A Farmer's Guide to

Profitable Groundnut Production in Nigeria

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International Crops Research Institute
for the Semi-Arid Tropics

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Abstract

Nigeria used to be the highest groundnut exporting country in Africa, but a combination of drought, rosette and other diseases wiped out groundnut production in the 1970s. ICRISAT, IAR and partners have developed and released new improved high-yielding varieties with combined resistance to major biotic stresses. It is, however, necessary to disseminate these varieties with improved crop management packages on a large scale to increase and restore the profitability of groundnut cultivation in Nigeria. This handbook aims to be an effective guide to farmers on groundnut crop production and general management best practices for efficient groundnut production in Nigeria and its neighboring countries.

Photos: ICRISAT

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Foreword

Groundnuts (*Arachis hypogaea* L), are a significant subsistence and food crop in sub-Saharan Africa. Groundnuts are grown in practically every country, with the continent accounting for roughly a quarter of the world's production. Despite this rosy African statistic, problems abound: for example, nearly half (40 percent) of the of the world's total acreage for groundnuts is in Africa, which dramatically dims the 25 percent global production quota. In Africa, groundnuts are typically cultivated in moderate rainfall areas across the continent, usually by women. In the past, groundnut was grown mainly as a secondary crop in subsistence farming conditions, but in recent years the crop has gained importance due to the shortage of edible oil particularly in Asia and African countries. Today, farmers consider groundnut as a high-input high-risk crop because of the large seed requirement, the scarcity of good quality inputs and appropriate production technologies.

Groundnut production in Nigeria has suffered major setbacks from the groundnut rosette epidemics and foliar diseases, aflatoxin contamination and lack of sufficient and consistent supply of seed of improved varieties. This has significantly affected productivity and thus production and subsequently led to lose its share in the domestic, regional and international markets. To regain its competitiveness, groundnut yield would have to increase substantially, using yield enhancing technologies including varieties tolerant or resistant biotic and abiotic stresses. Since the 1990s, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and NARS partners–Institute for Agricultural Research (IAR) have developed or introduced a range of groundnut varieties with various attributes including different maturity groups resistant to groundnut rosette disease, foliar diseases and other desirable agronomic traits. The major constraints facing the development of the groundnut sector in Nigeria are known to be, among others, the poor access and availability of high yielding groundnut varieties resistant to the rosette virus and foliar diseases and its cultivation in infertile soil, at seeding rates that are unlikely to optimise productivity. It is however necessary to disseminate the seeds of these varieties with improved crop management packages on large scale to increase the profitability of groundnut cultivation through Groundnut Transformation Value Chain (GNVC) in Nigeria.

The handbook contains valuable scientific information about crop management topics such as land preparation, varietal selection, seed management, crop protection and postharvest management under Nigerian conditions. The appendices contain a catalogue of recently released groundnut varieties with suitable agro ecologies and sowing window. Recommended practices at major growth stages covering pre- and post harvest operations with illustrative pictures. I believe that the handbook on **"Farmer's guide to profitable groundnut production in Nigeria"** will become an essential source of ideas and information for any farmer, extension staff, and researchers interested in cultivating groundnuts in Nigeria. I sincerely thank the development partners for their contribution towards the production of this handbook. The FMARD applauds this effort by the authors and hope that the messages in the handbook reach the intended users as we strive towards a sustainable quality groundnut production and productivity, and improvement of livelihoods.

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Contents

Introduction

Groundnut *(Arachis hypogaea L.)* is a leguminous oilseed crop cultivated in the semi-arid and subtropical regions of the world. It is grown in nearly 100 countries on six continents between 40° N and S of the equator on nearly 24.6 m ha, with a production of 41.3 m.t. and productivity of 1676 kg ha^{-1} during 2012. China, India, Nigeria, USA and Myanmar are the leading groundnut producing countries in the world. Asia, with 11.6 m ha (47.15%), and Africa, with 11.7 m ha (47.56%), hold maximum global area under groundnut. Developing countries in Asia, Africa and South America account for over 97% of world groundnut area and 95% of total production. However, the productivity of Asia (2217 kg ha^{-1}) and Africa (929 kg ha^{-1}) is very poor as compared to Americas (3632 kg ha^{-1}) (FAOSTAT 2014). Groundnut is usually grown as a smallholder crop in the semi-arid tropics under rainfed conditions. It is an important crop in many countries, especially in SSA, where it is a good source of protein (25%-34%), cooking oil (48%-50%) and vitamins. The haulms are a good source of feed for livestock, especially during the dry season when fresh green grasses are not available. This serves as an additional source of income for farmers in the dry season when the fodder is in high demand.

Groundnut improves soil fertility through nitrogen fixation, thereby increasing the productivity of other crops when used in rotation or in a cereal cropping system. The poor productivity of groundnut cultivation in African countries may be attributed to a combination of factors such as unreliable rains, mostly nonirrigated nature of cultivation, traditional small-scale farming with little mechanization, outbreaks of pests and diseases, use of low-yielding varieties, increased and/or continued cultivation on marginal land, poor adoption of agronomic practices and limited extension services.

Groundnut in Nigeria

Nigeria is the largest groundnut producing country in West Africa, accounting for 51% of production in the region. The country contributes 10% of total global production and 39% that of Africa. Between 1956 and 1967, groundnut was the country's most valuable single export crop, exemplified by the famous Kano groundnut pyramids. Groundnut is a major source of edible oil as well as livelihoods for small-scale farmers in Northern Nigeria. Being a labor-intensive crop, it generates employment for the rural poor. It is planted on about 34%

of total cultivated area and contributes to 23% of household cash revenue. Groundnut products like oil and cake accounted for a significant percentage of total Nigerian export earnings. Before the fossil oil boom, groundnut was one of the major sources of revenue and foreign exchange earnings. However, in the post-1967 period, the combined effects of drought, increasing prevalence of diseases such as rust, leaf spots and groundnut rosette disease (GRD) have caused a decline in groundnut production. The total output of groundnut in 1970 was 1.6 m tons, but fell to 0.47 m tons in 1980. Due to insufficient groundnut stocks, processors and marketers in Kano State source groundnut from as far as Chad Republic. The year-round demand for groundnut means farmers can increase production without any fear of market glut. Since 1984, production has been increasing at an estimated growth rate of 8%, resulting both from area expansion (6%) and increase in productivity of 2% (Ndjeunga and Ibro 2010).

