Hybrid maize seed production

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HYBRID MAIZE SEED PRODUCTION

A resource and reference manual

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MAIZE PRODUCTION

Maize (*Zea mays* L.) also referred to as corn is a cereal crop that is grown worldwide under diverse agro-ecologies or environments. Of recent, maize is produced annually than any other cereal. There are several varieties under cultivation and consist of different colours, textures, shapes and sizes. However, white yellow and orange cultivars are the most common types cultivated in Ghana depending on the geographical region.

ECONOMIC IMPORTANCE OF MAIZE

Maize is important to the economy of man due to its wide range of uses. Maize is used as feed for livestock and poultry. However, in sub-Saharan Africa (SSA), it serves as food for millions of people. This shows that, there is a heavy dependence on maize by both humans and animals. It is used to create a variety of food and non-food products including oil, starch and ethanol. In northern parts of Ghana for instance, the stalk and cob serve as a source of fuel for thousands of households. The endosperms of some maize genotypes contain high levels of lysine and tryptophan; often referred to as quality protein maize (QPM). Lysine and tryptophan are essential amino acids that are very important for growth and development of children a good source for combating malnutrition related conditions such as "kwashiorkor" among children.

HYBRID MAIZE SEED PRODUCTION

Hybrid maize provide resource limited farmers varieties with superior genetics such as high yield potential and distinctive quality to combat biotic (diseases and pests) and abiotic (drought, low soil nitrogen, etc) stresses. Generally, seeds of improved varieties (OPVs and hybrids) should be of high quality both genetically and physically. Physically, it should be pure; at least, 98% free from other crops and weeds seeds, free from inert materials, free from diseases, pests and should be vigorous with high germination rate. Open pollinated maize seed production is relatively straightforward contrary to hybrid seed production, which requires additional field practices that are critical for success.

In spite of the advantages of OPVs, the yield potential is typically 10-25% lower than those produced from hybrids and the non-uniformity may lead to difficulties in carrying out certain field operations such as harvesting with combine harvesters and other mechanized

field practices that require plant uniformity. Table 1 presents the different characteristics of the common types of hybrid maize varieties.

It is important to note that, the superiority of hybrid seed depends to a great extent on field production methods, proper agronomic practices as well as strict adherence to quality assurance standards.

TABLE 1. TYPES OF MAIZE HYBRIDS AND THEIR GENERAL CHARACTERISTICS

Hybrid type	Female parent	Male parent	Seedyield	Seed price	Hybrid characteristics	Hybrid grain yield
Single-cross	Inbred line	Inbred line	lowest	High	Uniform	Highest
Three way	Single-cross hybrid	Inbred line	High	Moderate	Slightly variable	High
Double-cross	Single-cross hybrid	Single-cross hybrid	Highest	Low	Highly variable	Moderate to high
Top-cross	OPV	Inbred line	Moderate	Low	Highly variable	Moderate
Varietal cross	OPV	OPV	Moderate to high	Low	Highly variable	Moderate to low

Source: MacRobert *et al*, **2014**

ACTIVITIES BEFORE PLANTING

SELECTION OF SITE

Seed production sites should be in a productive agro-ecological zone, preferably the savannas and open forests (Plate 1).

