SOYBEAN CROPPING GUIDE

4R NUTRIENT MANAGEMENT AND BEST AGRONOMIC PRACTICES

NORTHERN GHANA

AFRICAN PLANT NUTRITION INSTITUTE

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4R NUTRIENT MANAGEMENT AND BEST AGRONOMIC PRACTICES

NORTHERN GHANA

Authors
Samuel Njoroge[1], Abdulai Haruna[2], Askia M. Mohammed[3], A.L.A Aziz[2]

Affiliations
[1]African Plant Nutrition Institute; [2]CSIR-Savanna Agricultural Research Institute; [3]Tamale Technical University, Department of Sustainable Agriculture

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APNI Website: www.apni.net
e-mail: info@apni.net

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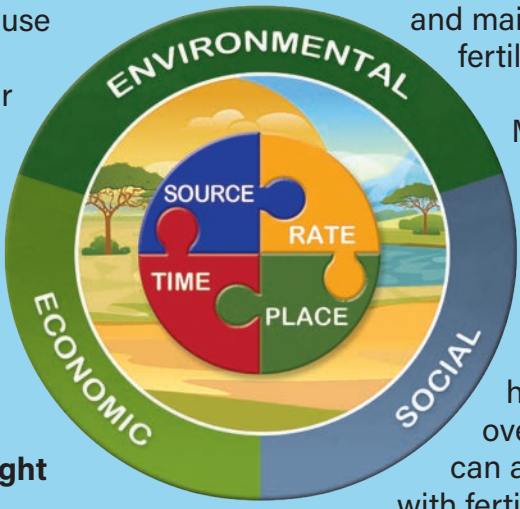
THE 4R NUTRIENT STEWARDSHIP CONCEPT

4R NUTRIENT STEWARDSHIP - is a framework developed to communicate the **Right way** to ensure sustainable and efficient use of fertilizer based on four principles namely: applying the **Right Source** of fertilizers, at the **Right Rate**, at the **Right Time**, and in the **Right Place**.



Effective fertilizer use, as guided by 4R Nutrient Stewardship, is important for developing sustainable smallholder cropping systems that support improved food production, increased income for farmers, and enhancement and maintenance of soil fertility.

More and better-quality soybean can be produced with fertilizers. The fertility of soils, which has been largely over-exploited, can also be restored with fertilizers. Correct management of fertilizers based on the 4Rs can therefore result in better social, economic and environmental outcomes for farms, villages, communities, and entire countries in Africa.

RIGHT SOURCE:

refers to applying the correct fertilizer that provides crops with the nutrients required for good growth and high yields.

Different crops have different nutrient requirements. Different fertilizer also provide nutrients in different proportions. Matching a crop's nutrient uptake requirements with the fertilizer that supplies the right mix and proportions of required nutrients ensures that the Right Source is achieved.

RIGHT RATE:

refers to supplying growing plants with the right amount of nutrients for healthy growth and development.

Different crops require different quantities of nutrients for healthy growth and development. The quantity of nutrients required by a particular crop also depends on soil fertility and the crop yield target. Nutrient requirements will increase as the soil fertility decreases. Similarly, as crop yield targets increase, the quantity of nutrients required to achieve these targets increases.

RIGHT TIME:

refers to matching nutrient application with the timing of plant nutrient uptake.

Most crops take up nutrients slowly during the early stages of growth, but the rate of nutrient uptake increases as crops develop. Fertilizer applications timed to match with periods of high plant nutrient uptake ensure efficient uptake of applied nutrients.

RIGHT PLACE:

refers to adding nutrients to the soil at a place where plants can easily access them.

Different crops have different rooting characteristics and this influences their ability to efficiently access and take up applied nutrients. The right placement of fertilizer for a particular crop should be selected to match a crop's rooting characteristics, and other aspects such as the planting density and tillage system. The right placement method will ensure reduced nutrient losses.

FIELD MANAGEMENT & LAND PREPARATION

- To ensure good soybean yields each season, avoid growing soybean on the same field continuously and rotate soybean with cereal crops such as maize.
- Planting soybean in the same field continuously increases the chance of pest and disease infestations.
- Start field preparation 2 to 3 weeks before the start of the rainy season (from mid-May to early June).
- Before ploughing and harrowing, first clear any overgrown weeds, shrubs and stumps.
- After the field is cleared of shrubs and stumps, plough the field uniformly to a depth of 20 to 30 cm.
- Ploughing should be done when the soil moisture level is low to minimize soil compaction.
- After ploughing, harrow the field uniformly by breaking up any large soil clods that may be present, then make ridges 50 to 60 cm apart.
- Good ploughing and harrowing help to control weeds, kill some insect pests, and also makes it easier to incorporate manure, apply fertilizer and plant.

