SEED PRODUCTION IN SORGHUM, PEARL MILLET AND FINGER MILLET -THEORY AND PRACTICE

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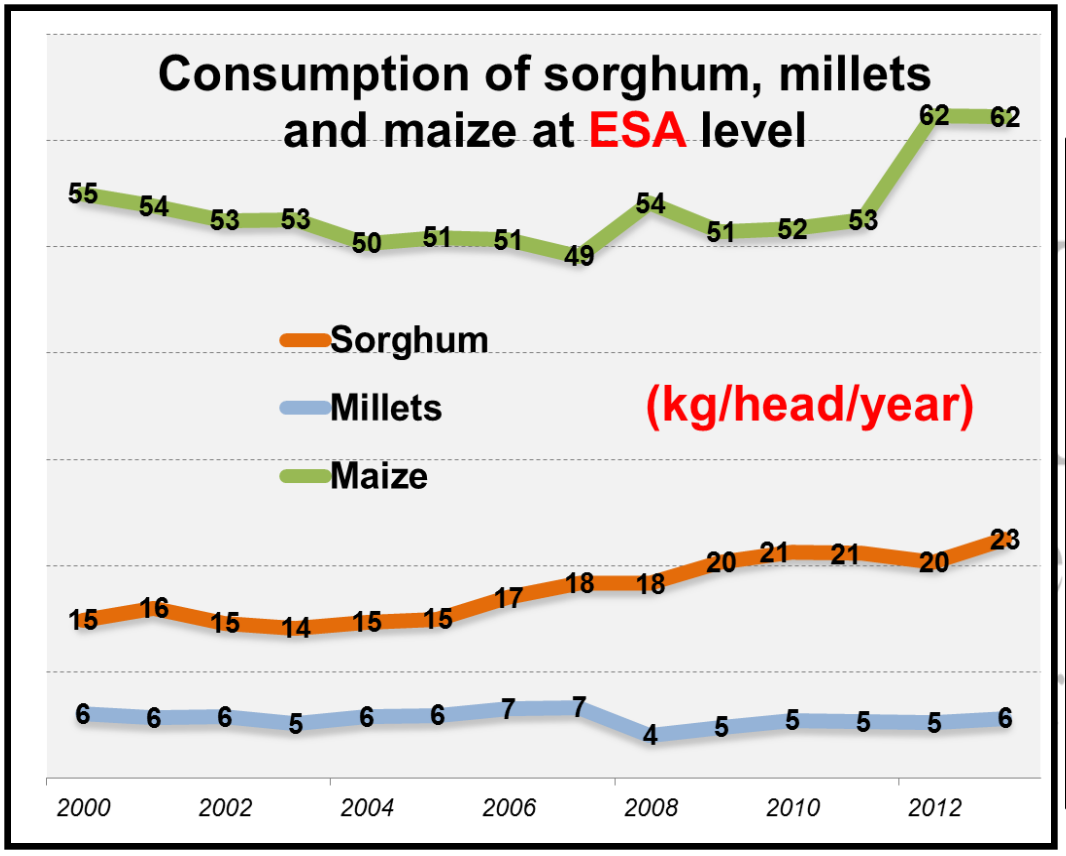
Introduction

- **Sorghum area:**
  - Africa 27.5M Ha (12M in ESA)
- **Pearl millet area**
  - Africa >12M Ha (>4M in ESA)
- **Finger millet area**
  - Africa 2M Ha (1.7 M ESA)

Consumption Trends in Dryland Cereals for East Africa (ESA) (ETH, KE, UG, TZ)

Population: Annual growth rate in 2013 (in %)

ETHIOPIA	KENYA	TANZANIA	UGANDA	ESA
2.6	2.7	**3.1**	3.4	2.9



- High population growth is a challenge for maintaining national food security in staple cereals
- Consumption and production of cereals is similar (cross-border trade is minimal)
- Positive trend in per capita prod/cons since 2010 across ESA
- **Maize** significant growth
- **Sorghum**: Steady but slower growth
- **Finger Millet**: kind of stagnant

- Sorghum and millets seed systems

  - Both formal (certified) and informal (non-certified) seed systems,
  - Informal dominant
  - > 80% of smallholder farmers rely more on their saved seed.