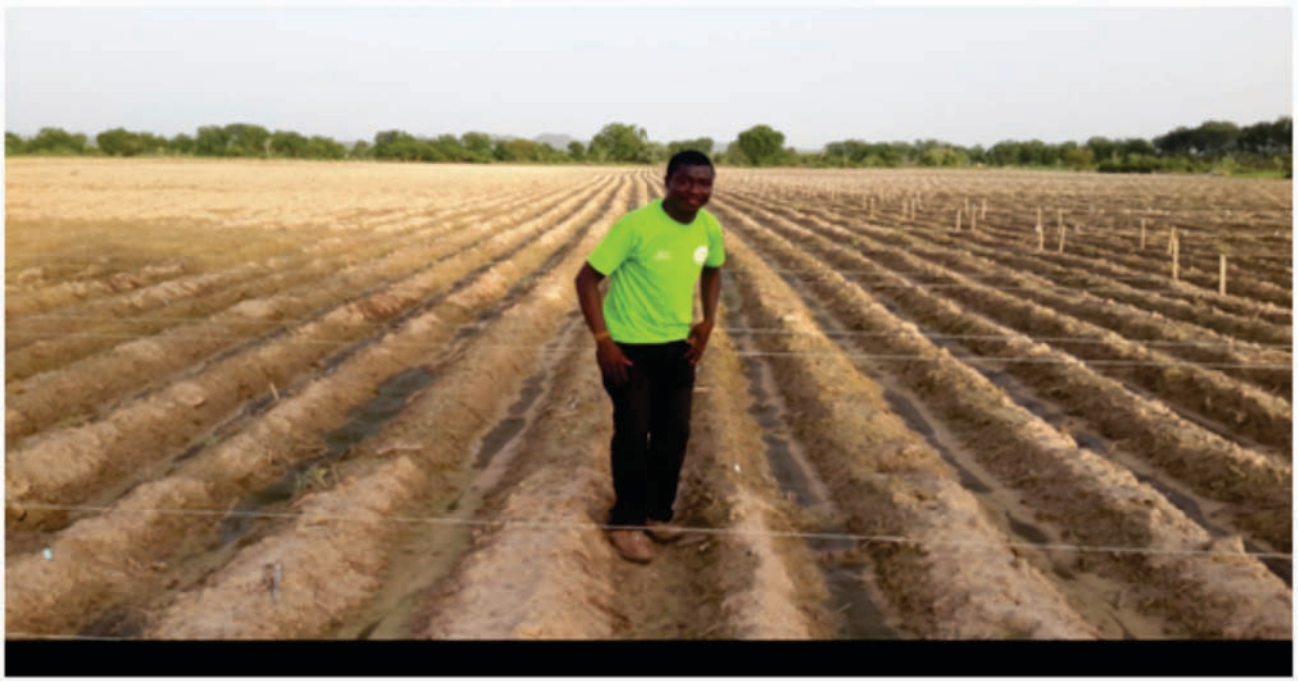

Plate 1. *An open field suitable for seed production*

The best fields on a farm should be used for hybrid seed production, but other considerations include:

- Accessibility - the field needs to be inspected regularly and therefore must be easily accessible throughout the season.
- Suitable, reliable and well distributed annual rainfall.
- Abundant sunshine during the cropping season that also provides dry weather at the time of harvest.
- Low incidence of pests and diseases.
- Cropping history - the previous crop should not be maize, to minimize the possibility of re-growth (volunteer) plants and other weeds associated with maize.
- Isolation - the field must be sufficiently isolated from contaminant maize crops by the required distance (at least 400m) or by time (3-4 weeks planting interval).

- Size of field - due to limited time for de-tasselling, a maximum field size of between 10 to 40 ha should be staggered when planting to ensure proper control of de-tasselling of female lines before pollen is shed. Larger fields may not allow efficient de-tasselling.
- Field map - this is helpful to establish the size of the field, isolation distances and for future records.
- Registration of the seed field - usually seed regulation authorities require seed fields to be registered within a short time of establishment.
- Prior to planting, soil samples must be collected from the field for analysis to ascertain nutrient status to enable appropriate fertilizer recommendations.
- If the soil is acidic, apply lime with appropriate calcium and magnesium ratios according to the soil nutrient content, soil pH and other soil test results. Apply phosphorous and potassium fertilizers prior to or at the time of sowing.

ISOLATION

- Maize is a cross-pollinated crop. Pollination is mostly by wind. Contamination will occur if isolation distances are below a certain minimum (400m).
- Select fields with natural barriers such as hills or trees or that are located in areas with different prevailing wind direction from neighboring maize farms.
- Keep at least 400 m distance from neighboring maize fields for certified seed production.
- Use different planting dates - a three-week minimum planting interval for two parental materials of similar maturity or four-week planting interval for two parental materials of different maturity (plant the early maturing parental material first) to minimize contamination from neighboring fields.

PARENTS OF HYBRIDS

- Accurately assess days to tasselling and silking of parents of hybrids to determine appropriate date for planting to achieve good seed set under isolation.
- Choose parental inbred lines with good synchrony between pollen shed and silking.
- Choose male parents that grow as tall or taller than the female parents for effective pollination under isolation.
- Seeds of the parental lines (male and female parents) should be kept in separate seed bags.
- The bag of each parent should be properly labelled, and the label firmly attached to the bag. This should include the name of the parent, year of production and location.
- Receipt of parent seeds purchased should be retained after sowing for certification purposes and for any claims that may arise.
- Store seeds in a cool dry place. Depending on the duration the seed is going to be used after production, it may be stored in short, medium and long-term storage facilities.

