Non-destructive sampling procedures for studying nitrogen use efficiency throughout the sugarcane crop growth cycle

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Abstract

Nitrogen (N) is a fundamental nutrient in agroecosystems, but has considerable negative environmental impact when used in excess. Meeting N demand while reducing excess N can be achieved by improvements in N use efficiency (NUE) of a crop agroecosystem. This is generally determined destructively (i.e. by cutting the cane) at the end of the crop cycle during harvest, where NUE is typically higher than during initial phases of crop development. Here we present the findings of a methodological study that aimed at developing non-destructive estimations of NUE throughout the crop cycle.

We investigated the ability of allometric relationships to estimate sugarcane biomass by testing different functions and measurable traits (cane height and basal diameter) on six sampling dates. A dilution curve was constructed to predict N content of the sugarcane biomass by harvesting 20 stalks of cane on five separate dates. The number of harvested stalks was then rationalised to reduce the amount of harvested cane without affecting the ability of the curve to predict N content. As N derived from fertiliser (Ndff) can be determined from a representative leaf using an ^{15}N-labelling approach, ^{15}N content of each leaf on three stalks of cane was determined on four sampling dates. This enabled identification of the most representative leaf for determining ^{15}N content of the biomass.

The percentage difference and the associated error between sugarcane biomass predicted by allometric models and 2.5m harvested plots varied depending on the combinations of measurable traits used for the allometric relationships. The values for cane: 1) height on each date; 2) height x diameter on each date; and 3) height x diameter using a global relationship across sampling dates was 2±3 %, 2±3 % and 5±3 % respectively. In order to construct an adequate dilution curve, we determined statistically that a minimum of 5 sugarcanes needed to be sampled. The leaf with an ^{15}N content most representative of the entire cane aboveground biomass was L+1 at 3, 8 and 11 months and L+3 at 5 months of growth (L+1 is the first leaf from the top with a visible dewlap).

Allometric relationships appear to predict sugarcane biomass effectively at a plot scale. Models developed for each month may provide slightly better predictions, but a single global model across dates using cane height combined with basal diameter is best practically. The results indicated that sugarcane N concentration can be determined by non-destructive means using dilution curves based on sampling of five sugarcane stalks once a month during the cane cycle. In order to determine the Ndff, only a single leaf from the cane plant needs to be harvested rather than the entire plant. These methods make it possible to study NUE by using mostly non-destructive techniques throughout the crop cycle.

Keywords: Nitrogen Use efficiency, Sugarcane, Non-destructive sampling procedure