SEED SELECTION & SEED RATE

- For best soybean yields, plant improved soybean varieties recommended for your area.
- To ensure good germination and high yields, plant newly purchased certified seeds of the recommended varieties.
- If newly purchased certified seeds are not available, you can use seeds from the 1st crop of certified seed as seed for the 2nd crop, or 2nd crop seeds for the 3rd crop. Do not plant seed from the 3rd crop.
- Before planting, make sure the seed selected for planting is not more than 12 months old to ensure good germination.
- If using seed from the previous season, sort out the good seeds for planting to ensure that they are free from insects, disease infestation and weed seeds.
- The recommended seed rate for good soybean yields is about 50 to 60 kg per hectare.
- Based on the size of your farm and the recommended seed rate, acquire enough quantities of seeds in consultation with your agro-dealer.
- Before planting, conduct a germination test at least 10 days before planting by planting 50 seeds. If at least 40 emerge, the seed is good for planting. If 30 to 40 emerge, plant more seeds than recommended. If less than 30 seeds emerge, get new seeds.

Table 1: Soybean varieties recommended for Northern Ghana.

				Attainable yield	
Variety	**Special attributes**	**Grain Color**	**Maturity period, (days)**	**t/ha**	**Bags/ha**
Jenguma	Tolerant to shattering	Purple	110 - 115	2.5 - 2.8	25 - 28
Afayak	Trap crop for Striga	Purple	110 - 115	2.0 - 2.4	20 - 24
Favor	Tolerant to lodging and rust diseases	Cream	115 - 118	2.0 - 3.5	20 - 35
Songpun-gun	Trap crop for Striga	Cream	90 - 95	1.5 - 1.8	15 - 18
Songda	Tolerant to shattering	Cream	110 - 115	1.8 - 2.2	18 - 22
Quarshi		Cream	110 - 115	2.0 - 2.4	20 - 24

4R Tip

1. *Ensure to buy your soybean seed from trusted dealers only.*
2. *Seed packs should contain the following information.*
   - *Soybean variety*
   - *Packing date*
   - *Expiry date*
   - *Germination rate*
3. *Check the seeds to ensure they are of good quality and uniform in appearance with no deformed or discolored seeds.*

BIOLOGICAL NITROGEN FIXATION

- Soybean forms root nodules which contain bacteria called rhizobia.
- The rhizobia bacteria can fix nitrogen from the air into a form that soybean can use for growth. This is called biological nitrogen fixation.
- Some of the nitrogen is also left in the soil through fallen leaves and roots, helping to improve soil fertility. This makes soybean a good crop to grow as an intercrop or in rotation with cereal crops such as maize as they can benefit from the nitrogen provided by the soybean crop.
- As a result of this biological nitrogen, soybean does not require application of nitrogen fertilizers.

INOCULATION

- To form nodules and fix nitrogen, soybean needs specific rhizobia.
- In most soils, these rhizobia are not present in high quantities. In such cases inoculation of soybean seeds with inoculants which supply the required rhizobia bacteria is required.
- Examples of inoculants available for northern Ghana are *Legumefix, Sarifix* and *Nodumax*.
- The right method for inoculating soybean seeds with inoculants depends on the type of inoculant used. Therefore, always check the inoculant package for instructions on inoculation or inquire from an agro-dealer or extension officer.
- Examples for inoculation using commonly available inoculants are provided below.

Inoculation with solid-dry inoculants: Example, Sarifix and Legumefix:

1. Measure 15 kg of soybean and place in a clean plastic container (preferably with a lid).
2. Moisten the seed by adding a small amount of clean water (30 ml, 3 tablespoons or 6 teaspoons or soda bottle-tops) and mixing well with the seeds.
3. Add 75 grams (7 tablespoons or 15 teaspoons) of inoculant to the seeds.
4. Mix the seeds and the inoculant thoroughly until all the seeds are uniformly covered.
5. Cover the container with the inoculated seeds with a lid, cloth or gunny bag, and place it in a shaded area until planted.
6. Plant the inoculated seeds within 1 to 2 hours of inoculating them.

NOTE: You can adjust the volumes above to any quantity of soybean seed. For each kilogram of seed, use 5 grams (1 heaped teaspoon or soda bottle-top) of inoculant.