FIELD REGISTRATION AND INSPECTION

Field inspectors are required to verify the origin or source of seed, identify the variety, verify the cropping history, check isolation distance(s) (or time of planting), as well as production practices to ensure that all certification procedures are adhered to. Usually, three-to-five field inspections are required during the cropping season.

LAND PREPARATION

- Start your land preparation at the onset of rain, but the soil should not be too wet prior to ploughing.
- Plough and harrow to have a well loosen and levelled land.
- Plant on a flat land or on ridges using recommended planting distance (Plate 2).
- In areas that are prone to water logging, plant on ridges to minimize effect of excess water on the plants. Even though maize requires water for its development and growth, excessive water is detrimental to its growth.

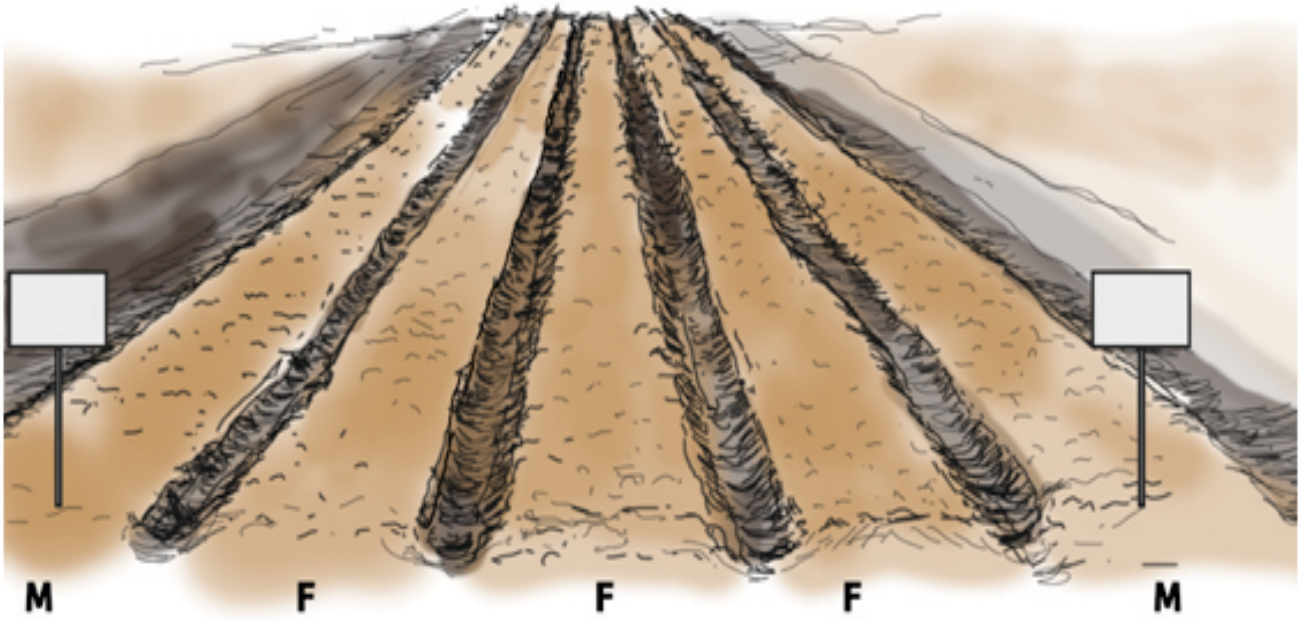

Plate 2. *Field arrangement of three female (F) rows to one male (M) row planting pattern with well labelled male rows.*

PLANTING

- Conduct germination test before sowing. The result of germination test determines the number of seeds to be sown (Table 2).
- Plant only when the rains are stabilized in the production site to ensure good crop establishment.
- Plant parents of the hybrid either on the same date or on different dates depending on the flowering times of the parental lines.
- If there is any uncertainty about the flowering dates in your areas or if flowering of the female is variable, spread planting of male parent over 3 - 5 days to increase duration of pollen availability.

