HIGH-SPEED CULTIVATION AND BANDING FOR WEED MANAGEMENT IN NO-TILL CORN

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ABSTRACT. *Replacing herbicides with mechanical cultivation can reduce pesticide use in row crop production. Although a majority of Iowa's corn land is cultivated, most is cultivated only once and herbicide is broadcast applied. To increase grower confidence in reducing herbicide use and in using cultivation for interrow weed control, a three-year field experiment compared various single-cultivation plus band-herbicide application strategies with broadcast application strategy and no-control strategy. To cover larger acreages in a narrow window of time, cultivation speed was increased each year from 11.3 to 14.1 to 16.9 km/h (7.0, 8.8, and 10.5 mph). A 38-cm (15-in.) herbicide band treatment had less weed growth, and generally greater yield, extended leaf height, and corn population than did a 19-cm (7.5-in.) band treatment. Few differences were noted among cultivator styles. Weed management and grain yield were as good or better with the traditional low-crown sweep as with other styles. Its wider cutting width (56-cm or 22 in.) in 76-cm (30-in.) rows resulted in a lower corn population, however, when operated at 16.9 km/h (10.5 mph) with a crosswind. Differences in weed population and visual weed cover rankings when comparing single-cultivation with broadcast-only strategies varied with years. Grain yield from a treatment using a single cultivation with a low-crown sweep and a 38-cm (15-in.) wide herbicide band was statistically equivalent to that from a broadcast-only treatment in all three years. Results of this study indicate that herbicide use can be halved and weed control and corn yield can be maintained by use of a 38 cm (15 in.) herbicide band and a single sweep cultivation.*

Keywords. *Cultivators, Weed control, Speed, Tillage, Herbicide, No-till, Residue.*

Mechanical row-crop cultivation is an alternative to broadcast herbicide application for interrow weed management. Different cultivation techniques have not been widely investigated due to reliance on broadcast herbicides.

Mt. Pleasant et al. (1994) in New York studied various combinations of chemical and mechanical weed control for three years in corn. No differences were detected in weed cover among a broadcast herbicide treatment and treatments with band-applied herbicide combined with cultivation. When herbicides were banded, a rolling-cultivator treatment had lower yields than a sweep-cultivator treatment.

Eadie et al. (1992) in Ontario, Canada, compared combinations of chemical and mechanical weed control for two years in no-till corn. A single cultivation and banded application of herbicide adequately maintained weed control and yield at two of three sites. At one site, banding herbicide with two cultivations had better weed control and greater yield than did broadcast herbicide.

Parish et al. (1995) in Louisiana compared conventional sweep cultivation with a wide (45 cm, 18 in.) herbicide band to precision guided cultivation techniques with a narrower herbicide band in cotton. With a narrow (20 cm, 8 in.) herbicide band, using beds and cone guide wheels or an electro-hydraulic guidance system maintained weed control without loss in yield as compared with a conventional sweep and wide band treatment.

Although these studies support use of cultivation for interrow weed control, growers are reluctant to rely on cultivation alone. Duffy (1998), in a 1994 survey, found that although 74% of Iowa corn acreage is cultivated at least once, only 17% of corn acres received herbicide applied in a band. Corn growers may be concerned about being able to cultivate a rapidly growing crop in a window of time that is sometimes shortened by wet weather.

Paarlberg et al. (1998) in Iowa studied row-crop cultivation of no-till corn at two implement travel speeds. Treatments were applied at the same location each year in a fixed weed management strategy. Using a 38-cm (15-in.) herbicide band improved weed control and yield over use of a 19-cm (7.5-in.) herbicide band. Cultivating at a faster speed (11.3 km/h or 7.0 mph) had a positive or neutral effect on grain yield and weed control, but required less time. For example, cultivating 200 ha (494 acres) with a 12-row cultivator on 76-cm (30-in.) rows at a speed of 8.0 km/h (5.0 mph) and with a field efficiency of 80% requires 34 h. Using the same cultivator at 11.3 km/h (7.0 mph) and a slightly reduced field efficiency of 78%

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would require just 25 h. Paarlberg et al. (1998) also noted that replacing interrow chemical application with cultivation could reduce costs. Growers could increase profit by approximately $12.50/ha ($5.00/a) in a single cultivation system if yields were the same.

