low input use especially seed and pesticides with most of the producers using seed from previous harvest.

Beans offer the cheapest and most reliable source of protein and micronutrients mostly B vitamins, iron, calcium and zinc. The crop offers a good source of balance nutrition for rural households especially the poor who can barely afford animal protein. Furthermore, beans are important source of income especially for women and youth hence improving their livelihoods and quality of life.

The manual aims at transforming the beans production sub-sector from predominantly subsistence, low input and low productivity to fully commercialized where beans are grown as a Business. This will consequently improve household incomes, food and nutrition security of rural households/farmers in Uganda.

First, the manual will be used by extension workers to provide appropriate training and advisory services to farmers. Secondly, it will also be used by other actors along the bean value-chain for improving beans sub-sector.

I wish to thank everyone who contributed to the development of this document, particularly; stakeholders that provided input into the drafting and validation of this document; members of the development team for reviewing the document and steering the whole process, Feed the Future Uganda Enabling Environment for Agriculture Activity for facilitating the process and Sasakawa Global 2000 for its technical expertise in the development of the document.

It is my hope that this manual will be resourceful and used adequately by extension workers and other value chain actors to strengthen the beans sub-sector in Uganda.

Yours faithfully

Pius Wakabi Kasajja
PERMANENT SECRETARY,
MINISTRY OF AGRICULTURE ANIMAL INDUSTRY AND FISHERIES

Acronyms & Abbreviations

CBO	Community Based Organizations
CSP	Climate Smart Practices
CT	Conservation Tillage
DAP	Di Ammonium Phosphate
EAC	East African Community
EAS	East African Standard
EIL	Economic Injury Level
GAP	Good Agricultural Practices
GHP	Good Hygiene Practices
GMP	Good Manufacturing Practices
Ha	Hectare
ICT	Information Communication Technologies
IPM	Integrated Pest Management
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
NAADS	National Agricultural Advisory Development Services
NARO	National Agricultural Research Organization
MC	Moisture Content
MFIs	Micro Finance Institutions
MT	Metric Tones
MTIC	Ministry of Trade Industry and Cooperatives
NGO	Non-Government Organization
PHH	Post -Harvest Handling
QDS	Quality Declared Seed
UCOP	Unit Cost of Production
UNBS	Uganda National Bureau of Standards
WFP	World Food Program
WRS	Warehouse Receipt System

Module One:
Introduction and Background

Importance of Beans:

Common bean, scientifically known as Phaseolus vulgaris L. is an important legume staple crop in Uganda. National annual consumption of beans is estimated at about 58 kg per capita. In 2016, the area planted under beans was 683,120 Ha with a total production of 1,104,770MT. Volume of beans exported increased from 157,152 MT (2015) to 200,000MT (2017). Beans production system is predominantly small-scale accounting between 60–90% (on less than 2 acres) with average production of 0.25 tons (250kg) per acre despite potential yield of 700 to1500kg/ acre depending on the variety. The system is characterised by low input use especially seed and pesticides with most of the producers using seed from previous harvest.

Beans are important source of protein and micronutrients mostly B vitamins, iron, calcium and zinc. The crop offers a good source of balance nutrition for rural households especially the poor who can barely afford animal protein. Beans can be consumed as immature pods, mature fresh grain or dry beans and its leaves are used to complement carbohydrate diets. In addition, dry beans are important source of income especially for women and youth.

Besides, beans is able to fix nitrogen into the soil through its root nodules. This enhances soil fertility and further reduces the amount of nitrogen fertilizer used in bean cultivation and other crops majorly intercropped with beans. When intercropped, it plays many other functions including reducing pests and disease prevalence, weed control as well as controlling soil erosion. It is therefore an important food and nutrition security crop that can be used to enhance the economy of Uganda as well as a means of practicing sustainable climate smart agriculture.

Ecological Requirements

Beans thrives best in a warm climate of optimum growing temperature range of 20 to 28oC with a minimum of 15oC and a maximum of 32oC. Temperatures above 32oC and below 15oC will cause poor pod set resulting in yield loss. Bean production is more successful in areas where rainfall is moderate to light during the latter part of growing season. Beans are adapted to a wide range of soils as long as the soils are reasonably fertile, well drained and free of conditions such as saline. An optimum soil pH of 5.8 to 6.5 is ideal for beans production.

Challenges and Opportunities

The bean sector experiences a number of problems at different nodes of the value chain namely; input, production, trading, processing and consumption levels. Major challenges include poor agronomic practices, declining soil infertility, lack of seed from improved cultivars, poor selection of bean seeds (seed mixtures), moisture stress, weed competition, pests and diseases, high post-harvest losses; unstable prices; limited postharvest handling technologies and lack of storage capacity.

On the other hand, a number of opportunities exist in beans industry including; increasing demand of beans at domestic, regional and international levels; established research institution/ infrastructure to promote bean production in Uganda; availability of a wide range improved bean varieties that are suitable to the different agro ecologies; and possibility of value addition.

Key value chain actors

There are several actors in the beans value chain in Uganda. They include; input suppliers, producers: seed multipliers, aggregators/assemblers/ agents, wholesalers, retailers and consumers. Beyond the major actors, the value chain also has enablers such as researchers like NARO and Makerere University; extension workers and a number of NGOs, Financial Support Institutions, and policy makers such as MAAIF, MTIC and Uganda National Bureau of Standards (NBS), among others.

Module Two:
Pre-planting and Planting Activities

This module covers recommended pre-planting and planting activities for bean production. Beans have a short maturity period of 58 to 120 days from planting time. Beans need proper attention and suitable growing conditions in order to maximize yields. To attain this, there is need to apply Good Agricultural Practices (GAPs). GAPs are a set of practices for crop cultivation and farm management that help farmers to best use resources to achieve high yields while minimizing costs of production. GAPs are the foundation for better yields and a profitable bean production venture.

GAPs should be observed at all stages of bean production right from site selection, land preparation, seedbed preparation, seed selection, planting, weed management, soil fertility management, harvesting, postharvest handling and storage

2.1: *Planning at household level*

At household level, there is need for family members to agree on the variety of beans, the purpose, acreage and when to plant. This brings in sense of ownership and togetherness for sustainable management. Women tend to grow beans for food while men grow beans for cash.

2.2: *Site Selection*

Beans production requires a suitable site that will support optimal bean growth through the life cycle of the crop. To achieve high bean yields, selection of highly productive land is crucial.

The recommended site for beans planting should have the following;

a) Deep fertile well drained and aerated, sandy loams or loamy soils
b) An optimum soil pH of 5.8 to 6.5. Beans are highly sensitive to acidic soils (pH < 5.2)
c) Signs of soil fertility such as presence of indicator plants eg elephant grass, Guinea grass (Panicum maximum), Commelina sps
d) For steeply sloping areas consider contour hedgerows and terraces along the contour to stabilize the soil and minimize the runoff.

Deep loam soils make a ball that breaks on slight pressure

During site selection avoid the following;

a. Water logged areas because beans do not tolerate water logged places.
b. Very sandy soils
c. Soils that are compacted (clay) and too alkaline

Water logged soil is not ideal for bean production

2.3: Soil testing

It is essential to assess soil health before any soil management operations are implemented. Constraints such as soil acidity and soil nutrient deficiency can lead to significant reductions of crop yields. The soil pH and nutrients levels can be determined by conventional soil analysis in addition to observation methods of crops growing in the field.

Soil testing is an essential crop management decision-making tool that enables one to:

i) Determine acidity and alkalinity levels (soil pH);
ii) Identify any soil nutrient deficiencies;
iii) Estimate optimum fertilizer requirements for target yields;
iv) Estimate the optimum cost of fertilizer needed and the returns

In the field, a soil testing kit can be used or soil samples can be taken to a recommended laboratory for further analysis.

Tools for taking soil samples

Note:

ALWAYS get advice on how to test soils from extension workers

2.4: Land Preparation

Land preparation involves; bush clearing, removal of tree stamps, termite mounds, and ploughing. Beans require a fine seed bed for uniform and proper growth of roots to absorb the available soil nutrients. Well prepared seedbed reduces on the number of weeding times.

2.4.1 Timing of land preparation

The timing of land preparation is extremely important. Land preparation should begin either at the end of the harvesting period or at least 3 weeks (21 days) before planting to allow breakdown of organic matter. Land should be ploughed at least twice in some cases followed with harrowing to obtain a fine seedbed. Where the field has a known history of bean pests such as pod borers, bean fly and beetles, complement ploughing with harrowing to kill the surviving eggs, pupae and adult pests.

If the site is very bushy, first clear land by slashing down all plant parts and leave them on the ground, or plough in the plant residues using appropriate equipment. This will help soil to conserve moisture; improve the water-retention capacity, water-infiltration capacity and increase soil fertility.

If the field was previously covered with weeds like Amaranthus spp, which produce a lot of seeds, then the land needs to be prepared early in the season. This will encourage most of the weed seeds to germinate as soon as the soil gets any moisture. The field can then be lightly tilled down or sprayed with non-selective herbicides (glyphosates) before beans are planted; very shallow cultivation is needed, only along the topsoil, to remove the germinating weeds.

DO NOT BURN PLANT RESIDUES :

as burning destroys plant nutrients from the residues and cannot easily be replaced. Dig the plant residues into the soil to improve soil fertility, aeration and water retention capacity

No burning

2.4.2 Method of land preparation and related equipment

Seedbeds for beans production are mainly prepared using the conventional tillage procedures although some farmers may use conservation tillage.

1. Conventional Methods:

In conventional tillage the farmer uses equipment like hand hoes, animal traction, and conventional walking tractors to till land.

a) The hand hoe is the most commonly used equipment by small holder farmers though it is slow and labour intensive.
b) Animal traction: this involves use oxen to plough land, although it is not suitable under heavy soils and steep terrain. This method is the most appropriate, affordable, reliable and proven technology for small and medium scale farmers;
c) Conventional tractors open extensive land for commercial farming.
d) Walking tractors (Power tillers) can be used by small and medium scale farmers.

Land harrowing for a fire tilth

Animal traction ploughing

Power Tiller (walking tractor)

Tractor ploughing

If ploughing is to be done using oxen or tractor, care must be taken to work the land when it is dry

2. Conservation Tillage (CT) :

Is also referred to as no-till/zero till, minimum /reduced till, and ridge (ripper) till. It is an agricultural management approach that aims to minimize the frequency or intensity of tillage operations in an effort to promote certain economic and environmental benefits. The principle of conservation tillage involves maintenance of at least 30% surface soil cover through retention of crop residues. Retention of crop residue protects the soil from direct impact of raindrops and sunlight while the minimal soil disturbance enhances soil biological activities as well as soil air and water movement.

Under CT use of non-selective herbicides mainly Glyphosate is paramount. Depending on the area to be tilled, remove all tree stumps and other barriers like ant-hills. If the area is covered with thick thicket, first slash down the bush, wait for the new germination of weeds and then spray them herbicides (Round-up, Weedmaster, Mamba, Weedall).

CT allows timely planting at a reduced cost, improves soil structure, increases water infiltration and soil moisture retention. In addition, it creates more soil organic matter, controls weeds, reduces soil erosion, reduce labour and energy requirements.

Under CT, the farmer should adhere to the adequate planting depth since the seed needs more energy to penetrate the sub-soil with its roots and the top soil with its shoot as compared to a ploughed field.

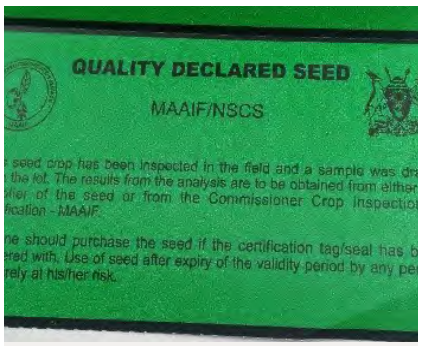
> Conservation tillage is suitable for all categories of farmers and higher returns are realized if GAPs are followed

2.4.3 Application of manure

Compost or animal manure should be added at rate of 2 – 4tons per acre during the first cultivation to allow for adequate decomposition and any weed seeds carried along to also germinate before the final tilling session prior to planting.

2.5: Source of quality seed

High yield begins with good quality seed, it is therefore important to select well developed, mature, uniform seed of sound vigour. Farmers should always buy seed from certified seed companies or use Quality Declared Seed usually produced by farmer groups (Community Seed Multipliers).



MAAIF QDS Label

Quality Declared Seed

2.5.1 Choice of suitable variety

There are many beans varieties grown in Uganda with varying traits for various locations (Annex 3).
Main types of common beans are;

- the bush bean type
- climbing beans –they are traditionally grown in high altitude (highlands) areas such as southern western and

mountainous areas of eastern Uganda although they are also becoming popular in low altitude. They require support (stakes), they yield higher than the bush beans,

Selection of varieties to be grown will depend on the factors listed below;

a. Market requirements. This varies depending on the buyer's preferences. It includes factors like colour and size of grain, nutritional value e.g. ROBA for High Iron, mode of utilization such as those for canning, pre-cooking, fresh or dried beans.

b. Adaptability and yield potential. Beans are produced under a wide range of cropping systems and environment as well as regions as diverse as high altitudes and low lands. Climbing beans such as Nabe 12C, NAROBEAN 4C and 5C are grown in altitudes as high as 2,000 m above sea level as they are suitable for the cooler climatic conditions while the bush types like Nabe4, Nabe 15, NAROBEAN 1, 2 and 3 are favoured by low altitude characterized by most of the regions in the country. Some varieties such as ROBA1 are resistant to drought and are, therefore, suitable for areas with low rainfall.

Farmer buying improved seed from a certified stockist

c. Resistance to Pests and Diseases: A wide range of pests and diseases attack the beans at the different stages of its growth cycle. A farmer therefore should select a seed variety that can resist or tolerate both pest and disease attack. Several tolerant bean varieties have been developed by NARO (Annex 3).

d. Length of Growing Season: The length of the growing season of varieties plays an important role, especially when there is unpredictable variation in the amount and distribution of rainfall. Farmers should plant varieties that have early maturity period and drought tolerant

2.5.2 Attributes of quality beans seed

- Uniformity
- High germination rate > 85%
- Well dried to 13% moisture Content
- Purity 98%: Ensure all seeds are of the same variety
- Clean: not mixed with foreign matter like stones or dirt, or other seeds
- Not damaged, broken, shrivelled, mouldy, or insect damaged
- Not rotten or discoloured faded
- All non-conformity should not exceed 2%.

A detailed criterion for determining seed quality is presented under Annex 4

Discoloured and shrivelled beans

Beans seed infested by weevils

Quality beans seed good for planting

2.5.3 Steps in conducting Germination Test

It is important to use seeds that will germinate and give healthy plants, therefore, seeds should be tested for their ability to germinate.

1. A week before planting, take a sample, count off 100 seeds randomly.
2. Put the seeds in a container with sand. The container should be pierced at the bottom to let water drain
3. Keep the seeds moist, but not wet. Too much or too little water can prevent or delay seed germination
4. After 7 days, carefully dig the seedlings up from the sand, put them on a paper and count seedlings in each category below:

   a. Normal seedlings: Well-developed roots, stems, leaves, & cotyledons.
   b. Abnormal seedlings: Have any of the following signs: no main root, weak roots, no leaves, weak leaves, no cotyledons, decayed cotyledons.
   c. Rotten, diseased and unviable seeds which have not germinated.

Record your results as below

Batch	Total ≠ seeds	Normal seedlings	Abnormal seedlings	Rotten, diseased, unavailable
Container 1	100			

5. If about 10 seeds (10%) have failed to germinate (90% germination) then use the recommended seed rate, if germination is below 90% but above 85%, increase the seeds per acre at planting following calculation below:

   Recommended seed rate = 30 kg per acre
   Percentage germination = 85%
   Adjusted seed rate = (100÷85) x 30kg = 35.3kg

The new seed rate will be 35.3 kg per acre
If germination percentage is below 85% reject the seed.

Always report back to the stockiest, extension worker or the seed company (supply) within 10 days after planting in case of germination failure.

2.6: *Planting*

Planting should be done on the onset of rains. For long rain seasons, farmers may delay planting by two to three weeks to avoid too much rainfall during pod filling stage which may lead to rotting of pods and reduction in yields. Early planting takes advantage of the nitrogen flush effect which is the release of accumulated nitrogen in the soil during the dry season.

Normally, the first season is dominated by planting in March up to Mid-April and harvesting in June-July; while the second season is from mid-August to December, depending on the area and variety. (Annex 7).

