Legume and cereal seed production for improved crop yields in Nigeria

Proceedings of the Training Workshop on Production of Legume and Cereal Seeds

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Edited by
H.A. Ajeigbe, T. Abdoulaye, and D. Chikoye

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Acronyms and abbreviations

ABU	Ahmadu Bello University
ACGF	Agricultural Credit Guarantee Fund
ACGS	Agricultural Credit Guarantee Scheme
ACSS	Agricultural Credit Support Scheme
ADB	African Development Bank
ADPs	Agricultural Development Projects
ADTFS	Agricultural Development Trust Fund Scheme
ADTPCP	Animal Disease and Trans-boundary Pest Control Project
AFCF	Agricultural Finance Credit Fund
BADEA	Arab Bank for Economic Development in Africa
BS	breeder seeds
CAFS	Channel Agricultural Finance Scheme
CBN	Central Bank of Nigeria
CS	certified seeds
CSDP	Community Seed Development Program
DAIMINA	Developing Agro-input Markets in Nigeria
DTCs	Demonstration Technology Centre
FACTS	First Bank Agricultural Credit to Schools
FAO	Food and Agriculture Organization
FAOSTAT	FAO Statistical Database
FBN	First Bank of Nigeria Plc
FCT	Federal Capital Territory
FGN	Federal Government of Nigeria
FMARD	Federal Ministry of Agriculture and Rural Development
FS	foundation seeds
FFS	farmers' field school
FTFSD	farmer-to-farmer seed diffusion
GFC	Guaranteed Fund Credit
IAR	Institute for Agricultural Research
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IITA	International Institute of Tropical Agriculture
IPM	integrated pest management
KMC	Kano Media Corporation
KNARDA	Kano State Agricultural and Rural Development Authority
LGAs	local government areas
LGCs	local government councils

MAAN	Maize Association of Nigeria
NACWC	National Advisory Committee on Weed Control
NAIC	National Agricultural Insurance Cover
NAERLS	National Agricultural Extension and Research Liaison Services
NARIN	National Agricultural Research Institute
NC	north central
NCA	National Council for Agriculture
NCAM	National Centre for Agricultural Mechanization
NCRI	National Cereals Research Institute
NFRA	National Food Reserve Agency
NGO	nongovernmental organization
NPFS	National Program for Food Security
NSPRI	Nigerian Stored Product Research Institute
NSS	National Seed Service
NVRI	National Veterinary Research Institute
ONAHA	Office National des Aménagements Hydro-Agricoles
OPV	open-pollinated varieties
PCU	Project Coordinating Unit
PROSAB	Promoting Sustainable Agriculture in Borno State
QPM	quality protein maize
SAP	Structural Adjustment Program
SEEDAN	Seed Association of Nigeria
SS	south-south
SSA	sub-Saharan Africa
SSC	South-South Cooperation
SSRP	Strategic Seed Reserve Project
SW	southwest
TAD	Trans-boundary Animal Disease
TFC	total fixed cost
TVC	total variable cost
UN	United Nations
USAID	United States Agency for International Development
VIP	very important person
WARDA	West Africa Rice Development Authority, now AfricaRice

Foreword

The Arab Bank for Economic Development in Africa (BADEA) as part of its technical assistance to the Federal Government of Nigeria (FGN) for the implementation of the National Program for Food Security (NPFS), sponsored a training workshop on legume and cereal seed production as well as other training programs. There were 44 trainees: 20 crop facilitators from the northern ADPs, 17 from the southern ADPs, and 6 crop coordinators from the National Food Reserve Agency (NFRA) Regional Offices. IITA organized the course at its Kano Station from 27 January to10 February 2008.

It was a training of trainers (TOT). The trainees were expected to train/retrain seed growers at 109 NPFS sites on seed production for maize, rice, sorghum, millet, cowpea, and groundnut. This is expected to improve the skills and competencies of these seed growers to ensure the timely availability of quality seeds of these crops for NPFS and outreach farmers to improve their productivity, income, and standard of living.

The proceedings, a good reference document, is a compendium of lectures delivered by an array of specialists carefully selected from relevant NARS, NFRA, NASC, IITA, and seed companies. Subjects covered were (i) the Community Seed Development Program, (ii) recommended seed production practices, such as pest and disease control measures for the four cereals and two legumes covered in the course, and (iii) quality control measures and seed marketing.

I sincerely thank BADEA for providing the fund for the training, IITA for organizing the course, and the course coordinators, Dr H. Ajeigbe of IITA and N. Utoh of NFRA. I strongly recommend this publication to policy makers, agronomists, seed specialists, crop facilitators, and enlightened farmers as a veritable source of information on cereal and legume seed production.

Cheikh Tidiane Sarr
Chief Technical Adviser, FAO/NPFS
Abuja, Nigeria

Preface

This was a follow-up to the collaborative training conducted in 2005 for the National Program for Food Security (NPFS), where state coordinators from some of the northern States of Nigeria were brought to IITA-Kano Station, for training on “improved crop–livestock systems”. A training workshop on the production of legume and cereal seeds was held in IITA-Kano Station, from 27 January to 10 February 2008. These were 44 trainees made up of 37 Seed Officers/Crop Facilitators from the 37 Agricultural Development Projects (ADPs) and 6 Regional Project Coordinating Units (PCU), and one representative of the National Seed Service (NSS). The workshop was sponsored by Arab Bank for Economic Development in Africa (BADEA) and organized by IITA in collaboration with NPFS.

Topics for discussion included grain legume and cereal seed production techniques, weed and pest control strategies on seed farms, safe handling of agrochemicals, postharvest handling and safe storage of seeds, seed quality control, the setting up of seed production entities, economics of seed production, and banking and credit facilities. Resource persons were drawn from among the universities (Ahmadu Bello University (ABU), Zaria; Bayero University, Kano, and the University of Agriculture, Umudike). research institutes [Institute of Agricultural Research (IAR), ABU, Zaria; National Agricultural Extension and Research Liaison Services (NAERLS), ABU, Zaria; National Cereals Research Institute (NCRI), Badeggi; Nigeria, Stored Product Research Institute (NSPRI), and IITA); private seed companies (Premier Seeds Nigeria Ltd. Alheri Seeds Nigeria Ltd.), ADPs, NSS, and a commercial Bank (First Bank Plc). The training included classroom presentations with audiovisual aids and participatory practical demonstrations in the field and screenhouse, as well as field trips to NPFS sites and seed companies.

Acknowledgment

The series of trainings was organized by IITA and NPFS. The authors are grateful to the staff and management of IITA, Kano Station, for their support during and after the trainings. The production of the proceedings and the conduct of the training were sponsored by BADEA. We are grateful to the the Coordinator of NPFS, Dr S. Ingawa, and his Deputy, Dr O. Oyebanji, and Cheikh T. Sarr, Chief Technical Adviser, NPFS, for their support and encouragement in organizing the training and for their assistance in this proceedings. The authors are grateful to Ms Rose Umelo of IITA, Ibadan, for editorial help.

Welcome address

Dr Ousmane Boukar

Chairman, IITA Kano Station Management Committee

Dear honorable guests, Dear participants, ladies and gentlemen:

It is my pleasure to welcome all of you to the International Institute of Tropical Agriculture for this important training workshop on legume and cereal seed production, organized by IITA and the NPFS, and sponsored by BADEA.

This training is a follow-up to the collaborative training conducted for NPFS in 2005, where State Coordinators from some of the northern States were brought to the station for training on improved crop–livestock systems. The objective of the current training is very relevant and I congratulate the organizers for their foresight in choosing the title, legume and cereal seed production.

We all know that seeds are the foundation of agriculture and the most important input to ensure good production. However, the Nigerian seed industry is still developing and until such a time that it is well developed, seed production at the community level, by government agencies, and from farmers' savings will still be very important for agricultural productivity. Efforts should therefore be made to improve the quality of seeds produced by those involved through training and retraining. At the same time, the seed companies should be encouraged to diversify into various crops, including self-pollinated crops.

The topics for this training have been carefully chosen and will be delivered by some of the best presenters on these subjects in the country. Resource persons were drawn from among the scientists from the Institute, from the universities, seed companies, and experienced farmers. Seed Officers, Crop Facilitators, and Crop Coordinators will have this opportunity to review the concepts and practices of seed production and to exchange their experiences. All the important agronomic practices/techniques, all the important production constraints, as well as the main solutions to alleviate these constraints, will be covered. While here for the next 7 days, I will ask you to take this opportunity to interact with the scientists and staff of the Station. I would like also to inform you that there is the opportunity in the Station for students to conduct their graduate and postgraduate research projects. Those of you interested could contact the scientists in the relevant field of interest.

Before I stop, let me use this opportunity to thank BADEA, the sponsors of this training, and assure them that the money invested in this training is money well spent. We are also grateful to the NPFS for choosing IITA to collaborate in this training and we look forward to many more collaborations in areas of interest. IITA Kano is proud to contribute to the improvement of the skills and competencies of the participants of this training in the production of certified seeds of cowpea, groundnut, sorghum, maize, rice, and millet.

With these few words, I, on behalf of the Management Committee and all the staff, welcome you to the Station. Please feel free to contact the organizers or any of our staff for necessary assistance. I wish you blessings from Allah.

Part 1:
Improved agronomic practices for the production of seeds

1. Cowpea and groundnut seed production practices

B. Ousmane and H.A. Ajeigbe
International Institute of Tropical Agriculture, Kano Station

Introduction

The most important prerequisite for good crop production is the availability of good quality seeds of high yielding varieties, adapted to the growing area, and preferred by the farmers. The quality of seeds alone is known to account for an increase in productivity of at least 10–15%. To achieve this high quality, all the factors in production that will affect viability, and genetic purity should be taken into account. The production techniques should be mastered and the environmental conditions (soil fertility and climate) known.

Cowpea and groundnut are both self-pollinated crops and seed production does not differ significantly. Agronomic practices in both crop and seed production are similar to those used for producing food grain. The difference lies in the standard of the output. Good quality seeds should meet the following characteristics:

- Genetic purity and uniformity conform to the standards of the particular cultivar.
- Seeds are disease-free, viable, and free from admixtures of seeds of other crops and weeds, and inert material.
- Seeds are uniform in size, shape, and color.

To be successful, seed producers must understand seed quality, know how it is achieved and maintained, and how they can process the seeds from harvest to their delivery to the farmers.

Characteristics of seed lot quality

Improved seeds have five related components.

Genetic purity: Genetic superiority is inherent in the variety and has an effect on the maturity date, disease and insect resistance, and nutritional quality. Protecting genetic purity depends on accurate record keeping, the use of clean equipment, and good handling.

Crop purity: Crop purity means that crop is free from contaminants, including the seeds of weeds and other crops, and inert material.

Seed health: Seed health refers to the absence of seed-borne diseases existing on or in groundnut or cowpea seeds.

Germination: Germination is the measure of a seed's ability to produce a normal seedling when planted in ideal conditions (with optimal temperature and moisture plus good aeration). The seed germination test is the universal standard measure of seed quality.

Vigor: Seed vigor has an important implication in the emergence rate and the final plant stand. According to their vigor, seeds can withstand stress during germination and early seedling development.

Classes of seeds

Breeder seeds: This is the primary source for the entire system. They are usually produced by crop breeders or at least under their supervision. Breeder seeds are usually produced in a limited quantity at a time (from about 100 kg to 2–3 t/variety). This is to ensure high quality. Breeder seeds should have not less than 100% variety purity.

Foundation seeds: These are the seeds produced from the breeder seeds. An enlightened farmer can produce foundation seeds under a contract agreement with a national seed regulation body, such as the National Seed Service (NSS). Other agencies such as research institutions, ADPs, and NGOs can also be commissioned to produce foundation seeds. Foundation seeds should have 99.9% varietal purity and are used for certified seed production.

Certified seeds: Certified seeds are produced from foundation seeds, usually by seed companies and other private seed producers certified by the NSS. Production is guaranteed by inspection and certification by an agency independent of the seed production agencies. Certified seeds are used for grain production.

Preplanting and planting decisions

Seed selection*:* It is important to use genetically pure seeds of a given variety from a reliable source (registered seeds). Pure seeds should be obtained from the breeder or the research institution responsible for developing the variety, or from registered growers in your area.

Field selection: The choice of field is an important component of good seed production. Cowpea is less demanding than groundnut and can be grown in soils of diverse types, ranging from predominantly clay to predominantly sand, and from acidic to basic. For both cowpea and groundnut, the best soil is a well-drained, sandy loam to clay loam soil with pH 6 and 7. To manage disease, insects, and weeds, the history and crop rotation of the field should be known. It is important to select a field that was not planted in the previous year with another variety of cowpea (or groundnut, in the case of groundnut seed production). The field should be isolated from other fields of the same crop by at least 3 m for certified seed production and by 5 m for foundation seeds.

Equipment tune-up: Planting equipment should be tuned-up to maximize planting efficiency with uniform plant spacing and planting depth.

Land preparation: Land should be prepared as early in the season as possible. The land should be cleared of old crop residues that could be burned. For cowpea that is planted later in the season, herbicide can be used before planting. Generally, deep plowing and harrowing once or twice will provide good root growth that enables plants to get moisture from the soil. The recommendation for groundnut production in drier areas is a flat seedbed and in the forest, ridges 1 m apart and running across the slope.

Fertilization: For good cowpea or groundnut seed production, phosphorus and potash fertilization are required, notably in the poor soils of the Sudan savanna and Sahelian regions of West Africa. Fertilizer applied at the rate of 200 kg/ha of 0-5-15 or a combination of 30–40 kg/ha P_2O_5 and 25–30 kg/ha K_2O is sufficient to ensure good growth of the cowpea crop. The fertilizers should be incorporated in the soil before planting. Top dressing is not advised. For groundnut, the application of 54 kg/ha P_2O_5 and 25 kg/ha K_2O is required to get good crop production. Fertilizer can be applied before or immediately after planting. If available, organic manure at the rate of 3 t/ha should be applied.

Method of planting and spacing: Both cowpea and groundnut can be grown in flat beds or on ridges, depending on the field conditions. For cowpea, a spacing of 75 cm between the rows and 20 cm between plants within the rows is used for the medium maturing varieties; spacing of 50 cm between the rows and 20 cm between the plants within the row is used for early maturing varieties. The recommended spacing for groundnut is 75 cm between the rows and 25 cm between the plants within the rows.

Planting date: For groundnut, planting should be done as soon as possible after the onset of the rains. Early planting is recommended to avoid rosette attack. For cowpea, planting is done when there is sufficient moisture in the soil to allow germination and when there will be enough time for the varieties to mature after the end of the rainy period. In general, IITA recommends that the ideal time for planting medium maturing varieties is about 60–75 days before the rains are expected to end and for extra-early varieties, about 45–50 days before the end of the rains.

Growing season decisions

Weed control: It is important to keep the field for seed production free of weeds from planting to harvesting. All available and effective weed control methods should be used according to growing or field conditions. Mechanical weeding, hand weeding, preemergence and postemergence herbicides can be adopted to keep the fields weed-free.

Disease control: All the available control methods should be used to reduce disease incidence. Treatment of seeds with chemicals is recommended for both groundnut and cowpea. Fungicides are used to control fungal disease in cowpea. For groundnut, two main diseases are reported in Nigeria: *Cercospora* leaf spot and rosette during the growing period. Resistant varieties are available for their control.

Insect control: To ensure good quality and quantity, it is important to control insects in both groundnut and cowpea. Millipedes and termites are the most damaging for groundnut. The most important insect pests of cowpea include aphids, flower thrips, *Maruca* pod borers, and pod sucking bugs. Insecticides are recommended to prevent crop losses. In general, the number and the type of insecticide spays will depend on the nature and severity of infestation and also the cowpea variety. However, 3–4 insecticide sprays are recommended for cowpea seed fields.

Rogue off-type plants: Field inspection is one of the important activities in seed production. Off-type plants are removed from the field as soon as they are seen. Off-types have different leaf types, different flower colors, different pod colors, or different maturity periods compared with the variety being multiplied. Not more than 0.5% of off-type plants should be found in a good seed production plot after roguing has been completed. Diseased plants should also be discarded.

Harvesting

Harvesting should timely when most pods are dry. For cowpea, multiple picking may be necessary.

Digging and harvesting for groundnut

Groundnut is indeterminate in growth habit. Usually, better germination is obtained when seed fields are harvested one week earlier than commercial fields. Optimum harvest dates differ from one variety to another and from one set of growing conditions

to another. Harvesting very early is not recommended. Although immature seeds can grow, their germination is slow, their vigor is low, and their survival can be difficult In stressful growing conditions. Early harvesting can decrease the seed value. Too late harvesting also has an adverse effect on seed quality (deterioration of the pods, more mechanical damage to the seeds, increased number of seed pathogens). Harvesting is recommended when at least 70% of the seeds are close to or at maturity, i.e., when most of the pods are in the brown and early black stages.

Some environmental elements can influence seed quality during harvesting because of high moisture content (35–60%). High temperatures will cause physiological heat damage that will reduce germination and vigor. A good rule of thumb is to harvest groundnut as soon as possible after seed moisture has reached 20 to 25%.

Threshing/decorticating

Threshing and decorticating can be done by hand or by using a hand-operated decorticating machine. Care should be taken to prevent cracking the kernels. For cowpea, it is possible to identify off-type seeds (different seed coat colors, different seed sizes).

Big seeds versus small seeds

In general, many farmers and seed producers think the bigger the seeds, 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 poor quality but they take more time to hydrate and germinate. Small seed size is usually associated with immaturity. This is not always true, as some larger seed sizes can be immature.

Postharvest handling of seeds (curing)

Groundnut should be cleaned before being dried. Cleaning and spreading of seeds will reduce drying time and costs. Seeds can be damaged by excessive drying, rapid drying, or drying at high temperatures. For cowpea, the moisture content should not be more than 10%.

Seed storage

Groundnut seeds should be stored in a cool, dry, airy environment. They can be shelled soon after harvest and stored in bulk containers. Continuous airflow should be ensured.

Cowpea seeds should be properly stored to avoid attack by bruchids. Seeds should be stored using fumigants in closed containers or in closed rooms.

Summary

The production of high quality groundnut and cowpea seeds necessitates a high level of management that covers the period from planting to the delivery of seeds to the growers. Seed growers should plan all farm operations well in advance to ensure the seed crop has the highest priority. Lastly, agronomic practices (disease management and maturity at harvest) should be applied properly in seed fields.

2. Recommended seed production practices for maize

I.S. Usman
Department of Plant Science, Institute for Agricultural Research
Ahmadu Bello University, Samaru, Zaria

Introduction

Breeding programs are continuously developing new maize varieties. These are often higher yielding than the older varieties or farmers' varieties, and may have other value-added traits, such as early maturity or better disease resistance. To benefit from a new, improved variety, farmers should first obtain seeds. Seed production should be done in a manner that maintains the purity of the variety and gives good quality seeds. The experience of other countries has shown that community-based seed production systems are sustainable as long as the seeds have been produced and stored properly. This system will lead to the emergence of small-scale seed enterprises that could form a network with private seed companies in making good quality maize seeds available to farmers across the length and breadth of the country and help in ensuring food security. At the outset, the farmers will need good seeds of appropriate varieties and other forms of technical assistance to establish their productive capacity in the short term and to stabilize food production and rural livelihoods in the long term.

Maize is grown worldwide and is a major traditional food cereal in the tropics. In Nigeria, maize production is increasingly popular owing to its increased use as food for humans and livestock. In addition, maize has a relative yield advantage over traditional crops, such as millet and sorghum. International research centers, such as IITA, in collaboration with national research institutes, are continuously developing new maize varieties.

However, being relatively new to the African savanna, maize is plagued by a lot of production constraints. Most notable among these are *Striga*, streak virus infestation, and insect pests, as well as environmental problems such as drought and low soil fertility. Poor quality seeds are another important limiting factor in maize production. Often, farmers obtain seeds from the previous season's harvest or purchase seeds directly in the open market without regard to genetic purity. A key activity in raising crop yields and agricultural output is increasing the availability of quality seeds and other inputs. This paper describes the recommended practices for the production of open-pollinated maize varieties (OPVs).

Reproduction in maize

The maize plant has separate male and female flowers. The male flowers, or tassels, are located at the top of the plant, whereas the female flowers (ears and silks) develop about halfway up the stalk. The location of the tassel at the top of a relatively tall plant and its separation from the female flower promote cross-pollination among plants. Commonly, pollen from a tassel will be blown by the wind to one or more plants nearby. Pollen is very small, and a single tassel may produce up to 25 million pollen grains. Shortly after pollen makes contact with the female silk, it germinates and grows down through the silk, eventually fertilizing the young ovule. The fertilized ovule develops into the embryonic plant within the developing seed.

The classes of maize seeds and choice of maize varieties

There are three classes of maize seeds.

Breeder seeds: Usually handled by the breeders, this is the first stage in the chain of seed production. The breeders impose strict control, observe isolation distances, inspect the crop, and rogue off-types regularly to maintain genetic purity. Breeder seeds are produced with wide spacing to allow maximum expression and easier roguing.

Foundation seeds: Breeder seeds are used to produce the foundation seeds, either by researchers or by contracted seed growers. Guidelines are followed similar to those used to produce the first class of seeds. The seed crop must be inspected at least three times by NSS inspectors.

Certified seeds: From foundation seeds certified seeds are produced in a planting pattern similar to that used for breeder and foundation seeds.

Choice of maize varieties

Farmers embarking on maize seed production should be familiar with the available maize varieties and their characteristics. Farmers should be able to select from these varieties those that are most suitable for their location and preferred in their market. Some of the varieties available in Nigeria are presented in Annex 1. Foundation seeds of the selected variety can be requested from either the national maize program or an international center, such as IITA. Alternatively, foundation seeds may be available through sources in the private sector.

Isolating a seed production field

When producing seeds, a farmer wants to maintain the characteristics of a variety. Cross-pollination between different maize varieties should therefore be prevented. Isolating the seed production field from other maize fields helps to achieve this. If two different varieties are grown next to each other, cross-pollination will occur between the varieties and the crop grown from such seeds will have a mixture of the characteristics of both.

Isolation of a seed crop can be done in four ways.

By space. Maintain a distance of at least 300 m between the seed crop and any other maize field where a different variety is planted.

By time. Sow your seed crop at least 2 weeks earlier or later than in the neighboring maize fields.

By certified seed barriers. A barrier of genetically pure seed of the same variety may be planted within the isolation distance of the seed production field.

By natural barriers. Seed production plots can be established on land isolated by natural or artificial forests.

Isolation by distance or time is the approach most commonly used. The goal is to have no other maize variety shedding pollen nearby when the seed production field is flowering. Wind may carry pollen further than 300 m. Thus, if there are constant strong winds in one particular direction, the distance to the next maize field should be at least 400 m.

Considerations for breeder and foundation seed multiplication

The half-sib method is commonly used to produce breeder and foundation seeds of maize. With this method, rows are arbitrarily designated as males and females in a ratio of 1 male to 2–4 female rows just before flowering. All plants in the female rows are de-tasseled. Undesirable and off-type plants in the male rows are also de-tasseled to ensure a better control of the pollen source. The best ears are selected from the female rows and used as progenitors for the next generation of breeder seeds. The remaining ears are harvested and bulked to provide foundation seeds after being sorted and graded.

Site selection

Soil for growing maize should be fertile and well drained, with sufficient and reliable rainfall evenly distributed over the growing season. Waterlogged conditions should be avoided. Recommended maize varieties for the area should be obtained from a reliable seed source and planted. Depending on the history of the site, seed treatment with fungicides or insecticides may be necessary before planting. Consult your neighbors about when and where they will plant their maize, so you can sow yours in a field that is properly isolated. Apart from considering isolation, select your best field for maize seed production and manage it well, because the value of good seeds is higher than the value of grain. Choose a field where no maize has been grown during the previous year to reduce the possibility that seeds from last year's maize crop may germinate and cross-pollinate your seed maize. Farming communities may want to produce the seeds of one variety for the entire community in a single field [e.g. Quality Protein Maize (QPM) villages]. This will help in the choice of a well-isolated field with good soil. Also, the village can make a collective effort to look after the maize crop well.

Cultural management of a seed production field

Cultural management practices are crucial to the success of any crop. For better aeration and retention of moisture, land preparation becomes necessary. Land is prepared in the form of ridges, 75 to 90 cm apart, manually, by ox-drawn ridgers, or by tractors. Animal traction is also commonly used on lighter soils. Large-scale commercial farmers use tractors to plow, harrow, and ridge their farms. Seeds are sown as soon as the rains are established to ensure sufficient soil moisture for proper germination. Three seeds/stand are usually sown about 3–4 cm deep on the ridges, 75 cm apart with an intrarow spacing of 50 cm. The seedlings are thinned to two/stand at 2 weeks after sowing. In small-scale production, hand weeding two to four times may be required to control weeds. The weeding should be at 3–4 week intervals. On large-scale production fields, however, recommended preemergence herbicides, such as atrazine and metolachlor at 4 L/ha, could be applied.