Hartzler et al. (1993) evaluated on-farm mechanical and chemical weed management strategies. A comparison was done on 64 Iowa farms during 1987 to 1991. Treatments were broadcast herbicide application with one cultivation, band herbicide application with one or two cultivations, two or three cultivations with no herbicide, and no weed control. Weed populations in banded herbicide treatments were greater at five locations than were populations in the broadcast with one cultivation treatment. Yield, however, was lower in the banded herbicide treatment at just one location.

Research suggests that use of a banded herbicide, when combined with mechanical cultivation can maintain weed control and corn yield. Although a no-till system implies no tillage prior to planting, post-plant row-crop cultivation potentially reduces herbicide use as an environmental tradeoff to reduced ground cover. High levels of residue cover in no-till may present some challenge to cultivator operation. With a single cultivation system and a fixed weed management strategy, cultivating at a faster speed is beneficial, but using a narrow herbicide band has not resulted in adequate maintenance of weed control and yield. Evaluation of different cultivator styles operated at high speeds and herbicide bandwidths on plots with a common weed management history may indicate that less aggressive weed management is acceptable in some situations.

Objective

The objective of this research was to determine the effects of three selected cultivator sweeps and two herbicide bandwidths on factors resulting from cultivator performance in a high-speed cultivation, high-residue production system with common weed management applied the previous year. Measured factors affecting cultivator performance included weed control, ground cover, soil movement, crop growth and population, and crop yield.

Materials and Methods

Experimental Design

The randomized complete block experimental design had four replications, each containing eight treatments. Individual plots were five rows wide with 76-cm (30-in.) row spacing and were 50 m (164 ft) long. Plots were re-established at a different location within the same field each year so that weed management history from the previous year would be common to all treatments. Previous weed management consisted of broadcast residual herbicide applied at planting in the no-till corn with cultivation over the entire experimental area (all of the following year's plots) if needed for post-emergence weed control.

Treatments included factorial combinations of three cultivator styles and two herbicide bandwidths, along with two uncultivated treatments: a broadcast application of residual herbicide at planting and a no-herbicide control. The three cultivator styles included a 56-cm (22-in.) conventional low-crown sweep, a 51-cm (20-in.) point-and-share sweep, and a 46-cm (18-in.) smith fin sweep. The point-and-share sweep (fig. 1) included a protruding point that often fractures soil before it is processed by plowshare-like wings set at a steeper rake angle than the conventional sweep. The point-and-share sweep was used as a conservation sweep option on the Deere 886 (Deere and Co., Moline, Illinois) row-crop cultivator. The smith fin sweep (fig. 2) is not commonly used in the northern midwestern United States for row-crop cultivation, but is used extensively in peanut farming and in some cotton farming in the southeastern United States. This sweep had a low rake angle and was selected for use because its flatter profile might minimize soil movement at faster-than-normal cultivator speeds. Disc-hillers and open-top shields adjacent to both sides of each row were used on all cultivated treatments.

Field Operations

The experimental site was at the ISU Agricultural Engineering/Agronomy Research Center near Boone, Iowa. Soil types at the site are Clarion loam (fine-loamy, mixed, mesic, *Typic Hapludolls*) and Coland-Spillville

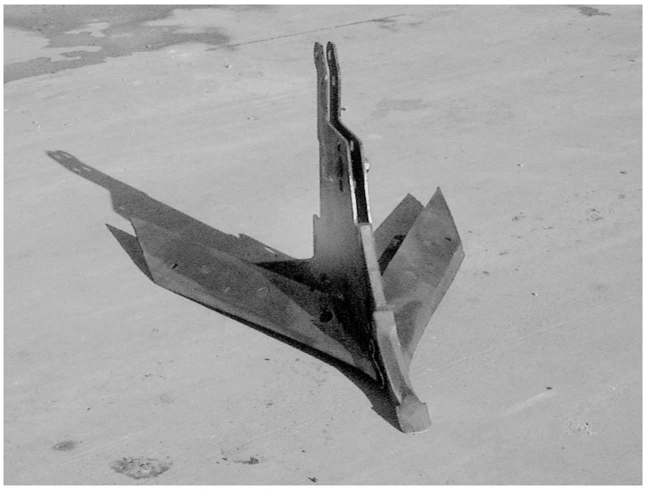

Figure 1–Point-and-share sweep.