TABLE 2. RECOMMENDED SEEDING RATE AFTER GERMINATION TEST

Number of plants counted	Number of seeds to be planted
85 or more	2 seeds per hole
70-84	3 seeds per hole
50-70	Get better seeds
Less than 50	Do not attempt planting, get better seed

DATE OF PLANTING

- March - April: Major season in the forest and transitional zones of Ghana.
- Middle of June - early July: Guinea savanna zones of Ghana.
- August - September: Minor season in the forest and transitional zones of Ghana.
- Farmers with irrigation facilities can plant all year round.

PLANTING PATTERN

Female - to - male row arrangement depends on:

- Type of hybrid to be produced.
- Pollen production potential of the male parent.
- Duration of pollen supply by male parent.
- Usually a female (F) to male row ratio of 3:1 is recommended.
- The male (M) rows should be labelled for ease of identification during planting (Plate 2).

MAINTENANCE OF OPTIMUM PLANT POPULATION DENSITY

- Row spacing (distance between rows) - 75 cm (Plate 3).
- Intra-row spacing (distance within rows) - 40 cm for extra-early and early maturing parental lines and 50 cm for intermediate and late maturity ones, that is when maintaining two plants per stand. However, when maintaining one plant per stand, spacing of 20 cm for extra-early and early maturing parental lines and 25 cm for intermediate and late maturity ones should be used.
- Plant population - 66,666 plants per hectare for extra-early and early maturing parental lines and 53,333 plants per hectare for intermediate and late maturity ones.
- Plant 3 seeds per hole (when seed viability is less than 85%) and thin to 2 plants per stand at 14 days after planting before basal fertilizer application.
- Follow strictly agronomic recommendations of the originator of the variety.

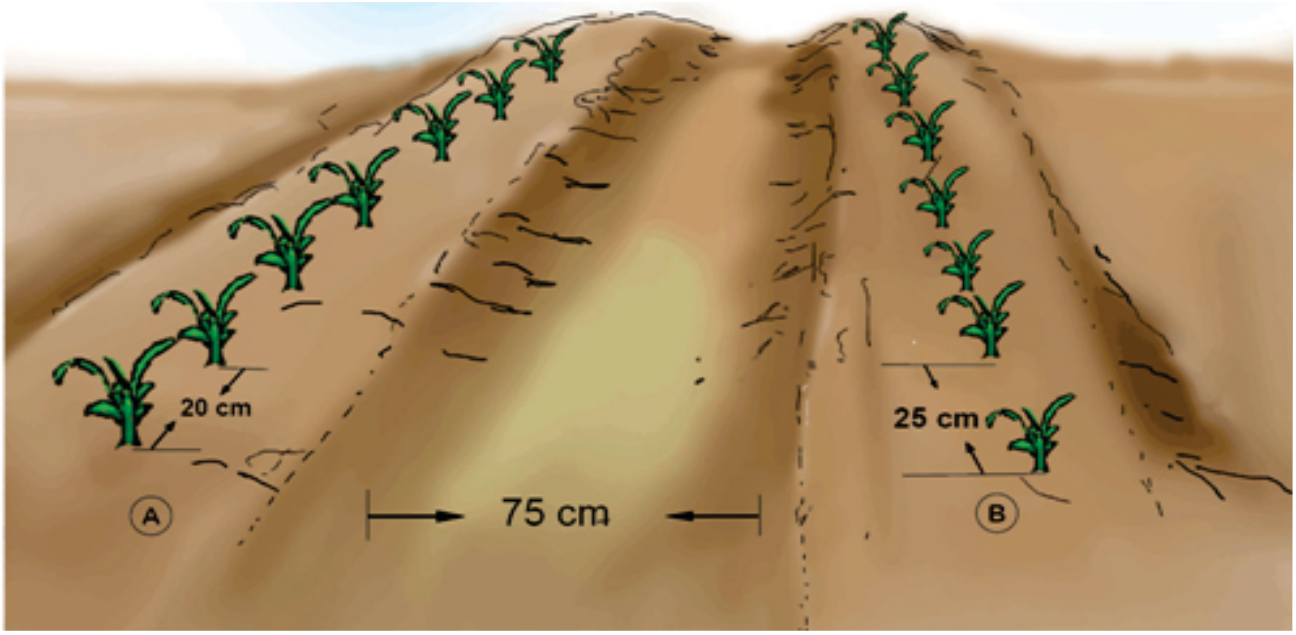

Plate 3. *Recommended planting spacing for early maturing (A) and intermediate (B) varieties when one plant is maintained per stand.*

