

20 weeks under frequent irrigation. Although >50% of the K in this product was released within the first 4 weeks of our study, there was still some K released after 20 weeks of incubation. Holcomb (1981) also reported the rapid initial release of K from MagAmp, although his study was terminated after 12 weeks when this material was still releasing K.

One of the primary objectives of this study was to obtain release curves for K fertilizers for comparison to those available for controlled-release N fertilizers. However, Patel and Sharma (1977), Prasad and Woods (1971), and Allen et al., (1971) terminated their studies after 17, 14, and 16 weeks, respectively, while many of the materials were still releasing N actively. Thus the effective life of the N sources they tested cannot be determined from their data.

In summary, although soluble K fertilizers like KCL, PMS, and PCARB are leached rapidly through sand, most controlled-release K fertilizers released K over a period of about 5 months. Exceptions included OSM-A, OSM-B, and POLY, which released K very slowly over 2 to 3 years. The 5-month life of most controlled-release K products is comparable to several controlled-release N products currently marketed in the United States for fertilizer blending purposes.

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Yield and Quality Attributes of Rainfed Green Immature Corn in Trinidad

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Additional index words. two-dimensional partitioning, maize, *Zea mays*, Creole seasoning

Summary. Three local varietal types of corn (*Zea mays* L.)—an improved landrace 'ICTA Farm Corn' derived from the Tuson population, the open-pollinated 'Across 7728', and the hybrid 'Pioneer 3098'—were grown at three cash-crop farms in Trinidad, and evaluated as green corn for agronomic, quality, and chemical traits. 'Pioneer 3098' and 'ICTA Farm Corn' had similar numbers of marketable ears and marketable yield per hectare, and both were superior to 'Across 7728'. Sensory evaluations revealed that the three varieties did not differ in overall quality when boiled with Creole seasoning. When ears were not seasoned, the hybrid variety was preferred over the two open-pollinated varieties. Two-dimensional partitioning indicated that ear appearance and kernel color were the major contributors to total variation in overall quality. The importance of quality characters of green corn to local farming system priorities affects extension recommendations and breeding objectives in Trinidad.

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In Trinidad, and other islands of the Lesser Antilles, corn (*Zea mays*) is grown primarily on subsistence or mixed-subsistence and cash-crop farms of <4 ha. It generally is harvested in the green immature milk stage for human consumption as either boiled or roasted ears. Green immature corn as a subsistence or cash crop accounts for 95% of corn production in Trinidad, with dry field corn and sweet corn accounting for the remaining 5%.

In 1990, the government Chaguaramas Agricultural Development Project (CADP) began multiplying and selling an International Corn and Wheat Improvement Center (CIMMYT) open-pollinated variety, 'Across 7728'. A 1994 survey (unpublished data) of 71 corn producers in Trinidad and Tobago found that 52% used hybrid seed, 27% used local open-pollinated seed saved from a previous crop, and 20% used 'Across 7728' seed.

Most public and private research on corn production in Trinidad has focused on increasing local production of grain corn to supplant high imports of feed grains. These efforts have failed due to a number of social and economic considerations. Before the oil boom economy of the 1970s and early 1980s, most green corn in Trinidad was grown from open-pollinated seed saved by the growers. Cropper and Brathwaite (1977) reported that local open-pollinated varieties were preferred to the then recently available imported hybrids. Subsequently, the use of imported hybrid seed has increased, and now the high cost of seed purchased in foreign currency has become a substantial component of the input cost of green corn production.

Little information is available on the relative performance of the three types of varieties (local landraces, introduced open-pollinated varieties, and imported hybrids) available in Trinidad. In addition, the relative importance of various green corn quality traits has not been reported. The present study was designed to assess the contribution of several components of green corn marketable yield and to evaluate sensory attributes of green corn quality.

The sensory evaluations were undertaken to find whether and to quantify how much ear appearance and other quality traits dictate consumer preference or overall quality.

