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Performance of CP Sugarcane Cultivars Grown in Different Locations in Florida. [1]

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Introduction

The Everglades Agricultural Area (EAA) is a 700,000 acre agricultural region south of Lake Okeechobee in Florida. Sugarcane (*Saccharum* spp.) is harvested at different locations throughout the EAA, and growers must factor in the effect of sugarcane genotype (G) and environment (E) on potential yield performance when scheduling their harvests. “Environment” is defined to include the effects of soil type, climate and management factors at different locations. The vast majority of research addressing the effects of environment on sugarcane yields has focused on G x E interaction effects. Although numerous studies have reported significant G x E interactions and recommended sugarcane selection in differing environments (Arceneaux and Hebert, 1943; Glaz et al., 1985; Milligan et al., 1990; Bull et al., 1992; Mirzawan et al., 1994; Bissessur et al., 2000), other studies have concluded that the number of locations in sugarcane breeding programs could be reduced (Gravois and Milligan, 1992; Milligan, 1994; Jackson and McRae, 1998; De Sousa-Vieira and Milligan, 1999).

While G x E interactions have been studied primarily as a tool to help breeders make informed decisions regarding the design of sugarcane breeding programs, less information has been published in the scientific literature on G x E interactions and their impact on yield performance within recently-released commercial sugarcane cultivars. Improving our understanding of the significance of environment, genotype, and G x E interaction in recently-released cultivars would help growers make confident cultivar-selection choices for their growing environments and would also help breeders verify the success of their sugarcane breeding program. In addition, since breeding programs often lack the resources to allow replanting of the same cultivars in the same environment (Brown and Glaz, 2001), multi-site data sets in which environment, crop age, and year are not confounded are often limited or simply not available.

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The following discussion reports the results of a series of experiments (Gilbert et al., 2006) that were designed to compare and contrast relative sugarcane cultivar performance at different locations throughout the EAA.

Methodology

The data for this analysis were collected from a series of experiments conducted in the EAA of south Florida at five locations (Figure 1), including the University of Florida/IFAS Everglades Research and Education Center (EREC), Hundley Farm (HU), Lakeview Farm (LV), Sundance Farm (SU), and Hillsboro Farm (HB). The sites represented diversities in soil depth and expected minimum temperatures that occur during freezes throughout the sugarcane production region on organic soils. Soil types included a Torry muck (euic, hyperthermic Typic Haplosaprist) for the Lakeview location and Lauderhill muck (euic, hyperthermic Lithic Haplosaprist) for the remaining 4 sites (Rice et al., 2005). Harvest data were collected from October to March during 4 consecutive seasons (1998/1999 to 2001/2002).

Cultivars were selected for this study based on either their recent release date or their economic importance as documented in the most recent sugarcane variety census (Glaz, 2006). The first two digits in the cultivar name represent the year the clone was named, usually 7-10 years prior to cultivar release. A brief description of the cultivars included in this study can be found at http://edis.ifas.ufl.edu/SC069. Cultivars are ordered by release date in tables and figures throughout this article. For more information on this study please see Gilbert et al. (2004) and Gilbert et al. (2006).

Overall Ranks

Using combined data from all study sites, Table 1 presents the overall cultivar ranking for sucrose concentration (lbs sucrose/ton; SPT), cane yield (tons cane/acre; TCA), and sucrose yield (tons sucrose/acre; TSA) for each cultivar. Ranking was based on yield; from highest (1) to lowest (13). CP89-2143 was notable for the highest rank in SPT, TCA and TSA. The acreage planted to CP89-2143 has increased by 44,000 acres in the EAA over the last four years, and its census rank (based on planted