ACTIVITIES AFTER PLANTING

FERTILIZER APPLICATION

- Use the recommended rates of NPK and Urea/Sulphate of Ammonia application for optimum yield.
- Apply micro-nutrients such as calcium, magnesium, sulfur, zinc, etc to soils that are deficient in them.
- Observe the growth and development of the parental lines, look for plants showing signs of nutrient deficiency and correct these with foliar or soil fertilizers if required.
- Apply the fertilizer at the recommended time.
- Basal fertilizer application should be done at planting or at most 2 weeks after planting (Plate 4).
- As much as possible, avoid contact of fertilizer with plants most especially, young plants. Also, ensure that, fertilizer is buried to prevent escape of the volatile compounds into the atmosphere.
- Ensure top-dressing at 4-6 weeks after planting, depending on the maturity group of the variety (Plate 5).

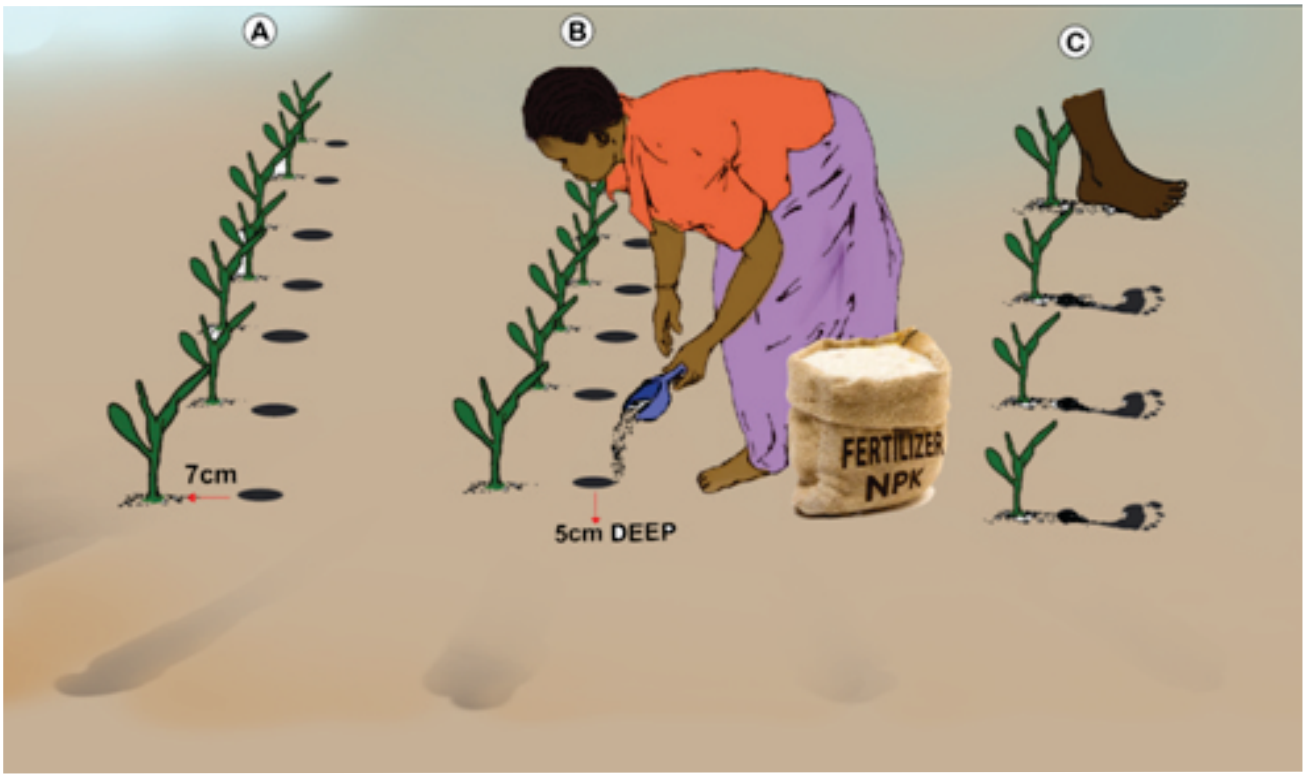

Plate 4. ***Basal fertilizer application at 2 weeks after planting***

Plate 5. Top dressing with urea or sulphate of ammonium at 4-6 weeks after planting

