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Sugarcane Genotype Repeatability in Replicated Selection Stages and Commercial Adoption

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ABSTRACT

The sugarcane (interspecific hybrids of *Saccharum* spp.) breeding and selection program in Canal Point (CP) Florida increased the number of genotypes advanced to its final selection stage, Stage IV, from 11 to 14. This change resulted from recently reported evidence that replications could be decreased without reducing experimental precision in Stage IV. The major purpose of this study was to determine if advancing an additional three new genotypes to Stage IV would improve the likelihood of identifying successful cultivars. A secondary objective was to determine if genotypes with high or mediocre yields in the penultimate stage, Stage III, could be expected to have similar yields in Stage IV. Data were reviewed from 24 cycles of Stage III, and 16 cycles of Stage IV. Genotype correlations between Stage III and Stage IV were significant but low for sugar yield (Mg sugar ha^{-1}) ($r = 0.27$) and economic index (\$ ha^{-1}) ($r = 0.28$). No genotype that ranked worse than 15th in both sugar yield and economic index in Stage III was later used on more than 1% of Florida's annual sugarcane hectarage. It is usually necessary to select

from genotypes ranking worse than 15th in Stage III to advance 11 genotypes to Stage IV, because genotypes are normally discarded due to disease susceptibility and poor agronomic type. It is unlikely that advancing more than 11 genotypes from Stage III would improve the likelihood of identifying productive commercial cultivars, unless other changes are made that improve the quality of genotypes advanced to Stage III.

INTRODUCTION

The sugarcane breeding and selection program at Canal Point, Florida is a cooperative program conducted by the USDA-Agricultural Research Service, the Florida Sugar Cane League, Inc., and the University of Florida Institute of Food and Agricultural Sciences. A previous study examined the final replicated testing stage (Stage IV) of the CP program (Brown and Glaz, 2001). Before that study, 11 promising genotypes were tested at 10 locations in Stage IV. Each genotype was replicated eight times and harvested as three annual crops, the plant-cane, first-ratoon, and second-ratoon crops at each location. The 11 promising genotypes in Stage IV were advanced from approximately 130 genotypes that were annually advanced from Stage II to Stage III (Glaz et al., 2001). Major criteria for advancement from one stage to the next are high yields, economic index, disease resistance or tolerance, and agronomic traits. A principal conclusion of Brown and Glaz (2001) was that experimental precision would remain similar in Stage IV if replications were reduced from eight to four.

The Florida Sugarcane Variety Committee selects the genotypes to advance from Stage III to Stage IV. This committee is composed of personnel representing growers, mills, and research and extension agencies participating in the CP breeding and selection program. Many criteria are considered in the selection process by committee members. However, most of the genotypes advanced to Stage IV in any given year can be classified into three groups using yield, disease, and agronomic criteria. The first group of genotypes has high yields and acceptable disease profiles and agronomic characteristics at all locations in Stage III. The second most desirable group is composed of genotypes with high yields at some locations. If 11 genotypes are not yet selected, the remaining entries are selected from among genotypes that had mediocre yields in Stage III but may have had some other redeeming characteristics, such as desirable agronomic traits, high theoretical recoverable sugar yields, or excellent disease resistance.

The committee usually limited its selections to 11 genotypes due to resources assigned to Stage IV. However, Brown and Glaz (2001) proposed a redistribution of resources in Stage IV that would not compromise experimental precision and allow for testing of more genotypes. In most years, there were not more than 11 genotypes in the first two groups of genotypes advanced from Stage III to Stage IV. However, several genotypes from the third group usually needed to be discarded when only 11 genotypes were advanced.

Among the genotypes with high yields, several usually have severe disease susceptibilities. The committee is very strict about not advancing such genotypes to Stage IV. Due to this policy and the ever increasing disease pressures on sugarcane in Florida, the committee often selected genotypes that ranked below 20th in yield or economic index in Stage III to advance 11 relatively disease-free genotypes.

Kang et al. (1988) reported that genotype repeatability was low between the two stages for 11 genotypes tested for one Stage III and one Stage IV cycle. Glaz and Miller (1982) reported that Stage IV results predicted reasonably well the commercial yields of five released genotypes. A logical follow-up to the studies of Brown and Glaz (2001), Kang et al. (1988), and Glaz and Miller (1982) was to determine how well genotype performance in Stage III corresponded to performance in Stage IV, and ultimately to commercial success for many Stage III and IV cycles. With this information, a more informed choice could be made about whether to reduce replications and increase the number of genotypes in Stage IV. The major purpose of this study was to determine if advancing an additional three new genotypes to Stage IV would improve the likelihood of identifying successful cultivars. This led into a secondary objective which was to determine if a genotype with high or mediocre yields in Stage III would be expected to have similar yields in Stage IV.

MATERIALS AND METHODS

Results from 24 Stage III cycles from the CP 69 through the CP 92 series of the CP sugarcane cooperative breeding and selection program were reviewed. The CP 69 series was planted in Stage III in 1970; and the final harvest of the CP 92 series in Stage III was in 1995. Stage III is the penultimate selection stage, and the first stage of the program in which genotypes are planted at multiple locations, replications, and annual crop cycles. About 130 new genotypes are now annually advanced to Stage III. These remain in the field for a plant-cane and a first-ratoon harvest. This study specifically focused on 21 to 42 of the Stage III genotypes in each Stage III cycle for which data were collected for both the plant-cane and first-ratoon crops.

