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Management Practices for Carnival-season Production of Immature Field Corn in Trinidad and Tobago

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Abstract. **Immature field corn (*Zea mays* L.) grown for pre-lenten carnival festivities in Trinidad and Tobago can be a profitable cash crop. Hybrid and local unimproved open-pollinated corn were grown with two levels of weed control and fertilizer application late in the rainy season at two locations each on Trinidad and on Tobago. The Trinidad locations were situated on more productive agricultural land than those on Tobago. The hybrid 'Pioneer 3098' yielded more edible corn than the local variety at all locations and at all treatment levels. Manual weed removal at the four- to five-leaf stage was sufficient to allow corn to out-compete the weed canopy, and an additional field operation would not be justifiable. On Tobago, the application of fertilizer just before tasselling, in addition to an earlier application of urea, increased the number and yield of edible ears. Few boiling-quality, marketable ears were produced on Tobago. On Trinidad, the additional fertilizer did not alter yield. For commercial carnival-season production of immature field corn on productive soils in Trinidad, the purchase of imported hybrid seed is economically justifiable, but high inputs into weed control and fertility management may not be needed.**

In Trinidad and Tobago most field corn is grown for harvest in the immature milk stage for human consumption as either boiled or roasted ears, or in soup preparations. Sweet corn is rarely grown, due to rapid postharvest quality degradation and limited consumer acceptance. The rainy season on these islands lasts ≈8 months, and generally occurs between June and December. The main planting time for corn is at the onset of the rainy season. Some corn is also planted late in the rainy season, in October and November. Immature field corn is then harvested for traditional pre-lenten carnival festivities during the dry season. From Christmas to Ash Wednesday, various popular gatherings mark the carnival season. Boiled and roasted corn, and corn-based soups, are traditional fare at such gatherings. During this time, corn can be a highly profitable cash crop: sold in the central market at U.S.$ 0.13 to 0.21 per ear, or marketed as a boiled or roasted snack food at U.S.$ 0.67 to 0.83 per ear (1996 prices).

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Most corn in Trinidad and Tobago is grown on small landholdings of less than 2 ha. Two main cropping systems are employed for corn production. Roughly one-half of all growers intercrop corn, mainly with pigeon pea [*Cajanus cajan* (L.) Huth]. Such growers generally produce corn on a subsistence level, using minimal inputs. Most growers producing immature field corn for commercial sale use monocropping. They use manual weeding, normally at the four- to five-leaf stage. At the same time, they usually apply locally-produced urea fertilizer, and hoe soil over the fertilizer towards the base of the corn plants (moulding). Many growers make a further application of fertilizer, locally known as "bearing salt" (e.g., 12N–12P–17K–1.2Mg or 13N–13P–20K mixes), sometime between 40 days after planting and tassel emergence. About half of commercial corn growers also use herbicide, normally 1,1"-dimethyl-4,4"-bipyridium ion (paraquat) applied between corn rows or along drainage ditches at the side of cambered beds. The majority of monocrop corn producers use imported hybrid seed, but some use open-pollinated seed saved from a previous growing season or purchased from a government agency. Generally only one or two imported hybrid varieties are available in a given year. 'Pioneer 3098' was sold at commercial outlets during the year of this study. During the last 5 years, 'Pioneer 3078' and 'Pioneer X304' have also been available at various times.

The relative importance of weed control, fertility management, and varietal choice to corn production can be specific to climate and soil conditions, cropping systems, and the cultural and economic realities of a given region (Tripp, 1992). CIMMYT (1994) reported that hybrids yielded an average of 56% more grain than local corn when grown under low-input conditions over 212 locations in Africa. Ahn (1993), however, indicated that proper choice of planting time and weed management was more important than the use of hybrids or fertilizer application for raising corn yields in east Africa. Increasing corn production on small landholdings may also involve the complex interaction of diverse management and varietal options. Following a process of on-farm adaptive research in Indonesia, scientists recommended the use of improved varieties, chemical pest management, lower seeding rate, and increased phosphate application as an alternative and improved management strategy for small-scale farmers (Tripp, 1992).

Corn production for harvest during the carnival season in Trinidad and Tobago requires that the crop be planted late in the rainy season and that it grow during the dry season. Such corn is not subject to as much weed competition as earlier plantings. For corn planted early in the rainy season (June) on Trinidad, Brathwaite (1979) reported that chemical weed control increased the yield of marketable immature ears. For corn planted at the end of the rainy season on Trinidad, Bridgemohan and Brathwaite (1989) reported that chemical weed control did not increase grain yield. These studies used clean-weeded controls, but neither of them assessed the commonly employed weed management practice of a single moulding operation. The herbicides used were not those generally used by small-scale growers.

