SHORT NON-REFEREED PAPER

AN INVESTIGATION INTO FACTORS INFLUENCING FLOWERING AND PITHING OF SUGARCANE IN SOUTHERN AFRICA

EKSTEEN AB[1], HALSE E[2], SIMWINGA E[3] AND SUTHERLAND D[4]

[1]*South African Sugarcane Research Institute, P/Bag X02, Mount Edgecombe, 4300, South Africa*
[2]*Illovo Sugar Limited, PO Box 46, Dwangwa Estate, Malawi*
[3]*Zambia Sugar, PO Box 670240, Nakambala Sugar Estate, Mazabuka, Zambia*
[4]*Illovo Sugar Limited, PO Box 194, Mount Edgecombe, 4300, South Africa*
alana.eksteen@sugar.org.za Ehalse@illovo.co.za
ESimwinga@zamsugar.zm DSutherland@illovo.co.za

Abstract

Flowering in sugarcane is a physiological process that can affect cane yield and quality. Pithing is a phenomenon in sugarcane stalks whereby dry cavities are formed within the internodes, which can affect sucrose extraction during processing. The aim of this study was to investigate the effect of selected climatic factors on the extent of sugarcane flowering and pithing, and the effect of these phenomena on cane yield and quality in southern Africa. Weather, the extent of flowering, pithing, cane yield and quality data for selected cultivars from Dwangwa Estate (Malawi) and Nakambala Estate (Zambia), were analysed over five (2008-2012) and three seasons (2008-2010), respectively. Flowering was more profuse in 2008 and 2009 at Dwangwa and 2010 at Nakambala, and the extent of flowering was significantly influenced by cultivar choice ($p<0.001$). Pithing was observed to range from 5.88-19.46% and 9.00-19.41 % at Nakambala and Dwangwa, respectively. The extent of flowering was well correlated with pithing ($R^2=0.69$; $p<0.01$). Flowering and pithing also appeared to be significantly influenced by daily minimum temperature (T_{min}) during the flower initiation stage at Nakambala only ($p<0.001$) and daily maximum temperature (T_{max}) during the flower initiation stage at both Nakambala and Dwangwa. Flowering in sugarcane ensures a very high chance of pithing in cultivars with a high propensity for flowering. No relationship was found between flowering and sugarcane yield, and pithing and sugarcane yield, which indicates that post-flowering harvest management was well scheduled. Further investigation into the management factors that affect pithing is required.

Keywords: flowering, pithing, rainfall, sugarcane yield effects, temperature

Introduction

Flowering in sugarcane is an economically important process known to affect crop yield and quality, and plant selection against flowering has been shown in tropical sugarcane breeding programmes (Berding and Hurney, 2005). Flowering acts as a natural ripener because it inhibits further stalk growth and can improve cane quality in the short term (Berding and Hurney, 2005). Flowering can be divided into five stages (induction, initiation, development, emergence, and opening of the panicle) each of which have a specific photoperiod requirement (Moore and Berding, 2013).

Flowering in sugarcane cultivars with a medium to high propensity for flowering takes place between March and June in the southern hemisphere. With decreasing latitude toward the equator, the propensity for flowering increases because specific climatic conditions that initiate heavy flowering occur more frequently. The climatic conditions known to cause profuse flowering include: an average decreasing day length starting at 12.5 hours (Coleman, 1968), an average optimum day temperature (T_{max}) of 28°C (Berding and Hurney, 2005) and an average night temperature above 18°C (T_{min}) for at least 15 uninterrupted nights during the flower initiation stage (Coleman, 1963; Gosnell, 1973), little or no soil moisture stress (Nuss *et al.*, 1999) and physiological maturity of the sugarcane stalks (Coleman, 1968). Flowering impact of yield and sucrose content depend on the time between flowering and harvesting, and the temperature experienced during post-flowering (Gosnell and Julian, 1976; Hardy *et al*., 1986).