Materials and methods

Three corn varieties were evaluated: the open-pollinated 'ICTA Farm Corn' and 'Across 7728', and the hybrid 'Pioneer 3098'. 'ICTA Farm Corn' is a white-yellow mainly dent variety, developed through mass selection in the *Tuson* West Indian landrace (Gooding, 1960). It was used here to represent the type of variety used by local farmers who save open-pollinated landrace seed. 'Across 7728' is a tropical lowland yellow dent variety incorporating germplasm from Latin America and the Caribbean (CIMMYT, 1984). 'Pioneer 3098' is one of a few locally available yellow semi-dent hybrids, all commercially marketed in Trinidad as 'Pioneer Hybrid'.

The varieties were planted in three randomized complete blocks at each of three sites during the wet season of 1994. The sites were on cash-crop farms in Aranguez and Valsayn (10°38'N 61°26'W) and Sangre Grande (10°35'N 61°07'W) in

Trinidad. Soils at the Aranguez and Valsayn sites were clay loam containing 0.8% and 1.5% organic matter, with cation exchange capacities of 6.0 and 7.1 meq/100g and pH of 6.1 and 6.5, respectively. Soil at the Sangre Grande site was a silty clay loam containing 3.4% organic matter, with a cation exchange capacity of 7.3 meq/100g and pH of 4.8.

The experimental areas were disced and rotovated. Corn seeds were hand-planted in June, at the beginning of the rainy season, on cambered beds in rows spaced 75 cm apart. Each experimental unit consisted of ten 10-m rows. Two to three seeds were placed in hills spaced 50 cm apart in the rows. At the four- to five-leaf stage, 100 kg·ha⁻¹ of 50% N urea fertilizer was broadcast manually and the fields were hand-weeded. Aside from hand-weeding, no other field operations were performed until harvest.

Within each 75-m² experimental unit, one 15-m² sampling unit (4 rows × 5 m) was chosen at random from the inside rows for data collection. Ears

Table 1. Mean yield and yield component values for three varieties harvested as green corn at three environments in Trinidad.

Varieties	Marketable ear			Culls/ ha (1000)	Marketable	
	Length (mm)	Diam (mm)	Wt (g)		Yield (Mg·ha ⁻¹)	Ears/ha (1000)
Across 7728	153	43	146	8.7	2.50	17.6
ICTA Farm Corn	163	44	155	11.4	3.84	26.0
Pioneer 3098	158	47	178	6.5	4.62	26.4
Variety F test	NS	**	**	*	**	*
LSD (<i>P</i> ≤ 0.05)		2	18	3.6	1.00	6.8

NS, **, * Nonsignificant or significant at *P* = 0.05 or 0.01, respectively.

Table 2. Means of sensory attributes for three green corn varieties grown at three environments in Trinidad.^z

Variety	Ear appearance	Kernel color	Texture	Sweetness	Flavor	Overall quality
Nonseasoned						
Across 7728	6.0	5.7	6.3	6.1	6.1	6.1
ICTA Farm Corn	5.3	4.6	6.5	5.1	5.2	5.4
Pioneer 3098	8.2	7.9	7.2	6.6	6.6	7.8
Variety F test	**	**	NS	*	*	**
LSD (<i>P</i> = 0.05)	1.4	1.1		1.0	1.1	1.1
Seasoned						
Across 7728	5.9	7.8	6.8	6.6	6.6	7.3
ICTA Farm Corn	5.0	5.4	6.6	6.6	6.2	6.2
Pioneer 3098	8.1	7.3	5.9	6.6	6.6	6.8
Variety F test	**	**	NS	NS	NS	NS
LSD (<i>P</i> = 0.05)	1.3	1.2				

^zTerms anchoring the line scales were (0–10) poor-excellent (ear appearance, colour, flavor, overall quality); too hard-good (texture); not sweet-sweet.

NS, **, * Nonsignificant or significant at *P* = 0.05 or 0.01, respectively.

Table 3. Two-dimensional partitioning of the total sum of squares of overall quality (%) for nonseasoned boiled ears of green corn in Trinidad.