Baynes (1972) compared recently available Caribbean hybrids with local open-pollinated corn on four islands of the Lesser Antilles, and concluded that maximum grain yields were only attainable with the hybrids. However, Spaner et al. (1996) reported similar numbers of marketable ears from a hybrid and an improved local landrace variety grown under relatively low input conditions following plantings early in the rainy season on Trinidad.

In research conducted on Trinidad, Dalal (1986) found that, in the absence of lime, hybrid grain yield increased linearly for urea N applications of 0, 50, 100, and 200 $kg \cdot ha^{-1}$ at planting. Small-scale growers generally apply urea by hand and prefer to increase N supplements by returning for additional field operations. This lessens the potential for fertilizer loss through leaching during heavy tropical rains.

Information on immature field corn production in the Lesser Antilles is limited, even though this is the most common use for corn in the region. The present study was designed to assess which commonly employed weed management, varietal, and fertilization options would lead to higher corn yields for carnival-season production in Trinidad and Tobago.

Materials and Methods

Corn was planted late in the rainy season (November) at four locations in 1995. Two locations were on commercial farm lands near Valsayn, Trinidad (10° 38'N 61° 26'W), and two on market gardens near Buccoo, Tobago (11° 11'N 60° 53'W). Soils on Trinidad were River Estate loams (fine loamy, micaceous, isohyperthermic Fluventric Eutropepts) and considered Class I agricultural lands, while those on Tobago were Milford clays (fine, montmovillomitic, non-acid, isohyperthermic Udorthentic Chromusterts) and considered Class III agricultural lands. Rainfall (November–February) near the Tobago locations was 308 mm, 98 mm of which fell after 1 Jan. Rainfall (November–February) near the Trinidad locations was 291 mm, 67 mm of which fell after 1 Jan. Mean monthly maxima and minima varied little, averaging 32 and 22 °C, respectively, on both islands.

Experimental areas on Trinidad were disc-plowed and rotovated immediately before planting. Experimental areas on Tobago had been disc-plowed earlier in the rainy season and were brush-cut by hand immediately before planting. Corn seeds were hand planted in rows spaced 75 cm apart. Three to four seeds were placed in hills spaced 50 cm apart in the rows. Seedlings were later thinned to no more than three per hill. At the four- to five-leaf stage, urea fertilizer (50% N) was manually broadcast onto all treatments at 150–170 $kg \cdot ha^{-1}$. At this time, all plots were weeded manually with hoes, scraping soil around the base of the corn plants, to cover the fertilizer. On Trinidad, insect pests were controlled by applications of 0,0-diethyl 0-[2-isopropyl-6-methyl-4-pyrimidinyl]-phosphorothioate (diazinon), as needed. No insecticide was used on Tobago.

The experiment was a split-split plot with the main plots arranged in randomized complete blocks. There were four blocks on Trinidad and two on Tobago. Weed control was assigned to main plots, variety to subplots, and fertilizer to sub-subplots. Each subsubplot consisted of three 7.5-m rows, with the two outside rows employed as borders. Treatments were as follows:

A. Weed control (W)

W_1 = Manual moulding operations (weeding with hoes, scraping soil around the base of the corn plants) performed once at the four- to five-leaf stage.

W_2 = Moulding plus one additional weed removal operation, 35 to 40 days after planting. On Trinidad, the second weeding was inter-row back-pack spraying of paraquat. On Tobago, the second weeding was manual hoeing.

B. Variety (V)

V_{Hybrid} = 'Pioneer 3098'.

V_{Local} = Local unimproved open-pollinated corn.

C. Fertilization (F)

F_{Low} = Urea applied manually at moulding (N at 75–85 $kg \cdot ha^{-1}$).

F_{High} = Urea applied manually at moulding (N at 75–85 $kg \cdot ha^{-1}$) and 12N–12P–17K–1.2Mg (150–170 $kg \cdot ha^{-1}$) broadcast manually just before tasselling.