Avoid late planting as this leads to increased pests and disease attack, and reduced yields

The process of preparing furrows for bean planting using a string to ensure that rows are straight.

Inoculation

Root system with nodules

To be able to form nodules and fix nitrogen, bean seeds need rhizobia. Each legume crop needs a different type of rhizobium bacteria. Rhizobia are bacteria that are common in the soil and they fix nitrogen after becoming established inside root nodules of legumes.
Always check out for the right inoculant for beans. Directions/steps for using inoculants are described below;
Steps of inoculation of bean seeds

- Measure 15 kg of legume seed, this will be approximately 15 litres. Place in any container that will accommodate the seeds.
- Measure one soda bottle (300 ml) of clean lukewarm water (40oC).
- Pour the water into a larger bottle (500 ml plastic bottle)
- Add 2 tablespoons of sugar to the water.
- Mix thoroughly to get an even solution of sugar. This solution is called the sticker.
- Add the sticker to the seed.
- Mix the seed with sticker solution until all the seeds are evenly coated.
- Add the rhizobium inoculant of 125g black powder onto the seeds and sticker.
- Mix the seeds and the inoculant thoroughly but gently until all seeds are uniformly covered with the inoculant.
- Protect the inoculated seed from direct sunlight by covering the container with paper, cloth or gunny bag and keep under a shade until planted.
- Plant the inoculated seeds as soon as possible in well prepared moist field.

For smaller amounts of seed, use 4 teaspoons or soda bottle-tops (20 ml) of the sticker solution, and 2 heaped teaspoons or soda bottle-tops (10 g) of inoculant for every 1 kg of seed.

2.7: *Spacing and Seed rate (population density)*

Plant in lines (rows) in order to achieve optimum plant population and also ease field operations such as weeding, scouting for pests and diseases, spraying and harvesting.

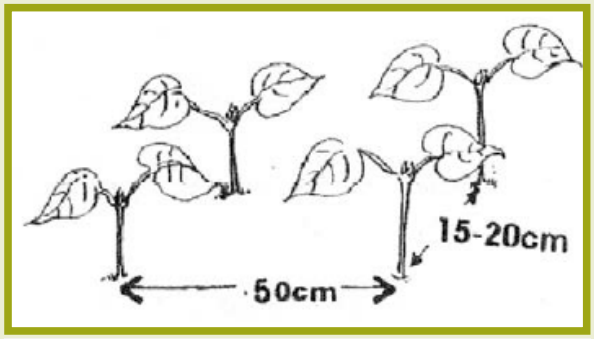
To ensure line planting, mark out the field using marked strings or line markers following the recommended spacing. For bush beans e.g Nabe 4, Nabe 15, use the spacing of **50cm x 10cm** for sole crop with one seed per hole, or a spacing of **50cm x20cm** and two seeds per hole.

Spacing of bean plants depends on the soil fertility, plant type (growth habits), and cropping pattern. Optimum plant population is critical because:

- High population leads to competition among the bean plants resulting into weak plants and ultimately low yield. It also provides a favourable environment for growth and hide- out for most bean pests and diseases
- Lower plant population will result into low yields due to reduced number of plants per unit area.

The seed rate varies depending on the seed size but on average, the rate is between 25-30 kg of seed per acre giving a plant population of approximately 80,200 plants per acre,

Climbing beans: Use a spacing of 60cm (between row) and 20cm (between plants). You may also check with Seed Company and Research Institutions for correct spacing.



Recommended spacing between plants

Beans planted in lines

Intercropping:

- Where intercropping is practiced, adjust the spacing as per recommendation. Bush beans can be intercropped with maize, sorghum, coffee, cassava or banana however, the beans do not grow very well when over shaded.
- Various plant spacing combinations can be used in an intercrop.

Examples include:

a) Two rows of beans with one row of maize at a spacing 100cm by 25 cm for maize and 50cm by 10cm for beans
b) Two rows of maize with two rows of beans

Beans - maize intercrop

Where climbing beans are intercropped with maize especially for support, beans should be planted 2 weeks after maize, so that the maize stems are strong enough to support the bean plant.
When planting different bean varieties, make sure to maintain a space of 2 meters between plots where each different variety is planted to prevent mixing of varieties.

2.8: Planting depth

The speed at which seed germinates and emerges out of soil depends on planting depth, soil moisture and temperatures. Beans are best planted at the depth of 5 cm and lightly covered with a layer of soil. Deeper planting may lead to delays in emergence and low or poor germination. On the other hand, surface planting may lead to poor germination as the seed may not obtain sufficient moisture needed for emergence and it also exposes the seed to rodents and other vermins.

2.9: Methods of Planting and Related Equipment

Traditionally, farmers in Uganda use hand hoes. For ease of work, farmers should work in teams of three people; one for digging holes, second person placing fertilizers and covering it with a thin soil layer and the third person placing seeds and final covering.

Working in teams at planting

Jab Planter

Jab planters: common with farmers practicing minimum tillage (refer to 2,3). The planter is manually operated, and the advantage is that it digs the holes, places fertilizer, then the seed and covers it.

For mechanized planting, tractors or oxen are mounted with special equipment for planting are used. Digging of holes, placing of fertilizers and placing of seed is done simultaneously. Check the machine well before the anticipated planting date to make proper adjustment. Always read the operator's manual and seek advice from the suppliers for effective usage.

Mechanized planter

2.10: *Basal Fertilizer Application:*

In case of poor soils, farmers should apply basal fertilizer (organic and or inorganic) at planting. Use only recommended fertilizers especially after testing your soils.

Placement of fertilizers and seed

Follow recommended application rates e.g. 50kg of DAP per acre (one bottle cup per hole) depending on initial soil fertility status, use crop specific fertilizers (blended fertilizers) where available. Beans require modest amounts of nitrogen because of the symbiosis with Rhizobium bacteria that transform atmospheric nitrogen into nitrates available to the plants.

Always cover the fertilizers lightly with soil before placing the seed, because most fertilizers are corrosive.

After planting, inspect your field 3 to 4 days after germination to ensure that a healthy crop is produced. Any gaps in the row as result of seed failing to germinate or other seedling damages should be addressed immediately by gap filling.

Module Three:
Crop Management Practices

This module focusses on management practices during beans crop growth and includes; staking climbing beans, weed management, soil fertility management and pests and disease control.

3.1: *Staking of climbing beans*

The practice of providing climbing crops with support is known as staking. Climbing beans grow vertically and thus need support and this helps the plants to grow faster, healthier and help rto reduce disease attack especially anthracnose, the plant accesses enough light and produce higher yields. Staked beans can be harvested over a more continuous period compared to bush beans. Staking is usually done on crops planted in rows with the stakes placed between the crop rows. Staking should be done 2 weeks after germination when the plants start forming tendrils for climbing.

One stake can support one to three plants, depending on the bean variety and the strength of the stake, and overall, about 18,220 stakes are required per acre. An average stake length is 2.5 meters.

The technology of staking can be; by wooden material or wiring using different materials. For wood, the common tree species from which stakes are produced are bamboo, Acacia mearnsii (black wattle), Calliandra spp, Eucalyptus spp, Markhamia lutea, and Sesbania sesban. Stakes can also be made from dry or fresh wood. They can also be cut from reeds or maize stalks, especially when other staking materials are scarce. Generally, tree stakes can be used for 2-3 seasons depending on type.

Wire staking involves use of non-wood threads such as metal wires, banana fibers, sisal threads and other feasible materials together with few strong poles which support the threads. The poles remain fixed and can be reused in the successive seasons while threads are stakes removed and put on seasonal basis.

Where maize stalks are used, plant climbing beans right after maize harvest so that the old maize stem functions as stakes. This structure is not very strong and beans cannot climb high, so yields will be lower.

Climbing beans growing on wooden

Climbing beans on threads stakes with fixed poles

3.2: Weed Management

Effective weed control is a prerequisite for high bean yields. Beans, being low-growing plants, struggle to compete with weeds. Early control of weeds recommended at 2-3 weeks after planting is extremely important, because the root system of the plant develops at this stage and some weeds secrete chemical inhibitors which limit plant growth. It is also recommended to weed 5-6 weeks after planting to avoid weeds hampering with the harvesting and threshing processes, and not to adversely affect the quality of the crop. Control of weeds can be by mechanical and or chemical means.

3.2.1 Weeds and their effects on beans

Weeds are plants that grow where they not wanted. It is very important to control weeds in the early stages of crop development to avoid their effects on the bean crop.

Effects of Weeds on beans

- Weeds reduce yield by competing with the bean crop for minerals, light and moisture especially during the early stages of crop growth.
- Some weeds are alternative hosts of pests and diseases
- A thick growth of weeds in beans makes harvesting difficult.
- The weed seeds and shoots increase labor for winnowing and sorting; they also reduce the purity and/or quality and market price of harvested grain

Poorly weeded bean crop

Well weeded bean garden

3.2.2 Categories of weeds

Annual weeds:

These complete their life cycle within one season. In most cases, the seeds produced by annual weeds will germinate very fast and even grow faster than the bean crop itself. These weeds will interfere with the growth of the crop during the critical period of the first four weeks. Annual weeds also produce a lot of seed which can survive and germinate the following season. Examples include, black jack, goat weed, wandering jew etc

Perennial weeds:

These carry on from one season to another. The weeds persist in bean garden all the time every year and reproduce through roots, stems (rhizomes) and seeds. It is very difficult to control perennial weeds using mechanical methods because only the top of the weed is cut, the bottom continues consuming the nutrients and water meant for the bean plants. Perennial weeds should be controlled early before the beginning of the planting season. Examples include; couch grass, spear grass, etc

Common weeds in bean field

Annual Weeds	Perennial Weeds
Black jack 	African love grass, Bristy foxtail 
Wandering jew 	Coach grass 
Gallant solder 	Nutsedge grass 
Goat weed 	Spear grass 
Devil's horsewhip 	Tick-berry 
Wild finger millet 	Oxalis 

3.2.2 Categories of weeds

Weed management must be addressed with a holistic approach and begins with correct land preparation. Identification of the main weed types will determine the correct control methods to use. The common methods of control include cultural practices, mechanical and application of chemicals using selective herbicides.

Preventative and Cultural weed methods refer to any technique that involves maintaining field conditions such that weeds are less likely to become established and/or increase in numbers. They include use of clean seed (uncontaminated by weed seeds), site selection, land preparation, timely planting, soil fertility management, proper spacing, crop rotation, mulching etc

Manual weed control involves the use of farm tools and equipment like hoes, rakes, fork jembes, and pangas, among others. It should be done carefully to avoid damages to the crop. Always earth up as you weed to help the crop become stronger and help secondary root system develop especially where there has been effects of bean fly attack and root rot.

Mechanized weed control: Involves use of mechanized farm equipment such as ox-traction weeders, tractor weeders (tines) that remove weeds from the gardens. Beans must be planted in rows and weeding takes place at particular crop growth

Avoid weeding when the crop is flowering to avoid flower dropping

Chemical control- This method of weed control either speeds up, stops, or changes the weed's normal growth patterns. This in turn causes the leaves, stems and roots to dry out.
Herbicides are very effective if used properly. Farmers using herbicides need to know the type, the correct dosage and stage to apply the herbicide.

All safety precaution measures need to be adhered to and all label instructions strictly followed.

Advantages of Chemical weed control

- Herbicides are very effective and take a short time to work.
- Reduces the amount of tillage hence labour saving
- There no root damage and no soil disturbance to bring more weeds seeds to the surface for germination
- Herbicides are a must under zero or minimum tillage

If the incorrect herbicide is used, the consequences could be disastrous. Herbicides are also expensive and may be a health hazard (poisonous) to the user when not properly used

Only selective herbicides should be used during weeding. Selective herbicides act against weeds by killing all other plants and leave only beans to grow. Selective herbicides are most effective if applied on weeds when they are actively growing. These herbicides are important for weeding beans gardens. Examples include Bentazon, Beans clean

Avoid weedin Always use recommended herbicides at their recommended rates and wear protective clothing when using herbicides when the crop is flowering to avoid flower dropping.

3.3: *Improvement and Management of Soil Fertility*

Plants need nutrients and water to grow and give good yields. Most of the nutrients come from the soil and hence soils have to be fertile to sustain plant yields.

A fertile or healthy soil should:

a. Be deep enough and well drained
b. Have good structure, texture and well aerated for proper root development.
c. Have a favourable soil reaction (i.e. degree of acidity and alkalinity pH range 5.5 to 6.5 for most crops)
d. Have a good supply of both available and reserve plant nutrients
e. Be able to store soluble nutrients
f. Contain sufficient organic matter >2%
g. Support a wide range of micro and macro organism (fauna and flora)

3.3.1 Causes of Soil Nutrient losses/Soil infertility

Nutrient mining is the removing of more nutrients (from the soil through crop harvest, soil erosion, etc.) than what is replaced through addition of organic and inorganic fertilizers. Soil nutrient losses can result from the following ways;

a. Loss of soil cover by destruction or removal of crop residues;
b. Accelerated loss of soil organic matter through destruction of vegetation, ploughing, burning of crop residues, decomposition etc.;
c. Poor soil physical properties leading to limited water infiltration and restricted rooting caused by soil compaction;
d. Soil erosion
e. Leaching
f. Unusually low or high soil pH levels

3.3.2 Essential plant nutrients

These are nutrients that are required for the entire plant growth cycle. Deficiency of any one of these nutrients will make plant have limited growth, affect flowering and or seed formation.

The essential plant nutrients are divided into two groups: macro nutrients and micro nutrients.

i) Macronutrients are required by plants in relatively large quantities and include; Nitrogen (N), Phosphorus (P), and Potassium (K), Sulphur (S), Calcium (Ca), and Magnesium (Mg)
ii) Micronutrients (Trace elements) are required in small (or micro) amounts by plants. They include Manganese (Mn), Iron (Fe), Boron (B), Zinc (Zn), Copper (Cu), Molybdenum (Mo), etc.

3.3.3 Signs of nutrient deficiency in beans

Role	Deficiency signs	
Nitrogen Contributes to the green colour of the plant; is directly involved in photosynthesis;	Lower leaves become yellow and eventually die. Young leaves may be lighter green than normal. Growth is stunted, few flowers develop and pods fill poorly.	

Phosphorous Promotes early root formation, and growth in young plants and improves quality of grains, and water-use efficiency	Beans usually take long to display symptoms of P deficiency. By the time a visual deficiency is recognized, it may be too late to intervene. Symptoms include small, dark green upper leaves that turn purplish and later die. Plants are stunted with thin stems and the number of flowers, pods and seeds are reduced, while seed and fruit development is poor or absent	
Potassium Increases crop yield, water use efficiency and disease resistance. It also improves grain quality and regulates the opening and closing of stomata	The tips and edges of older leaves appear burnt or scorched, and poor filling of pods. The leaf midrib usually remains green. Deficient plants stay small and weak, and their leaves later fall off. The pods are poorly filled	
Calcium Used in cell division and formation, nitrogen metabolism, translocation of carbohydrates from leaves to fruiting organs and increases fruit set	Stunting in stems, flowers and roots. Leaves are curled or cupped with black spots and yellow margins. Pods wilt and seeds fail to develop.	
Magnesium Used in chlorophyll production, improves utilization and mobility of phosphorus, activates many plant enzymes and influences earliness and uniformity of maturity	Older leaves have yellowing between leaf veins; but veins stay green	
Boron Is an essential in protein and carbohydrate metabolism., seed and cell wall formation and for germination of pollen grains and growth of pollen tubes.	Stems abnormally thickened, longitudinal splitting of epicotyl, death of growing points and inter-vienal chlorosis on middle aged leaves.	
Iron Needed for chlorophyll formation, plant respiration, formation of some proteins, and enhances N fixation rates.	Yellowing occurs between the veins of the newest growth. The veins will remain green except in extreme cases.	

Manganese Involved in photosynthesis and chlorophyll production and helps to activate enzymes involved in the distribution of growth regulators within the plant.	Stunting and yellowing between veins of young leaves. Leaves gradually turn pale-green with darker green next to the veins.	
Zinc Important in seed formation. Plays a role in chlorophyll, carbohydrate and starch production, and aids plant growth hormones and enzyme system	Younger leaves first become mottled and show interveinal chlorosis, with browning of the older leaves.when deficiency is severe, the area between leaf veins will become light green and yellow near the leaf tips and outer edges. A general downward curl of the leaves also occurs and pod set will be poor. Plants tend to be stunted due to shortening of the internodes.	
Molybdenum Aids in the formation of nodules supports nitrogen metabolism, pollen viability and seed production	Early deficiency symptoms are similar to nitrogen deficiency. Affected plants become stunted and lack vigour. Leaves may turn brown along the margins. Deficiency leads to poor nodule formation.	

