Measurement of sorghum grain yield and aboveground biomass at maturity by crop cut at plot level

SOP ID: 011
Version: 1
Crop: Sorghum (*Sorghum bicolor*)
Relevant KPIs: Productivity — yield; Resource use efficiency — nutrient use efficiency
R&D stage (example of activities):

- Discovery stage (yield decomposition)
- Proof-of-concept stage (testing of improved agronomic practices in on-station and/or on-farm trials)
- Pilot stage (on-farm participatory trials, randomized control trial)
- Scaling stage (panel studies, ex-post impact assessment)

Module 1: Measurement of grain yield

1.1 Required equipment/materials

- Measuring tape
- Pegs
- String or rope
- Cloth or woven polyethylene sacks
- Sickle bar headers
- Digital weighing balance
- Grain moisture meter
- Data recording tools/sheet.

1.2 Procedure for the taking sample from the field

Step 1: Identify the right harvest time. Sorghum pollinates first at the top of the head and progresses steadily downward to the base of the head (or flower cluster) in 4 to 7 days. Hence, seeds at the top will mature before those at the bottom of the head. Sorghum is considered mature when a black spot appears at the point where the seed attaches to the plant. It is ready to harvest when (i) grain moisture content is less than 28%, and (ii) the heads are yellow and the grains hard.

Step 2: Select net harvest area (m^2) following SOP001 Determination of the minimum number of plants and the minimum area to be harvested for correct crop yield determinations.

Step 3: Locate and mark the net harvest area by placing four pegs — one at each corner. Net harvest area should be representative of the entire plot and should not include border rows to avoid the border effect. When marking the net harvest area, take into account the crop establishment method. For example, if line-seeded, pegs should be placed centrally between two rows on both sides (Fig. 1 left). If plants are in random geometry (e.g. randomly broadcasted), only heads from stems that fall inside the delineated area should be harvested.

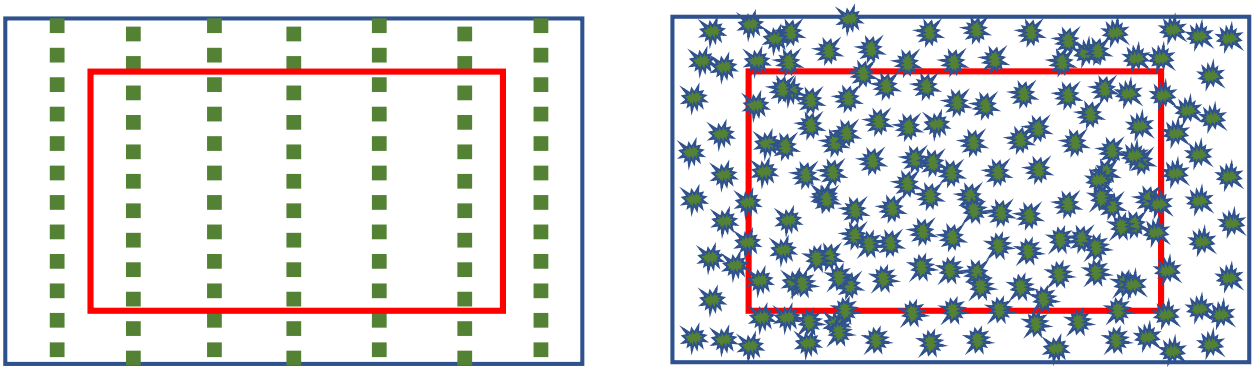

Figure 1. Illustration of row-planted (left) and random or broadcast (right) crops and area demarcation for harvesting both planting systems

Only the plants that fall inside the marked area (red box) need to be harvested.

Step 4: Cut all grain heads within the net harvest area. For harvesting grain, raise the sickle bar header high enough to harvest only the grain heads with a minimum of leaves and stalks. Place harvested heads in sacks with proper labels (barcode, or location, harvesting date, treatment, replication, plot number, etc.).

Step 5: Transport the harvested grain heads to a research station or any other place where samples can be properly processed, dried and stored before measuring grain weight.

Step 6: After sun-drying**,** thresh manually or mechanically to separate grains from heads and clean to remove the chaff.

Step 7: Measure grain weight (grams) from the net harvest area using a digital balance and then immediately measure the grain moisture content using a grain moisture meter.* Make sure that the balance is placed on a well-leveled surface. Also, make sure the grain moisture meter is calibrated for sorghum.

Note: * If there is no grain moisture meter available, grain moisture content can be determined for a representative subsample by weighing the sample fresh (at the same time as the total grain weight is determined) and drying it to constant weight either in an oven (typically at 75°C) or by sun and air. Then dry-weigh the subsample. The moisture content of the total grain weight is calculated by dividing the difference between fresh and dry weights of the subsample by the fresh weight of the subsample.

Note: If harvested grains are used for grain quality assessment, take a subsample of around 300 g and put it in a ziplock bag or container ready for lab analysis.

1.3 Calculation

Step 1: Convert the grain weight (net harvest area) to 12% moisture content using formula (1).

$$\text{Grain weight at 12\% moisture content (g)} = \text{Grain weight (g)} \times \frac{100 - \text{Grain moisture content (\%)}}{88} \quad (1)$$

Step 2: Calculate grain yield (kg/ha) (at 12% moisture content) using formula (2).

$$\text{Grain yield (kg/ha) at 12\% moisture content} = \frac{\text{Grain yield (g) of net harvest area at 12\% moisture}}{1000} \times \frac{10{,}000}{\text{Net harvest area (m}^2\text{)}} \quad (2)$$

Where the division by 1000 is the conversion of grams to kg; and the multiplication by 10,000 is the conversion from m^2 to ha.