WEED CONTROL

- Pre-emergence weedicides may be applied soon after planting or the following day at most to control weeds.
- Monitor and manage the crop throughout the season, control weeds, pests and diseases and irrigate as and when necessary.
- Some of the weedicides are phytotoxic to inbred lines. Hence, when applying post-emergence weedicides, it is advisable to apply these between the rows and ensure that the nozzle of the sprayer is positioned such that no contacts between the herbicide and your plants occur. Fields should be weed-free to avoid weed competition and incidence of other pests and pathogens.
- Control weeds timely; either manually or with pre-emergence and post-emergence weedicides.

DISEASES AND PESTS CONTROL

- Use disease and pest resistant parents.
- Dress seed with fungicides before planting.
- Spray plants with insecticides to protect plants against insects when necessary.
- Practice crop rotation to suppress pressure from weeds and diseases associated with maize.

ROGUING/ REMOVAL OF UNDESIRABLE PLANTS

The identification and elimination of plants with undesirable features (volunteer plants, diseased plants and off-types) from seed plots/fields is known as roguing. Roguing is done in order to preserve the quality and genetic purity of seed being produced. Off-types including volunteer crops are mostly identified as vigorous and taller plants, smaller and weaker plants, earlier or late flowering, or based on the plant architecture and other morphological features/characteristics.

- Roguing should start immediately after seedling emergence. At this stage, volunteer plants are identified by their size and position along (out of) the planting rows.
- Rogue plants that do not have the descriptive features of the given parent with respect to root and stalk development, pigmentation, leaf and stem pubescence, etc.

- Rigorous roguing during the vegetative stage will help reduce the work load during the critical flowering period.
- The highest form of genetic contamination occurs during the flowering stage. It is therefore essential to ensure that thorough roguing is done on the male plants before pollen starts shedding. On the other hand, roguing of female plants should be completed soon after silk-emergence.
- It is important that, seed producers know the variety they are growing very well and must be familiar with the descriptive features and characteristics provided by the originator of the parents under cultivation.
- Ideally, roguing should be conducted by trained and skilled persons who are familiar with these characteristics to ensure that only off-types are removed.
- To ensure effective roguing, targeted plants should not be cut but rather uprooted to avoid side shoots from emerging which may consequently produce undesirable cob and tassel.
- It is advisable to conduct roguing during the early hours of the day before noon. Roguing during mid-day is not as effective as in the morning or late afternoon due to the glare of the sun.
- Detailed report should be submitted to the breeder in charge of maintaining the parental lines on the type of rogues identified at the end of the cropping season if he /she was not actively involved in the roguing activities.

DETASSELING

Detasseling is the removal of the tassel (male gamete) from the top of a maize plant before its pollen is shed (Plate 6).In hybrid seed production, tassel from the female parent or rows are removed to avoid possible selfing and to also ensure that the female plants are pollinated sorely by pollen from the designated male parent.

Plate 6. *Detasseling of female rows of a hybrid seed field.*

- Ensure removal of the tassels from the female parents before they shed pollen and before silk emergence (Plate 6).
- Detasseling must commence when the top 3-4 cm of the tassel is visible above the leaf whorl.
- Detasseling must continue every day until complete, come rain or shine.
- Tassels from the female plants must be removed completely and this should be on time (Plate 6 and 8). Inappropriate removal of tassels from the female plant ''tassel-stubs'' (Plate 7) will be detrimental to the genetic purity of the hybrid. This may result in rejection of the field for certification by seed inspectors.
- Remove off-type and diseased plants from both the male and female rows before they shed pollen and produce silk.
- Avoid contamination of female silks with unwanted pollen, particularly from females, off-type males and foreign pollen.
- Make sure you avoid seed mixtures among the male and female parents.

