Stem diameter: A rapid and accurate parameter for monitoring growth of sorghum

Angela Clough[1,3] and Malcolm N. Hunter[2,3]

[1]Department of Natural Resources and Environment, 402 Mair St, Ballarat, Vic 3350
angela.clough@nre.vic.gov.au
[2]ANOVA Solutions, 20 Stralock St, Chapel Hill, Qld, 4069 mhunter@powerup.com.au
[3]formerly of The University of Queensland, St Lucia, Qld, 4072

Abstract

Glasshouse and field experiments with Sorghum bicolor (L. Moench) were conducted in Queensland. The aim was to determine whether stem diameter could be used instead of the relatively laborious leaf area technique to monitor treatment effects.

In the glasshouse, under optimal water conditions, leaf area and stem diameter of sorghum were measured on three occasions until 44 days after transplanting (DAT), and were shown to be closely related ($r^2 > 0.95$, n = 59). Both parameters accurately indicated shoot fresh weight ($r^2 > 0.96$, n = 59) and shoot dry weight ($r^2 > 0.94$, n = 58). The close relationship between stem diameter and dry shoot weight was also valid in the field ($r^2 = 0.98$, n = 21).

The pragmatic advantage of using stem diameter instead of leaf area to monitor plant growth was apparent at 44 DAT. Measuring the leaf area of 60 plants took 4.5 h while measuring stem diameter took about 30 minutes. Stem diameter may therefore be a preferable non-destructive parameter used to measure treatment effects on the growth of young sorghum grown in the glasshouse and the field. A similar relationship may exist for other field crops.

Key Words

Diameter, Stem, Sorghum, Indicator

Introduction

Destructive plant sampling during glasshouse and field experiments is often unsuitable because plant material or time are limited. Thus, it is necessary to define growth responses to nutrients and water use over time by monitoring experiments using non-destructive growth indices.

Accurate manual indicators such as leaf area or leaf number are readily accessible, however they can be time consuming. High technology alternatives such as reflectometry can be used, but their validity may vary depending upon background environmental conditions (Bellairs *et al*., 1996). Stem diameter is used in forestry to estimate leaf area and transpiration (Vertessy *et al*., 1995) and is also used in perennial horticulture crops to estimate vigour (George and Nissen, 1987). The use of stem diameter to estimate growth in annual agricultural crops has rarely been reported (Camberato and Bock, 1989).

In this paper, we report the relationships between several indices and plant growth determined whilst conducting a pot experiment with forage sorghum and a field experiment with grain sorghum.

Methods

Glasshouse experiment with forage sorghum

The glasshouse experiment was conducted to assess the impact of benomyl fungicide applications upon vesicular-arbuscular mycorrhizae (VAM). Two soils were placed in sterilised pots and subjected to a range of soil sterilisation and VAM inoculation treatments under two consecutive sunflower crops. After harvesting the second sunflower crop, sorghum seedlings (cultivar Sugargraze) were transplanted into the pots and a three replicate complete randomised block design experiment was conducted with ten benomyl and phosphorus treatments. Soil was kept at field capacity by using a semi-automatic watering system (Hunter, 1981). The results presented are from all treatments.

Monitoring growth of sorghum in the glasshouse and in the field

The total leaf area (TLA) of each plant grown in the glasshouse was estimated at 29, 36 and 43 DAT by measuring the length and breadth of all leaves which were at least 50% elongated, and multiplying these measurements by 0.795 (Bhishnoi, 1966). The diameter of the stems were measured across the narrow face directly below the auricle of the third leaf at 30, 37 and 44 DAT. At harvest 44 DAT, plant height was measured from the base of the plant to the tip of the longest leaf, and fresh weight was recorded immediately after harvest.

In the field, the stem diameter of 21 sorghum plants grown at seven locations near Emerald, Queensland, was measured at 42 to 70 days after sowing (DAS) using the same technique used in the glasshouse. Each plant was harvested by cutting the plant at ground level immediately after the stem diameter was measured. All shoots from glasshouse and field experiments were dried immediately after harvest at 80?C in a forced draught oven for 72 h.

Results

Relationship between stem diameter and total leaf area

Stem diameter measured in the glasshouse accurately reflected total leaf area for the three times it was measured ($r > 0.97$). Stem diameter measured at 44 DAT was also closely related to fresh shoot weight ($r = 0.98$), dry shoot weight ($r = 0.98$) and shoot height ($r = 0.97$). There was also a close relationship between stem diameter and dry shoot weight for young plants grown in the field under unregulated water conditions ($r = 0.99$). These high correlations were not an artefact of having one or two outlying data points. There was a spread of data points due to the broad range of nutrient treatments in the glasshouse experiment (Fig. 1) and various ages of plants in the field (Fig. 2).

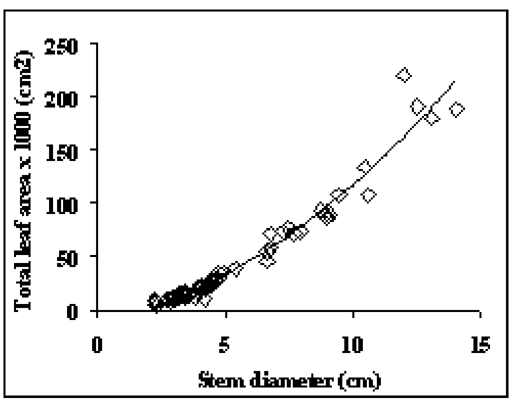

Fig. 1: The relationship between total leaf area at 43 DAT and stem diameter at 44 DAT of forage sorghum grown in the glasshouse (n = 58).

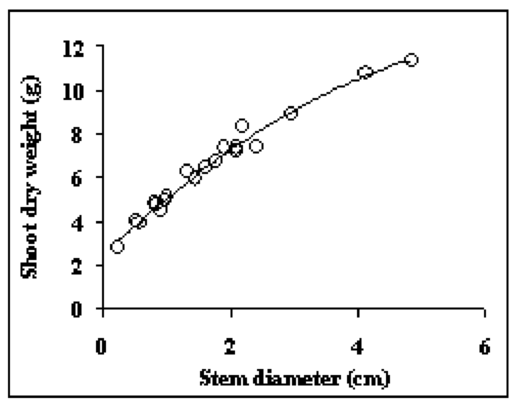

Fig. 2: The relationship between stem diameter and shoot dry weight of grain sorghum 42 - 70 DAS at seven locations near Emerald, Queensland (n = 21).

Conclusion

Stem diameter is an accurate and rapid means of monitoring sorghum growth under a range of agronomic conditions. However, the relationship between stem diameter and other growth indices is not expected to be as close as shown in these experiments when some sorghum plants in an experimental or field situation are drought stressed. We expect that stem diameter is an accurate growth indicator for other annual species and suggest that the technique be trialed on other crops.

References

(1) Bellairs, S. M., Turner, N. C., Hick, P. T., and Smith, R. C. G. (1996) Aust. J. Agric. Res., 7:1017-1034.

(2) Bhishnoi, U. V. (1966) Ann. Arid Zones, 5:255-256.

(3) Camberato, J. J., and Bock, B. R. (1989) Plant Soil, 113:79-83.

(4) George, A. P., and Nissen, R. J. (1987) Sci. Hort., 31:269-274.

(5) Hunter, M. N. (1981) Plant Soil, 62:455-459.

(6) Vertessy, R. A., Benyon, R. G., O'Sullivan, S. K., and Gribben, P. R. (1995) Tree Physiol., 15:559-567.