Using Full-sib Recurrent Selection in a Tropical Open Pollinated Corn Population for Cultivar Use in Sustainable Agricultural Systems

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ABSTRACT

Synthetic varieties of corn (Zea mays L.) may be better buffered against environmental stresses in sustainable agricultural systems than cultivars with a narrow genetic base. A full-sib (FS) recurrent selection (RS) program was started at the University of Florida using a tropical open pollinated corn population. The goal was to develop a synthetic with a broad genetic base suitable for growing during the fall in north-central Florida under conservation practices. Full-sib crosses were made in the spring of 1987. Then, in August a progeny test was planted in a randomized complete block design with six replications. Collected data included; ear, husk, and grain weight, insect damage (ID), whole plant yield (WY), seed and leaf N percent, and plant height. Analyses included ANOVA, correlations (r), heritabilities, and frequency distribution. There were differences among FS families for most of the traits. Ear weight (EW) was highly positively correlated with yield and plant height traits. Ear weight was negatively correlated with ID and positively correlated with leaf N percent. Tip ID was negatively correlated with husk weight. Heritability varied for all traits. The mean EW of the FS were higher than the parents and 'Pioneer brand X-304C'. Selection for EW improved WY, earworm (Heliothis zea L.) tolerance and N uptake.

INTRODUCTION

Duvick (1981) claimed the diverse gene pool contained in synthetic corn varieties serves as a buffer against environmental stresses allowing their use in conservation agricultural systems. Crosson and Rosenberg (1989) predicted in decades to come, researchers will have to develop many new technologies for expanding food production while preserving land, water, and genetic diversity. Sherrard et al. (1984) proposed correlating physiological traits and growth parameters to predict yield, nutrient assimilation, and pest resistance. Bullard and York (1985) found resistance to earworm to be associated with husk length and thickness. Brewbaker and Kim (1979) associated earworm and fall armyworm (Spodoptera frugiperda L.) resistance with husk number. Cameron and Anderson (1966) found that long husks themselves are of no value in insect resistance unless they are compressed over the tip (small silk-channel diameter). The objectives were to 1) develop a synthetic with a broad genetic base suitable for growing during the fall, 2) determine the correlations among all traits and select the one advantageous to predict yield, 3) determine the heritability of traits contributing to yield and quality, and 4) evaluate the synthetic against commercial hybrids and the parents.

MATERIALS AND METHODS

This corn program had its origin in 1982, when Dr. R.N. Gallaher collected tropical corn from a subsistence farm in the Limon province of eastern Costa Rica and crossed this material with temperate and tropical hybrids in Florida. A total of six mass selection cycles under no-tillage, summer double-crop planting and low input management were accomplished in a 5-yr period. A recurrent selection program was started in 1987 at the Green Acres agronomy farm at Gainesville, Florida. The genetic pool included three population selections

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from Dr. Gallaher's mass selection program; one Levy County, Florida open-pollinated cultivar; and 6 open-pollinated varieties from Central America, Mexico and the Caribbean. This blend of 10 different germplasm was called Population 1 (P_1). A total of 65 full-sib crosses were made in the spring nursery. The full-sib progeny test was planted in early August at the same location in a RCB design with six replications. The parects, the cycle 6 of the mass-selected populations, and the tropical hybrid 'Pioneer brand X-304C', were used as controls. Planting was done using a jab-type planter at a plant population of 65,000 seed ha^{-1}. As in the nursery, standard recommendations were followed to grow the progeny test.

Field data collection corresponded to traits 6, 7, 9, and 10 at the 50% silking stage and traits 16 and 17 at harvest time (Table 1). Post-harvest data collection corresponded to traits 1, 2, 3, 4, 5, 8, 11, 12, 13, 14, 15 and 18 (Table 1). The micro-Kjeldahl N analysis method was used to determine the N concentration in leaves and seeds.

Several statistical parameters were used to analyze the data. These included the analysis of variance (ANOVA) of a RCB design at 5% probability level for all traits, correlation coefficients (r) among all traits, the genetic component of variance (σ_t^2), heritability (h^2) and the expected genetic gain (G_s). Finally, the frequency distribution of the FS families in classes was done for ear weight based on ANOVA, correlations, h^2, and G_s. The top 27% of the full-sib families were selected for initiation of the next cycle.

