

LEAD FARMER GUIDELINES FOR SOUTHERN AFRICA¹

Section 1 (Welcome to N2Africa):

The N2Africa project is here to help farmers improve their incomes and household nutrition with better production of grain legumes: soybean, common bean, cowpea and groundnuts (Malawi: soya, nyemba, khobwe, mtedza; Zimbabwe: soya bhinzi, shuga bhinzi, nyemba, nzungu).

These crops are of special interest because by growing them, you can also improve the fertility of your soils, especially “nitrogen” fertility. “Nitrogen” is what farmers pay a lot of money to get when they buy fertilizers such as ammonium nitrate. Farmers who grow legume crops with the improved methods N2Africa helps them to learn will not have to spend so much money on nitrogen fertilizers.

For farmers who do not have money or access to fertilizers, and are concerned mainly about having enough food to eat, legumes are very interesting in that they can be grown in ways which do not take a lot of additional labor, or compete with maize. Additionally, if the family has even a small amount of grain legumes to eat, their nutritional value is so high that the family can eat less nsima/sadza when combined with legumes than they need when they have no legumes. And legumes can to a large extent replace nyama, which is very expensive.

In addition to helping farmers to grow these crops, N2Africa provides information and training on how to add value to the grain harvested so that they can make more money from these crops and better feed their families.

N2Africa works, via partner organizations, in eight countries in Africa; here in southern Africa, the project works in Mozambique and Zimbabwe, in addition to Malawi. The project began with the 2010/2011 growing season in southern Africa, and will continue to the end of October 2013.

Nitrogen on the Farm and Biological Nitrogen Fixation

All crops need nitrogen, along with water, sunlight and other elements, to grow and produce a good harvest. A sign that a plant isn't getting enough nitrogen is when the lower leaves turn yellow, especially in young plants. If they continue to be deprived of nitrogen, plants will not grow tall, and the yields will be low. Plants get nitrogen from several sources: from the broken-down remains of crops previously grown on soil (or gathered from other sources and incorporated into the soil). From animals in the form of manure (and a combination of manure and crop remains called “compost”). From fertilizers such as 23:21:0+4S or Compound D . And from legume crops.

Legume crops, when grown correctly, help to add “nitrogen” to your soil because of something called “biological nitrogen fixation” – we call it BNF. What happens in BNF is that “nitrogen” in the air is captured by very small organisms which, under the right conditions, will live in the roots of legume. There, these organisms, called rhizobium, are able to take the nitrogen in the air, and convert it into a “fertilizer” form which they feed to the plants.

¹ Based upon the booklet “Biological Nitrogen Fixation and Grain Legume Enterprise: Guidelines for N2Africa Lead Farmers” by Ajeigbe, H.A., Dashiell, K. and Woomer, P.L. 2010 and published by the Tropical Soil Biology Institute of the International Centre for Tropical Agriculture. Nairobi. 21 p. Additional information sourced from S. David. 1998. Producing bean seed: handbooks for small-scale bean producers. Handbook 1. Network on Bean Research in Africa, Occasional Publications Series, No. 29. CIAT, Kampala, Uganda.

Because crops remove nitrogen, no matter what is the source, from the soil in order to grow and be harvested, additional nitrogen must be added to the soil in one form or another every growing season. By growing legumes under the proper conditions, farmers are able to renew soil nitrogen with each legume crop grown.

Farmer groups and the Role of the Lead Farmer: *Farmers are the best teachers of other farmers!*

N2Africa works with farmer groups, each of which has a Lead Farmer selected by the community. Lead Farmers organize Farmer Groups to test N2Africa technologies based on topics of interest to the farmers. Farmer members provide feedback on the new technologies (Are they working? Which ones? Why/why not?) to the Lead Farmer, who in turn informs the extension agent and project team, as well as the other farmers.