3.3.4 Soil fertility management

Beans grow well on fertile soils but where soils are deficiency in nutrients, the use of fertilizers is encouraged. Soil fertility can be improved through use of:

- Organic manure
- Inorganic fertilizer
- Other soil amendment practices.

3.3.4.1 Organic manure

These are decaying organic matter or humus derived from plant and animal residues. They include: farm yard manure, compost manure, green manure and organic mulches. Organic fertilizers maintain soil structure, improve water holding capacity and improve aeration in addition to providing the majority nutrients for plant growth.

Application of organic manure

In one acre, use 2 to 4 tons of manure, it should be applied during ploughing and should have decomposed for at least 2 to 3 months. Planting should be done after two to three weeks from the date of manure application.

Compost manure

Crop residues and organic household wastes are left to decompose for two to three months, after which the compost is ready for use.

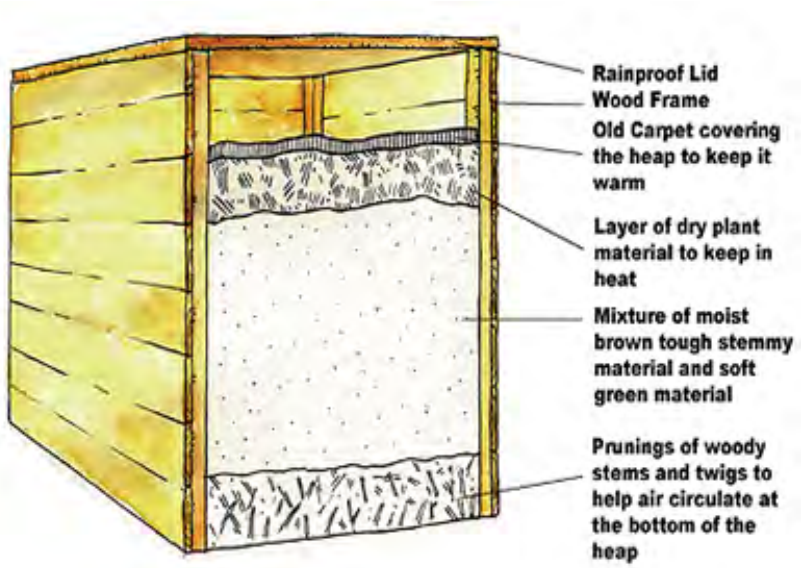
The compositing process

Requirement: dry plant materials, water, ash, green plant materials, animal droppings and top soil

Steps

1. Making the base: Find a shady area, dig a pit for the compost or use the wooden box design and make a bed with twigs or stalks
2. Chop the materials and heap the layers; sprinkle water to help the heap rot; add animal droppings from chicken, goat cow; add top soil for insects and worms; add green plant material; sprinkle with ash for potassium, and water. Repeat the layers 3 or 4 times and cover with soil and dry grass to keep the compost moist.
3. After 3 weeks, turn the heap layer by layer (this helps the rotting process). After another 3 weeks, the compost will be ready.

NB: Use a temperature stick to monitor the rotting of the heap. Composting manure is applicable for smallholder farmers



Application of compost manure:

- Using a small container to a size of 3 spades, or a half basin,
- distribute the well decomposed manure in the field evenly
- and hallow/dig it up, so that it mixes well into the soil and plant after 2 to 3 weeks

Benefits of composite manure

- It's cheap to make because of the readily available raw materials
- It improves soil texture, water holding capacity and nutrient up-take
- Gradually release of nutrients for a period of time

3.3.4.2 Inorganic fertilizers

These are manufactured fertilizers which rapidly provide/release nutrients to the plant. The inorganic fertilizers provide specific nutrients, which are lacking in the soil. Examples of inorganic fertilizers include DAP, UREA, MOP, NPK, TSP, blended fertilizers to cater for specific crop needs.

Fertilizer is supplied in form of Nitrogen (N), Phosphorous (P) and Potassium (K). For the solid particles, mineral fertilizers can be of many different sizes and shapes: from granules, pellets to fine powder (dust), but also available in larger compacted granules that release nutrients slowly.

Powder (e.g. single superphosphate

Crystals (e.g. ammonium sulphate)

Prills, granules (e.g. urea, diammonium phosphate)

Supergranules (urea supergranules)

Liquid fertilizer

i) Factors to consider when using fertilizer:
- Availability,
- Affordability
- And accessibility
- Awareness

Accessibility

Fertilizers are in most cases with the agro-dealers, stockists in urban, and at Sub county level, in most cases fertilizer distribution chain stops at Sub County level. Farmer need to be aware of the distribution chain. Always buy recommended inorganic fertilizers from reputable suppliers or dealers. Ensure that the bags are well labelled with all necessary information such as the numbers and nutrient symbols of the contents (percentage of content by weight), the total weight and expiry date.

Availability

This depends on what farmers demand and what the stockists have in stock

Affordability

The fertilizer should be cost effectiveness, and farmers must be willing to pay for the fertilizers.

Awareness

Farmers knowledge of soil nutrients availability and need for the nutrients

ii) The 4Rs of fertilizer application:

a) The *Right Source* of nutrients needed by a plant - Matching fertilizer type to crop need eg application TSP, DAP, SSP at planting time in the soils which are low in phosphorous to establish roots.

NOTE; in highly acidic soils, lime should be applied in appropriate rate to allow uptake of nutrient by the crop.

b) At the *Right Rate* to supply the quantity needed by the plant - Matching amount of fertilizer type to crop needs or growth stage. For instance, at planting, plants require more of P for root development. Amount to apply should be equivalent to the amount the crop is likely to remove from the soil. Beans needs 12 – 24 kg P2O5 per acre basing on soil tests

c) At the *Right Time* to be taken by the plant - fertilizers should be applied when the soil is moist. Under water stress crops, the nutrients cannot move from the soil through the plant system

d) In the *Right Place* accessed by plant roots (within 10cm in farrows)- Keep nutrients where crops can use them. Place fertilizer near plants but avoid contact between fertilizer with seed or plant.

To maximize bean yield, use the right type of fertilizers, the recommended rates and methods of application after carrying out soil testing

3.3.5 Other methods to manage soil fertility include:

- Practice minimum tillage. In a used field, spray with a non-selective herbicide (Glyphosate), after 14 days, make fallows or hole (basins) and plant with minimal disturbance of soil.
- Soil and water conservation: construct contour bunds and terraces on steep slopes, planting cover crops to limit loss of water and soil nutrients.
- Correct soil pH by liming: Beans grow well an optimum soil pH) ranges from 5.8 to 6.5 and are very sensitive to highly acidic (pH < 5,2) soils. Beans will also not grow well in soils that are compacted, too alkaline or poorly drained.
- Crop rotation: Beans should be grown in a rotation sequence of legume, cereals, root crops and back to legumes so as to reduce; the risk of depleting the soil of specific nutrients and to break disease and pest cycles
- Intercropping: Beans can be intercropped with cereals to manage soil fertility. This has been discussed in details under Module 2.4
- Fallow management: for farmers with adequate land, fallowing or allowing the land to rest for at least 2 years to rejuvenate the soils is advisable. However, in case, of inadequate land, a rotation program should be observed to reduce pests and disease accumulation.

3.4: *Field Pests and Disease Management*

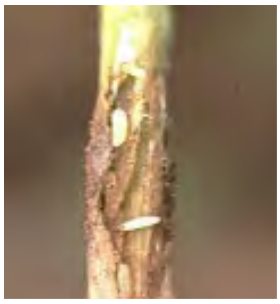
Beans are attacked by several pests and diseases while in field. The level of pests and disease incidence depends on the presence of the causing organisms, weather, soil conditions, and the relative resistance or susceptibility of the variety. Management techniques to minimize losses due to pests and disease attack include:

Biological

- Habitat manipulation
- Modification of cultural practices and
- Use of resistant varieties

3.4.1 Major Bean Insect Pests and their Management

Type of pest	Damage Done	Control Measures
Cutworms *Agrotis sp;* The larva is dull, hairless brown, or black and hides in the soil near the cut plants 	Larvae feed on roots and base of stem killing seedlings	• Early planting • During primary tillage, dig soil to expose larvae to predators such as birds and ants • Hand pick and destroy the larvae • Apply recommended insecticides such as Thiamethoxam to the ground around affected plants

Bean fly (Bean stem maggot) *Ophiomyia sp* A dults are small shiny black flies with clear wings that reflect a metallic blue colour in sunlight. 	Female fly pierces the young leaves to lay eggs and sucks the exuding sap, leaving yellow blotches on the leaves Larvae tunnel into leaves and down petioles to the stem cutting flow of nutrients causing withering and drying	• Earth up soil around the plant to cover the roots • Plant early • Provide adequate fertilization for plant vigour • Avoid planting beans near cowpea, beans and other leguminous crops • Use resistant varieties developed by researchers • Use treated seed • Use insecticides under severe attack examples include Imidacloprid, Azadirachtin
Flower Thrips Adults are tiny, slim, elongated, shiny black and are distinguished from other species of thrips by pale bands across the top of the forewings.  	Feed on young leaves, developing flowers and pods causing curling of leaves, flower abortion and scars on pods	• Early planting • Fertility management • Inspect flowers and Use recommended insecticide e,g Dimethoate 40% only when 10 thrips /flower are seen, early detection important • Spray with botanicals
Aphids  	They suck plant sap Infested leaves curl under and inward and become severely distorted. Leaves also become mottled due to viruses spread by aphids.	• Early planting • Fertility management • Use bio-pesticides not harmful to natural enemies e.g. neem, soapy water • Monitor crop regularly and apply insecticide if • at least 1 in 10 plants is • heavily infested • Examples of insecticides include Dimethoate 40%, Azadichtin
Flower beetles 	They feed on petals and pollen of flowers.	• Remove the plant debris from the field. • Remove the weeds from field. • Manually pick and destroy the beetles

Foliage beetles *Ootheca spp*  	Adults defoliate the crop while the larvae feeds on roots causing patches of yellowed plants in the field. Such plants are stunted and may dry up prematurely.	• Fertility management • Crop rotation with non-host plants e.g maize • Plough the field after harvest to expose the dormant adults, eggs and larvae to sun heat • Use recommended insecticide only if 3 plants out 10 are heavily infested or > 30% leaf loss • During flowering stage treat when > 3 beetles per plant seen. • Spray when bees not active Examples include Lambda-cyhalothrin + Chlorpyrifos, Beta-cyfluthrin
Pod borers  	Feed on flowers, pods and seeds causing flowers abortion, wilting of pods, shrivelled or half eaten seeds and reduced quality of grain	• Crop rotation with non-host plants • Scout the field for the pest and initiate control at an early stage of infestation • Use systemic insecticides e.g Acephate, Dimethoate
Pod sucking bugs  	Bugs suck on pods causing tiny depressions (dimples), and may cause shrivelling and rotting of the seeds, which lose viability.	Hand collect and kill when few are seen Well-timed (45 days after planting) application of insecticides such as Cypermethrin + Dimethoate
Bean Bruchid  	Infestation starts from the field. The larvae bore into bean seeds leaving them perforated with holes. Cause faecal contamination	• Timely harvest (before shattering of pods) • dry seeds thoroughly before storage • Clean the storage facility prior to storage • Use a disinfectant like Actellic dust or fumigate aluminium phosphide • Do not store old beans with newly harvested beans • Store beans in air-tight containers e.g hermetic bags/silos

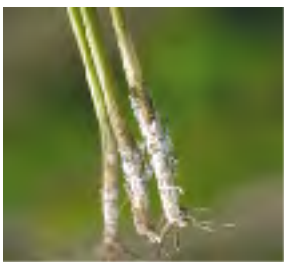
3.4.2 Major Bean Diseases and Associated Control Measures

Most diseases affecting beans are caused by fungi and bacteria; and can cause 60 to 100% yield loss if not well controlled.

Disease	Transmission	Symptoms/signs	Control
Common blight	•Survives in the seed but may also be carried over in diseased debris. Bacteria spread by rain, wind or mechanical means.	Initial symptoms are small, water-soaked spots on the underside of the leaves, which enlarge and merge to form large brown irregular lesions surrounded by a narrow yellow zone. Pods have sunken circular spots which are initially water-soaked but later dry, with a reddish brown narrow border. Under wet conditions, yellow slimy bacterial exudates ooze out of the lesions and form a crust.  	• Use healthy seed. • Remove all infected portions of the plant or the entire plant from the garden, as soon as disease is detected. • Practice crop rotation • Spray with Mancozeb
Halo blight	Transmission similar to Common Blight Disease: in seeds, plant debris, rain splash and by physical contact.	•Has a distinct yellowing around the initial leaf spot, which spreads outwards, though generally, the symptoms are similar to those of common blight disease 	Control is as for common blight disease
Bean Common Mosaic Virus (BCMV), Bean Common Mosaic Necrosis Virus Disease (BCMNV)	The virus may be transmitted by insects like aphids or through the seed.	Symptoms range from puckering of the leaflets along their midribs to leaflet mottling and elongation; pod, leaf and petiole distortion; dwarfing of leaves or of the entire plant; or premature death of the plant. Affected leaves may show light green or yellow and dark green mosaic pattern. 	• Use certified seeds; • Rogue any plants infected with the virus • Avoid adjacent planting and overlapping bean crop during the rainy season (i.e. only one crop per rainy season

Bean Anthracnose	Mainly seed-borne. Can survive on infected seed and on crop debris. Rain splash and wind will spread the spores of the fungus within the crop.	Small reddish-brown, slightly-sunken spots form on the pods and rapidly develop into large, dark-sunken lesions. In moist weather, masses of pink spores develop on these lesions. Black-sunken spots, similar to those on the pods, are produced on the stems and the leaf stalks. Infection of the leaves causes blackening along the veins, particularly on the under surface.  	• Use disease-free seed certified seed • Avoid cultivating and harvesting an infected crop when wet to prevent the spread of spores. • Do not pack lightly diseased pods as anthracnose can develop during transport • Use recommended fungicides. Ref; annex 5
Bean rust	Survive mainly on bean plant debris of the previous season and volunteer crops. Spread mainly by wind and to a less extent by farm animals, insects and implements.	The initial symptom small, whitish, slightly raised spots which produce reddish pustules, and later, turn dark-brown. The leaves turn yellow, then brown and dry.  	• Timely application of fungicides. • Use tolerant varieties • Practice crop rotation and intercropping • Avoid adjacent planting and overlapping bean crop during the rainy season • Destroy infected materials.
Fusarium Wilt/ Fusarium Yellows	• Infected soil is the main source of infection. Other sources are infected plant residues and seed. • Spread is through irrigation, wind-blown soil particles and contaminated farm equipment.	• The fungus causes a reddish discoloration throughout the root, stem, and petioles Infection causes yellowing of lower leaves and may progress to the upper leaves, causing premature defoliation. • Infected seedlings are stunted, wilt, and die. The fungus can also cause water-soaked lesions on pods.  	• Crop rotation with non-host crops • Deep ploughing of infected plant debris • Use of organic amendments such as manure to improve the soil fertility • Seed dressing with recommended fungicides,

Bean root rot diseases

Fusarium root rot	The main source of infection is infected soil. Infected seeds, drainage and irrigation waters, splashing rains, and infected manure are common means of dissemination. Survives in the soil on decaying organic matter.	The first symptom is reddish discoloration of the taproot which gradually intensifies, eventually turning brown, fissures develop and the rot becomes dry and papery. 	• Long-term rotations (4 to 5 years) with non-legumes • Improve drainage and avoid injury to the root system. • Planting in raised beds or ridges and hilling up soil around the stem before flowering. • Apply farm yard manure or other soil amendments • Deep plough infected plant material during land preparation.
Pythium	As for Fusarium root rot	Damping-off of seedling. Also attacks lateral roots causing plant wilt and death. The pathogen can extensively prune roots and destroy much of the hypocotyls and main root system.  	• As for Fusarium root rot
Sclerotium Root Rot (white mold)	The disease is spread by, wind-blown soil particles and farm tools and machinery.	• Symptoms initially appear on the stems just below the soil line as grey water-soaked lesions, which later become dark-brown and extend downward to the tap-root, leading to wilting. Foliage symptoms consist of leaf yellowing and defoliation in the upper plant branches, followed by sudden wilt. • A fan of silky white mould and large, round sclerotia (which are at first white but gradually become dark) appear at the base.  	• As for Fusarium root rot

Module Four:
Safe Handling and use of Agro-chemicals

Agro-chemicals are crop protection products used in production and preservation of crops or crop products. Agro-chemicals are becoming an increasingly integral part of crop production.