Data were recorded for days to 50% silking (50% of plants in plot having 1 cm or more of exposed silk) for each weed treatment by variety combination. At immature corn harvest, two quadrats of 900 cm^2 were randomly placed within each main plot. Above-ground weed biomass was harvested from these quadrats. Fresh and, later, oven-dry mass of above-ground weed biomass were recorded. Plant height (soil level to node of the uppermost leaf) was recorded just before ear harvest. Ears were hand-harvested at the "silk-browning" stage when immature field corn is commonly harvested. Fresh-mass yield and the number of edible ears were recorded for each plot. Edible ears were considered to be those longer than 50 mm, with more than 90% seed set, and no visible disease or insect damage. Marketable boiling-quality ears were considered to be those longer than 120 mm, weighing more than 125 g fresh, with more than 90% seed set, and no visible disease or insect damage. The average of a subsample of five randomly chosen edible ears from each plot was measured for ear length and for width at the base of the ear. Analysis of variance was conducted with locations, weed control, variety and fertilization considered as fixed factors (Steel and Torrie, 1980).

Results

Data were analyzed separately by location (data not shown) and then combined by island (Trinidad or Tobago). By harvest, an additional weed control operation had reduced above-ground dry weed biomass 62% on Trinidad and 82% on Tobago (Table 1). Weed control treatments did not alter the planting to silking interval on either Trinidad or Tobago, nor plant height on Trinidad (Table 1). Location × W interaction was significant for plant height on Tobago. Plant height rank reversal for the two treatments occurred over the two locations (W_1 at L_3 124 cm, W_2 at L_3 111 cm; W_1 at L_4 175 cm, W_2 at L_4 196 cm). Differences between weed control treatments were not significant at either location, however, when analyzed separately. Varieties differed for days to silking and plant height on both islands, and interactions were not significant (Table 1). Local corn was taller and took ≈1 week longer to reach 50% silking than the hybrid.

Soil moisture was not limiting for either Trinidad trial, and yields were quite high for local conditions. Yields of 15,600 and 24,200 boiling-quality ears/ha (Table 2) would be very profitable during the carnival season. Growers on the more productive agricultural lands in northern Trinidad have average total production costs of approximately U.S.$ 600/ha (unpublished survey). Given U.S.$ 0.13 as a low estimate of marketable ear price, net profits at the two locations would have been between U.S.$1400 and 2550/ha.

On Trinidad, weed management did not affect yield traits (Table 2). Varieties differed for all measured yield traits, and interactions were not significant. The hybrid yielded more edible ear mass, and more edible and boiling-quality marketable ears, than the local variety. The local corn had longer edible ears, while hybrid ears were wider. Fertilization treatments did not alter edible and marketable ear count/ha. Location × V × F interaction was

Table 1. Analysis of variance and main effects of variety and weed control on above-ground dry weed biomass, days to 50% corn silking, and plant height for corn in Trinidad and Tobago.

	Plant characteristics					
	Trinidad			Tobago		
	Weed	Corn		Weed	Corn	
Treatment	dry biomass ($g \cdot m^{-2}$)	Days to silking	Plant ht (cm)	dry biomass ($g \cdot m^{-2}$)	Days to silking	Plant ht (cm)
W_1[z]	693	62	231	103	70	---[y]
W_2	262	63	228	19	70	---
Weed (W) F test	*	NS	NS	*	NS	NS
Location (L) × W	NS	NS	NS	NS	NS	*
V_{Hybrid}		59	197		66	140
V_{Local}		66	261		74	163
Variety (V) F test[x]		*	*		*	*

[z]W_1 = one weeding operation at the 4–5 leaf stage; W_2 = W_1 + one additional weeding operation before flowering. V_{Hybrid} = 'Pioneer 3098'; V_{Local} = Local unimproved open-pollinated corn.

[y]Main effect treatment means are not presented where interactions were significant ($P < 0.05$).

[x]W × V, L × V, and L × W × V interactions were all nonsignificant ($P \geq 0.05$).

[NS,*]Nonsignificant ($P \geq 0.05$) and significant ($P < 0.05$), respectively.

significant for edible yield (Table 2). Fertilization main and interaction effects were not significant at L_1 for edible yield. At L_2, V × F and V × W × F interactions were significant, making interpretation of the effect of fertilization treatments on edible yield at this location difficult. Three- and four-way fertility treatment interactions were also significant for the secondary yield traits of ear length and width (Table 2).

On Tobago, soil moisture was limiting at L_3, and yields at both locations were low to average for local conditions (Table 3). Very few boiling-quality marketable ears were produced at either location, and this variable is not presented. The Tobago locations differed for edible ear mass and number, and ear width (Table 3). Location 4 produced higher yields than L_3. Moisture limitation at flowering at L_3 contributed to many barren plants, especially for the local corn.

