Regeneration Guidelines

Sorghum

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Introduction

Sorghum (*Sorghum bicolor* (L.) Moench.) belongs to the Poaceae family and is widely cultivated. It is considered to be one of the most important cereal crops in the world. There are about 30 *Sorghum* species; *S. bicolor* is cultivated for grain and forage while *S. halepense* (L.) Pers. (Johnson grass) and *S. propinquum* (Kunth) Hitchc. are cultivated only for forage. Wild relatives of sorghum include *S. bicolor* subsp. *verticilliflorum* (Steud.) de Wet ex Wiersema & J. Dahlb. (common wild sorghum; synonym: *S. arundinaceum*), *Sorghum purpureosericeum* (Hochst. ex A. Rich.) Asch. & Schweinf. and *Sorghum versicolor* (Andersson).

Sorghum is an important part of the diet for many of the world's population. It is mainly consumed as flat bread or porridge. It is also used as a forage crop (ICRISAT 2008) and sweet sorghum is grown to produce sorghum syrup.

Sorghum is extremely drought-tolerant, making it an excellent choice for semi-arid and dry areas. Most cultivars are annuals although some are perennial. Sorghum stems may reach over 4 m height, with small grains of 3–4 mm diameter. It is usually grown in clumps. The inflorescence varies greatly in size and shape, ranging from loose drooping branches to a compact-oval shape (IBPGR and ICRISAT 1993).

Although it is mostly self-pollinating, protogyny may cause at least 5% natural cross-pollination (Purseglove 1972). The genetic integrity of sorghum accessions is thus maintained by selfing.

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Choice of environment and planting season

Climatic conditions

Sorghum can be divided into three groups, based on adaptation to temperature and daylight:

- Cool-tolerant, tropical (high-altitude) sorghums grow and reproduce under relatively low temperatures, especially low night temperatures. They occur in the highlands in the tropics and are photoperiod sensitive.
- Temperate sorghums are relatively insensitive to photoperiod and tolerate cold conditions at the beginning and end of the growing season but not during flowering. They are adapted to warm or hot days with cool nights.
- Lowland tropical sorghums are adapted to relatively warm days and warm nights throughout the growing season; they are photoperiod sensitive.

Regeneration should be planned according to the type of sorghum and the prevailing environment.

Preparation for regeneration

When to regenerate

- When seed stocks are <50g.
- When germination falls below 75%.
- If the percentage of seeds infected by one or more of the following fungi is >25%: *Alternaria*, *Aspergillus*, *Cladosporium*, *Curvularia*, *Fusarium*, *Macrophomina*, *Penicillium*, *Phoma* and *Rhizopus* spp.

Seed sample

- Sorghum is seed propagated. To maintain genetic integrity, use seed from the original source as far as possible.
- At least 50 plants are required for regeneration, preferably more.
- About 8–15 g of seed (depending on seed size) are required for regenerating an accession.
- For each accession, prepare one seed packet for planting each row.
- Label the packets with identification number and row number and arrange them according to field lay-out.

Field selection and preparation

Sorghum can be grown on a wide range of soils but vertisols (black soils) are best for regeneration. Soil pH should be 5.5–8.5 and the plant will tolerate some salinity, alkalinity and poor drainage.

- Select fields in which sorghum was not grown in the previous year.
- Choose a field with good drainage that is weed-free at the time of sowing to ensure a good reserve of soil moisture.
- Prepare the land to a fine tilth by deep ploughing, followed by three or four harrowings.
- Level the field and make ridges 75 cm apart. This facilitates better establishment of seedlings and plant stands.

Method of regeneration

Planting layout, density and distance

- Divide the field into plots (also known as tiers), leaving 1-m walking space between them. The plots can vary from 3 to 9 m wide depending on the size of the field.
- Mark rows 75 cm apart across each tier, perpendicular to the length of the field, giving rows of 3–9 m long, depending on the width of the plot.
- Ensure a minimum distance of 3 m between different accessions.

Planting method

- Assign row numbers in a serpentine pattern (i.e. planting from left to right in the first row followed by right to left in the second row or vice versa).
- Sow mechanically using a tractor-mounted four-cone planter if planting a large number of accessions or plant by hand.

Labelling

- Label each accession with a tag fastened to a stake about knee height.
- Use strong paper for tags to withstand weathering.

Crop management

The genetic integrity of sorghum accessions is maintained by selfing when large numbers of accessions have to be regenerated simultaneously and isolation is not possible.

- Trim flag leaves of emerging panicles.
- Cover the panicles in well labelled paper bags of 10 x 5 x 37 cm prior to anthesis (photo 2).
- Staple or use a paper clip to hold corners of bags together so they are not blown off the panicle.
- Remove bags after 21 days (i.e. at dough stage) and tie them around the peduncles to identify selfed panicles when harvesting.

Fertilization

- Apply fertilizers on the basis of soil test results. In the absence of a soil test apply nitrogen and phosphorus, each at 40 kg/ha. If potash is required, apply 35 kg/ha.
- Apply fertilizer alongside the rows in 5-cm-deep furrows 5 cm to the side of the seed at the time of sowing. As a second dose, apply nitrogen at the rate of 40–60 kg/ha between rows 30 days after planting.