All inoculated seeds should be planted on the same day.

Inoculation with solid-wet inoculants: Example, Nodumax

1. Dissolve the contents of the gum Arabic packet (included with the inoculant) into 30 ml of water (6 teaspoons or soda bottle-tops). This is the sticker solution.
2. Measure 15 to 20 kg of soybean seed and place in a clean plastic container that can be enclosed with a lid (see images on the following page).
3. Moisten the soybean seeds by applying the gum Arabic sticker solution to the seeds and mixing well.
4. Add 150 grams (15 tablespoons or 30 teaspoons) of inoculants to the seeds.
5. Mix the seeds and the inoculant thoroughly until all the seeds are uniformly covered.
6. Cover the container containing the inoculated seeds with a lid, cloth or gunny bag, and place it in a shaded area until planted.
7. Plant the inoculated seeds within 1-2 hours of inoculating them.

NOTE: You can adjust the volumes above to any quantity of soybean seed. For each kilogram of seed, use 10 grams (1 tablespoon or 2 teaspoons) of inoculant. All inoculated seeds should be planted on the same day.

4R Tips on inoculants

- *Once the inoculant package is opened, all contents must be used and not kept for reuse.*
- *Maximum storage period for inoculants under farm conditions is between 6 to 8 months. Check the expiry dates at the back of the package.*
- *Inoculants lose their effectiveness when exposed to heat or direct sunlight. Therefore, always store the inoculant package in a cool place in the house and only purchase close to planting time.*
- *Inoculants also lose their effectiveness when stored in an open package. Therefore, do not open the package until you are ready to use it.*
- *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.*
- *Directions for using inoculants can be found on the package.*

Planting

- Soybean planting in the northern region should be done between mid-June and late July based on the onset of the rains and the variety.
- Planting should be done in the morning or evening to avoid direct sunlight on the inoculated seeds as direct sunlight can make the inoculant ineffective.
- For good growth and yields, plant soybean in rows using planting lines.
- Planting in rows ensures that the right planting density is achieved, and also makes weeding and harvesting easier.
- The recommended plant spacing for soybean in northern Ghana is a row to row spacing of 50 cm and 15 cm spacing between plants in a row.
- To achieve the desired spacing, make planting holes that are about 5 cm deep at a spacing of 15 cm between holes.
- To ensure the right spacing between rows, use wooden pegs and planting lines to demarcate row positions and ensure consistent between row spacing of 50 cm.
- To achieve the right spacing between plants, use planting lines marked at 15 cm intervals (using ink or knots), and make planting holes adjacent to these markings.
- If soybean is grown as an intercrop with a cereal crop, it should be grown in strip intercrops to avoid shading as soybean does not grow well when shaded.

- When planting soybean as an intercrop with a cereal such as maize, plant in strip intercrops with 2 to 4 rows of soybean followed by 2 rows of maize.

- Fill gaps one to two weeks after sowing where no plants have emerged

FERTILIZER APPLICATION

For good soybean yields, fertilizer application should be based on the 4Rs of fertilizer management so as to ensure that the soybean crop is supplied with the **Right Source** of fertilizer, applied at the **Right Rate**, at the **Right Time** in the growing season, and at the **Right Place** where growing plants can easily access nutrients supplied.

To understand the best 4R practices for good soybean yields, it is important to understand the key nutrients required by the soybean crop for good growth and how they should be supplied.

- For good growth and yields, soybean requires to take up large quantities of nitrogen, phosphorus and potassium.
- Since soybean can biologically fix (manufacture) its own nitrogen, it does not require fertilization with nitrogen rich fertilizers such as ammonium nitrate or urea.
- Soybean is however not able to fix other nutrients it requires in large quantities such as phosphorus and potassium, and these need to be supplied through fertilizers.

Right Source

- The right source of fertilizer for soybean are compound fertilizers or fertilizer blends that supply large quantities of phosphorus and potassium. Different fertilizer companies have developed legume-specific fertilizers that contain no nitrogen but are rich in phosphorus and potassium. Consult your agro-dealer for available legume-specific fertilizers that are suitable for soybean.
- If legume-specific fertilizers are not available, farmers can use compound fertilizers that are rich in phosphorus and potassium but low in nitrogen such as NPK 11:22:21 + 5 S + 0.72 Zn + 0.5 B.