Plate 7. *Tassel-stubs caused by late and improper detasseling should be avoided.*

Plate 8. *Well detasseled females rows (2nd- 4th rows from the right) of a hybrid seed field.*

HARVESTING AND POSTHARVEST ACTIVITIES

Seed quality is at its maximum when the plant reaches physiological maturity. But at that time, the seed is difficult to handle because;

i. moisture content is too high (over 30%).

ii. only manual shelling can be done because of the high moisture.

iii. there may not be available facilities to dry immediately.

The seed grower can therefore decide to allow the crop to dry on the field for some few days before harvesting. It should be noted however, that the longer the matured crop remains on the field the higher the rate of deterioration and pest infestation. Germination percentage may not go down drastically, but seed vigour will reduce significantly.

HARVESTING

- Harvest seeds as early as possible. Consider availability of drying and processing requirements/facilities before harvesting. Reduce the time mature seeds remain in the field to enhance seed quality. Timely harvesting can minimize pest and disease infestations.
- Male plants should be cut and removed from the field after pollination. This ensures that there will be no mixture of male and female seeds at harvest. But if allowed to mature they should be harvested at least two days before the female plants and stored separately.
- The cobs of maize may be harvested when moderately dried, preferably at a moisture content of 25-30%, and dehusked immediately.

DETECTING MOISTURE CONTENT OF SEED BEFORE AND AFTER HARVEST

Ascertain whether moisture content of seeds is suitable before they are harvested. This can be done using the moisture meter (Plate 9). Normally at moisture content of 24-30%, they can be harvested and dried further before shelling.

Plate 9. *Seed moisture-testing device (moisture meter)*

EAR SELECTION/SORTING BEFORE SHELLING

- Prior to shelling, pick and discard cobs that look odd or with undesirable traits/features (looks like off types, diseased, pests infected, mouldy, etc.) (Plate 10).

Plate 10. *Sorting out of harvested cobs prior to shelling: Desirable (A) and undesirable (B) ears.*

SHELLING AND DRYING

- Cobs should be dried at moderate temperatures; it can be dried in the shade when the sun's intensity is too high. It could also be dried in a mechanical drier if available.
- The cobs should be shelled when the moisture content is between 12% to 14%.
- Hand shelling is ideal to maintain high seed quality but not always economically feasible. If maize shellers are to be used, then it should be set at half the rotor speed to prevent seed from breaking or cracking.
- Shelled seed should be dried further to about 12% moisture content or below before they are stored. When using conventional driers, it should be set at low temperatures (< 60°C).
- When using open sun drying it should be done on a cemented floor, mats or tarpaulins to prevent contamination. To ensure uniform drying constant turning should be done, preferably with a rake (Plate 11). Since dried maize has the tendency to absorb moisture from the atmosphere during the night, seeds under drying should be protected well before or soon after sunset, by heaping it and covering them well with several jute sacks. Note that if this is not done the process of drying (during the day) and rewetting/moisture adsorption (during the night) will decrease the quality of seeds. Also, the weather needs to be monitored during the drying period and the seed should be protected well is it threatens to rain.

Plate 11. *Open drying of shelled grains in the sun*

Plate 12. *Hand sorting of shelled seeds.*

SEED CLEANING

- Shelled seeds often contain foreign materials like broken cobs, husk, kernels, dirt, weed seeds, etc. These debris must be removed to improve seed appearance, to promote storability and ensure quality.
- Cleaning may be done manually (winnowing and hand sorting)(Plate 12), or using seed cleaning machines, which use a combination of screens and air movements to remove unwanted materials.

SEED SAMPLING AND CERTIFICATION

In order to obtain certification for the seeds produced, samples (at least 1 kg) of seeds are taken for laboratory tests by the Ghana Seed Inspection Division. The seed samples are then subjected to purity test, (presence of other seeds and inert materials), germination percentage and moisture content. The seed samples sent for laboratory tests must conform to the standards set by the Ghana Seed Inspection Division. If the seeds do not conform to standards, they will not be certified for sale. It is always advisable for seed producers to consult the nearest Seed inspector(s) for guidance on seed certification standards/procedures.

