Floral initiation in maize is regulated by the growth of leaf primordia

Stephen E Ockerby[1,2], Zongjian Yang[2]

[1] AgSight Pty Ltd, 10 Palmerston St, Pimlico, QLD, 4812, www.agsight.com.au, stephen@agsight.com.au
[2] Formerly CQUniversity, Rockhampton, QLD, 4702.

Abstract
Agronomists and plant scientists roughly calculate the timing of floral initiation in crops based on mathematical models of heat units (or thermal time) adjusted for day-length. To sanction this approach, there is dogma that plants have apparatuses or ways for measuring day-length and accumulating temperature, and intrinsic pathways between leaves and the shoot apical meristem for signalling the plant's developmental status. In this brief paper, we present data that describe the growth of maize leaf primordia in response to photoperiod treatments. The results show that the architecture of the shoot apical meristem is responsive to photoperiod and that a slow rate of leaf primordia elongation is coincident to tassel initiation.

Key words
Flowering, photoperiod, shoot apical meristem, tassel initiation, leaf elongation

Introduction
In two species, sorghum and maize, the timing of floral initiation was precisely synchronized with the slow elongation rate of leaf primordia (Ockerby *et al*., 2014; Yang *et al*., 2014). Measurement of the lengths of leaf primordia revealed that a consistent structure and function of the shoot apical meristem occurred just prior to floral initiation.

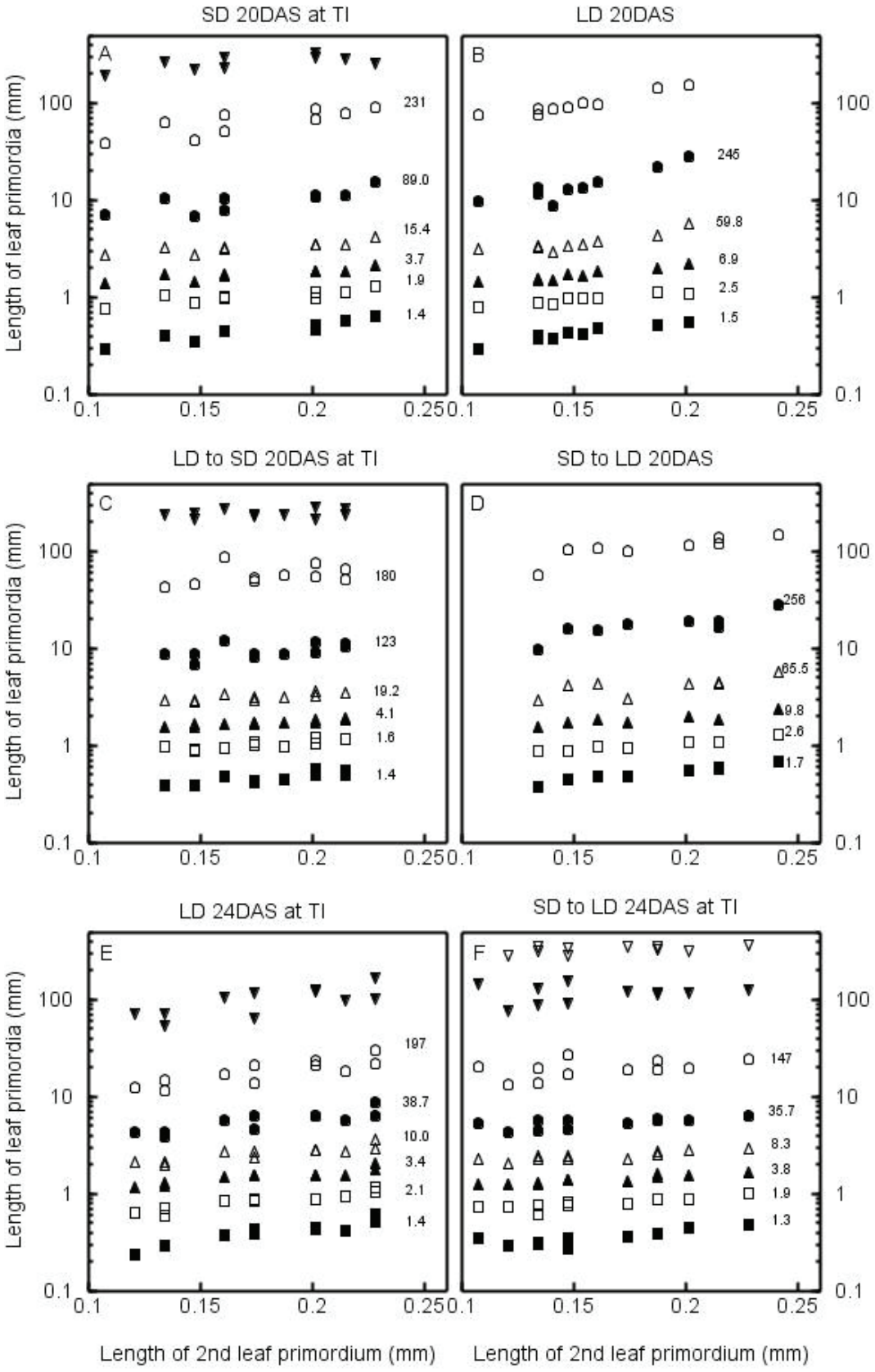
Methods
Maize (*Zea mays* L. cv. DK689) plants (eight per pot) were grown in several 15-L black plastic pots each containing 13.5 kg sandy clay loam soil (field capacity: 0.25 g g-1; permanent wilting point: 0.11 g g-1). Water and fertilizer were supplied as needed.