4.1: *Agro-Chemicals*

4.1.1 Groups of Agro-Chemicals

- Herbicides (for killing weeds/herbs)
- Insecticides (for insect pests
- Fungicides (for fungal diseases)
- Nematicides (for nematodes)
- Rodenticides (for rodent pests)
- Fertilizers (providing plant nutrients)

4.1.2 Advantages of using agro-chemicals

1. Increases food production
2. Improves quality of produce
3. Decrease costs of production e,g use of herbicides
4. Are labour saving
5. Increased profits for farmers

However, agro-chemicals are very harmful if not properly handled, can cause detrimental health hazards to the user, consumer and the environment.

Example of health hazards include; Nausea, diarrhea, stomach ache, nasal bleeding, vomiting, loss of sight, dizziness, and sometimes death.

Environmental hazards include pollution and contaminated of water bodies, bees and livestock death.

Agro-chemicals are poisonous substances that must be handled carefully and safely

4.2: *Safe use of agro-chemicals*

To optimize use of agro-chemicals, it is important that proper identification of the exact problem is undertaken.

4.2.1 Identification of the pest

The farmer should make sure that he/she has scouted his/her field and has identified the pest and level of infestation. In case of any doubt, consult the extension worker or take a sample with you to the trusted and qualified input stockiest or plant clinic.

4.2.2 Buying agro-chemicals,

Always buy chemicals from licensed and registered agro-input dealer shops.

- Read the label on the container for expiry date and any other important messages e.g active ingredient.
- Always buy pesticides in their original containers and also make sure the containers are intact.
- Where possible verify whether chemical is not a counterfeit by using **Kakasa (e-tag)** application.

Always get a receipt from the agro-input dealer indicating date of purchase, name of chemical and batch number

4.2.3 Transporting the agro-chemicals

- Ensure that all containers are tightly sealed and the mode of transportation does not cause any leaks or spillage.
- Never transport agro-chemicals with any food or feed items.

4.2.4 Storing Agro-Chemicals

In case a farmer is not using the agro-chemical immediately, he should store agro-chemicals in safe isolated places (cupboards, shelves that are safely located) away from children and family members.

4.3: Application of agro-chemicals

4.3.1 Reading the Product label

The label provides all the necessary information such as, active ingredient, mixing and application rates, first aid, disposal of containers, pre-harvest and pre-entry intervals etc. Read the product label and follow instructions on how to handle and apply the chemical. If you do not understand the instruction, seek advice from extension agents.

Ensure that you buy the necessary protective clothing as recommended on the product label (cap, masks, overalls, gumboots, gloves, goggles)

Look out for colur coding, warning symbols, pictogram, or any additional safety instructions on the label. (Agro-chemicals are also classified according to their toxicity and should be used as recommended on the label of the product).

Color Coding

Class 1a		Extremely Toxic
Class 1b		Highly Toxic
II		Moderately Toxic
III		Slightly Toxic
IV		Handle with care

4.3.2 Determining how much pesticide to use

The single most asked question in pesticide application is: "How much pesticide (ml) do I put in a knapsack (20lts)?" The answer is; it depends on the calibration of your sprayer. In short, how many square metres one spray pump full of water + pesticide will cover.

Always Read the label for recommended dilution rate or dosage.

It is important that the amount of pesticide to be used is precise to avoid excess that could lead wastage of resources, damage of the crop and contamination of the environment. When quantity is inadequate, it is likely that the pest will not be effectively controlled and this can result into pest resistance.

Always Read the label for recommended dilution rate or dosage.

Common Knapsack Spray pump

Steps of calibration of a knapsack sprayer

Every sprayer has a different capacity, different nozzles with higher or lower output. Also spray operators work at a different speeds and pump at a higher or lower pressure. To realize appropriate application, there is need to calibrate the spray equipment as follows:

1. Measure and mark out an area of 10m x 10m = 100sq.m
2. Fill the knapsack with known volume of water e.g 15 litres of water
3. Put the knapsack on your back and start pumping, walk at a steady walking pace, spraying with the nozzle at knee height and recite the word 'one thousand' over and over again making one pump stroke per 'one thousand'.
4. Spray the marked area.
5. After spraying, measure the litres of water that has remained in the spray tank (e.g 10lts remained)
6. Amount used to spray area of 100sq.m = 15lts -10lts = 5lts
7. To work out how much pesticide to measure into the sprayer is now very easy. Look at the application rate on the product label.

eg. Roundup is 1.5L (=1500ml) per Acre and an acre = 4,000 sq. metres

To calculate how much to measure into your sprayer:

8. Calculate the volume of water needed to spray an acre

If 5lts covers 100sq.m

$$\text{An acre} = \frac{4000\text{sq.m} \times 5\text{lts}}{100\text{sq.m}} = 200\text{lts}$$

9. Using Round up at a rate of 1.5lts/acre, calculate the amount of chemical for a knap sack of 20lt capacity as 200lts of water is need to dilute 1.5lts of Round up

$$\text{Therefore a knapsack will require: } \frac{20\text{lts} \times 1.5\text{lts}}{200\text{lts}} = 0.15\text{lts of Roundup}$$

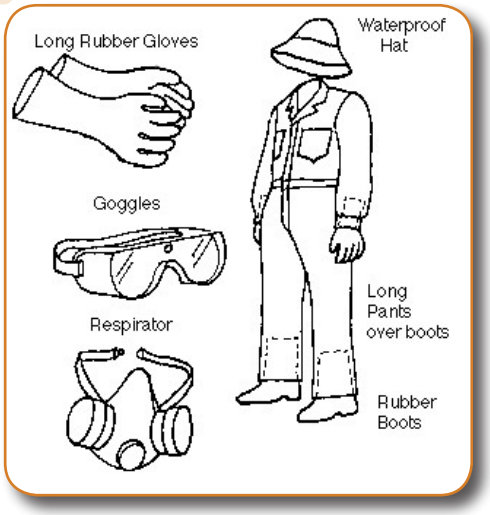
1litre = 1000ml

0.15 x 1000ml = 150mls

10. Farmer can also calculate needed mls per litre of water = 150ml/20 = 7.5ml.

4.3.3 Mixing Agro-Chemicals

Always wear full protective gear to prevent skin contamination



Mixing and filling operations are the highest risk time for pesticide accidents.

- Read the label carefully and understand the instruction.
- Ensure recommended rates are followed
- Always mix and fill outdoors to avoid pesticide fumes that can concentrate in closed area
- Open pesticide containers with extreme care
- In case of spillage, wash it off with clean water as soon as possible
- Use clean water to mix chemicals
- Use suitable equipment for measuring out chemicals.
- Never use hands as scoops or for stirring liquids
- Add only enough pesticide to the tank for the job you will be doing

4.3.4 Before Spraying

- Before spraying, check the spraying pump for any leaks, use the right nozzle for the particular activity, i.e the flat nozzles are for herbicide application, the cone nozzles are for spraying fungicides and insecticides.
- Check the nozzle for blockages, if clogged, do not try to blow it out with your mouth, use a small soft twig or grass or soft brush to remove the clogs.
- Wear protective gear before spraying activities

Spraying in teams

4.3.5 During Spraying

- Put warning signs in field during spraying to alert the community.
- Do not spray near other people or water sources
- Spray in the direction of the wind.
- Walk within the rows and direct the nozzles to the targeted pest
- Preferably spray in the morning hours before 11.00 am or late in the evening after 4.00 pm bearing in mind when the pest is most active
- Do not spray when it is about to rain or when it is raining
- Do not eat, drink or smoke while working with chemicals
- Minimize talking when spraying
- Do not touch your face or any other bare skin with soiled hands or gloves
- Apply the pesticide evenly and in the right amounts
- Turn off the equipment whenever you pause.
- If your co-worker shows signs of pesticide poisoning, stop the spraying immediately and begin first aid measures

4.3.5 After spraying:

- Use all the pesticide in the sprayer, at least spray it over adjacent field if it remains
- Do not leave pesticide containers at the application site
- Do not re-enter the treated area until after sometime (at least 24 hours)

4.3.6 Disposal of empty containers

- Rinse the empty container at least three times pour the rinse back to the spray pump
- If it a metallic, puncture it or if plastic bottle, cut it several times to avoid re-use.
- Select a disposal site away from home and mark it properly " Container disposal"
- Disposal off the containers following the guide lines on the label

4.3.7 Cleaning the spray pump and yourself

- While still dressed in protective gear, wash the knapsack and rinse it well to ensure that no residues remain
- Pour all the washing on bare ground
- Do not wash spray pumps near water sources like rivers, lakes or swamps
- Remove the protective gear ending with gloves. Wash the protective gear.
- Wash your body thoroughly well with clean water after spraying.
- Put on clean clothing
- Store the clean spray pump properly.
- Keep records of spray application

Washing of spray pump

Bathing after spraying

Module Five:
Harvesting and Post-harvest Handling

The Market requires supply of quality beans in desired quantities at desired time. Good quality beans attract better market price that help farmers earn high income. Many times, farmers experience high losses of beans from harvesting to marketing. It is estimated that farmers in Uganda loose up to 40% of their produce from harvesting to marketing as a result of poor postharvest handling practices which results in poor quality of the beans. It is therefore crucial for farmers to adhere to good practices to maintain the quality of beans during harvesting and postharvest handling.

5.1.1 Harvesting

Harvesting is the process of removing the plant from the garden after it has achieved full physiological maturity. To ensure quality, harvesting should be carried out on time to avoid losses and deterioration of quality. Beans are harvested at different physiological stages depending on the intended use. When it is for fresh eating, it is harvested when the pods are tending to yellow. If it is meant for dry grains, the whole plant is harvested when it has dried and achieved full physiological maturity.

Beans at right time to harvest

Bean Physiological Maturity: Is stage when the crop has achieved maximum growth (usually 58-120 days) after planting depending on the variety grown) and has the following indicators:

- Bean leaves turn yellowish with mature veins
- Shading of leaves in some varieties accurs
- Seed texture hardens
- Seed colour becomes more pronounced
- Pods harden, becomes light brown

5.1.2 Methods of harvesting

Manual/ Hand harvesting.

Manual /Hand harvesting is the commonest method in Uganda and is considered practicable for crops under small scale production. It is carried out by uprooting of bean plant from the soil. The activity requires 6-10 people /acre/day

Mechanical harvesting:

This is the harvesting of beans using machines and is suited for large farms. Machines simultaneously harvest, thresh and clean the grain. It has an advantage of ensuring quality, reducing losses in addition to time & labour saving.

A combine harvester

Common practices to avoid during harvesting

- Harvesting pre- mature/ early harvesting: This results into shrinkled and rotten beans
- Delayed harvesting: Leads to attack by pests and animals, shattering of pods, physical loss and rotting of grain
- Carrying soil on the roots of the harvested beans: This increases contamination opportunities for aflatoxins and other contaminants
- Leaving the beans to dry in the field after they are harvested: Leads to attack of pests and animals, shattering of pods, loss of grain and rotting

Delayed harvest causing shattering of beans

Quality control measures (the DO's) ALWAYS:

- For fresh beans, harvest as pods start yellowing.
- For dry beans, harvest when pods turn brown.
- For climbing beans continue harvesting as they mature
- Place the harvested plants on a tarpaulin or mat
- Where weather does not allow uniform drying of beans in the garden, carry out selective harvesting

5.2: *Postharvest handling (PHH)*

Postharvest handling practices are activities carried out immediately after harvesting and they include; transportation, drying, threshing, cleaning, packaging and storage. Good PHH practices ensure that the harvested product reaches the consumers in the desired quality and quantity

5.2.1 Transportation:

Beans are transported home for further activities to be carried out. Transportation is carried on head, bicycles, motorcycles and vehicles depending the volume of produce.

5.2.2 Drying of beans in the pods

Drying is the systematic reduction of crop moisture down to safe levels for storage. It is one of the key postharvest operations that ensures bean grain quality. During harvesting the moisture content of grain is between 18-24% and this should be reduced to 14% for safe handling.

During drying, the following steps should be observed:

a. Sort the beans to remove weeds and immature pods.
b. Spread the beans loosely on the tarpaulin, drying rack, drying yard and mat to allow drying of the pods.
c. Dry the beans until the pods can easily open to release the grain.

Drying beans on racks

5.2.3 Threshing of beans

This is the process of separating the bean grain from the pods to make grain available for further processes. Threshing can be carried out on threshing rack (fig. xx) that protects the seed from damage, dirt and prevents it from scattering. A threshing rack consists of strips of wood arranged on a platform with a wire mesh that sieves seed from chuff. Grain is collected on the bottom tray or tarpaulin. Scattering of grain during threshing is prevented by the high wooden sides.

Beans threshing rack

Methods of threshing

a. Hand threshing: Beans are threshed by gently beating the pods with a stick.
b. Manual bean thresher: (illustration) Human powered (hands or peddle) machine used for removing grain from the pods
c. Motorized bean thresher: It is a machine used for removing grain from pods. The machine is equipped with a fan that helps in blowing off the chuff from the grain.

Note: After the beans have been threshed, clean for further drying.

Motorized bean thresher

5.2.4 Drying threshed grain/

After threshing, the grain contains higher moisture content than the standard. It is therefore recommended that grain be dried further to the desired moisture content level. Dry the grain on a clean tarpaulin, plastic sheets, mats and drying yards. Where big volumes are involved, use a drying machine.

Methods and technologies of drying

a. Sun Drying

Drying is carried out in the open air on tarpaulin, mats, plastic sheets, drying yards and collapsible dryers.

b. Mechanical drying

Hot air is blown in the grain to remove excessive moisture under controlled conditions. Hot air is generated using burning fuel, solar, electricity and biomass.

During drying of the grains, take note of the following precautions to ensure quality

- Turn the grain regularly to hasten and ensure uniformity of drying especially when using sun drying
- Keep off animals from beans to avoid contamination of grain with animal droppings
- Protect the grain from adverse weather conditions by covering the grain with tarpaulin or keeping it under well ventilated facility
- For mechanical drying, ensure appropriate temperature is maintained through close monitoring of the temperature. and care should be taken not to exceed 400C for bean grains
- Ensure close monitoring of the the moisture content to ensure that recommended standard is achieved
- Dry the bean grains until required moisture content is attained

5.2.5 Methods of checking moisture content

Traditional methods

- Shaking grain in a tin and judging from the sound made: grain with high MC gives a dull sound compared to the sharp sound made by dry grain.
- Pushing the hand into grain bulk: wet grain offers more resistance to penetration than dry grain. In addition, grain with high moisture content has high temperatures in the middle due to high metabolic rate while grain with optimum moisture content is cold in the middle.

Biting the grain with teeth

Deeping the hand into the grain

- Biting with teeth: a dry bean is relatively hard and cracks when you bite with teeth while grain with high moisture content is soft, the teeth penetrates when you try to bite
- Salt method: Take a small sample of bean grain mixed with dry salt, put it in a clean dry jar, shake it vigorously for several minutes and allow it to settle. If salt becomes wet and sticks on the wall of the jar, then the grain has high moisture content above 15% and therefore it needs to be dried further.

Scientific means

- Moisture meter: It is the equipment used for measuring moisture content in grain. It measures the percentage moisture content in a given sample. Different types exist on the market depending on the manufacturer.

5.2.6 Grain cleaning

Bean grains with chaff

It is the removal of foreign material and un conforming beans from the normal ones. A number of technologies are employed to clean the grain and they include; traditional winnower and mechanical cleaners (human and motor operated),

Cleaning technologies

Traditional winnower- Common at small holder farmer level, winnowers of different shapes and material are used to clean the grain. Farmers usually take advantage of the wind so that it can remove some of the light dirt during winnowing. One person can clean 100 kgs per hour.

Women winowing beans

Use of screen/sieve- Common at bulking sites and warehouses. A screen/sieve mounted on a wooden frame is used for cleaning. It is more efficient than using a traditional winnower. One person can clean 500 kgs per hour. Foreign materials and dirt that are smaller than the screen size pass through. One of its shortcomings is that grains that can pass through the screen have to be sorted from the dirt and this increases the labour time. On the other hand, foreign material that is bigger than the screen hole size and none conforming grains have to be removed by hand.