Module 2: Measurement of aboveground biomass

2.1 Required equipment/material

- Measuring tape
- Four pegs
- String or rope
- Cloth or woven polyethylene sacks
- Sickle
- Paper bag
- Ziplock bag
- Digital weighing balance
- Drying oven
- Data recording tools/sheet.

2.2 Procedure

Step 1: Identify the physiological maturity stage in the field. Sorghum is considered mature when a black spot appears at the point where the seed attaches to the plant.

Step 2: Select net harvest area (m^2) following SOP001 Determination of the minimum number of plants and the minimum area to be harvested for correct crop yield determinations.

Step 3: Locate and mark the net harvest area by placing four pegs — one in each corner. When marking the net harvest area, take into account the crop establishment method. For example, if line-seeded, pegs should be placed centrally between rows on both sides. If plants are in random geometry (e.g. randomly broadcasted), only stems that fall inside the delineated area should be harvested.

Step 4: Harvest all plants from the net harvest area: to minimize the grain loss, first harvest grain heads using the sickle bar headers and place them in a large woven polyethylene sack and label them properly. After removing grain heads, cut stems at ground level and make sure that no dried leaves or stems (including dead tillers) are left in the harvest area.

Step 5: Chop each plant into 3–4 pieces (bottom, middle and top parts), bundle them together and record the total fresh weight of biomass (g) using a digital weighing balance. Immediately take a representative subsample of about 300 g (depending on the total biomass weight) to measure dry biomass. Measure the exact fresh weight of the biomass subsample (g) using a digital weighing balance and put the subsample in a paper/cotton cloth bag. The bag should be pre-labeled (barcode, or location, farm number, year, treatment, date of sampling, plot number, etc.).

Note: For representative sub-sampling for biomass, take three pieces each from the bottom, middle and top parts of the plant, and chop them into small pieces to facilitate proper drying.

Step 6: Transport samples (grain heads and biomass subsample) to a research station or any other place where samples can be properly processed, dried and stored before further processing.

Step 7: Thresh the harvested grain heads manually or mechanically to separate grains from heads.

Step 8: Separate harvested grain heads into grains and chaff and place them in separate bags that have been properly labeled. Record the total fresh weight of grains (g) and chaff (g) from the net harvested area using a digital balance.

If the samples are small, all samples can be put into the oven for measuring dry weight. If grain sample size is large (more than 1 kg), take a grain subsample of 200 g (depending on sample size) and put it into a paper bag properly labeled. Record the weight of subsamples using a digital balance — this is the grain subsample fresh weight (g).

Step 9: Oven-dry the subsamples of grains, biomass and chaff at 70°C for 3 days or until reaching a stable weight. Record the oven-dried subsample weight of grains (g), biomass (g) and chaff (g) immediately after taking out from the oven (do not let the samples rehydrate!).

Note: Avoid over-packing samples in the oven because good air circulation is needed for rapid and even drying.

Step 10: Grain and biomass samples for quality analysis: take a subsample of 20–30 g of the oven-dried grains and place them in a ziplock bag properly labeled, and take a subsample of 20–30 g of the oven-dried biomass and place it in a paper bag properly labeled. These samples can be used for further laboratory analysis.

2.3 Calculation

Step 1: Calculation of grain and chaff dry weight

For small samples

$$\text{Dry weight of grain (kg/ha)} = \frac{\text{Dry weight of grains (g)}}{1000} \times \frac{10{,}000}{\text{Net harvest area (m}^2\text{)}} \quad (3)$$

$$\text{Dry weight of chaff (kg/ha)} = \frac{\text{Dry weight of chaff (g)}}{1000} \times \frac{10{,}000}{\text{Net harvest area (m}^2\text{)}} \quad (4)$$

For large samples

$$\text{Dry weight of grain (kg/ha)} = \left[\frac{\text{Total fresh grain weight (g)} \times \frac{\text{Dry weight of grain subsample (g)}}{\text{Fresh weight of grain subsample (g)}}}{1000} \right] \times \frac{10{,}000}{\text{Net harvest area (m}^2\text{)}} \quad (5)$$

$$\text{Dry weight of chaff (kg/ha)} = \frac{\text{Dry weight of chaff (g)}}{1000} \times \frac{10{,}000}{\text{Net harvest area (m}^2\text{)}} \quad (6)$$

Step 2: Calculation of dry weight of biomass

$$\text{Dry weight of biomass (kg/ha)} = \left[\frac{\text{Total fresh biomass weight (g)} \times \frac{\text{Dry weight of biomass subsample (g)}}{\text{Fresh weight of biomass subsample (g)}}}{1000} \right] \times \frac{10{,}000}{\text{Net harvest area (m}^2\text{)}} \quad (7)$$

Step 3: Calculation of total aboveground biomass (oven-dried weight) and harvest index

$$\text{Total aboveground biomass (kg/ha)} = \text{Dry weight of grains (kg/ha)} + \text{Dry weight of chaff (kg/ha)} + \text{Dry weight of biomass (kg/ha)} \quad (8)$$

$$\text{Harvest index} = \frac{\text{Dry weight of grains (kg/ha)}}{\text{Total aboveground biomass (kg/ha)}} \quad (9)$$

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