Remolding 30–35 days after planting improves weed control and reduces fertilizer losses. Stem borers, army worms, ear worms, and other insects should be effectively controlled using recommended insecticides, such as vetox 85, carbaryl, or primicarb. Similarly, maize diseases, such as downy mildew, stalk and ear rot, streak disease, rust, leaf spots, or smut, should be effectively controlled. Planting disease resistant varieties is the cheapest control method. Crop rotation and burning crop residues are other effective pest and disease control measures.

Recommended fertilizers should be applied at recommended dosages and times, and with the right methods of application. Fertilizers applied at 120 kg/ha N, 60 kg/ha P_2O_5,

and 60/ha kg K_2O are often recommended as a blanket dose. The actual rates and types of fertilizer should be based on the nutrient status of the soils, which can be determined through soil tests. In drier areas, irrigation may be required before planting and at intervals up to physiological maturity. In general, light-textured soils need more frequent irrigation than heavy soils.

Prepare the soil in your field at least 2 weeks before planting. If there are any seeds from previous maize crops left in the soil, they may germinate in these 2 weeks and you should remove them when you sow your maize seed crop. If possible, sow your maize seed crop early. Choose a plant density that is recommended for your area. A common seeding rate for maize is 20 kg/ha. Planting in straight rows will facilitate crop management and seed production operations. Apply fertilizer and remove weeds in time.

Eliminating undesirable plants

Carefully examine your maize seed crop as it grows. You may find plants that look very different or flower much earlier or later than most other plants in the field. These plants are called off-types and they should be removed—a process known as roguing—before pollen shedding starts. Most farmers do not like to remove any maize plants from their field, but roguing is critical in maintaining varietal purity.

Harvesting and drying

During harvesting and drying, be careful that the seeds of your maize crop do not get mixed with seeds or grain from other maize varieties. Keep only the best and healthiest ears and kernels for seeds, and use the rest of the harvest as grain. Your best seeds come from healthy, undamaged ears that are typical for the variety. Thus, discard off-types, rotten and damaged ears, and ears where the kernels have started to germinate or are affected by insects. Place the harvested ears on a clean and dry surface, such as concrete or plastic, and dry them well in the sun. To make sure that all kernels get exposed to the sun, spread the ears in a flat layer and turn them several times. Maize seeds can best be stored at <12% moisture content.

Shelling, cleaning, and storing seeds

When the maize is dry, it can be stored on the cob or shelled. Be careful not to damage the seeds when shelling. Your best seeds typically come from the middle part of the ear. After shelling, clean the seeds, removing dirt and other inert matter. Remove any that are small, look diseased, have started to germinate, or are damaged by insects. Treat the seeds with an insecticide–fungicide combination, and store in a dry and cool place. When treating the seeds, follow the guidelines on the seed treatment package carefully. One good way to store seeds is to place them in a jute bag, close the bag and drop it into a plastic bag, close the plastic bag and place this in another jute bag, finally closing the outer jute bag. Seed bags should be stored in a seed warehouse on wooden pallets in cool conditions, away from fertilizer and chemicals.

Quality control in maize seed production

The production and distribution of quality maize seeds require diligent efforts both during field production and in postharvest handling. Field inspections are commonly conducted at different stages of crop development to ensure quality. Farmers are advised to contact the NSS to notify the officials of their seed production plans and arrange for field

inspection. Cooperative groups, seed companies (in the case of out-growers), or the ADPs may facilitate this arrangement.

A planting inspection is commonly conducted to determine that the maize seeds planted are genetically pure, of known origin, and an appropriate variety for the area. If a mechanical planter is used, it should be checked to ensure that it is clean and free of maize seeds of other types and properly calibrated to achieve the recommended seeding densities. The field should be inspected to verify that it is properly isolated and free of volunteer plants. A second field inspection may be made during the vegetative growth phase. Isolation should be checked, along with the presence of disease, insect pests, or weed infestations. At this stage, off-type and diseased plants may be rogued. The most important field inspections are made just before and during flowering. At this time, the maize seed field is most susceptible to genetic contamination from wind-blown pollen coming from off-type plants within the field or from other maize varieties in surrounding fields. Therefore, it is essential during the pre-flowering inspection to confirm that the maize seed field has been properly rogued and is sufficiently isolated. Plants that are off-type or diseased, along with harmful weeds, should be removed at this time. A pre-harvest or harvest inspection may be conducted as the crop reaches maturity and the maize has lost a significant portion of its moisture content. Off-type plants, such as those that are still green when most of the other plants are dry, may be removed at this stage. At harvest, ears with a different grain color or texture from the produced variety should be removed.

Various standard tests for moisture content, germination, and physical purity can be conducted to evaluate the quality of the seeds. This is usually carried out on samples collected from the field during inspection visits or drawn from seed stocks before the beginning of sales. The most common evaluation is the germination test, designed to determine the seeds' capacity to germinate and produce normal plants when sown under appropriate conditions.

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3. Recommended seed production for sorghum and millet

J.O. Adeosun
National Agricultural Extension and Research Liaison Services
Ahmadu Bello University, Samaru, Zaria

Introduction

Sorghum and millet are the two crops that constitute the largest volume of cereals produced and consumed in Nigeria. Millet is more drought tolerant and one of the few crops that thrive well in drier areas where sorghum and maize cannot grow to full maturity without irrigation.

Salient points on quality seed production

The availability of good quality seeds of improved varieties at reasonable prices plays a vital role in agricultural productivity. All other things being equal, attempts to increase productive areas will achieve nothing without seeds of good quality and improved varieties. Seeds are the first component to be adopted when tested with others in any technology package designed to increase crop yield. The reasons for the importance of improved seeds are numerous and include, but are not limited, to the following:

- They serve as the most cost-effective means of increasing the yield/unit area of cultivated land.
- They determine the upper limits of the efficiency of all other inputs including fertilizer, agrochemicals, labor, equipment, and management practices.
- They serve as a tool to transfer to farmers the benefits of Government's investments in research efforts.
- They justify the investment in agricultural production through the economic returns gained by their use.
- The following should be noted.
- The economic benefits derived from improved seeds are much higher than the prices paid for the seeds.
- Improved seeds have practical benefits for both small and large-scale farmers.
- Good seeds are needed for a good harvest.
- Improved seeds give higher yields and greater farm incomes.
- The use of improved seeds is a key tool for abundant food production, national food security, and food for all.
- The type of seeds sown determines the types of harvests obtained under any management regime.

Vital responsibilities of seed producers

- Select and produce the varieties of open-pollinated millet varieties or hybrids most appropriate to the needs of farmers and use the approved seed production practices.

- Use good sources of seeds for planting.
- Use a compact area approach for close supervision.
- Use sites that prevent external contamination and volunteer plants.

Recommended practices for quality seed production

The basic seed production practices include the following:

- proper site selection for production
- the source of seeds
- isolation from other varieties
- removal of undesirable plants (roguing)

Site selection criteria

- Adaptation of crop/variety to the production environment.
- Previous cropping history as related to same variety/species.
- Accessibility of the site to the transport network for ease of field inspection, supervision, and monitoring of field activities.

Source of seeds planted

- Seeds must be pure varieties of known origin.
- Seeds must be free of other crop seeds, weed seeds, and seed-borne diseases.

Isolation from other varieties and roguing of undesirable plants

- Seed production plots must be properly isolated in distance or in time.
- Roguing should be routinely done to remove undesirable plants, off-type plants, variants and out-crosses, various weeds, diseased plants, and other crops.
- Roguing is done at all stages of crop growth to prevent contamination.

Seed production practices of cross- or open-pollinated millet varieties

Variety for a cross-pollinated crop means a self-reproducing population of plants that, although not genetically identical, exhibit the same unique, recognizable characteristics. Such varieties include landrace varieties, synthetic varieties made from inbred parents, and varieties resulting from recurrent selection, including mass selection. A variety, therefore, is a narrow-based breeding population exhibiting a range of variability that needs to be protected against contamination by pollen of external origin during seed multiplication.

Land preparation: Millet needs well-prepared land, but as it is the first crop of the season, most farmers sow it directly after the first rain or sometimes even before rain, without preparing the land. For seed production, the land should be prepared well at the onset of rain with ridges 75 to 100 cm apart.

Site selection: Millet does well in a wide variety of soil types but the best performance is achieved in a sandy loam, well-drained soil, rich in organic matter.

Recommended varieties: There are two major groups of recommended and local varieties available for planting, Gero and Maiwa. Gero varieties include the improved recommended variety SOSAT Ex-Borno as well as the dwarf Nigeria composites that include varieties recommended for most millet producing areas. Maiwa varieties include SAMIL 1–7 (see Annex 2).

Seed treatment: Use recommended seed dressing chemicals to dress the seeds. Shake the seeds with the powder in a closed container or gourd thoroughly for about 3 min or until the seeds are completely covered. Allow the seed dressing to settle before opening the container. As a safety precaution, bury the empty seed-dressing container completely and wash your hands thoroughly after planting or handling dressed seeds.

Spacing and seeding rate: Plant 6–8 seeds/hill at an interrow spacing of 75 cm and thin to 2–3 plants/stand after a rain to avoid excess seedling competition. Maintain a plant population of 50,000/ha. For seed production, a close spacing of 25–30 cm is advisable to avoid excessive tillering.

Time of planting: To get proper plant establishment, it is important to plant at the beginning of the early rains.

Fertilizer and manure

Manure: Apply 5–8 t/ha of farmyard manure or compost (if available) in old furrows before splitting the ridges. However, when planting is done in the old furrows, apply the manure in a ring around each stand at planting or soon after germination and ridge up later. It is less laborious to apply the manure in between the stands before ridging up if the latter planting method is adopted.

Inorganic fertilizer: Application of 60 kg N/ha, 30 kg P_2O_5/ha, and 30 kg K_2O/ha is recommended for millet producing areas. The recommended nutrient rates could be supplied by a combination of inorganic fertilizers that contain these nutrients. When NPK is to be used, a split application method should be adopted, i.e., about 4 bags of NPK at planting and urea top dressing between weeks 4 and 6 after planting.

Weeding: Regular weeding and earthing up are necessary to minimize weed competition.

Herbicides: Application of recommended herbicides has been found to provide effective weed control. Spraying about 4 L/ha of Gardroprim 'A' is recommended for preemergence application at planting or at about 2 days after planting.

Pests: Stem borers can cause severe damage in some seasons, particularly to long-season or late millet. Early planting will make attack less likely. Destroying cereal crop residues by burning or composting will help to reduce the buildup of stem borers. Bird damage can be particularly severe on millet and the employment of bird deterrents may be necessary. The production of hairy composite varieties may help to minimize bird damage.

Harvesting and threshing

Harvesting should be done when the grain is thin or hard and during any suitable dry period. The heads usually require further drying after being removed from the field. Thresh on clean slabs to avoid contamination.

Storage

Millet to be kept for 6 months or longer should be treated with phostoxin to protect it against storage pests. Follow the instructions for the safe use of agrochemicals. The millet seeds should be bagged and well labeled and kept under shade in a protected building.

Recommended seed production practices for sorghum

Varieties: Varieties and strains for the various important producing areas are shown in Annex 3.

Site selection: Sorghum is suited to a wide range of soil types, from light loams to heavy clay soils. While best results can be expected from free-working, well-drained soils of high fertility, useful returns are frequently obtained from second-class agricultural land. In selecting a site for sorghum that is expected to ensure a very high yield, the following points should be remembered. Select fertile, well-drained soil and choose a site that has not been cropped continuously with sorghum without a fallow or a different crop break.

Land preparation: For best results, the seedbed should be well prepared. The best seedbeds are freshly prepared ridges constructed 75 cm apart (approximately one normal walking pace) in shallow row openings.

Planting date: Planting should be done soon after the rains are well established and immediately after a good rainfall. Hence, the planting date will vary, depending on the location. Assuming the rains arrive on time, the planting dates written against some of the recommended varieties should be observed for good results.

Early planting has also been shown to benefit from the early release of mineral nitrogen, and this usually occurs at the onset of the rains. Too early or too late planting will both produce a poor crop because of the inadequacy of moisture throughout the growing season, as well as attacks by pests and diseases, etc. Too early sowing of short-duration varieties may lead to grain maturing during the rains, thus resulting in moldy or black heads.

Seed treatment: Seed dressing helps to ensure the prevention of decay before germination and smut disease after germination. Thus, it ensures even stands at the recommended population density, and a higher yield of sorghum grain. The seed treatment chemicals come in different packages, so read the label to know how to use them. The seeds are poured into a closed container or gourd till half full. The dressing powder from a packet is then emptied into it and the container is shaken thoroughly until every seed is uniformly coated with the dust. This operation is carried out just before planting. The material used for seed dressing should be kept for use again in the future. Bury the empty packet of seed dressing chemical in the soil and wash your hands thoroughly with soap and water before touching food.

Spacing: The recommended spacing between ridges or rows is 75 cm, approximately one normal walking pace. The stands on the rows should be spaced at 20 cm. About 6–8 seeds should be planted in each stand, at about 2.5 cm deep, covered with soil, and made firm. About 2 weeks after germination, seedlings should be thinned to two plants/stand. The best seed yields, as indicated by studies on sorghum populations, were obtained at populations ranging between 40,000 and 55,000 plants/ha. Under mechanized farming, the ridges should be adjusted to make ridges 75 cm apart. Where

this is not possible and the 90 cm ridges have to be made, the intrarow spacing of 25–30 cm should be maintained, except that the plant population will fall short of 55,000 plants/ha to about 45,000 plants/ha. Wider intrarow spacing may be necessary in dry areas for a more efficient use of limiting soil moisture.

Fertilizer application: Results of research have confirmed that sorghum (particularly the improved varieties) responds to nutrient application. The following are the nutrient recommendations for sorghum: 64 kg/ha of nitrogen and 32 kg/ha of phosphorus (P_2O_5). For very sandy soil, especially in the Sudan and the northern Guinea savanna zones that are known to be deficient in potassium, 30 kg K_2O/ha are recommended in addition to nitrogen and phosphorus. A combination of compound fertilizer 15-15-15 and urea could be used to meet these requirements; 5–10 t/ha of manure could also be applied.

Weed control: Weeds constitute a major problem in crop production. Considerable reduction in yields may result from competition by weeds for light, moisture, and nutrients. Under large-scale production of sole crop sorghum, herbicide application, e.g., armetryne, may provide effective control. Preemergence herbicides could be applied not later than 2 days after planting on a weed-free seedbed.

It is essential to keep strictly to the rates recommended to avoid injury to the sorghum crop. These herbicides are not effective against *Striga*, *Rottboellia,* sedges, speargrass, and other perennial grasses. Where such weeds are dominant or most common, it is not advisable to use these herbicides. Where preemergence herbicide use is intended in fields with weeds of these types, an application before land preparation of glyphosate as Round up or Delsate or Touchdown or Novasate at the rate of 3.5 L/ha is recommended. A waiting period before land preparation of not less than 14 days is necessary for pre-planting effective control of weeds with glyphosate. *Striga* is the most serious weed parasite of sorghum for which no definite recommended control measure is available at the moment.

However, the following interim methods of control are suggested.

- Use *Striga*-resistant or tolerant varieties to secure an appreciable grain yield under suppressed infestation.
- Apply a high dosage of nitrogen if possible. About 100 kg/ha N could be applied, although an economic response has been observed after 50 kg/ha in some places.
- Although crop rotation has not been found to be completely effective, it is advisable to rotate with crops that do not allow *Striga* to produce seeds, e.g., root crops, soybean, cotton, and fibers. This will help to reduce the *Striga* seed population in the soil. Some legumes (cowpea and soybean) have been found to induce suicidal germination of *Striga* seeds and are recommended for the control of *Striga.* Production of these legumes for two seasons followed by sorghum has been found to reduce *Striga* attack.
- Spot application of the recommended herbicide—armetyme—is effective and relatively cheap for low populations of *Striga* and can also be used in a mixed crop.

For heavy infestation by *Striga*, the application of 1 kg a.i/ha of cyanazine is advisable. Cyanazine may be available as Bladex and should be applied at the rate of 2 kg/ha of the powder with a knapsack sprayer in 200–250 L/ha of water. The addition of non-phototoxic oil has been known to enhance the activity of this herbicide at the rate of 4% of the spray liquid.

The spray jet should be directed from below the leaves towards the *Striga* plants at the base of the plant. Effective control of *Striga* could be enhanced by a combination of all the interim methods suggested.

Disease control

Three general groups of diseases attack sorghum.

1. Some diseases rot the seeds and retard germination or kill seedlings.
2. Some attack the leaves, thus reducing the forage value and potential for high grain yields.
3. Some cause root and stalk rots, resulting in lodging, poor head and seed development, and premature ripening.

Losses from these diseases can be reduced by the following control measures.

Seed treatment: Proper seed treatment with Apron star 50DS, Super Homai, and Luxan will improve germination in stands by minimizing seed rot and seedling diseases. In addition, spores of loose and covered smut, which are often present on the seeds, will be killed

Cultural control: The objective of roguing for smut is to destroy spores before they are shed. Loose smut and head smut that affect the entire flowering head or panicle are visible at heading. Such plants should immediately be pulled, carried from the land, burned, or buried deeply. With other types of smut that affect individual grains, roguing will depend on the extent of infection on each plant and over the whole field. If many plants are mildly affected, roguing is not done but grain from this field should not be used as seeds.

Harvesting

The time of harvesting will vary with the variety. In the case of Farafara and dwarf sorghum, which are varieties that mature more quickly than the other kinds, harvesting takes place between late October and December. Harvesting should start soon after the crop is mature, especially in the case of Farafara that has a tendency to shed, if allowed to be completely dry on the stalks (still standing). The stalks are laid in such a position that the heads may have maximum aeration during the drying process. This takes about 1–2 weeks, depending on the moisture content and the weather conditions after harvest. When the grains are completely dry, (i.e., when the moisture level is about 14%), the heads are severed from the stalks and tied into bundles. The grains are most popularly stored in this fashion by farmers. In some cases, the heads are immediately threshed to separate the grains from the trash.

Threshing

This process separates the grains from the heads of sorghum. This is often done manually by piling the sorghum heads in small heaps on a clean floor and beating them with sticks. The loose grains are then separated from the chaff by the use of calabashes or similar containers. This rhythmical up-and-down movement of the container with the chaff being blown away by the wind on a breezy day is a very tedious method. Threshing can also be done mechanically with the use of threshing machines. Cheap threshing

machines are unavailable at this time but the Agricultural Engineering section of the Institute for Agricultural Research and the National Center for Agricultural Mechanization are working on some threshing equipment and it is hoped that such equipment will be made available very soon.

Storage and storage pests

In sorghum, the losses incurred through insect damage in storage were estimated to be 35% of the total production. Major storage pests of sorghum are grain moth (*Sitotroga cerealella*) and the grain weevil (*Sitophilus* spp.). Infestation takes place in the field and in the old granaries where insects are already present in the stores, and also by cross-infestation between granaries during storage. Dry the grain properly before storage. Store grain in airtight containers or triple bags with a phostoxin tablet/100 kg seeds.

Summary

For the production of good millet and sorghum seeds, the following steps need to be taken.

- Start with a good source of seeds—pure seeds.
- Contact a Seed Certification Officer.
- Maintain isolation from other fields.
- Follow recommended agronomic practices.
- Rogue off-type plants.
- Harvest and thresh carefully.
- Remove any off-type seeds.
- Clean and dry the seeds well.
- Store the seeds properly.

4. Recommended seed production practices for rice

A.T. Maji
National Cereals Research Institute, Badeggi
Niger State

Introduction

Seeds are regarded as the most important input in crop production. All other inputs, such as fertilizer, pesticides, and insecticides, are only supportive. Good seeds start with a good crop variety with high productivity and resistance or tolerance to major prevalent biotic and abiotic stresses in the production environment. Other factors include varietal genetic purity, full and uniform size, and a high level of viability (80%), with good seedling vigor and freedom from weed seeds, seed-borne diseases, pathogens, and insects.

Good seeds lead to a lower seeding rate, high crop performance, reduced replanting costs, uniform plant stands, vigorous and early crop growth, fewer weed problems, and better resistance to pests and diseases. Where these are achieved, the crop yield increases by about 5 to 20%.

Seed quality is determined by activities from cultivation to postharvest and the practices followed will also depend on the type of seeds being produced. The three types of seeds have been discussed in a previous presentation.

Rice biology

Rice is a self-pollinated annual crop with out-crossing varying from 0.34 to 0.67%, depending on climatic conditions and varietal differences. The rice inflorescence is a panicle, which is much branched and bearing spikelets. There are three florets in each spikelet. The two lower florets are reduced to a sterile, scale-like lamina called the sterile lemma. The sterile lemma can be long in some varieties, even longer than the fertile lemma. The terminal floret forms the grain. The glume is made up of the lemma and the palea. The fertile lemma is tough, rigid, keeled, and can be with or without hairs on the outer surface. It could be awned or not. The palea is similar to the fertile lemma in texture, slightly smaller, and with its rolled edges fitting into the edges of the lemma.

Inside the lemma and palea are two rounded lodicules whose swelling at flowering time assists in the opening of the floret. There are six stamens with slender filaments bearing versatile anthers. The pistil consists of a one-celled ovary with a single ovule. The style is short and bears two or three plumose stigmas.

The time of the day when the flowers open for pollination depends on humidity, temperature, and the variety, but generally varies from 9 am to 1 pm. The lemma and the palea separate; the stigma protrudes, followed by anthers bursting to liberate the pollen. After pollination, the spikelet remains open for about 6 minutes to one hour, depending on weather conditions. This is the time when out-crossing could take place.

Production practices

Source of seeds: The seed source for seed production will depend on the type of seeds being produced.

For breeder seed production, the seeds can be sourced from the following;

1. Varietal maintenance stock, if it is a variety already in use;
2. Advanced yield trial plots or seed multiplication plots for the purpose of producing breeder seeds for varieties that are about to be released.

For the production of breeder seeds, the seeds must be sorted before planting. If seeds are being sourced from maintenance stock they must be sorted for purity and maturity. Seed sorting machines are available that can sort seeds based on weight or size. Otherwise, hand sorting may have to be practiced. This is to remove immature or diseased seeds and weed seeds, if possible. Otherwise, breeder seeds can be selected from the previous breeder seed plots. Here, single plants are harvested, sun-dried, and bagged individually. These plants are used as head rows.

In the production of foundation seeds, the source is always breeder seeds while for certified seeds, the source should be foundation seeds. In some production systems, foundation seeds can also be used in producing more foundation seeds. In such systems, we have foundation seeds step 1 and step two. This is usually practiced where breeder seeds are not available.

Site selection

In choosing a site for rice seed production, climatic factors, such as the rainfall pattern, humidity, and temperature of the location, should be taken into consideration, especially where an irrigation facility is not available. It is better, however, to produce rice seeds under irrigation and preferably in a lowland ecology. This reduces the risk of crop failure as a result of drought and also provides an avenue for off-season seed multiplication. When the crop is drought stressed, it can lead to attack by diseases and pests, especially blast and brown spot. Seed production under lowland conditions also allows for the transplanting of single plants/hill, leading to greater purity of seeds.

Where rice seeds are to be produced under rainfed lowland or upland conditions in Nigeria, the following should be noted.

Establish your crop early, as soon as the rains become established. In the southern part of the country, establish your plot between April and May. Late planting can result in serious attacks by insects and diseases, even if you are able to avoid drought. In the central zone and the north, establish the plot as soon as the rains are stable. The raining period is short, between 4 and 6 months. Under rainfed lowland ecology, make sure the conditions are favorable. Avoid deep water fields; there may be too much water or complete submergence. These conditions can result in seeds of poor quality. If possible, have a standby irrigation facility to avoid total crop failure if the situation changes.

Select a fairly flat plot for ease of water distribution, with uniform soil fertility, free of soil problems such as iron toxicity or deficiency, acidity, and noxious weeds, e.g., wild rice, and

purple nutsedge. If possible, use the same variety as in the previous year or allow the plot to fallow if you are going to use a different one. Control volunteers during the fallow period.

Land preparation

There is no specific land preparation technique for rice seed production; most practices are ecology dependent. Under irrigation, pre-irrigate the plot before land preparation to germinate volunteer seeds of the preceding rice crop and weeds. A total weed killer, such as glyphosate, can be used to knock out perennial and noxious weeds. Plow or rotivate into the soil the rice ratoons, any volunteer crop, and weed vegetation. Harrow twice and level properly for direct seeding in dry soil. Otherwise, level wetland for wet direct seeding or transplanting to avoid erosion in any upland areas and for even water distribution in the lowland parts.

Direct seeding

For dry direct seeding, use about 70–75 kg/ha of treated dry seeds, either by dibbling or drilling. In wet soils, use pre-germinated rice seeds at 70–75 kg/ha. Rice can be pre-germinated by soaking the seeds for 24 hours and incubating for 48 hours. Pre-germinated seeds are better broadcast in wet soil but there should be no standing water in the field.