Basics of Seed production

- Objective of a seed production program
  - produce and make available to farmers and growers, adequate and appropriate quantities of:
    - High quality seeds. These are products of a good plant breeding program, whose primary aim is to generate and develop new improved varieties which would increase agricultural productivity.
    - Pure seeds
    - True seeds as per variety required

Basics of Seed production

- For a viable seed production program:
  - Breeder seeds of released and pre-released varieties have to be regularly injected in multiplication programs
  - Breeder seed of varieties which are already released or are in on-farm verification and advanced testing need to be produced in relevant quantities of breeder seed

Basics of Seed production

- Only those varieties on the national list of released and approved varieties are eligible for large scale production and certification

- All released varieties approved for certification are maintained by the breeder in their original form together with those in on-farm verification and advanced testing.

Loss of Genetic purity

1.Residual genetic variation

2. Developmental variations

3. Natural crossing with undesirable pollen

4. Mechanical mixtures

5. Damage due to pest and disease

6. Mutations

7. Techniques of plant breeders in selection

Maintenance of Genetic Purity

- Adequate isolation distance
- Frequent rouging
- Raising the seed crops in appropriate agro-ecologies
- Use of approved seed for seed multiplication
- Inspection and approval of seed fields prior to sowing
- Field inspection at critical stages of crop growth
- Sampling and testing of seed lots
- Conducting grow out tests
- Best cultural practices
- Attention to avoid mechanical mixtures

Environmental influence on sorghum and millets seed production

Major factors

- Temperature
- Rains
- Relative humidity

Soil Chemical Reaction

  - If the Calcium carbonate in soil exceeds 300g./cu.ft. -- Induction of sterility

CATEGORIES OF SEED

Three categories or generations of Seed

1 **Breeder seed** (Pre-Basic Seed)

2 **Foundation seed** (Basic Seed)

3 Certified seed

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4. QDS

Description of Categories of Seed

- **Breeder Seed-** is the parent seed multiplied and directly produced by the plant breeder. This category of seed is not available for general use by the growers. It is the parent seed for any released, developed or unique farmer variety.

- **Foundation Seed**- is the progeny of Breeder Seed. It is the next level of pure seed that most nearly maintains the uniqueness, genetic identity and purity of the variety as described at the time of release.

– Foundation Seed is produced on specially selected seed farms and under strict control

Description of Categories of Seed (contd)

- **Certified Seed**- is the progeny of Foundation Seed. It is intended for certification by seed certifying agencies, and to be sold to farmers for production of grain

Integrated Seed Supply System (QDS)

- combines elements of the formal- and informal systems.
- good quality seed of improved varieties obtained by farmers to produce their own seed
- Production may be inspected village field officers, district experts and seed certification authorities.
- The seed produced not certified - given a distinct quality-related name e.g. Quality Declared Seed (QDS) in Tanzania
- seed is available to crop producers even in remote areas where formal system does not operate
- Also easiest and quickest way of popularizing new improved varieties.
- Not suitable for hybrids

- **Sold within production districts**

- The continuity of seed generations is dependent on the regular supply of Breeder Seed

- Quantities of seed produced/produceable increases from the Breeder Seed (smallest quantities) to Certified Seed (largest quantities for the market).

Pollination biology sorghum/millets

Sorghum (Diploid: 2n=20)

- Flowering top to bottom 4-6 day
- 2-10% outcrossing

Fmillet (Allotetraploid 2n=4x=36)

- Flowering top to bottom
- 99% self pollination

Pmillet (Diploid 2n=14)

- Protogynous nature
- Pollination in two stages
- Styles emergence begins from upper middle region of panicle and proceeds upward and downward
- Complete stigma emergence completes in 2-3 days and remain receptive for 2-3 days.
- Emergence of 1st anther takes place after 3-4 days of 1st stigma emergence.

