Measuring Biomass, Nutrient Utilization, and Yield in a Maize Crop Part I.

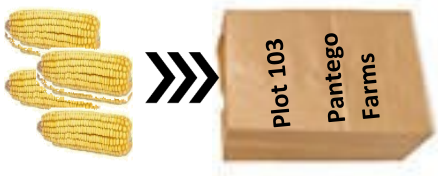
Preamble

Maize, or corn, ranks as the most important annual cereal crop in the world. Maize provides a staple food and feed crop, has numerous industrial uses, and is a source of income for millions around the world. Maize originated in central Mexico some 9,000 years ago. Today it is grown on all continents except Antarctica in a global band from 58 degrees north latitude in Canada and Russia, to 40 degrees south latitude in South America. Studies aimed at sustainably improving the maize cropping system routinely involve measuring biomass, nutrient content, and grain yield. Indicators of agronomic efficiency, and dry matter partitioning of maize, rely on quantitative measurements following standard procedures. In Part I, we outline a procedure for field sample collection and processing preparatory to quantifying aboveground biomass, nutrient utilization, and yield of a maize crop. In Part II, we provide a worked example, and identify different expressions of cereal grain yield and their relationship to moisture content.

Field Sample Collection

Step 1. Samples of whole maize plants are taken at R6 stage (physiological maturity) by cutting the stem cleanly just above the brace roots. Any sharp tool will suffice; we have used and can recommend bypass lopping shears (see **Appendix A** for materials list). The standard number of plants sampled per field is usually six, three from each of two adjacent rows. If you are sampling replicated field plots, the sample number can reduce if all plots are being sampled, replications have been treated exactly the same, and the plants are within reasonable proximity. In all cases, the bulk sample should number no less than 6 plants. It is not necessary to sample adjacent plants in the row; however, the plants should be representative of the whole plot. Do not select plants that are irregular looking compared to their neighbors, have blighted ears (smut, etc.), or are near (within 5') borders of the field plot or near openings or gaps in the plant row.

Step 2. Separate the plants into two fractions: ear and stover. Remove ears from the main stem, taking care not to detach the husk. If the husk accidentally breaks off, reattach it by tying the outer husk leaves around the main stem. Place the ears in a hardware-grade paper bag and label with plot number, location, and any other pertinent information.



Ears will be processed separately to measure total kernel moist "as is" weight, and oven-dry weight of kernels and cobs. If maize plants are taken from rows designated for machine harvest, add kernel weights back to the combine weight to adjust the final plot yield. In turn, add cob weights back to the stover fraction. Stover is, by definition, everything that is shot out the back of the combine during harvest, including cobs. This residue is the fraction of non-grain biomass.

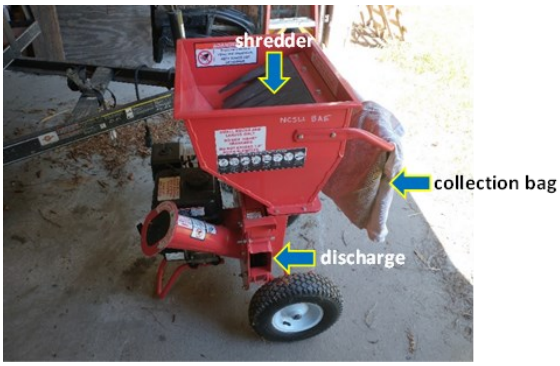
Step 3. Wrap the six corn stalks with a section of ½" VELCRO® garden ties. Label a 1.5" × 10" row band with the same information on the ear bag and staple it to the stalk bundle.

Collect the stalk bundles + ear bags and store them in a rodent-proof enclosure where they can air dry until processing. If moisture content of the grain is high (>25%), put the ear bags in a gas-fired crop dryer and allow to dry 12-48 hr. At this stage, the grain need only be dry enough to prevent decomposition.