Cleaning beans using a sieve

Mechanical cleaners-These are machines that are operated by engines or mortars and have capacity to clean above 1ton/h with automated sorting system based on the quality parameters like colour, size, and shape. They are appropriate for big companies, bulking centers and warehouses where big volumes of grain are being handled.

5.2.7 Storage

Storage is the process of keeping grain until an appropriate time of use. The primary aim of storage is for quality maintenance, food & nutrition security, seed and better price. Note: Good Storage does not improve grain quality but it maintains it.

Storage Technologies

Various storage technologies (traditional and modern) can be used by smallholder farmers to store bean grain and these include;

Traditional technologies	Modern technologies
• Mud and wattle granaries • Baskets • Pots • Jute bags	• Hermetic storage o PVC Tanks/ Silos o Metallic tanks/ Silos o Cocoons o Triple/Pics bags • Flatbed Warehouse/Silo • Grain store (Farm level)

Hermetic storage is an airtight facility that allows for maximum protection of stored products from insect infestation. It seals off the exchange of oxygen and moisture between the produce and environment

Pic bags for storage of small quantities

Advantages of hermetic storage include:

- Eliminates the use of chemicals in controlling storage pests
- Beans can be stored safely for more than12 months
- Stores seed without losing seed viability
- Simple to use
- affordable by small holder farmers

Metallic and plastic silos

Where big volumes of produce are required to be stored, a grain store/ bulking centre/ware house is used and good storage management practices are required to ensure grain quality. The type of storage facility depends on volume of grain, purpose and the financial resources.

Storage management

Reception

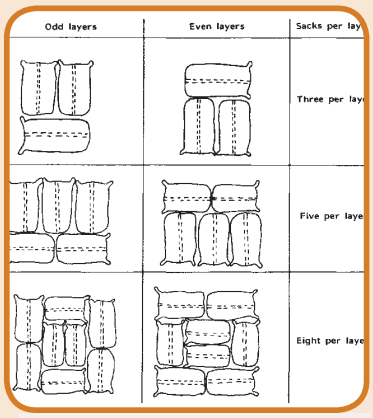
This is the process of receiving grain into a storage facility and involves the following;


Grain store

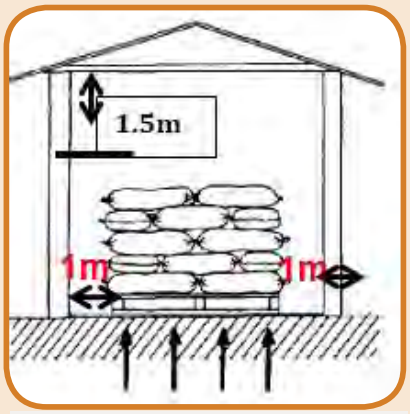
1. Inspection; Grain received for bulking is checked for physical appearance and any possible signs of non-conformity to grain standards.
2. Sampling; Small quantities of grain are taken from different bags for analysis (EAS 902).
3. Testing; analysing grain samples as per set quality standards (EAS 2).
4. Off Loading: If the grain meets quality standards, it is offloaded, Weighed and Recorded
5. Stacking (bagged); Offloaded grain is placed on pallets in a design that will ensure safety, stock taking, fumigation and ease of movement within the facility. The stacks of the produce should be 1m away from the wall to allow inspection. Where produce covers the whole store, a corridor of 1.5m should be left in the middle. When stacking bags, space of 1.5m from the roof should be left. For silos storage, grain is poured on a reception pit and conveyed to the silos by elevators.


Storage on wooden pallets

6. Stacks should be placed by crossing the layers to increase stability. Organize the produce in a well-defined pattern to ensure safety, easy stock taking and air flow as indicated in the lay out below (Fig. xxx). Note: bags of the same weight and shape should be stacked together
7. Where hermetic grain storage tank/bag has been used, it should be placed on pallets/dunnage poles/ wooden platform.



Layout of bags



Spacing of bags in the pallets

Warehouse layout

General Hygiene Practices

Storage facilities and surrounding environment should be kept in good hygienic conditions to ensure quality and safety of the product.

- The store should be cleaned thoroughly before and after storage of produce
- The floor, walls and roof should be cleaned regularly to remove the dust, cobwebs and any other dirt
- During cleaning, the stacks should be covered with tarpaulins or canvas to avoid contamination
- Bush surrounding the storage facility should be cleared regularly to avoid inhabiting rodents and other insects
- Avoid heaping rubbish near the storage facility to keep away rodents and other sources of contamination
- Storage facility should have access to social amenities as per the required standards
- Storage structures on poles should have rat guards
- Ensure that the store is closed all the time and is opened as and when required
- Ventilators and other outlets should have screens that prevent rodents, birds and insects from entering the store
- Nonfood materials must not be kept in grain store. They should be kept in a separate nonfood store.
- Avoid storing bean grain with chemicals like herbicides, fumigants, pesticides, fuel and other materials that are hazardous (harmful, dangerous) to life
- Avoid fire in the storage area. It should be a "NO SMOKING" zone. Flammable materials should not be kept near the food store
- In case other types of food are kept it the store, each type of produce should be stacked separately to void mixing of produce and cross contamination.

Good storage practices

It is important to inspect the internal and external areas of the store.

- Regularly, check the store for signs of water leakage, floor cracks and crevices, signs of damage on bags (rodent or insect), leakage of grain on the floor, presence of live insects and any signs of contamination.
- Always inspect the surrounding environment to ensure hygiene
- Carry out quality control checks on a regular schedule
- Carry out fumigation to control storage insect infestation (Use licensed and professional fumigator)
- Ensure FIFO rule when handling stock in storage

Storage infrastructure design and maintenance:

The following should be taken into consideration to ensure good conditions of bean grain storage:

- The roof should be leak proof
- The floor should be impermeable and easy to clean
- The walls should be easy to clean
- There should be sufficient ventilation for easy flow of air to remove disorders that may develop during storage and cool the stored bean grain/ produce (Note: Fans, cyclones and transparent sheets are not recommended on grain storage structures)

Record keeping

Storage records are required for quality control good handling practices and business management. They include;

- Stack cards (The stack card fixed to a bag stack, used to keep a tally of the number and weight of bags of grain either added or removed from the stack.
- Received stock ledger book
- Outgoing stock ledger book
- Quality control records
- Cleaning records
- Fumigation records

5.3: *Storage pests, mycotoxins and their control*

During storage, beans like other grains is attacked by insect pests, moulds, and rodents like rats. Pests form the major problem in a storage especially where good storage management practices are not adhered to.

5.3.1 Pest Control

A number of pests attack grain during storage and they include;

Sitophilus spp.

Sitotroga cerealella

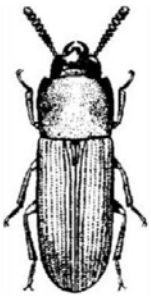
Rhizopertha dominica

Prostephanus truncates

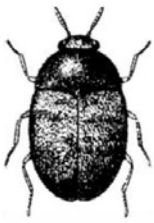
Callosobruchus maculates

Pyralid moths

Tribolium



Gnatocerus



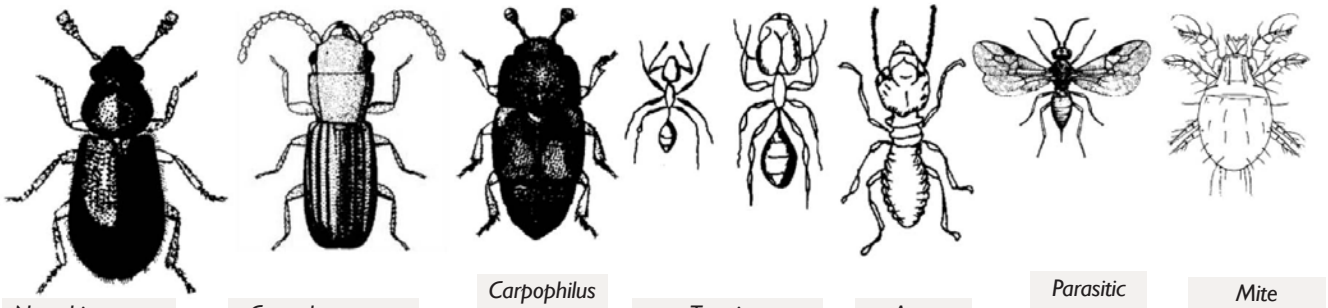
Trogoderma granaria

Oryzaephilus spp

Lasioderma serricorne

Araeocerus fasciculatus

Dermestes spp



Necrobia ruppes | *Cryptolestes spp* | *Carpophilus spp* | *Termites* | *Ants* | *Parasitic wasps* | *Mite*

5.3.2 Control of pests

Storage pests can be controlled by physical, chemical and biological methods. Improved storage technologies like the use of hermetic technologies can be used to control pests. Grain infested with weevils when stored in a hermetic storage the insects die due to suffocation.

Fumigation

This is the application of chemicals/fumigants in controlling storage pests of food mainly grains. Fumigants commonly used include; phosphine

Widely used fumigants include:

• Phosphine • 1,3-dichloropropene • Chloropicrin • Methyl isocyanate • Hydrogen cyanide • Ethylene dibromide	• Sulfuryl fluoride • Formaldehyde • Iodoform • Acrylonitrile • Ethylene oxide

Phosphine is the commonly used fumigant for controlling storage insects however misuse leads to development of resistance of some storage insects.

<u>Safety precaution:</u> Fumigation is a hazardous operation. It is a legal requirement that the operator who carries out fumigation operation holds official certification to perform the fumigation as the chemicals used are toxic to most forms of life, including humans.[1]

Advantages of fumigants:

- Toxic to a wide range of pests
- Can penetrate cracks, crevices, wood, and tightly packed areas such as soil or stored grains
- Single treatment usually kills most pests in treated area

Disadvantages of fumigants:

- Nonspecific in that they are usually highly toxic to humans and all other living organisms
- Require the use of specialized protective equipment, including respirators specifically approved for use with fumigants

Safety measures during fumigation (see safe use pesticides)

- The target site must be enclosed or covered to prevent the gas from escaping
- Keep fumigants safely and out of reach of ordinary persons. Only licensed persons should carry out the fumigation work.

- Wear protective clothing.
- Wash and preferably take bath after fumigation.
- Use a display board indicating the fumigant being used, date of application and person in charge.
- Aerate the grain and stores after uncovering.

5.3.3 Mycotoxins

Mycotoxins are poisonous substances produced by fungi which contaminate grains under poor postharvest handling practices. The common mycotoxins and fumonisins which are known to cause cancer and growth impairment in children and can cause death if taken in high doses. Humans and animals are all affected by consumption of food and feeds containing mycotoxins.

Module Six:
Value Addition

Value addition can take a number of forms such as drying, threshing, cleaning, sorting, milling, packaging and branding depending on the level of the value chain. Quality control is the first step to adding value to any produce. Value addition is important because of the following:

- high market prices
- extended shelf life
- diversifies grain products hence alternative sources of incomes

6.1: *Cleaning and sorting of bean grain*

This normally done at farm level and bulking centers.

Sorting at farm level

Women sorting beans to add value at bulking center

6.2: *Milling*

Beans to less extent can be milled to produce value-added bean products such as bean-based flours, bean cookies and snacks.

6.3: *Biofortified beans*

The bio fortified beans are bred to have high levels of iron and zinc. They can be grown easily like any other common beans that farmers are growing. The only difference with these beans is that they have relatively higher levels of iron and zinc and this translates into higher levels of these nutrients being taken up by whoever consumes them.

6.4: *Pre-cooked beans*

Under new technologies and innovations, selected bean varieties are pre-cooked under high temperatures and pressure resulting into dry processed pre-cooked beans. The product is packed in various types of packaging materials made of weather-proof aluminium sachets, plastic containers and bags of varying sizes and sold to the market/ consumers. The product has a shelf of up to 6 months.

Canned beans

Beans are further processed by cooking through steaming and packed in tins.

Module Seven:
Marketing of Beans

A market is an arrangement which facilitates exchange of goods and services. It can also be a place or forum where buyers and seller meet to perform their transactions.

Marketing of beans consists of all activities involved in moving beans and bean products from the point of production to the point of consumption (Farm to the plate). In other words, marketing involves all those activities linking producers and consumers. Effective marketing should ensure that goods are supplied according to the demand i.e on time and of the quantity and quality that consumers want.

7.1: *Bean Products*

Beans are mainly marketed as fresh or dried grain. However, there also exist niche or specialized beans. These may include; milled bean flour, canned, or frozen beans, snap or French beans and pre-cooked dehydrated beans

Single colour beans

Fresh beans are marketed with their pods in various markets in the country while in urban areas, pods are opened and sold as fresh beans.

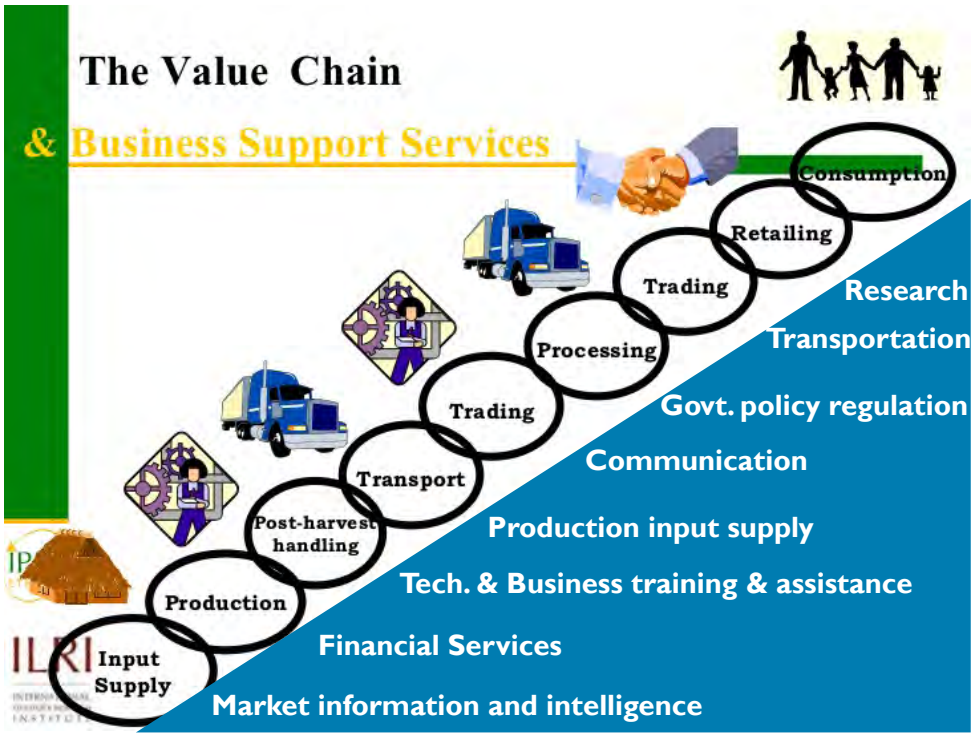
mixed colour beans

Dry beans are sold at local, regional and international markets. The local market is comprised of individuals, institutions (schools, hospitals, prisons, army), relief organizations, processors and traders. Markets demand varying standards ranging from color, variety and size.

7.2: *Access to markets*

Access to competitive markets requires establishment of both backward and forward linkages between organized farmers (suppliers) and buyers (customers). Farmers need to access other value chain support services such as market information, transport, warehousing, financing, and packaging to enable them produce good quality beans in big quantities as desired by the market.

An illustration of the Value Chain and the support services to show how marketing is interlinked



7.3: *Entrepreneurial skills and Marketing*

Entrepreneurship: Capacity and willingness to develop, organise and manage a business venture along with any of its risks in order to make profits. Bean farmer can become an entrepreneur if he/she comes up with technology innovations and adoptions that will help him increase on his net profits. It is important therefore that bean farmers acquire good entrepreneurship skills to enable them access better markets.

Marketing of beans follows the 7Ps model (Product, Price, Place, Promotion, Packaging, Positioning and People) and 2Cs (Customers and Competition). For beans to be sold to the market, there must be people who want to buy it (the customers), at the same time, sellers must be aware of the competition on the market.