Agroecologies for groundnut production in Nigeria: Traditional commercial groundnut producing areas encompass the Sahel, Sudan and derived savanna, Northern Guinea and most parts of the Southern Guinea vegetation zone. The major groundnut producing states are Kano, Katsina, Kaduna, Jigawa, Sokoto, Zamfara and Kebbi in the Northwest; Adamawa, Bauchi, Yobe and Borno in the Northeast; and Benue, Plateau, Taraba, Nasarawa, FCT Abuja, Kogi, Niger and Kwara in the Central Zone. The recommended varieties and planting time of each of these agroecologies are presented in Table 1.

Table 1. Agroecologies, recommended varieties and planting time for groundnut production in Nigeria.

Agroecological zones (AEZ)	State	Recommended Varieties	Planting date
Wet Season			
Sahel Savanna	Sokoto, Yobe, Borno, Jigawa	Samnut 24 Samnut 25 Samnut 26	Early July
Sudan Savanna	Kebbi, Sokoto, Zamfara, Katsina, Kano, Jigawa, Yobe, Borno, Bauchi	Samnut 24 Samnut 25 Samnut 26	End of June to early July
Northern Guinea Savanna (NGS)	Kebbi, Zamfara, Katsina, Kano, Kaduna, Bauchi, Gombe, Adamava, Niger	Samnut 21 Samnut 22 Samnut 23 Samnut 24	Mid- to end June
Southern Guinea Savanna (SGS)	Niger, Kwara, Nasarawa, Borno, Bauchi, Gombe, Benue, Taraba, Adamava	Samnut 10 Samnut 21 Samnut 22	1st Planting: May 2nd Planting: End July
Derived Savanna	Kwara, Nasarawa, Benue, Taraba, Kogi, Oyo	Samnut 10 Samnut 21 Samnut 22	1st Planting: May 2nd Planting: End July
***Dry Season**	All states	Samnut 24 Samnut 25 Samnut 26	End October or Early February

*The challenge in the dry season is the low temperature during Harmattan months of December to January. Low temperatures significantly affect germination and growth.

Production Challenges

Rainfall variability and drought – This is one of the major causes of rainfed crop failure in the Sudan Savanna of Nigeria. The probability of drought is highest at the beginning and end of the growing season. Farmers sow their crops with the first rains when there is generally enough moisture for the seed to germinate and then accept the risk of having to reseed if subsequent rains are delayed. Drought stress at the beginning of the growing season severely affects plant establishment, leading to reduced yield or complete crop failure. Mid- and end-of-season drought is also common and often occurs at the critical physiological stages of pod formation and filling.

Drought also increases the probability of preharvest aflatoxin contamination (due to infection by Aspergillus flavus). Aflatoxin contamination of groundnut is a major hazard to human and animal health and is one of the major constraints to the groundnut trade. Risks related to human health and death and declining productivity in livestock after consuming aflatoxin-contaminated feed have led to groundnut importing countries setting standards that allow only extremely low levels of contamination and that are often not achievable by most resource-poor groundnut farmers.

Improved, early-maturing and drought-tolerant groundnut varieties, crop diversification (cereal-legume-livestock), improved soil and water management practiced on a large scale and coupled with appropriate policies will provide the opportunities to alleviate the adverse effects of drought on productivity.

Poor soil fertility: The soils of the dry savannas where groundnut cultivation is most popular are generally sandy, poor both in terms of nutrient content and water-holding capacity, and prone to erosion by wind and water. Any situation that precludes careful soil management can therefore easily lead to soil degradation, particularly in the dry areas where droughts are frequent. With the increase in demand for agricultural products arising from the ever increasing human population, farmers are forced to crop the same piece of land year after year, without allowing for any fallow period that would

Figure 1. A dry season farmer in Safana LGA Katsina State.

encourage soil restoration. However, rotating the staple cereal crops with a leguminous crop like groundnut also encourages livestock integration, and will alleviate the effect of continuous cropping (Fig. 1).

Biotic and abiotic constraints: Groundnut rosette disease, early leaf spot (ELS), late leaf spot (LLS) and rust are the major biotic constraints responsible for low yield of groundnut in Nigeria. Groundnut rosette is one of the most destructive diseases that affect groundnut, and wiped out more than half of the groundnut cropped area Nigeria in 1975. Resistant cultivars provide the most appropriate means of controlling the diseases, especially for smallholder farmers. Therefore, development and cultivation of rosette-resistant, high-yielding groundnut varieties with optimal duration is important to enhance and stabilize productivity.

Constraints to input supply: A range of high-yielding varieties of groundnut and improved agronomic practices to optimize their yield potentials are available, but wide-scale dissemination is limited by lack of seed. The seed sector faces many constraints including the limited supply of breeder seed, poor seed demand estimation and lack of interest by seed companies resulting in inadequate distribution systems. In addition, farmers are poorly linked to credit and input markets which are necessary to increase productivity for crops such as groundnut.

Opportunities

Government Intervention

Groundnut Value Chain: The Federal Government of Nigeria launched the Agricultural Transformation Agenda (ATA) which is implemented through various crop commodity chains. The vision of ATA is to achieve a hunger-free Nigeria through an agricultural sector that drives income growth, accelerates achievement of food and nutritional security, generates employment, and transforms Nigeria into a leading player in global food markets to grow wealth for millions of farmers. The Growth Enhancement Support (GES) investment is targeting 20 million farmers. The ATA action plan initially focuses on priority agricultural commodities including groundnut. ICRISAT and FMARD have signed an agreement on a project titled Rebuilding the groundnut pyramids: boosting farmers' income through new groundnut varieties, cropping

systems and processing technologies, value addition in Nigeria. This project will bring all major players along the value chain together, ensure they complement each other, and also ensure that ICRISAT is a major player in the implementation of the GNVC activities. In order to enhance the performance of the groundnut sector along the value chain, groundnut productivity needs to increase. Crop management practices that significantly increase yields of grain and fodder at competitive cost will be promoted. Because of largely proven integration between input and product market, marketing strategies that link the different players will be promoted. Farmers and/or farmers' organizations will produce for the market; they will be strengthened and organized around collective marketing in order to reduce transaction costs and increase their returns to investment.

This handbook, one of the outputs of the GNVC-ICRISAT collaboration, is written to help farmers, agricultural extension agents, and researchers in Nigeria and neighboring countries grow groundnut profitably.