Source	df	Variable							Dependent Overall quality
		Independent							
		Ear appearance	Kernel color	Texture	Sweetness	Flavor	Residual	XX ²	
Environment (E)	1	0	0	0	0	0	0	-1	0
Judges/E	16	3	10	3	2*	3*	6	6	34
Varieties (V)	2	5**	5*	0	0	0	1	14	25**
E × V	2	0	2	0	0	0	0	1	4
Error	32	9	24	7	2	3	13	-20	37
Total	53	18**	41**	10*	4	5	21**	0	100

²XX = compensation (product terms).

***Significant at $P = 0.05$ or 0.01 , respectively. Significance in the columns refers to analysis of variance and in the total rows to regression analysis. A value of zero results from rounding 0.01 to 0.49 downward to zero.

were hand-harvested at the silk-browning stage when green corn is commonly harvested. Marketable fresh-weight yield and number of marketable ears were recorded for each plot. Marketable ears were considered to be those >10 cm in length, with >80% seed set, and no visible disease or insect damage. The average of a subsample of 10 randomly chosen marketable ears from each plot was measured for ear length, diameter at the base of the ear, and fresh weight. Ear moisture content at harvest was determined from the fresh and dry weights of an additional five randomly chosen marketable ears per plot.

At the Aranguez and Sangre Grande sites, representative marketable ears of the three varieties were harvested from buffer areas and immediately stored, without removing husks, at 10C. Qualitative descriptive analysis was used for sensory evaluation (Shamaila et al., 1992), using nine trained judges, on the day following harvest. The blind sensory evaluation panel included judges chosen to approximate the demographic makeup of Trinidad. On each evaluation date, randomly chosen samples of 70 to 90 marketable whole ears were dehusked. Subsamples of 30 whole ears were frozen in plastic bags at -7C. Of the remaining ears, half was used for evaluation of ear appearance (from poor to excellent) and the other half was cut into 5-cm segments, discarding the tip and butt. The 5-cm segments were boiled in water for 15 min, with or without seasoning. The Creole seasoning was a blend of salt, garlic, celery, green onion, shadow beni (*Eryngium foetidum* L.), and Scotch Bonnet hot pepper (*Capsicum frutescens* L.). Nonseasoned segments were evalu-

ated first, followed by seasoned segments, for kernel color, flavor, overall quality, sweetness, and texture. Individually, judges used a 10-cm unstructured horizontal line scale for each parameter. Each line was anchored at the ends with the words poor and excellent for ear appearance, color, flavor and overall quality, with too hard and good for texture and not sweet and sweet for sweetness. To indicate the intensity of each attribute, the panelists made a vertical mark on the scale. Quantification of the results was obtained by measuring the distance from zero to the vertical line.

Three to four weeks after harvest, a 5-g sample of grain was removed from each of the frozen ears and analyzed for reducing and total sugar as described by Miller (1959). Data were analyzed by analysis of variance of a completely random design.

Agronomic and sensory data were analyzed by analysis of variance with variety means separated by Fisher's (protected) LSD (Steel and Torrie, 1980). The contributions of several quality attributes to overall quality were assessed by two-dimensional partitioning (TDP) of the total variation in the overall quality assessment (Eaton et al., 1986).

Results and discussion

Environment × variety interactions were not significant for yield and yield components and, thus, combined environment analyses are presented. 'Pioneer 3098' and 'ICTA Farm Corn' had similar numbers of marketable ears per hectare and marketable yield, which were higher than 'Across 7728' (Table 1). 'ICTA Farm Corn' had the most culls and 'Pioneer 3098' having the widest and heaviest ears. There were

no differences for marketable ear length. Pollak (1993) reported relatively high yields for landrace corn germplasm during the large-scale screening of the Latin American Maize Project in Puerto Rico. Germplasm from Trinidad and Tobago generally did not perform well in that study. This may have been because it is better suited to more southern locations. In our study, 'ICTA Farm Corn' performed well. It could be useful as an alternative to 'Across 7728' for green corn production in Trinidad.