PROTECTING SEED FROM STORAGE PESTS

Old seed stocks should be removed from warehouses when new seeds are to be stored. The warehouse(s) should be swept, floors and walls cleaned and sprayed with suitable insecticides to destroy any storage pests that may be hiding in crevices. Recommended chemicals for spraying empty warehouses and bins include beta-cyfluthrin, deltamethrin and deltamethrin + chlorpyrifos methyl.

Seeds should be treated to protect them against storage pests such as weevils. Chemicals used for treating seeds are different from those used for treating grain. But since most seed dealers sell unused seeds as grain, it is advisable to treat seeds with grain insecticides. However, when seed protectants are used then the seeds should be coloured to prevent them from being consumed when not sold or used as seed. Recommended chemicals include Actellic SE (pirimiphos-methyl), deltamethrin, Aluminum Phosphide (phosphine gas as fumigant), Phostoxin 60% pellets and tablets.

STORING SEEDS IN BAGS

After shelling, cleaning and treating, seeds must be stored until ready for planting/use. It is important to note that, before storage, the moisture should be at least 12%. Store seeds in bags at cool dry environment to maintain their quality. The seeds in bags must be packed on pallets away from the bare floor and walls of the warehouse (Plate13).

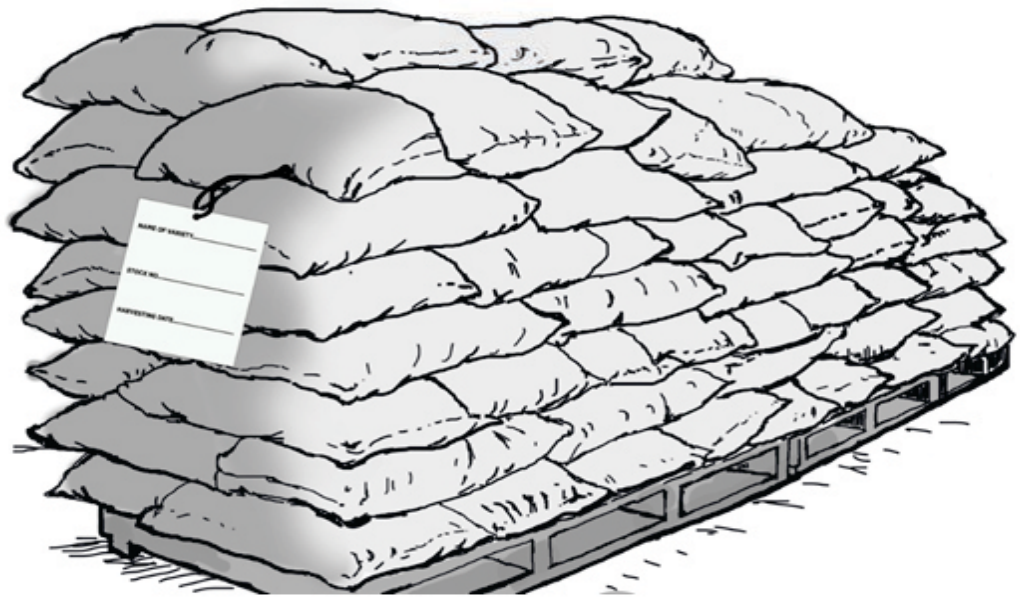

Plate 13. *Shelled seeds in bags, packed on pallets for storage.*

REASONS FOR SEED DETERIORATION IN STORAGE

Note that irrespective of how good the storage environment is, storage will not improve the quality of seeds. However, if the storage environment is poor the quality of seeds will deteriorate. Reasons for seed quality deterioration may include the following:

- Low quality seed is placed in storage.
- Seed with high moisture content is stored.
- The first-in, first-out rule not followed, so that seed remains for too long in storage.
- The warehouse is not ideal; e.g. poorly ventilated, prone to heating, exposed to moisture penetration and/or insecure.
- The environment is too humid or too hot for seed storage.

CONDUCT PERIODIC INSPECTIONS FOR WARNING SIGNS

If possible, inspect stored seeds weekly.

- Musty odour is an indication that the seed is growing moldy.
- Warming seed is an indication that respiration rate is too high, which might be due to high grain moisture content.
- Crusted seed at the surface shows that either the roof is leaking or moisture is condensing at the roof top and dripping onto the "seed".
- Dry immediately if any of the above problem is detected. Fumigate or apply pesticides if insect pests are found.

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