Thinning

- Thin out seedlings when they are 2 weeks old to maintain a distance between plants of 10–15 cm. At least 90 plants per accession are needed.

Weed management

- Apply pre-emergent herbicide. Inter-cultivate twice during early stages of crop growth and hand weed if necessary at later stages.
- Eliminate off-types and plants growing off-row.

Irrigation

- Irrigate after sowing if soil is dry, to avoid wilting of leaves at any stage of crop growth and to ensure moist soil at flowering.

Common pests and diseases

Contact plant health experts to identify pests and diseases and recommend appropriate control measures.

- The main diseases of sorghum are: Anthracnose (*Colletotrichum graminicolum*), leaf blight (*Helminthosporium turcicum*), downy mildew, honeydew (*Sclerospora sorghi*) and smut (*Sphacelotheca* spp.).
- The main insect pests are sorghum shoot fly and stem borer (*Chilo partellus*).
- Sorghum crops can also be attacked by birds.

Monitoring accession identity

Comparisons with morphological data

Compare the following traits in characterization data:

- Panicle exsertion
- Panicle compactness and shape
- Glume colour
- Glume covering (race)
- Grain colour

Harvesting

- Identify seed maturity by the formation of a black layer on the seeds. A dark patch in the pericarp, apparently associated with black layer formation, indicates physiological maturity. The optimum time to harvest seed for maximum longevity is 7 weeks after anthesis.
- Harvest and thresh seed manually. Small precision seed threshers can also be used successfully provided the equipment is cleaned thoroughly between accessions.
- Bulk seeds from at least 50 selfed plants to maintain the accession.
- Cut the panicles (select only selfed panicles, one from each plant, identified by clipped flag leaf and selfing bag clasped around peduncles) just below the base with secateurs.
- Collect panicles from each row in a well-labelled gunny bag (label both inside and out with accession and row numbers).

Post-harvest management

- Dry panicles in shade for a week until seed moisture content is reduced to 12% (ideal for hand threshing).
- Thresh individual panicles by beating gently and clean the seeds of debris by winnowing.
- Collect equal quantities of seed from each panicle/plant and bulk them to reconstitute the original accession.
- Prevent spillover and contamination of accessions during threshing and subsequent handling.

- Verify accession identity using seed traits (see below). Send a representative sample for observations on seed traits, seed health and viability testing. Reject samples with a high percentage of infection and list for next regeneration.
- Avoid chemical treatment of seed intended for storage. Collect the seeds in a labelled muslin cloth bag for further drying, preferably at a lower temperature and relative humidity (20–25°C and about 30–40% relative humidity).
- Keep seeds at these conditions until seed moisture is 8–9% (for medium-term conservation). For long-term conservation, dry the seeds to 5–7% moisture content using forced ventilation in a seed dryer maintained at 15°C and 15–20% relative humidity.
- If a drying room and forced ventilation facilities are not available, dry seeds to a moisture content of 5–7% with silica gel or other suitable desiccant.
- Pack seeds in moisture-impermeable containers (plastic bottles or aluminium foil) for conservation and distribution.
- Move seeds to a short-term storage area.

Regeneration of wild sorghum

Grow wild species in an isolated area to avoid possible outcrossing with germplasm of related species or introduction of weeds. Grow weedy or invasive species, such as *S. propinquum* and *S. halepense*, in a glasshouse under careful management.

- For field grow out, prepare broad beds 1.5 m wide and 6 m long. For growing in a glasshouse, use pots of 30 cm diameter filled with a mixture of 3 parts black soil: 2 sand: 1 farmyard manure.
- Germinate the wild species in paper cups and transplant them at 20 cm spacing in the field or in pots in the glasshouse.
- Follow the same crop husbandry practices recommended for cultivated sorghum.
- Cover panicles in parchment paper bags before stigma emergence to prevent outcrossing.
- Harvest the panicles individually as they mature, i.e. before shattering.
- Collect the seeds from each plant into a labelled muslin cloth bag.
- Dry the seeds held in the cloth bags under shade and clean them by gentle blowing or winnowing.
- Take equal quantities of seed from each plant and reconstitute the accession for further drying and subsequent storage.

Documentation of information during regeneration

Collect the following information during regeneration:

- Regeneration site name and map/GPS reference
- Name of collaborator
- Field/plot/nursery/greenhouse reference
- Accession number; population identification
- Source of seed
- Generation or previous multiplication or regeneration (if generation is not known)
- Preparation of planting materials (pre-treatments)
- Sowing date and density

- Field layout used
- Field management details (watering, fertilizer, weeding, pest and disease control, stresses recorded, others)
- Environmental conditions (altitude, precipitation, soil type, others)
- Emergence in the field or greenhouse (number of plants germinated)
- Number of plants established
- Days from sowing to flowering
- Pollination control method used (method, number of plants pollinated)
- Harvest date and method
- Number of plants harvested
- Quantity of seeds harvested
- Agronomic evaluation; agro-morphological traits recorded
- Comparisons with reference materials (record any identification numbers or references of any samples taken from this regeneration plot)
- Post-harvest (describe any relevant procedures)

References and further reading

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1 Sorghum (*Sorghum bicolor*) plant.
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2 Sorghum panicles covered with paper bags prior to anthesis.
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Notes