The 7Ps

No.	The P	Relation to Beans
1	Product	Beans
2	Price	Price established by both parties (competitive price)
3	Place	The markets supported by storage, distribution and transportation (e,g farm outlet, shops, store/warehouses)
4	Promotion	The way in which the target market is informed about the product and where it can be found (e.g advertising, sales promotions, direct talks to customers).
5	Packaging	The way the product is presented to the customers. This creates impression that effects consumers decision to purchase.
6	Positioning	Product must be marketed in place where opportunities for purchasing it are high. Form of marketing that presents the benefits of your products to a particular audience
7	People	Marketing of beans require people to purchase and to aid in marketing

Farmers or stakeholder taking beans to market should first carry out market research to establish:

- the price being offered by buyers,
- players involved in the market
- other competitors that are willing to supply beans.

Sources of information include; district commercial offices, traders' information desk, NGOs, short message services (SMS) via phones, e-market apps, extension officers, media, traders and processors involved in grain trade etc. A beans entrepreneur will be successful in marketing if he/she: knows his/her customers, needs wants and sets attractive but competitive prices.

7.4: *Group/collective marketing in beans business*

7.4.1 Group/collective marketing in beans business

Marketing as a group involves gathering products from individual entrepreneurs and selling collectively. In order for group marketing to be effective, entrepreneurs should produce the same variety of bean synchronizing their production operations (planting, inputs used eg seeds, fertilizers, harvesting) and postharvest operations (sorting and grading of the product).

For smallholder farmers to access competitive markets; they should enter into group marketing/collective marketing (horizontal linkages) to attain big volumes and have marketing contracts with big buyers or marketing facilities (vertical linkages) e.g WFP

7.4.2 Advantages of collective marketing

- Attracts large-scale bean buyers such as NGOs, relief agencies and cross-border customers (e.g. Rwanda, South Sudan) and export market
- Provides bean entrepreneurs with more bargaining power (in terms of prices, sales volume, time of delivery of the beans etc).
- Makes small scale farming competitive - small farmers can access technology, credit, marketing channels and information while lowering transaction costs
- Reduces costs if activities are carried out as a group (transporting, grading and packaging of the beans are costs that can be shared).
- Promotes access to better marketing information and marketing advisory services.
- Improves quality of products due to timely and sequenced production.
- Enables groups to purchase quality inputs and transport in bulk.
- Provides a link to get trainings from the off- takers, NGO, implementing partners and government extension.

7.4.3 Challenges of collective marketing

Although collective marketing is beneficial to organized groups, the following challenges should be taken into consideration by group members:

- It may be difficult for the group to agree on crucial issues (decision making)
- Dishonesty/non-transparency among members especially the marketing committee may lead to conflicts.
- Poor record keeping may lead to losses.
- It requires safe collection and holding centers in accessible areas, which is not always possible in rural areas. thefts or losses can occur if the bulking facility is in a location that is poorly secured.
- Good road infrastructure is required to attract large scale buyers to remote/rural areas
- It may require heavy capital investments for assets such as, storage facilities and vehicles for transport.

7.4.4 Key success factors in group marketing

For group marketing to be successful, the following factors are critical:

- Members should be knowledgeable on business management.
- Members should attend group meetings regularly and participate actively in decision making.
- There should be mutual trust among members with emphasis on ethics and integrity.
- The group should have dedicated and committed leaders who are democratically elected.
- The group should have clear and enforceable bye-laws on corrupt and unaccountable leadership.
- There should be clearly defined roles and responsibilities especially in relation to promotion and marketing of group products.
- Existence of rural finance institutions from which to borrow additional capital funds to help finance the group's marketing operations.
- Conducting regular pre-production planning.
- Having access to marketing information through market research.
- Uniformity of group's product (beans) in terms of variety, size, quality, packaging, grading etc.
- Having access to safe storage facilities with good road infrastructure.
- The group should have accurate record keeping.
- There should be transparent and equitable distribution of benefits.

7.5: *Other Marketing Channels*

Beans producers may sell their beans through

- The warehousing receipt system or commodity exchange
- Through contracting

Warehouse Receipting System (WRS): In this system, the farmer deposits his/her grain in a certified warehouse and is issued with a warehouse receipt document. The receipt provides proof of ownership that a specified quantity and quality of grain has been deposited at a particular certified warehouse by a named depositor.

Benefit of the WRS

- Provides storage services to the farmers/suppliers that have insufficient storage facilities hence reducing postharvest losses.
- Enables grain supplier to sell their grain when market conditions and prices are favourable
- Ensures quality grain to the market
- Offers quality assurance services to the grain handlers
- Enables farmers or depositors get access to cash faster against the warehouse receipt
- Eliminates issues of delayed payments to farmers
- Eliminates the need to use title deeds as security for financing grain growers

Commodity Exchange: A commodity exchange is an open and organized market place where commodities are traded. It brings together many buyers and sellers. This effectively results in the greatest concentration of trading for a given product. It creates a mechanism for price discovery (true market position price for a product at that particular point in time) to occur in an organized manner through a system of price bidding or an auction

Contract farming

In contract farming, agricultural production carried out according to an agreement between a buyer and farmers. It establishes conditions for production and marketing of beans for a specified time. Typically, farmer(s) agrees to provide agreed quantities and quality of beans according to the set quality standards. In turn, the buyer commits to purchase the product and, in some cases, to support production through, for example, the supply of farm

inputs, land preparation and the provision of technical advice. This method is common with Community based bean seed multipliers.

Advantages of contract farming

- It ensures higher production of better quality, financial support in cash and /or in kind and technical guidance to the farmers
- Assured market for farmers produce
- It reduces the risk of production, price and marketing costs.
- Contract farming can open up new markets which would otherwise be unavailable to small farmers.
- In case of agri-processing level, it ensures consistent supply of agricultural produce with quality, at right time and lesser cost.

7.6: *Support services in beans marketing*

These are activities or products required for successful execution of marketing of beans. Support services are a necessity but also come with added costs (marketing costs). Examples of marketing costs are; cleaning, grading and packaging, handling, transport, storage, finance, insurance etc.
Financing: Beans like other enterprises require financial resources at different levels of the value chain. Financial services can be accessed from financial institutions such as; banks, microfinance institutions, SACCOs, external borrowing, leasing, hire purchase

Insurance: Importance of insurance is to hedge the beans value chain actors against agriculture risks/natural disasters over which they have limited or no control. The commodity for trade should be insured at all times whether in store or being transported. Warehouses should have full insurance cover against fire, burglary and other risks.

Transport: Transport is a major component of the beans trading and a well aligned transport logistics are necessary for the efficiency in the marketing effort. Transport costs vary depending on the distance between the farmer and the market, and the mode of transport used.

Market information: Market information is facts and figures that will help farmers, and other value chain actors involved in the marketing process to make informed decisions and minimize their risks. It may include current selling price of produce, potential buyers, quality and quantities needed; the price of inputs etc.

Benefits of access to market information to the farmer include:

- Farmers' bargaining power is increased.
- Farmers enabled to access more markets.
- Farmers' decision making is improved in terms of; what to produce, how much to produce, price to charge, how to promote the product, when and where to sell the product.

Source of market information include buyers, farmers' organizations, fellow farmer, media (newspapers, magazines, TV, radio), exhibitions (shows, fairs and field days), extension workers, developmental agencies (NGOs, CBOs WFP) as well as use ICT – internet messages, short message services (SMS)

License and taxation

For proper trade, ensure that you pay the business license, local authority taxes (Cess taxes) and sales taxes.

Benefits of business license include:

- Legal Protection: A business license protects the owner against being shut down for having an illegal business.
- Credibility: A license helps reassure customers that they are dealing with a legitimate business. and not a scam
- Financial requisition. To qualify for funds, a business must possess a business license
- Business licenses are important because they provide a record of all businesses who may owe tax to the government.

Module Eight:
Beans Grain Standards

A standard is a document that provides requirements, specifications, guidelines, or characteristics that can be used consistently to ensure that products, materials, processes and services are fit for their purpose.

Standards are developed by national, regional and international standards institutions often to enforce legislation. These bodies issue specifications for commodities as well as methods of testing.

8.1: *Importance of grain standards*

- Complying with standards reduces post-harvest losses and ensures final product is of high quality.
- Farmers get better prices, traders and processors get reliable supply of grain that they can sell to their clients.
- Consumers get food that is safe and nutritious to eat.
- Facilitates both national and regional trade

8.2: *Specifications*

The dry beans standard requires that grain should be free from foreign smell, diseases (moulds), live insects and insect damage, weed seeds, other edible grains, discoloration, immature/shriveled beans, animal droppings and any other contaminants such heavy metal, chemical residues.

Dry beans shall comply with maximum limits given in table below when tested in accordance with the test methods specified therein. Dry beans shall be categorized into three grades on basis of tolerable limits established as below

Specific requirements for dry beans

S/N	Characteristic	Maximum Limit			Test Method
		Grade 1	Grade 2	Grade 3	
i.	Foreign matter, % m/m	0.5	0.75	1	ISO 605
ii.	Other edible grains, % m/m	0.1	0.2	0.5	
iii.	Pest damaged grains, % m/m	1	2	3	
iv.	Contrasting varieties, % m/m	1.5	3	5	
v.	Broken/split, % m/m	1	2	3	
vi.	Shrivelled/diseased and discoloured, % m/m	3	5	7	
vii.	Total defective grains, % m/m	3.5	6.3	9.1	
viii.	Filth, % m/m	0.1			
ix.	Moisture, % m/m	14			ISO 24557

NOTE 1 The parameter, total defective grains is not the sum total of the individual defects. It is limited to 70 % of the sum total of individual defects.
NOTE 2 Discolouration is limited to at least 25 % change in colour on both sides of the grain.

FDEAS 46:2017

Quality requirement

Current market trends and regulations require safe food to be availed to the market. Consumers of beans and its products expect to consume safe and good quality beans products. Dry beans must meet quality standards. Farmers should know that beans quality assurance involves prevention of defects from the earliest stages of cultivation. Therefore, quality of bean grain starts from proper land preparation up to when beans are sold. It is therefore, important to ensure good practices are followed at all levels.

Aflatoxins and fumonisins

Aflatoxins and fumonisins are poisons released by certain moulds. They come from soil and air and grow when grain is handled poorly. Aflatoxins are not visible by eyes. Determination of presence and level of aflatoxin is done in analytical laboratories and the tests are very expensive. Aflatoxin can cause cancer and liver damage. Consumption of high levels of aflatoxin can cause cancer and liver damage and may also lead to death. Always avoid growth of fungus at all stages of the bean value chain.

Other Contaminants (heavy metals, chemical residues)

Dry beans shall comply with limits for heavy metals specified in CODEX STAN 193 established by the Codex Alimentarius Commission. Heavy metal quantities can only be determined by testing in a laboratory using a special equipment. The contaminant limits are:

Arsenic	0.1 mg/Kg
Cadmium	0.1 mg/Kg
Lead	0.2 mg/Kg
Mercury	0.1 mg/Kg
Tin	0.1 mg/Kg

1Mg/Kg is equivalent to ppm (parts per million)

Pesticide residues:

Pesticide residue means any specified substance in food, agricultural commodities or animal feed resulting from the use of pesticides. Dry beans shall comply with those maximum pesticide residue limits established by the Codex Alimentarius Commission for this commodity

Grain Grading

Grain grading is a process of categorizing grain based on certain quality parameters. This informs decisions such as storage of the grain, uses of the grain and the purchase price

Method of Sampling

Sampling shall be done in accordance with the ISO 24333

8.3: *Hygiene*

Dry beans shall be prepared, packed, stored, transported and distributed under hygienic conditions in accordance with CAC/RCP1-1969. This implies that maximum care must be taken to ensure that Dry beans are packaged in clean containers by clean people.

The areas that the dry beans are stored should be clean and meet hygiene standards. These stores should be free from pests e.g. rats, cockroaches, weevils and other vermin. Modes of transport should also be clean.

When tested by appropriate methods of sampling and examination the dry beans shall be free from pathogenic micro-organisms, substances originating from micro-organisms, or other poisonous or deleterious substances in amount(s) which may constitute a health hazard.

Pathogenic micro-organisms are those minute living microbes that may cause diseases. They are commonly referred to as germs. They include harmful various bacteria, yeasts and moulds. A quick test for these harmful bacteria is determination of coliforms. This is done by incubating a weighed sample in specific media at specified temperature for a period of 48 hours.

8.4: *Packaging*

- Dry beans shall be packed in suitable packages which shall be clean, sound, free from insect, fungal infestation and the packaging material shall be food grade. Food grade material, made of substances which are safe and suitable for their intended use and which will not impart any toxic substances or undesirable odour or flavour to the product.
- Dry beans shall be packed in containers which will safeguard the hygienic, nutritional, technological and organoleptic qualities of the products.
- Each package shall contain dry beans of the same type and of the same grade designation.
- If dry beans are presented in bags, the bags shall also be free of pests and contaminants.
- Each package shall be securely closed and sealed.

8.5: *Labelling*

The following information shall be provided in order to comply with the requirements of EAS 38 and EAS 46.

1. The name of the product should be declared as "Dry Beans" on the bags. The variety of the beans and the grade of the dry beans should also be indicated.
2. The name, address and physical location of the producer/packer/importer should be indicated on the bags
3. The bags should have a lot/batch/code number for traceability
4. The net weight in kilograms should be shown on the package. The EAC partner states are signatories the International Labour Organization (ILO) for maximum package weight of 50 kg where human loading and offloading is involved.
5. The packages should have declaration that the "food is for human consumption"
6. The packages should also have storage instructions "Store in a cool dry place away from any contaminants".
7. The package should indicate the crop year and the packaging date.
8. The packages should have instructions of the disposal of used packages.
9. The country of origin should be indicated
10. A declaration on whether the dry beans were genetically modified or not should be included.

Module Nine:
Farming as a Business

A business is a commercial activity designed to supply goods and/ or services that are demanded by the market with a major aim of making profit. Farming as a business is built on the principles of improving farm production to increase profits and/or ensure sustainability of farm output. To make profits in a business, the cost of production must not exceed income. Farmers need to understand and update business practices as technology changes.

Farming as a business requires farmers to have entrepreneurship skills that can enable them carry out farming on a commercial scale.

9.1: *Commercial farming*

Farming as business is based on the commitment of the farmer entrepreneur to carry out farming as an occupation with a major aim of making profits. The farmer must ensure proper business planning; enterprise selection, business record keeping and as well as farm enterprise budgeting.

For commercial farming to be a viable venture, farmers must accurately know their cost of production, margins and how to maximize profits by lowering costs of production while increasing yield.

Acreage: An area of land that can be used for agricultural purposes. It is measured in acres or hectares. However, different communities use different units for measurements of land area. 1 acre = 4000 square meters, 1 hectare = 2.5 acres = 10,000 square meters
The size of a farm land- is very important for;

- Planning accurate input requirements
- Forecasting potential yield and income
- Evaluating performance (potential vs actual)

Land is the principle capital for a business enterprise therefore it must be optimally utilized

Yield: It is the output per unit area. Usually expressed as: Kilograms per hectare (Kgs/ha) but is commonly expressed as kilograms per acre (Kgs/Acre). However, in most farming communities, it is expressed it in terms of bags/acre or otherwise. Yield can only be known if one knows the land size and the weight of the harvest.
Yield potential: Maximum yield that can be achieved, assuming all factors are favorable. It is determined by seed variety as specified by scientist who developed it. E.g NABE 4 is 800 – 1000kg/acre, and NABE 12C is 1000 – 1400 kg/acre.

Yield potential should be the target at planning. Other value chain management practices will determine the deviation from the potential (100%)

Productivity

This is the yield per acre (Kgs/acre). As a commercial farmer, it is important to aim at maximum productivity as this determines the total volume of produce supplied to the market. The bigger the volume, the higher the sales and the higher the profits, assuming other factors are held constant.

