**Technology brief for soybean production in Ghana**

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| **Background** |
| Soybean was introduced in Ghana as far back as 1909 but it was rarely utilized in food preparations until recently due to difficulty in processing it at the household level. Even now that it is being promoted as a food crop little of the crop is consumed at the household level (estimates vary from 5-15%). Recent interest in the cultivation of the crop by both men and women was mainly due to the availability of a market for soybean as a cash crop. For many women, their interest lies in the fact that it could be produced easily with minimal external inputs. The Women in Agriculture Development (WIAD) Directorate of the Ministry of Food and Agriculture and some NGOs have trained many women in the use of soybean to prepare various traditional dishes. This also stimulated recent interest in soybean cultivation.**This brief sets out the answer the questions:*** How can I grow the soybean the market demands?
* What barriers exist?
* How do I solve those problems?

**Summary: How to increase soybean yield**1. Improve the physical aspect and health of the rooting zone. Choose a good site and prepare it well and apply the right fertilizer
2. Select the best variety and seed (larger farmers should include monitoring the soil pH)
3. Use inoculant to improve plant health, nitrogen production and yield
4. Choose the right row spacing in order to achieve the optimum plant population
5. Rotate with maize and other crops. Do not crop soybean more than 2 times in the same field.
6. Manage weeds early and completely
7. Scout for pest and diseases throughout the season. The most likely pest is the leaf roller. Know your threshold and use the appropriate control measures
8. Harvest at the right time and store with the right storage facility
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| **Overview: Why grow soybean?** |
| **Core** | **Nutrition**: Soybean is one of the cheapest sources of protein for people, containing essential amino acids not present in other grain legumes and other minerals and vitamins the human body needs. Soybean grains can be processed for multiple uses including soy-milk, cooking oil and a range of other uses including infant weaning food and kebabs. Breweries also can also be buyers of soybean. Soybean cake is a good source of animal feed. The crop residues are also rich in protein and are good fodder for livestock or form a good basis for soil organic matter if returned to the soil.**Market**: Market demand for soybean is high but prices fluctuate largely following the world market prices for soybean even if produced locally**Nitrogen fixation**: Soybean forms root nodules that contain bacteria called rhizobia. The bacteria can fix nitrogen from the air into a form that soybean can use for growth. This is called biological nitrogen fixation. The soybean residues (falling leaves/ stover) and roots, contain lots of nitrogen and when incorporated into the soil the soil fertility and soil organic matter are improved. For soybean, the amount of free nitrogen brought into the soil is the equivalent of over a 100 kg (2 bags) of urea. This makes soybean a good crop to grow in rotation with other crops. In addition, soybean has the potential to control the parasitic weed *Striga hermonthica.* Therefore, farm lands that are avoided as a result of Striga are put back into cultivation.  |
| **Tip** | Find out about the markets for soybean before you commit to planting: it is important that you have a plan for selling your surplus. Check what varieties are favoured in your local markets and then work out if they are varieties that suit your local conditions. Remember prices vary from year to year but the recent prices paid give you an indication of the income you might expect.  |

