Subtropical Plant Science, 52: 18-22.2000

Performance of Two Sweet Corn Cultivars Grown under Conservation Tillage and With-in-row Weed Pressure

D. J. Makus

U.S. Dept. Agriculture, Agricultural Research Service, Subtropical Agricultural Research Center, Weslaco, TX 78596[1]

ABSTRACT

In spring 1998, furrow-irrigated sweet corn cultivars 'Sensor' and 'G-90' (*Zea mays* var. *rugosa*) were grown under two conservation tillage (CT) systems in the presence or absence of weeds, and compared to conventionally-grown sweet corn, grown in the presence or absence of weeds. Tillage systems, consisting of conventional cultivation, ridge tillage, and no tillage, were in continuous rotation since fall 1994. Sweet corn yields were not influenced by CT but the later-maturing 'G-90' had higher yields than did 'Sensor'. The presence of weed pressure reduced yield and ears/ha in 'G-90', but not in 'Sensor'. Weed pressure reduced 'Sensor', but not 'G-90' average ear weight. 'Sensor' ear weights were lowest when grown under no tillage. 'G-90' ear weights were not affected by CT. Ear quality attributes, which included ear weight, length, diameter, dry matter, and incidence of earworm damage, were greater in 'G-90' than 'Sensor', but CT had no influence on these attributes. Cultivars supported different weed species underneath their canopies. 'Sensor' allowed more light penetration and sustained higher weed biomass than did the taller 'G-90' plants. CT increased weed biomass. Season soil moisture was lowest in the ridge tilled plots, but only in the 0-15 cm profile. Soil temperatures (unreplicated) at the 15 cm depth were similar between cultivar and tillage treatments over the growing season.

RESUMEN

Los cultivares de maíz dulce (*Zea mays* var. *rugosa*) 'Sensor' y 'G-90' irrigados por surco se cultivaron en la primavera de 1988 bajo dos sistemas de labranza de conservación (LC) y bajo condiciones de presencia o ausencia de malezas, y se comparó su crecimiento con el crecimiento de maíz dulce cultivado convencionalmente en presencia o ausencia de malezas. Los sistemas de cultivo, que fueron cultivo convencional, labranza en surco y no-labranza, estuvieron en rotación continua desde el otoño de 1994. Los rendimientos del maíz dulce no fueron influenciados por LC pero el cultivar tardío 'G-90' presentó mayores cosechas que 'Sensor'. La existencia de presión debido a las malezas redujo la cosecha y las mazorcas por hectárea en 'G-90', pero no en 'Sensor'. La presión por malezas redujo el peso promedio de 'Sensor', pero no de 'G-90'. Los pesos de las mazorcas de 'Sensor' fueron menores cuando se cultivaron bajo condiciones de no-labranza. Los pesos de las mazorcas de 'G-90' no fueron afectados por LC. Los atributos de la calidad de la mazorca, que incluyeron su peso, la longitud, el diámetro, la materia seca, y la incidencia de daño por gusano, fueron mayores en 'G-90' que en 'Sensor', pero LC no tuvo influencia en estos atributos. Los cultivares toleraron diferentes especies de malezas bajo la canopia. 'Sensor' permitió mayor penetración de la luz y permitió una biomasa de malezas más alta que las plantas más altas de 'G-90'. LC incrementó la biomasa de las malezas. La humedad del suelo en la estación fue menor en las parcelas con surco con labranza, pero solamente en el perfil de 0 a 15 cm. Las temperaturas del suelo (no repetidas) a la profundidad de 15 cm fueron similares entre los cultivares y tratamientos de labranza durante la estación de crecimiento.

Additional index words. Zea mays var. *rugosa,* sustainable, no-till

[1]Mention of trademark, proprietary product, or vendor does not constitute a guarantee by the U.S. Dept. Of Agriculture and does not imply its approval to the exclusion of other products or vendors that may also be suitable.

Adoption of conservation tillage, nation-wide, has resulted in average reductions in soil-water and wind-blown erosion in 1996 of an estimated 0.5 and 0.4 Mt/ha/yr, respectively, for non-highly erodible land, and 0.8 and 0.4 Mt/ha/yr, respectively, for highly erodible land (Uri et al., 1998). Total nation-wide yearly soil losses from sheet and rill erosion and from wind erosion were estimated at 60 and 45 million Mt, respectively. Conversely, the estimated benefits of incorporating conservation tillage practices were 113 and 45 million dollars, respectively.