Figure 2–Smith fin sweep.

complex (fine-loamy, mixed, mesic, *Cumulic Haplaquolls-Hapludolls*). Corn was the previous crop each year. Field operations included nitrogen fertilizer application, planting, row-crop cultivation, and harvest. Nitrogen fertilizer was applied as anhydrous ammonia at a rate of 217 kg N/ha (194 lb N/a) in the fall of 1994, 112 kg N/ha (100 lb N/a) in the spring of 1996, and 179 kg N/ha (160 lb N/a) in the spring of 1997.

Herbicide and insecticide were applied with the row-crop planter. Residual herbicide was applied in either a wide 38-cm (15-in.) band or a narrow 19-cm (7.5-in.) band behind the press wheels without incorporation. Residual herbicide application was 0.93 kg/ha (0.83 lb/a) alachlor and 2.22 kg/ha (1.98 lb/a) cyanazine in 1995 and 1996, and 2.62 kg/ha (2.34 lb/a) metolachlor and 0.07 kg/ha (0.06 lb/a) flumetsulam in 1997. Fonofos insecticide was applied at a rate of 0.11 g/m (1.22 oz/1000 ft) of row to control rootworms. Pioneer 3394 seed was planted at a rate of 69,200 seed/ha (28,000 seed/a).

The cultivator used was a Deere 886. The cultivator was modified to be used on a five-row system. Cultivator gangs between each row were connected to the toolbar by parallel links with adjustable downpressure springs. Each cultivator gang consisted of a depth control wheel (front), a single straight coulter to cut residue (center), and a cultivator shovel mounted to a shank (rear). Shovels were set to till 5 cm (2.0 in.) deep. Shanks used for the conventional sweeps were slightly wider to accommodate mounting of the stem of the sweep on the shank than shanks used with the smith fin or point-and-share/conservation sweeps. Disc-hillers were mounted on either side of the cultivator gang between the depth control wheel and straight coulter. Disc-hillers were set to till 3 cm (1.2 in.) deep and 10 cm (3.9 in.) from the row to cut soil away from the row. Some soil was moved into the row during cultivation underneath the open-top shields by the shovels and disc-hillers.

Paarlberg et al. (1998) had reported favorable results of high-speed cultivation. To evaluate effects of cultivation at higher speeds than those commonly used by midwestern growers and because of satisfactory results from cultivated treatments during the first and then the second year, greater cultivation speeds were used in each year. Cultivation speed was 11.3 km/h (7.0 mph) in 1995, 14.1 km/h (8.8 mph) in 1996, and 16.9 km/h (10.5 mph) in 1997.

Harvest was accomplished by a combine harvesting the center three rows of each five row plot. The weight of grain from each plot was adjusted by grain moisture content from the plot to determine corn yield. Dates of planting, cultivation, and harvest for each year are indicated in table 1. At the time of cultivation, corn was approximately stage V9 in 1995 and stage V7 in 1996 and 1997.

Data Collection and Analysis

Effects of cultivation were evaluated by measuring weed control, groundcover, soil movement, corn population, extended leaf height, grain yield, and grain moisture content. Weed control was measured by counting weed populations. Visual weed cover was the average rating of three different observers using a rating from zero to ten, where the rating equaled the estimated percentage of weed cover divided by 10. Groundcover was measured using the average of two measurements by the line-transect method in each plot (Morrison, 1991). To measure protection of soil from detachment and erosion, both residue from prior years' crops and any green weed or crop cover present were counted as groundcover during 1995 and 1996. In 1997, living or green groundcover was measured separately from dead or residue groundcover. Soil movement into the row was measured by the exposed height of 10 dowels uniformly spaced in the center three rows of each plot. Dowel locations marked sample areas for measurement of weed and corn populations and extended leaf height. Data were taken before and after cultivation. Additional measurements were taken late in the season, approximately five weeks after cultivation for weed population and visual weed cover. Crop vigor was evaluated by measuring corn plant population and extended leaf height. A late season measurement of extended leaf height was taken approximately 10 days before tassel emergence.