Nursery bed preparation:

- Prepare the nursery bed near the field in fertile soil.
- Raise the nursery bed above the water level.
- Loosen and level the soil for easy germination and the emergence of seedlings.
- Treat seeds with fungicide before seeding.
- Incorporate NPK fertilizer in the nursery bed before seeding.
- Seed at a relatively low density for the healthy growth of seedlings.
- For the production of breeder seeds, plant the seeds from each single plant separately.
- Cover the seeds with dry soil and grass.
- Remove grass one week after emergence.

Transplanting: Transplant 3-week-old seedlings as soon as they are removed from the nursery bed. Transplant seedlings at a spacing of 20 × 25 cm or 30 × 30 cm if the soil is rich. In breeder seed production, transplant seeds from single plants in 5 rows of 5–10 m length at the rate of one seedling/stand. Leave the remaining seedlings at the end of each head row for gap filling later. Leave a gap of 30–40 cm after each plant in head rows. Number the rows and the head rows and keep a record of off-type head rows.

For both foundation seeds and certified seeds, do not transplant more than three seedlings/stand; one seedling/stand is ideal. Provide walking gaps by dividing the plots into subplots.

In general, supply seedlings 1 week after transplanting (gap filling) from the remaining

seedlings. Late gap filling can result in a longer maturity period and ineffective roguing.

Fertilization: Apply the optimum level of fertilizer. For the lowland crop, apply 40 + 40 + 40 kg/ha of N, P, and K as basal dressing. Apply an additional 40 kg/N at tillering stage (20 kg) and panicle initiation (20 kg). For the upland crop, apply 30 + 30 + 30 kg/ha of N, P, and K as basal and 15 kg N each at tillering and panicle initiation. In the lowland where iron toxicity is a problem, additional P may be required at the tillering stage.

Crop protection: Give adequate protection against diseases and pests, if necessary. This is to avoid producing disease-infected seeds that will result in poor quality and can spread diseases to users' fields. Also provide protection against rodents. Use human labor to scare birds.

Roguing

This is the practice that most differentiates grain production and seed production. In the production of breeder seeds of rice, watch out for full head rows that are not true to the varietal plant type. Watch out for early or late maturity of head rows, differences in plant height, grain type, and other morphological differences among the head rows.

In general, start roguing from the early seedling stage and continue the process to maturity. Remove all known off-types and do not hesitate to remove doubtful plants also. At seedling stage, pay particular attention to leaf color, whether deep green or light green; sheath base and leaf shape, whether broad or narrow. At the tillering stage, look out for the tillering pattern; it could be compact or loose; the color of the sheath base and leaf sheath becomes clearer. At the reproductive stage; check for early and late flowering; plant height may also begin to differentiate. At the maturity stage, plant height becomes distinct. Look out for the flag leaves, whether erect or droopy; panicle characteristics, such as length and density; grain characters, such as color that could be straw, golden, black, deep brown furrow on straw or golden color; grain size, whether long or short; grain shape, whether slender or bold; awns, whether present or absent, partial or full, short or long. Where it becomes too difficult to identify *Oryza glaberrima*, take a look at the ligule and see whether it is short and truncate. In *O. sativa* the ligule is long and pointed.

Harvesting

Harvest all rogues before true-to-type plants. In the production of breeder seeds, harvest head rows that are not true-to-type; harvest the 2 or 3 middle rows from each head row, and bulk the crop as your breeder seeds. Harvest at about 30 days after 50% flowering or at 80% maturity, i.e., when 80% of the grains have turned to the mature grain color; the moisture content will be about 20–23%. This is the physiological maturity stage. Staggered harvesting may be necessary if the maturity period is prolonged to minimize mechanical injury during threshing. Slightly advanced harvesting is better than delayed harvesting. Early harvesting reduces damage from lodging or from alternate wetting and scalding.

Harvesting can be manual or done with the use of machines. Where machines are used, especially a combine harvester, thorough cleaning is necessary after the harvesting of each variety before another is harvested.

Threshing: During threshing, do your best to minimize mechanical injury. If a machine is to be used for threshing, use a lower cylinder speed and rubber-coated beater bars, and

thresh the crop at an appropriate moisture content. If manual threshing is used, thresh one variety at a time on a concrete floor or tarpaulin. Clean the threshing floor before threshing another variety to avoid mechanical mixture.

Drying: Rice seeds can be dried on the field before threshing, especially the dry season in-field crop. In the rainy season, seeds are difficult to dry through in-field drying. Hence, drying after threshing or winnowing is ideal. Sun-drying is most practicable but may cause radiation damage. Freshly harvested rice seeds at about 18% moisture content can be dried in commercial driers, using forced ventilation of heated air, if the temperature is not above 40 ºC. Seed dried this way (to about 12% moisture content) should be cooled in a dry atmosphere and quickly packaged to minimize moisture reabsorption.

Cleaning: Rice seeds are cleaned to remove chaff, weed seeds, soil, and other inert particles, including poorly developed spikelets. Mechanical cleaning includes winnowing and sorting of seeds of the proper size by means of sieves or gravity separators that separate seeds into grades of seed weight. After sorting, each seed lot (seed bulk produced under the same field and agronomic conditions) is visually observed to remove off-types, discolored seeds, diseased seeds, and smut balls, before being packaged for storage.

Packaging

Packaging of rice seeds depends on size, storage duration, and type of storage facility to be used. For small-sized seeds for a long period of storage, use hermetic containers, airtight containers that can maintain the moisture content irrespective of changes in the surrounding atmosphere. Metal and glass are often used. For commercial stocks of large quantities or high volumes of seeds, plastic materials can be used. Also, high quality sacks of about 50 kg capacity made of polyethylene materials and sealed with a sewing machine can be used. Small lots of about 1 to 5 kg can be heat-sealed in polyethylene bags. Under normal room temperature and relative humidity, rice seeds can be stored in jute bags for one year without significant deterioration. However, the storage room must be free from rats and should be fumigated regularly to avoid storage insects.

Storage

Producers of rice seeds must take cognizance of biological, physical, and human factors in production to maximize longevity during storage. Biological factors include seed physiological maturity (as stated above), seed health, freedom from mechanical injury (this is most likely to occur during threshing), grain dormancy (the wet season crop has stronger grain dormancy than the dry season crop), inter- and intraspecific varietal variations. Crop varieties vary in seed longevity. Observation has shown that upland NERICAs have a shorter longevity than intraspecific varieties.

The physical factors include temperature. The rule of thumb is that, for every 5 ºC increase in the temperature of seeds (between 1 and 50 ºC) the life span of the seeds is halved. The effect of temperature starts from physiological maturity through harvesting, transport, and drying, to storage, either on an open shelf or in cold storage. Since rice seeds are hygroscopic, seed moisture will reach equilibrium with the ambient relative humidity and temperature. Another rule of thumb is that, for every 2% increase in moisture content, the life of seeds is halved. The rule applies from 5 to 14% moisture content.

Table 1. Rice seed storage conditions and expected longevity of stored seeds.

S.no.	Initial moisture content (%)	Temperature condition (ºC)	Relative humidity (%)	Expected longevity
1.	12	20	60	Slightly above 3 years
2.	12	20	50	Slightly above 5 years
3.	12	2	8.5	Above 20 years

Other physical factors include a high oxygen content that hastens viability loss; a high CO_2 or N_2 content or the use of a vacuum will retard deterioration; exposure to ultraviolet light deteriorates seeds faster.

The human factors needed are vigilance, continuity, and administrative support, particularly in large seed production programs. Political instability and natural disasters, such as earthquakes, add to the vulnerability of stored stocks of seeds.

Fumigation: Granary insects that infect the ripening seeds must be eliminated before storage. Common fumigants are carbon tetrachloride (weakest), ethylene dichloride, and methyl bromide (strongest) or a combination of any two. Fumigate both the seeds and the storage room. Rice seeds are better fumigated at above 10% moisture content.

Seed treatment: Adequate drying and cold and dry storage control the majority of microbes that cause seeds to deteriorate. It is advisable to treat seeds just before planting. However, commercial seeds to be held in short-term storage should be treated before packaging.

Storage conditions: The key words for optimum storage conditions are *cold* and *dry.* Such storage facilities are costly to obtain and maintain in tropical and subtropical areas. The expected longevity of the seeds to be stored will determine the type of storeroom conditions, in terms of temperature and relative humidity. Other factors are the insulation of the room and the flow of air inside the room. Table 1 may serve as a guide for storage conditions and the longevity of seeds.

Quality rice seeds are easier to produce than the seeds of other cereals. However, efforts should be made to meet the requirements enumerated above in both production and storage.

5. Major weeds of legumes and cereals and control measures

F. Ekeleme
International Institute of Tropical Agriculture
PROSAB, Maiduguri, Borno State

Introduction

Legumes and cereals are important food and cash crops in sub-Saharan Africa. Weed competition is a major constraint in Nigeria. In recent years, the production of these crops has continued to increase, largely due to the increase in food demand arising from population expansion and higher consumer incomes. The highest costs in the production of these crops are for labor and weeding operations that amount to about 25 to 55% of the total costs.

Weed problems

Cereals and legumes are most sensitive to weed competition during their early growth periods. The growth of most legumes and cereals in the first week is rather slow and it is during this period that weeds establish rapidly and become competitive. Maximum weed competition in legumes and cereals occurs during the period of 2 to 6 weeks after sowing. This suggests the importance of maintaining fields weed-free during this critical period. Fields that are kept free of weeds for the first 4 to 6 weeks after planting give the crop a “head start” which enables it to shade out or otherwise out-compete the weeds that emerge later in the season. Uncontrolled weed growth in legumes and cereals causes a grain yield reduction of about 50–70%. A severe weed infestation may not only reduce stands but could lead to the abandonment of the entire farm, especially if it is infested with parasitic weeds, such as *Striga* spp., or perennial grass weeds, such as *Imperata cylindrica.* Apart from causing yield reduction through competition for light, space, and soil nutrients, weeds can produce allelopathic substances that are toxic to these crops. Weeds also often serve as hosts for most insect pests that attack legumes.

Depending on agroecological zones, weeds found in legumes and cereals are essentially the same as those in other arable crops in the same zone. However, parasitic weeds, such as *Striga* spp., infest legumes and cereals mainly in the dry savannas where *I. cylindrica* that infests crops in the moist savanna does not constitute a major production constraint. Some of the major weeds found in legumes and cereals are *Striga hermonthica*, *S. gesnerioides*, *Imperata cylindrica*, *Sporobolus pyramidalis*, *Rottboellia cochinchinensis*, *Chrysanthellum indicum*, *Hackelochloa granularis*, *Thelepogon elegans*, *Boerhavia erecta*, *Vernonia galamensis, Setaria pallide-fusca, Acanthospermum hispidum*, *Eleusine indica*, *Ludwigia abyssinica*, *Commelina nigritana*, *Mariscus alternifolius*, *Fimbristylis hispidula*, *Kyllinga squamulata*, *Mitracarpus villosus*, *Schwenckia americana*, *Cyperus rotundus*, *Ageratum conyzoides*, *Digitaria horizontalis*, *Oldenlandia corymbosa*, *Leucas martinicensis*, *Oldenlandia herbacea*, *Portulaca oleracea, Dactyloctenum aegyptium*, *Solanum nigrum*, *Euphorbia hirta*, *Euphorbia heterophylla*, *Physalis peruviana*, *Cynodon dactylon,* and *Panicum maximum.*

Weed control principles

Weed control is an essential part of all crop production systems. The effectiveness of any weed control program in legumes and cereals depends largely on how timely is the application of control. Most weed control measures (cultural, mechanical, and chemical methods) are effective if applied at the correct time. To plan an effective weed management program, farmers must be able to identify those weeds present in their farms because different weeds vary greatly in their ability to compete with crops and reduce yields. Broadleaf and grass weeds have been reported to compete at different levels of intensity, depending upon the competitiveness of the crop, the tillage system, the environmental conditions, and the other weeds present. In general, broadleaf weeds are more damaging to a broadleaf crop; grass weeds are more competitive in a grass-leaf crop (Anon 2007). Broadleaf weeds are generally more competitive against legumes than grass weeds. Weed control measures should be matched to the specific weed problem.

The use of herbicides is perhaps the most economically viable option for weed control in legumes and cereals planted in large areas. The use of herbicides in legume and cereal production, however, must be combined with agronomic or management practices that would enhance the ability of the crops to compete with weeds. Some of the management practices are (1) suitable and properly timed land preparation, (2) the planting of a competitive crop cultivar, (3) appropriate crop population and spacing, (4) the best time and method of planting, (5) the right method of fertilizer placement (6) rotation, and (7) intercropping. The most effective herbicide on weeds may fail to achieve the desired goal if these management practices are neglected. It is important to note that these practices usually result in little addition to production costs or none. I will discuss briefly some of these methods.

Land preparation

Tillage is an important and practical method of controlling weeds. Suitable land preparation depends on having a good knowledge of the weed species prevalent in the field. I don't mean here that farmers must begin to learn or memorize names of weed species written in Latin but they should be able to recognize a perennial or an annual weed species. An annual weed flowers and produces seeds and dies within a growing season. Perennial weed species tend to grow for more than one growing season before producing seeds. For example, when perennial grass weeds, such as *I. cylindrical,* are predominant in the farm, it is best to plow and harrow in such a way that the roots and rhizomes are fragmented and exposed on the soil surface, facilitating desiccation by wind and sun. Deep plowing is needed when perennial weeds dominate the weed spectrum. Deep plowing buries the weed seeds, generally delays their germination, and distributes them throughout the work soil zone where they remain viable but dormant, until returned to the soil surface by further cultivation. When annual weeds are predominant, shallow cultivation of the soil surface is desirable, as this helps to keep seeds near the surface and often stimulates early germination. *Cynodon dactylon* (bermuda grass) and *Panicum maximum* (guinea grass) can be effectively controlled by frequent shallow cultivation and by subsequently removing the plant parts to prevent reestablishment.

Planting method and time

Depending on the agroecological zone and farm location, legumes may be planted on ridges or on the flat. However, whether on ridges or on the flat, planting in rows

is recommended as this makes the management of farm practices easier. When legumes and cereals are planted in rows, it is easier to achieve the recommended plant population and spacing. The application of herbicide in the form of a directed spray is also easier. Planting should be done soon after land preparation to reduce the risk of weeds germinating before the crop. Weeds that emerge with the crop are generally more destructive. Legumes and cereals should be planted at a time when there would be adequate moisture during the first few weeks after planting to ensure good germination and establishment as these lead to rapid canopy closure and minimize weed growth. Once the full canopy is formed, further weed removal may no longer be necessary as the density of the weeds may fall below the economic threshold. An economic threshold for weeds is the density of a weed population at which control is economically justified because of the potential for yield reduction, quality loss, harvesting difficulties, or other problems that weeds may cause.

Competitive cultivar/appropriate stand population

An optimum plant population of a competitive legume or cereal cultivar is important in maintaining a relatively weed-free farm after the crop has developed a full canopy. Standard spacings are available for rows and interrows for optimum populations for most legumes and cereals. Improved cultivars of legumes and cereals for different agroecological zones in Nigeria are also available. For example, farmers in southern Borno State have adopted several *Striga* resistant/tolerant cultivars of legumes and cereals. Only cultivars that can develop a full canopy cover within few weeks after planting to shade the ground can compete effectively with weeds, provided that these cultivars are planted at a high enough population. Farmers must take the extra pains to replace dead plants as soon as any are noticed to maintain an optimum plant population. Any practice that provides optimum conditions for early and vigorous growth of crops helps to give them a competitive edge over weeds.

Crop rotation

Crop rotation is the practice of growing a series of crops of dissimilar types in the same piece of land in sequential seasons for various benefits, such as to avoid the buildup of weeds, pathogens, and pests that often occurs when one species is continuously cropped on the same field (Anon 2007). Planting different crops over time on the same field is a well-known primary means of preventive weed control (Bàrberi 2003). Different crops bring about different cultural practices, which act as a factor in disrupting the growing cycle of weeds and, as such, preventing the selection of the flora towards an increased abundance of problem species (Karlen 1994; Barberi 2003). In contrast, continuous cropping selects the weed flora by favoring those species that are more similar to the crop and tolerant to the direct weed control methods used (e.g., herbicides) via repeated application of the same cultural practices year after year (Bàrberi 2003).

Chemical weed control

The use of herbicides is probably the most economically viable option for weed control in large-scale legume and cereal production. It is less expensive to use herbicides in such large-scale production than to use other weed control methods, which may require a large amount of paid labor. With herbicides, weeds are controlled early, during the critical period of crop growth when other methods may not be effective or applicable. Less labor is required, compared with other methods. Herbicides can also be combined with other weed control methods. It is important to select herbicides based on the weeds

present in a field, since no single herbicide will control all species of weeds. Herbicides usually control weeds selectively. In most cases, herbicides are often combined to control more species, reduce carryover, or crop injury. Using them effectively requires specific conditions to be met. For example, the correct herbicide for the weed spectrum in legumes and cereals must be selected. It must be applied uniformly at the correct rate at the right time under specific environmental conditions. Soil type, soil organic matter content, soil moisture, rainfall, temperature, and air movement are some of the environmental conditions that can affect the performance of herbicides.

Preemergence herbicides have the advantage of eliminating early competition between crops and weeds. A number of broad-spectrum preemergence (PRE) and postemergence (POST) herbicides are available for use in legumes and cereals (Annex 4). These herbicides are active against most annual grasses and annual broad-leaf weeds. Note that the preemergence herbicides are soil-active and will not kill established vegetation. The preemergence herbicides also will not kill or stop shoots emerging from fragments of rhizomes and stolons of *I. cylindrica* and *Cynodon dactylon,* and from the remains of the basal rootstock of *Panicum maximum* left in the soil after plowing.

In the case of a large field infested with a weed such as *I. cylindrica*, the appropriate approach would be to slash the field mechanically and allow regrowth for 2 weeks. Alternatively, the area needed for cultivation should be burned (controlled burning) and the shoots allowed to grow for 2 weeks. Apply glyphosate (Roundup or Touch down) at the rate of 6–8 L/ha to the young shoot regrowth. Allow 2 weeks or 14 days before plowing and harrowing. Apply Primextra at the recommended rate soon after planting. It is very important that the desired preemergence herbicide is applied immediately after planting with some measure of precision to meet the objective. Excess use of herbicide is wasteful, and may also damage the crop. Too little will result in poor weed control. In either situation, the farmer will sustain economic loss. The key to successful herbicide spraying is the proper calibration of the sprayer. Before herbicide is applied in the field, the amount of water required to give an even coverage to the plot should be determined. The National Advisory Committee on Weed Control (NACWC 1994) recommends the following procedure for calibrating a knapsack sprayer.

- Check all parts of the sprayer to ensure that they are functioning properly.
- Calibrate the sprayer in the field shortly before spraying to simulate the conditions usually encountered during actual operations.

1. Measure and mark off an area of 100 m^2 (2 m × 50 m).
2. Fill the sprayer with water to the desired level.
3. Spray the marked area, walking at a normal and comfortable pace and using a constant pumping speed.
4. Determine the time it takes to spray the area.
5. Repeat the procedure at least three times and determine the average time.
6. Determine the nozzle discharge rate.

The nozzle discharge rate refers to the volume unit area of spray solution discharged. To determine the nozzle discharge rate, fill the spray tank either to the top or to a known level. Following step 3, spray the marked area and measure the amount of liquid required to refill the tank to the original level after the spraying. In each of the above methods, repeat the procedure at least three times to ensure a constant discharge and determine the average volume used to cover the 100 m^2.

Example: Assuming that, in the above calibration exercise, a knapsack sprayer delivers 2.5 L of water over the 100 m^2 test area. Delivery rate is:

$$\frac{2.5 \text{ litres}}{100 \text{ m}^2} \times \frac{10000 \text{ m}^2}{1 \text{ ha}} = 250 \text{ L/ha}$$

The quantity of water delivered in 1 ha = 250 L. Therefore in 5 ha, the quantity of water delivered will be 1250 L. Assuming the farmer has a 20 L capacity knapsack, the sprayer will carry approximately 63 loads of the knapsack to spray a 5 ha maize plot. Assuming that a farmer is to apply Primextra 500 FW at the rate of 6 L/ha, he would need to add 480 ml of the herbicide to his 20 L capacity knapsack. Note that delivery rates can be increased or decreased by changing the sprayer nozzle, sprayer speed, and nozzle pressure.

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6. Major field and storage pests of cereals and legumes and their control

S.O. Okunade
Nigerian Stored Product Research Institute, Kano

Introduction

Pests are living organisms that are capable of causing economic damage to our cultivated plants, stored agricultural produce, forest products, and household goods. In addition to the damage caused, pests could also be harmful to man and animals. There are pests whose activities are restricted to the field/farm while others are found only in the store. Some are both field and store pests; oscillating between the two environments while others are field-to-store pests, i.e., they could begin their life on the field and continue in the store. Examples of pests are insects, mites, and rodents.

Grain crops are plants with small, edible hard seeds utilized for feeding man and livestock. As an essential requirement our daily diet, grains occupy a central position in the well-organized food security system of a country. Grains are of two types, based on their chemical composition and food value. These are cereals, composed mainly of carbohydrates (starches) and legumes, made up mainly of proteins.

Cereals include maize, millet, sorghum, rice, and wheat. Legumes include cowpea, groundnut, soybean, and benniseed. Quite a large proportion of the harvested produce of cereals and legumes never gets to the consumers' table because they are lost, either on the field, or in transit, or in the store. The loss may be between 1 and 100%, depending on the situation and other factors involved. Any loss above 5% is considered an economic loss/damage, since the threshold has been exceeded. The situation could threaten the food security system of a nation with a teeming population, such as Nigeria, and indeed is a danger to all Africa. The efforts and resources of poor farmers in producing the grains will be jeopardized while farmers may lose their motivation to produce more in future. This situation, apart from making the farmers poorer, could also increase the food crisis and bring about quite a number of other societal problems. This is why a critical study of these pests and their control is of paramount importance.

Major field pests of cereals and legumes

There are quite a number of insect pests that attack cereals and legumes on the field; some are specific while others are general. Some are pests as adults or as larvae (nymphs), or as both. They attack and damage roots, stems, flowers, cobs, ears, seeds, pods, grains, as well as the leaves. Those that attack the roots could completely destroy the plant, since the root is the anchor of the plant and the source of nutrients for survival. The stem borers weaken the plant, tunnel into the stem up to the tip to destroy the embryo and prevent further growth. This destruction continues even in the store as the grains may be damaged before harvest. Flower feeders could prevent the plant from producing seeds while leaf eaters (defoliators) are capable of reducing the photosynthetic ability of the plant. The grains harvested are reduced both in quality and quantity. More than one type of insect pest can attack a plant at the same time, damaging different parts simultaneously. Cereal pests could suddenly become legume pests and vice versa. Some of these pests are in Annex 5.

Major pests of cereals and legumes in the store

The pests that attack stored cereals and legumes are fewer in number but more in types when compared to those attacking these crops on the field. Some of these pests begin their damage on the field and continue in the store, having survived threshing, bagging, transportation, and other handling practices. These pests could be divided into four categories; insect pests, mites, rodents, and microorganisms

The pests could be primary pests, i.e., those that attack and feed on whole/unbroken grains; secondary pests, i.e., those that attack broken, milled, or cracked grains or those that primary pests have previously damaged, and tertiary pests, i.e., those that oscillate between primary and secondary pest behavior.

Control of field pests of cereals and legumes

Because field pests are more in number than storage pests, they are more difficult to control. In most cases, a combination of control measures has to be employed to be effective. Even where single control measures are sufficient, these have to be repeated at various stages of the life of the plant to have a good result.

Early detection and prompt action can bring field pests under control. Prevention at times is better than control. Consequently, control measures will be considered under prevention and control. It should be noted again that some control measures are general and could destroy all categories of field pests (especially insects). Where there are no clear control methods, preventive measures are better.

Preventive measures

***Farm sanitation*:** This includes ensuring that farmlands are adequately cleared and free of all foreign agents before planting. .Plow the land before planting and expose the eggs and breeding sites of pests. When a crop is grown, no weeds should be allowed to grow for too long with the plant. They should be removed far away from the farm site. After harvesting, the remains of the stalks, leaves, etc., should not be allowed to stay in the field. If such residues are to be left on the farm and used as fertilizer/manure for next season, they should be cut down and spread out to decay before the next planting season.

Use resistant varieties: These are available for quite a number of cereals and legumes in respect of each pest.

***Observe the correct planting time*:** This ensures that plants will grow far beyond the stage of attack by pests by the time such pests start appearing.

Have a good knowledge of the agroecosystem; Study the farm area and work on that knowledge.

Plant sound healthy seeds on healthy soils. Use appropriate seed-dressing before planting. Practice crop rotation and mixed cropping, e.g., planting sorghum and cowpea together on the same farm at the same time.

***Observe social aspects*:** Farmers should consider joint action with their neighbors or any large-scale action that requires Government's intervention for assistance and coordination. A good example is when there is a locust invasion.