The social and ecological benefits of conservation tillage are sometimes offset by diminished crop yields. However, increases in net return per acre, in the case of field corn, are greater because of reduced tractor, labor and equipment costs (Smart and Bradford, 1999). Additional benefits of conservation tillage generally include improved soil structure and organic matter, increased soil biota and arthropods, cooler sub-tropical soils, reduced power and labor required for tillage operations, and decreased pre-plant soil moisture loss (Beare et al., 1997; Blevins and Frye, 1993; Dick, 1997; Jordan et al., 1997; Karlen et al., 1994; Tyler et al., 1994).

The potential for successfully incorporating conservation tillage into horticultural cropping systems will be greatly influenced by season and plant architecture, particularly as it relates to weed competition. A three-year study conducted near Weslaco, Texas, determined that type of tillage, conservation tillage vs conventional tillage (CVT), did not effect winter broccoli yields (Makus, 1997). Weed competition, as measured by weed biomass, was higher under conservation tillage, particularly no tillage (NT). However, in winter, weeds were not as aggressive; prostrate spp. were more common; and erect spp. such as *Amaranthus* were not as tall during winter's short days. Although water use efficiency may have been reduced under furrow irrigation, weed-induced soil moisture stress was not observed.

In the United States, about 60% of all field corn (*Zea mays* L.) is grown on highly erodible land using conservation tillage methods on approximately 5 million hectares, and about 39% is produced by conservation tillage on 18 million hectares of non-highly erodible land (Uri, 1998). In spring of 1997, two early season sweet corn cultivars, 'Champ' and 'Sensor', yielded as well under ridge tillage (RT), but not under NT, as did CVT-grown sweet corn (Makus, 1998). Weed competition was greatest under NT. Unreplicated plots of a more aggressive growing mid-season cultivar, 'G-90', which was not part of the latter study, but grown in the same field, did not appear to be affected by weed competition in any tillage system. Based partly upon the latter observations, objectives in 1998 were to evaluate 'Sensor' and the taller-growing 'G-90' under CVT, RT, and NT and with 'ideal' and 'less than ideal' weed control.

MATERIAL AND METHODS

Three tillage systems, consisting of conventional (CVT), ridge tillage (RT), and no tillage (NT), were established in Aug., 1994, in a Hidalgo silt loam (fine-loamy, mixed, hyperthermic Typic Calciustolls) near Weslaco, Tex. (Lat. 26º 13'). Prior to Aug., 1994, crops planted at the experimental site were conventionally managed. Conventional tillage consisted of plowing, discing, bedding, cultivation, spraying, and

Table 1. Effect of tillage system and weed pressure on yield of two sweet corn cultivars.[z]

Source	Yield	Ears	Ear wt.
	(Mt/ha)	($x10^4$/ha)	(g)
Main effects:			
Tillage:			
Conventional	9.89	3.84	256a
Ridge tillage	10.05	4.00	249ab
No tillage	8.86	3.69	238b
	NS[y]	NS	0.10[x]
Weeds:			
Yes	8.35b	3.43b	242b
No	10.85a	4.26a	253a
	**	**	*
Cultivar:			
Sensor	8.60b	3.68b	232b
G-90	10.85a	4.01a	264a
	**	0.08	**
Interactions:			
Cv X Tillage:			
Sensor - Conventional	8.33	3.37c	248ab
Sensor - Ridge tillage	9.34	3.92abc	236b
Sensor - No tillage	8.12	3.72abc	213c
G-90 - Conventional	11.46	4.32a	265a
G-90 - Ridge tillage	10.76	4.09ab	263a
G-90 - No tillage	9.60	3.61bc	263a
	NS	*	*
Cv X Weeds:			
Sensor - yes	7.82b	3.53b	220c
Sensor - No	9.37b	3.84b	244b
G-90 - Yes	8.88b	3.34b	265a
G-90 - No	12.33a	4.68a	263a
	0.08	*	*

[z]Tillage X weeds and tillage X weeds X cultivar interactions both NS.
[y]NS, *, ** = not significant, significant at P<0.05, P<0.01, respectively.
Mean separation at probability level shown.
[x]Probability > 'F' value.