Role of the farmer groups:

- Adopt the program into their activities
- Report on progress and issues/problems that affect their satisfaction or dissatisfaction with project technologies
- Get other farmers interested in the technologies and in trying them
- Invite extension workers to attend meetings and see progress of the trials
- Arrange “see and learn” events around their trials to which all farmers are invited (not just those in group)
- At the end of the season, to decide which technologies were good and are to be adopted for the following cropping season
- Members of a farmer group should live and have their farms close to each other (not more than 10 minute walk) so that they can visit each other easily

Responsibilities of the Lead Farmer

- Assist with project planning, together with the other farmers
- Help the extension agent to train the farmer group as well as other farmers
- Host evaluations of the test plots and demonstrations (during and at the end of the cropping season)
- Help to get information about the technologies out to all members of the community
- Hold meetings with other farmers and present their concerns to the group as well as extension agents
- Serve as a linkage between the community members and the extension agent

Lead Farmers will be trained in project technologies, so that they can train other farmers in turn. Lead Farmers will organize group discussions, with or without the assistance of the extension agent, on the new technologies:

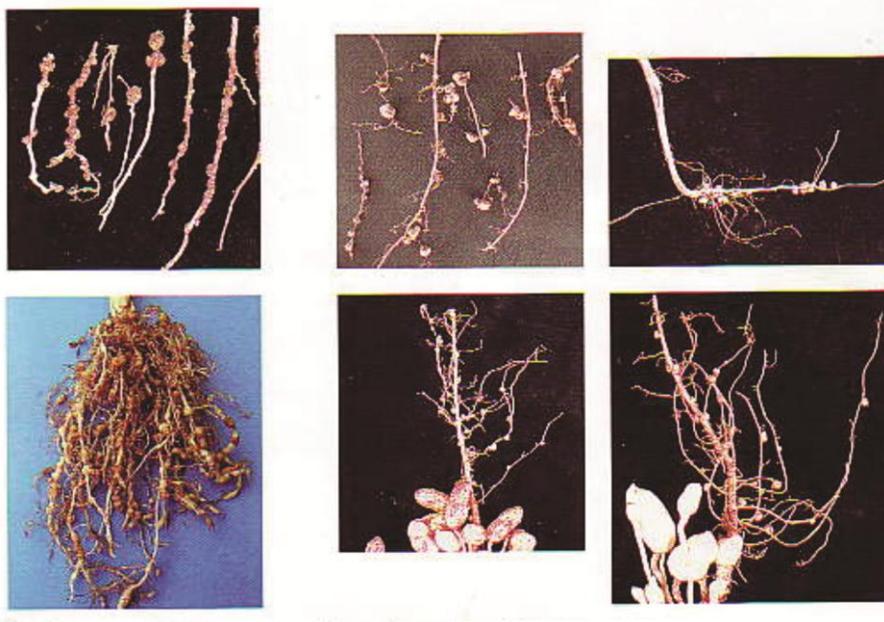
- Which work/do not work and why?
- How can they be modified so that they are better suited to local conditions?
- What other skills do the farmers need in order to get more from the legume crops and technologies (e.g. farming as a business, post-harvest handling and storage)?

Lead Farmers should visit other members of the group to understand their needs and continue to share and develop their skills and knowledge.

Root Nodules and Rhizobium-Legume Relationship

As mentioned above, legumes can form relationships in their roots with rhizobium, the very small organisms which capture and “fix” nitrogen from the air and feed it to the plant. The rhizobium themselves are too small to be seen, however once they have settled in the plant roots and start to grow, they form visible “root nodules” which can be round, elongated or even branched. Large nodules with red interiors are best as they “fix” more nitrogen. Do not confuse legume nodules with the nematodes you see on tobacco and tomato!

Photo 1: Comparison of roots infected with nematodes with those containing rhizobium nodules (from Coyne et al, 2007).



LEFT SIDE: Photos of **nematodes** in roots.

RIGHT SIDE: Photos of **nodules** in soybean (top left), bean (top right) and groundnut (bottom two photos).

Nodules form *only* with legumes, and if they are alive and fixing nitrogen, they should be pink to deep red on the inside. Nodules can form which fix very little to no nitrogen; they are usually smaller and when cut open are green or white inside. So plants with more numerous and larger nodules which are pink inside will get more nitrogen.