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| **1 Land selection and preparation** **1.1 Land selection**  |
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| **Core**  | Soybean requires land that is fertile with deep soil and good capacity for water retention. Soybean can be grown in a wide range of soils, but preferred soils are those with a loamy texture and a relatively high organic matter content. Well-prepared land ensures good germination and reduces weed infestation and pest and disease challenges. On average the roots are usually as deep as the plant is high, so it is not a drought resistant crop. Ideally your plot should not have too much shade; you may need to prune some trees. Soybean yields higher in full sun. **Think about the rotation** scheme for the field you want to plant. You should not plant soybean in the same field for two successive seasons, as this increases the chance of disease. Avoid strong acid soils. Acid soils must be limed before planting for good growth and development of the crop. Soybean grows better at a temperature between 21 -320C. The correct application of herbicide will help curb the weeds before planting.Do not burn the dead stalks from last year’s crops. Try to leave them on top of the soil. This will create a mulch that will retain moisture in the soil and suppress weeds. If you cannot stop others from burning the residues or grazing animals, you should plough the dead stalks into the soil i**mmediately** after harvesting. This will improve the organic matter of the soil for the next season crop.  |
| **Tip** | If you face constraints in accessing certified – quality seeds, you can save your best grain to replant the next year. See the harvest section on grain kept as seed. |
| **Tip**  | You can plant soybean on ridges or on a flat seedbed. Ridges are useful where you need to overcome waterlogging problems.  |
| **Tip**  | If the soil pH is below, 5.6 lime can be added to the soil but it may require a lot of lime to make a difference. So, it may be better to choose to grow a different crop. |
| **1.2 Land preparation for planting**  |
| **Core**  | **Prepare the field:** Clear all larger vegetation and prepare the field manually with a hoe, or use animal power or a tractor. Smaller weeds that have not set seed can be dug into the soil to improve the organic matter. Plough and harrow the land before the rainy season and aim to have a good tilth ready for planting. If you are using a tractor to plough this should happen around 2 weeks before planting: ploughs need to get to a depth of 15-20 cm. This is achieved by slow steady progress – 6-8 km/hour. Harrowing should ideally take place a week later. Here faster speeds, 30-40 km/hour, are better at breaking the soil to a fine tilth. With conservation tillage, ensure that weeds are killed with appropriate herbicide before planting. |
| **Tip**  | If you are using a non-selective herbicide this should be applied 2 weeks before ploughing. This should prevent weed seeds germinating. So, you need to cover the whole planting area.Pre-emergence herbicides can be applied within 3 days of planting – before the seeds emerge at 5 days.To ensure good tilth and effective weed control, plough first and allow weeds to germinate. Then 2 to 3 weeks later, harrow and plant. Follow up with a recommended pre-emergence herbicide 2 to 3 days after planting. Start with hand/hoe weeding as soon as weeds start to emerge. |
| **Tip**  | If you left crop residues on the field they can all be ploughed into the soil to provide organic matter, improve moisture retention and provide soil nutrients. Adding an organic fertilizer will have the same effect. |
| **Tips**  | Pay attention to weeding the area around your field. These areas can harbour pests like rodents and pests and diseases that may impact on your yields. Also, if this area is kept clean, the bare soil it will act a fire break, which is important in areas where bush fires are possible. |

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| **1.3 Variety and seed selection** |
| **Core** | Select a good soybean variety that suits your agro-ecological zone. Select a suitable variety and use certified seed. Certified seed is of good quality and more than 9 out of every 10 seeds will germinate. Store the seed in a safe, dry and cool place. Soybean seed is sensitive to damage from mishandling – such as being bumped, or from high air temperatures or excessive moisture. Soybean easily losses its viability as compared to other legumes. Avoid using old seed. Qualities to look for when choosing your bean variety: non-shattering pods, tolerance to known diseases and grain versus vegetative varieties. **Maturity period** - pay attention to the maturity period. Some varieties have a relatively short maturity period and are suitable for areas with low rainfall, or when planted late in the season. Late maturing varieties are less suitable for drier environments, but often produce higher grain and biomass yields, fix more nitrogen and contribute more to soil fertility than early maturing varieties. Late maturing varieties are good for farmers who harvest their staple food crops such as maize before the soybean. This is because they will not mature at the same time. Also, remember to consider the market requirements – what will sell well? |
| **Tip** | You should only buy seed from a trusted dealer.Seed packs should contain the following information: * Packing date
* Expiry date
* Germination rate (but still do the germination test yourself)

You should check the seeds are in date and look healthy and that they all look the same. |
| **Tip** | Seed can be saved from one season to the next – although you should buy new seed every 3 seasons. so that yields do not drop.  |