Table 2. Effect of tillage system on ear attributes of non-weed-free grown sweet corn.

	weight	Ear length	diameter	dry matter	Earworm damage
	(g)	(cm)	(mm)	(%)	(%)
Cultivar:					
Sensor	223b	19.7b	43.0b	24.1b	1.29b
G-90	273a	20.8a	44.4a	25.1a	1.42a
	**[z]	**	*	*	*
Tillage:					
Conventional	257a	20.3	43.7	24.2	1.31
Ridge tillage	250a	20.4	44.0	25.0	1.39
No tillage	237b	20.2	43.4	24.7	1.36
	0.09[y]	NS	NS	NS	NS
Interactions:					
Cultivar x Tillage	NS	NS	NS	NS	NS

[z]NS, *, ** = not significant at P<0.05, P<0.01, respectively. Mean separation at probability level shown.
[y]Probability > 'F' value

shredding operations. No tillage consisted of leaving the soil undisturbed after the previous crop, utilizing a stalk puller to loosen stubble before planting, applying an additional herbicide for weed control, and shredding plant stand after harvest. Ridge tillage differed from NT in that both bedding and cultivation practices were utilized. The plowing and discing operations used in CVT were not used in NT. Sweet corn in both 1997 and 1998 was followed by a late summer legume, *Crotalaria juncia*, and then fall-planted broccoli. Only results of the 1998 sweet corn planting are discussed here.

The experimental design was a randomized complete block design with four replications. Weed-free and weedy conditions were treated as sub-plots, and cultivars as sub-sub-plots [when weed presence was part of the model (Table 1), and as sub-plots when weediness was dropped from the model (Tables 2 and 3)]. Differences between means were tested using the PDIFF option of the LSMEANS statement of PROC GLM of SAS Version 6.04.

Seeds of 'Sensor' (Asgrow, Kalamazoo, MI) and 'G-90' (Novartis, Minneapolis, MN) were sown at a rate of 5.4 kg/ha with a John Deere Maximerge planter on 27 Feb. Terbufos (S-[[(1,1-dimethylethyl) thio] methyl) O,O-diethyl phosphorodithioate) was banded with the seed at a rate of 1.4 kg a.i./ha for corn root worm control. Rows were on 0.75 m centers in 9.1 m wide x 91 m long main plots. Cultivar sub-plots were 4.5 m or 6 rows wide. Nitrogen fertilizer (as NH_4NO_3) was added to the first irrigation on 23 Mar. at a rate of 60 kg N/ha. A second N application was applied as a directed spray to the base of the corn plants on 6 Apr. and irrigated into the soil on 13 Apr. A final irrigation was made 5 May. Stand counts were made on 16 Mar.

Insecticides were used at similar rates and frequency in all tillage treatments. On 1 Apr. weeds were sprayed with Glyphosate (1.1 kg a.i. /ha) in the NT and mechanically controlled in the CVT and RT systems.

Soil moisture, as percent volume, was measured with a portable TDR instrument (Moisture-Point Model MP-917, Environmental Sensors, San Diego, CA) at the 0-15, 15-30, 30-45, 45-60, and 60-90 cm profile on 13 dates beginning 17 Mar. and ending 22 May in the 'G-90' sub-plots. Continuous hourly soil temperatures at 5 and 15 cm were monitored in replication 3 of the 'G-90' sub-plots.

On 30 Apr. weeds were removed by hand in a 4 m wide strip across all treatments to facilitate leaf area index (LAI) and diffuse non-intercepted canopy radiation (DIFN) measurements with a LAI-2000 Plant Canopy Analyzer (LI-COR, Lincoln, NE). This same area was used for 'weed-free' yield measurements. Measurements taken on 4 May and 12 May were virtually identical, so the latter date was used in Table 3. Weed type and total weed biomass were determined in the weedy sub-plots one day prior to the main harvest of each cultivar based upon a 0.25 m^2 within row sample area. Final plant height was measured on 12 May.

The first 'Sensor' and 'G-90' harvests were made 72 and 77 DAP, respectively. Ear attributes, consisting of weight, diameter, length, corn earworm damage and dry matter were