Control measures

Use appropriate botanicals, e.g., *Annona* sp. (on aphids), *Ocimum* sp., Neem plant products, and also garlic (although this is still under research).Also apply wood ashes, lime, etc.

Use baits or traps to lure pests to places where they die or where they can be easily destroyed.

Introduce natural enemies such as ducks, chickens, birds, etc., but with close supervision and control.

Incorporate green manure, especially against termites.

Use hand picking, especially where the insects concerned are slow moving and few in number.

Partially burn harvested stalks of cereals before storing these for fuelwood. This will kill diapausing larvae of stem borers, for example.

Chemical control: This is very effective and could be used even on a large scale for quick results. It is important to note that some of these synthetic chemicals are broad spectrum and could be used on a number of crops (cereals and legumes) to control quite a number of pests. Examples of such chemicals include carbofuran (granules) carbaryl, deltamenthrin EC, dimenthoate, Lambda-cyhalothrin, monocrotophos, primiphos–methyl, dichlorvos, endosulfan (dust/spray), cypermethrin, permethrin, malathion, diazinon, bendiocarb, chlorophyrifos, and propoxur. However, sometimes a, combination of chemicals gives better results, e.g., Dimethoate + Cypermethrin; Deltamethrin + Dimethoate; Lambdacyhalothrin + Dimethoate, especially in the control of *Maruca testulalis* on legumes.

These chemicals could either be sprayed or introduced as applied baits using wheat bran, to act as a stomach poison.

Notes on the use of chemicals

Chemical control becomes necessary only if the damage level is above the threshold of 5%.

More than a single spraying is usually required; legumes always need 4–5 sprays. However, if a single spray is sufficient, this is better done at the budding or flowering stage.

Where chemicals are used, contact and systemic (stomach-acting) types are very useful and effective for field pests.

For active flying pests, chemical spraying should be done when pests are less active, e.g., very early morning.

On termites, chemical application should be employed when the infestation is severe and crop loss is likely. This is because of their beneficial effect on the field. However, wherever the need arises for it, persistent application of gamma HCH, carbofuran, or chlorophyrifos, for example, gives better results.

Control of major storage pests of legumes and cereals

These are insects, rodents, microorganisms, and birds. They attack stored grains, either from survival from the previous season or by a fresh infestation. .

Preventive measures

- Use appropriate resistant varieties: These are available for each crop in most localities.
- Practice mixed cropping, such as planting cereals with legumes.
- Harvest at the due time.
- Site the grain store/warehouse far away from farm and livestock sheds.
- Ensure that only clean, whole (unbroken) grains are stored.
- Employ good threshing method(s) that will not break the grains.
- Maintain good stored hygiene throughout the storage period.
- Do not store old stock of grain (cereals or legumes) together with the new intake.
- Dry all grains (threshed or before threshing) to the safe moisture content before storage.
- Provide rodent-proof facilities in the storage structures.
- Keep up-to-date records of all the various operations conducted on the grain stock.

Control measures

This will be discussed under three categories: traditional, chemical, and non-chemical methods.

Traditional methods: These are cultural practices and traditional beliefs held by the people and include the following.

- Sorting, sifting, drying, and re-drying
- Mixing with plant materials, e.g., neem, *Ocimum* sp.*,* lemon grass, ash, pepper, etc., or with other materials, such as sand or cow dung.

Chemical measures: Synthetic chemicals are used (liquid, solid, or gas).

- Such chemicals must not have reached their expiry date nor have been banned as hazardous. They should be genuine, harmless to the environment, and applied by trained personnel.
- The store/warehouse must first of all be well cleared, sprayed with chemicals, e.g., Primiphos methyl (i.e., Actellic 25EC, Prime, Stored Force), Dichlovous (i.e., VIP, Delvap, Nuvan, Dizvan, Nopest, Snipper, etc.) and locked up for a few days before the farmer brings in grains.

Chemical application is done in two phases.

Phase 1: This is the application of fumigant tablets, such as Aluminum phosphide (e.g., Phostoxin, Celphos, Protest, etc.,) on cowpea at the rate of one tablet/bag (100 kg). One tablet should be wrapped in a sheet of paper and introduced into each bag. Thereafter,

the bags are arranged in an orderly way on prepared pallets in the store. More tablets are placed in between the bags and everything is covered immediately with airtight materials, such as tarpaulin, for at least one week. The essence of this operation is to kill off all stages of pests in the grains. This must be done within the first 2 weeks after bringing the cowpea into the store/warehouse.

Phase 2: This is the method for the long-term storage of grains and should be done at least one week after phase 1 is concluded. Liquid chemicals are sprayed immediately the airtight materials are removed. Such chemicals include Pirimiphos methyl, Dichlorvous or Dichlorvous + Cypermethrin at the manufacturers' recommended dose. Thereafter, the store/warehouse is locked up and inspection of the cowpea/sorghum is done at least once in a month. ***Note that chemicals are not to be sprayed directly on the seeds but on the pallets, walls, and floor of the store.*** Before consuming the grains, ensure that the waiting period after chemical use has expired.

Non-chemical methods: These are similar to traditional methods to some extent.

- Use airtight facilities, e.g., plastic/metal drums, tins, cans, jerry cans, triple nylon bagging, etc. The structures must be filled to capacity to expel air out of them.
- Store grains in pods (without threshing)..
- Hang unthreshed cowpea/sorghum in cooking areas.
- Sun-dry or re-dry regularly. This is better done by spreading grains on black plastic sheets in an open area. Cover them with another black plastic sheet and press down the edges with stones or sandbags.
- Store under a low temperature, e.g., in a refrigerator.

Integrated pest management (IPM) This will also be considered under prevention and control measures.

Prevention

- Make sure the store is always clean and free from grain, droppings, dirt, spills, etc.
- Do not use damaged bags or structures to store grains.
- Clear away bush or rubbish for at least 2 m from the store.
- Block all holes inside and outside the storage area.
- Provide rodent-proof facilities in the storage area.

Control

- Use traps—either local or manufactured. There should be enough traps of suitable sizes set around the store. Any dead rodent should be removed immediately.
- Use glue: Place the glue on paper with a little bait, e.g., fish, around it to attract rodents to the place.

Chemical

- Use acute (single dose) poisons, e.g., Zinc phosphide, Norbormide, Sodium Monofluoroacetate, etc.
- Use chronic (multiple dose) poisons, e.g., Wafarin, Cholrophacinone, Bromaidilone, Indomethacin capsules, etc.

Note the following precautions to be followed while applying rodent poison.

Attractive bait such as smoked fish, crayfish, or grains should be used in mixing the poison. Never use your bare hand or any kitchen utensil. The poison should not be mixed with the bait until the need arises for its use. First, poison-free bait should be placed at strategic locations continuously for 2 to 3 days. Thereafter, some bait should be placed at the same locations continuously until the store area is declared rodent-free. Poison should be kept away from children. Other workers must be informed when rodent poison is being introduced.

Dead rodents should be removed immediately.

Microorganisms (mold): These will also be considered under two headings: prevention and control.

Prevention

- Store only grains that have been dried to the safe moisture content.
- Avoid leaks in the store/warehouse. Keep it dry. When the grains have already been kept in the warehouse, don't allow water inside at all.
- Ventilate the store/warehouse adequately.
- Deal with the presence of rodents immediately any traces are noticed.

Control

- Sort out affected grains and destroy them some distance away from the store/ warehouse.
- Ensure regular sun-drying and re-drying of the grains when the need arises for it.
- Limit the rate and number of people visiting the warehouse.

Integrated pest management (IPM)

This is a general pest control strategy that restricts use of harmful pesticides and favors the use of natural methods of pest control, such as the use of predator species, and hygienic and cultural practices. IPM is cheaper and safer but slower pest control.

Conclusion

Pests are indeed numerous and occupy virtually all habitats. Losses incurred by their activities could be enormous. However, detection and quick action could significantly reduce the spectrum of problems posed by pests on the field and in stores.

Part 2:
Safety and postharvest issues

7. Safe uses of agrochemicals

R.S. Adamu
Department of Crop Protection, Institute for Agricultural Research
Ahmadu Bello University, Zaria

Introduction

Agrochemicals are all chemical products manufactured or processed for use in agriculture and allied industries. They include pesticides, veterinary products, and fertilizers. Agrochemicals are used to improve or protect crops and livestock. Fertilizers are applied to obtain a good yield from crops. Farm animals are similarly protected from parasites and disease by veterinary treatment, such as vaccination, oral dosing, immersion, or dropping.

Agrochemical use encompasses handling, storage, transport, spillage, and disposal. The chemical substances used as agrochemicals also vary and may include liquids, powders, granules, or gases. These substances could be applied through self-propelled or manually operated sprayers. Many of these substances are harmful or poisonous to humans, livestock, wild life, and the environment. Their indiscriminate use might pollute the air, water, and soils, resulting in high residual levels in foodstuffs and the contamination of drinking water.

Fertilizers are chemicals that supply plant nutrients and trace elements when applied generally to soils to promote the growth of crops and are available in solid and liquid forms. Fertilizer use poses hazards to the user. Dry (solid) fertilizers attract moisture and can draw water out of the skin; they cause burns, characterized by reddened skin and minor discomfort, but can be painful to people with sensitive skin.

Dry fertilizer can also get into and irritate the mouth, nose, and eyes. The way to prevent burns is keep fertilizer off the skin. Wear a long-sleeved shirt buttoned at the collar and a cap or hat to keep dust out of your hair. It is also advisable to change your clothes after applying fertilizer. Do not let the chemical stay in contact with your skin for long. Wash your exposed face, hands, and arms with soap and water.

Pesticide is a broad term for a large number of chemicals aimed at controlling pests. They include herbicides, insecticides, fungicides, bactericides, and algicides, as well as plant growth regulators and harvest aid chemicals.

Safe use of pesticides

Safety and health are of great concern to all users of agrochemicals because of their extreme risk to the users, general public, and the environment. In warm weather, the chance of pesticide contact is greater than in cool weather. The flow of blood in the skin increases with higher temperatures and therefore pesticides are more easily absorbed.

There are three ways in which pesticides can cause health damage:

1. through acute poisoning by direct contact.
   An acute poisoning is the result of sudden and severe exposure to a large amount of pesticide.

2. through frequent exposure, causing chronic health damage.
   Chronic poisoning is through long-term repetitive exposure to small amounts of poisons that would remain ineffective after a single exposure.

3. through environmental contamination.

This has detrimental effects on various ecological systems—ultimately affecting humans as well.

Pesticide application

The use of a spraying machine instead of using the hands (as in fertilizer application) confers some amount of protection for the operators. However, that alone is not sufficient for complete protection. Usually the chemical is broken up into small droplets during spraying and these can enter the operators' system.

Many farmers and agricultural workers die, and many more are poisoned or injured each year, by substances that enter the body; the main routes of absorption are through the respiratory tract (inhalation), the skin (dermal contact), and the digestive system (ingestion).

Inhalation of the agrochemical through the lungs mostly occurs during packing, mixing, spraying, or treating enclosed spaces, with pesticides in the form of fine spray droplets, or through dust, fumes, and smoke. Skin absorption comes through direct contact, through spillage from the container or during mixing or by contact with drifting spray particles. Most of the pesticides, especially emulsifiable concentrates, are highly penetrative, particularly those formulated with solvents such as kerosene, petroleum products, or xylene.

Ingestion through contamination of the lips and mouth or by the accidental swallowing of the agrochemical is often caused by poor hygiene or bad practices, e.g., keeping pesticides in unlabelled containers, especially if they resemble those used to store food and beverages. It can also occur if food or drink is consumed in the vicinity of the area where the mixing of the chemical is carried out. Failure to wash properly before eating is another common cause, so is smoking during the mixing or spraying of pesticide. Also, any attempt to clean a blocked sprayer nozzle by putting it between the lips and blowing into it is another bad practice.

Personal protective devices

***Overalls*:** These protect the body, especially to prevent skin contact with sprayed chemicals. For tropical use, fabric/cotton overalls are preferable to those made from synthetic materials. The overalls should have long sleeves and should extend below the boot top level.

Aprons: These are an additional form of protection recommended for wearing, during mixing/loading operations. They should be of material resistant to chemicals, such as PVC or coated nylon.

Gloves: These should invariably be used during mixing/loading as well as spraying operations. Gloves should not contain cotton or any fluid-absorbing material(s), since such materials when wet can be dangerous by providing a continuous source of contact. Gloves should be washed before being removed from the hands.

Head covering: Any protective, nonabsorbent head covering can be used to protect the head and forehead.

Shoes: Preferably lined or unlined boots are recommended for use during the preparation of a mixture and spraying. Leather and fabric shoes should be avoided as they absorb pesticide and hence can be dangerous.

Eye shields: Normally, a full shade should be worn. If a full shield is not available, ordinary wide-brimmed goggles with nonabsorbent strips can be used for eye protection against splashes.

Gas masks: They are protective devices for the respiratory system. They are generally of two types. The cartridge type covers the mouth and nose and has a one-way valve, allowing inhalation of air only through an absorbent type of cartridge and filter. The gas mask contains more absorbent material than the chemical cartridge type and usually covers the entire face.

The degree of protection needed when mixing and applying a pesticide should be indicated on the product label. However, in hot climates, it is uncomfortable to wear heavy protective devices/clothing. Rubber boots, gloves, masks, and respirators soon become extremely irritating to wear, especially if humidity is high. Operators are generally reluctant to wear such very uncomfortable protective equipment.

Other protection is desirable against indirect sources of hazard.

Vibration effect: This can be experienced on motorized knapsack sprayers. Care has to be taken to ensure that the sprayer is provided with suitable rubber cushions to prevent the engine's vibrations from affecting the operator.

Noise protection: This too is applicable in a motorized unit. Where machines are too noisy, it is desirable that the operators use earplugs or earmuffs to protect their hearing.

It is essential that all operators are adequately trained in all aspects of the job and are made fully familiar with the necessary safety precautions before being allowed to carry out spraying operations.

Labels

The purpose of the label is to convey a message about the product, what it is, who makes it, and how it may be used safely and effectively. Any instructions in pesticide labels should be in simple and comprehensive language.

Before using any agrochemical, the user should read the label well. The following should be indicated on any label: hazard symbol, trade name of the product, name and quality of the active ingredient, purpose for which it is to be used, registration number, name and address of the manufacturers, distributors or agents, directions for use, safety precautions, warning and statement of good practice, amount by weight or volume in the container, interval between agrochemical application and harvesting.

Users of agrochemicals should always read the instructions before use. If they do not understand them, they should ask someone who can explain them.

Pre-spraying precautions

- Read and understand the instructions on the label.
- Ensure that the spray operator knows how to apply the pesticide with the intended equipment.
- Check the application equipment to ensure that it functions satisfactorily without leaking or spilling, and is calibrated for the necessary application rates.
- Ensure that the necessary protective devices are ready.
- Check that the weather conditions are satisfactory to avoid excessive drift from the wind.
- Warn people nearby if the sprays may affect them. Move livestock and other animals away from the vicinity to be sprayed.
- In preparing mixtures for spraying, take care to ensure that measuring cups and mixing buckets are not to be used for other purposes.

Precautions during application

- Wear protective clothes
- Avoid windy conditions; always start sprays downwind.
- Avoid spraying near beehives, lakes, and streams.
- Minimize drift hazards; use the lowest nozzle pressure and spray at a low height.
- Afterwards, ensure the safe disposal of empty containers and surplus pesticide.

General rules for safe use of pesticides

1. Always read the label thoroughly before using pesticides.
2. Take extra precautionary measures when mixing pesticides. Use proper pouring equipment and funnels and wear protective clothing/devices.
3. Before use, check spraying equipment with care; never use leaking equipment.
4. When spraying, make sure that water, soap, and towels are available so that the skin can be washed immediately in the event of contamination. After spraying, wash the whole body and change clothing.
5. When preparing the spray solution, do not eat, drink, or smoke, and do not do so until the spraying is completed and the hands have been washed thoroughly.
6. Be aware of the possibility of poisoning; keep pesticide away from children and animals.
7. Avoid over-long working days when spraying to prevent mistakes being caused by fatigue.
8. Never rinse spraying equipment in surface water.
9. Always keep away from recently sprayed crops.
10. Spraying should not be carried out in blazing sunshine or a strong wind.

11. Leftover spray mixture should be kept in a safe place or given to another farmer who can finish it.
12. Empty containers should be disposed off safely (destroyed or buried).

Conclusion

Agrochemicals, particularly pesticides, are designed to be toxic and can be dangerous if they are misused or handled carelessly. Therefore, safe and effective use should be the concern of everyone.

Calibration of spraying equipment is mandatory to ensure that the equipment has no leakages or worn-out nozzles and is delivering the desired quantity of pesticides/unit area.

8. Quality control measures for seed production of legumes and cereals

B. Sule[1] **and P.O. Ojo**[2]

[1]*National Agricultural Seed Council, Samaru, Zaria*

[2]*National Agricultural Seed Council, Abuja*

Introduction

Seeds are the part of a plant which, when planted under favorable conditions, are capable of germinating to reproduce the original plant. Examples are grain/true seeds (rice, maize, millet), rhizomes (ginger, some grasses), tubers (yam, cocoyam) and stem portions (cassava, sweetpotato). Improved seeds are seeds derived from the efforts of research and so are genetically superior to the traditional varieties. The objective of seed quality control in a seed production program is to produce high quality seeds that meet the National Certification Standards set for both the seed crop and the seeds.

Seed quality attributes

- Varietal purity: free of mechanical damage or injury, superior, high yield.
- Good consumer acceptability.
- Viable, with high germinability.
- High seedling vigor.
- Free of disease infections.
- Free from insect pests.
- Free from weed seeds.
- Right moisture content
- High level of physical purity.
- Uniform (homogeneity of the seed lot).
- High level of performance potential.
- Good maturity period.

To meet set quality standards, a number of factors have to be taken into consideration during seed multiplication, storage, and handling.

Seed source: Seeds for planting should be bought or collected only from approved sources and must be certified: Breeder seeds from the National or International Agricultural Research Institutes, high quality foundation seeds from National Seed Service, now the National Agricultural Seed Council, certified seeds from private seed companies, ADPs, NGOS, and agricultural input supply companies. Both foundation and certified seeds of a particular variety must be authentic (true to type).

Land requirements and preparation: Choose fertile land having a good capacity for water retention. The cropping history for most seed crops prescribes that a period of at least one fallow season is required between two seed crops of the same variety and the same generation, i.e., seed growers must not produce foundation seeds stage I of a particular variety on the same land where foundation seeds stage I of same variety was

grown the previous year. This is to prevent contamination from the previous seed crop through volunteer stands and diseases.

Land preparation begins with slashing and burning any previously growing bush on the selected seed plot. This should be followed by plowing and harrowing so that, at the time of planting, the seed plot will be clean and free of weeds. The concept of minimum tillage where the slashing of land is followed by the application of a herbicide before planting is also acceptable in seed production technology.

Isolation: To prevent contamination by foreign pollen, a certain isolation distance in terms of land area is required between seed crops of the same species or different varieties of the same species, of the same color, or different colors.

Isolation distance is also a check on pest infestation and disease infection. An isolation distance should be maintained round the seed crop. A larger isolation distance is required for cross-pollinated crops than for self-pollinated crops. Most crops that are considered as self-pollinating are not 100% self-pollinated. They have some percentage of out-crossing. Therefore, even in the real self-pollinated crops, a certain distance is required between two fields and such a distance, too, is required to prevent diseases and pests. Buildings, lakes, and mountains are some physical barriers used for isolation. Time isolation can be employed but the certification agency must be notified because experience has shown in Nigeria that unless the time isolation between two seed crops is really large, the young crop will usually catch up with the older crop, particularly if field conditions favor the younger crop, and so contamination can take place. Examples of minimum isolation distances of some crops are as follows.

Hybrid maize/foundation seeds	-	400 m
Certified seeds	-	200 m
Cowpea, groundnut, rice	-	3 m
For seed-borne diseases	-	150 m

Nutrition: A healthy seed crop will give rise to seeds with high vigor if other conditions are optimum. Based on soil tests, the right fertilizer should be applied to the seed crop. Lack of nutrients (macro/micronutrients) can lead to some deficiency diseases. It is important that all fertilizer applications to most varietal seed plots are completed before the flowering stage.

Weed control: Keep the seed field weed-free and clean. Noxious weeds must be avoided totally and are difficult to get rid of, using normal cultural practices. If a seed crop is too weedy, the certification inspector may fail it, usually after the seed grower has been warned.

Weeds compete with the seed crop for soil nutrients, water, and sunlight. Weeds can carry/harbor diseases and pests. Weeding can be manual or through the use of suitable herbicides. It is essential that seed plots are free of weeds, especially during the early stages of growth and harvesting.

Plant protection: The seed crop should be free of diseases and pests, especially seed-borne diseases (diseases transmitted from one generation to another through seeds). Only certified seeds from an approved seed source should be used as planting materials.

Report any early observation of noticeable disease to the certification inspector and

follow his advice to avoid damage to the complete crop. Field pests at maturity need to be checked before the harvested seed crop is taken into the processing plant.

Roguing: This is the removal of off-type plants and variants. The certification inspectors will show you what rogues are in a particular seed crop. Uproot rogues, collect and throw them out of the seed field, and burn them. Seed fields are rogued several times to remove off-type varietal contaminants, diseased plants, other crop plants, and troublesome weeds.

Inspections: Seed fields must be registered with the certification agency for inspection services. Seed fields are inspected to check on isolation distance, off-types, other crop varieties, troublesome weeds, and diseases. The equipment used for planting, harvesting, drying, processing, and storage is also inspected for cleanliness. Harvesting should be done only after authorization from the certification inspector/agency and this is usually at physiological maturity of the crop.

During harvesting it is important to prevent physical admixture so that one seed lot should be harvested and removed from the field before the harvesting of another seed lot commences. A moisture meter is used to determine the safe handling and storage of seeds. Extra care must be taken when harvesting, manually or mechanically, to prevent soil clogging to seeds.

Hybrid seed production: Mark the end of either the male or female row in the seed field for proper identification. The tassel of the female parent must be removed before pollen shedding by male parents starts to prevent self-pollination. When removing tassels, do not pull out the flag leaf or penultimate leaf with the tassel. These leaves contribute a lot of synthates to seed formation. The male rows must be harvested first and kept out of the field before the harvesting of the female rows commences.

Drying: The seed crop should be dried only at a recommended temperature. Too high a temperature will damage seeds by reducing their vigor or can result in death. Too low a temperature may cause heating and molding which can also result in the death of seeds. Most grains are dried to a safe moisture level, between 12 and 14%, before processing and storage. Drying is important to prolong shelf life and protect seeds from easy attack by insects and pests during storage.

Seed processing: This is the process of physically removing undesirable elements in a given seed lot, leaving only the pure seed component. It involves pre-cleaning; grading, treating, weighing, and packaging. The seed processing plant should be clean and free from pests. If pest infestation is frequent, we prescribe fumigation before the new season. Run a small quantity of the seed crop through the machine; this is a discard. Then you put in the bulk of the seed crop. Use sieves of the right size, as prescribed in the National Standards. Follow instructions for the dosage in chemical treatment; too low is not effective and too high may cause phytotoxicity. Label all seed lots for proper identification and sanitize the surroundings of the plant.

After processing, samples must be drawn for laboratory analysis, physical purity, germination percentage, and moisture content. The first two tests are required for labeling, the last for information on the storability of the seed lot. If the seed lot meets the National Standard, then certification labels can be issued to be fixed to bags containing approved seed lots.

Seed storage: Relative humidity and temperature are the two most devastating problems for seed storage, if not well managed. Therefore, these two factors that are responsible for seed deterioration during storage must be properly controlled. Some useful sample rules of thumb developed by Harrington on seed storage are as follows.

For every 1 ^{o}C decrease in the storage temperature, you can double the storage life of a seed lot. The rule applies within a specified temperature range **(between 38 ^{o}C and 0 ^{o}C)**.

- For every 1% decrease in moisture content, you can double the storage life of a given seed lot. The rule also applies within a specified moisture content range **(between 13% and 5%)**.

Generally, a good storage area for many other grains must be protected from rain, high temperature, pest invasion, and diseases. Do not carry new seed stocks to join diseased or pest infested seeds. Always ensure cleanliness and proper sanitation before fresh seed stocks are put in the store. All seed lots must be properly labeled for identification with each container bearing its labels with the necessary information. The seed store must be cool to cold, with a dehumidifier installed, particularly in the humid tropics.

Seed distribution: At all stages, where seeds are handled, extra care should be taken to prevent physical admixture, spilling, and damage to containers. The quality of the seeds must be maintained as much as possible at the level at which they left the store. Remember that the Certification Officer is a friend, not a policeman, so always call him if you are not sure of what to do.