The development and activity of nodules (which together make up BNF) is greater when there is less nitrogen in the soil; plants are “lazy” and it takes more work for them to get nitrogen from BNF, so if ready-made sources of nitrogen are provided by the soil, they will chose these first. Where soil nitrogen is low, and conditions are right, large amounts of nitrogen can be produced by BNF with legumes. Leaving or returning crop residues to the field after harvest adds the most nitrogen to the soil.

N2Africa Target Grain Legumes and their Management (FOR REFERENCE PURPOSES ONLY)

Common bean (Malawi: nyemba/Zimbabwe: shuga bhinzi)

There are many different varieties of bush beans, and the crop is grown in a wide range of environments. Beans do not do well, however, under hot, humid conditions found at some lower elevations. Beans need moderate rainfall during the growing period followed by a dry period for ripening. Soils which are extremely acid are not good for beans. Beans are attacked by a wide range of pests and diseases; they are often grown in intercrops with maize or other cereals, which may help to reduce pest/disease attacks. When grown as a sole crop 70-80 kg of seed/ha is needed for varieties like Kholopethe. Average bean yields in Africa are 530 kg/ha. Beans originated in America, and there are not a lot of rhizobium species which will form nodules with beans in most African soils.

Cowpea (Malawi: Khobwe/Zimbabwe: Nyemba)

Cowpea originated in Africa, and tolerates heat, drought and acid soils but not water logging. Cowpea is attacked by many insects, and some (e.g. aphids – Nyinda/Nhata) are especially dangerous as they can infect cowpea with viruses which will seriously reduce crop growth and yields. When grown as a monocrop, 25-35 kg cowpea seed/ha is used. Average cowpea yields in Africa are 340 kg/ha. Cowpea leaves are often used in relish, and the crop residues make a good feed for livestock. There are many species of rhizobium in African soils which will form nodules with cowpea, and the nodules formed can be round or odd shaped.

Soybean (Soya)

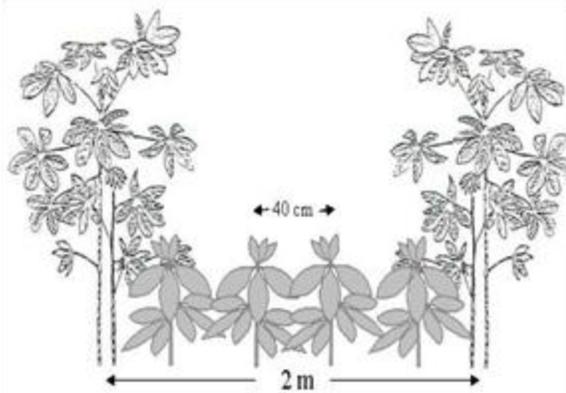
Soybeans are noted for their hairy leaves and pods; the crop can be grown from lowland to upland tropics and tolerates moderately acid soils as well as short-term drought. It performs poorly under cool and shaded conditions, so does not do well when planted as intercrop under tall, leafy crops planted at dense spacing. Soybeans are attacked by a brown fungal disease (“rust”) which can seriously reduce yields, so it is highly recommended to grow soybeans in rotation with other crops. There are some varieties available in southern Africa with some tolerance to rust. When grown as a monocrop from 50 to 80 kg of seed/ha are used, depending on seed size and planting distance. Current average yields in Africa are 830 kg/ha. Soybean crop residues can be used for livestock feed. Most soybean varieties need to be sown with specific rhizobium inoculants for good BNF, however there are some new varieties which will form effective nodules without inoculants. In soybean, nodules that are close to the top of the root system (discuss later) are best for BNF but nodules lower down in the roots also contribute to BNF.