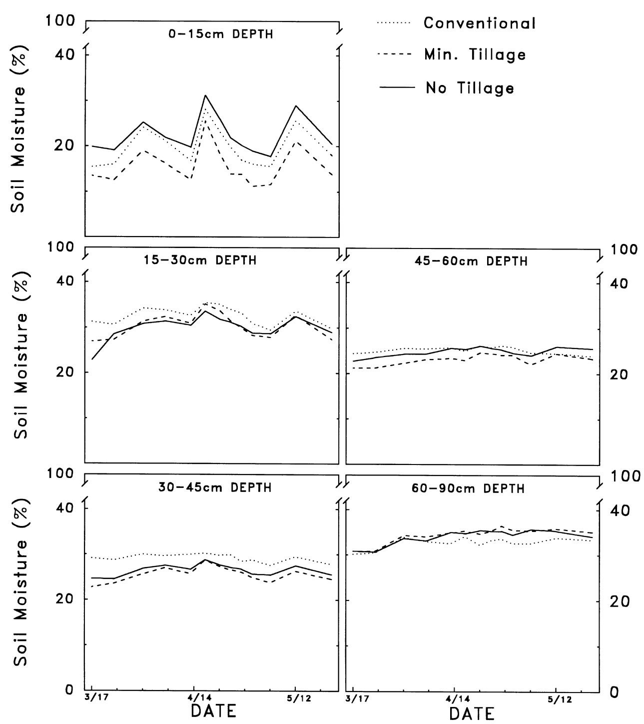

Fig. 1. Tillage effect on seasonal soil moisture at 0-15, 15-30, 30-45, 45-60 and 60-90 cm soil depths

Table 3. Effect of tillage system and sweet corn cultivar on weed dynamics, corn plant height, and canopy cover.

	Texas panicum	*Amaranthus* spp.	Purslane	All weeds	Total dry weed wt	Plant height	DIFN[z]
	------weeds/ha (x 10^5)------				(Mt/ha)	(cm)	(%)
Cultivar (CV):							
Sensor	1.80a	1.30	6.60a	9.87a	8.31a	142b	52a
G-90	0.93b	1.77	1.80b	4.50b	4.07b	180a	31b
	**[y]	NS	**	**	**	**	**
Tillage (TIL):							
Conventional	0.65b	0.80b	3.95	5.65	2.74b	159	43
Ridge tillage	0.35b	2.45a	5.55	8.35	7.56a	160	40
No tillage	3.10a	1.35ab	3.10	7.55	8.28a	164	42
	0.60[x]	0.09	NS	NS	**	NS	NS
Interaction:							
CVxTIL	**	NS	NS	NS	NS	NS	NS

[z]DIFN = Percentage of diffuse non-intercepted light reaching the bottom of the plant canopy.
[y]NS, *, ** = not significant at P<0.05, P<0.01, respectively. Mean separation at probability level shown.
[x]Probability > 'F' value

determined from samples from the initial harvest. Dry matter was used as an index for maturity. No ear attributes, other than ear weights, were determined on 'weed-free' harvested corn. The following scale was used to score corn earworm damage along the length of the ear: 1= <5, 2= <10, 3=< 25, 4= <50, 5= >50%, respectively.

RESULTS AND DISCUSSION

Mean monthly air, soil (at 15 cm), evapotranspiration and cumulative daily light values for Mar., Apr., and May (through 22 May) were 24.9, 22.5, and 27.2ºC, respectively; 21.3 25.0, and 25.8ºC, respectively; 199, 168, and 177 mm water, respectively; and 4.15, 4.15, and 4.29 Kw/m2, respectively. Cumulative supplemental rainfall of 7.6 mm occurred in Mar. Three irrigations contributed a season total of 168 mm of supplemental water. Although there was a water shortfall of 3:1, the profile soil moisture below 50 cm appeared to be constant throughout the growing season (Fig. 1). Season soil moisture in the 0-15 cm profile was 22.4, 19.8, and 15.6% for NT, CVT, and RT, respectively. Ridge tilled soil was lower in moisture than either NT or CVT (P<0.05). The combination of greater soil compaction and surface area may have contributed to greater soil surface water loss in ridge tilled soil. Tillage operations did not affect soil moisture at other depths.

Tillage system had no significant effect on total season yield (Table 1). The presence of weeds reduced yield in 'G-90', ears/ha in 'G-90', and average ear wt. in 'Sensor'. 'G-90', grown in the absence of weeds, had greater yield (P<0.08) and ears/ha than 'Sensor', grown in either the presence or absence of weed pressure, and greater than 'G-90', grown in the presence of weeds. 'G-90' ears were larger than 'Sensor' ears and were not affected by the presence of weeds. Conservation tillage reduced 'Sensor' ear weight but not those of 'G-90'.

In the presence of within-row weeds, ear weights were reduced in NT management (P<0.09) compared to CVT or RT. Ear length, diameter, dry matter, and incidence from corn earworm damage were not affected by tillage (Table 2). The later-maturing 'G-90' had larger and longer ears and was 1% (actual) higher in dry matter than 'Sensor'. The higher earworm damage index in 'G-90' may be due to greater insect pressure as the season progressed. There were no cultivar x tillage interactions.