- If phosphorus and potassium-rich fertilizers are not available, farmers can use fertilizers that supply phosphorus such as Triple Super Phosphate (TSP), which also contains calcium (Ca) that promotes good soybean growth and yields.
- To supply potassium, Muriate of Potash (MOP) which supplies large quantities of potassium can be used in combination with TSP.

Right Rate

- Soybean needs to be supplied with about 15 kg P/ha (35 kg P_2O_5) and about 25 kg K/ha (30 kg K_2O/ha).
- To achieve the right rate using different fertilizer sources, follow the guidelines in **Table 2** below.

Table 2: Recommended soybean fertilizer application rates.

Fertilizer Type	Rate (bags per acre)	Apply	
		1 Teaspoon in	*1 Soda bottle-top in*
TSP	0.5 bags	Every 10 holes	Every 10 holes
MOP	0.5 bags	Every 10 holes	Every 10 holes
NPK (11:22:21)	1 bag	Every 5 holes	Every 5 holes

NOTE: If TSP fertilizer is used as the source of phosphorus, it should be applied together with MOP, which supplies the soybean plant with potassium. NPK fertilizer can be used alone. The rates above can be adjusted for any size of field by multiplying the size of the field in acres by the number of bags indicated above for each fertilizer per acre.

4R Tip

If you do not have any fertilizer, you can grow soybean in a field where maize had previously been grown and applied with fertilizer containing phosphorus.

Right Time

- Soybean should be fertilized at two weeks after planting when the crops have emerged.

Right Place

- To ensure Right placement of fertilizer, use a stick to make small holes about 5 cm from each soybean plant stand.
- Use a bottle top or teaspoon to apply equal amounts of the selected fertilizer in each hole (as indicated in **Table 2** above).
- Cover the applied fertilizer with soil to avoid nutrient losses.
- Applying fertilizer 5 cm away from the plant prevents the fertilizer from coming into direct contact with the plant as this may cause damage to the plant as the fertilizer dissolves.

SOYBEAN CROP MANAGEMENT

4R Tips for management of soybean plants

- *At 10 days after planting, check for gaps along the rows and plant additional seeds to fill any gaps.*
- *After germination, protect young plants from attack by rodents and birds using local methods.*
- *Regularly scout for pest and disease infestations by walking through the farm in a zig zag pattern every week. Perforated leaves, presence of larvae, egg clusters or insects on soybean leaves are all indicators of pest infestation.*
- *Discoloured leaves and small, stunted plants may be indicators of nutrient deficiency or disease infestation. Farmers should consult local AEA's for assistance with interpreting any signs observed.*

Management of Weeds

- Weeds reduce the growth and yield of soybean by competing for nutrients, water and light. For best yields, soybean fields should be kept weed free by conducting timely weeding at regular intervals. Weed control can be manual, chemical, or both.
- Manual weed control: Weed about 3 to 4 weeks after planting and again at around 6 weeks after planting. If the crops grow very well and the canopy closes early, the second weeding is not required.
- Chemical weed control: Herbicides can be used for both pre-emergence and post emergence weed control.
- To control the early and post emergence of weeds, apply weed control herbicides recommended for soybean. Avoid using herbicides that are in the atrazine family for soybean.
- If there are actively growing weeds in the field at planting, spray non-selective herbicides such as glyphosate or paraquat after applying the pre-emergence herbicide.
- If only pre-emergence herbicide is applied at planting, one weeding may be required at 5 to 6 weeks after planting.
- Before applying any herbicide, carefully read and follow instructions provided by the manufacturer or consult your local AEA.

Management of Pests

- Common pests that affect soybean are caterpillars and whitefly. If pests are only damaging leaves, spraying may not be required as leaf damage is unlikely to reduce yield.
- From flowering onwards, soybean becomes attractive to pod-sucking bugs that can seriously reduce seed quality.
- If pests are damaging pods, control the pest using recommended insecticides. Taking care to follow instructions provided by the manufacturer or consult your local agricultural extension agent.
- The following pesticides can be used to control pests damaging pods.

Product name	Recommended use rate	Amount for one sprayer load	For which pest
MagicForce	0.4–0.8 liter per ha	35–70 ml in a 15 liter sprayer	Control of leaf, seed and soil dwelling insects and migratory insects.
CyperDiForce	1 liter per ha	70 ml in a 15 liter sprayer or 100 ml in a 20 liter sprayer	
Wormforce	25–100 kg per ha	3 g per plant or 7–10 g per m^2 of soil during seed-bed preparation	Control of foliar and soil-borne insects and nematodes

Management of Diseases

Major soybean diseases include those caused by fungal, bacterial and viral infections. The table below presents the major soybean diseases common in Northern Ghana.