Profitability

A state of yielding profit or financial gain from a business activity and depends on how the farmer manages costs of production, yield and market price. It is expressed as;

Profit = Sales – Costs of Production

Benefits of farming as a business

Farmers that engage in Farming as a business enjoy the following benefits:

i. Growth in income as a result of increased profit margins.
ii. Improved standards of living due to increased income.
iii. Diversity of consumed products purchased using increased income.
iv. Improved nutrition and household food security.
v. Increased productivity and efficiency of the family farm

9.2: *Principles of business*

i. Invest resources with a profit motive
ii. Provide products or services of value to satisfy the market in exchange for a monetary return
iii. Legal and ethical activities with a defined purpose: Businesses undertake activities that conform to the laws and standards of the society in which they operate, and they clearly state what they exist to do for customers and stakeholders, including their core business
iv. Plan, analyze the environment, and manage risk: Businesses must undertake planning to, continuously check what happens within and outside of the businesses, stay alert to uncertain events, and work to reduce potential loss.
v. Record keeping: Businesses out to keep up-to-date records for reference in planning and decision making
vi. Relationship management and continuity: Businesses should develop long-term relations with other stakeholders and continue to operate even beyond the life of the founder

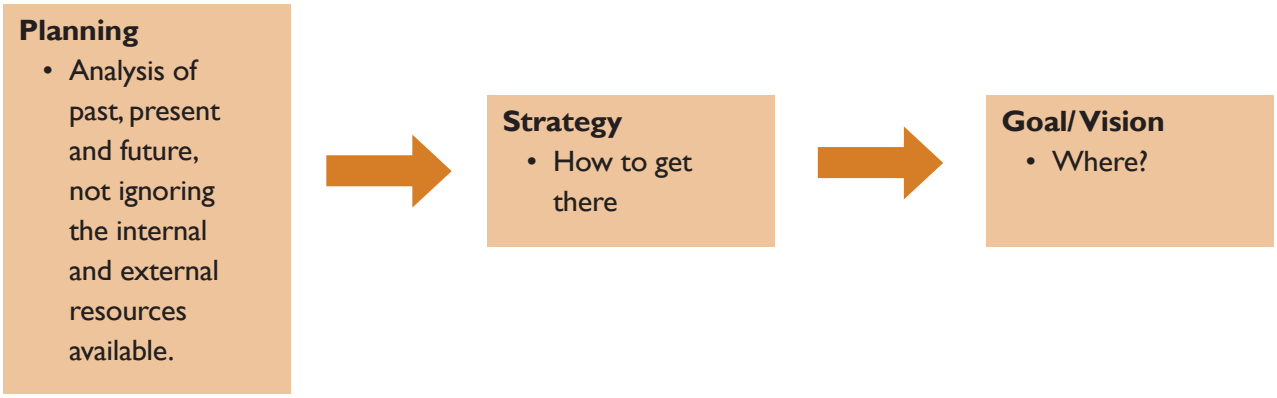
Farming as business = **Inputs** (seed, fertilizers, pesticides, herbicides, farm equipment) + **Processes** (land preparation, planting, weeding, fertilizer application, harvesting, and output marketing) = **Beans grain at a profit.**

9.3: *Farm planning and decision making*

Farm planning is an important aspect of farm business and it involves setting where the business is going **(goals)** and how to get there **(strategy)**. A successful farm is not the result of chance or luck - it is the result of good planning. **Planning** is the process of thinking through what is desired and how it will be achieved. Plans must be made before any other management activities can be performed. Assessment of past, present and expected future performance are integral to the planning process.

A poor plan is better than no plan, and not planning is planning to fail

It is important to take time to analyze past financial and production records to find out which production practices worked well which did not and identify weak spots and while planning for present consider internal (resource availability) and external (markets, economy, weather) forces on the decision-making process. There is need to emphasize joint family household planning and visioning to agree on tasks and roles.



9.4: *Risk Management*

Risk refers to the probability of occurrence of hazards and shocks that impact negatively on agricultural production, trade, markets and consumption. These could be due to weather, diseases, pests, market, and price. Risk management are the measures put in place by the farmer to avoid or minimize the negative impact of hazards and shocks. Managing risk is very important for the success of agricultural operations. While some risks can be managed through changes in farming and marketing practices, others cannot be avoided as they are natural (for example, droughts and floods). Therefore, managers of farm businesses need to focus on managing manageable risks and take measures to reduce the negative impact of those that are uncontrollable.

Bean farming like other businesses is supposed to generate income but this is not always certain. This is because businesses operate in a rapidly changing and unpredictable environment that impacts upon the outcomes of business activities. While the physical, political, economic, social, technological, and trading environment presents opportunities for business, it also offers threats that make business risky. However, this does not stop businesses from operating. Entrepreneurs have to expect, accept, and manage risks as they relate to business. An identified risk is not a threat but a management problem.

Risk and associated mitigations

Value Cain Level	Risk	Possible effects	Mitigations
Production	• Climate change/ droughts / floods • Input shortages /inaccessibility • High input costs • Poor quality inputs (counterfeits) • Pests and diseases • Ill health and labour shortages • Theft • Fire	• Total loss or reduction in beans yield	• Adoption of climate smart technologies (irrigation, green house etc) • Good business planning • Diversification of enterprises (crops and livestock) • Adoption of appropriate technologies • Staying up to date with disaster warnings • Collaboration with other farmers in acquiring funds and inputs • Crop Insurance

Market	• Price flactuation • An foreseen competition • Government intervention • Poor infrastructure	• Loss of income	• Insurance • Contract farming • Taking advantage of established market systems such as Warehouse receipt system and commodity market exchange • Collective marketing • Value addition • Proper planning

9.5: *Farm record keeping*

This is the documentation of all the farming activities. Farm records facilitate quick reference to previous activities and this enables the farmer to make quick informed decision. Record keeping also provides useful information for assessing the performance of a business at any time. It is important for farmers to emphasise record keeping to enable them carry out financial analysis and budgeting as well as making informed business decisions

Farm records include; human resource, finance, production, operation, storage, and marketing.

Types of Farm records

i. Human Resource:

These include; details of the labor force, leave calendar and profiles of the workers for the farm

ii. Financial:

They include;

- Invoices: document issued by the seller to the buyer demanding payment for the goods and services offered. It indicates the quantity, unit price, taxes and details of the payee.
- Payment vouchers: A document prepared to pay service providers after invoices have been received and verified
- Receipts: It is a document issued acknowledging payment
- Pay in books: Documents indicating money you have paid in the bank
- Cash book: contains information of the money banked, received and spent

iii. Operation:

These are records that contain all farm activities as part of farming as a business. A farmer needs to design a simple comprehensive record entry/ report which can easily be understood by all the people on the farm. Records must be easy to understand and written in such a way that they can easily be accessed for analysis.

iv. Storage:

- Stock card: It is a document in form of a card hanged on a batch of food product or grain indicating the quantity of stock you have at that time. You can also have stock card for all inputs at your farm. Keeping track of stock helps with identifying theft, guarding against wastage and unnecessary purchases and planning for production
- Stack Card: Card fixed to a bag stack used to keep a tally of the number and weight of bags of grain either added or removed from the stack.
- Goods Received Note (GRN): Document issued out to acknowledge receipt of goods
- Received Stock ledger books: Records of the stock that has been received in the store/ware house
- Outgoing stock ledger books: Records of stock that has been removed from the store

- Quality control records: Records for quality status of the stored grain.
- Fumigation records: Records indicating fumigation activities carried out on the farm

v. Marketing:

- List of customers
- Price lists
- Details of buyers and quantities desired by the market
- Product types

Characteristics of good records

- It should be simple and easy to use. If your record keeping system is complicated, it is more likely to generate mistakes.
- The financial records maintained should have appropriate level of details depending upon the type of your business. A more complex farm operation requires a more detailed system.
- A good system provides essential information in a timely manner. Make sure that your records provide essential information on a timely basis.

9.6: Resource mobilization and management

Resource mobilization are activities involved in securing required inputs and products for the given program. It involves making better of, and maximizing existing resources such as land, capital and labour (human) that determine the day to day activities and accomplishments. For any given farm activity, it is important to know the resources required and how they can be acquired.

Resource management refers to decision making process (setting goal) whereby limited resources (information, land, labour and capital) are allocated to a number of production, marketing, and financing alternatives.

Sources of finance

Savings:

Saving is an act and a habit of putting money away to use at a future date. This can be in the form of cash or material goods whose value appreciates over time. It entails discipline and sacrifice, as one postpones consumption from now to a future date. It leads to capital accumulation over time, which can be invested in profitable enterprises.

Group saving through Village SACCOS

Why saving is important

- Source of capital for farm investment
- Easy source of soft loan for the farmer
- It helps in meeting household needs like paying school fees, hospital bills and buying food.
- Money can be used to expand a business.
- Many organizations that provide loan will want to see that a farmer has the ability to save before giving him/her a loan.
- Saving can be used to meet urgent unforeseen emergencies.
- Saving allows a farmer to keep their money safe.

Loan or credit

A loan or credit is money borrowed by an individual from relatives, friends, groups, moneylenders, micro-finance institutions (MFIs) or banks in order to meet either social or economic obligations. A loan is usually paid back over a specified period of time with or without interest depending on the source and purpose. Where the loan is acquired for agricultural development, it is referred to as agricultural credit.

Pre-requisites of accessing agricultural credit

- Must be a commercial farmer
- Have production records.
- Has understanding of credit facilities.
- Willingness to pay back
- Must have a business plan

It is advisable that agricultural credit be used to finance;

- Yield -enhancing inputs and technologies e.g. inputs (fertilizers, pesticides, opening up land)
- Cost reducing inputs such as herbicides

A loan has a cost(interest) that will increase total cost, therefore your yield must increase significantly to both cover this cost and make more profits than a non-borrower.

9.7: *Formalisation of business*

Registration of small-holder farmers is through farmer groups, associations and cooperatives. Large scale farmers can register as companies and this will require a business name, physical location, Articles of Association and other relevant documents as required by the law.

9.8: *Writing a business plan*

A business plan is written description of a business' future. It is a road map that describes what you plan to do and how you plan to do it. It is an important first step for any size of business- no matter how simple a business is. It helps to get organized and make sure all necessary steps are taken and acts as a guide to help you think carefully about what you want to farm and what to achieve in future. It is one the documents always required by funders and finance institutions when applying for laoan or seeking credit.

A simple but good business plan should include:

- The goal – the direction of the business
- Plans to make your farm more efficient or more profitable.
- What crops are being planted and what acreage.
- The stages of planting to marketing of beans and what activities need to done at each of this stage.
- Yield and prices used to estimate income.
- How to market your products.
- Business expenses to be incurred.
- Additional resource needed (source of funds e.g saving, loans etc)
- How to measure success of your business
- Cashflow of the business

9.9: *Cost Benefit Anaylsis (CBA)*

During enterprise selection, profitability of the enterprise should be taken as key. One of the ways for determining the profitability is by carrying out Cost Benefit Analysis of the enterprise.

Gross Margin = Sales – Costs of production

Note: Costs of production involves total costs from production to marketing.

COST BENEFIT ANALYSIS FOR BEANS USING 3 METHODS OF FARMING				
		Scenarios		
		Traditional	Low input	High input
Inputs	Improved Seed	-	50,000	80,000
	Bean clean	-		40,000
	Foliar fertilizer	-	42,000	42,000
	Basal fertilizer			120,000
	Round up			15,000
	Pesticides (2 ltr)	-	30,000	30,000
Field Operations	1st ploughing	100,000	100,000	100,000
	2nd ploughing			80,000
	Fine harrowing		40,000	40,000
	planting	40,000	60,000	60,000
	weeding/ spraying	40,000	40,000	52,000
Harvesting	Harvesting	10,000	30,000	50,000
	Drying and Threshing	10,000	20,000	40,000
	Winnowing/Cleaning		40,000	80,000
Marketing	Transport to market		10,000	20,000
	Packaging bags	3,000	5,000	10,000
Total Production cost		**203,000**	**467,000**	**859,000**
Expected Yield		**200**	**500**	**1,000**
Production cost/KG		1,015	934	859
Total Sales (@ 2000/=per Kgs)		400,000	1,000,000	2,000,000

NB: When conducting training on CBA, the table should include all the realistic activities carried during the selected enterprise from production up to marketing.

Gross Margin = Sales – Costs of production

1. Tradition approach: Profit = 400,000 – 203,000 = Shs.197,000
2. Low in put: Profit = 1,000,000 – 467,000 = Shs. 533,000
3. High input: Profit = 2,000,000 – 859,000 = Shs. 1,141,000

Based on the calculation above, it is clear that high input method generates high margins and therefore, high income. The farmer can use the information to make investment decision.
High profitability leads to quick return on investment.

Return on investment (RoI) is the performance measure used to evaluate the efficiency on an investment

$$\text{RoI} = \frac{\text{Gain} - \text{Investment costs}}{\text{Investment Cost}} \times 100 \text{ or } \frac{\text{Benefit}}{\text{Cost}} \times 100$$

= 1. Traditional: $\frac{197{,}000 - 203{,}000}{203{,}000} \times 100 = 3\%$

2. Low input: $\frac{533{,}000 - 467{,}000}{467{,}000} \times 100 = 14\%$

3. High input: $\frac{1{,}141{,}000 - 859{,}000}{859{,}000} \times 100 = 33\ \%$

Module Ten:
Climate Change

Climate change is the shift in the average weather conditions of an area observed over a long period (30 years and above) of time. Climate Change effects are accelerated by human activities such as deforestation, burning of fossil fuels among others. This is mostly evidenced by the overall trend in raising maximum and falling minimum global temperatures. Climate change may affect the beans value chain in various ways depending on the agro ecological zones. It reduces the prediction predictability of seasonal weather patterns and increases the frequency and intensity of severe weather events e.g. floods, drought and hailstorms.

10.1: *Climate Change risks*

Climate Change risks include negative impacts on, crop production, and farmers' livelihoods mainly resulting from prolonged dry spells, erratic and excessive rains, storms and lightening. Some regions experience floods while others have prolonged dry spell, pest and disease build up and water shortages which may result into poor quality and low beans yields. Climate variation, also contributes to the destruction of infrastructure e.g. road network and market. All these factors threaten the overall agricultural production value chain.

10.2: *Climate Change Impacts on:*

Crop production

Effect of drought on beans production

- Unpredictable rainfall patterns affect planning for field activities such as sowing, weeding, applying inputs especially fertilizers and harvesting, this results into crop failure hence low yields and poor crop quality leading to food insecurity
- Prolonged dry spell causes water shortages resulting in low yields
- Prolonged dry spell cause crop pest outbreaks
- Floods destroy bean gardens, cause water logging, rotting and increase diseases build up.
- Excessive rains affect beans especially at flowering
- In mountainous areas, excessive rain may cause landslide leading to destruction of bean gardens, homes and infrastructure

Socio-economics

- Land degradation due to cutting down of trees, bush burning, silting of rivers, destruction of river banks
- Decreased crop yield
- Decreased income
- Increased production costs
- Food insecurity
- Increased poverty levels
- Increased migration of the communities e.g. from flooded/landslide areas.
- Labour shortage due to migration
- Destruction of the infrastructures (road & markets)
- Increase in human diseases e.g. Cholera and Malaria
- Water shortage.

10.3: *Adaptation and Mitigation of Climate Change effects on Beans value chain*

There are two approaches to responding to climate change impacts. These include climate change adaptation and mitigation measures.

Climate Change adaptation refers to the making of anticipatory or reactive adjustments to prepare for expected climate variability and changing average climate conditions, to moderate harm and exploit beneficial opportunities in agriculture such as climate smart agricultural practices.

Climate change mitigation refers to efforts taken to reduce or prevent emission of Green House Gases that warm the planet. These include planting trees, use of environment friendly technologies, -renewable energies (such as solar, biogas etc.)

10.4: *Why Adapt to Climate Change in the Beans Value Chain?*

There is a need to address effects of Climate Change on production, storage, processing and packaging of agricultural products such as beans.

10.5: *Climate Smart Agriculture Practices on the farm*

Practice	Why the practice
1. Soil testing	To determine soil fertility levels so that in case of certain mineral deficiencies they can be added back.
2.Pay attention to seasonal weather forecast	so that expected weather patterns are known and are followed by farmers; because lack of early warning information perpetuates untimely planting and harvesting leading to increased post-harvest losses
3. Practice minimum tillage e.g. basin conservation farming	Reduces the cost of production, improves soil texture, conserve soil moisture especially in dry areas
4. Plant certified, early maturing and high yielding beans varieties better suited to weather conditions	Certified for quality assurance, early maturing (60days) & high yielding to withstand drought & disease.
5. Safely use recommended agro-chemicals to control weeds, pests, and diseases	Safety is emphasized to avoid harm on farmer, the plant and the consumer. Apply agro-chemicals at recommended rates. Buy from registered/Licensed agro-input dealers and follow the crop cycle to manage diseases & pests such that you realize optimum yield.
6. Practice crop rotation	It is prudent to rotate (beans –cereals -root crops then back to beans) to break pests and diseases buildup, improve the soil texture

Practice	Why the practice
7. Harvest water for agricultural production	To irrigate bean crops during the dry spell
8.Plant boundary trees and hedge row	To have wind breaks, control soil erosion, fix nitrogen, improve soil texture & fertility
9. Harvest of beans during cool weather	To avoid losses in yield due to shuttering. Thresh and use the residues (Stover) for mulching.