Suggestions for further reading

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9. Recommended seed processing and storage practices for legumes and cereals

H.A. Ajeigbe
International Institute of Tropical Agriculture, Kano

Introduction

Seed lots received from the field often have a high moisture content and contain trash and other inert materials, weed seeds, deteriorated and damaged seeds, off-size seeds, etc. Therefore processing is necessary to dry the seeds to a safe moisture level, to remove or reduce to the extent possible the various undesirable materials, and to have a uniform seed size and general seed treatment to upgrade the quality. In its common usage, seed processing refers to all the steps necessary for the preparation of harvested seeds for marketing: handling, drying, shelling, preconditioning, cleaning, size grading, treating, and packaging,

The primary purpose of storage is to save seeds from one season to the next. However, seed companies, seed marketers, government agencies, and farmers often find it useful or necessary to store seeds for at least 2 to 3 years, and sometimes for longer.

There are several reasons for this: seed yields and quality (germination and vigor) may be unpredictable due to growing conditions; stored seeds are a strategic reserve to guard against unfavorable weather conditions. Government policies and the market demand for certain crops may vary significantly from one year to the next. Market demand itself can be strongly influenced by media coverage of certain varieties that may quickly fall in or out of favor, depending on media exposure. Likewise, the psychological effects of poor growing conditions from the previous season may also influence market demand. The purpose here is to provide guidelines for minimizing damage to seeds and maximizing their viability and vigor from preharvest through postharvest processing. The first section deals with the general principles of processing and storage while the second gives specific processing and storage practices promoted in Nigeria.

General principles of seed processing and storage

Because seeds are routinely stored for more than one year, it is important to understand how harvesting, processing, and storage affect their longevity and vigor. Seeds are fragile living organisms, and their shelf life is affected by factors at the beginning of the plant's life cycle, such as soil nutrition. For example, if the soil is deficient in zinc, the quality of the seeds will be adversely affected. The factors that can have the most important effects on viability and vigor are harvesting, extraction, cleaning, transportation, and storage. It is easy for seeds to become damaged at any of these stages.

Harvesting: The basic rule is to allow the seeds to mature as long as possible on the plant without them or the fruit becoming diseased or overly ripe. Each type of plant has an optimal time for the seeds to be collected, but factors such as climate, weather, disease, insects, birds, or predatory mammals may require that the seeds are collected before that time. When seeds are ready to be harvested, the entire cob, panicle, or pod

will become brown and dry. During the maturation process, the ripening cob, panicle, and pod change color from green, to yellow green, to yellow, to light brown, to a darker brown, or dark gray. Ripening and maturation may be uneven within the pod, cob, or panicle, or uneven on the plant, and uneven within the stand of plants. For that reason, the pods of many plants are harvested individually. Seeds of legumes often develop a split along one side of the pod. This is the best time to collect the seeds, before the pods start to open and scatter their seeds. Confidence in knowing when to harvest comes both with experience and familiarity with different species and crops.

Threshing: After harvest, seeds are threshed to remove them from the surrounding plant material. A period of air-drying is important before seeds are threshed. Plant material should be spread out in thin layers until all layers are dry; otherwise mold, decay, and heat from decay will cause damage to the seeds. As the plant material dries, pods may split open or shed seeds. Harvested material should be stored in a well-ventilated room with low humidity. During this time you should be aware of insects, especially weevils that feed on the seeds. Plant material that is ready to be threshed should be brittle. Threshing is best done outside on a dry day. The threshing process involves the application of mechanical force using controlled pressure and a shearing motion and is accomplished by hand or by machine.

There are many different methods for threshing seeds. Plants that have pods, such as cowpea and soybean, can be threshed by placing the pods in a large feed sack, tying the bag securely shut, and then placing it on the ground where it is flailed, stepped on, jogged on, or danced on with a twisting motion. The sack is turned often to redistribute the plant material for further threshing. Care must be taken to not apply so much pressure that the seeds are abraded or broken (this is especially a concern with angular seeds). A mortar and pestle could also be used for threshing a small quantity at the farm level.

For small-scale seed production, it is often not cost-effective to purchase threshing equipment because of the small volume produced. It is difficult to locate low-cost, low-tech shredders for small-scale threshing. The options are to locate old, used equipment or to construct your own.

Seed drying: Drying is a normal part of the maturation process. Some seeds must dry down to the minimum moisture content before they can germinate. Low moisture content is a prerequisite for long-term storage, and is the most important factor affecting longevity. Seeds lose viability and vigor during processing and storage, mainly because the moisture content is high (>18%).

Seeds should be dried fairly quickly after threshing. Slow drying may result in mold growth or premature sprouting. Seeds should be spread out in thin layers and then stirred several times a day until dry. Use a polythene sheet, tarpaulin, or any hard non-stick surface as the base when drying seeds.

High levels of seed moisture cause a number of problems. Moisture increases the respiration rate, which in turn raises seed temperature. For example, in large-scale commercial storage, respiring seeds may generate enough heat to kill the seeds quickly or to even start a fire, if they have not been sufficiently dried. Small-scale growers are not likely to have such an extreme condition, but longevity will, nevertheless, be affected. Mold growth will be encouraged by moisture, damaging the seeds either slowly or

quickly, depending on the moisture content. Some molds that don't grow well at room temperature may grow well at low temperatures, causing damage to refrigerated seeds. In such a case, there may be no visual sign of damage.

Seed cleaning: It is not necessary to have expensive equipment to clean seeds for small-scale production. The majority of crop seeds can be cleaned with homemade screens. Winnowing will still be necessary to remove the smaller chaff.

Winnowing: The classic method of winnowing involves placing seeds in a wide basket and tossing the seeds and chaff into the air. The chaff is carried away by the wind. The most vexing part of the process is that the wind is always changing in velocity and direction. It can work for certain kinds of seeds, but it actually works better to use two large bowls, pouring seeds from one bowl into another bowl below, while blowing on the plant material as it falls.

This method works satisfactorily if the seeds are heavy and the chaff is very fine, and susceptible to being carried away by a gentle current of air. In any case, hand winnowing should be done, not on windy days, but when the air is calm. When dealing with large volumes or certain types of seeds, it is helpful to use mechanical equipment for winnowing.

Seed storage

Effect of temperature on seed longevity*:* The general effect of temperature on longevity is that longevity increases as temperature decreases. This is true of "orthodox" seeds: that is, most seeds that follow some general "rules of thumb" regarding longevity during their storage life. The relationship between temperature and longevity is that for each decrease in temperature of 10 ^{o}F (5.6 ^{o}C), longevity doubles. This rule applies to seeds stored between temperatures of 32 ^{o}F (0 ^{o}C) and 122 ^{o}F (50 ^{o}C). This rule assumes that the moisture content is a constant. This is a general guideline.

Subfreezing temperatures generally do not effect longevity provided the moisture content is less than 14% (because ice crystals do not form). This is the ideal way to store seeds, especially small seeds that do not require much freezer space.

Effect of moisture and humidity on seed longevity: Moisture has a greater effect than temperature. Most seeds also follow some "rules of thumb" regarding moisture and longevity. The general relationship is that for each 1% increase in seed moisture, longevity decreases by half. This rule applies to seeds with a moisture content between 5 and 13%. Above 13% moisture content, storage fungi and increased heating from seed respiration cause longevity to decline at a faster rate. Once seed moisture reaches 18 to 20%, increased respiration and the activity of microorganisms cause rapid deterioration. At 30% moisture content, most non- dormant seeds germinate.

Relationship between relative humidity and seed moisture content*:* When commercially grown seeds are to be stored, it is impractical and too costly to use desiccants to dry them for storage, unless the seeds are small and expensive. Commercial seeds are usually packaged for short-term or long-term storage under conditions of ambient humidity (unless special equipment is used). Because relative humidity has a significant effect on seed moisture content, it is important to understand the relationship between them, regardless of the type of storage conditions.

Tips on the solarization of seeds and triple bagging technique: This method of storing seeds is easily adopted, cheap to practice, and compatible with the facilities of small and large-scale farmers. Cowpea seeds stored using this method can be planted as seeds or used as grain for consumption.

Materials needed: Two plastic bags, black plastic sheet, polybag, 100 kg of seeds, Phostoxin, gloves, and mask to cover the nose and mouth.

Precautions

- Use white plastic bags to allow ease of inspection.
- Ensure that the bags are intact without perforations and strong enough to withstand damage during transactions.
- Use a good quality plastic sheet that will not melt under high light intensity.
- Use new Bagco bags; old bags may harbor bruchids or their eggs.
- Start drying cowpea when the sun has become hot; 3–4 hours continuous drying is recommended, depending on light intensity.
- Ensure that one tablet of Phostoxin in a matchbox is stuck at the center of the bag.

Procedures

- Place the black plastic sheet on the floor to retain heat and prevent seeds from taking up soil moisture.
- Place well-cleaned cowpea seeds on the plastic sheet and spread them evenly.
- Cover them with another plastic sheet that may be of any color.
- Place weights on the top sheet to prevent it from blowing away.
- Dry the seeds continuously for 3 to 4 hours.
- A sign of complete drying is when a cowpea seed will break sharply with a cracking sound when bitten between the teeth.

Heat generated under the plastic sheets is sufficient enough to kill the eggs, larvae, and adult bruchids without affecting the seeds' viability.

- Slip one of the plastic bags into the second one and place the two neatly inside the Bagco bag.
- Pour the well-dried seeds into the inner plastic bag and drop one tablet of Phostoxin wrapped in an envelope or in a matchbox when the bag is half-full
- Fill up the plastic bag with cowpea seeds, squeeze out the trapped air, and tie the bag.
- Then tie the second plastic bag and finally tie the Bagco.

When bagging 100 kg of seeds, use plastic bags with 120 kg capacity. When bagging 50 kg of seeds, use plastic bags with 70–80 kg capacity. The extra space left after the required amount of seeds will permit the mouth of the plastic bags to be tied. The use of a fiber bag may not be necessary although it protects the plastic bags against perforation.

- Periodically inspect the bags by looking through the white plastic bag.
- If there is a bruchid buildup, re-dry and place one tablet of Phostoxin.

Cowpea seeds stored by this method can be stored for more than a year without spoilage; however, it is strongly advised that regular inspection be carried out.

Important considerations in seed processing and storage

Harvest the crop as soon as it is mature to avoid field infestation, the earlier the harvest, the less the chance of infestation.

1. Dry the grains properly, making maximum use of sun and wind. Low moisture content is crucial for extended storage life.
2. Clean the seeds properly. Broken grains, dirt, and pieces of straw increase the chances of storage problems from insects and molds.
3. Select clean and healthy seeds to be retained for long-term storage.
4. Clean the stores thoroughly before filling them with new seeds.
5. Ensure dry and cool storage conditions.
6. Repair all cracks in the floor and roofs to deny places to insects.
7. Inspect the seeds frequently to detect any infestation early through sampling and sieving seeds, and shaking the bags.
8. Otherwise use airtight storage/insect-proof containers such as oil drums with perfectly fitting lids. Also plastic bags or sacks with no holes can be utilized or dry pumpkin gourds.
9. Triple bagging, using polyethylene bags, has been found to deter bruchid infestation for up to 6 months.
10. Small quantities of seeds at the farm level can be protected from bruchids by the use of minerals such as fine sand, ash, or limestone.

- 1 kg of fine sand mixed with 10 kg of cowpea seeds.
- 1 kg of wood ash mixed with 40 kg of cowpea seeds.

Vegetable oil provides some degree of protection to seeds in storage against bruchids for up to 3 months.

- Groundnut oil – 5 mL/kg of cowpea seeds.
- Neem seed oil – 3 mL/kg cowpea seeds.

Use of insecticides: Only a few insecticides can be used to control storage pests because of strict regulations concerning safety. It is important to note the following.

- The use of insecticides is a waste of money and effort when good storage practices are not implemented. Find out which insecticides to use under specific circumstances or against specific pests. Know the quantity and timing of application.
- No single insecticide is safe. Advertisements proclaiming that an insecticide is safe or nontoxic should be taken with a pinch of salt and strongly doubted.

Use insecticide only on stored products that are clean and dry, and in good storage conditions.

Never buy or use an insecticide without a label. Follow the directions for use strictly; do not use more than the recommended dose. Wear protective clothing while applying the insecticides to avoid contact.

There are two main ways to apply insecticides to control storage pests.

1. Mix the insecticide with the grain. The insect is killed when it gets in contact with the poison. This can be applied through several formulations, i.e., dust, wettable powder (WP0, and emulsifying concentrate formulation (EC0. However, such grain should *not* be consumed and, therefore, this method is strongly discouraged.

2. Fumigate—the insecticide is in a gaseous form and so penetrates the stored product.

When chemicals are used, it is very important to follow laid down safety precautions.

Part 3:
Socioeconomic issues

10. Dissemination of legume and cereal certified seeds using the community seed approach

N.O Utoh[1] **and H.A. Ajeigbe**[2]

[1]*National Program for Food Security*

[2]*International Institute of Tropical Agriculture, Kano*

Introduction

Crop research institutions in Nigeria (national and international) have developed many varieties of their mandate crops that are high yielding, disease and pest resistant, early maturing, and aimed at increasing the productivity, income, and livelihoods of resource-poor farmers. It is important that improved seeds of these varieties are disseminated to farmers at the right time and in the right quantity and quality. There are many channels for seed dissemination and this presentation will look at the community seed approach as a viable strategy.

Background information

There are three classes of seeds: breeder, foundation, and certified seeds (CS). It is important to stress that CS are the seeds that farmers use for crop production and are produced by the seed companies, ADPs, some NGOs, out-growers, and NPFS community seed growers. The seed subsector policy of the country stresses the importance of high quality seeds for crop production and provides that "the seed industry program would be invigorated and the community seed program promoted to ensure provision of adequate and good quality seeds to local farmers."

The seed supply situation

Seeds are the most important and cheapest input in crop production as 50% gain in productivity is attributable to use of improved seeds and the balance is due to other inputs, such as fertilizer. The seed system can be either formal or informal. The formal system generally consists of public sector research institutions, seed companies, and organizations (National Agricultural Seed Council) responsible for seed certification and quality control. The CS used for commercial crop production are produced mainly by five seed companies: Premier Seeds ltd, Alheri Seeds, Nagari Seeds (all in Zaria), Seed Project (Kano), and Savanna Seeds, Jos. Although there are a few emerging suppliers, these are the leaders in terms of infrastructure and branch network, and have been around for quite some time. It was estimated that about 62,250 t of CS of the major cereals and legumes would be required by 2010. The total production by these seed companies is less than 10% of this national requirement. Furthermore, their focus is mainly on hybrids and a few open-pollinated crops; other crops, such as cassava, and millet, are not in their production profile. The informal system consists of large numbers of farmers who produce both traditional and improved varieties and market their own production. A larger percentage of the smallholder farmers' seed requirements is met through the informal sector. It is therefore important to give due recognition to the informal sector and to use it as a vehicle for providing resource-poor farmers with quality seeds of improved varieties of crops at affordable prices.

Seed dissemination by these companies

Dissemination is the array of activities along the channel through which the processed seeds (CS) from the factory are supplied to the consumers**.** Channels of seed dissemination include: distributors who sell wholesale, stockists (retailers), agricultural organizations or programs and projects, and also through direct supply to farmers.

Different levels of discount are provided, depending on volume. It is important to realize that seeds are alive (they contain a dormant embryo) during the dissemination process and should be handled with a lot of care. In spite of these channels, it has been established that the seeds of these companies do not get to resource-poor farmers because the dealers who stock them are limited to State capitals and some LGAs. There is, therefore, a compelling need for a complementary dissemination strategy that will get the improved seeds as close as possible to the farm. This new dissemination system is the community seed strategy for farmer-to-farmer seed diffusion.

Farmer-to-farmer seed diffusion

IITA, IAR, and Kano State Agricultural and Rural Development Authority (KNARDA) jointly used this strategy in 1997 to promote new varieties of cowpea (IT90–277-2 and IT93K-452–1) and millet (SOSAT C88). About 8 kg of the cowpea varieties were given to each of the primary farmers selected to establish 0.4 ha of seed farm. The 300 kg of seeds produced by each of the primary farmers (foundation seeds step 1 = FS 1) were distributed/sold to 12 secondary farmers. Each secondary farmer in turn established 0.4 ha of seed farm (FS 2) and the 300 kg produced by each farmer gave a total of 3600 kg, enough to plant 144 × 0.4 ha of the commercial crop. The NSS, IITA, IAR, and the ADPs of Kaduna, Jigawa, and Kano States inspected the seed farms under the Strategic Seed Reserve project, sponsored by USAID. This dissemination strategy aimed to promote improved varieties of sorghum, groundnut, millet, and cowpea in these States. In 2004, there were 2042 primary farmers working directly with IITA and 30,000 secondary farmers who had collected CS of these crops from the primary farmers. This led to these participating states being saturated with these improved varieties, and increased productivity and production of these crops.

Seed dissemination using the farmer-to-farmer seed diffusion approach

It is a faster and cheaper means of seed dissemination than the conventional method. It hastens the adoption of new varieties, leading to increased productivity, enhancement of food security, and poverty reduction.

Cowpea seed dissemination in the FCT

Two improved varieties of cowpea (IT90K-277-2 and IT93K-452-1) were disseminated in the FCT through a collaborative program involving IITA, NSS, and FCT ADP under the Strategic Seed Reserve project of USAID. In 2003, twenty cowpea farmers were selected and trained in cowpea seed production and storage. Each farmer established 0.25 ha of IT93K-277-2 with 6 kg of FS I provided by IITA together with insecticide for insect control.

On average, each farmer produced 125 kg of FS 2, giving a total of 1250 kg of FS 2 from the 10 primary farmers. Seed fields were inspected by NSS. Seeds were distributed/sold to 50 secondary farmers in 2004 to produce CS for commercial crop production. Because of the success of this dissemination strategy, over 500 cowpea farmers in the FCT participated in the program in 2005.

Seed dissemination at NPFS sites

In 2005, the NPFS and IITA organized a training program on the integration of legumes into the farming system. Site managers and Apex chairmen from 13 states where cowpea were grown were trained from 5 to 7 September 2005 at IITA, Kano. Each trainee was given 25 kg of IT93k-452-1 to establish 1 ha of seed plot. The 800 kg from each plot (allowing for about 20% to be retained by the farmer) were distributed/disseminated to other farmers using the farmer-to-farmer strategy (the seeds from each farmer would be enough to establish 32 ha). Thirty-two secondary farmers each got 25 kg from each primary farmer; (13 of them), leading to the establishment of 32 × 13 ha, i.e., a total of 416 ha of cowpea CS seeds. These were distributed to other cowpea farmers for commercial crop production. The fields were inspected by the NSS.

Strategies to Improve community seed approach (informal seed system)

The rate of adoption of improved seeds is low, partly due to lack of interaction between the formal and informal seed systems. It is rare to find improved varieties bred at the research stations being passed on to the informal sector for multiplication and sale as an essential part of the national seed policy. Yet it is the informal sector that holds the key to improving access to seeds and crop productivity among smallholder farmers, especially seeds of self-pollinating crops. In recognition of this fact, the NPFS has made community seed production an integral part of its activities. The formal seed sector has shown little interest in seed multiplication for self-pollinating crops and crops with high seeding and low multiplication rates. The cost of production, processing, and transportation has made seeds of these crops expensive. Also farmers tend to save and use their own seeds, thus offering little demand for them and low returns to seed companies. For such crops the most economical way is to produce FS or high quality CS and sell these to identified seed growers within the community.

The quality of Informal sector seed used by farmers can be improved in several ways:

1. Train farmers in seed production strategies (selection, isolation, treatments, storage, etc,).
2. Link farmers to seed companies and research institutions for routine renewal of seed stock by giving them new stocks of FS or CS.
3. Develop new improved varieties meeting local quality and market preferences and produce good quality seeds of these varieties through formal and informal channels and popularize the varieties to increase demands for seeds.
4. Use effective extension services. Extension plays a crucial role in training farmers in crop and seed production and is therefore a prerequisite to establishing a seed system, since farmers needs training in various aspects of seed production.

Conclusion

The community seed dissemination strategy has been used by IITA, IAR, and the ADPs of Kano, Kaduna, and Jigawa States to promote the adoption of new varieties of cowpea, sorghum, groundnut, and millet in these States. IITA, NSS, and FCT ADP under the Strategic Seed Reserve Project used the same strategy to promote IT90K– 277-2 and IT93K–452-1. The NPFS is also using the strategy to promote cowpea, sorghum, maize, and millet varieties at 109 NPFS sites in the 37 states including FCT. It is a strategy complementary to the conventional means of seed dissemination by the seed companies and NGOs. Two factors determine farmers' demand for seeds of improved varieties: (1) level of interest in the new varieties, and (2) whether the seed system is appropriate for the crop and varieties and practical for farmers.

11. Community seed production at National Program for Food Security sites: concept, justification, and achievements

N.O. Utoh
National Program for Food Security

Introduction

Seeds are the most important and cheapest input in crop production. There is documentary evidence to show that a 50% productivity gain in crop production is due to the use of improved seeds; the balance is attributable to other inputs, such as fertilizer and agrochemicals. Seeds differ from grain in the following ways:

- Seeds are used to propagate the species; grain is for consumption by human beings and livestock.
- Seeds are produced from a field that is specifically for seed production and has met the minimum approved field standards.
- Seeds are alive; they contain a dormant embryo that germinates when the suitable conditions are provided.
- Since seeds are alive, they have to be kept in a cool, dry place to retain viability.

The community seed development program (CSDP)

The Community Seed Development Program (CSDP) was approved in 1998 by the National Council for Agriculture (NCA), the highest policy-making body for the Federal Ministry of Agriculture, to address the inadequacies in seed supply to resource-poor farmers, the majority of whom are in the rural areas. Furthermore, the Nigerian Agricultural Policy (2002) states that seed industry development would be invigorated and CSDP promoted to ensure the adequate supply of good quality seeds for all farmers. The concept is for selected and trained seed growers to establish 1 ha of seed plots, based on crop preference and agroecology, and to produce and sell their seeds (producer sellers) to other farmers in their immediate environment, at the right time, quantity, and quality, to improve their productivity, income, and livelihood.

The seed supply situation

There are five seed companies; Premier Seeds, Alheri Seeds, Nagari Seeds (all in Zaria), Nagoma Seeds (Kano), and Savanna Seeds (Jos). Currently, they meet only 10% of the requirements of Nigerian farmers for improved seeds. The companies are involved mainly in high-value crops (hybrids) and low volume crops (vegetables), mainly the exotic varieties. Because of logistic problems, their sales outlets are limited to the State capitals. The net result is that improved seeds do not get to farmers who therefore recycle whatever they have, with its implications for poor quality, low yield, etc., and are unable to service their credit facilities. It is necessary to stress that certified seeds (CS) the third category in the seed generation system, are what farmers use for crop production. Seed companies, NGOs, ADPs, and NPFS community seed growers all produce CS.

It was estimated that about 62,250 t of CS of the major cereals and legumes would be required by 2010. But the total production by the seed companies, NGOs, etc., is less than 10% of this. Therefore, there is a need for additional sources of CS.

Seed production at NPFS

The introduction of CSDP at 109 NPFS sites in the 2005 cropping season signaled the commencement of organized seed production to meet the needs of NPFS farmers for CS. Based on selection criteria, the ADPs in the south (17) selected two farmers/site, giving a total of 102 growers; the ADPs in the north including FCT (20) selected three farmers/site, giving a total of 108 growers, i.e., 282 growers in the 109 NPFS sites. Each grower established a 1 ha seed farm, based on crop preferences and agroecology. The foundation seeds (FS) were supplied by relevant National Agricultural Research Institute (NARI) and the National Seed Service (NSS). Protocols on seed production were given to the ADPs for guidance, including these crop varieties.

- Sorghum = SK 5912 and ICSV 400
- Maize = ACRO 97, SUWANI–SR, TZSR–W
- Rice = FARO 44 (Sippi) and FARO 55 (NERICA–1)
- Cowpea = IT93K–452–1, IT90K–277–2, and Ife Brown.
- Groundnut = Samut 23 and Sampea 12
- Millet = Sosat C88

A total of 96 t of varieties of these six crops were produced to support crop production at NPFS sites. The program operates on a cost–recovery basis.

Roles and responsibilities of stakeholders in NPFS

NPFS

- Conduct overall coordination of the program.
- Develop selection criteria and protocols for seed production to guide the ADPs.
- Procure and distribute FS.
- Organize training for seed growers.

State ADPs

- Select growers based on approved criteria.
- Supervise the implementation of protocols for seed production.
- Assist the growers in setting selling prices for improved seeds.
- Ensure internal quality control.
- Provide technical assistance and monitoring.

NARIs

- Provide FS of mandate crops.
- Provide resource persons for various training courses.

NSS

- Conduct seed certification.
- Provide resource persons for various training courses.

Participating farmers

- Express interest in the program.
- Implement the protocols on seed production.
- Process, package, and market the seeds, assisted by the ADP.
- Keep records and maintain cost-recovery accounts.

Proposed activities in the second phase of the NPFS

These activities include the following.

- A series of training programs, especially in seed enterprise development, seed marketing, seed certification, and quality control, to improve the skills and competencies of seed growers. The goal is to nurture them to the level of small-scale seed producers.
- Support for the NSS through;

– Provision of laboratory equipment to strengthen the five regional seed testing laboratories in the area of seed certification.