Pollen Viability & Stigma Receptivity

- Pollination around 8am leads to high seed set (breeding-onstation)
- Pollen production is reduced due to low temperatures (<10 °C)
- Stigma retains good receptivity up to 3 days
- Very high temperatures (>36°C) , the receptivity is lost owing to desiccation of stigmas

Seed Production Management

- Selection of agro-climatic regions
- Selection of seed plot
- Preparation of land
- Selection of variety
- Selection of seed
- Seed treatment
- Time of planting
- Method of sowing

Seed Production Management

- Supplementary pollination
- Weed control
- Disease and insect control
- Nutrition management
- Irrigation management
- Harvesting & threshing of seed crops

Field quality control in seed production

- Hand pollination
  - Bagging of panicles
- Isolation
  - Space isolation
  - Time isolation
- On-farm
  - Farmer level technique

Field quality control in seed production

- **Isolation distances**
  - These depend on:
    - crop species (self or cross-pollinated),
    - category of seed (foundation, registered, certified or common/farmer)
  - Isolation distances are more important in cross pollinated species than in self pollinated ones
  - Crop must be guarded from all possible sources of contamination either by extraneous pollen or physical admixtures at harvest.
  - For farmer level seed, the seed is harvested from the centre of the farmers' fields.

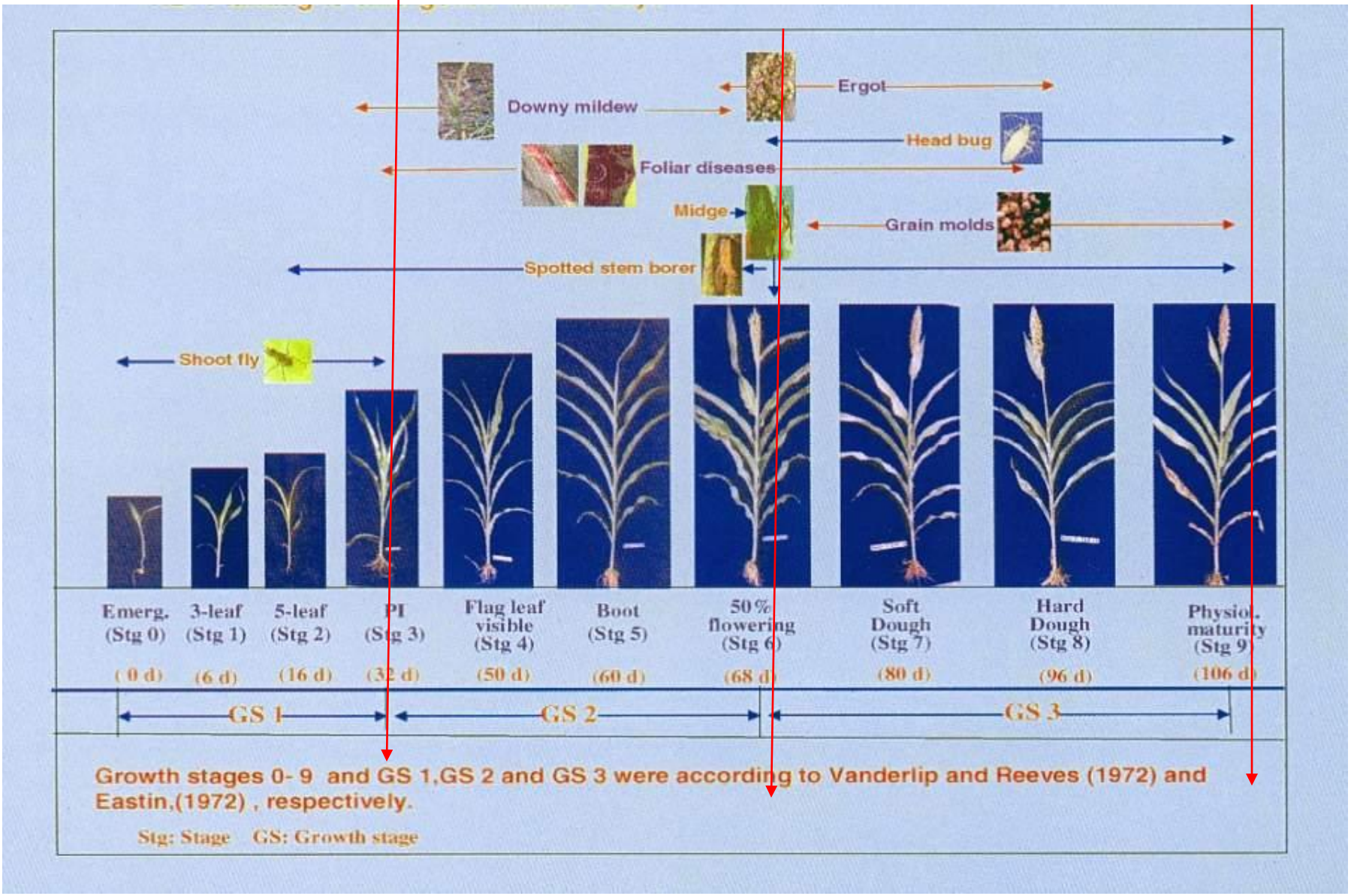
Isolation distances in sorghum, pearl millet and finger millet