Fungal Diseases	Symptoms
Soybean rust	▪ Infected leaves have small tan to dark brown or reddish-brown lesions ▪ From the lesions, small raised bumps can occur on the lower surface of leaves ▪ Severe infection leads to premature defoliation and can cause high yield losses
Seedling blight	▪ Leads to rotting of seeds before emergence from the soil or death of seedlings after emergence ▪ Emerged seedlings often have brown, sunken cankers on the leaves which can become covered with pink spores in moist weather ▪ Infestation occurs mostly during cool wet weather
Frog eye leaf spot	▪ Infected leaves have brown circular to irregular spots with narrow reddish-brown margins on the leaf surfaces ▪ When mature seeds are affected lesions can develop on stems and pods ▪ Infected seed can show dark grey or brown discoloration in small specks to large blotches ▪ The disease-causing fungus survives in infected crop residue and in infected seeds
Root and stem rot	▪ Roots and stems turn chocolate brown and leaves turn yellow and wilt ▪ Sometimes a lesion occurs on one side of the plant ▪ When plant dies, the wilted yellow leaves cling to the plant ▪ The disease-causing fungus can infect seeds, seedlings and plants during whole growth period, but especially when soils are very moist and on poorly drained soils

4R Tips for safe use of chemicals for pest and disease control

- *Use only herbicides, pesticides and fungicides that are recommended for soybean to avoid damage to plants.*
- *Chemicals can be toxic to humans, so always follow instructions on the product package or from the agro-dealer for safe use. Also follow instructions about the time needed between spraying and safe consumption of fresh pods.*
- *Do not store chemicals in the same place as food.*
- *Do not eat from the same spoon used to measure chemicals.*

Bacterial Diseases	Symptoms
Bacterial blight	▪ Plants infected early in the season may be stunted and die ▪ Young leaves are most susceptible and the disease is mostly noticeable in the upper canopy ▪ In later growth stages, symptoms consist of angular lesions which begin as light to dark brown spots on leaves surrounded by a yellow halo ▪ Centers of these spots turn a dark reddish-brown to black and dry out ▪ Disease spreads during windy rainstorms and during cultivation when the foliage is wet ▪ The bacteria can be carried over in crop debris and in infected seeds ▪ Infected seeds usually have no symptoms
Bacterial Pustule	▪ Small yellow-green spots with reddish-brown centers occur on the leaves ▪ Small raised pustules usually appear from the center of the lesions ▪ Presence of a pustule and absence of water-soaked parts distinguishes bacterial pustule from bacterial blight

Bacterial Diseases	Symptoms
Bacterial Pustule (cont'd)	▪ In later stages, the small lesions may connect to form large, irregular, cracked, brown areas with a yellow margin ▪ In infected pods, the disease appears as slightly raised spots with some discoloration on seeds ▪ Infection may cause premature defoliation and often under severe conditions premature death
Viral Diseases	**Symptoms**
Viral diseases	▪ Transmitted by aphids, beetles and whiteflies ▪ Soybean seeds resulting from infected plants can also carry viruses ▪ Most viral diseases result in mosaic and mottling of leaves, and thickening/brittling of older leaves ▪ Leaf distortion, severe reduction in leaf size, and stunting of leaves

To control fungal and bacterial diseases:

- Plant resistant varieties.
- Avoid poorly drained or compacted soils.
- Rotate soybean with non-legumes such as maize to prevent build-up of diseases.
- Treat seeds with fungicides for protection against soil-borne fungal diseases.

To control viral diseases:

- Plant resistant varieties.
- Do not plant seeds from mosaic-affected plants. Instead, use certified seed or use seed from non-infected plants.
- Uproot and destroy affected plants. This can reduce the incidence of insect transmitted viruses.
- Control weeds in and around the soybean farms.
- Soybean is most vulnerable to virus infections in the pre-flowering stage. During this period, you can spray one or two times with insecticides to reduce the number of insects that can transmit viruses.

HARVESTING & STORAGE

- Soybean should be harvested when 9 out of 10 pods are mature (brown in color or dry).
- Leaving the crop in the field too long makes the pods very dry, so they might shatter during harvesting.
- To avoid shattering, it is best to harvest early in the morning.
- Do not harvest soybean by hand pulling as this may remove the roots which contain nitrogen and contribute to soil fertility. Instead, cut the mature plants at ground level using a cutlass, hoe or sickle.
- After harvesting, 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.
- When the plants are fully dry, thresh the plants to remove grains from the pods.