RESULTS AND DISCUSSION

Analyses of variance for a RCB design showed a highly significant difference ($P = 0.01$) among full-sib families in P_1 for 15 of the 18 traits evaluated. Ear weight was positively correlated (+r) with 13 of the traits. Acceptable +r were with whole plant dry matter, grain weight, number harvested ears, stalk weight, and tassel height with +r values of 0. 94, 0.89, 0.63, 0.58 and 0.53, respectively with $P < 0.01$. Tip insect damage was negatively correlated with husk weight, with $r = -0.30$ and $P = 0.01$. Lodging per cent was a function of tassel height and silk height with $r = 0.26$ and 0.21 respectively, at $P = 0.01$.

The best h^2 was given by parent's seed N and the full-sib leaf N with 99 and 98%, respectively (Table 1). Yield traits had h^2 ranging from 54% for husk weight to 29% for grain weight. Ear weight had h^2 of 41%. Both plant height traits showed the same $h^2 = 52\%$. Ear insect damage had h^2 fluctuating from 48% for total insect damage to 32% for body insect damage. The highest G_s was given by the stalk weight (11.4%), followed by ear weight (6.1%). Since they were +positively correlated ($r = 0.58$), any improvement in ear weight should result in a general improvement of the quality of the plant. Because ear weight coefficients σ_t^2 and h^2 were among the highest for yield components ear weight will be used as the main selection criterion (Table 1).

The ear weight of the top 15 full-sib families ranged from 675 to 823 g m^{-2} with a $\bar{x}$ of 710 g m^{-2}. The ear weight mean of the selected families had 92 g m^{-2} (10%) increase over the population mean. The $\bar{x}$ of the two parents, 'Flopup'86' and 'Flopup'87', was 515 and 531 g m^{-2}, respectively. 'Cenia-12' and Pioneer brand X-304C had almost equal ear weight but lower than the top 15 full-sib families selected and averaged 496 and 490 g m^{-2}, respectively.

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Table 1. Analysis of variance of full-sib families, heritability and expected gain of traits in Population 1.

Trait	Computed F	Probability Value	Probability Signif.	CV	Unit	σ_t^2	h^2	Gg	G%
				--%--			-%-		-%-
Insect damage traits:									
1- Harvested ears	1.90	0.000	**	18.50	#	3.40	48	1.40	5.40
2- No damage	1.70	0.004	**	66.60	%	11.15	40		
3- Tip damage	1.80	0.001	**	23.90	%	28.40	44		
4- Body damage	1.50	0.024	*	52.00	%	12.20	32		
5- Total damage	1.90	0.000	**	10.90	%	13.30	48	-3.00	-0.03
Nitrogen conc. traits:									
6- Parent's seed	79.50	0.000	**	4.30	dag/kg	0.10	99		
7- FS family leaf	23.20	0.000	**	6.45	dag/kg	0.20	98	0.60	20.90
8- FS family seed	2.40	0.000	**	6.10	dag/kg	0.01	60		
Plant height traits:									
9- Tassel	2.00	0.000	**	6.85	m	0.01	52	0.00	0.00
10- Silk	2.10	0.000	**	13.50	m	0.01	52	0.01	0.80
Yield component traits:									
11- Ear weight	1.70	0.003	**	23.70	g/m2	2,482.10	41	37.90	6.10
12- Grain weight	1.40	0.042	*	27.80	g/m2	419.20	29	13.40	4.70
13- Husk weight	2.20	0.000	**	23.90	g/m2	194.70	54		
14- Cob weight	1.90	0.000	**	33.20	g/m2	672.50	47		
15- Shelling percent	1.80	0.000	**	27.30	%	38.90	46		
16- Stalk dry weight	2.20	0.000	**	28.90	g/m2	1,367.10	53	33.20	11.40
17- Lodging percent	1.50	0.018	*	147.80	%	3.40	34		
18- Whole plant DM	1.70	0.003	**	23.80	g/m2	5,323.80	41	55.90	6.20

(*,**)= different at the 95% and 99% level of significance, respectively. σ_t^2 = Genetic variance component. h^2 = Heritability. Gg = Expected gain in the corresponding unit over the population mean. G% = Expected gain in percent over the population mean.

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