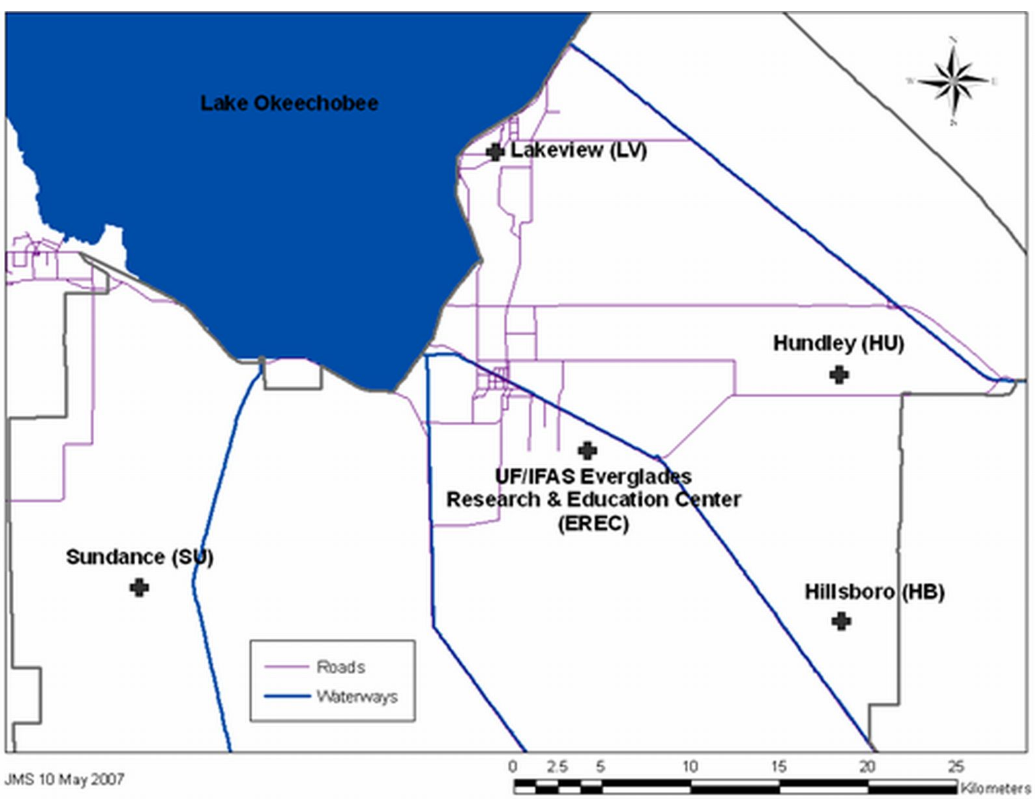

Figure 1. General vicinity of experimental variety trials for evaluation of performmance by location in the everglades Agricultural Area

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acreage) has increased from #7 to #2 during the same time period due to its superior sucrose content and yield performance compared with other cultivars. CP88-1762 and CP72-2086 also had high ranks ranging from 2 to 5 in SPT, TCA and TSA. These 3 clones (CP89-2143, CP88-1762, and CP72-2086) are among those with the highest acreage in the EAA in recent years. In contrast, CP85-1382 and CP88-1508 fared poorly in all three ranking categories (rank = 8) when compared to other CP clones. It is not surprising that growers have lost interest in these 2 clones, which are absent from the latest census. Although CP80-1743 reflects average rankings of either 5 or 6 for SPT, TCA, and TSA, it still occupies the most acreage (census rank = 1), reflecting its continued popularity among sugarcane growers. However, it is difficult to obtain accurate yield data from small plots using CP 80-1743 because it is extremely susceptible to rodent damage in small plots, whereas rodent damage is not nearly as severe in commercial fields.

Some clones are characterized by high sucrose concentrations (SPT) and low cane tonnage (TCA) or vice-versa. Growers prefer to plant clones with high SPT as transport and milling costs are reduced. Cultivars like CP78-1628 with high SPT (rank = 2) and low TCA (rank = 8) are more profitable and are more likely to be adopted by growers than low sucrose concentration, high cane tonnage clones like CP88-1834 (SPT rank = 13; TCA rank = 4) or CP89-2377 (SPT rank = 12; TCA rank = 2).

Performance at Different Locations

Table 2 presents performance ranks for sucrose concentration (SPT), cane tonnage (TCA) and sucrose yields (TSA) for each genotype at each of the five sites included in this study. CP70-1133 tended to have higher relative SPT (rank = 7) and TSA (rank = 7) at EREC than other sites, whereas CP72-1210 recorded poor TSA yields (rank $\geq$ 8) at all locations. CP72-2086 recorded higher relative TSA yields at the EREC (rank=5) and Sundance (rank=4) sites compared to the Hillsboro (rank = 11) site. CP78-1628 recorded relatively high performance (ranks $\leq$ 6) for all yield traits at all locations, whereas CP80-1743 was notable for good relative sucrose yield performance at EREC (TSA rank = 2), but poor performance at Lakeview (TSA rank = 11). CP80-1827 had low sucrose yields (TSA rank at all locations, and CP84-1198 recorded high relative sucrose yields at the Hundley site (TSA rank = 3), as did CP85-1382 (TSA rank = 5). CP88-1508 recorded poor relative sucrose yields (TSA rank $\geq$ 8) across all locations, whereas CP88-1762 demonstrated high relative yields (TSA ranks ranging from 1 to 6) across the five locations. CP88-1834 was notable for poor sucrose concentration (SPT rank $\geq$ 10) at all locations, but high TCA (rank = 1) and TSA (rank = 2) at the Lakeview site. CP89-2143 was a clear standout, with superior SPT and TSA (rank =1) at four of five sites, and very high SPT and TSA performance (rank = 2) at one of the five farm sites. Finally, CP89-2377 tended to have lower sucrose concentration performance (SPT rank $\geq$ 6) but higher cane tonnage performance (TCA rank $\leq$ 7).