Technological: Before 1992, 20 groundnut varieties had been officially released in Nigeria. Most of these are medium- to late-maturing varieties, requiring more than four months to mature. The growing season in the savanna zone is short (90-100 days) and requires short–duration varieties. In 2001, three varieties, SAMNUT 21 (UGA 2), SAMNUT 22 (M 572.80I), and SAMNUT 23 (ICGV-IS 96894) were formally released. Subsequently, early-maturing varieties resistant to several biotic stresses were released: SAMNUT 24 (ICAR19BT) in 2011, and SAMNUT 25 and SAMNUT 26 in 2013. These varieties have minimized the incidence of GRD which causes considerable annual yield losses, and are making a discernible difference in the lives of groundnut farmers in Nigeria. This is excellent news for farmers, who thought they had lost not only their primary cash crop but also their staple food. Scaling up the diffusion of these improved varieties will enable them to reach more farmers with significant impacts in a short time. Studies showed that only about 13% of the area under groundnut is planted with improved varieties (Njeunga et al. 2012).

Groundnut varieties intended for use in confectionery are also available. With the enormous irrigation potential in Nigeria, these varieties can contribute to new groundnut market niches. Several pre- and postharvest technologies to reduce aflatoxin contamination, including host plant resistance via

conventional and biotechnological approaches, agronomic practices and biological control, are currently being tested in farmers' fields in West Africa. ICRISAT has also developed inexpensive methods for the detection of aflatoxins in food and feed, like the ELISA based diagnostic test which is reliable and cost effective. The GNVC involves collaboration between FMARD, ICRISAT, IAR, NGROPPMAN, WAAPP, marketers and other stakeholders to scale up the best technologies to manage aflatoxins in food and feed. This will significantly improve the livelihood of the farmers and create better market opportunities.

Groundnut Production Practices

Soil and Climatic Requirements

Groundnut grows best in a well-drained sandy loam or in sandy clay loam soils. Deep, well drained soils with a pH of 6.5-7.0 and high fertility are ideal. Heavy soils are not suitable as this leads to high pod loss and difficulty of harvest. Pegging is also difficult on heavy soils; unlike sandy loam soils which facilitate pegging. The optimal soil temperature for good germination and vegetative growth is 27°C-30°C and 24°C-27°C for reproductive growth. Low temperature at the time of sowing delays germination, and increases likelihood of seed and seedling diseases and of infestation by sucking pests. An evenly distributed annual rainfall between 450 mm and 1250 mm per annum is required for good growth and yield. While groundnut can be produced in most parts of the country, in regions with over 1,000 mm rainfall the crop must be grown either in well-drained soils or on ridges. Groundnut can be produced under irrigation, and irrigated groundnut produces on average higher pod and fodder yields than groundnut in the main wet season (rainfed crop). The GNVC have started promoting dry-season groundnut cultivation in the vast irrigated lands in the country. This will boost the production of the crop in the country as well as availability of quality fodder for ruminant livestock.

Site Selection and Land Preparation

The ideal field for groundnut production should have soil that is well drained and light colored with either sandy, loamy sand, or sandy loam texture. Soils that make a ribbon when moist soil is rubbed between index finger and thumb are not advisable but soils that fall apart when rubbed should be used, as produce from such soils are clean and bright. It is not advisable for groundnut

to be grown repeatedly on the same field for a long period, as this may lead to build-up of soilborne groundnut diseases and nematodes. Groundnut-cereal rotation is ideal as the fertilizer applied to the cereals in previous season(s) can be effectively used by groundnut, which in turn enriches the soil with nitrogen through biological nitrogen fixation for the subsequent cereal crop, which then requires a lower dose of fertilizer. Therefore, proper crop rotation can lead to higher yields and substantial reduction in cost of disease control and fertilizer requirements.

Prior to sowing, the field should be cleared of all shrubs and stubble and crop residue from the previous crop. This helps avoid fungal attack and provides a smooth ground for growth and development. Conventional tillage is encouraged for groundnut production, as this ensures higher yields than conservation tillage (no-tillage, minimum tillage, reduced tillage and strip tillage). The land should be plowed and harrowed before making ridges to provide a good tilth for seed emergence. Groundnut may be planted on flat or on ridges, but planting on ridges produces higher yield compared to flats. In addition, ridge planting allows easy drainage of excess water, avoids compaction of seed beds and facilitates field operations such as weeding.

Choice of Seed and Seed Treatment

Some farmers usually think that the larger the seed, the better the seed quality. Others believe that smaller seeds germinate faster and are therefore better than larger seeds. Although this is true, it does not mean that larger seeds are of poor quality, but rather that they take more time to hydrate and germinate. Of course, this might not always hold true as some larger seed sizes can be immature. Essentially, seeds should have uniformity in size, shape and color that conform to the variety in question.

The seed used for production will determine the ultimate yield that will be obtained at the end. When selecting seeds of groundnut for cultivation, there are three important factors to consider – the source of the seed, the viability of the seed and its lifecycle. When a good viable seed is obtained, it is necessary to know how long it takes to mature so that the prevailing rain in the particular environment suits its production. Early-maturing varieties, for instance, are more suitable for areas with shorter annual rainfall, while late-maturing types will not perform in such environments but rather in areas with

longer rainfall duration. The maturity period usually comes from the source of the seed, and information about this may be obtained from extension agents and senior farmers. Disease-free, clean, unbroken and physiologically-matured seeds should be used for planting. Some newly released groundnut varieties in Nigeria with large kernel size and high fodder yield potential and with resistance\tolerance to important constraints are listed below:

Samnut-21: Medium-maturing (115-120 days) with dual purpose (kernel and haulm), high pod yield (2.5 t ha^{-1}), high haulm yield (4-5 t ha^{-1}) and good oil content (51%).

Samnut-22: Medium-maturing (115-120 days), dual purpose (kernel and haulm), high haulm yield (4-5 t ha^{-1}), high pod yield (2-2.5 t ha^{-1}) and good oil content (45%).

Samnut-23: Early-maturing (90-100 days), 2 t ha^{-1} haulm yield, good pod yield (2-2.5 t ha^{-1}) and high oil content (53%) and quality.

Samnut-24: Early-maturing (80-90 days), good haulm yield (2.5-3 t ha^{-1}), vigorous plant growth, good yield (2-2.5 t ha^{-1}) and high oil content (53%).

Samnut-25: Early-maturing (80-90 days), good yield potential (2.5-3 t ha^{-1}), highly resistant to rosette and moderately resistant to ELS and LLS disease, with high oil content (51.5%).