Pithing (pithiness) in sugarcane is a physiological condition that occurs in sugarcane stalks which causes dry 'pith' or cavities within the internodes, instead of being filled with sugarcane juice. Pithiness is also of economic importance because it affects sucrose extraction in the milling process. There is very little information available on the extent of pithing in the southern African sugarcane industry although pithing has been thought to be associated with flowering. This association is thought to be genotype-specific (Deren, 1992). The climatic or management factors that contribute to pithing are not well known.

The aim of this study was therefore to investigate the effect of selected climatic factors on the extent of sugarcane flowering and pithing, and the effect of these phenomena on cane yield in selected sites in southern Africa.

Methods and Materials

Site and measurement detail

Data were analysed from two sites, Nakambala Estate in Zambia (15°52'S; 27°46'E) and Dwangwa Estate in Malawi (12°29'S; 34°8'E). Climatic conditions at both sites are characterised by warm, wet summers, and cool, dry winters (average maximum temperature (T_{max}) of 29.3°C and 29.9°C and average minimum temperature (T_{min}) of 15.9°C and 18.7°C at Nakambala and Dwangwa, respectively). The long-term average rainfall is 696 mm (Nakambala) and 1181 mm (Dwangwa), and at both sites sugarcane is irrigated primarily with furrow irrigation. The milling season typically stretches from April to November, and cane is harvested on a 12-month cutting cycle. The sugarcane floral initiation period occurs during February (4 to 25 February at Dwangwa and 15 February to 8 March at Nakambala), followed by flower emergence in April, and full flowering during May of each year.

The extent of flowering (number of stalks with flowers, expressed as a percentage of the total number of stalks counted per field), pithing (number of internodes with dry pith expressed as a percentage of the total number of internodes per stalk), selected cultivars, final yield (t/ha) and sucrose content (%) were collected for selected fields from 2008-2012 (Dwangwa) and 2008-2010 (Nakambala). Selected cultivars (N14, N23, N25, N32, N35) with a medium to high propensity for flowering were chosen to correctly compare the extent of flowering in each season.

Data analysis

The average extent of flowering (%), pithing (%), yield (t/ha) and stalk sucrose content (%) were reported for selected cultivars at each site, and for each season. A linear regression was

used to analyse the relationship between the extent of flowering and pithing, and yield and sucrose content in response to flowering and pithing, using Genstat, v.14 (provided the data were normally distributed).

Results and Discussion

The propensity for flowering was highest in cultivars N14 and N23 at Dwangwa, and N23 at Nakambala (Table 1), and pithing was greatest in N14 (Dwangwa), and N23 (Nakambala) (Table 1). Flowering and pithing in sugarcane were found to be significantly influenced by cultivar type ($p<0.001$), which confirms that the propensity to flower in sugarcane is a genetically determined trait (Moore and Berding, 2013). Flowering was less profuse in 2010 and 2012 at Dwangwa because there were seven and 13 days, respectively, where the daily T_{max} was higher than 30°C, which is not considered optimal to initiate heavy flowering. Flowering was considerably more profuse in 2010 at Nakambala because there were more than 10 uninterrupted nights during which T_{min} was greater than 18°C, compared with 2008 and 2009, which had less than five uninterrupted nights in which T_{min} was greater than 18°C.

The proportion of internodes found to contain dry pith ranged from 9.00 to 19.41% and 5.88 to 19.46% at Dwangwa and Nakambala, respectively. Pithing peaked in 2008 (Dwangwa) and 2010 (Nakambala), the seasons in which the highest annual T_{min} and lowest rainfall (January to March) occurred.

Table 1. Average extent of flowering, pithing, yield and sucrose content of selected sugarcane cultivars, and over five seasons (2008-2012) at Dwangwa and Nakambala Estates.