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| **Variety** |  **Grain characteristics** | Benefit/Cost Ratio: | **Grain yield (kg/ha)** | **Maturity period****(in months)** |  **AEZ**  |  **Other characteristics**  |
| Afayak TGX 1834-5EBreeder: CSIR-SARIYear of release: 2012 | Golden yellowFairly spherical Thousand grains weight 120-130 g | 2.04 | 6-10 maxi bags per acre 0.8 -1.2 tonnes /acre  | 110-115 days after emergence (40-45 days to flowering) | Preferred ecology: Broadly adapted | Pod Shattering Score: Less than 8%Excellent for Striga control (as a trap-crop)Disease resistance: Tolerant to both Cercospora leaf spots and bacterial pustule Consumer Preference: Very acceptableTollerant to both Cercospora leaf spots and bacterial pustule Largely determinate |
| JengumaName of breeder CSIR-SARI Year of release 2003 | Cream grainFairly spherical 40% protein and 20% oil content – suitable for industrial useThousand grain weight 130-140 g |  | 6-10 maxi bags/acre or 0.8 -1.2 tonnes /acre  | 110-117 days after emergence and 45-48 days after emergence) | Jenguma responds to the [agroecology](http://en.wikipedia.org/wiki/Agroecology) of Ghana and was developed to withstand the specific stresses of the climatic conditions of the region | It is high yielding, field resistant to pod shattering and resistant to the striga weed that hinders crop performance and yieldTolerant to bacterial pustuleLargely determinate |

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| **2 Planting**  |
| **Core** | *T*he seed rate for all the above varieties is 20 kg per acre (Jenguma is slightly heavier than Afayak)Use only high quality seed for planting:* Always plant saved seeds in the following season to ensure good germination.
* Sort out the good seeds for planting to ensure that they are free from insect damage or infestation, disease, mold or weed seeds. Remove any seeds that do not look perfect!
* Test the seed (germination test) at least 10 days before planting. Plant 100 seeds. If at least 90 emerge, the seed is good for planting. If 60-80 emerge, plant more seeds than recommended. Try to get new seeds if less than 60 seeds emerge.
* Planting occurs between mid-June and mid-July, but after 2-3 weeks of rain.
* Planting early (as soon as the soil is moist) can make it less likely that rust will occur. Do not prepare the tilth soil too soon as excessive rains may impact it. This can affect germination.
* Do a moisture test on the soil: – when you make a handful of soil into a ball it should hold together in your hand.
* If soils are too wet or too dry it will impact on the germination of the seed.
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| **2.1 Inoculation** |
| **Tip** | To form nodules and fix nitrogen, soybean needs specific rhizobia. In most soils, these rhizobia are not abundant. Thus, inoculating soybean seed with the correct rhizobium strain increases biological nitrogen fixation and gives a good yield for very little cost. With good practices and the right varieties, grain yields can be as high as 1,000 kg/ acre when grown as a sole crop. |
| **Core**  | It is good practice to apply rhizobium inoculant with the seed before planting. This assists the plant to develop nodules for nitrogen fixation. Obtain rhizobium inoculant from a reputable supplier, and keep it cool and in the dark until use. Inoculate soybean seeds with registered rhizobia to ensure nodule formation. Always check you have the right inoculant for soybean since each legume crop needs a different type of rhizobium bacteria. You will find directions for using inoculants on the inoculant package, or follow the instructions below. Inoculant is a living product and must be kept in cool place. Once the pack is opened it does not store well.  |
| **Core**  | There are three inoculant brands in Ghana: Legumefix, Nodumax and Sarafix. Legumefix is fully registered for sale and comes in a 250 g bag. Nodumax and Sarafix will be available in 100 g packs when they pass all registration requirements. There are slight differences in the way that they are applied, so it is always important to check the manufacturer’s instructions. |
| **Tip** | Inoculant has a limited shelf-life – check that it is within date. |
| **Tip**  | Do not consume seed that has been inoculated ready for planting. |