Samnut-26: Early-maturing (80-90 days), highly resistant to rosette and moderately resistant to ELS and LLSs disease, good yield potential (2-2.5 t ha^{-1}) and good oil content (50.9%).

It is recommended to treat groundnut seeds with chemical fungicides to avoid rot and pre- and/or postemergence damping off of seedlings due to fungal attack. Some insects are also known to attack germinating or emerging groundnut seedlings. In addition to seeds and seedling protection, seed treatments also reduce seedborne infections during seedlings germination and allow initial vigorous growth. To control the pathogens causing seed and seedling diseases, it is necessary to coat the seed with either Thiram® or Mancozeb® (50% a.i. at 3 g kg^{-1} seed) before sowing. Seed treatment before planting ensures the establishment of good plant stand and, subsequently, good yield.

Care should be taken while mixing these chemicals as they are poisonous, and the directions for use indicated on the label should be strictly adhered to.

Sowing and Sowing Date

Groundnut should be sowed immediately after the onset of the rainy season. This varies with the agroecological zone in Nigeria, usually happening towards the end of June in the Sudan Savanna zone but sometimes much earlier in the Northern and Southern Guinea Savannas. Table 1 displays details of optimal planting time per agroecological zone. With the current fluctuation in weather, it is difficult to give a standard date for planting, but farmers should plant as soon as there is adequate and consistent moisture in the soil for good germination and subsequent plant growth. The seed rate depends on the variety, the seed mass, planting distance and germination rate of the seed lot. The recommended spacing for bunch varieties is 75 cm x 20 cm; 75 cm x 10 cm, or 50 cm x 20 cm, while semi-spreading and spreading varieties can be planted at 100 cm x 20 cm or 75 cm x 25 cm. It is, however, important to find out the required or optimum plant population with inter- and intra-row spacing for any selected variety at one's location from extension agents or the seed source. Sowing should ideally be done with two seeds at a depth of 5 cm. Sowing deeper than this leads to delayed emergence, elongated hypocotyl (stem of germinating seedling), poor shoot and root development, poor nodulation and decreased nitrogen fixation, which will consequently lead to reduced yield. Thinning is not normally required in groundnut as this disturbs the seedling and because groundnut seeds are normally expensive. Therefore farmers should pay attention to the seed source and quality of seeds to ensure maximum germination and good seedling vigor.

Figure 2. Farmers inspecting SAMNUT 22 in Warji Bauchi State.

Figure 3. Dry season harvest SAMNUT 24, Minjibir Kano.

Figure 4. Groundnut in processors warehouse in Kano.

Weeding

Groundnut cannot compete effectively with weeds, especially during the first 3-6 weeks after sowing. There is a need, therefore, for early weed control for better yield. The average yield loss due to weeds has been reported to be about 30% and may reach up to 60% under poor management practices. It is thus advantageous to control weeds on groundnut fields using cultural, mechanical, physical or chemical means, especially during the initial six weeks

of growth. A combination of two or more control measures usually provides better results and is more economical. The most effective way is to apply a pre-emergence herbicide like pendimethalin followed by mechanical or hand weeding once or twice to keep the crop free of weeds after emergence. However, the ultimate choice depends on the species of weeds involved and the level of infestation. Generally, 2-3 weeding operations are recommended, the first before flowering and at least one more during pegging. Once pegging begins, however, soil disturbance near the plant should be avoided or kept to a minimum, so as not to interfere with the developing pods. Instead, the tall weeds at this stage can be controlled by hand-pulling.

Fertilizer Requirements

Groundnut has been reported to respond better to residual fertility than to direct fertilization. This means if a well-fertilized crop precedes a groundnut crop, direct fertilization may not increase the yield or quality of the groundnuts. If fertilizer is needed, it is best to broadcast and incorporate it with the soil during the land preparation. A soil test is the best way to determine whether fertilizer or lime is required in groundnut cultivation. Liming is necessary only when the soil pH is below 5.8. However if soil test results are not available, the general fertilizer recommendation of NPK kg ha^{-1} is: 25 kg of N - 50 kg of P2O5 - 100 kg of K2O. However for practical purposes two bags of NPK 15:15:15 plus two bags of Single Super Phosphate (SSP) and a bag of Muriate of Potash (MOP) can be applied per ha. (The latter is not commonly found in Nigerian markets). If the groundnut crop follows a well-fertilized cereal crop then two bags of SSP may be sufficient per ha. Application of 400 kg ha^{-1} gypsum at peak flowering/pegging stage both improves the seed filling and increases the oil content.

Harvesting

Groundnut is an indeterminate plant, so the pod maturity is not uniform. Harvesting should therefore be timed when most of the pods are mature because waiting for all the pods to mature will result in sprouting of the already matured pods especially in the southern States. or early planting in the Sudan Savanna zone. Early or premature harvesting, however, lowers the yield, oil quantity and seed quality. Plants from immaturely harvested seeds

germinate slowly and have low vigor and their survival can be difficult under stressful conditions. In addition to sprouting of pods, delayed harvesting also leads to loss of over-mature pods during harvest due to weakening of pegs, and increase possibility of Aspergillus flavus infection, and aflatoxin contamination in pods/seeds. In areas with early rainfall cessation, the crop should be harvested as soon as possible to avoid hardening of the soil, which makes harvesting difficult. One easy and practical way of determining the optimal time for harvest is to look for darkening of the internal surface of the pericarp (i.e. the shells turning dark brown inside) and when the seed coat is thin and tight on the kernel. This is a sign of seed maturity and the crop should be harvested as soon as it reaches this stage. Harvesting is also advisable when 70-80% of the pods have matured and seed are plump and show true color of the variety in use.

Groundnut can be harvested either by hand pulling the entire plant (this is possible only when there is enough moisture in the soil) or using a hoe or ox-drawn plow (usually used for spreading groundnut varieties on heavy soils and during dry conditions). This method is effective in lifting the entire crop from soils, with low pod loss. The harvested plants should be shaken well to dislodge soil from the pods and kept inverted with the pods facing upward for 2-3 days. This allows faster drying of the pods and prevents fungal growth.

Drying and Storage

After the harvested groundnut plants are stacked in the field for a few days for air and sun drying before stripping the pods, the pods are continuously dried till the moisture content is below 10%. This helps avoid the development of aflatoxin caused by yellow mold (Aspergillus flavus) and also preserves seed viability. In smallholder farming, the harvested plants are usually taken home for drying.