In the sensory evaluation, the preference was for the large, wide ear shape and yellow kernel color of 'Pioneer 3098'. There was a significant ($P < 0.01$) interaction between variety and seasoning effects on overall quality. For the nonseasoned treatment, the preference was for 'Pioneer 3098' and 'Across 7728' for sweetness and flavor (Table 2). 'Pioneer 3098' was preferred over 'ICTA Farm Corn' and 'Across 7728' for overall quality. No differences could be discerned for texture.

Ear appearance (18%), kernel color (41%), and texture (10%) accounted for 69% of the total variation in overall quality evaluations of the varieties when unseasoned (Table 3). Unexplained residual contributed 21% to the total sum of squares. There were significant varietal effects on overall quality, ear appearance, and kernel color for the nonseasoned treatments.

For texture, sweetness, flavor, and overall quality, no differences were found among the three varieties when seasoned (Table 2). The judges were the main source of variation (49%) for overall quality. Lack of agreement among judges is not unusual and has been attributed to inconsistent use of

the sensory terms or use of different levels of the rating scale (Shamaila et al., 1992). Ear appearance (20%) and kernel color (41%), again accounted for most of the variation in overall quality (data not shown).

Reducing sugar kernel content ranged from 1.3% to 1.7%, total sugar kernel content from 2.5% to 2.8%, and ear moisture at harvest from 68.2% to 70.5%. The three varieties did not differ for these traits.

Conclusions

There has been little evaluation of the three main corn varietal types in Trinidad. In previous studies, the main criterion for performance has been grain yield determined from small-plot on-station trials (Spaner et al., 1995). Extension recommendations generally reflect a bias toward imported hybrid material, although the advantages of hybrid varieties may not be as apparent under the local nonmechanized green corn farming system as under a mechanized grain production system. Our results point towards different recommendations depending on farming system and could be incorporated into breeding strategies for corn in the region. Cash-crop farmers must consider yield and market acceptance of green ears. Although the yield of marketable ears per hectare of the landrace open-pollinated variety was similar to that of the hybrid, the current consumer preference for the ear type of the hybrid would make it difficult for cash-crop farmers to return to open-pollinated varieties. Given the high cost of hybrid seed and the good performance of the open-pollinated landrace variety used here, subsistence farmers might be better served using local open-pollinated saved seed. All

green corn growers would benefit if local plant breeding could incorporate consumer preferences for green corn into breeding strategies to develop locally adapted open-pollinated varieties with the large ears and yellow kernel color currently found only in hybrids.

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Forcing Treatment and Rootstock Affect Budbreak and Growth of Containerized Citrus Nursery Trees

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Additional index words. budding, grafting, propagation

Summary. Two experiments were conducted to determine the effects of rootstock and bud-forcing treatment on scion budbreak and nursery tree growth of 'Hamlin' orange. In Expt. 1, 'Carrizo' citrange, 'Swingle' citrumelo, and 'Cleopatra' mandarin were budded with 'Hamlin' orange and forced by one of the following methods: cutting off (pruning away the rootstock top about 2 cm above the inserted scion bud); lopping (cutting half to two-thirds of the way through the rootstock stem 2 cm above the bud union, and breaking over the stem but leaving it attached); or bending (bending the rootstock shoot above the inserted scion bud and tying it to the base of the plant). For 'Swingle' only, percent budbreak was less for bending or lopping compared to cutting off. For 'Carrizo' and 'Swingle', scion dry weights were less when plants were forced by cutting off compared to bending or lopping. For all rootstocks, whole-plant dry weights were greater for plants forced by bending and lopping than for plants forced by cutting off. In Expt. 2, scion buds on 'Swingle' and 'Cleopatra' plants were forced by the three methods in Expt. 1 plus combinations of bending with notching (making an inverted V incision through the bark and into the wood on the rootstock stem directly

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