On Tobago, as on Trinidad, weed management treatments did not alter yield traits, and interactions were not significant (Table 3). Varieties differed for edible ear count and ear width, but not for ear length. The hybrid yielded more and wider edible ears than the local corn. Location × V interaction was significant for edible yield. The hybrid yielded more than the local corn at both locations (V_{Hybrid} at L_3 1.50 $Mg·ha^{-1}$, V_{Local} at L_3 1.00 $Mg·ha^{-1}$; V_{Hybrid} at L_4 4.72 $Mg·ha^{-1}$, V_{Local} at L_4 3.17 $Mg·ha^{-1}$). Variety effects were significant at L_4, but not at L_3 (P = 0.08). Fertilization treatments altered edible ear count, with F_{High} resulting in higher yields than F_{Low}. Location × V × F interaction was significant for edible yield. Fertilization main and interaction effects were not significant at L_4 for edible yield. At L_3, V × F interaction was significant, with the hybrid showing greater response to increased fertilization than the local corn (V_{Hybrid} at W_1 1.14 $Mg·ha^{-1}$, V_{Hybrid} at W_2 1.86 $Mg·ha^{-1}$; V_{Local} at W_1 0.97 $Mg·ha^{-1}$, V_{Local} at W_2 1.02 $Mg·ha^{-1}$). Location × V × W × F interactions were significant for ear length, making interpretation of the effect of fertility management on this trait difficult.

Discussion

There were no differences between the two weed management treatments for edible ear mass, nor for numbers of either edible or boiling quality marketable ears, on either Trinidad or Tobago. The moulding weed removal operation provides competitive advantage to the growing corn plants during the first 5 weeks of plant growth, the critical period for weed control in corn (Neito et al., 1968). Moulding soil and fertilizer towards the growing corn plants, and thus away from weeds, provides further competitive advantage to the corn crop. During the rainy season, weeds can be quite prolific due to unlimited moisture and ideal temperatures. For corn planted and harvested during the rainy season, weeds can provide enough competition to diminish economic yield (Brathwaite, 1979), even after early season weeding. Following late rainy season planting, moisture becomes limiting with the onset of the dry season, and the corn crop and weeds generally rely on residual soil moisture. Our results suggest that, for carnival-season corn production, weed removal at moulding is sufficient to allow corn to outcompete weeds. One manual weeding operation can take between 7 and 14 days labor per hectare, while one chemical weeding operation may cost 5% to 10% of total production costs (unpublished survey). Limiting weed control operations to a single moulding operation would allow the small-scale grower to concentrate on other farming activities, or save on economic inputs.

The hybrid yielded more immature corn ears than the local unimproved variety for all location, weed, and fertilizer treatment combinations. Pioneer hybrids imported to Trinidad and Tobago are generally shorter and earlier flowering than local varieties. They are also high yielding for grain and immature field corn (Spaner et al., 1995, 1996). On Trinidad, they have become the corn of preference for local consumers (Spaner et al., 1996). Local corn varieties, though capable of high yields following planting early in the rainy season (Spaner et al., 1996), are evidently not suited for production systems that require late rainy season planting, possibly due to the longer interval between planting and flowering of local corn. Moisture normally becomes limiting by January, and this limitation can adversely affect pollination and grain-fill of later maturing genotypes. This situation evidently prevailed for at least one Tobago location, where the local corn produced many barren ears. Hybrid seed costs the local grower, on average, U.S.$ 80/ha, or 16% of total average production costs (unpublished survey). Local corn seed is essentially a free commodity. For commercial carnival-season production of immature field corn, however, our results suggest that the purchase of more expensive imported hybrid seed would be profitable.

The additional application of fertilizer following moulding did not increase edible or

Table 2. Analysis of variance and main effects of location, weed management, variety, and fertilization on yield and yield components of immature field corn on Trinidad.