After cleaning and grading, the dry pods is stored in bags stacked up to 10 bags high in separated stacks to allow free air circulation or ventilation. The bags should be piled on wooden planks, not directly on the floor to avoid damage from damp. Dusting the bags with 5% Lindane® helps protect the pods from many storage pests.

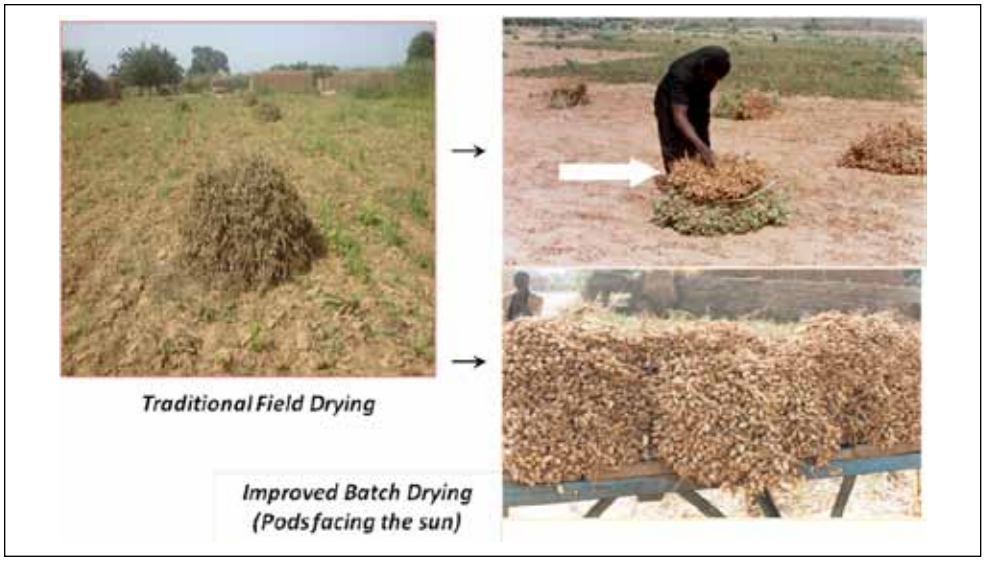

Figure 5. Groundnut drying methods.

Decortication or Shelling

Shelling is usually done by hand in Nigeria; however, hand-operated decorticating machines are currently available. Care should be taken to prevent cracking of the kernels. The following steps are important for maximum benefit in groundnut decortication:

- Separate immature pods as well as those infested with pests and diseases
- Do not shell by beating or trampling
- Either manual or motorized shelling can be used, but only if the shellers do not damage the pods
- Remove shriveled, discolored, moldy and damaged grains from the lot including groundnuts with damaged testae and dispose of them
- Remove dust, and foreign material which can provide a source of contamination.

Groundnut Diseases and their Control

Groundnut production is adversely affected by a large number of fungal, viral and bacterial diseases. Most of these are widespread, but only a few of them are economically significant. The major diseases in Nigeria include groundnut rosette, ELS, LLS, rust and aflatoxin contamination.

A. Groundnut Rosette Disease

Groundnut rosette disease, a viral disease transmitted by aphids, is the most common and most significant disease of groundnut in all regions where this crop is grown. It is widespread in SSA and has been a major factor in the decline of the Nigeria groundnut pyramids.

Symptoms: The disease can manifest two types of symptom: green or yellow (chlorotic). The affected plants are stunted and present a bushy appearance with a marked reduction in leaflet size with visible mottling.

- Yellow (chlorotic) rosette causes plants to initially develop a faint mottling on young leaves. Subsequently, leaflets are yellow with green veins. Plants infected when young produce progressively smaller, distorted, curled and yellow leaflets, while the symptoms in older plants are generally restricted to a few branches or the apical portion of the plant.
- Green rosette disease shows middle mottling on young leaflets with some leaf curling, but leaves are not distorted. Plants infected when young are severely stunted and dark green in color. Total yield losses have been reported in susceptible varieties. Early infected plants produce no yield and there is no control once a plant is infected.

A 100% loss in pod yield due to either chlorotic or green rosette disease may result if infection occurs before flowering. Control of aphids will prevent further spread of the disease.

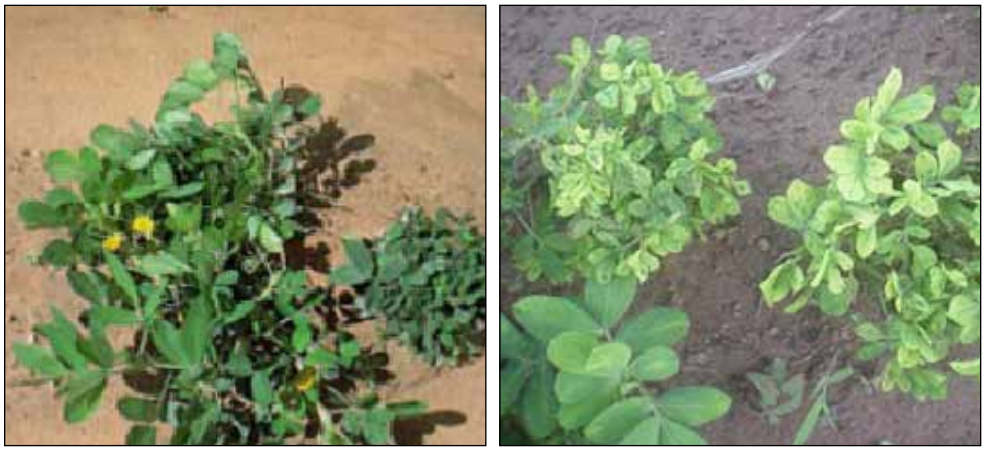

Figure 6. Groundnut green and chlorotic rosette disease.

Management

1. Chemical control:

- Spray the entire plant with insecticides, 14 days after emergence (usually 5 ml per 2 l of water, but check the label for instructions) and then at 14-day intervals with a total of three sprayings.

2. Cropping practices:

- Planting should be done as soon as there is enough moisture in the soil
- Close planting should be adopted
- Intercropping with cereals (maize, millet or sorghum) has been found to be effective in reducing the disease incidence

Note: Early sowing and close spacing of rows reduce disease incidence

3. Host plant resistance:

- Rosette-resistant varieties should be used for planting. Resistant varieties (Samnut 24, 25 and 26) have been released in Nigeria.