Our results highlight the influence of environment on sugarcane yields in a visually homogenous region. The EAA sugarcane production area is characterized by flat basin topography, well-drained organic soils with high N mineralization rates, and high to very high organic matter contents (Bottcher and Izuno, 1994). Unlike other sugarcane production areas in the world, rainfall is not normally considered a limiting factor to sugarcane production in the EAA due to the excellent water-holding capacity of the organic soils and generally abundant water supply from Lake Okeechobee (Alvarez et al., 1982). Sucrose yields averaged over the same cultivars, growing season, crop age, and time of harvest varied greatly from 2 to 46% among locations. In contrast to the results of Julien and Delaveau (1977) in Mauritius, this study supports arguments for multi-locational evaluation of sugarcane germplasm in Florida both during the breeding program and following cultivar release. South Africa has had a released variety trial program in place since 1966 (Redshaw, 2000) to recommend cultivars to growers in different agroclimatic zones. Released variety trials make inherent sense in S. Africa where 23 bioresource regions have been identified in Kwa-Zulu Natal province, where sugarcane production areas range from loamy sandy soils in warm coastal areas to clayey soils in cooler highlands. Our study in the EAA of south Florida

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indicates that a similar approach to released variety trials may also be useful in more homogenous regions.

Sugarcane germplasm is released after numerous years of replicated on-farm trials, yet considerable variation in cultivar relative performance may occur following cultivar release. Many breeding programs do not have the resources available to assess cultivar performance following release. Relative performance of new cultivars compared to industry standards is often obtained ad hoc from mill managers and industry professionals without replicated tests. Ellis et al. (2004) compared variety trials to commercial production in Australia, and reported that differences in cultivar ranking between data sets were due to uneven deployment of cultivars in commercial fields. They concluded that variety trials could not be enhanced to evaluate uneven deployment effects. However, in S. Africa post-release variety trials have been used to recommend varieties to growers (Redshaw, 2000). Our study indicates that a systematic agronomic evaluation of released sugarcane cultivars is valuable in determining relative cultivar performance and identifying recommendation domains most suited for different cultivars.

When the rankings of genotypes at different sites were compared, the cultivar rankings at the Lakeview site did not correlate well with the other locations in this study. Significant G x E interactions indicated that the Lakeview site was located in a different agroecological zone than the other sites. Differences in soil depth, mineral content and air temperature may contribute to G x E interactions in the EAA. Lakeview is < 1 km from Lake Okeechobee in a “warmland” area, with soils containing appreciably greater mineral content than the other sites included in this study. Early breeding strategies in the EAA recognized the importance of selection for both “warmland” sites and “coldland” sites further from Lake Okeechobee (Bourne, 1972). Cultivars F31-962, F31-436, and CL41-223 occupied over 50% of the EAA acreage in the 1940s – 1960s, but faded from prominence as sugarcane acreage spread further from the lake. Rates of leaf appearance vs. thermal time differ among sugarcane cultivars (Bonnett, 1998; Sinclair et al., 2004). Differing cultivar growth rates at different cumulative thermal time may be part of the mechanism involved in the G x E interaction of “warmland” vs. “coldland” sites. Although the CP program breeds new cultivars in a “warmland” environment adjacent to Lake Okeechobee, all cultivars are tested in multiple “coldland” areas and one “warmland” environment before cultivar release.

Conclusions

This data set indicates that a significant G x E interaction still exists in many recently-released cultivars, with the recommendation domain of CP88-1508 and CP88-1834 closer to Lake Okeechobee than CP72-2086 or CP80-1743. However CP89-2143 had a remarkably high, stable sucrose concentration and sucrose yield across all locations. Growers in the EAA interested in improving sucrose concentration of their sugarcane crop should plant CP89-2143.