– Training of NSS Seed Certification officers.

– Backstopping/monitoring missions that will involve staff from FAO, NPFS, NSS, and ADPs.

Conclusion

Site-level seed production using the community seed approach has ensured the availability of quality seeds at the right time, quality, and quantity. This has resulted in increased productivity. A successful implementation of the activities proposed in the second phase will lead to higher productivity, enhanced servicing of loans, and the graduation of some of the growers to become small-scale seed producers.

12. Agricultural seed marketing and development of marketing network

O. Ogungbile
Premier Seeds Nigeria Ltd. Zaria

Introduction

Most of the increase in agricultural production recently experienced came from an increase in land area sown to crops and not from a yield increase. This means that Nigeria has not fully embraced science-based agriculture, involving the appreciable use of fertilizer, improved seeds, and crop protection products.

A key strategy for the development of sustainable agriculture is an efficient and well-functioning agricultural input market that makes use of the complementarities among fertilizer, improved seeds, and crop protection items.

All farming depends on a continuous supply of good quality seeds and planting materials. Traditionally, farmers select the best grains from their harvest and store these for use as seeds in the following season. But having enough for reproduction in the coming season has become increasingly difficult as a result of a drop in crop yield and the food shortage that has made it difficult for farmers to save enough seeds. The alternative is to turn to commercially produced seeds.

Seed marketing in Nigeria

Increases in the output of agricultural crops depend not only on the development of higher yielding varieties of seeds, but also on the efficiency of the system available to ensure that these seeds reach the farmer on time, at the right place, and at affordable prices. An efficient seed marketing system is thus an essential component of activities to increase productivity and enhance food security.

Seed supply in Nigeria

The National Seed Service (NSS) was established in 1992. It is responsible for coordinating development, monitoring policy, and implementing quality control in the seed industry. Agricultural institutes are responsible for the production of breeder seeds. NSS and the private sector produce foundation seeds while the private sector produces certified seeds. Certified seeds are sold to farmers through public and private sector markets. Public sector seed sales are made to farmers through farm service centers, ADPs, and cooperatives. There are a number of private seed companies that obtain breeder seeds from national research institutes and International agricultural research centers, such as IITA, ICRISAT, and AfricaRice. The companies produce certified seeds through an out-growers' scheme. An informal seed market also operates that provides farmers with improved, but uncertified seeds. The supply of improved seeds has increased substantially with the emergence of private commercial seed companies. The total production of certified seeds from the private seed companies can be estimated to be about 5000 t. There is, however, a great deal of underutilization of the companies' capacity.

Demand for seeds

The demand for certified seeds is still very low. Quite a small percentage of farmers use certified seeds in the country, although there is a significant increase in the demand for cereal crop and vegetable seeds, such as those for maize and sorghum. Incidence of carry-over stock is common in the company's warehouses. Brands of maize seeds include hybrid maize, Oba-super-1, New Kaduna, Oba-super-2, and Oba-98, exclusively produced by Premier Seeds, and improved open-pollinated varieties of maize, sorghum, cowpea, groundnut, cotton, and vegetables. The adoption of improved seeds remains very low because farmers still prefer their own seeds and are not easily persuaded about their traditional stock.

Other reasons include the following.

- The rate of replacement of a variety in use with a newly released variety.
- Quality of seeds.
- Low-level awareness and ineffective promotional activities.
- Inefficient arrangements for seed distribution and marketing.
- Price charged for seeds.
- Availability of complementary inputs, such as credit, fertilizer, and agro- chemicals.

The demand for seeds is derived from the demand for the farmer's product.

Concentration of participants in the seed supply chain

Participants in the seed industry include commercial seed companies, Government parastatals, ADPs, community-based growers, and other individuals. Only the commercial seed companies produce and sell certified seeds. Although there are a number of seed companies registered with the NSS, only about six companies are functional and they will be referred to as seed suppliers or producers.

The seeds produced require the development of marketing intermediaries to provide assembly, storage, and selling services. Many middlemen and long channels of distribution are needed. The distributors are generally small and numerous. Very few promotional or demand-creating activities are involved and branding is unimportant. Companies are very small with little or no capital to invest.

Seed distribution and channels

Distribution involves the physical movement of a product to the ultimate consumers. It therefore bridges the gaps of space and time between production and use. It is a useful vehicle for adding value to products and moving seeds to the market. The channel of distribution can be defined as a combination of institutions through which a marketer sells his product.

Seed marketing necessitates broad distribution. Seeds are normally marketed through intermediaries referred to as distributors who can be classified as big or small. They are referred to as wholesalers (if big) and retailers (if small), depending on the volume of seeds they handle. Promotional activities are unimportant to them. The distributors may carry several brands, so they are not able to promote any single brand. The entire promotional burden is virtually shifted to the company. The suppliers must advertise

extensively to develop recognition of and preference for their brand. Sales promotion devices, such as posters and displays, are critical in marketing and packaging.

Marketing department

A typical company's marketing department has a marketing manager who is responsible for the development of marketing plans that includes distribution, product development, pricing, and budget.

Marketing officers work closely with the retailers. Direct distribution from manufacturer to retailers and consumers is common. Marketing officers are members of the staff of the company assigned to a location for the purpose of marketing a company's product by making the product available for all categories of buyers who include some farmers, large-scale farms, and Government institutions.

Government purchases

The Government market consists of Governmental units, Federal, State, or Local, who purchase on behalf of the farmers at subsidized rates. The Government does not purchase to achieve profit-making objectives or for motives of personal consumption. It buys primarily for the benefit and maintenance of the farmers and the society at large.

An example is the Presidential Maize Doubling Initiative program in which Maize Association of Nigeria (MAAN) is given the responsibility of supplying maize seeds to growers at a subsidized rate. States also purchase seeds on behalf of their farmers through the commercial wing of the State ADPs. Some States have separate commercial outfits. Large farms and cooperatives buy seeds on behalf of their members. Of all these channels of distribution, the most sustainable is the private distribution or dealership system.

Marketing strategies

Seed pricing: Price is defined as a value or sum of money at which a supplier of a product and a buyer agree to carry out an exchange and be paid for seeds. In other words, price is the value of seeds expressed in a monetary form. The transaction takes place at either in a fixed or a negotiable price. Price-setting decisions have to be based on middlemen margins, allowances, discounts, freight payments, and geographical considerations. Seed prices should be affordable and competitive with suppliers of competitive products and almost standardized. Brand insistence is not yet very high. Farmers usually compare the prices of seeds and grains (in the ratio of about 3:1). Sales discounts and commission can be used to further reduce prices. The price assessment of the business will be determined by the company's effectiveness at pricing its goods and services. It must be reasonable to satisfy the customers and meet the company's objectives of a realistic profitability. The objectives of pricing include profitability, market share, and competition.

Zonation

Seed markets in Nigeria can be classified by geographical area into national, regional, local, eastern, north, western, and middle belt, and to divisions according to climatic variation. For instance, the Nigerian market should take into consideration all the States and the Federal Capital Territory. A regional market consists of a number of States in

the region, e.g., the middle belt region. Cultural preferences and tastes are taken into consideration. These are reasons why some companies establish zones for an effective coverage and better targeting of seed products to relevant zones of the country.

Promotional and advertising activities: Promotion is an essential activity within marketing. It creates awareness that stimulates interest in the product or brand.

Objectives and target of promotional activities may include the following.

- Building primary demand.
- Making an immediate sale.
- Giving information about a product's availability and price.
- Building brand recognition, preference, or insistence.
- Aiding salesmen by building awareness of a product.
- Increasing the market share.
- Creating a reputation for service, reliability, and research strength.
- Building up the general image of the company.
- Reaching new segments of the population within existing areas.

Information system: Most of the seed companies still pay less attention to information, which is a vital resource. Marketing information has become an important element in effective marketing. The emergence of computers, microfilming, photocopying machines, and mobile telephones has created a revolution in information handling. The Internet has made the world a global village. Most business firms do not operate yet at a high level of sophistication regarding information. There is the need to develop information systems that will provide readymade marketing information. There is a need for up-to-date information on the production and market prices of agricultural inputs and produce to be collected, analyzed, and disseminated.

Seed quality

The seed quality must meet the expectation of farmers in terms of attributes such as high purity, viability, vigor, and high yield. These aspects fall within the responsibility of NSS and the internal quality control mechanism of the company.

Constraints to market development

- Low demand for improved seeds.
- Inadequate arrangements for seed certification and seed control.
- Low funding of public sector institutions.
- Slow release of new varieties.
- Inadequate extension services.
- Inadequate funds on the part of the farmers to purchase improved seeds and complementary products.
- Low level of education among dealers and farmers.
- Poor organization to coordinate the activities of the stakeholders

Development of a marketing network

The seed-marketing subsector has been relatively dominated by the private sector, although the public sector has been providing support in the area of regulating policies and infrastructure. The market is inefficient and works fairly well but links in the chain are weak or completely separated.

To facilitate sustainable access to seeds and supplementary inputs, the farmer's partnership between public and private stakeholders must be strengthened. Organizations such as the Seed Association of Nigeria (SEEDAN) that draws members from all sectors of agriculture must be revived. The seed marketing system could be made effective by the promotion of the agribusiness concept in the rural market. This will entail a program of training and networking to improve farmers' access to seeds and complementary support services. Benefits of such training will include improved business management, book and record keeping, product knowledge, and credit mobilization. The profitability of fertilizer use by a farm heavily depends on the seed subsector producing and distributing certified seeds. The programs and achievements of the DAIMINA project should be sustained and built upon.

The preconditions for the provision of sustainable seed marketing are as follows.

- Create a conducive micro-policy environment.
- Build human capital for market development.
- Improve access to finance.
- Develop and implement a regulatory framework.
- Promote marketing transparency through information systems.
- Promote technology transfer activities.
- Strengthen research capacity for the private seed industry.
- Strengthen SEEDAN and MAAN.

13. Economics of seed production and the seed industry: case studies from Niger Republic and Borno State, Nigeria

T. Abdoulaye[1] and P.S. Amaza[2]

[1]*Agricultural Economist, IITA, Kano*

[2]*Agricultural Economist, IITA, Maiduguri*

Introduction

Agriculture has remained the mainstay of the sub-Saharan African economy with over 70% of the population depending on it for household food security, livelihood, and incomes. An increase in agricultural output has been a permanent objective. Technological change was identified as a way to achieve increased agricultural production. National and International research programs were then set up to develop new technologies in general. In particular, the development of new cultivars was given top priority, because the low yields and inadequate response to fertilization by local cultivars were seen as major factors hindering agricultural production. New cultivars with high yield potential have been developed to increase agricultural output and to improve farmers' income.

The adoption of these new cultivars has been rather disappointing to most experts and African farmers are still mostly using traditional cultivars, despite their limitations. Among the causes of this low rate of adoption of the improved varieties is the lack of enough seeds. Most farmers in the region have little or no access to improved seeds and continue to recycle seeds that have become exhausted after generations of cultivation (Zulu 2004). The resultant effects of depending on these poor quality seeds have been poor yield and persistent food insecurity.

This paper investigates the profitability conditions for hybrid seed production in Niger Republic and community-based seed production in Borno State, Nigeria. Specifically, the study will do the following.

- Determine the farm-level profitability of hybrid sorghum seed production by smallholders in Niger and the profitability and productivity of community-based seed producers for different crops in Borno State
- Identify the factors that influence the productivity of community seed producers.
- Determine the profitability conditions in the hybrid sorghum seed production industry in Niger.

Hybrid sorghum seed production in Niger

In Niger, the National Institute for Agronomic Research (INRAN) for a long time focused its effort on developing early maturing open-pollinated varieties (OPV) of the main cereal crops for the country (millet and sorghum). The sorghum program of INRAN later shifted its emphasis from OPV to hybrids, which led to the development and release of the first hybrid sorghum, NAD-1.

In this section, an activity budget analysis is used at the farm level to examine the profitability of hybrid sorghum seed production. Even though it does not consider the whole system, budget analysis is often the starting point in profitability evaluation. Positive returns are usually a good indication of the potential of an activity. Budgeting is quite a simple method of determining the net profit of an activity. It consists in the determination of the total costs that will be subtracted from revenue to get the net returns.

Historically, the rate of adoption of new cultivars has been low in Niger. Input markets (seeds and fertilizers), profitability, and policy in the environment have been blamed for this situation. Access to inputs, especially seeds, is critical for the continued diffusion of hybrid technology. There are potentially several ways to assure a consistent supply of quality seeds. Farmer-to-farmer diffusion is one potential model for seed supply (Venkatesan 1993). It was argued that this system is suited to OPV technologies. However, experience in Niger has shown that, with some supervision, farmers can produce hybrid sorghum on plots as small as 0.125 ha (House 1999). If hybrid seed production is profitable for small farmers, they can serve as contractors for a seed company or a farmers' cooperative.

The analysis suggests that a farmer with access to irrigation can profitably produce hybrid seeds in Niger. Budget analysis suggests a positive monetary income for a seed production activity (Table 1). This important feature makes it attractive for contract

Table 1. Farm-level seed production budget.

	Unit	Value per unit	Quantity	Total cost
1. Cash Expenses	CFA			144,000
Foundation seeds	kg	1600	30	48,000
Fertilizers	kg	200	250	50,000
Manure[1]	kg	10	1000	10,000
Irrigation fees[2]	CFA			36,000
2. Opportunity Cost (labor)	CFA			34,950
Land preparation	MD	750	2	1,500
Planting	MD	1000	1	1,000
First weeding	MD	1250	9	11,250
Second weeding	MD	1250	6	7,500
Third weeding	MD	800	4	3,200
Irrigation	MD	750	2	1,500
Fertilizer application	MD	750	1	750
Pollination	MD	750	1	750
Roguing	MD	750	1	750
Harvest	MD	750	9	6,750
3. Total Cost (1 + 2)	CFA			178,950
4. Cash Revenue	CFA			437,500
Seeds	kg	350	1250	437,500
5. Grain Production Value	CFA			44,500
6. Total Revenue (4 + 5)	CFA			482,500
7. Cash Return (4 – 1)	CFA			293,500
8. Return to Labor and Management (6 – 1)	CFA			338,500
9. Return to Management (6 – 3)	CFA			303,550
10. Return/kg of seeds (9/1250)	CFA			242.8
11. Rate of Return (9/3)				169%

Note: MD = person-day and $1 = 450 FCFA.

programs, in which farmers receive inputs at the beginning of the cropping season and repay them at harvest. In this case, a cooperative or private company can supply foundation seeds and fertilizers to farmers, who will supply the hybrid seeds. This significantly reduces the risk and it has been proved to be successful in all parts of West Africa with cotton.

In addition, given the estimated rate of return of 169%, this activity can successfully compete with most other investments available in rural Niger. For large investments, like those required for hybrid seed production, Lowenberg DeBoer et al. (1994), using data from Niger and Burkina Faso, estimated the expected rate of return in rural areas to be between 50 and 100%, depending on the activity. Small farmers, with access to suitable land, can therefore profitably adopt hybrid sorghum seed production.

The profitability of hybrid sorghum seed production depends on both yields and prices. There is some randomness in the yields, even though production is assumed to be under irrigation. Due to management differences, yields will be different. If the average seed yield falls from 1250 kg/ha to 410 kg/ha (the average sorghum yield in Niger was 307 kg/ha), the return to management will be zero and make the activity unattractive. Yields can fall below average for several reasons including poor management (weeding not done when needed, for example), poor quality control (poor roguing), and plant disease. If a minimum return to management of 150,000 FCFA (the average annual income in Niger) is assumed, then a minimum seed yield of 830 kg/ha will be required for the producer to, at least, break even.

It is also estimated that a minimum seed price of 114 FCFA/kg is necessary for a positive return to management. The average annual price of sorghum in Niger was 89 FCFA/kg in 1998. At this price, the producers are not getting any returns for their management.

If seed producers must receive compensation for their management which is equal at least to the annual average income in Niger, the seed price has to equal at least 230 FCFA/kg for the farmers to produce. However, It should be noted that 230 FCFA/kg is a relatively low price for seeds because it corresponds to a seed/grain price ratio of only 2.6 for 1 (2.6:1). For example, in the 1950s when the hybrid corn industry was taking off in the USA, the seed/grain price ratio was as high as 50:1 (Heisey et al.1998).

Community-based seed production in Borno State

In Borno State, with a weak seed system and poor access by farmers to improved seeds, the rate of adoption of improved varieties has also been historically low. The project *Promoting Sustainable Agriculture in Borno State* (PROSAB) initiated community-based seed production because farmers in Borno State lacked quality seeds at the time of planting. This section presents the steps in the calculation of the gross margin and net farm profit accruable to the seed producers.

Cost of seed production

The total cost for any firm is composed of the total variable cost (TVC) and the total fixed cost (TFC). Seed production then also has those two components that we will now look at in more detail.

Total variable cost items

The TVC is defined in accounting as that part of the production cost that varies with the production level. The major components of the TVC that the producers incurred in the

Table 2. Description of TVC Items (in Naira).

Description	2006
Synthetic fertilizer	5609.64
Organic manure	1285.71
Planting seeds	2356.95
Insecticides	1151.63
Herbicides	1300.83
Labor cost	2215.91
Hiring of work bull	2203.53
TVC	16,124.20

Table 3. TVC by seed type (in Naira).

Seed type	2006
Maize	43,658.23
Cowpea	4,949.94
Soybean	18,309.14
Rice	10,613.12
Groundnut	10,949.94
Sorghum	8,264.78
Overall average TVC	16,124.20

Table 4. TFC by seed type (in Naira).

Description	2006
Maize	3,463.12
Cowpea	2,064.54
Soybean	3,118.78
Rice	2,854.63
Groundnut	3,048.95
Sorghum	3,143.68
Overall average TFC	2,948.95

Table 5. Description of total cost items (in Naira).

Total cost	2006
Maize	47,121.40
Cowpea	7,014.48
Soybean	21,427.92
Rice	13,467.75
Groundnut	13,998.89
Sorghum	11,408.46
Overall average TC	19,073.15

course of production include labor cost, synthetic fertilizer, organic manure, seeds for planting, insecticides, and herbicides. The average costs incurred within the PROSAB community seed system for these items are presented in Table 2.

Some variable costs, such as labor costs, are not direct costs in the case of family operations.
They are, in fact, the opportunity cost of the family labor that the farmer used to produce the seeds. As indicated (Table 2), expenditure on synthetic fertilizer constituted the highest TVC item in the production of seeds. Specifically, it constituted 34.8% of the TVC in 2006.

Therefore, for increased efficiency, a seed production firm should look for ways to reduce this cost item. Table 3 presents the TVC incurred in the production system of each seed type. The largest TVC incurred was recorded for maize seed type in 2006, while the lowest TVC was recorded for cowpea in 2006. The observed TVC distribution across the seed types may be connected with the overbearing effect of synthetic fertilizer.

Total fixed cost items

The TFC of a firm are those costs that are not dependent on the level of production. These costs are related to the nature of the business and are incurred as soon as the business is established, even without any production. For seed production, this constitutes the amount incurred in the use of the durable farm tools that include axes, hoes, cutlasses, hand forks, wheelbarrows, spades, watering cans, head-pans, knapsack sprayers, sickles, and generating sets. The expense incurred on the knapsack sprayer constitutes 35% of the TFC. Table 4 presents the TFC incurred in producing seeds in 2006.

Table 6. Total revenue receivable for each crop (in Naira).

Seed type	2006 records		
	Unit price	Quantity sold (kg)	Total revenue
Maize	39.67	1668.42	66,186.22
Cowpea	38.70	334.18	12,932.76
Soybean	40.95	740.15	30,309.14
Rice	50.01	400.00	20,004.00
Groundnut	26.3	739.47	19,396.30
Sorghum	38.57	619.08	23,877.92
Overall average			23,737.92

Table 7. Farm gross margin and net farm profit in 2006.

Description	Gross farm income (GFI/ha)	TVC/ha	TFC/ha	Gross farm margin (GFI–TVC/ha	Net farm margin (GM–TFC/ha)	O/I index
Maize	194,665.35	128,406.7	10,185.65	66,258.65	56,073.00	1.40
Cowpea	38,037.53	14,558.64	6,072.18	23,478.89	17,406.71	1.84
Soybean	89,144.53	53,850.41	9,172.88	35,294.12	26,121.24	1.41
Rice	58,835.29	31,215.06	8,395.97	27,620.23	19,224.26	1.49
Groundnut	57,047.94	32,205.71	8,967.50	24,842.23	15,874.73	1.38
Sorghum	70,229.18	24,308.18	9,246.12	45,921.00	36,674.88	2.09
Overall	69,817.41	47,424.12	8,673.38	22,393.29	13,719.91	1.24

Total cost Items

The components of Tables 3 and 4 provide the necessary information for computing the total cost, as shown in Table 5. The sum of the TVC and TFC constitutes the total cost of the seed production operations. The total cost incurred in producing seeds in 2006 stood at ₦19,073.15. On a hectare basis, the total cost would be ₦56,097.50 for 2006.

Revenue from seed production

Total revenue receivable for each crop type is presented in Table 6 and reveals the magnitude of revenue that accrued to seed producers. Total revenue accruable to maize was N66,186.22 in 2006. The lowest recorded revenue came from the sale of cowpea (N12,932.76) in 2006.

Gross margin and net profit analysis

The gross margin and net farm profit of the seed producers are presented (Table 7). As shown, producers of the different seed types recorded some levels of profitability. As such, the enterprises producing certified seeds have an impressive return to capital and are profitable. However, the profitability levels vary with seed types. The profit margin recorded by maize seed producers was consistently largest; it was N56,073.00/ha in 2006.

The observed profit margins across the seed types conclusively reveal that, for every N1 spent in cultivating the seeds, some levels of financial benefits were derived, as indicated

by the output/input indices. Specifically, in the case of sorghum, every N1 spent brought to the producers financial benefits of about N2.09. Each of the seed type production processes was fairly financially sustainable in the planting season of 2006.

Seed industry level issues

So far, it has been assumed that all seeds produced are sold at no extra cost. In other words, quality control, marketing, and distribution costs were not taken into account. These costs are critical at the seed industry level of analysis.

Equally critical is the size of the market for the hybrid NAD-1. These are the questions examined in this section.

First, on the supply side, it is expected that farmers will produce seeds of a new cultivar if the price offered to them is high enough to cover their costs. Also a firm will supply seeds only if the price of seeds is high enough so that it can cover its variable costs. Other factors that influence seed supply include the structure of the seed industry, the importance of the crop in the country, and the cost of research. The supply of seeds is then a function of price, and some supply shifters, such as the cost of fertilizer, institutional environment, and price threshold. Supply is also expected to have an inelastic portion because of limited land area suitable for seed production. However, because of potential technological change (yield increase), the supply schedule will not be vertical. Supply function will be discontinued at the price threshold level because of the sunk costs and high transaction costs, which will require a minimum price level before the firm can start selling seeds. Below the price threshold, production will be zero. *This implies that, at the beginning of the industry, high prices are required which will compensate seed producers for the risk borne and give incentives to starters.* To sustain the prices at these levels, a certain market size will be required.

Seed production costs are not particularly stressed here, because under the current hybrid sorghum seed production scheme, the seed company wants to contract with farmers (producers) and offers them a price/kg, which will cover their production costs. Until the price offered to them covers at least their costs, farmers will not agree to the contract. The setup of these contracts is also of importance because it can determine the quantity of seeds available to the seed firm. The contracts should be based on a per kg basis and also include both yield and quality premiums because of the differences in the farmers' management abilities. When contracts are based on a flat payment, farmers have no incentive to deliver all the seed produced. Yield premiums give incentives for good crop management, but create quality control problems because farmers will be very reluctant to rogue. A quality premium allows for the compensation of the yield dilemma, especially if the premium offered for quality is higher than that for yield.

Currently in Niger, sorghum crop yields are low. There is also a large gap between yields on experiment stations and those on farmers' fields; the rate of adoption of improved crop varieties is low; a seed production system is almost nonexistent. According to Srivastava and Jaffee's indicators, these will qualify the Nigerien seed system as being one in need of investment. Srivastava and Jaffee (1993) have identified some indicators that help to determine if a country's seed sector is in need of investments. However, investors are interested first in potential profits. Therefore, profitability is the main factor that determines if investments can be made.

Estimation of potential seed demand

In 1999, the total area of sorghum harvested in Niger was 1,400,000 ha (FAOSTAT). Using this figure, the potential demand for sorghum seeds in Niger can be estimated. With an assumed average of 10 kg/ha, the potential quantity of sorghum seeds needed is 14,000 t.