B. Early and late leaf spots

Early leaf spot (*Cercospora arachidicola Hori*) and LLS (*Phaeoisariopsis personatum* Berk & Curt) are the most damaging diseases of groundnut worldwide. Besides adversely affecting the yield and quality of pod, they also affect the yield and quality of haulm. Although just one leaf spot pathogen usually predominates in a production region, both leaf spot species are generally found in a single field. Shifts in leaf spot species have also been observed over a period of years.

Symptoms: Early leaf spot causes small necrotic flecks (spots) to develop which usually have light to dark-brown centers and a yellow halo. The spots may range from 1 mm-10 mm in diameter. Sporulation is on the adaxial (upper) surface of leaflets. In LLS, small necrotic flecks develop that then enlarge and become light to dark brown. The yellow halo is either absent or less conspicuous in LLS. Sporulation is common on the abaxial (lower) surface of leaves. Farmers often confuse leaf spots with harvest indicators, making mitigation measures difficult. The disease(s) may be expressed on both the leaves and stems, which results in poor crop stand and yields.

Management

Cultural control

- Crop rotation with crops like maize has been shown to provide partial management of leaf spots
- Early sowing has been shown to reduce the severity of leaf spot diseases. The date of sowing should be adjusted to avoid conditions favorable for rapid disease development.
- Burying all groundnut crop residues by deep plowing will reduce initial inoculum.

Chemical control

- Multiple applications of a fungicide such as benomyl, captafol, chlorothalonil, copper hydroxide, mancozeb or sulfur fungicides may control ELS and LLS. However, carbendazim (0.05%) has been found to control both leaf spots very effectively.
- Three sprayings of 0.2% chlorothalonil at intervals of 10-15 days starting at 40 days after germination up to 90 days provides effective control to ELS and LLSs.

Use of resistant lines

- Grow cultivars tolerant to LLS: Sources of resistance to both ELS and LLSs have been identified in groundnut and used to develop varieties with resistance. Recently released groundnut varieties in Nigeria are tolerant to foliar diseases.

Figure 7. Symptoms of foliar diseases (ELS, LLS and Rust).

C. Groundnut Rusts

Rust (*Puccinia arachidis* Speg.) is one of the important foliar diseases that reduces seed quality and causes substantial losses to groundnut production worldwide. If this occurs along with LLS over the losses can be as much as 50%.

Symptoms: Rust pustules (spots) are orange colored and appear on the lower surface of leaflets. On rupturing, they release masses of reddish brown spots. In contrast to the rapid defoliation associated with leaf spots, leaves infected with rust become necrotic and dry up but tend to remain attached to the plant.

Management

Cultural Control

- Crop rotation and field sanitation. This helps to reduce the initial inoculum in the soil
- Strict plant quarantine regulations should be enforced to avoid the spread of rust on pods or seeds to disease-free areas
- Early sowing minimizes incidence of the disease
- Intercropping cereal (maize, pearl millet or sorghum) with groundnut has been found useful in reducing the intensity of rust.

Mechanical Control

Destroy volunteer (self-sown) groundnut plants and crop debris to reduce/ limit primary source of inoculum.

Chemical Control

There are some chemicals effective for the control of rust disease, and these should be applied as soon as the symptoms are noticed. Some of the chemicals used are Chlorothaalonil 0.2%, Mancozeb 0.25% and Hexaconazole/ propaconazole.

Use of resistant varieties

In places where rust disease is endemic (common), the use of resistant/ tolerant varieties in combination with a little chemical control provides the best results. Rust-resistant varieties have been released in Nigeria.

D. Aflatoxins

Aflatoxins are a group of toxic metabolites produced by the fungi *Aspergillus flavus* and *Aspergillus parasiticus*. Aflatoxins are some of the most potent toxic substances found in foods and feeds. Scientific research shows that aflatoxin can cause various types of cancer in both animal species and humans. It has been reported to cause severe illness and death in many parts of the world. Chronic intake of aflatoxin in animals can lead to poor food intake and weight loss.

Aflatoxin contamination can occur in the field, during postharvest drying and storage, and even during transportation. Crop husbandry practices, mechanical damage, insect and bird damage, climatic conditions (drought, stress or excessive rainfall), and soil factors, in addition to host-plant susceptibility, significantly influence aflatoxin contamination.

Recommended postharvest practices to manage aflatoxin infection

Harvesting:

- Do not delay harvest when groundnuts have reached maturity
- Immediately after harvesting, pluck the pods off the haulms and place to dry as soon as possible
- Harvest carefully to avoid mechanical damage. This is particularly important if hand hoes are used to harvest the pods.
- Avoid field drying of groundnuts when attached to haulms as aflatoxins increase with delays of produce in the field.

Figure 8. Aflatoxin contamination in groundnut.

Drying

- Do not dry produce in contact with soil. Use clean sheets, for example polythene sheets or tarpaulin or mats made of papyrus, cemented grounds or raised structures
- Dry harvested pods to moisture content level below 13%
- Avoid mixing diseased or infected pods with healthy ones.

Shelling

- Separate out immature pods as well as those infested with pests and diseases
- Do not shell by beating or trampling on groundnut in shells
- Manual or motorized shelling is recommended but care should be taken that the shellers do not damage the pods. Use hand or motorized shellers specifically designed for groundnuts
- Do not sprinkle water on dry pods while using mechanical shellers. Instead, adjust (where possible) the space between blades and the sieve according to pod size to reduce breakage
- Remove shriveled, discolored, moldy and damaged grains from the lot including groundnuts with damaged testa and dispose of them.
- Remove dust and foreign material which can be a source of contamination.

Storage

- Properly dry groundnuts for safe storage to moisture content to less than 10%
- Place them in packages that will maintain suitable environment and prevent or restrict moisture pick-up and insect/rodent infestation
- Use new/clean gunny or polybags to store the groundnuts
- Put only clean sorted kernels into the bags
- Do not place bags directly on floor
- Do not heap groundnuts in shells/pods on the floor/ground inside storage structure
- Maintain proper storage facilities (well-ventilated, dry and with low relative humidity) and take care not to expose produce to moisture during transport and marketing
- Control insects and rodents during storage
- Do not mix new produce with old stock.

Major Pests of Groundnut

The majority of insect pests that attack groundnut can be grouped as: soil inhabiting insects (e.g. termites, white grubs, earwigs, subterranean ants); foliage feeding insects (leaf miner, caterpillars, armyworm, bollworm); those that transmit viral diseases (thrips, aphids); and insects that damage flowers and growing parts (blister beetle). Of all these, termites, aphids, thrips and leaf miner are the most important.