Groundnut (Malawi: Mtedza/Zimbabwe: Nzungu)

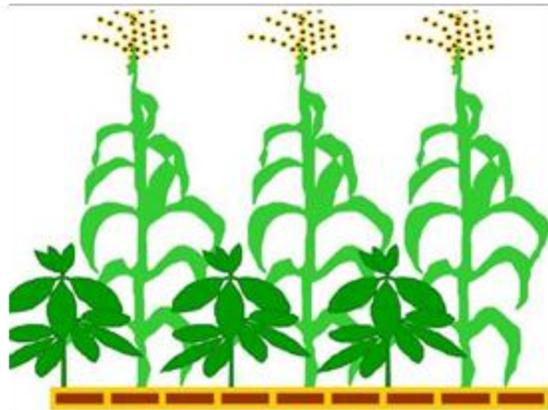
Groundnut pods are formed underground, in the soil, hence the name. For best growth and production, groundnut needs moderate (about 600 mm) rainfall during growth followed by a dry period for ripening. Groundnut does best on a sandy loam soil and can tolerate acidic soils, but may need calcium for good pod development. The crop is susceptible to a viral disease called “rosette” which is spread to groundnut plants by aphids (Nyinda/Nhata). There are some new varieties available which are resistant to this disease. About 50 kg of seed/ha are needed for monocropped groundnut and average yields in Africa are 950 kg/ha. Groundnut easily forms nodules in African soils and have high rates of BNF. The nodules can be harder to see than with other legume crops since they are very small, flat and formed throughout the root system.

Management of grain legumes

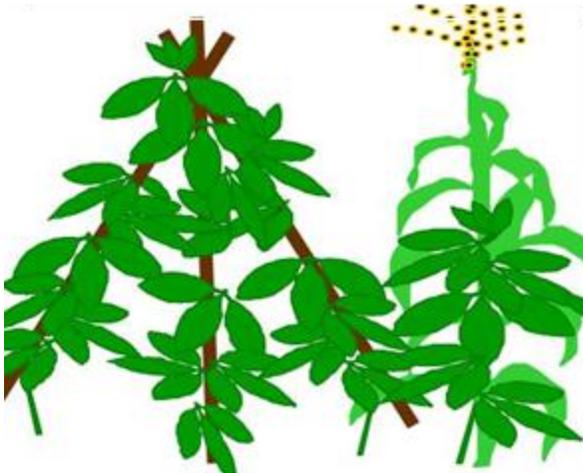
Grain legumes can be grown in a number of different ways. In **intercropping**, the legumes are grown in with other crops, often maize; it is common to grow one row of beans or cowpeas in alternation with one row of maize. The legume yields tend to be low with this arrangement because they are heavily shaded by the cereal, but at least some grain is harvested and very little additional (to maize production) labor is required. An intercropping arrangement which shades the legume crop less is to sow the legume crop into a field of newly planted cassava cuttings. For short season legume crops, such as cowpea, the legume is sown into the maize field a few weeks before maize harvest; since the maize is drying down, it doesn't shade the cowpea as much. The timing of the legume sowing has to be planned carefully if the crop is complete growth before the dry season begins.



Cassava may also be intercropped with grain legumes (above). Climbing beans require support from either stakes or companion crops (below).



Intercropping arrangements of maize and grain legumes with alternate (above) and staggered rows (below).



Climbing bean varieties exist and can have higher yields than bush beans, however they are only practical in environments with a longer rainy season, as they produce lower amounts of grains but over a longer period of time. They require staking which is expensive, so an alternative is to intercrop climbing beans with maize.

Use of fertilizer with grain legumes: recommendations

Acidic soils will reduce plant growth and BNF, especially for soybean and bean; application of lime can correct the problem. Legumes need phosphorous (P) in the soil for good BNF and growth. Signs of P deficiency include lower leaves turning purple and stunted plant growth.

- Lime: good for correcting soil acidity, also adds other nutrients (e.g. calcium, important for groundnuts)
- TSP: high concentration of P and best source but expensive
- SSP - need to apply much higher amounts than with TSP (250 Kg/Ha)
- Ground rock P: lower concentration of P but remains available in soil for more than one season; problem is very bulky therefore expensive to transport

Using Rhizobium Inoculants

For most varieties of soybean, and many beans, there are not enough effective rhizobia already in the soil for effective BNF to occur. It is therefore best to use rhizobia “inoculants” with these varieties.