Given the potential and the quality of land in lowland areas, it is likely that hybrid sorghum will first be adopted in these areas. Farmers on irrigated perimeters and/or with access to private irrigation face lower risks and have the potential to benefit more from the adoption of hybrid technology. It is estimated that the total irrigated area in Niger is 36,000 ha, which include 13,000 ha that are Government-managed (ONAHA) and the remainder are privately managed (République du Niger 1991; Norman and Walter 1997). The required quantity of hybrid sorghum seeds needed for these areas is 540 t. In principle, the potential demand for hybrid sorghum also includes sorghum growing areas with agroecological conditions similar to those of Niger in other Sahelian countries. Due to transportation and distribution costs, the most likely markets are those in Burkina Faso and Mali, at least at the beginning of the process. Potential quantities can serve only as proxies. An actual estimate demand schedule will establish a relationship between the quantities demanded and market conditions, including prices, policy environment, and other factors.

In the case of NAD-1 in Niger, a survey is needed to determine the extent of the adoption of the hybrid in the country and some characteristics of the adopters so that it can be used to predict future adopters within and outside the country. The demand for hybrid sorghum can be estimated as a function using regression technique. The demand for the seeds of new cultivars depends primarily on the profitability of the technology and its risk. Risk and profitability are measured, compared with the existing technologies. The demand for hybrid sorghum seeds is also influenced by factors such as the policy environment, and the actual or potential availability of inorganic fertilizer, because the yield potential of hybrid sorghum is better expressed when associated with the use of fertilizer, and most farmers are aware of that.

The profitability of hybrid sorghum technology depends on the factors identified above. Relative prices (input/output) return on other investments (crops and non-crops), the farmer's own characteristics (management ability, financing options, etc.), the quality of infrastructure in the area, and the policy environment all influence the demand for hybrid sorghum seeds. Alternative investments are important, as economic resources are always first allocated to their best uses. Therefore, investments will be made in hybrid technology only if it is more profitable than the available alternative investments.

Oresajo (1999) indicated that the following elements, among other things, have an influence on the profitability of the seed business.

- Seasonality of production
- Total area under cultivation
- Farm income and profit margin of the usage, if certified seeds
- Seed demand and rate of seed change
- Number of contract farmers
- Government interventions
- Marketing and distribution of certified seeds
- Support services for the farmers
- Seed research

Demand and supply and the economic environment for the market are critical for the seed industry. The market size (demand) and policy environment are the most important factors. The price in this market is assumed to depend mainly on demand. As long as the demand for hybrid sorghum seeds is not satisfied, prices will increase and a new supply will be created (at least until all land suitable for sorghum seed production is exhausted). The market size determines sales and how transaction costs can be spread. The policy environment is equally important, because it creates and guarantees profitability conditions.

Policy environment

In addition to price, the policy environment is another factor present in both supply and demand equations. Government policy has an impact on profitability in nearly all sectors of an economy. Especially in the hybrid seed industry, profitability depends a lot on how Government regulations can protect seed companies from free riders.

In Niger, the Governmental agencies tried in the late 1970s and early 1980s to produce and distribute seeds, and failed. Opponents of direct intervention by the public sector think that the public sector is not needed for the seed industry that should remain a private matter. Therefore, according to them, the public sector is needed to continue research and regulate the market. However, given the current conditions in Niger, the public sector should also produce foundation seeds and define market conditions (seed law). A minimum involvement of the public sector in the industry is needed to help it to take off. The involvement of the public sector might increase the consumers' confidence in the product, since they have little experience with it. Also, public sector involvement might ensure continuity in the event of a bad cropping season at the beginning of the process. Usually, following a drought, the demand for hybrids collapses and all the private businesses pull out of the market. The public sector can keep the process going until favorable conditions for private businesses are reestablished. For example, in the Sudan, Tennassie and Sanders (1997) reported "the public sector kept the diffusion of HD-1 (a new hybrid sorghum cultivar at the time) going during the 1980s when private seed producers left the industry." A certain number of policy reforms are necessary to make the seed industry take off. Policy should shift toward demand-driven actions, private initiative, competition, and market pricing (Srivastava and Jaffee 1993).

Conclusions

Seed production and distribution are essentially a business. As such, profitability is the key for any producer who wants to make a living out of seed production. Profitability can be determined by evaluating and comparing costs and incomes as done above. A seed producer can improve profitability by reducing costs or increasing income. Quality control is the key in the seed business to ensure survival for the seed firm. With good quality control, a firm can also build a reputation over time that might allow it to charge higher prices than the competition. There are substantial economies of scale in the seed industry, therefore, the adoption of those improved production techniques that increase yields is crucial for seed producers.

At the industry level, several other factors have been identified as the most influential on the profitability of the seed sector. This paper has mentioned the demand factor, technology level, Government interventions, seed laws, and public policy as important for business in the agricultural sector.

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14. Agricultural Finance Product program

M.A. Liman
First Bank Agricultural Business Unit, Kano

Introduction

First Bank Plc provides applicants/prospective farmers with the following list of agricultural products for consideration and choice.

- Guaranteed Fund Credit (GFC) CBN/ACGS.
- Agricultural Produce Finance.
- Cooperatives/Linkage Banking Scheme.
- Multi-channels Agricultural Credit Finance Schemes. (Multi-CAFS).
- First Bank Agricultural Credit to Schools (FACTS).
- Industrial end-users' out-growers' scheme.

The Bank would be glad to be a partner with organizations and related agencies to enhance farmers' empowerment, especially those in pursuit of agro-based commercial enterprises and development.

Summary requirements for each product

Guaranteed fund products

Agricultural financing under this product is based on the guaranteed fund model. The Federal Government introduced the Agricultural Credit Guarantee Scheme (ACGS) to encourage increased agricultural production. The scheme is managed by the Central Bank of Nigeria (CBN) that provides guaranteed covers for loans granted by Banks to the agricultural sector of the economy. Facilities granted under the scheme are guaranteed to the level of 75% of the amount in default after the realization of securities held against such lending. Individuals, cooperative societies, and corporate bodies could enjoy credit limits from N20,000.00 to N10 million that could be guaranteed. Eligible beneficiaries are expected to take agricultural insurance policy cover with the Nigerian Agricultural Insurance Corporation (NAIC) for the enterprises.

The ACGS provides for a refund of up to 40% of interest paid by the farmers under the Interest Drawback program sponsored by the Federal Government and CBN.

Target market

- Individual farmers.
- Cooperative societies.
- Corporate bodies.
- Eligible activities/enterprises
- Cultivation of arable crops.

- Animal husbandry (poultry, fish farming, fish capture, cattle fattening, sheep and goat fattening, piggery, etc.).
- Maintenance of tree-crop plantations (oil palm, cocoa, rubber, coffee).
- Crop processing (cassava, oil palm, fruits, groundnut, etc.).
- Farm machinery acquisition and hire service.

Please note, credit facilities do not cover the cost of land acquisition, the establishment of new tree-crop plantations or agroforestry, and the development of farm infrastructure in the case of start-ups.

Other requirements

The identified or marketed customer is prescreened by First Bank Nigeria (FBN) and should complete the Agricultural Finance Credit Fund (AFCF) credit facility forms and submit them along with a letter of application stating the amount, purpose, repayment plan, and collateral offered and/or a simple feasibility report.

The Bank Agricultural Specialist-Relationship Manager (Agric.) carries out a farm project survey/appraisal and submits a project report to confirm or otherwise the feasibility, viability, and profitability of the project along with a disbursement and repayment schedule for the loan facility.

The applicant is a bona fide farmer with a verifiable investment in the enterprise of interest.

The applicant opens a current account and undertakes to fund this for the servicing of the loan interest.

The applicant undertakes to bear the cost of agricultural insurance cover by NAIC (2–3% of the loan amount depending on the enterprise) and notify NAIC, CBN, and the Bank of any perils within 48 hours.

The applicant provides a Savings Bank cash deposit balance of 25% to be charged as security, with a commitment of a monthly build-up of the balance throughout the life of the facility (for facilities of ₦1 million and below).

The applicant provides acceptable collaterals in the form of landed property with adequate title, shares, life insurance, or third party guarantee supported with assets with estimated forced sale value (EFSV) of 130% of the facility amount, or 100% of the facility amount plus 25% of cash collateral (for requests of over ₦1 million).

The activity to be sponsored is in season and within the list of eligible enterprises.

The loan tenor does not exceed 24 months, inclusive of moratorium, which may range from 3 to12 months depending on the type of enterprise.

Loan limit range

Individual — ₦100,000.00 to ₦1 million

Cooperatives — N500, 000.00 to N5 million (subject to membership strength and aggregate needs of members).

Corporate bodies — N10 million.

Agricultural produce

Merchants who have adequate storage facilities to mop up excess grain and other commodities at the time of harvest are provided with credit facilities under the scheme.

Target market

- Produce merchants
- Individual farmers
- Cooperative societies
- Corporate bodies
- Eligible activities/enterprises
- Cocoa, coffee, cashew
- Palm oil and palm kernel
- Cotton
- Groundnut
- Grains and pulses (maize, rice, guinea corn, sesame/beniseed, soybean, cowpea, etc.)

Requirements

In addition to those under Guaranteed Fund Credit (GFC), the following shall apply specifically to this product.

- The applicant is a produce merchant with minimum of 3 years experience, or a farmer, and has been in an account relationship with any Bank for a minimum of 6 months.
- The applicant has a store or warehouse with adequate capacity for the volume of produce envisaged.
- The produce/commodity is in season and within the list of eligible enterprises.
- The loan period does not exceed 9 months, inclusive of moratorium.
- The applicant provides adequate collateral, e.g., a letter of domiciliation of payment where a bulk buyer of produce is a trusted customer of First Bank plc plus 10% cash deposit, landed property, or marketable securities of 130% of the loan amount, or other acceptable collateral.

Loan limit range

Individual—₦500,000.00

Cooperatives/corporate bodies—₦10 million

Cooperatives/linkage banking scheme

This product is an adaptation of First Bank's vintage microfinance scheme known as the community farming scheme, which was launched in the 1980s. It is designed to inculcate a healthy banking culture based on a two-way relationship between the Bank and the farmer/microfinance clientele.

It encourages a flow of deposits from the clients to the Bank and a flow of credit from the Bank to the clients. It is a Savings Linked Credit in which beneficiaries' build up a savings deposit of at least 25% of their eventual credit requirements within a period of 6 months, as a functional and cohesive group, before applying for credit and maintain such buildup all through the life of the credit facility.

To qualify for this scheme, farmers must first come together in informal groups and associations of 10 to 25 persons. In addition to the group savings, each member undertakes to accept liability for the borrowing of other members of the group. It carries the benefits of the guarantee of the CBN under the Agricultural Credit Scheme (NAIC) as well as the Interest Drawback program of the CBN.

Target market

- Cooperative societies.
- Informal farmers' associations and farmers' groups.

Eligible activities/enterprises

- Cultivation of arable crops.
- Animal husbandry (poultry, fish farming, fish capture, cattle fattening, sheep and goat fattening, piggery, etc).
- Maintenance of tree-crop plantations (oil palm, cocoa, rubber, coffee).
- Crop processing (cassava, oil palm, fruits, groundnut).
- Produce buying/storage.
- Farm machinery acquisition and hire service.
- Land acquisition and the establishment of new tree-crop plantations are not eligible under the program.

Requirements

In addition to some of the requirements captured under Guaranteed Fund Credit (GFC) product, this product requires the following:

A letter of introduction or identification of an informal group is issued by the Village Head, a recognized community leader, or the Local Government authority. For formal associations and cooperatives, the certificate of registration and the by-laws are to be submitted.

Group structure: Membership is not below 10, and not more than 25, all of whom have verifiable proof of investment in the proposed enterprise, and traceable contact addresses; and the Joint and Several Guarantee of members is obtained to the tune of the loan principal and interest.

A group account or individual member savings accounts have been operated with any Bank for about 6 months to accumulate the balance to about 25% of the envisaged loan amount with a commitment to a monthly build-up throughout the life of the facility.

Loan limit range

₦250,000.00 (minimum)–₦ 500,000.00 (maximum).

Multi-Channels Agricultural Finance Scheme (MULTI-CAFS)

To survive the harsh economic climate due to the introduction of SAP, a substantial number of salary earners have taken to farming as a way of augmenting their income. The Bank, strategically responding to the needs of the people, came up with this product to assist farmer–civil servants or salary earners generally who engage in farming activities.

Target market

Employees of Federal, State, and Local Governments, the Government parastatals, educational institutions, or private sector establishments, etc., applying as individual farmers, and duly registered cooperative societies empowered to borrow by their constitutions or the Memorandum and Articles of Association.

Eligible activities

These are the same as those captured under the GFC and cooperative linkage banking scheme.

Requirements

These are those captured under the GFC or cooperatives linkage scheme plus the following:

A written undertaking of the employers to domicile the salary account and terminal benefits of the members of the Staff Association (the value of which, as advised by the employer in writing, must be at least 100% of the loan principal) with First Bank throughout the duration of the facility and authorize First Bank to deduct an amount not more than 40% of the staff's monthly salary for the repayment of the loan principal and interest after 2 months' moratorium.

The Association is duly registered with a certificate of registration and byelaws; and exists in the establishment with the full knowledge of the employers (evidenced by a letter of introduction from the employers).

Members of the Association are staff of the establishment with existing farm investments, and are duly introduced by their Heads of Department or the Leader of the Association.

The loan tenor does not exceed 18 months, inclusive of moratorium.

The customer undertakes to pay 2.0–2.5% of the loan amount as premium to NAIC insurance against farm failure (as evidenced by his monthly pay slip) and to notify NAIC, CBN, and the Bank of any peril or variation in the employment contract within 48 hours.

Limit range

Individual—₦50,000.00 (minimum)—₦250,000.00 (maximum).

Group/Association/Cooperative—10,000,000 subject to the number of members, individual capacity, and combined credit need of the members.

First Bank Agricultural Credit to Schools (FACTS)

This product is meant for secondary and tertiary institutions that have Agricultural Science programs, school demonstration/pilot farms, and bakeries. It is designed to take advantage of the technical know-how available in the educational institutions and commercialize such school farm projects/businesses. It is an avenue for schools to diversify their revenue sources in the face of insufficient funding. The product is unique to First Bank.

Target market

Educational institutions (secondary, tertiary, etc.) with viable Agricultural Science programs, demonstration or pilot farms, or commercial agro-allied businesses.

Eligible activities/enterprises

- Cultivation of arable crops, such as yam, maize, cowpea, cassava.
- Poultry farming: layers and broilers.
- Livestock: sheep and goat fattening.
- Agro-processing, e.g., groundnut oil, cassava (*gari*), etc.

Requirements

Participating schools offer Agricultural Science as a subject up to SS3 or SSCE level and above; activity to be sponsored is in season and in the list of eligible enterprises.

A school demonstration/commercial farm or agro-allied business is in existence.

Detailed and comprehensive farm record/inventory control is available.

A functional PTA and PTA Board of Trustees comprising the school principal and officials of the PTA with a qualified Agricultural Science teacher and two attendants exist to provide project management.

Where the applicant is a tertiary institution, the Students' Union or Faculty Association with Deans of Students and Faculty, Head of Agriculture, and project manager are to constitute the management.

For private schools, a copy of the certificate of registration or statute creating the school, and PTA Board of Trustees (if applicable).

The school submits a loan application for the commercialization of the demonstration/pilot project.

PTA/Students' Association contributions of at least 50% of the loan raised from the PTA at a level of say ₦500.00/student are held in a fixed deposit or domiciliation of subvention/school fees payments, guarantee of sponsors backed by assets, or 25% cash collateral under Agricultural Credit Guarantee Fund (ACGF) held as collateral.

The school undertakes to bear the cost of Agricultural Insurance Cover by NAIC (2–3% of the loan amount depending on enterprise), and to notify NAIC, CBN, and First Bank of any peril within 48 hours.

The school submits the written approval of the supervising Ministry or its promoters for the borrowing, along with an undertaking to service interest when due.

The loan application is submitted to the Bank along with a feasibility study or business plan on a selected enterprise for the school's commercial project.

Loan tenor does not exceed 24 months inclusive of moratorium, which may range from 3 to 12 months, depending on the enterprise.

Limit range

Per school/PTA—₦500,000.00 (minimum)—₦20 million (maximum).

Individual end-users' out-growers' scheme

This product brings together the various parties involved in a commodity—production, processing, utilization, and marketing value chain. The parties in this model are the primary producers/peasants/artisans, an industrial end-user or exporter, and First Bank. These parties are joined in an agreement.

The out-grower arrangement creates a mutually beneficial relationship which offers a guaranteed market for the primary producer and a guaranteed supply of raw material for the end-user at an agreed term. The Bank provides credit to finance the working capital needs (acquisition of production inputs and processing) of the farmers/primary producers.

- Target market
- Individual farmers.
- Farmers' groups/trade associations.
- Cooperative societies.

Requirements

a. A properly worded MOU is executed between the parties (customer/end-user, out-grower farmers, and the First Bank) in which the end-user agrees to buy the farm produce at an agreed price and to pay the farmers through their accounts with First Bank.

b. The output of the out-grower farmers is a raw material/input for the end-user's operations.

c. The out-grower farmers are bona fide farmers with verifiable existing investments in the enterprise of interest.

d. The industrial end-user is a manufacturer or commodity merchant/exporter with a verifiable investment in the enterprise of interest.

e. The out-grower farmers undertake to bear the cost of NAIC insurance cover of between 2 and 3% of the loan amount, and to report any peril to NAIC, CBN, and First Bank within 48 hours.

f. The out-grower farmers open a current account to service the loan and execute a cross-guarantee of members, if applying as a group.

g. The farmers' places of residence and farm location are verified and confirmed accessible all year round via the Manager's farm survey report.

Limit range

- Individual—₦100,000.00 (minimum)–₦250,000.00 (maximum).
- Group/association- ₦500, 000.00 (minimum)–₦5 million (maximum).

Apart from the above products, the Bank's conventional products are as follows:

a. Loans and overdrafts

b. Agricultural Credit Support Scheme (ACSS)

c. Agricultural Development Trust Fund Scheme (ADTFS)

Part 4:
Concept, seed production, and distribution activities of the National Program for Food Security

15. An overview of the first phase of the National Program for Food Security

O. Oyebanji
Deputy National Project Coordinator
National Program for Food Security

Introduction

At the World Food Summit in 1996, Nigeria and other member countries of the Food and Agriculture Organization of the United Nations committed themselves to reducing the numbers of their malnourished population by half through the establishment of a program for food security. The National Program for Food Security (NPFS) is presently being implemented in 109 sites, one in each of the three Senatorial Districts of the 36 States of the Federation with the Federal Government of Nigeria bearing its total cost of US$67,481,896, as follows, NPFS, US$45,236,296 and South–south Cooperation (SSC), US$ 22,245,600. The program operates through six subprograms.

- Food security.
- Aquaculture and inland fishers.
- Animal disease and trans-boundary pest control.
- Soil fertility initiative.
- Marketing of agricultural commodities and food stock management.
- South–South cooperation.

Implementation of the program in most of the states started in 2001.

The thrust of NPFS

NPFS focuses attention on the application of innovative, low-cost approaches to improving the productivity and sustainability of agricultural systems, with the objective of contributing to the better livelihoods of poor farmers through a bottom-up development approach. In specific terms, the program aims to do the following:

Assist farmers to achieve their full potential for increasing output productivity and incomes.

Strengthen the effectiveness of research and extension services by facilitating the transfer of improved technologies and new farming practices developed at research institutes to farm and village levels.

Train and educate farmers in the effective utilization of available land, water, and other resources and facilities to enhance their contributions towards the nation's goal of food security and employment creation.

Program targets

Implementation of the nation-wide program was designed to address four major areas of constraints.

- Shortage of available water.
- Lack of access to improved technologies.
- Excessive dependence on a narrow range of products.
- Lack of incentives for raising output and improving sustainability.

Quantifiable achievements

The modest achievements of NPFS can be summarized under the following components.

Irrigation and water use

Presently, almost 1400 ha are being supported under irrigated farming, with about 2800 beneficiaries. Also, 296 tube wells and 73 wash bowls have been sunk, and over 603 irrigation pumps were distributed to participants. Meanwhile, two trailer-mounted rigs have been procured for tube well construction at the NPFS sites. With regard to rural potable water supply, 52 boreholes and seven open wells were constructed.

Water-harvesting structures

Since January 2005, nine earth micro-dams have been constructed or rehabilitated, with close involvement of SSC 13 more dams are at various stages. In addition to the above, a total of 36 water-harvesting structures (earth micro-dams, wells, and ponds) were planned to be built before the end of 2007. A solar powered borehole development project for potable water supply and orchard irrigation was completed between January and July 2007 at the SPFS site of Kwasauri in Kano State.

Crops

A total of 13,258 beneficiaries cultivated some 15,000 ha under the rain-fed cropping system. Generally, sole and mixed cropping patterns were common; major crop combinations were yam, cassava–maize intercrop in the south, and cereal–legume mixture in the north. Profits derived from crop enterprises have been encouraging. For example, the average profits obtainable for cassava cultivation ranged from N30,633.00 to N55,830/ha in a production cycle, depending on cropping systems and patterns.

Community seed production

Producing seeds in the community encouraged the sustainable growth of the project; this program was introduced in 2005. Local farmers have been trained to produce crops, such as maize, rice, sorghum, millet, cowpea, and groundnut. A total of 96 t of improved varieties of these crops were produced by NPFS seed growers and distributed to NPFS farmers to support crop production.

Input distribution

Input distribution at the sites was through the NPFS, the Developing Agro-input Market in Nigeria (DAIMINA) project, and the private sector. Agricultural inputs provided to some 22,300 beneficiaries included 11,770 t of fertilizer subsidized by the Federal Government, 25,300 L and 484 kg of agro-chemicals; 181,000 bundles of cassava cuttings, 1.35 million yam seeds, and 78,000 head of livestock were also distributed.

Agro-processing

The implementation of the agro-processing module was a success. A total of 1390 participants benefited from 689 assorted items of processing equipment during the review period. The involvement of women in processing activities was also observed to be increasing. Four postharvest demonstration technology centers (DTCs), funded by FAO under the TCP/NIR2904 project, provided opportunities for the spread of production units.

Health and nutrition

A total of 57 integrated school gardens across the country and five home gardens in each site were established. Demonstrations on micronutrient deficiencies and community lessons on child nutrition were completed in households and commercially in all 109 sites. One health center/site was equipped with food demonstration materials while one VIP pit latrine/site was constructed for use by women patients attending antenatal and postnatal clinics.

Group development

A group approach to NPFS implementation continued to be emphasized. A total of 1440 groups have been identified, out of which 1167 participants were registered (81.18%). Existing groups consisted of 531 male, 248 female, and 390 mixed groups. Group development collaborators continued to encourage the dynamic cohesion of these groups.

Agroforestry

Implementation of this subcomponent commenced in February 2005. To best address the problems of desertification and deforestation, a country development strategy has been set in motion. It established community nurseries and woodlots in many of the NPFS sites.

Livestock

A total of 986 modules were implemented under this subcomponent and comprised broiler and layer production, ruminant improvement and upgrading, and cattle and pig fattening. A total of about 45,000 broilers have been produced, 50,000 layers raised, and 241,000 crates of eggs were obtained. In addition, 75 herds of cattle and 1109 pigs were fattened. Technical backstopping has been rendered on livestock technologies such as pig–fish integrated farming, hatchery technology, and pasture management.

Fisheries

Aquaculture and artisanal packaging were implemented by the 1115 beneficiaries on board. A total of 79 ponds were constructed, and about 53,000 fish fingerlings were stocked. In addition, fishing inputs were distributed to fishermen and fish farmers applying for modules in the cost-recovery program. About 755 t of assorted fish mix were obtained under these interventions. Demonstrations of modern fish smoking, using *chorkor*, *burkinabe* and steel drum adapted technologies for the reduction of postharvest losses, were carried out in 10 States with over 200 participants. A manual on fish-pond construction and management has been published for participants as well as for other agricultural extension agents.

Aquaculture and inland fisheries

Four fish farm clusters have been established in the southwest, south-south, and north-central areas where the economic critical mass for aquaculture development is present. The project organized a public awareness campaign with the publication of 21 newsletters entitled *Farming Nigeria's Water*. The publication has been spread to many communities as many local agriculture newspapers have also distributed it. The project also led the first Presidential Forum on fisheries.

Animal disease and trans-boundary pest control project (ADTPCP)

This project facilitated the first technical backstopping mission to review the work program. Furthermore, two laboratories (veterinary faculties in Nsukka and Sokoto) are being supported by the project. The project is working on the deployment of the Trans-boundary Animal Disease information System (TAD info) in the country. The project carried out a needs assessment for the National Veterinary Research Institute (NVRI) vaccine production and rendered technical assistance on disease control on SPFS sites. The project was also involved in the monitoring, selection, and training of animal health specialists for the NPFS sites and sponsored 11 animal health support officers to the participatory epidemiology workshop.

Marketing and food stock management

A comprehensive food marketing study was conducted in the six geopolitical zones as well as an assessment of the existing silo management, their operations, and maintenance. Presently, eight silos are operational and being selected for assessment; they have been launched and their Board inaugurated by the Hon. Minister for Agriculture and Rural Development. A legal framework is being developed for the creation of a strategic food agency.