Sixteen Stage IV cycles were reviewed; these cycles included the CP 77 through the CP 92 series. The CP 77 series was planted in Stage IV in 1980; and the final harvest of the CP 92 series in Stage IV was in 1999. Stage IV is the final selection stage in the CP program. Ten to 13 new genotypes were advanced to most of these Stage IV cycles, but only 10 or 11 were planted at all Stage IV locations. The genotypes in Stage IV were analyzed from the plant-cane through the second-ratoon crop. The characteristics compared between Stage III and Stage IV were sugar yield, (Mg sugar ha^{-1}), and economic index, measured in \$ ha^{-1} (Deren et al., 1995). The economic index calculation accounts for costs such as planting, milling, and transportation of cane to the mill. For calculations of economic index, the same costs were used over all years of the study. Also, theoretical recoverable sugar (kg sugar Mg^{-1} cane) was discussed for some genotypes. Theoretical recoverable sugar (TRS) was calculated according to Arceneaux (1935) until 1993 and according to Legendre (1992) since 1993.

Sugar yield and economic index were reported for both Stage III and Stage IV as a percentage of a commercially grown check cultivar. The check was CP 63-588 in Stages III and IV in the CP 77 and 78 series. In the CP 79 series, the check remained CP 63-588 in Stage III but was CP 70-1133 (Rice et al., 1978) in Stage IV. From the CP 80 through the CP 92 series, the check was CP 70-1133 in both Stage III and Stage IV.

Stage III was planted at four locations each year, three with organic soils and one with a sand soil. In most cases, Stage IV was planted at these same locations, on the same days as Stage III. The organic soils were Terra Ceia mucks (Euic, hyperthermic Typic Medisaprists), Pahokee mucks (Euic, hyperthermic Lithic Medisaprists), Lauderhill mucks (Euic, hyperthermic Lithic Medisaprists), and Dania mucks (Euic, hyperthermic, shallow Lithic Medisaprists). The sand soils were Malabar sands (Loamy, siliceous, hyperthermic Grossarenic Ochraqualfs) and Pompano Fine sands (Siliceous, hyperthermic Typic Psammaquents). Stage IV was planted at an additional 5 to 8 locations each year. One of these locations had Pompano Fine sand soils, and another had Torry muck soils (Euic, hyperthermic Typic Medisaprists). The Torry mucks have 30-50% organic matter rather than 70-85% organic matter which is characteristic of the organic soils at the Stage III locations. The remaining Stage IV tests were on organic soils similar to the organic soils of the Stage III locations.

Stage III plots were 4.6 m long with rows spaced 1.5 m apart. Plots were two rows wide, with a border row surrounding the Stage III experiment, but not individual plots. Each Stage III plot had a 1.5 m alley on one end and a 6 m alley on the other end. Stage III experiments were planted in randomized complete-block designs with two replications. Stage IV plots were 10.7 m long with rows spaced 1.5 m apart and 1.5 m alleys, and planted in randomized complete-block designs. From the CP 77 through the CP 88 series, plots were four rows wide with four replications per experiment. From the CP 89 through the CP 92 series, plots were two rows wide with eight replications per experiment. A border row surrounded all Stage IV experiments, and in the case of the CP 89 through the CP 92 series, a border row surrounded each Stage IV plot. Agronomic practices, such as fertilization, pesticide application, cultivation, and water control, were conducted by the landowner in whose field each experiment was planted.

Sugar yield was estimated by multiplying cane tonnage by TRS. Cane tonnage was estimated by multiplying stalk number by stalk weight in all Stage III tests and in all Stage IV tests after the CP 88 series. Stalk number was estimated by counting total millable stalks per plot during the summer. Stalk weight was estimated from a 10-stalk sample collected in October in Stage III and from October through April in Stage IV. The TRS was estimated from the juice extracted from the same 10-stalk sample. In Stage IV, from the CP 77 through the CP 88 series, cane tonnage was estimated by weighing entire plots, and TRS was estimated from 15-stalk samples. The stalk samples from which TRS and stalk weights were estimated were collected from sugarcane that was burnt in the field before it was cut and sampled for the Stage IV CP 77 through CP 88 series. All other stalk samples were of stalks not previously burnt.

RESULTS AND DISCUSSION

By the year 2000, 32 CP sugarcane cultivars were released in Florida since the CP 69 series finished its second year of testing in Stage III in 1972 (Table 1). With sugar yield used as the ranking criterion, 18 of these 32 cultivars ranked among the top four places in Stage III (Fig. 1). Eight of these 32 cultivars ranked number one in Stage III in sugar yield. Five cultivars ranked from fifth through eighth place, seven ranked from ninth through twelfth place, one ranked in fourteenth place, and one ranked below fifteenth place.

