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Environmental stimuli promoting sucker initiation in sugarcane☆

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Abstract

The presence of suckers, late-formed tillers, in mature sugarcane crops reduces the sugar concentration of harvested material to the detriment of profitability. The amount of suckering varies with cultivar and season. However, the environmental stimuli promoting suckering, i.e. the number of suckers, are not understood. This paper describes the effects on suckering of increasing soil moisture, nitrogen, and the level of light penetrating the canopy. Light was manipulated by plant spacing or removal of dead leaf from mature stalks. Increased nitrogen availability late in the crop's growth cycle promoted suckering, even in a cultivar of low suckering propensity. Higher levels of nitrogen applied at the beginning of the growing season had inconsistent effects, possibly due to variation in rainfall. Increased soil moisture late in the growing season greatly increased suckering and also had a positive effect when combined with high levels of nitrogen. The effect of plant spacing on sucker number was only significant in the plant crop, and then only when expressed as sucker number per mature stalk. Removal of dead leaves had a significant effect on suckering at one site but not another. In all cases, higher plant spacing and dead leaf removal increased light levels recorded under the canopy. The quality and quantity of light required to promote suckering still remain unknown, as does the means by which the plant perceives the light stimuli. The differences in suckering between the plant and ratoon crops suggested that not all stimuli were tested in the treatments applied, or that other factors negated stimuli that were present or that suckering is inherently more prevalent in ratoon crops. All cultivars tested responded similarly to the environmental stimuli that produced a significant effect.

Keywords: Nitrogen; Light; Soil moisture; Dead leaf removal; Suckers

Abbreviations: DAP, days after planting; DAR, days after ratooning; PAR, photosynthetically active radiation
☆ This symbol (⦶) denotes a cultivar protected under Australian Plant Breeders' Rights legislation.
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1. Introduction

Sugarcane is propagated vegetatively from stem pieces containing axillary buds. Like most grass crops, yield (biomass and sugar) comes from mature stalks arising from primary shoots from the axillary buds originally planted and from higher order shoots produced from axillary buds on these primary and other shoots (tillers) during the early stages of growth. Shoot number then declines because competition for light, moisture, and nutrients increases as the crop canopy closes (Borden, 1948; Bell and Garside, 2005, in this issue). Unlike many other grasses, sugarcane produces tillers later in the growth cycle, called suckers. Their morphology differs from tillers produced earlier in the growing cycle (Hes, 1954; Barnes, 1974; Bonnett et al., 2001). Suckers are characterised by thicker stems with shorter, broader, and thicker leaves than found on earlier-produced primary and secondary shoots.

Suckers have negative consequences in mechanically harvested sugarcane production systems as they are harvested together with mature stalks. The overall sucrose concentration of the harvested material is lowered (Berding et al., 2005, in this issue) because of the lower sucrose concentration of suckers (Ivin and Doyle, 1989; Berding et al., 2005). Reducing sucker number would improve sugar concentration and profitability for growers in industries where sugar concentration is part of the payment system.

Environmental factors that affect tiller number in sugarcane have been studied previously. That increasing nitrogen fertiliser increases secondary shoot number has been demonstrated many times (e.g., Borden, 1945, 1948; Shrivastava and Kumar, 1984). Other factors have been less well studied but have demonstrated some significant effects. Duration, intensity, and spectral composition of light affects grass tillering. Martin and Eckart (1933) demonstrated that reduced light intensity prevented secondary shoot development in sugarcane grown in large pots under three light levels. We can find no reports of manipulation of spectral composition of light and its effect on sugarcane tillering. However, red:far-red ratio has been shown to affect tillering in other grasses (Casal et al., 1987). Ludlow et al. (1990) measured the spectral composition underneath canopies of several sugarcane cultivars but could not determine if observed differences in red:far-red ratio were a cause or effect of measured differences in tillering.

Reports on environmental factors affecting suckering are rare. Borden (1948) and Salter and Bonnett (2000) reported the effect of nitrogen on suckering in single factor experiments. Manipulation of the amount of light reaching the stalk by removing dead leaves increased sucker numbers in the outside rows of sugarcane crops (Bonnett et al., 2001). Long-term observations of suckering resulted in the proposal of a hypothesis that harvest-season soil moisture, soil nitrogen, and increased light affected sucker initiation. The objective of the studies reported here was to determine whether soil moisture, soil nitrogen and light or a combination of these factors stimulate sucker development in a range of cultivars. A companion paper (Berding et al., 2005) reported on the yield and quality components of suckers in the multifactor experiment described here.

2. Materials and methods

2.1. Multifactor experiment

An experiment to test the effects of moisture, nitrogen, and light on suckering of two cultivars of sugarcane was established. This experiment has been fully described (Berding et al., 2005 in this issue). Briefly, the experiment was established south of Cairns, north Queensland (17°5′ S, 145°47′ E), and consisted of two moisture regimes, rainfed and a post-monsoonal irrigation treatment. These treatments were used to test the hypothesis that harvest season rainfall (July–October), which has been shown to correlate with low CCS (Bonnett et al., 2004), promotes suckering which contributes to the low CCS problem (Wilson and Leslie, 1997). Irrigation was applied on 15 June 2000 until 24 August 2000 in the plant crop to maintain soil moisture close to field capacity (18% water content by mass). In the ratoon crop, a similar strategy was in place from 17 May 2001 to 25 September 2001. This gave a significantly wetter soil environment in the irrigated treatment (Berding et al., 2005). Within each moisture regime two cultivars, three within-row plant spacings and three nitrogen treatments were incorporated into a five-replicate, factorial experiment design. The cultivars included in the experiment were Q138 and Q152,