Soil fertility initiative

Implementation achievements recorded have been impressive. The project in 2002 developed site- and crop-specific fertilizer recommendations for all NPFS sites through soil testing to promote the rational use of fertilizer, sustained crop production, and environmental protection. The soils of 13 NPFS sites have so far been fully characterized in a series of detailed soil surveys and land capability classification studies. Farmers have also been trained on a communal small ruminant/alley farming system; two pilot communal grazing lands were rehabilitated in two States. Participatory on-farm demonstration trials on the use of lime in acid soils, phosphorus (P) recapitalization in P-deficient soils, balanced fertilization involving micronutrients, the use of rhizobium inoculants in legume production, and the combined application of organic and inorganic fertilizer were successfully carried out. The project has also completed a modern fertilizer-testing laboratory in Kaduna with an annual analytical capacity of 50,000 samples.

South–South cooperation

The 393 Chinese experts and technicians on board are already extending their improved technologies at the implementation sties to assist farmers. A total of 23 dams have been completed; 13 others are at various states of completion. Also, 61 boreholes/tube-wells have been sunk, with over 40,500 beneficiaries. Over 100,000 seedlings have been

distributed to private farms. Eleven beehives have been established and assorted items of farm equipment and tools were fabricated for local farmers' use.

Capacity building

Training and workshops were utilized to enhance the performance of all stakeholders, including farmers. A total of 664 trainings were conducted for 9376 beneficiaries.

Impact of NSPFS on the economy

Evidence from the field and the perceptions of the beneficiaries show clearly that NPFS has contributed to raising agricultural productivity in the country with obvious improvements in the livelihoods of the participating farmers. Their increased production translated to higher income, the reduction of household food insecurity, improved employment, and better health and nutrition.

Constraints

At the same time, there have been some problems that have included the following:

- Delays in the release of funds by the State ADPs to the implementing sites.
- Inadequate veterinary support.
- Poor management of farmers' groups.
- Inadequate access to quality inputs by the program.
- Market gluts.
- Conflicts between crop farmers and pastoralists.
- A language barrier between the local operators and Chinese technicians under the SSC project.

Conclusion

The commencement of the second phase is the result of the lessons learnt and the success achieved in the first phase of the NPFS. The National Project Coordinator will highlight salient features of the phase in his paper.

16. Salient features of the second phase of the National Program for Food Security

S. Ingawa
National Coordinator
National Program for Food Security

Introduction

The NPFS was a 5-year program that started in 2002 and terminated in 2006. The total budget of $5.2 million was entirely funded by the Federal Government of Nigeria (FGN). In addition, the FGN and the Government of the People's Republic of China agreed to cooperate within the framework of the South–South Cooperation initiative in direct support of the SPFS in Nigeria. The agreement involved a cost of $22.2 million over a 4-year period.

The positive results so far obtained under the first phase of the NPFS spurred the Government to embark on a 5-year expansion phase, effective January 2007, and to increase the number of sites from one to three in each Senatorial District, that is, to expand the program from 109 sites. The program would also have through Local Government Councils (GLC) wide outreach and community development components, all managed under a flexible and decentralized administrative arrangement.

Objectives

The objectives of the program are as follows.

- To improve household food security and incomes through an increase in productivity, diversification, and the sustainable use of natural resources.
- To enhance the food security of consumers through improved availability and access to a variety of foods. To increase the income of producers through more efficient marketing.
- To enhance farmers' and consumers' access to support services, such as extension, credit, nutrition and health education.
- To foster the participation of the poorer section of the rural population in the development of the community.

Component description

The project has four components: site development, site support, and Local Government Area (LGA) management outreach, community-driven development, and management support. The estimated total cost for all the components is ₦48 billion (US$ 364 million), including contingencies

Component 1: Site development would involve the establishment of 218 production demonstration sites in selected LGAs. It covers the following four subcomponents.

Agricultural productivity enhancement would involve introducing low-cost irrigation

techniques, supporting project farmers for the adoption of economically attractive soil fertility-enhancing techniques and promoting sustainable land use, extending agro-forestry technologies to address land productivity improvement, environmental protection, and crop intensification.

Diversification would assist project farmers to increase livestock production, provide improved access to animal health services, and promote fishery production.

Agro-processing and on-farm storage would support processing by farmers' groups, taking into account the financial viability of the enterprises.

Site extension would provide intensive extension support at the sites.

Component 2: Site support and outreach would entail improving critical rural services in the project area, facilitate the access of farming communities to these services, and foster the outreach of agricultural productivity enhancement, promote the outreach of production diversification, and support health and nutrition education. It has the following four subcomponents.

- Support services
- Agricultural productivity enhancement—outreach
- Diversification of production—outreach
- Nutrition and health

Component 3: Community-driven development: would respond to the felt needs of rural people for the development of facilities such as roads and culverts, markets, and small dams for which there is community commitment but a lack of financial resources. This would involve fostering community empowerment and group development and providing funding for community development. The component would have four subcomponents.

- Group development
- Small-scale rural infrastructure
- Earth micro-dams
- Community forestry and off-farm income generating activities

Component 4: NPFS project management support: Responsibility for nation-wide implementation of the program would continue to rest with the Federal Ministry of Agriculture and Rural Development (FMARD). The Ministry would use the Project Coordinating Unit (PCU) for the coordination of activities between and within the Federal and State institutions with the participation of the LGC given greater prominence. At the State level, the ADP manager would serve as State Coordinator and work closely with the participating Councils for effective program implementation. FAO would provide support for program implementation. The component would have four subcomponents.

- NPFS project management support
- Planning, monitoring, and evaluation

- LGC-level coordination
- Project cost and financing plan

The program's total cost is ₦84 billion ($364 million). Unlike the previous program, which was entirely funded by the FGN, the proposed funding ratio for the expansion phase is 60% local and 40% from donor pledging meetings, which have yielded positive results. Specifically, in support of NPFS, the African Development Bank (ADB) has committed $32 million, Arab Bank for Economic Development in Africa (BADEA) $18 million, and the Islamic Development Bank (IDB) $30 million. There are indications that other donors will soon follow suit.

For the local contribution, the sharing formula approved during the last meeting of the National Council for Agriculture was 47% (Federal), 26% (State), 19% (LGC), and 8% (beneficiary), for the three tiers of Government and ₦46,000.00 per annum per community. The beneficiary community contribution would be mainly in kind. Mr President had already directed that the FGN contribution be included in the annual budget, starting from 2007.

Project benefits

The direct benefits of the program include the following.

- Improved land and water use, higher crop productivity through the use of improved seeds and agronomic practices.
- Value addition in rural areas through processing and packaging, incremental animal and fish production and catches; a reduction in storage losses.
- Enhanced income for the farmers and increased household food security in conjunction with improved nutritional standards.
- Establishment of a nation-wide and demand-driven extension service and a concomitant outreach program using the Farmer Field School method.
- Setting up of a real-time market information service.
- Provision of rural infrastructure linked to the economic progress of the requesting communities.

About 70,000 farm households as primary beneficiaries at the sites and 785,000 farm families under outreach, amounting to over 850,000 households or approximately 6,000,000 rural dwellers, would directly benefit.

Start-up activities

To ensure the smooth start-up of this program in 2007, some implementation activities were carried out. These included the National Stakeholders' Sensitization meeting that familiarized senior government officials and policymakers with the objectives, concepts, principles, and implementation arrangement of the program. It also provided the opportunity for consultation with all the principal stakeholders on program financing. A similar exercise was carried out at the State and LGC levels. One of the major recommendations in the series of meetings was the need to ensure regular funding of the

program by the three tiers of Government through deduction at source of the counterpart-funding requirement on an annual basis. The other start-up activities scheduled to be completed before the end of the year included the following.

- Site and LGA selection
- Participatory Rural Appraisal/needs assessment of selected communities
- Conduct of baseline studies
- Inception planning workshops
- Mobilization of participating communities into economic groups along commodity lines

Conclusion

This paper has highlighted the salient features of the second phase of the NPFS. The priority of the expansion phase would be the establishment of six additional development sites in each of the 36 States and two additional sites in the FCT. The FGN, States, LGAs, and communities will contribute 60% of the total cost of $364 million while 40% will be from external donors. A successful implementation of this program will improve the productivity, income, and livelihoods of the resource-poor farmers, enhance food security, and reduce poverty.

Annexes

Annex 1. Some maize varieties available in Nigeria.

Variety name	Characteristics
Sammaz 14 (Obatanpa)	White quality protein maize (QPM), medium maturity (100–110 days), yield potential 3–4.5 t/ha
Sammaz 11 (Acr 97 TZL Comp1-W)	White normal maize, *Striga* resistant, medium maturity (100–110 days), yield potential 3–4.5 t/ha
Sammaz 13 (TZEE-Y)	Yellow extra-early maize, 70–80 days maturity, 1.5–2.5 t/ha
Sammaz 12 (TZEE-W)	White extra-early maize, 70–80 days maturity, 1.5–2.5 t/ha
2000 SYN-W STR	White extra-early maize, *Striga* resistant, 70–80 days maturity, 1.5–2.5 t/ha
99 TZEE-Y STR	Yellow extra-early maize, 70–80 days maturity, 1.5–5 t/ha
EV 99 DT-W STR	White early maize, drought tolerant, *Striga* resistant, 80–90 days maturity, 2.5–3.5 t/ha
EV 2000 DT-Y STR	Yellow early maize, drought tolerant, *Striga* resistant, 80–90 days maturity, 2.5–3.5 t/ha
TZE COMP3 DT	White early maize, drought tolerant, *Striga* resistant, 80–90 days maturity, 2.5–3.5 t/ha
ACR POOL 16 DT STR	White early maize, drought tolerant, *Striga* resistant, 80–90 days maturity, 2.5–3.5 t/ha

Annex 2. The new code and distributor list of millet varieties, their characteristics, and where they can be successfully planted.

Descriptor list	Old variety code	Year of release	Yield (kg/ha)	Maturity (days)	Outstanding characteristic	Adaptation
SAMMIL–1	Ex Borno	1966	2000–3000	70–90	High yielding	All savanna zones
SAMMIL–2	Nigeria Composite	1977	2000–2500	70–90	Tolerates high moisture stress	All savanna zones
SAMMIL–3	Dwarf composite	1983	1500–2000	70–90	Good for mechanization because of short stature, able to survive moderate seasonal drought	Sudan savanna and Sahel zones, e.g., Kano, Borno, Yobe, Jigawa, Kebbi, Sokoto.
SAMMIL–4	Maiwa composite		1000–2000	100–120	Strong straw used for fencing	Southern, Northern Guinea, and Sudan savanna zones.
AMMIL–5	Bristie composite	1983	2500–3000	70–90	Minimum bird damage which is an advantage over non-Bristie	All savanna zones
SAMMIL–6	S.E.B	1986	2500–3000	65–85	Early maturing and high yielding	All savanna zones
SAMMIL–7	S.E.214	1986	2000–3000	65–85	Good seed quality, high yielding	All savanna zones

Annex 3. Recommended sorghum varieties.

Ecological zone	State	Location area	Strain	Release name
Northern Sudan savanna and Sahel	Borno	Entire State	H.P.3	KSV3
	Kano, Jigawa	Gumel, Dambata, and Hadejia areas	BES L.2257	KSV 4 ICSV 111, ICSV 400
	Katsina	Katsina area	L.2250	KSV 12 ICSV 111, ICSV 400
	Sokoto Kebbi and Zamfara	Sokoto B/Kebbi and Argungu areas	L.2250	KSV 12 ICSV 400 ICSV 111 KSV 12
	Kano Jigawa	Most parts except Gumel and Hadejia	YG 5760 KSV 2 A–9025 KSV 8	
Sudan savanna	Sokoto Kebbi Zamfara	Gusau, Bakura, and Jega areas	RZI KBI ICSV111, ICSV 400	
	Kaduna	Kafinsoli area	KL 538	KSV 7
	Bauchi	Azare area	KL 538 HP. BES ICSV 111,ICSV 400	
	Borno Yobe	Potiskum, Fika, Darazau Marguba, Bama, and Gwoza	KSH 89002 NG KSV 10 ICSH 89002, ICSV111, ICSV 4000	
	Bauchi Gombe	Bauchi and Gombe areas	BES–KSV 4 SK 5912–SSV 3 HP3–KSV 3 L 187–SSV 6	
	Katsina Kebbi	M/Fashi, Daudawa, Samaru, and Shika areas	HP 3–KSV 3 L. 1499–SSV 7 FFBL–SS V 2 L. 243– SS V7 ICSV 111–ICSV 400	
Northern Guinea savanna	Sokoto	Fandani Zuru area	L.533 SSV 10	
	Taraba Adamawa	Mubi, Numan Hong area Jalingo area	BES–KSV 4 KSH 8902 ML 4 NSV 2	
	Kaduna	Kaduna, Saminaka, B/Gwari, and Zonkwa	C–7 = 4 NSV 1 ISCV.111, ICSV 400 ICSH 89002 NG KSV–4	
	Plateau	Entire State	SG43	
	Benue, Kogi	Entire State	FD1 NSV 3	
	Niger	Entire State	NSV3–SSV 3 ICSW 400, ICSV 111	
	Kwara	Entire State	NS43–SS2	
Southern Guinea savanna	Osun Oyo	Most parts of Oshogbo Ogbomosho,	SSV–3 MSV–1, MSV 2	
	Benue Nasarawa	IIuju, Saki area Gboko, Makurdi Entire State	MSV–3, SSV 6	
	FCT	Entire State	MSV–3, SSV 6	

Annex 4a. Herbicides for weed control.

Recommended herbicides for weed control in sorghum

Name of herbicides	Area where they could be used and rate of application	
	Guinea zones	Sudan zone
1. Gardoprim A	4 L/ha	4 L/ha
2. Sorgoprim (Terbutryne + thylazine, i.e., 3 L of product/ha)	1.5 kg a.i/.ha	1.0 kg a.i/.ha 3 L of product/ha
3. Atrazime 80WP/or 500FW	2–3 kg/ha or 5–6 L/ha	2–3 kg/ha or 5–6 L/ha

Annex 4b. Chemical weed control in legumes and cereals.

Product	Time of application	Dosage/ha	Remarks
Soybean			
Codal Gold 412.5 EC	PRE	3 to 4 L/ha. Spray in 200 to 400 L/ha of spray liquid.	Good control of many annual grasses and dicot weeds.
Igram Combi Gold 450EC	PRE	3 to 4 L/ha. Spray in 200 L/ha of spray liquid.	Excellent control of many annual grasses and dicot weeds.
Pendimethin 50EC	PRE	3.0 L/ha. Spray in 200 L/ha of spray liquid.	Does not control sedges.
Dual gold	PRE	1–2 L/ha. Spray in 200 L/ha of spray liquid.	Broad spectrum grass control. Good activity against *Cyperus* sp. Controls some dicots (*Amaranthus*).
Fusilade Forte 150 EC	POST	2–3 L/ha. Spray in 200–400 L/ha of spray liquid.	For the control of grass and noxious weeds, such as *I. cylindrica* and *Cynodon dactylon*. Does not give good control of sedges. Application must be made at 2 to 4 leaf stage of weed growth and not later.
***Note**: It is important to note that the slow early development of soybean can make it difficult to achieve effective weed control with a single application of PRE or POST herbicides. For this reason, a supplementary weed management may be necessary. Because weeds will typically start to emerge within 4 to 8 days after tillage, an application of paraquat at 3–4 L/ha is necessary. In fields infested with dense vegetation of annual or perennial weeds, application of glyphosate (i.e, Touchdown Forte at 1–2 L/ha for annual weeds and 2–4 L for perennial and difficult-to-control weeds) at the recommended label rate is necessary. Glyphosate should be applied before land preparation. A waiting period of 10–14 days is required before land preparation or planting.*			
Cowpea			
Codal Gold 412.5 EC	PRE	3–4 L/ha. Spray in 200–400 L/ha of spray liquid.	Good control of many annual grasses and dicot weeds.
Pendimethin 50EC	PRE	3.0 L/ha. Spray in 200 L/ha of spray liquid.	Does not control sedges.
Butachlor	PRE	4.0 L/ha. Spray in 200 L/ha of spray liquid.	Good control of most annual weeds.
Dual gold	PRE	1–2 L/ha. Spray in 200 L/ha of spray liquid.	Broad spectrum grass control. Good activity against *Cyperus* sp. Controls some dicots (*Amaranthus*).
Fusilade Forte 150 EC	POST	2-3 L/ha. Spray in 200–400 L/ha of spray liquid.	For the control of grass and noxious weeds as *I. cylindrica* and *Cynodon dactylon*. Does not give good control of sedges. Application must be made at 2 to 4 leaf stage of weed growth and not later.
***Note**: Because weeds will typically start to emerge within 4 to 8 days after tillage, an application of paraquat at 3 to 4 L/ha is necessary. In fields infested with dense vegetation of annual or perennial weeds, application of glyphosate (i.e., Touchdown Forte at 1 to 2 L/ha for annual weeds and 2 to 4 L/ha for perennial and difficult to control weeds) at the recommended label rate is necessary. Glyphosate should be applied before land preparation. A waiting period of 10–14 days is required before land preparation or planting.*			
Maize			
Primextra Gold 660 SC	PRE	4 L/ha. Spray in 200-400 L/ha of spray liquid.	Excellent control of many annual grasses and broadleaf weeds.
Igram Combi Gold 450EC	PRE	3–4 L/ha. Spray in 200 L/ha of spray liquid.	Excellent control of many annual grass and dicot weeds.
Dual gold	PRE	1–2 L/ha. Spray in 200 L/ha of spray liquid.	Broad spectrum grass control. Good activity against *Cyperus* sp. Control some dicots (*Amaranthus*).
Lasso	PRE	3–4 L/ha. Spray in 200–400 L/ha of spray liquid.	Good weed control
***Note**: Because weeds will typically start to emerge within 4 to 8 days after tillage, an application of paraquat at 3–4 L/ha is necessary. In fields infested with dense vegetation of annual or perennial weeds, application of glyphosate, (i.e., Touchdown Forte at 1–2 L/ha for annual weeds and 2–4 L/ha for perennial and difficult to control weeds) at the recommended label rate is necessary. Glyphosate should be applied before land preparation. A waiting period of 10–14 days is required before land preparation or planting.*			

Annex 5. Major field pests of cereals and legumes.

Cereals

S/N	*Scientific name*	Common name	Pest stage	Damage done
	Mussidia nigrivenella	Maize pod borer	Larvae	Young larvae damage cobs/ears
	Sessamia calamista	Pink stalk borer	Larvae	Larvae attack and damage stems
	Therigona soccata	Sorghum shooter	Larvae	Leaves eaten up and grains reduced due to lower photosynthesis
	Spodoptera exempta	Armyworm	Larvae	Leaves eaten up and grains reduced due to lower photosynthesis
	Agrotis sp.	Cutworms	Larvae	,, ,,
	Locrotis sp. *Poophilus adustus*	Spittle bugs	Adults and nymphs	Sap suckers
	Mylabris sp. *Coryna* sp.	Blister beetles	Adults	Attack and damage flowers
	Zonocerus variegatus	Variegated grasshoppers	Adults and nymphs	Eat young leaves and stems
	Locusta migratoria	African migratory locusts		
	Oedaleus senegalensis	Senegalese locusts		
	Kraussaria angulifera	Grasshoppers		
	Brachytrupes membranaceus	Giant cricket	Adults	Eat up seedings and destroy them completely.
	Busseola fusca	Maize stalk/stem borer	Adults	Bore stems and tunnels into cobs/pods
		Rodents	Adults	Feed on all parts of the plant and damage them completely, irrespective of the stage.

Legumes

S/N	Scientific name	Common name	Pest stage	Damage done
	K. anguilifera *Nomadacris septemfasciata* *O. nigericus* *O. senegalensis*	Grasshoppers/ locusts	Adults and nymphs	Damage leaves and shoots, thereby reducing yield and destroying plants.
	Aphis craccivora	Aphids	Adults and nymphs	Damage leaves, shoots, and pods,, thereby reducing yield and destroying plants
	Empoasca christiani *E. dolichi*	Leafhoppers	Adults and nymphs	Adults and nymph suck sap from the underside of leaves thereby making the edge turn yellow, curl up, and boiler death of tissue.
	Spodoptera littoralis	Cotton leafworm	Adults and nymphs	Defoliate plant, bore into young pods and cut through stems = crop loss.
	Coryna apicorma	Pollen beetle	Adult and nymphs	Adults feed on pollen from open flowers, damaging anthers.
	Megalurothrips sjostedti	Legume thrips	Adult and nymphs	Both adults and nymphs feed on and damage shoots, flower buds and pollen causing distortion, drying and shedding of flowers leading to significant yield loss. They are also vectors of *Cowpea yellow mosaic virus*
	Maruca testulalis	Legume pod borer	Adults and nymphs	Young larvae feed and bore into flower, young stems, terminal shoots, and peduncles, causing webbing of flowers, leaves, and pods.
	Clavigralla tomentosicollis (Acanthomis tomentosicollis)	Spring brown bugs	,,	As adult and nymphs feed by sucking sap from the green pods, they cause dumping of seed coat, pod abscission abortion, deformation through premature drying or shriveling, and incomplete pod fill
	Fusarium oxysporum	Cowpea wilt disease	Adult aphids	Cause rapid wilting, stunting, yellowing, and dropping of leaves, and plant death
	Striga gesnerioides	*Striga* (witchweed)	Parasite	Prevents pod formation. Seeds could remain viable in the soil for many years.
	Rattus sp.	Rodents	Adults	Feed on all parts of the plant and damage them completely, irrespective of the stage.

Annex 6. Participants.

S/n	Name	Organization	State/City
1	Ubani J.C.	ADP	Abia
2	Christian T.	ADP	Adamawa
3	E.B. Auguo	ADP	Akwa Ibom
4	Luka Daniel	ADP	Bauchi
5	M.B. Kudu	PCU	Bauchi
6	Karibo K.	ADP	Bayelsa
7	Robert A.A.	ADP	Benue
8	Stephen A.B.	ADP	Borno
9	Ubi O.O.	ADP	Cross River
10	Igwoku C.C.	ADP	Delta
11	Patrick Ogbuya	ADP	Ebonyi
12	Ileubere Victor	ADP	Edo
13	Ogunjobi A.J.	ADP	Ekiti
14	Ilo Moses E.	ADP	Enugu
15	Anjugu A.M.	ADP	FCT
16	Nneka Ononiwu	ADP	Imo
17	Hussainai Abubakar	ADP	Jigawa
18	D.E. Jacob	ADP	Kaduna
19	Balarebe Shehu	ADP	Kano
20	Mohammed U.	ADP	Kebbi
21	Medugu John	ADP	Kogi
22	Yusuf A K/ Soli	ADP	Katsina
23	Ogunsola O.	ADP	Kwara
24	Ajijola F.S.	ADP	Lagos
25	Yahuza Umar B.	ADP	Nasarawa
26	Izuakor C. Festec	NERA	Enugu
27	Tanko Garba	ADP	Niger
28	Awe S.A.	ADP	Ogun
29	B.O. Adegbite	ADP	Osun
30	K.A. Bakigbola	ADP	Oyo
31	Luka Keyas	ADP	Plateau
32	E.A.N Bira	ADP	Rivers
33	A.I.Gatawa	ADP	Sokoto

34	Jonathan Mangbon	ADP	Taraba
35	Ahmed A. Teka	ADP	Yobe
36	Abdullahi Nakwada	ADP	Zamfara
37	D.A. Okoroyemaraye	PCU	Benin
38	Liman, M.A.	First Bank Plc	Kano Main
39	Agbaya K.A.	PCU	Ibadan
40	J.A. Oche	PCU	Kaduna
41	Bashir A. Aroye	PCU	Lokoja
42	Dr. P. Ojo	NASC	Abuja
43	N.O. Utoh	NPFS	FCT
44	G.N. Bello	NPFS	FCT
45	Hakeem Ajeigbe	IITA	Kano
46	Onu Y.A.	IITA	Kano
47	Ishaya Jockson	IITA	Kano
48	Taibat Abdulkadir	IITA	Kano
49	S.U. Ewasiha	IITA	Kano
50	Boukar Ousmane	IITA	Kano
51	Tahirou Abdoulaye	IITA	Kano
52	F. Ekeleme	IITA	Maiduguri
53	Abubakar Musa	ILRI–IITA	Kano
54	S. Usman	IAR–ABU, Zaria	Zaria
55	A.O. Ogungbile	Premier Seed Nig. Ltd	Zaria
57	Micheal K.O.	Premier Seed Nig. Ltd	Zaria
58	Ashiru Sabo R.	Nagoma Seed	Kano
59	Umaru Ibrahim	Triumph	Kano
60	Isiyaku Ahmed	VOA	Kano
61	Kabiru Moh'd K.	NTA	Kano
62	Jaafar Jaafar	Kano Daily Trust	Kano
63	Abdulkadir M.	Freedom Radio	Kano
64	Blessing E.E.	Feedom Radio	Kano
65	Hamisu Magashi	CTV 67	Kano
66	Nura S.S.	CTV 67	Kano