Inoculants are relatively easy to use, but must be protected from high temperatures. Some general rules for good use of inoculants are as follows:

- Use the correct inoculants for each legume crop: soybean inoculants for soybean, bean inoculants for bean.
- Protect the inoculants from sun and heat; ideal storage temperature is below 26 C and above 4 C
- Store inoculants in tightly closed bags; use a clean spoon to remove it from bag
- Use a “sticker” (something that helps the inoculants to stick onto the seed); smaller seeds need more sticker
- Use the right amount of inoculants
- Inoculate seeds just before planting; do not leave the inoculated seeds in the sun or the rhizobia will be destroyed
- Plant inoculated seed into **moist** soils so that seeds will germinate while the inoculants are still good (they will be destroyed if soil is dry at or shortly after planting)

In southern Africa, it is most common to use a sugar-water mixture to inoculate seed:

When planting rains fall, a Lead Farmer is supposed to call all his/her club members for a demonstration on soybean inoculation and planting. The Lead Farmer should gather all the required ingredients and equipment before the day of inoculation, this include the seed, sugar, a clean and empty Fanta bottle, inoculants and water. The Lead Farmer will demonstrate how to use Inoculum on soybean seed as follows:

1. Put the club’s seed (about 20 kg) together into a plastic pail.
2. Measure sugar into a matchbox inner box
3. Measure 200 ml water or use a Fanta bottle that is not full (just above three-quarter full).
4. Mix the sugar with the water until it is well mixed.
5. Add the inoculants (Malawi-80 g, Zimbabwe – 200 g) into the water-sugar mixture and mix well again.

6. Mix with the seed in the plastic pail. Make sure that all the seed is coated with the inoculants mixture.
7. Spread the inoculated seed on a tarpaulin under a shade (a tree) for about 30 minutes to dry.
8. Share the seed again.
9. The Lead Farmer should demonstrate to the group members how to plant the soybean at the demonstration site.
10. Let each group member see and try the procedure. This will ensure a hands-on training.
11. Then each group member should take his/her seed and plant in her demonstration plot the same day. Do not let the inoculated seed stay for over 24 hours.
12. At the same time plant a small area (5-10 rows) without inoculant so you can compare the growth and yield with and without inoculant.

Note that sugar helps the inoculums to stick to the seed.



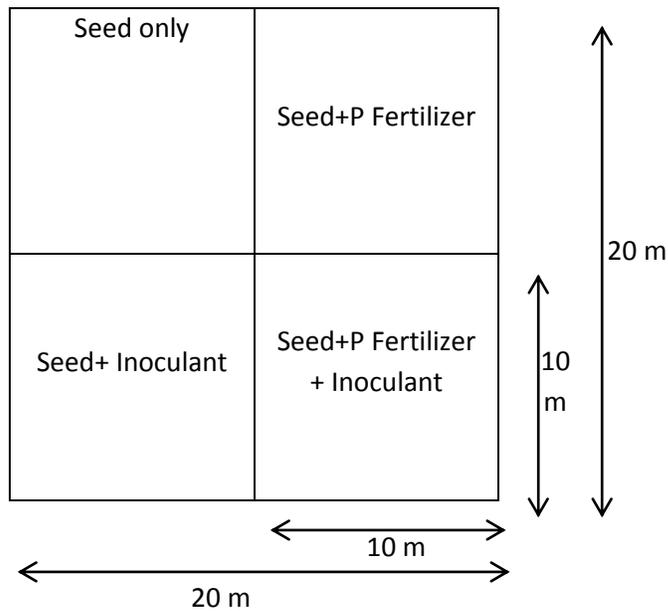
Inoculation of soybean seed with sugar-water mixture as a sticker.