Two photoperiod treatments were imposed to observe their effect on the time of tassel initiation and the morphological characteristics of the shoot apical meristem. Plants in short days (SD) were given 9 h natural light at 30°C and 15 h darkness at 25°C, and plants in long days (LD) were given 9 h natural light at 30°C, 7 h low light from incandescent bulbs at 25°C and 8 h darkness at 25°C. Twelve days after sowing, half of the plants in LDs were transferred to SDs and half of the plants in SDs were transferred to LDs.

Plants were dissected under a microscope at frequent intervals (10-12 plants per treatments on each occasion usually every three days) to count leaves and measure the length of leaf primordia. Tassel initiation was scored when 70% of sampled plants had swelling at the base of the shoot apical meristem; (From Yang *et al*. 2014).

Results
When plants in SD and LD to SD had initiated a tassel, the plants in LD and SD to LD were vegetative and maintained faster rates of leaf primordia (LP) elongation (Fig. 1). Just 4 days later, the plants in LD and SD to LD initiated tassels but had also grown 2.6 extra leaves (17.8 cv. 15.2: $P<0.05$) with green leaf area of approximately 600 cv. 300 cm^2 and the elongation rate of LP had slowed to resemble (in a chronological-sense and numbered from the shoot apical meristem) those on SD and LD to SD plants at tassel initiation. Plants in LD and SD to LD had slightly shorter LP and slower rates of LP elongation at tassel initiation than those of SD and LD to SD plants, but the differences were much less than the changes within treatments in the 4d before tassel initiation. Plants that had been transferred from SD to LD and vice-versa responded to the condition in which they were in at the time of tassel initiation.

Fig 1: The lengths of leaf primordia (log scale) relative to the length of the second leaf primordium in vegetative maize (Zea mays) seedlings at 20 days after sowing (DAS) in (A) short days (SD), (B) long days (LD), (C) LD transferred to SD and (D) SD transferred to LD; and at 24DAS in (E) LD and (F) SD transferred to LD. Linear slopes of lines fitted to the untransformed data are shown for leaf primordium (■) 3, (□) 4, (▲) 5, (Δ) 6, (●) 7, (○) 8, and (▼) 9. Values of Y for each value on the X-axis represent the leaf lengths of a single plant. Tassel initiation (TI).



Discussion

The results were typical of those reported in our papers (Ockerby *et al*., 2014; Yang *et al*., 2014) for both sorghum and maize plants that were subjected to natural and artificial treatments: season, agronomy, light intensity, photoperiod, cultivar or defoliation; which resulted in variation in the both plant growth and the timing of floral initiation.

Slowing in the elongation of leaf primordia (LP) to critical thresholds may have engendered conditions in the shoot apical meristem that triggered the transition from the vegetative to the floral phase. The phenomenon would be consistent with the thesis of Turing (1953) in the sense that the expression of genes in a cell (to determine what a cell looks like and does) can be regulated locally by chemical substances called morphogens. In the current study, the growth of maize LP may just indicate the growth status of the shoot apical meristem, or it may reckon between the rate of producing new vegetative tissue (cell division) and the capability to expand or grow those cells; and either may be physiologically-constrained by the resource supplied or the environmental controls that regulate plant growth. Knowing how a plant responds and what causes it to differentiate different cell types at the shoot apical meristem will enhance our faculty to work with the conditions causing the development of yield-forming plant structures (Otegui and Slafer, 2004).

Conclusion

The recurring association between the elongation rate of leaf primordia and floral initiation under a range of conditions and treatments in two species (photo-period and maize discussed in this paper) should be cause for scientists to rethink how floral development is triggered.

References

Ockerby SE, Midmore DJ, Yule DF, Foster SD (2014). Leaf growth controls the timing of panicle initiation in *Sorghum bicolor*. *Asian Journal of Agriculture and Food Science* 2(1), 28-38.

Otegui ME, Slafer GA (2004) Increasing Cereal Yield Potential by Modifying Development Traits. Proceedings of 4th International Crop Science Conference, Brisbane, Australia.

Turing AM (1953). The chemical basis of morphogenesis. *Philosophical Transactions of the Royal Society* (part B). 237, 37-72.

Yang Z, Midmore DJ, Ockerby SE (2014) Tassel initiation is synchronized to the elongation rates of leaf primordia in *Zea may*s. *Asian Journal of Agriculture and Food Science* 2(4), 296-306.

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