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| **Core**  | How to inoculate soybean using solid-dry inoculants (Legumefix)* + 1. Measure 15 kg of soybean. Place in a plastic container (preferably with a lid) that will accommodate the seed.
		2. Moisten the seed: 30 ml or 6 teaspoons or soda bottle-tops of water can be mixed with the seeds.
		3. Add 75 gram (7 tablespoons/15 teaspoons) of inoculants to the seeds.
		4. Mix the seeds and the inoculant thoroughly but gently until all the seeds are uniformly covered.
		5. Dry the inoculated seed in the shade for about an hour, for example cover the container with paper, cloth or gunny bag and keep under shade until planted.
		6. Plant the seeds within1-2 hours adding the inoculant
		7. You can adjust the volumes above to any quantity of soybean seed. For every 1 kg seed, use 4-5 gram (1 heaped teaspoons or soda bottle-tops) inoculant.
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| **Tip**  | **How to inoculate soybean using solid-wet inoculants (Nodumax)*** + 1. Dissolve the contents of the gum arabic packet (included with the inoculant) into 300 ml of warm water (6 teaspoons or soda bottle-tops). This is the sticker.
		2. Measure 15-20 kg of soybean. Place in a plastic container (preferably with a lid) that will accommodate the seed that you can plant in 1-2 hours.
		3. Moisten the seed with the sticker (can be mixed with the seeds).
		4. Add 150 gram (14 tablespoons/30 teaspoons) of inoculants to the seeds.
		5. Mix the seeds and the inoculant thoroughly but gently until all the seeds are uniformly covered.
		6. Air dry the inoculated seed in the shade for about 1 hour before planting.
		7. Plant the seeds on the same day you inoculate them – preferably within 1-2 hours of inoculation.
		8. You can adjust the volumes above to any quantity of soybean seed. For every 1 kg seed, use 4-5 gram

(1 heaped teaspoons or soda bottle-tops) inoculant. |
| **Tip**  | **Key points to note:*** Once the inoculant package is opened, all contents must be used and not kept for reuse.
* Maximum storage period under farmers’ conditions (below 30°C) is between 6-8 months or check the expiry dates at the back of the package
* Each legume crop needs a different type of rhizobium bacteria, so always check you have the right inoculant for the crop you want to sow.
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| **Core**  | **Facts about inoculants:*** The roots of legumes and rhizobium bacteria work together to biologically fix nitrogen. Inoculants contain the bacteria that help the soybean to make/ fix nitrogen.
* Inoculants are much cheaper than nitrogen fertilizer as a source of nitrogen in your soil for future crops.
* Inoculants lose their effectiveness when stored in an open package: do not open the package until you are ready to use it.
* Inoculants also lose their effectiveness when exposed to heat or direct sunlight: always store the package in a cool place in the house, ideally a fridge. Check the expiry dates at the back of the inoculant packet.
* Directions for using inoculants can be found on the package.

How to inoculate depends on the type of inoculant you use: always check the instructions on the package or ask an agro-dealer or extension worker. You can also contact the supplier through the contacts provided at the back of the packet. |

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| **2.4 Planting** |
| **Core** | * Plant when the rains are well established to avoid dry spells after planting.
* Plant in the morning or evening to avoid direct sunlight on the inoculated seed. Sunlight will make the inoculant ineffective so try to keep treated seeds covered or in the shade.
* Plant in rows or lines. This has many advantages: you use the correct plant density weeding is easier and harvesting takes less time. Losses are minimized as compared to broadcast fields. To do this you will need to use a rope stretched between 2 stakes.
* Plant at 2-5 cm depth. Planting deeper than 5 cm may result in loss of vigour or failure to emerge (2 cm is about the distance from the end of your thumb to first joint). Use a dibber or a stick to create the planting hole.
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| **Tip**  | * There some mechanized planting machines or dibblers. Dibblers are useful for getting the right seed density but the current models tend to be heavy and hard to operate.
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| **Tip**  | Planting too deep will impact on the germination rate. |
| **Tip**  | Not every bean will germinate so fill the gaps one week after sowing when plants have emerged (this can be combined with weeding). |