	Dwangwa, Malawi				Nakambala, Zambia			
Cultivar	**Flowering (%)**	**Pithing (%)**	**Yield (t/ha)**	**Sucrose (%)**	**Flowering (%)**	**Pithing (%)**	**Yield (t/ha)**	**Sucrose (%)**
N14	71.92	19.41	124.51	14.96	-	-	-	-
N23	60.21	12.65	111.79	14.69	59.75	22.52	124.16	15.09
N25	39.62	9.00	103.95	14.86	42.80	5.07	128.41	15.43
N32	47.73	13.75	110.35	14.06	-	-	-	-
N36	52.98	13.08	120.74	14.98	-	-	-	-
Year								
2008	63.44	16.81	114.81	15.17	23.34	17.19	125.71	14.09
2009	61.06	14.72	117.01	15.34	45.87	5.88	119.97	14.34
2010	56.92	13.12	117.60	14.88	56.18	19.46	120.88	14.58
2011	59.64	16.53	116.02	14.83	-	-	-	-
2012	51.21	11.35	108.32	14.92	-	-	-	-

There was a highly significant correlation between the extent of flowering and pithing in sugarcane at both sites ($R^2=0.69$; $p<0.001$). T_{max} was found to significantly affect both flowering and pithing ($p<0.05$ at both sites), whereas T_{min} affected flowering and pithing only at Nakambala. T_{min} at Nakambala was more variable between seasons during the flower initiation phase, compared with T_{min} at Dwangwa, where T_{min} was continually above 18°C and would not limit the extent of flowering and pithing in each season.

Flowering and pithing were found not to affect sugarcane yield (t/ha). Gosnell and Julien (1976) showed that flowering may increase, decrease or have no effect on sugarcane yield depending on temperature, and post-flowering harvest interval. If post-flowering harvesting is

managed correctly then sugarcane is harvested before reduced yields can occur as a result of side-shooting and stalk senescence. Sucrose content (%) had a weak but significant negative relationship with pithing (p=0.032) and the extent of flowering (0.023).

Conclusion

Flowering in sugarcane ensures a very high chance that pithing will occur because this condition is caused by the process of flowering. The fact that flowering and pithing did not have a significant or negative effect on final sugarcane yield at either Dwangwa or Nakambala Estates suggests that post-flowering harvest management is well scheduled However, pithing would have an impact at the mill because of slightly reduced sucrose content. Further investigation of the management factors affecting pithing (e.g. fertiliser application and irrigation scheduling) is required, as well as investigation of the relationship between pithing, flowering and climate at other sites in southern Africa.

Acknowledgements

The authors gratefully acknowledge the guidance of Dr Abraham Singels from SASRI and the assistance of the technical team staff at Dwangwa and Nakambala Estates who collected data over many seasons for this study.

REFERENCES

Berding N and Hurney AP (2005). Flowering and lodging, physiological-based traits affecting cane and sugar yield. What do we know of their control mechanisms and how do we manage them? *Field Crops Res* 92: 261-275.

Coleman RE (1963). The effect of temperature on flowering in sugarcane. *Int Sug J* 6: 351-353.

Coleman RE (1968). Physiology of flowering in sugarcane. *Proc Int Soc Sug Cane Technol* 13: 992-1000.

Deren CW (1992). Stability and heritability of pith in sugarcane and its influence on yield. *Plant Breeding* 109: 242-247.

Gosnell JM (1973). Some factors affecting flowering in sugarcane. *Proc S Afr Sug Technol Ass* 47: 144-147.

Gosnell JM and Julian HR (1976). Variations in the effects of flowering on cane yield and quality. Proceedings Sugarcane Ripener Seminar, Monsanto, Vol 1: 253-257.

Hardy G, Dove H and Awada M (1986). The use of ethephon for prevention of flowering in sugarcane in Sudan. *Proc Int Soc Sug Cane Technol* 19: 305-316.

Moore PH and Berding N (2013). *Sugarcane: Physiology, Biochemistry, and Functional Biology* Moore PH and Botha F (Eds). John Wiley and Sons Ltd, Chichester, UK.

Nuss KJ, Berding N, Singh V and Kumar V (1999). Planned recombination in sugarcane breeding: Artificial initiation of flowering in sugarcane in sub-tropical and tropical conditions. *Proc Int Soc Sug Cane Technol* 2: 504-508.