Ranking based on economic index resulted in a similar distribution as for sugar yield (Fig. 2). Seventeen genotypes ranked from first through fourth place in Stage III, five ranked fifth through eighth, seven ranked from ninth through thirteenth place, and three cultivars ranked below fifteenth in economic index in Stage III.

The only genotype from Stage III with a rank inferior to 15th that was released on the basis of sugar yield was CP 89-1509 (Tai et al., 2000) (Table 1). CP 89-1509 was released for production on sand soils only; it was not evaluated on organic soils in Stage IV due to its low yields on organic soils in Stage III. Using economic index as the selection criterion, three genotypes that ranked inferior to 15th in Stage III were released. One was CP 89-1509. Also released were CP 85-1308 (Tai et al., 1995) and CP 85-1432 (Deren et al., 1994). None of these cultivars has been used on more than 1% of Florida's sugarcane hectarage in any one year.

These 24 cycles of Stage III data show that the better the ranking for either sugar yield or economic index in Stage III, the more likelihood that the genotype would eventually be released. Twenty-eight of 31 CP cultivars released since 1979 ranked better than 15th in both sugar yield and economic index in Stage III. Only one has been released that ranked below 15th in both sugar yield and economic index, and two ranked inferior to 15th in economic index, but better than 15th in sugar yield. Of these three cultivars, one was a special release for sand soils.

Monitoring the level of commercial use after a genotype's release is a further measure of its success. We considered that a cultivar was commercially successful in Florida if it was used at least for one year on > 1% of Florida's sugarcane hectarage. With this lenient criterion, only 14 of the 32 released cultivars became commercially successful (Table 1). Eleven of these 14 cultivars ranked first through fourth in Stage III using sugar yield as the ranking criterion. The worst rank in Stage III was ninth. Using economic index as the ranking criterion gave similar results, except that one cultivar ranked 10th and one 13th in Stage III.

Five of the CP cultivars that were tested in Stage III since 1970 were used on more than 15% of the hectarage for at least one year (Table 1). The lowest ranking in Stage III for any of these "widely used" cultivars in Stage III was for CP 72-1210 (Miller et al., 1981); it ranked sixth in both Mg sugar and $ ha^{-1}. Cultivars CP 70-1133 and CP 80-1743 (Deren et al., 1991) were first in both categories, CP 72-2086 (Miller et al., 1984) second in both categories, and CP 80-1827 (Glaz et al., 1990) third in both categories in Stage III.

Most genotypes that later became commercial cultivars ranked among the top 15 in Stage III in either sugar yield or economic index. Further, the worst rank in Stage III for either sugar yield or economic index of any widely used cultivar was sixth. A conservative conclusion is that as long as there are at least 11 genotypes advanced from Stage III to Stage IV, Stage III, under its current structure, is adequate for identifying genotypes that will be widely used commercial cultivars in Florida. For the goal of identifying successful commercial cultivars (used on at least 1% of commercial hectarage for at least 1 year) for Florida, these data indicate that sufficient confidence can be placed in Stage III rankings to warrant not increasing the number of Stage IV entries beyond 11 if doing so would require advancing genotypes from Stage III that ranked worse than 15th in sugar yield and economic index.

For genotypes that are advanced from Stage III to Stage IV but not released commercially, another measurement of their success is how well they yielded in Stage IV. A benefit of identifying high-yielding genotypes in Stage IV is that they become a source of parental clones with reliable probabilities of producing commercially acceptable progeny. In general, both sugar yield and economic index as a percent of the check cultivar in Stage III were not good predictors of production in Stage IV. Correlations were significant but low (Fig. 3 and 4). This indicates that some genotypes that had poor yields in Stage III had high yields in Stage IV and vice versa. Therefore, we looked specifically at performance in Stage IV of (1) genotypes that ranked worse than 14th in sugar yield or economic index in Stage III and (2) genotypes that ranked either first or second in sugar yield in Stage III.

From the CP 77 through the CP 92 series, 40 genotypes advanced from Stage III to Stage IV ranked worse than 14th in Stage III in either sugar yield or economic index (Table 2). Twenty-seven of these genotypes ranked worse than 14th in Mg sugar ha^{-1} in Stage III. Five of these 27 proceeded to rank either first or second in sugar yield in Stage IV. Twenty-five genotypes ranked worse than 14th in economic index in Stage III. Six of these 25 ranked either first or second in economic index in Stage IV. Of these six, CP 85-1308 eventually became a commercial cultivar. Approximately 20% of the genotypes that were mediocre in Stage III were highly successful in Stage IV. Several of these genotypes probably would have been released commercially except for disease susceptibilities that manifested after they were advanced to Stage IV. Attempts were made to use all of these successful Stage IV genotypes in crosses for several years at Canal Point.

A more detailed analysis further refines the strategy of advancing genotypes from Stage III to Stage IV. The lowest ranked genotype in Stage III to later rank either first or second in Stage IV was CP 85-1308, which ranked 21st in economic index in Stage III (Table 2). However, it also ranked seventh in sugar yield in Stage III. Cultivar CP 85-1308 helps identify a characteristic of other genotypes that had poor rankings in Stage III, but then ranked either first or second in Stage IV in one of these characters. Each of these genotypes ranked better than 20th in either sugar yield or economic index in Stage III. Thus, the selection committee could choose not to advance to Stage IV any genotype that ranked below 20th in both sugar yield and economic index. However, the selection committee should be careful not to follow the above guideline when there are several genotypes with consecutive ranks and similar percentages of the check that rank below 20th in both sugar yield and economic index.