Independent variable	Edible[z] yield ($Mg·ha^{-1}$)	Edible ear characteristics: Count ($10^3·ha^{-1}$)	Length (mm)	Width (mm)	Marketable[z] count ($10^3·ha^{-1}$)
Location 1	8.93	52.0	143	36	24.2
Location 2	7.39	49.9	130	34	15.6
Location (L) F test	*	NS	*	*	*
W_1	8.17	51.4	135	35	18.8
W_2	8.15	50.5	138	35	21.0
Weed management (W) F test	NS	NS	NS	NS	NS
L × W	NS	NS	NS	NS	NS
Pioneer 3098	10.12	61.1	130	36	24.6
Local unimproved corn	6.20	40.8	143	34	15.2
Variety (V) F test	*	*	*	*	*
W × V	NS	NS	NS	NS	NS
L × V	NS	NS	NS	NS	NS
L × W × V	NS	NS	NS	NS	NS
F_{Low}	---[x]	50.5	---	---	20.4
F_{High}	---	51.4	---	---	19.4
Fertilization (F) F test	NS	NS	NS	NS	NS
W × F[w]	NS	NS	*	NS	NS
L × V × F	*	NS	NS	NS	NS
V × W × F	NS	NS	*	*	NS
L × V × W × F	NS	NS	*	NS	NS

[z]An edible ear is longer than 50 mm, while a marketable boiling quality ear is longer than 120 mm and weighs more than 125 g. Both have more than 90% seed set and no visible disease or insect damage.
[y]W_1 = one weeding operation at the 4–5 leaf stage; W_2 = W_1 + one additional weeding operation before flowering. F_{Low} = Urea fertilizer applied with first weeding; F_{High} = F_{Low} + 12N–12P–17K–1.2Mg applied at tassel emergence.
[x]Main effect treatment means are not presented where interactions were significant ($P < 0.05$).
[w]V × F, L × F, and L × W × F interactions were all nonsignificant ($P \geq 0.05$).
[NS,*]Nonsignificant ($P \geq 0.05$) or significant ($P < 0.05$), respectively.

Table 3. Analysis of variance and main effects of location, weed management, variety, and fertilization on edible yield and yield components of immature field corn on Tobago.

Independent variable	Edible[z] yield ($Mg \cdot ha^{-1}$)	Ear characteristic Count ($10^3 \cdot ha^{-1}$)	Length (mm)	Width (mm)
Location 3	1.24	21.8	82	33
Location 4	3.95	50.6	92	35
Location (L) F test	*	*	NS	*
W_1[y]	2.41	36.0	86	34
W_2	2.78	36.4	88	34
Weed Management (W) F test	NS	NS	NS	NS
L × W	NS	NS	NS	NS
Pioneer 3098	---[x]	43.5	85	35
Local unimproved corn	---	28.9	89	33
Variety (V) F test	*	*	NS	*
W × V	NS	NS	NS	NS
L × V	*	NS	NS	NS
L × W × V	NS	NS	NS	NS
F_{Low}	---	33.4	---	34
F_{High}	---	39.0	---	34
Fertilization (F) F test	*	*	NS	NS
L × V × F[w]	*	NS	NS	NS
L × V × W × F	NS	NS	*	NS

[z]An edible ear is longer than 50 mm, with more than 90% seed set, and no visible disease or insect damage.
[y]W_1 = one weeding operation at the 4–5 leaf stage; $W_2 = W_1$ + one additional weeding operation before flowering.
F_{Low} = Urea fertilizer applied with first weeding; $F_{High} = F_{Low}$ + 12N–12P–17K–1.2Mg applied at tassel emergence.
[x]Main effect treatment means are not presented where interactions were significant ($P < 0.05$).
[w]W × F, V × F, L × F, L × W × F, V × W × F interactions were all nonsignificant ($P \geq 0.05$).
[NS,*]Nonsignificant ($P \geq 0.05$) and significant ($P < 0.05$), respectively.

marketable ear counts at the two productive locations on Trinidad. On the less productive clay soils on Tobago, the application of 12N–12P–17K–1.2Mg broadcast manually just before tasselling did increase edible corn mass and ear count/hectare. However, these locations did not produce enough boiling-quality marketable ears to make this treatment economically viable. Dalal (1986) reported a linear response of grain yield to N up to 200 $kg \cdot ha^{-1}$ on acidic soils on Trinidad. Fertilizer is the most expensive economic input after land preparation for maize growers on small landholdings in Trinidad and Tobago, representing ≈20% of production costs. Though increased fertilizer application on less productive soils in the region may increase yield, it remains unproven whether this would be economical for the small-scale grower.

Our results indicate that for commercial carnival-season production of immature field corn on productive soils on Trinidad, the purchase of imported hybrid seed is economically justifiable, but high inputs into weed control and fertility management may not be needed. On less productive soils on Tobago, marketable yields were so low that neither hybrid seed nor high-input management were justifiable.

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