The population of Texas panicum (*Panicum texanum*, Buckl.) was higher in 'Sensor' than in 'G-90' grown under NT (Table 3). The occurance of *P. texanum* in RT and CVT was lower than in NT and was similar in both cultivars. Amaranth density was higher in RT than in CVT. Total weed populations were not significantly different between tillage treatments, but total weed biomass (dry wt. basis) was higher in the conservation tillage systems. Weed biomass was negatively correlated (P<0.01) with both total yield (r=-0.51) and average ear weight (r=-0.61) in the weedy sub-plots. Regression analysis of weed biomass and yield components indicated that, in both cultivars, yield/ha and ear weight were reduced 0.2 Mt/ha and 2 g, respectively, for every Mt of weed biomass/ha produced (data not shown). After five years of continuous corn grown in CVT and reduced tillage systems, Barberi et al. (1998) showed that soil seed banks essentially doubled in lower tillage-input systems. I reported a similar increase in the seed bank of NT soils at the site of this study at the 0-5 cm soil depth after three years of continuous management (Makus, 1997). Hoffman et al. (1999) reported that though the tillage system used in field corn and soybean production affected the vertical distribution of seeds, with increased seed deposition at the surface, the quantity of seeds in the top 5-cm of soil was regulated by weed control practices.

Plant stand (data not shown), final plant height, LAI (data not shown), and DIFN were not influenced by tillage. 'Sensor' supported higher weed populations and weed biomass than did 'G-90'. This appeared to be related to the shorter plant height which resulted in less DIFN or shading underneath the 'Sensor' canopy. Plant height was correlated 0.848 with LAI (P<0.01) and 0.853 with DIFN (P<0.01).

In conclusion, irrigated sweet corn grown in the absence of weeds had improved yield and ear size in all tillage systems. Based on this one year study, sweet corn yields were not adversely affected by conservation tillage, but the influence of tillage on ear weights was cultivar dependent.

LITERATURE CITED

Barberi, P., A. Cozzani, M. Macchia and E. Bonari. 1998. Size and composition of the weed seedbank under different management systems for continuous maize cropping. Weed Res. 38:319-334.

Beare, M.H., S. Hu, D.C. Coleman, and P.F. Hendrix. 1997. Influences of mycelial fungi on soil aggregation and organic matter storage in conventional and no-tillage soils. Appl. Soil Ecol. 5:211-219.

Blevins, R.L. and W.W. Frye. 1993. Conservation tillage: an ecological approach to soil management. In: D.L. Sparks (ed.), Adv. in Agron. 51:33-78.

Dick, W.A. 1997. Tillage system impacts on environmental quality and soil biological parameters. Soil & Tillage Res. 41:175-176.

Hoffman, M.L., M.D.K. Owen, and D. Buhler. 1998. Effects of crop and weed management on density and vertical distribution of weed seeds in soil. Agron. J. 90:793-799.

Jordan, D., J.A. Stecker, V.N. Cacnio-hubbard, F. Li, C.J. Gantzer and J.R. Brown. 1997. Earthworm activity in no-tillage and conventional tillage systems in Missouri soils: a preliminary study. Soil Biol. Biochem. 29:489-491.

Karlen, D.L., N.C. Wollenhaupt, D.C. Erbach, E.C. Berry, J.B. Swan, N.S. Eash, and J.L. Jordahl. 1994. Long-term tillage effects on soil quality. Soil & Tillage Res. 32:313-327.

Makus, D.J. 1998. Sweet corn performance under different tillage systems. HortScience 33:594. (Abstract)

Makus, D.J. 1997. Winter broccoli performance and nutrient quality when grown by conservation tillage. Subtropical Plant Sci. 49:16-21.

Smart, J.R. and J.M. Bradford. 1999. Conservation tillage corn production for a semi-arid, subtropical environment. Agron. J. 91:116-121.

Tyler, D.D., M.G. Wagger, D.V. McCracken, and W.L. Hargrove. 1994. Role of conservation tillage in sustainable agriculture in the southern United States. p 209-30. In: M.R. Carter (ed.) Conservation Tillage in Temperate Agroecosystems. Lewis Pub., Boca Raton, Fla.

Uri, N.D. 1998. Trends in the use of conservation tillage in U.S. Agriculture. Soil Use and Management 14:111-116.

Uri, N.D., J.D. Atwood and J. Sanabria. 1998. The environmental benefits and costs of conservation tillage. The Science of the Total Environment 216:13-32.