Isolation distances (M)	Breeder	Foundation	Certified
Sorghum	400	300	150-200
Pearl millet	1000	400	200
Finger millet	10	3-5	3-5
From high tillering and grassy panicle forage sorghums	400-1000	400	400
Permissible genetic off-types (%)	≤0.01	≤0.05	0.05-0.10

Rogueing

- Removal of off-type plants and contaminating pollen sources
  - Done continuously through growing period
  - Removed before flowering
  - Need for weekly visits at vegetative, heading, flowering
  - and maturation
  - Have descriptive features of the variety/parental lines
  - In hybrid seed production, remove all pollen shedders in female rows

Sorghum growth stages



Adopted from: SS Rao ,DSR,Hyd. 8th Feb.11

Hybrids development and seed production (Sorghum and Pearl millet)

Male sterility

- The male reproductive system cannot produce viable pollen
- Anthers or pollen are non functional,
  - eliminates the need for any sort of emasculation.

- Male sterility can be divided into 3 categories:

i. Cytoplasmic,
   - controlled by the mitochondrial gene and inherited as a dominant, maternally transmitted trait.

ii. Nuclear/Genetic male sterility
   - occurs due to a single recessive gene "ms",
   - dominant allele "Ms" produces normal anthers and pollen.

Anthers from male-fertile (left) and male-sterile (right) panicles

Male sterility

iii. Cytoplasmic-genetic

- caused by both cytoplasmic and nuclear genes
- It is restored by a fertility restoring (Rf) gene (nuclear gene), which results in the development of normal anthers and pollen.
- Has been widely used in hybrid seed production in sorghum, pearl millet, onion, safflower, corn, and sugarbeet
- It overcomes the problems of GMS and CMS

Male sterility

- When a genic male sterile (msms) crosses with a fertile heterozygous (Msms), 50% of the progeny will be male sterile
- pure male sterile population can never be achieved.
- Male sterility cannot be identified before flowering, and the chances of pollen contamination increase (Mol. Markers).