Another issue is how soon within the selection program decision makers can be reasonably certain that they have identified genotypes that will perform well commercially. In the case of the CP program, this question could be posed as: if a superior genotype is identified in Stage III, is it necessary to further evaluate it in Stage IV or could its release be immediately put on a fast track? There were 25 genotypes that ranked either first or second in sugar yield in Stage III from the CP 77 through the CP 92 series (Table 3). Of the 14 that ranked first in Stage III, two ranked first in Stage IV, and 6 became commercial cultivars. Of the 11 genotypes that ranked second in Stage III, two ranked first in Stage IV and only these two became commercial cultivars. Thus, 8 of the 25 genotypes that ranked either first or second in Stage III became commercial cultivars. However, 8 others of the 25 genotypes that ranked first or second in Stage III then ranked among the lowest 6 Stage IV genotypes in sugar ha^{-1} and \$ ha^{-1}. This shows that although Stage III successfully identified some high-yielding Stage IV genotypes, it also incorrectly predicted that an equal number would be high yielding.

There are several explanations for the poor correlations between Stage III and Stage IV yields. Stage III has smaller plots, fewer replications, and fewer locations than Stage IV. Probably of more importance, all Stage III samples for TRS were taken during the final three weeks of October. For Stage IV, TRS samples were collected from October through April, the typical Florida harvest season. Some genotypes remain low in TRS in October and through November and sometimes December, others remain low throughout the harvest season. Recently, additional TRS sampling was begun for Stage III in January and February. This new practice may help improve agreement between Stage III and Stage IV genotype performance.

Another important reason that genotype performance may not agree well between Stage III and Stage IV is that Stage III data are collected through the first-ratoon crop and Stage IV through the second-ratoon crop. Genotype CP 90-1113 serves as an example that second-ratoon yields can be markedly different from those of plant cane and first ratoon for a given genotype. In Stage III, CP 90-1113 ranked first in sugar yield and second in economic index (Table 3). In Stage IV, CP 90-1113 had high sugar yields in the plant-cane crop (Glaz et al., 1995) but ranked among the lowest in sugar yield in the second-ratoon crop (Glaz et al., 1998). Alvarez and Schueneman (1991) reported that the cost of planting is high relative to other costs in the Florida sugarcane cycle. Due to this high cost, the Canal Point program tries to release genotypes that will maintain high yields through at least three annual harvests. Therefore, it is critical to identify genotypes such as CP 90-1113 in Stage IV before they are released. However, this decline in yield does not occur with sufficient frequency among genotypes to warrant extending Stage III one more crop year.

Poor repeatability between the two selection stages can also be explained by using CP 80-1743 as an example. CP 80-1743 was the highest ranking genotype in its Stage III cycle for both sugar yield and economic index but was mediocre in Stage IV for both characters (Table 3.) From the CP 77 through the CP 88 series, yields were estimated in Stage III by counting stalks and weighing a 10-stalk sample. In Stage IV, whole plots were weighed. After the CP 88 series, yields were estimated in both stages by counting stalks and weighing stalk samples. The Stage III procedure was probably the more accurate for CP 80-1743 because its plot weights were substantially reduced in almost all Stage IV plots by severe rat damage after stalk counting would have occurred but before plots were weighed. Similar damage was not caused to other genotypes in the same Stage IV tests; and CP 80-1743 was identified as a mediocre genotype in Stage IV for sugar yield, although it was identified as a genotype with a high TRS (Glaz et al., 1985). It was only due to later work of Eiland and Miller (1992) that CP 80-1743 was released. CP 80-1743 is currently the most widely grown cultivar in Florida (Glaz, 2000), which suggests that rat damage in experimental plots does not predict similar damage in commercial fields.

Another reason that may account for differences in genotype performance between Stage III and Stage IV is that the genotypes are evaluated in each stage in different years. For Florida, Kang et al. (1987) reported significant genotype x year interaction for plant-cane sugar yields of Stage III genotypes; whereas, Brown and Glaz (2001) suggested that genotype performance across years was similar in Stage

IV. Milligan et al. (1990) reported that genotype x year effects were most important in ratoon crops in Louisiana, but not more important than genotype x location effects. Since Stage IV tests genotypes during later years than Stage III, genotype x year interaction may play a role in the differences in genotype performance noted between Stages III and IV.

This study reviewed 24 cycles of Stage III and 16 cycles of Stage IV data. During these cycles, at least 10 or 11 genotypes per year were advanced to all Stage IV locations where they were evaluated as potential commercial cultivars for Florida. The intent of the committee responsible for advancing genotypes from Stage III to Stage IV was generally to advance the genotypes with the highest rankings for sugar yield and economic index. However, due to concerns with pests and agronomic type, several lower ranking genotypes from Stage III were routinely advanced to Stage IV.

