Measurement of wheat grain yield and aboveground biomass at maturity for crop cut at plot level

SOP ID: 014

Version: 1

Crop: Bread wheat (*Triticum aestivum* subsp. *aestivum*) and Durum wheat (*Triticum turgidum* subsp. *durum*)

Relevant KPI: 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
- Four pegs (optional)
- String or rope
- Cloth or woven polyethylene sacks
- Labels
- Marker
- Sickle
- Digital weighing balance
- Grain moisture meter
- Data recording tools/sheet
- Plot combine harvester (optional)

1.2 Procedure for taking sample

Step 1: Identify right harvest time. Wheat is considered ready to harvest when grain moisture content is below 15% or spikelets are yellowing.

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.

For manual harvesting

Step 3: Locate and mark the net harvest area by placing four pegs — one at each corner. The dimensions of the harvest area should be representative for the field. When marking net harvest area, take into account crop establishment method. For example, if line-seeded, pegs should be placed centrally between rows on both sides (Fig. 1 left). If plants are in random geometry (e.g. randomly broadcasted), only spikes from stems that fall inside the delineated area should be harvested.

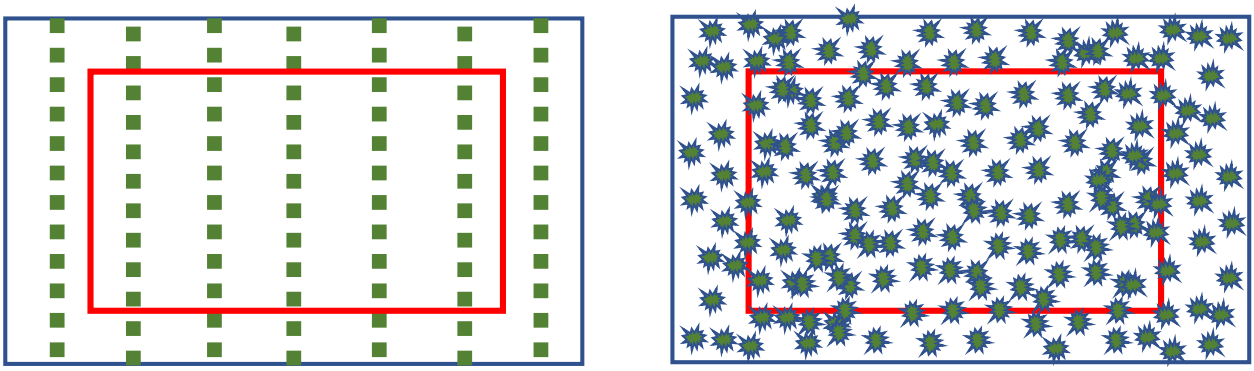


Figure 1. Sampling areas (red rectangles) for wheat planted in rows (left) and broadcast or random geometry (right)

Figure 1 illustrates wheat seeded in line and random geometry, with the area marked for net harvesting in each. Only plants that fall *inside* the marked area (inside the red box) need to be harvested. The sampling (net harvest) area is measured and marked out in the field accordingly.

Step 4: Record net harvest area (m^2): width [m] and length [m] as explained above.

Step 5: Cut all spikes within the net harvest area and place them in sacks with proper labels (barcode, or details of location, harvesting date, treatment, replication, plot number, etc.).

Step 6: Transport the harvested spikes to a research station or any other place where samples can be properly processed, dried and stored before measuring grain weight.

Step 7: Thresh the spikes manually or mechanically to separate grains from spikes, and clean the grain to remove chaff (i.e. winnow).

Step 8: Measure grain weight (g) from net harvest area using a digital balance and 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 wheat.

Note: The pegs to mark harvest area are especially important when seed was broadcasted. In other sowing arrangements (e.g. line sowing on the flat or on elevated beds) or when the whole plot is harvested in small plot experiments), the pegs can often be omitted, as long as the harvested area is clear.

When using a plot combine harvester

Step 3: After determining the net harvest area (the dimensions of the harvest area should be representative for the field) and marking it out, remove the surrounding border area manually.

Step 4: Record width (m) and length (m) of net harvest area. Consider the crop establishment method as described above.

Step 5: Use a properly labeled grain collection bag to collect grain and run the plot combine harvester in the net harvest area. Make sure that grain loss during harvesting is minimal.