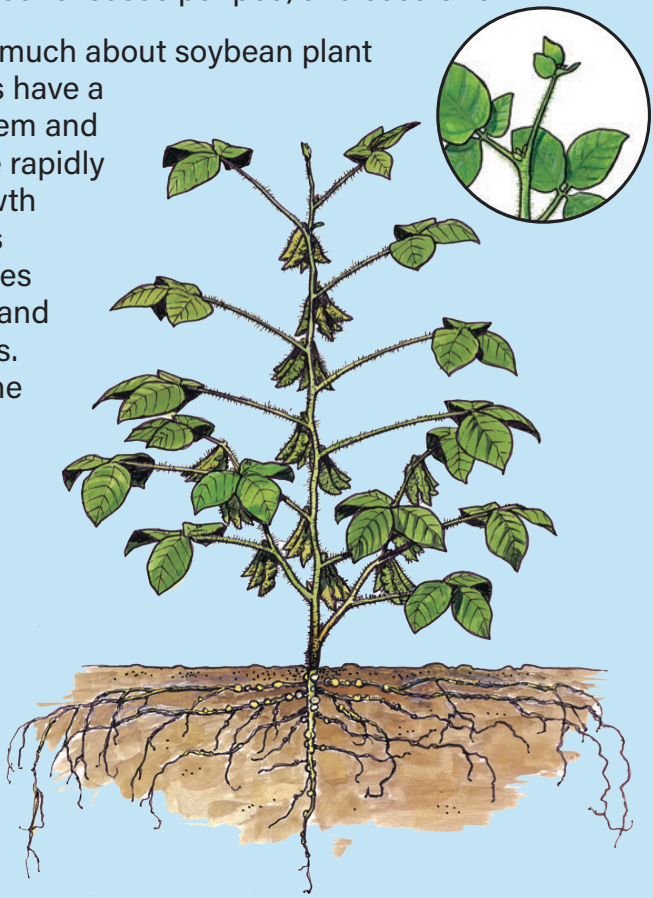
- Dry the threshed grains on mats, plastic sheets or other clean surface for two sunny days while protecting from rain and animals. Test the grain to see if it is dry enough by biting or pinching grain with your fingernails. Dry grain should break or crack, not bend or stick between your teeth of fingernails.
- Clean the grains by winnowing to remove chaff, dust and other rubbish. Also remove shriveled, diseased, broken grains and grains of other varieties.
- To store, place the dried and cleaned grain in clean bags or other containers. If reusing 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 polythene, make sure it does not touch the outside of the pot or it will melt. Completely dry the container/bag before placing the new grain.
- Grain can be treated before storage to control storage pests. Coating grain with ash or edible oil reduces storage pests.
- Make sure grain of different varieties is not mixed. Mixed grains lower the market value.
- Some storage chemicals can also be used to reduce damage by pests. If using chemicals, consult your agro-dealer or extension officer for advice.
- After treating grains and placing in storage bags, clean the storage room where the grain will be stored by removing all old grains and insects.
- Stack the grain bags on a raised platform or wooden pallet away from the wall.
- Avoid direct contact of storage bags with the ground.
- Inspect and remove rotting grains on a regular basis.
- Do not store grain which is to be eaten in the same place as pesticides or other dangerous chemicals.

SOYBEAN CROP GROWTH AND DEVELOPMENT

Soybean has two different growth habits depending on crop variety. Indeterminate varieties continue to grow after flowering begins. Soybean varieties with a determinate growth habit have a terminal leaf on the main stem (inset image), and finish most of their growth before the flowering stage begins.

Soybean yield is ultimately influenced by several plant characteristics including: numbers of seed per pod, weight per seed, pods per plant, and plants per hectare. Yields are especially influenced by the number of seeds per pod, and seed size.

Plant roots can reveal much about soybean plant health. Soybean plants have a branched taproot system and lateral roots proliferate rapidly during vegetative growth stages. Roots of plants infected with nematodes may be dark in colour and have few or no nodules. Nematodes damage the roots, reducing uptake of water and nutrients. Soybean roots have difficulty penetrating compacted soils. Since soybean roots grow close to the soil surface they can be damaged from in-crop cultivation or weeding.



The N requirement of soybeans is largely met through N_2 fixation occurring in root nodules. The bradyrhizobia that live inside the soybean nodules are typically added with the seed before planting. Using healthy and properly matched inoculants are a critical part of supporting high yields. The increase in seed production from inoculation far outweighs the cost.