Stage III results were analyzed by comparing them to actual commercial use and to Stage IV data. One conclusion was that advancing 11 genotypes from Stage III to Stage IV was sufficient for identifying commercial cultivars that would be widely used in Florida. The data showed that it would be very unlikely to identify widely used cultivars from genotypes that ranked worse than 15th in both sugar yield and economic index in Stage III as it is currently structured.

The study of Brown and Glaz (2001) has helped improve a limiting factor in the CP program, the low number of genotypes that can be analyzed in Stage IV. To take advantage of this opportunity, we recommend improving the caliber of genotypes that are advanced to Stage III to improve the likelihood of identifying cultivars from 14 advanced genotypes to Stage IV. The most logical immediate approach to achieve this objective is to expand genotype numbers in the three selection stages prior to Stage III: Seedlings, Stage I, and Stage II. However, Tai et al. (1980) reported that sugar yield in Stage II was not an effective predictor of sugar yield in Stage III. Further, much of the percentage of increased genotypes may be lost to disease susceptibility if new diseases or races of current diseases appear. Therefore, ongoing monitoring and review would be an important component of this strategy.

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Table 1. Commercial sugarcane cultivars released in Florida that were tested in Stage III since 1970, the year each cultivar was advanced from Stage III to Stage IV, number of genotypes with which each cultivar was compared, and its rankings for sugar yield and economic index in Stage III.

Cultivar	Year advanced to Stage IV	Number of genotypes in Stage III	Rank in Stage III		Highest commercial hectarage
			Mg sugar ha^{-1}	\$ ha^{-1}	%
CP 69-1052	1972	24	1	1	<1.0
CP 70-1133	1973	21	1	1	30.7
CP 72-1210	1974	22	6	6	61.0
CP 72-2086	1976	31	2	2	18.0
CP 73-1547	1976	31	4	13	9.8
CP 74-2005	1977	35	4	4	5.8
CP 75-1082	1978	32	11	12	<1.0
CP 75-1553	1978	32	5	5	<1.0
CP 75-1632	1978	32	14	7	<1.0
CP 77-1776	1980	28	11	4	<1.0
CP 78-1247	1981	38	11	8	<1.0
CP 78-1628	1981	38	1	1	7.9
CP 78-2114	1981	38	9	10	6.1
CP 80-1743	1983	23	1	1	22.1
CP 80-1827	1983	23	3	3	18.2
CP 81-1238	1984	38	3	3	<1.0
CP 81-1254	1984	38	1	1	1.6
CP 82-1172	1985	30	5	3	<1.0
CP 84-1198†	1987	36	21	32	3.8
CP 85-1308	1988	41	7	21	<1.0
CP 85-1382	1988	41	3	10	<1.0
CP 85-1432	1988	41	6	17	<1.0
CP 85-1491	1988	41	11	4	<1.0
CP 88-1508	1991	42	3	4	1.3
CP 88-1540	1991	42	12	12	<1.0
CP 88-1762	1991	42	1	2	4.1
CP 89-1509	1992	42	29	21	<1.0
CP 89-2143	1992	42	2	1	1.2
CP 89-2377	1992	42	1	2	<1.0
CP 92-1213	1995	42	10	9	<1.0
CP 92-1640	1995	42	4	6	<1.0
CP 92-1666	1995	42	1	2	<1.0

†A note describing CP 84-1198 suggests an error in its Stage III data. Therefore, CP 84-1198 is not discussed in the text.

Table 2. Rank and % of check in Stages III and IV for sugar yield and economic index of 40 genotypes from 16 years of Stage III that ranked worse than 14th in either sugar yield or economic index in Stage III.