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Table 1. Sugarcane sucrose concentration (SPT), cane yield (TCA), sucrose yield (TSA) and cultivar performance ranks[a] for combined data from all experimental sites in Florida. The census rank[b] indicates cultivar popularity (in terms of total plant cane and ratoon crop acreage) as documented in the 2005 Florida sugarcane variety census (Glaz, 2006).

Cultivar[c]	SPT	TCA	TSA	SPT rank	TCA rank	TSA rank	Census rank	EAA acreage
	lbs sucrose/ton	tons cane/acre	tons sucrose/acre					%
CP70-1133	253	45.1	5.7	10	10	11	not listed	< 1
CP72-1210	260	41.9	5.4	6	13	13	not listed	< 1
CP72-2086	266	50.9	6.8	3	5	4	5	6.3
CP78-1628	269	47.4	6.4	2	8	7	4	12.7
CP80-1743	260	50.2	6.5	5	6	5	1	28.6
CP80-1827	259	45.9	6.0	7	9	9	not listed	< 1
CP84-1198	257	49.7	6.4	9	7	6	6	4.4
CP85-1382	251	43.8	5.5	11	12	12	not listed	< 1
CP88-1508	259	44.9	5.8	8	11	10	not listed	< 1
CP88-1762	265	54.6	7.2	4	3	2	3	15.0
CP88-1834	242	52.5	6.3	13	4	8	not listed	< 1
CP89-2143	284	56.5	8.0	1	1	1	2	20.0
CP89-2377	247	55.8	6.9	12	2	3	not listed	< 1

[a]SPT, TCA, and TSA ranks: 1=highest performer; 13=lowest performer.
[b]Census rank: 1=highest acreage, 6=lowest acreage; not listed=<1% of total sugarcane acreage
[c]Cultivars are sorted in ascending order by year of introduction (i.e., CP70-1133 is a cultivar named in 1970).

Table 2. Cultivar rankings within each site for sucrose concentration (SPT), cane yield (TCA) and sucrose yield (TSA). Sites (see Figure 1) are: Everglades Research and Education Center (EREC), Hillsboro Farm (HB), Hundley Farm (HU), Lakeview Farm (LV) and Sundance Farm (SU).

	SPT ranks[a]					TCA ranks					TSA ranks				
Cultivar	EREC	HB	HU	LV	SU	EREC	HB	HU	LV	SU	EREC	HB	HU	LV	SU
CP70-1133	7	11	7	13	n.i.	9	8	12	12	n.i.	7	10	12	12	n.i.
CP72-1210	8	6	3	3	6	10	10	11	13	8	11	9	10	13	8
CP72-2086	2	7	5	6	5	7	12	7	6	3	5	11	8	7	4
CP78-1628	3	1	n.i.	4	2	3	3	n.i.	5	6	4	3	n.i.	5	5
CP80-1743	12	4	2	9	4	1	7	9	11	4	2	4	6	11	3
CP80-1827	4	8	9	5	n.i.	11	9	10	8	n.i.	10	12	11	8	n.i.

Table 2. Cultivar rankings within each site for sucrose concentration (SPT), cane yield (TCA) and sucrose yield (TSA). Sites (see Figure 1) are: Everglades Research and Education Center (EREC), Hillsboro Farm (HB), Hundley Farm (HU), Lakeview Farm (LV) and Sundance Farm (SU).

	SPT ranks[a]					TCA ranks					TSA ranks				
CP84-1198	10	9	11	2	8	8	5	1	7	5	9	5	3	6	6
CP85-1382	9	10	10	7	9	12	13	5	9	9	12	13	5	9	9
CP88-1508	6	5	8	11	n.i.	13	11	8	10	n.i.	13	8	9	10	n.i.
CP88-1762	5	3	4	8	3	4	2	6	3	1	6	2	2	4	1
CP88-1834	13	13	12	10	10	6	4	2	1	10	8	7	7	2	10
CP89-2143	1	2	1	1	1	5	1	4	4	2	1	1	1	1	2
CP89-2377	11	12	6	12	7	2	6	3	2	7	3	6	4	3	7

n.i. = “not included”, the cultivar was not planted at the specific site.
[a]SPT, TCA, and TSA ranks: 1=highest performer; 13=lowest performer.