While most of the Climate Change adaptation strategies such as conservation agriculture focus on effects of climate change on production, there is little consideration on appropriate climate smart interventions to cater for post-harvest value chain issues such as storage, processing and packaging. Below are the recommended climate smart agricultural practices for on farm, postharvest handling, storage and marketing.

10.6: *Climate smart practices for post-harvest handling and storage*

Practice	Why the practice
10.Threshing	Thresh on a raised platform or on tarpaulins to maintain good bean quality and minimize losses
11.Dry beans using tarpaulins, concrete floors and mats	To maintain good bean quality, minimize losses and aflatoxin contamination. Ensure that beans are dried to 13%mc,
12. Dry beans using recommended driers e.g. solar driers.	To maintain good bean quality, minimize losses and aflatoxin contamination. Beans are dried to 13%mc
13. Dry bean to the recommended moisture content (13%) before storage	To maintain good bean quality, minimize losses and aflatoxin contamination.
14. Store beans in dry safe places and on pallets, and air tight containers (hermetic storage)	To maintain good bean quality, minimize losses and aflatoxin contamination.

10.7: *Climate smart practices for marketing*

Practice	Why the practice
Grade and package beans	To obtain better prices
Sell off fresh dried beans when they are of good quality, good mc and well sorted	To minimize losses, attract competitive prices and builds good farmer's reputation for quality.

10.8: *Mitigation practices on the farm*

Practice	Why the practice
Agroforestry (fruit trees, shade trees)	Trees are carbon sinks which reduces on the accumulation of Green House Gases in the atmosphere. Fruit trees provide food while shade trees fix nitrogen in the soil.
Use of renewable energies	To prevent emission of Greenhouse gases

Annexes

Annex 1: Trends in dry bean production and export volumes in tones for Uganda between 2010 and 2016

Year	2010	2011	2012	2013	2014	2015	2016
Production (Ton)	949,000	915,445	869,607	941,182	1,011,435	1,079,943	1,104,770
Export volume (Ton)	23,309	33,169	29,309	32,616	39,482	157,152	290,662

Source: Production statistics: FAO stat, 2018; Export Volume: International Trade Centre (ITC), 2018

Annex 2: Newly released biofortified bean varieties by NARO

Annex 3: National bean crop (Phaseolus vulgaris L) variety list for Uganda

Variety name/code	Year of release	Owners	Maintainer and seed source	Optimal production altitude range	Duration to maturity (days)	Grain yield (T/Ha)	Special attributes
Banja 2	1968	NARO	NARO	1000 - 1600	80	1.5	Susceptible to anthracnose, Early maturity, unstable yields
K20	1970	NARO	NARO	1000 - 1600	95	2.0	Resistant to black root, BCMV, Large red mottled seed
K131	1994	NARO	NARO	1000 - 1600	90	3.0	Resistant to BCMV, BR, and anthracnose, good taste, high yield potential
K132	1994	NARO	NARO	1000 - 1600	80	2.0	Resistant to RR, susceptible to anthracnose and root rot, large red mottled seed
NABE 1	1995	NARO	NARO	1000 - 1600	80	1.5-20	Resistant to MSV, Br, and anthracnose, Tolerant to low soil nitrogen, phosphorous as well as high manganese soil conditions
NABE 2	1995	NARO	NARO	1000 - 1600	90	1.5-2.5	Resistant to BCMV, Br and anthracnose, black seeded
NABE 3	1996	NARO	NARO	1000 - 1600	88	1.5-2.5	Resistant to BCMV, Br and anthracnose, red seeded
NABE 4	1999	NARO	NARO	1000 - 1600	80-85	1.5-2.5	Resistant to BCMV, Br and anthracnose, red seeded, good for export
NABE 5	1999	NARO	NARO	1000 - 1600	80-82	1.5-2	Susceptible to anthracnose, seed is cream with light red irregular bands, shows color reversal, lodges under heavy rainfall conditions, very palatable, good for export
NABE 6	1999	NARO	NARO	1000 - 1600	85-90	1.5-2	Resistant to BR, small white seeds(navy), good canning quality for export
NABE 7	1999	NARO	NARO	1000 - 1600	90-95	1.5-2	Tolerant to anthracnose, root rot, CBB rust and BCMV

Variety name/code	Year of release	Owners	Maintainer and seed source	Optimal production altitude range	Duration to maturity (days)	Grain yield (T/Ha)	Special attributes
NABE 7C*	1999	NARO	NARO	> 1600	80-115	2.5-4	Tolerant to CBB, red/ maroon seeds
NABE 8C*	1999	NARO	NARO	> 1600	80-110	2.5-4	Tolerant to CBB, large red seeds, leaves suitable for consumption
NABE 9C*	1999	NARO	NARO	> 1600	90-115	1.5-3	Susceptible to anthracnose and angular leaf spot, white and black speckled seed
NABE 10C*	1999	NARO	NARO	> 1600	85-100	2.5-3.5	Resistant to anthracnose but susceptible to rust, red small seeds, leaves suitable for consumption
NABE 11 C*	2003	NARO	NARO	> 1600	90-110	2.3-3.0	Tolerant to anthracnose, root rot, CBB, rust and BCMV
**Varieties with a letter 'c' are climbing bean (type IV) which require staking*							
NABE 12 C*	2005	NARO	NARO	> 1600	90-110	2.3-3.0	Tolerant to anthracnose, root rot, CBB, rust and BCMV
NABE 26 C	2012	NARO	NARO	>1600			High yielding, tasty, tolerant to root rot, ALS, anthracnose
NABE 27 C	2012	NARO	NARO	>1600			High yielding, tasty, tolerant to root rot, ALS, anthracnose
NABE 28 C	2012	NARO	NARO	>1600			High yielding, tasty, tolerant to root rot, ALS, anthracnose
NABE 29 C	2012	NARO	NARO	>1600			High yielding, tasty, tolerant to root rot, ALS, anthracnose
RWR 2075	2006	NARO	NARO	1000 - 1600	90-95	1.5-2.0	Tolerant to anthracnose, root rot, CBB rust and BCMV
RWR 1946	2006	NARO	NARO	1000 - 1600	90-95	1.5-2.0	Tolerant to anthracnose, root rot, CBB rust and BCMV
NABE 15	2010	NARO	NARO	1000 - 1600	70	1.8-2.0	Resistant to anthracnose, red seed color

Variety name/code	Year of release	Owners	Maintainer and seed source	Optimal production altitude range	Duration to maturity (days)	Grain yield (T/Ha)	Special attributes
NABE 16	2010	NARO	NARO	1000 - 1600	60 - 70	1.8-2.0	Marketable, suitable for all regions, tasty and swells when cooked
NABE 17	2012	NARO	NARO	1000 - 1600	58 - 78	2.0-2.5	Highly marketable and tasty
NABE 18	2012	NARO	NARO	1000- 1600	65 - 75	2.0-2.5	Mostly suitable for Northern Uganda, very tasty
NABE 19	2012	NARO	NARO	1000- 1600	60 - 70	2.0-2.5	Highly marketable, tasty and cooks well
NABE 20	2012	NARO	NARO	1000- 1600	60 - 70	1.6-2.0	Marketable, tasty and cooks well
NABE 21	2012	NARO	NARO	1000- 1600	60 - 70	1.5-2.0	Marketable, tasty and cooks well
NABE 22	2012	NARO	NARO	1000- 1600	60 - 70	1.5-2.0	Mostly suitable for Northern Uganda and cooks well

Annex 4: Criteria for determining seed quality

Particulars	Improvedseed	Certified seed
Purity (by weight)	90%	99%
Germination(minimum)	80%	85%
Disease level (at final inspection)	Halo blight, Common bacterial blight, Anthracnose: signs on leaves only Bean common mosaic virus: none	None
Moisture	13%	13%
Varietal purity	N.A.	98%
Off types (maximum)	10/10,000	10/10,000

Annex 5: Definitions

Goods – Are tangible things or items that are consumable example food, feeds, tools, agro-chemicals

Services – Are activities people perform such as transportation, cleaning, shelling, storage etc

Value Chain - is a set of linked activities that work to add value to a product. It consists of actors and actions that improve a product while linking commodity producers to processors and markets

Supply – refers to the total amount of goods or services that are produced

Demand- Refers to the total amount that consumers will consume

Pest- is any unwanted organism (animal, plant, insect, bacteria, virus, fungus)

Annex 6: Examples of types of records a farm business can keep

A. Farm planning schedule:

These are details of the planned farm activities and the tentative dates for carrying them out. The planning schedule should be among the first records a farm manager produces.

An example of a farm planning activity schedule for starting bean production

Activity	Timeframe
• Buying tools and equipment	1st Month
• Preparing land including clearing and ploughing	
• Marking the field	
• Digging planting holes	
• Buying bean seeds and staking materials	
• Gap filling	2nd- 4th Month
•Routine management (weeding, etc.)	
• Looking for markets	
• Harvesting	

B. Production records:

These include input records, labor records and records of all other inputs that are used in the production of beans.

(i) Input records

An example of an input record for starting a bean farm

Input	Date of purchase	Expected useful life	Unit cost	Quantity	Total cost
Land					
Implements (hoes, pangas, etc.)					
Seed					
Fertilizers					
Pesticides					
Gumboots (pairs)					
Sisal rolls for marking planting holes					
Pegs for marking planting holes.					
Total expenditure on inputs					

(ii) Labour records:

This type of record details the labour used for the various tasks on the farm.

An example of labour records for a bean business

Input	Timing (e.g. March)	Duration of the activity (e.g. days)	Amount of labour (e.g. person-hours)	Total Cost of the labour (UGX)
Land clearing				
Ploughing and harrowing				
Field marking				
Digging holes				
Planting				
Weeding				
Thinning				
Harvesting				
Transport				
Marketing				

C. Marketing records :

(i)Sales record:

The sales record is used to capture information on the sales made. It should include the volumes of the produce sold, the date of sale, the average selling price, the type of buyers and mode payment.

Table 4: An example of sales record for a bean farm

Date of sale	Type of product	Quantity sold	Average. Price per unit sold	Type of buyer, e.g. bicycle traders, wholesaler, etc	Mode of payment, e.g. cash, cheque, credit etc.

Important financial statements

(i) Expected start up Budget:

This helps in projecting the required capital for a business. It can include the capital required for land hire, production, costs of fixed assets and other variable costs required to start your bean business. Can be developed at the start of the business or when planning for some activities. It therefore gives resource requirements for the business.

Format below for preparing a startup budget.

Required resource	Amount planned	Unit cost	Total cost
Land			
Labor			
Equipment			
Planting materials			
.....			

(ii) Cash flow

Simply the cash flow is an educated guess about when and how much money will come into and go out of your business. The cash flow and sales forecast will enable you to decide what you can afford, when you can afford it and how you will keep your business operating on a month-to-month basis. As part of the business plan, a cash flow and sales projection will give you a much better idea of how much capital investment your business idea needs.

Cash Inflows	Amount
Sell of bean grains	
Sell of bean leaves	
Sell of fresh beans	
Total Cash Inflows	
Cash outflows	
Payment for land	
Purchase of equipment	
Labor expenses	
Purchase of stationery	
Total cash outflows	

(iii) Balance Sheet

The balance sheet describes the assets, liabilities, and equity of a business at a particular point in time. It is a widely used accounting statement that indicates the economic resources of your organization and the claim on those resources by creditors. It shows the assets of the business and the debts/liabilities of the business

Assets	UGX
Cash	8,000,000
Oxen	1,850,000
Ox ploughs	850,000
Stores	850,000
Total Assets	5,550,000
Liabilities	
Bank Loan	1,500,000
Money from money lender	400,000
Money from a friend	400,000
Total Liabilities	2,800,000
Net assets/Owners Equity	8,250,000

Annex 7: Bean Cropping calendar for Uganda

Northern	First Season (Mid March - Mid July)						Second Season (Mid July-Mid November)					
Farm Activities	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Ploughing												
Planting												
1st Weeding												
2nd Weeding												
Harvesting												
Post-harvest activities & Bulking												
Eastern	**First Season (Mid March - Mid July)**						**Second Season (Mid July-Mid November)**					
Ploughing												
Planting												
1st Weeding												
2nd Weeding												
Harvesting												
Post-harvest activities & Bulking												
South Western	**First Season (Mid March - Mid July)**						**Second Season (Mid July-Mid November)**					
Ploughing												
Planting												
1st Weeding												
2nd Weeding												
Harvesting												
Post-harvest activities & Bulking												
Central	**First Season (Mid March - Mid July)**						**Second Season (Mid July-Mid November)**					
Ploughing												
Planting												
1st Weeding												
2nd Weeding												
Harvesting												
Post-harvest activities & Bulking												

Source: Kilimo Trust, 2016

Ploughing Planting 1st & 2nd Weeding Harvesting PH activities & bulking

Notes:

- The first season is commonly dominated by planting in March up to Mid-April and harvesting in June-July
- The second season shows variations in the planting and harvesting period depending on the region.
- The Southwestern region plants late for the second season i.e . November compared to other regions.
- There is a trading opportunity for Eastern, Central and North ern regions to supply beans in Southwestern in the month of December before the latter harvest

Annex 8: Climate Change Beans Poster

BEANS ARE MONEY:
PROTECT YOURSELF FROM CLIMATE CHANGE

BEST PRACTICES IN YOUR GARDEN

Test soil before planting

Pay attention to seasonal weather forecasts

Practice minimum ploughing

Plant certified, early maturing drought and disease tolerant beans varieties

Safely use recommended agro-chemicals to control weeds, pests and diseases

Practice crop rotation

Apply mulch to retain soil moisture

Always buy sealed bags of recommended fertilizer

Irrigate your garden

Practice hedge rows to control soil erosion

Practice basin conservation farming to retain soil moisture

Do not burn bushes and crop residues to avoid killing useful soil organisms

Practice terracing and hedge rows to control soil erosion

Practice agro-forestry

Post-Harvest Handling and storage

Harvest beans during cool weather to avoid shattering

Dry beans on tarpaulins

Dry beans using recommended driers

Store beans in dry safe places and on pallets

FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

For further information contact: Ministry of Agriculture, Animal Industry and Fisheries, P.O.Box 34518, Kampala, Uganda; www.agriculture.go.ug; Tel: +256 (0) 414 531 411

Annex 9: References and Resource Guides

Stanley Nkalubo & Gabriel Luyima, 2012. *Dry Bean Production Manual, National Crops Resources Research Institute*

Sasakawa Africa Association. Good Agronomic Practices Guide

Sasakawa Africa Association. Crop Production Handbook.

A Guide to Producing Quality Iron Rich Beans, USAID- Harvest Plus

Iron Rich Beans Cropping Calendar. Harvest Plus

CIAT 2010. *Beans Disease and Pest Identification and Management*

CIAT, *Business Skills for Small-Scale Seed Producers Handbook*

CIAT, *Producing Bean Seed, Handbook for Small-scale Seed Producers*

Kayuki C. Kaizzi et al, 2012. *Optimizing Smallholder Returns to Fertilizer Use: Beans, Soybeans and Groundnuts*

NARO 2013. *New Early Maturing Bush Beans for Uganda and Growing Improved Climbing Bean Varieties for Higher Productivity.*

Crop Production Training Manual for Agriculture Extension Workers, 2012 USAID /South Sudan

Dry Beans- Best Practices for Improved Nutrition and Income. Brochures/Posters

EAS 2013. *Dry Bean Specifications*

Understanding the Warehouse and Warehousing Standard for bagged Storage of Cereals and Pulses, 2017

Kilimo Trust, 2015. *Trainers Manual- Value Chain Development for Food Trade in Africa*

Kyamanywa S. et al, 2013. *A manual for Pesticide Dealers and Applicators on Safe Handling and Application of Pesticides*

Gatsby 2014: *Uganda Bean Production (NARO)*

DIMAT Project 2012. *Value Chain Analysis of Beans Sub-sector in Uganda*

Precooked Beans: For Improved Health, Food and Nutrition Security and Wealth, NARO

CIAT. *Enabling Rural Innovation in Africa. A Market Facilitator's Guide to Participatory Agro-enterprise Development*

USAID/APEP. *Farming as a Business and Production Credit Training Guide*

MINISTRY OF AGRICULTURE, ANIMAL INDUSTRY AND FISHERIES
P.O Box 102, Entebbe Plot 16-18, Lugard Avenue, Entebbe-Uganda
Email: www.agriculture.go.ug
Website: info@agriculture.go.ug
Tel: +256 41 4320004