A. Aphids: *Aphis craccivora* Koch

These are brownish-gray polyphagous (that feed on other plants) insects. They are vectors of groundnut rosette disease, peanut mottle virus and peanut stripe virus in Asia and Africa. Aphids can cause yield losses up to 40% in groundnut. They can cause serious damage in drought situations when the crop is still young. Aphids are sporadic (periodic) pests and attack crops at all stages. Both adults and nymphs feed mostly on growing tips and young foliage by sucking sap.

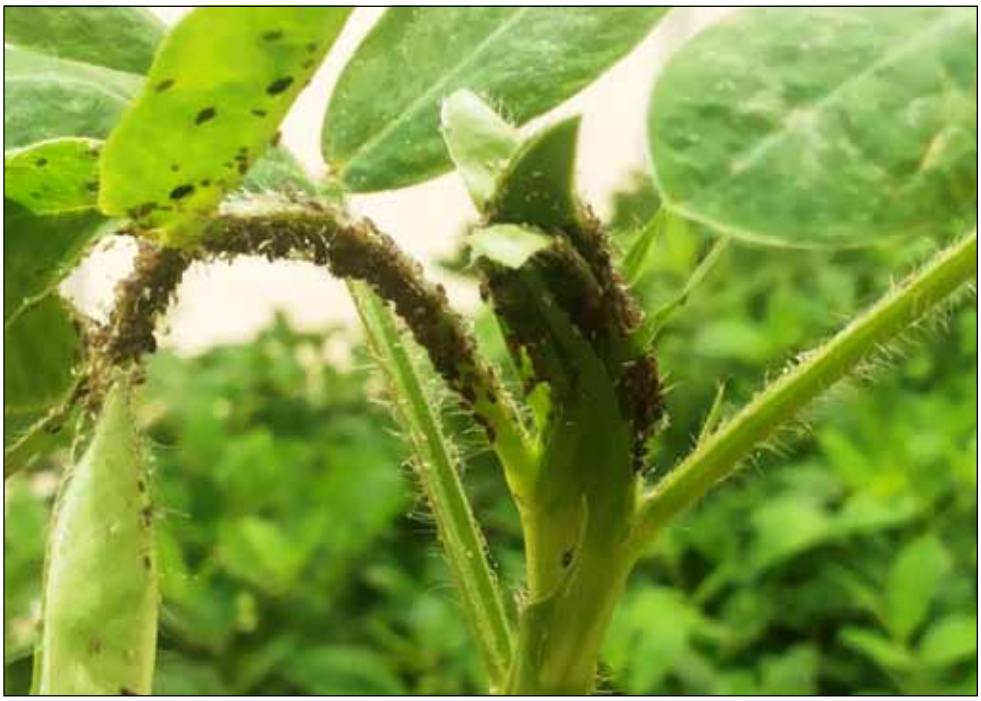

Figure 9. Groundnut aphid incidence.

Management

- Groundnut should be sown at the right time after good field sanitation
- Crop rotation should be practiced with non-host crop
- Intercropping with pearl millet has been found to be advantageous
- Destruction of volunteer groundnut plants and weeds
- Use of chemicals: Spray dimethoate 30EC at 650 ml ha^{-1}

B. Leaf miner

Groundnut leaf miner (*Aproarema modicella* Deventer), a defoliator from the order Lepidoptera, is a very serious pest of which attacks both the rainy and postrainy season crops and is regarded as the most important pest threatening groundnut production whenever outbreaks occur. It is much more damaging during the short rainy cycle when long drought precedes rains, and has been reported to cause total crop loss in some places.

Leaf miner larvae mine the leaves and feed inside the leaflets. Young larvae mine the leaves and later instars exit the mine to web together several leaflets. Damaged leaves become brownish, rolled and desiccated which leads to early defoliation and affects the growth and yield of the plants.

Management

- Use of chemicals such as Dimethoate 30 EC at 650ml ha^{-1} in 600 l of water
- Groundnut-cereal rotation has been found to reduce leaf miner incidence
- Manipulation of planting dates to avoid the pest buildup
- Use of leaf miner-resistant genotypes
- Use of trap crops
- Botanical pesticides and *Bacillus thuringiensis* Berliner can be used.

C. Thrips:

Groundnut plants are usually attacked by thrips (*Scirtothrips dorsalis* Hood) 6-8 weeks after planting. Thrips have short life cycle and may complete several generations per season under favorable conditions. They feed primarily in terminal leaf clusters between folds of young leaflets by rasping (scraping) the tender leaf surface and sucking the plant juice. Symptoms of thrips damage include dwarfing and malformation of leaves particularly in crops sown in

winter. Plants can outgrow this injury with no reduction in yield or grade under favorable conditions. However, the delay in vine growth from early-season thrips injury may retard maturity. Thrips can cause serious stunting of crops and yield loss from both direct feeding and virus transmission. They are carried, to a large extent, by wind; therefore, it is important to plant late groundnut upwind from earlier planted fields. Secondary spread occurs when immature thrips develop on virus-infected plants and then mature to the adult stage and feed on other groundnut plants within the same field. The virus can only be acquired by immature thrips feeding on infected plants. As the thrips mature they move to other plants nearby thus spreading the virus from plant to plant.

Symptoms of damage

Yellowish-green patches on the upper surface of tender leaves, and brown necrotic areas and silvery sheen on the lower surface.

Severe infestations cause stunting in plants.

Management

Use of chemicals such as dimethoate 30 EC 650 ml ha^{-1} or methyl demeton 25 EC 600 ml in 600 l of water.

Mixture of chemical and botanicals: use of monocrotophos 320 ml mixed with neem oil 1 l and 1 kg soap powder mixed in 200 l of water per acre, sprayed twice at 10 days interval.

Use resistant/tolerant varieties.

D. Termites: *Odontotermes* and *Microtermes spp*

Termite damage to groundnut is common in light (red and sandy) soil when rainfall is moderate. The *Microtermes* and *Odontotermes* species cause serious damage. Microtermes kills plants directly by destroying the roots. These are social insects that live in termataria, in distinct castes, workers, king and queen. The workers are small (4 mm) and have a soft, white body and a brown head. Termite damage groundnut includes wilting of plants in patches, penetration and hollowing out of the tap root and stem thus killing the plant, or holes bored into pods and damage to seed. Termite attack weakens the shells, making them vulnerable to entry and growth of *Aspergillus flavus*.