On-farm Technology Testing and Demonstration

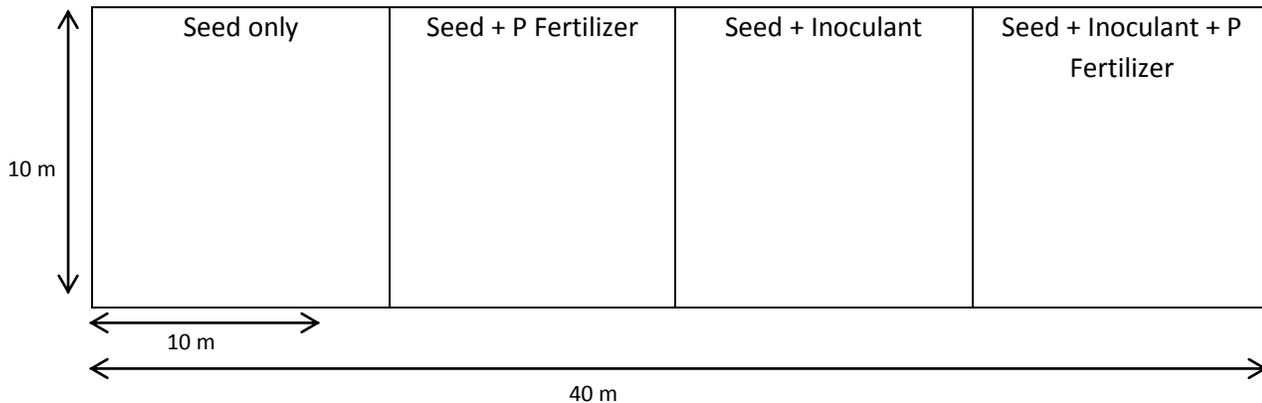
With assistance from N2Africa, lead farmers design, install and observe field demonstration trials to test and share project technologies with neighboring farmers. Each lead farmer should work with a group of neighboring farmers, preferably all being members of the same farming organization. The farmer group will jointly conduct the field demo which is led by the lead farmer; the demo will test several different combinations of crop varieties, inputs, management practices, etc., which are called “treatments”. Each member of the group obtains seeds and other inputs to try one of the treatments in their own fields and to compare it with their traditional practices.

The demo can be made of four plots which are the same size. The plots can be side by side, or in a block, according to what best fits the land the lead farmer has available.

One important test is whether or not there are enough rhizobia in the soil already, or if the crop grows better when sown with inoculants. Since P fertilizers are often beneficial to legumes, it is also important to test if the legume grows better with P fertilizers. And it is also good to see if the combination of both inoculants and P fertilizer gives the best crop growth and yield of all. This can be done by planting the plots as follows:



An alternative layout should this fit the farmer's available land is:



The lead farmer, other farmer group members and N2Africa team and partners evaluate and compare the four different treatments at different stages of crop growth to see if there are any differences in crop vigor, grain yield and root nodulation. If there are no differences between the plots, then there is no crop response to either inoculants or P fertilizer. If the inoculated plot does best, then inoculation is advised. If the P fertilizer plot grows best, then P fertilizers are good. If the +inoculants+P fertilizer plot grows best, then both practices should be recommended²

Other demos are designed to test whether or not N2Africa technologies can help farmers to overcome crop production constraints. For example, farmers who are more concerned about maize production can test different intercropping arrangements between maize and legume crops.

All farmers in the group should make observations on their trials as well as those of the lead farmer demos. Farmer groups should organize for other farmers to visit the trials at different stages in the cropping cycle to both learn about and evaluate the different technologies; it is important to invite farmers who are not conducting trials so that they too can be exposed to new technologies.

Why BNF may not occur (list of factors to explain)?

- Inoculation factors:
 - Correct (for legume crop in question) inoculants not used
 - inoculants not viable
 - inoculation procedure not followed correctly
 - seed not planted soon after inoculation
 - soils into which inoculated seed sown not sufficiently moist
- Drought (kills rhizobia)
- Extremely high or low temperatures (kills rhizobia)
- Soils too acid, no lime applied
- Not enough available P in soil
- Soil nitrogen levels high (high N fertilizers used current or previous season)

See and Learn

Lead Farmers should organize at least two “See and Learn” events at the demo trials during the cropping season: in the middle of the season, when everyone can evaluate the response of the crop in the field, and at the end of the season, when impact of technologies on crop yields can be assessed. The treatments used are explained to all participants and numerous other farmers have a chance to see and evaluate the impact of the new technologies on crop growth and yield.