Step 6: If necessary, clean the harvested grain, then weigh the total grain (g) using a digital balance and record the results.

Step 7: Immediately measure the grain moisture content (%) using a grain moisture meter.*

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 and put it in a paper bag, ziplock bag or container ready for lab analysis.

1.3 Calculation

Step 1: Calculate the net harvest area in m^2

$$\text{Area } (m^2) = \text{Width (m)} \times \text{Length (m)} \quad (1)$$

Step 2: Convert the grain weight (net harvest area) to 12% moisture content using formula (2).

$$\text{Grain weight at 12\% moisture content (g)} = \text{Grain weight (g)} \times \frac{100 - \text{grain moisture content (\%)}}{88} \quad (2)$$

Step 3: Calculate grain yield (kg/ha) at 12% moisture content using formula (3).

$$\text{Grain yield (kg/ha) at 12\% moisture content} = \frac{\text{Grain weight at 12\% moisture (g)}}{1000} \times \frac{10{,}000}{\text{Area } (m^2)} \quad (3)$$

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/materials

- 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. Physiological maturity is the point at which grain reaches hard dough stage, i.e. when spikes completely lose their green color; it typically occurs a few days before harvestable maturity.

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. When marking net harvest area, take into account 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. Record width and length of the net harvest area.

Step 4: Cut all plants from the net harvest area at ground level. Make sure to collect all aboveground biomass (including dead tillers). Remove other plants (weeds) and soil debris from harvested plants. Carefully place the harvested sample in large woven polyethylene sacks, with the spikes pointing downwards into the sacks. The bags should be pre-labeled (barcode, or details of location, farm number, year, treatment, date of sampling, plot number, etc.).

Step 5: Transport samples to a research station or any other place where they can be properly processed, dried and stored before weighing.

Step 6: Thresh the harvested sample manually or mechanically to separate grains and straw as soon as possible.

Step 7: Separate harvested samples into grains and straw, and place them into separate bags that have been properly labeled. Record the fresh weight of grains (g) and straw (g) from the net harvested area using a digital balance.

If the samples are small, whole samples can be put into the oven for measuring dry weight. If grain and straw samples are large (more than 1 kg), take a subsample of 100–200 g (depending on sample size) of each of grain and straw and put these into separate paper bags, properly labeled. Measure the fresh weight (g) of subsamples using a digital balance for both grain and straw subsamples.

Step 8: Oven-dry the samples of grains and straw at 75°C for 48 hours or until reaching a stable weight. Record the oven-dried subsample weight of both grains and straw (g) immediately after taking out of the oven (do not let samples rehydrate!).

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

Step 9: Grain and straw samples for quality analysis: take a 20–30 g subsample of oven-dried grain and place it in a ziplock bag, and take a 20–30 g subsample of oven-dried straw and place it in a paper bag. Both should be properly labeled. These samples can be used for further laboratory analysis.

2.3 Calculation

Step 1: Calculation of net harvest area in m^2

$$\text{Area } (m^2) = \text{Width (m)} \times \text{Length (m)} \quad (4)$$

Step 2: Calculation of dry weight of grain

For small samples

$$\text{Dry weight of grain (kg/ha)} = \frac{\text{Dry weight of grains (g)}}{1000} \times \frac{10{,}000}{\text{Net harvest area } (m^2)} \quad (5)$$

For large samples

$$\text{Dry weight of grain (kg/ha)} = \left[\frac{\text{Total fresh grain weight (g)} \times \frac{\text{Dry weight of grain subsample (g)}}{\text{Fresh weight of grain subsample (g)}}}{1000} \right] \times \frac{10{,}000}{\text{Net harvest area } (m^2)} \quad (6)$$

Step 3: Calculation of dry weight of straw

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

Step 4: Calculation of total aboveground biomass (oven-dried weight) and harvest index

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

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

Note: If harvesting all biomass in the harvest area is not possible, there is an alternative method of sampling a representative number of stems (e.g. 50 stems) to determine harvest index and estimate biomass from grain yield and harvest index. For this

method, please consult CIMMYT. 2013. *Yield and yield components: A practical guide for comparing crop management practices*. Maize and Wheat Improvement Center, Mexico. https://repository.cimmyt.org/xmlui/handle/10883/3387

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