	Mg sugar ha^{-1}				$ ha^{-1}			
Genotype	Stage III	Stage IV	Stage III	Stage IV	Stage III	Stage IV	Stage III	Stage IV
	----Rank----		% of check		----Rank----		% of check	
CP 77-1404	17	8	99.2	95.6	9	9	117.0	78.3
CP 78-1263	17	7	103.4	114.0	17	8	108.3	115.8
CP 78-1979	12	10	111.1	99.5	19	10	107.1	89.0
CP 79-1580	15	5	115.6	84.5	13	7	129.9	76.9
CP 81-1435	8	3	101.0	94.1	19	5	97.2	95.3
CP 81-2062	5	5	103.7	90.2	33	10	79.8	81.6
CP 83-1351	17	5	90.4	84.4	12	5	89.8	81.4
CP 83-1773	13	1	93.3	100.9	15	1	85.9	93.2
CP 84-1572	18	2	79.7	91.8	16	2	76.0	86.4
CP 85-1308	7	2	97.6	109.4	21	2	84.8	117.5
CP 85-1432	6	3	98.1	104.0	17	3	90.8	113.8
CP 86-1180	25	9	85.4	79.5	14	9	93.4	80.0
CP 86-1747	15	2	90.7	98.7	25	2	85.1	93.9
CP 86-1882	19	5	88.6	89.1	7	3	96.0	91.3
CP 86-1427	7	7	97.3	88.7	15	4	93.2	89.9
CP 87-1018	16	10	89.4	76.0	8	10	90.7	60.0
CP 87-1121	19	9	89.1	92.4	13	9	87.8	80.2
CP 87-1274	15	2	89.9	107.3	10	1	89.7	104.0
CP 87-1475	8	5	99.2	102.6	21	3	81.1	103.2
CP 87-1733	21	8	84.6	96.4	24	5	79.3	99.6
CP 88-1165	13	5	95.4	99.4	16	7	94.0	95.2
CP 88-1561	15	6	93.8	98.9	11	2	101.7	107.6
CP 88-1834	14	2	94.7	103.2	27	4	87.4	105.1
CP 88-1836	17	7	93.0	96.0	14	6	95.0	97.1
CP 89-1331	20	8	96.0	94.4	9	8	103.6	99.2
CP 89-1632	34	9	84.1	88.8	27	9	90.0	91.9
CP 90-1151	3	7	103.4	93.9	16	7	81.7	96.3
CP 90-1436	14	3	86.5	105.9	17	1	81.4	110.8
CP 90-1464	19	1	82.1	106.7	18	2	80.8	110.7
CP 90-1510	23	9	80.9	83.8	9	10	90.6	82.9
CP 90-1535	24	6	80.2	97.0	5	4	97.1	104.8
CP 90-1549	29	4	74.4	101.5	27	6	68.9	98.1
CP 91-1865	12	9	92.8	87.1	20	10	87.8	85.8
CP 91-1880	16	11	89.9	85.8	14	11	93.2	84.2
CP 91-1883	30	8	83.1	87.4	19	9	89.6	85.9
CP 91-1914	20	1	87.9	101.4	15	1	93.2	107.5
CP 92-1320	15	10	91.9	90.6	13	9	87.1	89.9
CP 92-1641	24	5	84.6	98.7	20	3	80.1	106.1
CP 92-1647	27	11	81.0	78.8	24	11	76.0	79.5
CP 92-1684	18	7	90.6	94.9	16	8	85.1	91.8

Table 3. Rank and % of check from 16 years of Stages III and IV for sugar yield and economic index of 25 genotypes that ranked first or second in sugar yield in Stage III.

	Mg sugar ha^{-1}				$ ha^{-1}			
Genotype	Stage III	Stage IV	Stage III	Stage IV	Stage III	Stage IV	Stage III	Stage IV
	----Rank----		% of check		----Rank----		% of check	
CP 77-1055	2	2	113.0	117.3	5	1	134.2	117.6
CP 77-1148	1	5	129.5	99.4	1	10	193.4	77.9
CP 78-1156	2	6	127.8	114.3	2	3	153.5	118.6
CP 78-1628†	1	2	156.6	122.2	1	2	183.8	128.8
CP 79-1288	1	8	161.3	79.7	1	6	216.5	77.9
CP 79-1380	2	1	152.9	94.1	2	3	165.3	84.8
CP 80-1743†	1	7	113.3	85.1	1	6	131.8	85.8
CP 80-1827†	2	1	96.7	105.7	3	1	97.6	110.7
CP 81-1254†	1	1	109.7	104.5	1	1	126.9	119.2
CP 81-2149	2	9	108.2	85.8	10	9	104.5	83.9
CP 82-1505	2	4	104.4	94.5	5	7	102.6	90.2
CP 82-1587	1	9	109.3	78.9	1	9	102.6	78.8
CP 85-1207	1	5	114.2	99.1	2	5	118.9	102.2
CP 85-1808	2	8	104.9	84.8	1	8	120.9	92.3
CP 86-2024	1	8	122.7	83.5	1	8	136.1	85.5
CP 87-1226	1	3	110.7	105.3	11	8	88.7	90.7
CP 88-1762†	1	4	109.0	101.0	2	5	118.1	103.0
CP 88-1912	2	3	108.7	101.9	1	3	119.9	105.8
CP 89-2143†	2	1	131.9	113.9	1	1	150.9	122.1
CP 89-2377†	1	3	132.8	105.4	2	6	131.7	106.5
CP 90-1113	1	10	107.6	83.7	2	9	117.3	88.4
CP 91-1924	1	3	125.2	96.1	1	2	152.8	99.8
CP 91-2246	2	7	103.3	88.2	2	6	111.2	90.4
CP 92-1167	2	2	108.3	108.4	5	4	102.8	106.1
CP 92-1666†	1	1	119.5	111.9	2	1	113.6	112.7

†These genotypes were later released as commercial cultivars in Florida.