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| **Core** | Spacing of mono-cropped soybean30 seedlings per square meter is considered a good spacing. When drilling, use a row spacing of 60 cm (about the length of two foot prints) and space the seed 5 cm apart (about the length of your little finger) in the row with 1 seedling per stand for medium maturing varieties. If planting manually, a spacing of 60 cm by 10 cm with 2 seedlings per hole is recommended or 75cm by 10cm with 2 seedlings depending on the maturity type. Sow seeds 2-4 cm deep. Soybean seedlings are very delicate when emerging from the soil so, when planting, soil in the planting hole must not be firmed. Do thinning out of seedlings to 5 cm apart within row if the drilled seed results in over emergence (more seed germinated than the spacing recommendation). * When you plant soybean on flat land, plant the soybean in rows which are 60 cm apart. Within rows, plant seeds at 5 cm apart from each other; in practice it is easier to do this in a furrow. At a spacing of 10 cm it is possible to use a dibber and to add 2 seeds per hole.
* When you plant soybean on ridges, space the ridges 60 cm apart. Plant soybean on both sides of the ridges. Within rows, plant seeds at 5 cm apart from each other (1 seed per stand).
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| **Tip**  | Use 75 cm between rows and 5 cm within rows for late maturing varieties: they have enough time to grow in all their stages (seedling, vegetative and fruiting) and to produce higher biomass, hence the need for more space. Usually that is why late maturing varieties are higher yielding. |
| **Core** | Intercropped soybeanAs an alternative to growing soybean as a sole crop, you can intercrop soybean with a cereal crop. Soybean does not grow well when shaded. Therefore, it is best grown in strip intercrops with 2-4 rows of soybean and 2 rows of a cereal crop. You can also plant soybean in between rows of newly-established crops of cassava. Use the recommended planting distances for both crops. |

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| **3 Growing** **3.1 Weeding**  |
| **Core** | **Weeding** Control weeds to minimize competition for nutrients, water, sunlight and space. Weed control can be manual or chemical, or both. Early weed control is very important in soybeans to ensure minimal competition from weeds in the first 6 weeks.**Manual weed control:** Weed about 2 weeks after planting and again 2 weeks later (4-5 weeks after planting) depending on the density of the weed. If the plants grow very well and the canopy closes early, the second weeding is not needed.The second weeding should be completed before flowering: productivity will suffer if the flowers drop. **Chemical weed control:** Post-emergence herbicides, if used properly, are safe and effective in controlling weeds. There are different types of herbicides. The type to use depends on the dominant weed species and what products are availability. If you are not sure, take the weeds to the agro-dealer or extension worker to get help. Once the crop has developed a good canopy, weed control will be easier. Keep the crop weed-free through to maturity. It is good practice to always clear all weeds/bush surrounding the fields as such bushes harbour pests, particularly rodents.  |
| **Tip** | If your soybeans do not get taller than your knees when they are completely grown, you may need to grow a different variety of soybean. |
| **Tip** | Herbicides are available for pre-emergence or post-emergence weed control. If pre-emergence herbicide is applied at planting, one weeding may be required at 5-6 weeks after planting. Use herbicides as presented in the table below or seek advice from an extension agent.

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| **Brand or common name** | **Use rate** | **Amount for one sprayer load****(15 l knapsack)** | **Time of application** |
| Bean clean | 0.5 l /acre  | 80-150 ml |  Post-emergence |
| Sateca | 0.5-0.75 l/acre | 80-120 ml |
| Dual Gold | 1 kg/ acre |  |  Pre-emergence  |

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| **Tip** | **Using Bean clean vs conventional weeding**

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| **For all investment decisions, it is possible to evaluate the benefits and the costs.**  |
| **Parameter/operation** | **Bean Clean** | **Conventional hand weeding** |
| Weeding | 26,000 (US$ 12)  | 26,000 (US$ 12) |
| Time taken | 1 day | 6 days |
| Efficiency | Very effective at any stage of growth | May not be effective during rainy season |
| Yield | Early weed control gives higher yield. | May be lower if not done at the right time and stage. |
| This example is based on research in Uganda. It suggests that the cost of chemical weed control and conventional hand weeding is similar. It also suggests that this can be a very effective post-emergence weed control. Other factors that may influence the decision could include the availability of labour at the time it is needed given all bean farmers will be planting on a similar time-frame.  |
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| **3.2 Pests & diseases**  |
|  | Pest control: Scout fields regularly for pests and look out for symptoms of diseases. When any abnormalities of the plant development are found, particularly with regard to leaf curling, consult the local extension agents as early as possible for identification of the problem and recommendations. When using agro-chemicals, be sure to follow all safety precautions inscribed on the labels. Follow the recommendations from the Extension Services Department.Pest control (though farmers do not pay much attention to the practice, this is sometimes necessary)1. Do regular scouting (looking closely at the crop) for pest.
2. Using recommended agro-chemicals when necessary
3. Hand picking of leaf rollers can be done where incidence is low to avoid high infestation.
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| **Tip**  | Keep bush rabbits away – rabbits love soybean shoots and will devastate the growing plants. |