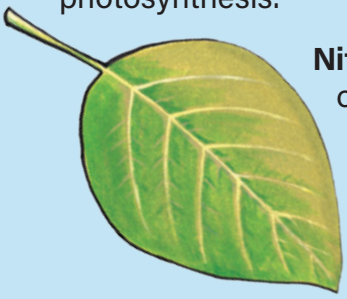
An adequate supply of other essential nutrients, especially phosphorus (P) and molybdenum (Mo), are required for the bradyrhizobia to make their full contribution to soybean health and high yields. They are also sensitive to low soil pH.

An unrestricted, well nodulated soybean root system.

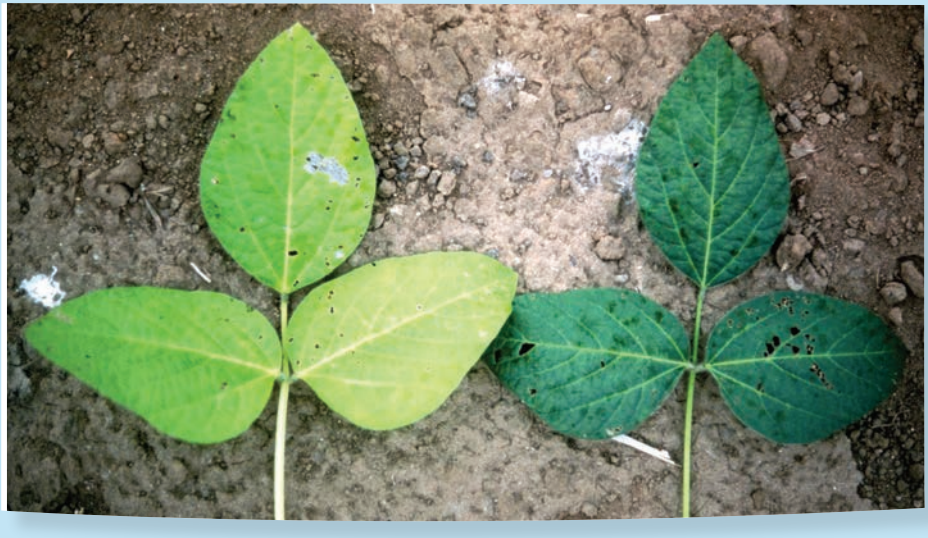
SYMPTOMS OF NUTRIENT DEFICIENCY AND TOXICITY

Plant leaves are the most obvious indicator of nutritional problems. Experienced crop scouts can recognize the most common leaf traits as tell-tale signs of specific nutrient deficiency or toxicity.

Plants with dark-green healthy leaves, strong stems, and vigorous roots will maximize the work of gathering sunshine and nutrients needed for photosynthesis.

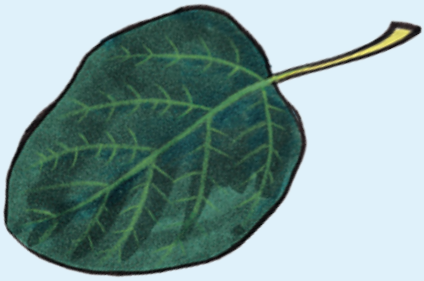


Nitrogen-deficient plants appear yellowish or pale green, although the symptoms are seldom seen. However, on acidic soils where molybdenum (Mo) deficiency interferes with nodulation, or on soils where soybeans have not been grown before, N deficiency is more likely without seed inoculation.



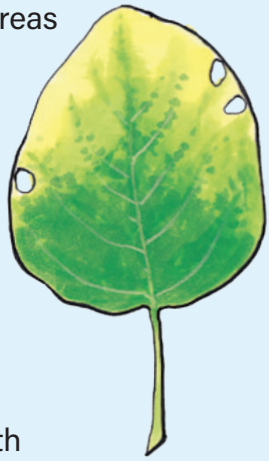
Nitrogen-deficient leaf (left); Healthy leaf (right)

Phosphorus (P) is an important nutrient for soybeans, but deficiency symptoms are not easily identifiable. Plants may be stunted and leaflets may appear blue-green. Soybean plants require relatively large amounts of P at pod set. Uptake of P is reduced in cool, wet soils. If P deficiency symptoms are seen, it is likely that N_2 fixation is not occurring at its full potential.