Prepare Stover and Grain For Analysis

Step 1. For each bundle of six plants: remove the VELCRO® ties and row band. Place the bundle on a scale and record the moist "as is" weight. Optionally, you can weigh the bundles with the ties and row band attached by recording the weights of these items separately then subtracting the amount from the scale weight afterward. Note: For flatbed scales, level the scale before weighing. Check the scale for accuracy each time it's moved. Place a 500 g or 1,000 g calibration weight (whichever is closest to the actual measured weights) on the scale and record this weight along with the date. Hanging scales are calibrated in the same manner using special hooked weights.

Step 2. Pass the six whole maize plants (minus ears) through a motorized shredder equipped with a collection bag. You may have to make more than one pass with the shredder depending on the size and moisture content of the plants. One champ we have used and can recommend is the Predator 6.5 HP (212cc) gasoline-powered chipper-shredder.



The collection bag now holds shredded maize stover from six plants, i.e. a "composite". Mix the shredded stover to thoroughly homogenize.

Step 3. Obtain a sub-sample (two handfuls) of homogenized, shredded stover and place it in a paper bag. Record the moist "as is" weight of the stover + bag.

Place the sample bags in a convection oven at 75°C (167°F) and dry until a constant weight is achieved. This takes about 72 hours for shredded maize stover like pictured above. Place 10 empty paper bags in the dryer along with the stover to determine their individual empty (tare) dry weight. Remove the sample bags one at a time and record the dry weight of the stover + bag. Remove the empty paper bags, place on a scale, and determine single dry weight by dividing the total weight of the bags by 10. Subtract the tared bag weight from the dry weight of the stover + bag.

Step 4. Pass the maize ears through a mechanical thresher. Collect all grain kernels and record their moist "as is" weight. Place a sub-sample of the moist kernels in an aluminum dish (or whatever you have on hand, except plastic), record the weight, and dry in a convection oven at 75° C until a constant weight is achieved. For whole kernels this may take up to a week. Record the oven-dry weight. The moisture content (MC) of the stover and grain is determined by:

$$Moist\,mass - dry\,mass = mass\,of\,water$$

$$\%\,MC = \frac{mass\,of\,water}{mass\,of\,moist\,sample} \times 100$$

We'll use these formulas to convert the moist ("wet") weight of the stover and grain to moisture-free, dry matter in Part II of this Agronomy Note. Alternatively, you can use a grain moisture meter to determine % grain moisture. The moisture meter should be calibrated annually before using.

Field Sample Collection

At this stage, you should have recorded, the following weights:

- Moist weight of whole six-plant stover fraction (minus ears).
- Moist weight of the shredded, composited stover sub-sample.
- Moist weight of the whole six-ear kernel fraction.
- Moist weight of the whole kernel sub-sample.
- Weight of the oven-dry, shredded stover sub-sample.
- Weight of the oven-dry, whole kernel sub-sample.

Now we have everything needed to determine biomass, nutrient utilization, and yield of a maize crop. Amaizing!

Appendix A

Materials needed for sample collection:

-Bypass loppers
-VELCRO® garden ties
-Heavy-duty 57 lb. kraft hardwater paper bags
-Row bands
-Arrow P-22 HD stapler
-Sharpie permanent markers
-Mesh bags for ear collection

Loppers can be purchased from any hardware supplier; we do not have a brand preference. We suggest ULINE S-7631 8 ¼ x 5 ¼ x 18" #25 or S-9621 12 x 7 x17" ⅙ barrel kraft paper hardware bags (link). These are the only type of paper bags that will stand up to field conditions. Row bands can be purchased from Midco Global (link), or alternatively, tailor-made from 13 pt. card stock if you don't need a carton of 1,000. Mesh bags are available for purchase from farm supply stores or online.

Materials needed for processing and weighing:

-Predator 212cc Chipper-Shredder or equivalent
-Digital hanging or flatbed scale accurate to at least 0.1 g
-Forced-air drying oven
-Safety glasses
-Hearing protection
-Weighing dishes or cans

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