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| **4 Harvesting****Harvest:** When the pods on the plant change colour from green to brown and the seeds are hard and dry, the crop may be harvested. Do not delay harvest for long so as to avoid loss of beans through shattering, particularly with those varieties that are highly susceptible to shattering (e.g. Songda). Be careful to minimize bean loss during harvest, threshing and transport. Thresh, winnow and store the beans in protected storage facilities. |
| **Core** | Soybean should be harvested when 9 out of 10 pods are matured (brown or dry). Leaving the crop in the field too long makes the pods very dry, so they might shatter during harvest. To avoid shattering, it is best to harvest early in the morning. Pick the pod and shake. If seeds are detached from pod, the crop is ready for harvest.1. Cutting the bean – leaving the roots behind - will increase the organic matter and nitrogen left in the ground for subsequent seasons.
2. Dry the soybean plants in the sun and protect from rain and animals. Preferably, dry on a mat, plastic sheet or tarpaulin, or on a raised platform.
3. Thresh gently on a clean surface when the plants are dry.
4. Dry the threshed grains on mats, plastic sheets or other clean surface until dry; protect from rain and animals. Test the grain to see if it is dry enough by biting - grain should break or crack, not bend or stick between your teeth.
5. Local fabricators can make machines to support the threshing process – although they have not proved very successful in trials.
6. Winnow to remove chaff, dust and other rubbish. Also, remove shriveled, diseased, broken grains and grains of other varieties. Dry the grains for 3 days before packing.
7. Place grain in clean bags or other containers; if re-using bags in which grain was previously stored, the bags must first be washed and 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 the container/bag.
8. If you are planning to keep grain for use as seed next season – select only healthy looking seed and remove any off-types (unusual looking seed) and any damaged grain. Store in a cool dry place.
9. Do not throw away or burn the residues. Soybean crop residues are rich in nitrogen and therefore excellent as livestock feed, or a good basis for compost. You can also incorporate the residues in the field directly.
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| **Tip**  | **Harvesting grain for seed**: Pay great attention to the drying of grain for seed avoid contact with excessive rains at harvest time as this can lead to mold. Avoid excessive threshing as this will damage the seed, DO NOT walk animals over the seed and also DO NOT drive a tractor over the seed. |

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| 5 Post-harvest  |
| **Core** | **6.1 Uses**The first step in making delicious soybean dishes is to put the dried grain in boiling water and quickly cook for around 45 minutes. This reduces anti-nutritional factors which can interfere with absorption of nutrients. Then remove the skin and dry. Soybean develops a bad flavour if this cooking step is left out. Soybean can make different products like soybean flours, cakes, milk, tofu, among others. Ask an extension agent for more soybean recipes!Crop residues can be fed to livestock or composted. Because the residues are rich in nitrogen, bringing them back in the form of compost or manure from the livestock enriches your field in nitrogen. You need to be aware that leaving the crop residues to improve your soil is the best option, but where this is not possible incorporating the manure is better than nothing.Crop residues can also be left on the field and be retuned into the soil when you plant. Do not leave residues that are infected or infested with insects.  |
| **Core**  | **6.2 Storage** Soybean can be stored for up to 1 year in an unprocessed form. This will require the moisture content in the seed in the bags to be right and control of the moisture levels in the storage areas. There is some risk of pests or diseases at this stage (less so than for many other legumes)Soybean should be stored in sacks that should be raised off the ground.  |
| **Tips**  | **Harvesting and storage moisture content of soybean for large-scale growers** 1. Grain moisture at harvest should be 13-15% for maximum weight and minimum field losses.
2. Grain with more than 18% moisture at harvest will lead to threshing difficulties. Grains will be crushed and bruised.
3. Moisture less than 13% leads to field losses from lodged plants.
4. Moisture less than 10% makes grains brittle and split during harvest handling.
5. Storage moisture should be 12-13%.
6. When storage moisture is high, spoilage is likely to occur and this will bring about poor seed viability.
7. Obtain a simple moisture meter from your extension agent or seek his advice.
8. Store seed in a cool, dry and air-tight container to prevent the seed from absorbing moisture.
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