Lead Farmers may also want to organize a demonstration of how to inoculate seed, just prior to planting, at the beginning of the season. This should only be done if enough rain has fallen and fields are already prepared for planting so that members of the group can take their inoculated seed from the demonstration site immediately for planting in their own fields.

Field Days

Extension Officers working with lead farmers will organize Field Days during the growing season to show and evaluate the N2Africa technologies with a larger audience.

Community Seed Multiplication

² N2Africa will gather information from all its trials with lead farmers in order to come up with the best recommendations.

In order for the grain legume activities of N2Africa to reach more farmers and continue to grow after the project ends, all participating farmers are expected to make a contribution by giving some of their harvested seed to the community for use in next season's trials. The general rule applied is that for each 1 kg of seed a farmer receives from the project for free, s/he must return 2 kg of seed, harvested from the crop sown, to the community. Seed multiplication can occur either on each farmer's individual field, or in designated community seed production plots to multiply larger amounts of seed. The implementing partner, extension agents and N2Africa team should decide together with the farmers which method of seed reimbursement to follow.

Seed harvested for seed multiplication should be graded, cleaned and stored in a safe place, preferably with chemical treatment to reduce pest and disease infestation.

Where seed companies exist who are interested in multiplying and selling legume seed, arrangements can be made between them and selected farmers with adequate land and the technical ability to undertake larger scale seed multiplication. This model is preferred as it enables seed supplies to become sustainable in the long run, and allows for better control of seed quality.

Post-Harvest Handling of Grain Legumes

All grain legumes must be harvested at the correct stage of maturity, threshed, dried, cleaned and packaged properly for long-term storage or sales. The harvesting and post-harvest handling steps differ for each grain legume crop, however some general principles apply to all:

- Harvest at the correct stage to avoid losses from shriveled grains (harvested too early) or losses due to pods shattering in the field
- **To dry the pods:**
- Grains must be dried down in the pods before threshing; if threshed while too moist, the grain will be damaged
- Dry the pods (usually still on the plant) on a mat, plastic sheet or tarpaulin, on a raised platform or maize crib
- Do not dry the pods on the ground – they will become dirty and wet and can be attacked by insects and animals
- Either place the pods in an area protected from rain, or have someone watch them so they can cover the pods/bring them inside in case of rain. They can also chase away animals.
- **To thresh the pods:**
- When threshing, do not:
 - Break or damage the grain
 - Mix the grain with dirt and rubbish
 - Lose grain
- Do not thresh the pods on the ground – place them on a clean surface, preferably surrounded by high wooden sides to prevent the grains from scattering
- **Drying the threshed grains:**
- Dry on mats, plastic sheets or other clean surface; protect from rain and animals
- Spread the drying grain thinly on the drying surface to allow air to pass through it
- Test the grain to see if dry enough by biting or pinching grain with your fingers – grain should break or crack, not bend
- **To grade the grains:**
- Winnow to remove chaff, dust and other rubbish
- Remove shriveled, diseased, broken grains and grains of other varieties

- If sorted on a platform sorter, no bending is required and the wire mesh helps get rid of some of the dirt mixed with the grain
- **Storage of grain:**
- Clean the storage facility, being careful to remove all old grains and insects
- Do not store grain which is to be eaten in the same place as pesticides or other dangerous chemicals
- Use CLEAN and dry storage containers; if re-using bags in which grain was previously stored, the bags must first be washed then disinfected by boiling them in water for 5 minutes. If the bag is polyethylene, make sure it doesn't touch the outside of the pot or it will melt. Completely dry container/bag
- Place grain in storage container which is raised off of the ground – avoid direct contact especially of storage bags with ground
- Inspect and remove infested or rotting grains on a regular basis