Management

- Digging the termataria and destroying the queen is most important in termite management.
- Using well-rotted organic manure
- Timely harvest of groundnut reduces the likelihood of termite damage to pods.
- Applying chlorpyriphos dust (30-40 kg ha^{-1}) to soil before sowing in endemic areas or application of carbofuran granules 3G (25 kg ha^{-1}).
- Chemical seed treatment may also reduce termite damage during sowing and the first part of crop phase.

Storage Pests of Groundnut

Groundnut is stored both as unshelled pods and as kernels for different uses. Both forms are vulnerable to attack by a number of insect pests after harvest. More than 100 insect species are known to live and feed on stored groundnuts, some of which are of economic importance. Groundnut kernels are more susceptible to insect attack than pods in storage. The amount of damage inflicted by insect pests during postharvest processing and storage depends on several factors such as moisture content in the product, the form in which it is stored, level of maturity at harvest, sanitation of storage space and the quality of the material itself.

Some important storage pests of groundnut include:

A. Groundnut bruchid (*Caryedon serratus* Olivier)

Groundnut bruchid, also known as peanut bruchid beetle, groundnut borer, or seed beetle, is a serious pest of stored groundnut, particularly when still in shells. The damage caused is particularly significant when the groundnuts are destined for confectionery purposes. C. serratus is of Asian origin, but has spread to many tropical and subtropical regions of the world.

Damage

The bruchid eggs (translucent milky-white) are attached to the pod walls of groundnut. After hatching, the larva burrows straight through the pod wall, and starts eating the seed. The first sign of attack is the appearance of ‘windows’ cut into the pod wall by the larva to allow the adult to leave the pod after emerging

from the pupal cocoon. They often live in the storage sacks and pupate in large numbers at the bottom of the pile of sacks. By this stage, the groundnut seeds are too severely damaged for human consumption or oil extraction.

Management

- To prevent primary infestation from alternative hosts, avoid drying groundnuts near alternative host trees such as tamarind and acacia
- When infestation is noticed, remove the infested seeds and follow up with the seed treatment for use in seed production
- Storing groundnut kernel with dried neem leaves (about 500 g of leaves for 10 kg kernel) in any sealed container can be effective
- Dusting storage bags with 5% Lindane® will protect the pods from many storage pests.

B. Red flour beetle (*Tribolium castaneum* herbst).

Red flour beetle, also known as rust red flour beetle, attacks stored groundnut and other grain products such as flour, cereals, meal, beans, and nuts. This beetle causes direct and indirect losses in groundnut that affects both the viability and quality.

Damage

The female lays eggs in cracks of the testa or on the damaged portions of the kernels to enable the young grub to feed on the kernel directly. The grub feeds on the kernels making them unfit for use as seed and human consumption. The damage results in powdery appearance in the produce. The infestation can be recognized by the presence of creamy-white grubs and active adult. Infestation by adult beetles can be readily observed by the tunnels they leave when they move through the flour and other granular food products. When infestation is severe, these products turn grayish-yellow and become moldy, with a pungent odor. Infestation may also be apparent by the appearance of adults on the surface of the seeds.

Treatment/control

- Fumigate the samples with methyl bromide by 32 g m^{-3} for 4 hours followed by treatment with chlorpyriphos at 3 g kg^{-1} seed
- Reject affected samples.

Dry Season Groundnut Production

Dry season irrigation plays a key role in the economics of Nigeria as a basic source of food, income and employment, especially for farmers in Fadama areas. The practice has increased significantly over the last few years because of increasing demand due to increasing population, high cost of vegetables especially in the dry season, and as an additional source of income to the farmers.

Groundnut was not commonly grown in the dry season in northern Nigeria, but a finding by ICRISAT-Kano on dry season groundnut production especially using early-maturing variety Samnut-24 revealed that it can successfully and profitably be grown. Unlike vegetables and fruits grown in the dry season, the groundnut produced during this period coincides with the period of demand for groundnut seeds, thereby making a market readily available to the farmers. In addition, the fodder from groundnut plants in the dry season provides a good source of income to the farmers, since fodder is usually most expensive in the dry season. The problems of postharvest losses and market congestion as in the case of fruits and vegetables are also not a problem with regard to groundnut. Through the effort of GNVC and availability of early-maturing heat-tolerant varieties, dry season groundnut production has been adopted by a large number of farmers in several states in Nigeria and the adoption rate is still growing.

Groundnut production in the dry season involves the same cultural practices as in the rainy season, but with slight modification. The basic cultural practices are as follows:

Land Preparation: Land preparation is same as in rainy season cultivation

Planting Date: The best time for planting is between January 15 and February 15, when temperatures are high (30^{o}C-38^{o}C), to enhance good seed germination and seedling development. Alternatively, groundnut can be planted at the end of the rainy season in mid-October.

Planting Pattern: planting can be done on ridges or flat beds using furrows. Planting on ridges should be done on sides of the ridges to ensure surface irrigation water reaches the seed for uniform germination and proper crop development.

Irrigation: Dry season groundnut production should be done where there is a source of water for irrigation. Depending on soil type and climatic condition, an irrigation interval of 7-10 days can sustain groundnut growth. Too much water should be avoided. Usually furrow irrigation is practiced, and it is advisable to adopt sprinkler irrigation to ensure more crop per drop of water.

Constraints: Since dry season groundnut production is usually done in areas where other crops are grown in the dry season, the major problem is that of defoliator and/or sucking insect pests. There are many alternative hosts for groundnut insect pests that may be present on other farms; therefore, 2-3 applications of insecticides such as cypermethrine + dimethoate should be undertaken to protect the plants.

Suggestions for further reading

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The **International Crops Research Institute for the Semi-Arid Tropics** (ICRISAT) is a non-profit, non-political organization that conducts agricultural research for development in Asia and sub-Saharan Africa with a wide array of partners throughout the world. Covering 6.5 million square kilometers of land in 55 countries, the semi-arid tropics have over 2 billion people, of whom 644 million are the poorest of the poor. ICRISAT innovations help the dryland poor move from poverty to prosperity by harnessing markets while managing risks – a strategy called Inclusive Market-Oriented Development (IMOD).

ICRISAT is headquartered in Patancheru, Telangana, India, with two regional hubs and six country offices in sub-Saharan Africa. It is a member of the CGIAR Consortium. CGIAR is a global research partnership for a food secure future.

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