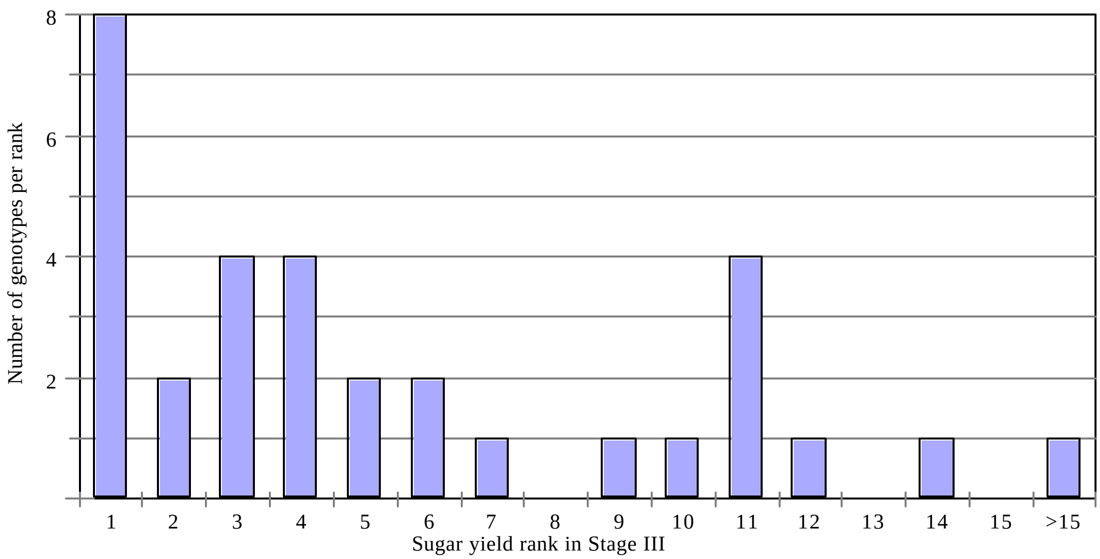
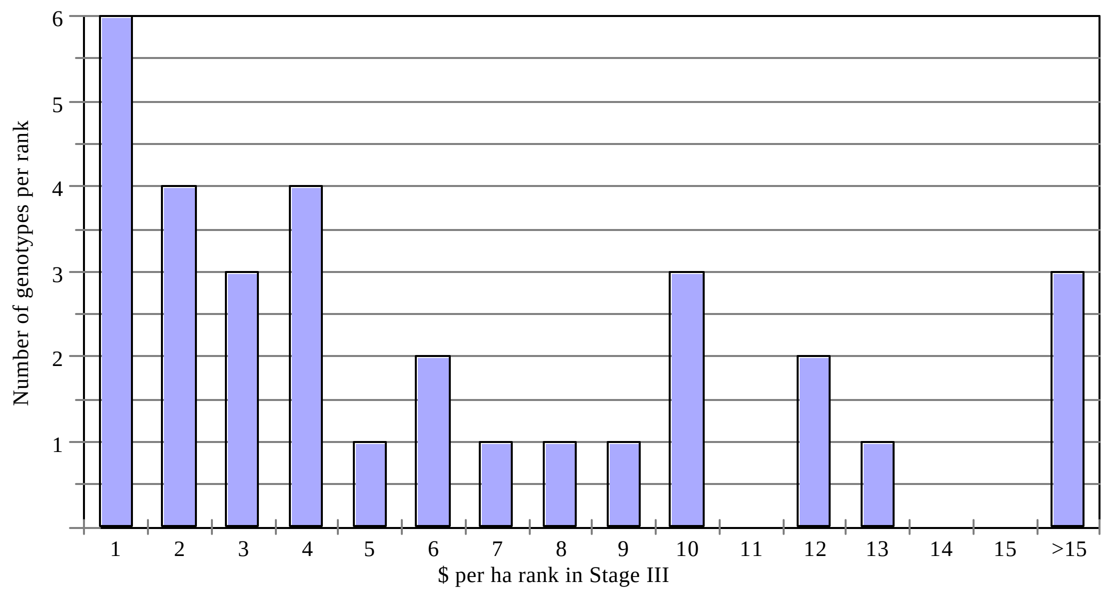


Figure 1. Rank of sugar yield (Mg sugar ha^{-1}) in Stage III and number of genotypes with the same rank for 32 sugarcane genotypes that became commercial cultivars in Florida from the CP



69 through the CP 92 series.

Figure 2. Rank of economic index ($ ha^{-1}) in Stage III and number of genotypes with the same rank for 32

sugarcane genotypes that became commercial cultivars in Florida from the

CP 69 through the CP 92 series.