Hybrid seed production

- Based on cytoplasmic-genetic male sterility
- Three parental lines
  - A line : male sterile (female)
  - B line : maintainer, identical to A line but with fertile cytoplasm
    - Maintains sterility of A line
  - R line: male line
    - Has fertility restorer genes
    - Crossed to A line, F_1 hybrid is male fertile.

ms ms S (A-line) X ms ms F (B-line)

↓

ms ms S (A-line) X MsMs F (R-line)

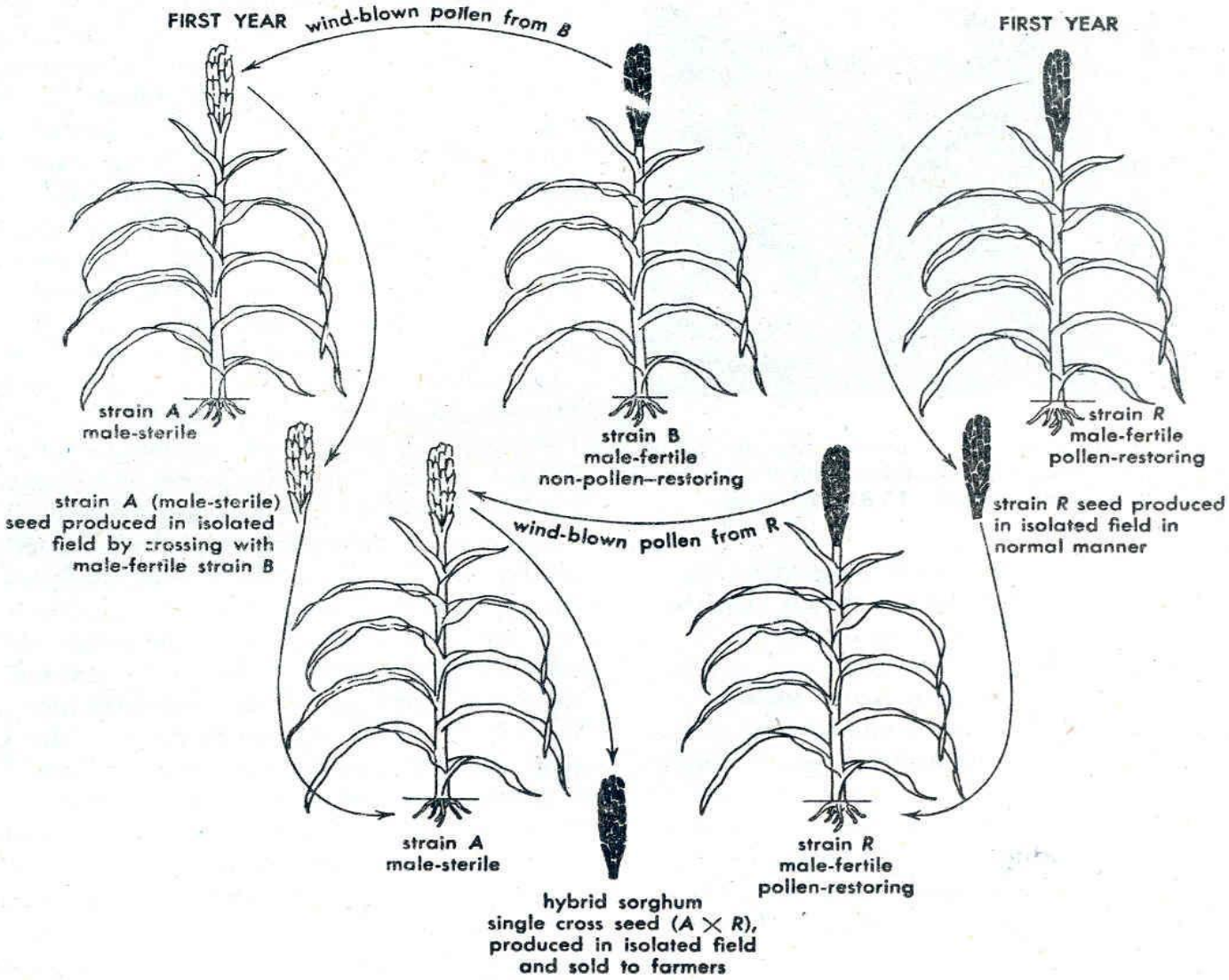
↓

Ms ms S (F1-Hybrid, Fertile)