Phosphorus deficient soybean plants (right) are smaller and have small leaflets due to slow and stunted growth.

Potassium (K) deficiency symptoms are well-defined, appearing first on older leaves. In early stages of growth, leaflet margins may show irregular yellow mottling. As these areas coalesce, they form an irregular yellow border (chlorosis).



This symptom may be followed by necrosis of chlorotic areas and downward cupping of leaf margins. Dead tissues may gradually drop away, so leaves appear ragged. The chlorosis and necrosis may spread inward to include half or more of the leaflet, while basal portions remain green.

Soybean plants require large amounts of K, with the maximum uptake occuring during periods of rapid vegetative growth. Deficient plants tend to have weak stems and are more susceptible to some plant diseases. Severe deficiency may result in misshapen and wrinkled seeds.

Magnesium (Mg) deficiency symptoms first appear as pale green to yellow interveinal tissues on the older leaves. Later symptoms may appear as purplebrownish lesions around the leaflet margins, sometimes giving older plants the appearance of early maturity. Magnesium deficiency is more prevalent on deep, sandy, acidic soils.

Sulfur (S) deficiency is characterized by small, yellowish-green leaves at the top of the plant. Stems are thin, hard, and elongated. Leaf symptoms may sometimes look like those caused by other nutrients, such as N, but stem elongation is characteristic of S deficiency. Availability of S is affected by the amount of S supplied through applied fertilizers, soil pH, and moisture.

Iron (Fe) deficiency may first appear as yellowing of interveinal areas on younger leaves. In later stages, the veins may become chlorotic and entire leaves may turn ivory to white in color. Near the leaf margins, brown, necrotic spots may appear, and plant growth will be slow. When leaf yellowing is caused by Fe deficiency in high-pH soils, it is sometimes called lime-induced chlorosis. The symptoms may also appear when plants are not using available Fe effectively, and large amounts of Fe accumulate in the leaves. Soybean varieties differ considerably in their tolerance to Fe deficiency.

Manganese (Mn) deficiency symptoms are seen more frequently in cool weather, during dry periods, and at relatively high soil pH. Interveinal areas of leaves become light green to white, while veins remain green. Symptoms appear first in the younger leaves and may initially resemble early signs of Fe deficiency. Necrotic, brown spots develop as the deficiency becomes more severe, and leaves may drop prematurely.

Manganese deficiency symptoms

Molybdenum (Mo) deficiency is more likely in acidic soils that are highly weathered and leached and in soils where the element is in unusable form. Symptoms of this deficiency resemble N deficiency. The young leaves are pale green or yellow, necrotic, and twisted. Necrosis is confined largely to the margins, midribs, and interveinal areas. Since Mo is essential for N_2 fixation, a deficiency can be confused with N.

Zinc (Zn) deficiency can reduce soybean yields, primarily due to the reduced number of seeds formed. Deficient plants may have stunted stems and chlorotic interveinal areas on younger leaves. Entire leaves may later turn brown and gray and drop early. Few flowers are formed and the pods that set are abnormal and slow in maturing. Deficiency of Zn is most likely on strongly weathered, coarse-textured soils that are alkaline, on eroded soils, on low organic matter soils, or fields excessively fertilized with P.

Boron (B) toxicity symptoms include crinkled leaves, with the edges of the younger leaves cupped either up or down. The older leaves fall off in extreme cases. Margins of leaves without previous yellowing may begin to die, followed by spreading of dead areas over the entire leaf. The growing point may die. Boron deficiency is not common in soybeans, but the range between deficiency and toxicity is narrower than for other micronutrients.

Further reading

Hartman, G.L., Murithi, H.M., Lee, N.M., Reynolds, D.B., Awuni, G.A., Pawlowski, M.L. 2021. Field Guide to African Soybean Diseases, Pests, and Nutrition Deficiencies (v.2.0). Published by the Soybean innovation Lab.

References

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2. How to grow soybean. Clinton development foundation, AGRA & ASHC
3. Crop varieties release and registered in Ghana, 2019 national variety catalogue.

Notes

Notes

ABOUT **The 4R Solutions Project**

www.4RSolution.org

The 4R Solutions Project is funded by Global Affairs Canada to improve the livelihoods of 80,000 smallholder farmers in Ethiopia, Ghana and Senegal by improving agricultural productivity and farm income through incorporation of 4R Nutrient Stewardship into local farming practices. 4R Nutrient Stewardship supports best management of plant nutrients based on four key practices: Right Source, Right Rate, Right Time, and Right Place.

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