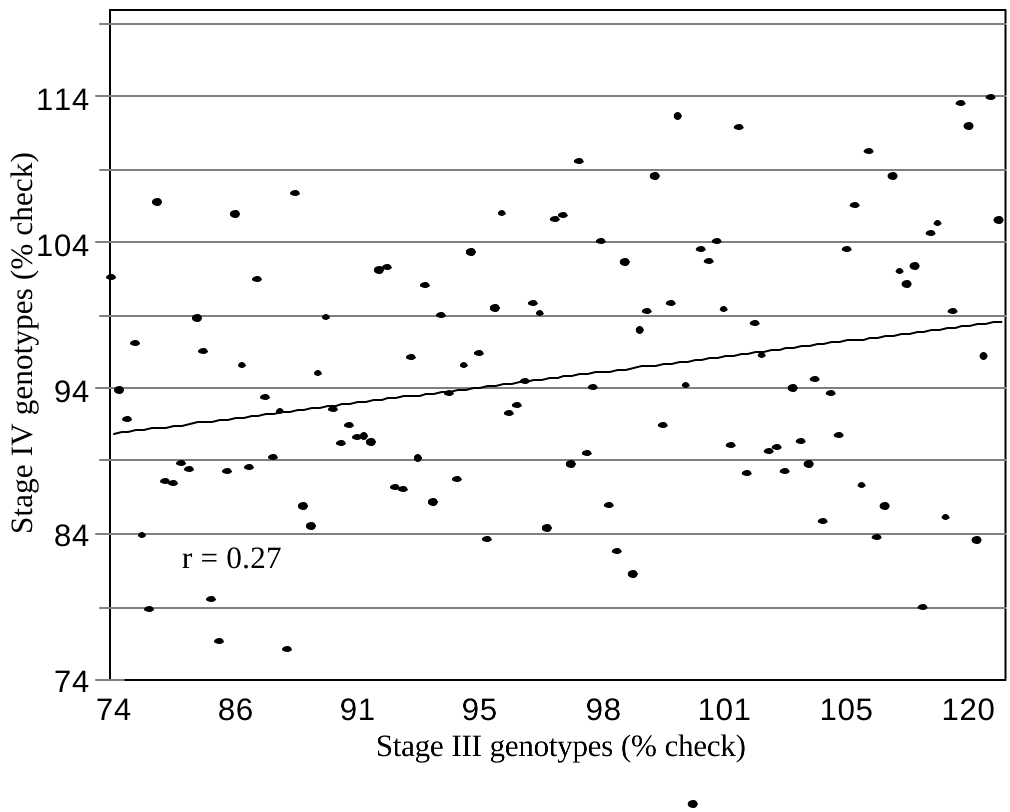


Figure 3. Correlation of sugar yield (measured as Mg sugar ha^{-1}) as percent of check cultivar in Stage III with sugar yield as percent of check cultivar in Stage IV for 117 genotypes from 16 Stage III and Stage IV cycles.

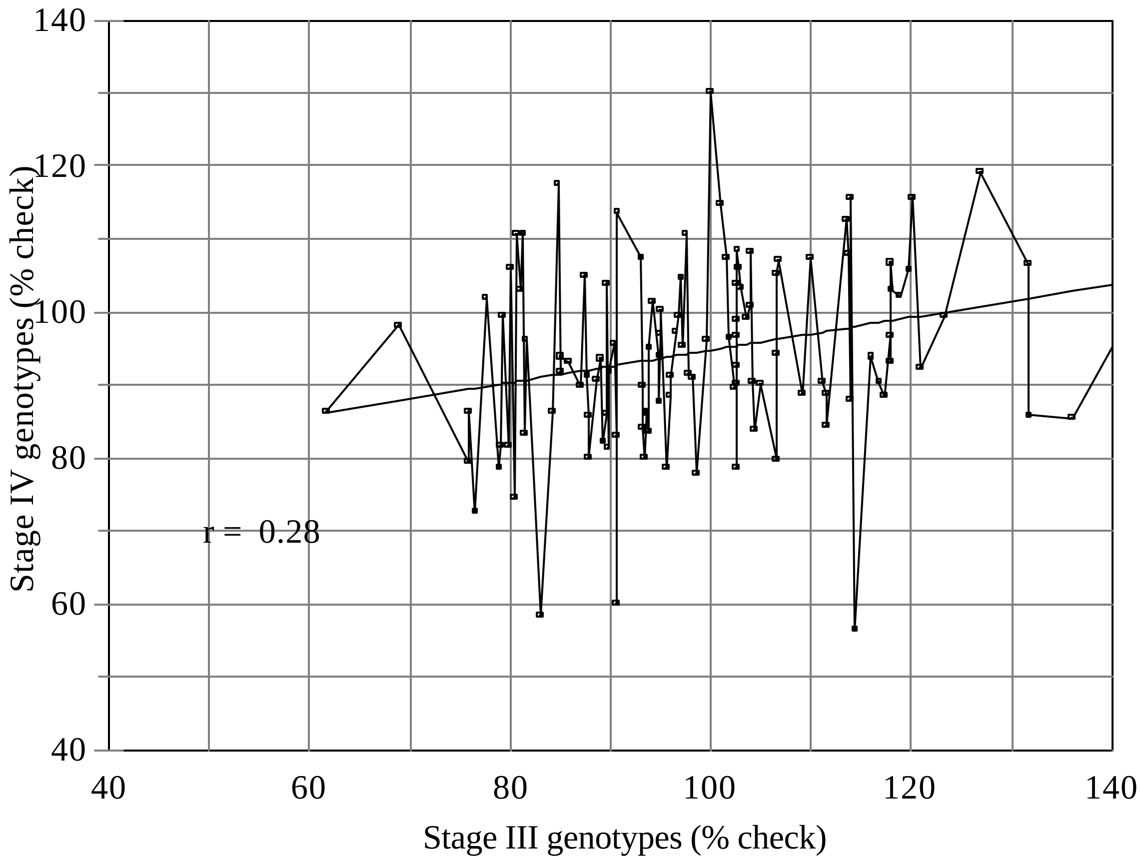


Figure 4. Correlation of economic index ($ ha^{-1}) as percent of check cultivar in Stage III with economic index as percent of check cultivar in Stage IV for 117 genotypes from 16 Stage III and Stage IV cycles.