Ms – fertlie gene, ms- sterile gene, S-sterile cytoplasm, F-fertile cytoplasm

F_2

	Ms	ms
Ms	Ms Ms	Ms ms
ms	Ms ms	ms ms (sterile)


FIRST YEAR
wind-blown pollen from B
FIRST YEAR
strain A
male-sterile
strain B
male-fertile
non-pollen–restoring
strain R
male-fertile
pollen-restoring
strain A (male-sterile)
seed produced in isolated
field by crossing with
male-fertile strain B
wind-blown pollen from R
strain R seed produced
in isolated field in
normal manner
strain A
male-sterile
strain R
male-fertile
pollen-restoring
hybrid sorghum
single cross seed (A × R),
produced in isolated field
and sold to farmers

Hybrid seed production

- Crossing various lines to A-line = F_1 either
  - Restorers
    - Male F_1s (potential hybrid male parents) or
  - Non-restorers
    - Male sterile F_1s (potential female parents)
- Seed production
  - Requires skill, experience and close supervision
  - Synchrony of flowering (nicking) of A and R critical

Hybrid seed production

- Planting ratio: 4 A_s to 2 R_s (4:2)
- Additional 4 rows put around the field to increase pollen availability
- Nicking improved through
  - Staggered sowing
  - Differential use of irrigation and fertilzer
- Harvest male rows (R/B) and remove from field then harvest the female rows

Efficiency in sorghum/millet hybrid seed production

- Synchrony in flowering
- Plant height
- Pollen dispersal
- Pollen viability
- Stigma receptivity
- Harvesting conditions

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Hybrid Seed Production of Sorghum - *Management of Non - Synchrony*

- Staggered sowing
- Additional application of nitrogen as basal dose or urea spray
- Irrigation to lagging parent
- GA spray to lagging parent
- Transplanting of the early parent if the gap is more than 12 days

- Short pollen parent are not desirable.
- Short pollen parent can be planted on raised ridges and tall seed parent in furrows
- Duration of flowering in male line
- Natural wind
- Adopting the planting ratio of 4:2 (female & male)
- Borders with 5 - 6 rows of male line
- Supplementay pollination

SPHPRC

Objective:

- **To diversify Sorghum and Pearl Millet and Pearl Millet hybrid parents for multiple uses and share these with partners to help them develop, test and market the commercial Sorghum and Pearl Millet hybrids that are highly productive in different agro ecological zones.**

This is expected to facilitate large-scale cultivation of multi-purpose Sorghum and Pearl Millet by poor farmers in developing countries.

Harvesting and threshing

- At physiological maturity : At black layer formation
- Male rows should be harvested first
- 37-45 days after flowering : Better seed quality
- Artificial seed drying where necessary to avoid grain molds
- Sorting for undesirable ear heads
- Clean threshers should be used at 13-14% seed moisture.
- Should be dried to 10-12% before storage

Quality control

- Precise assessment of seed quality is done by a seed technologist
- Good quality seed should have
  - High analystical purity
    - Low inert matter, seeds of other crops and weeds, broken seed, pest damage
    - High germination %
    - Right moisture content
    - High vigour
    - Trueness to variety type
- Neither good quality seed of poor varieties nor poor quality seed of superior varieties serve farmers well

Regional harmonized seed legislation in Eastern (EAC) , Western (ECOWAS) and Southern Africa (SADC)

Technical issues – basically similar across regions

- Seed quality assurance
- Variety release
- Plant quarantine and phytosanitary measures
- plant variety protection
- Biosafety measures to improve access to biotechnology

Regional Variety Catalogues

Sorghum and millets

"Good for you, good for the planet"

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