Table 1. Dates of primary field operations

Operation	1995	1996	1997
Plant	19 May	21 May	29 April
Cultivate	7 July	9 July	2 July
Harvest	20 October	12 November	2 October

A statistical analysis of variance of the data (Steel and Torrie, 1980) was evaluated in two ways. A factorial analysis was conducted with cultivator style and herbicide bandwidth as main effects. A separate, nonfactorial analysis included the six cultivated treatments and the uncultivated broadcast application and no-herbicide control treatments. In this analysis, statistical contrasts were used to compare cultivated treatments among each other and with the broadcast and control treatments. The contrasts made were nonorthogonal (i.e., not all were independent), however they can be used as a tool to compare broadcast and control treatments with cultivated treatments. Differences reported are at 5% level of confidence unless otherwise noted.

Results and Discussion

Results are reported first as a factorial analysis of the six combinations of cultivator style and herbicide band and then as cultivated treatments contrasted with the broadcast and control treatments. Interactions between cultivator style and herbicide bandwidth were not significant. Results are reported on differences in the main effects of cultivator style and herbicide bandwidth.

Weed Population

In 1995, no statistical differences were measured among cultivator styles (table 2). The wide herbicide band treatment had fewer weeds before cultivation than did the narrow band treatment. Weed population in the wide-band herbicide treatment was less than in the narrow-band treatment late in the season at a confidence level of α = 0.10. Using statistical contrasts, the control treatment had greater weed populations than all other treatments after cultivation and late in the season. Before cultivation, the broadcast treatment had statistically fewer weeds than did the narrow band, smith fin, and sweep treatments. Late in the season, the broadcast treatment had fewer weeds than did the sweep treatment.

In 1996, no differences in weed population were measured among cultivator styles. Weed populations were

Table 2. Weed population, weed/m² (weeds/yd²)

Treatment	1995 Before Cultivation	1995 After Cultivation	1995 Late Season	1996 Before Cultivation	1996 After Cultivation	1996 Late Season	1997 Before Cultivation	1997 After Cultivation	1997 Late Season
Cultivator Style									
Smith fin	18 (15)	6 (5)	4 (3)	3 (2)	1 (1)	4 (3)	184 (154)	55 (46)	56 (47)
Sweep	15 (12)	5 (4)	5 (4)	5 (4)	1 (1)	3 (3)	206 (172)	34 (29)	32 (27)
Point-and-share	12 (10)	4 (4)	3 (2)	4 (3)	1 (1)	3 (2)	151 (126)	27 (22)	27 (23)
$LSD_{0.05}$*	NS† NS	NS NS	NS NS	NS NS	NS NS	NS NS	NS NS	NS NS	NS NS
Herbicide Bandwidth									
Wide	10 (9)	4 (3)	3 (3)	3 (2)	0 (0)	2 (1)	157 (131)	25 (21)	25 (21)
Narrow	20 (17)	6 (5)	4 (3)	5 (4)	1 (1)	5 (4)	204 (171)	52 (44)	53 (44)
$LSD_{0.05}$	8 (6)	NS NS	NS NS	NS NS	1 (1)	3 (2)	NS NS	22 (19)	22 (18)
Uncultivated Treatments									
Broadcast herbicide	3 (3)	2 (1)	2 (1)	1 (0)	1 (1)	3 (3)	96 (80)	101 (84)	101 (85)
No-herbicide control	18 (15)	18 (15)	8 (7)	5 (4)	8 (6)	10 (8)	222 (186)	224 (188)	224 (188)

* $LSD_{0.05}$ is least significant difference at 0.05 probability level.
† NS is treatments not statistically significantly different.

Table 3. Visual weed cover (0-10 rating)

Treatment	1995 Before Cultivation	1995 After Cultivation	1995 Late Season	1996 Before Cultivation	1996 After Cultivation	1996 Late Season	1997 Before Cultivation	1997 After Cultivation	1997 Late Season
Cultivator Style									
Smith fin	5.5	3.9	3.5	0.5	0.3	0.5	6.8	2.0	3.1
Sweep	5.3	3.4	3.0	0.5	0.3	0.5	7.0	1.5	2.6
Point-and-share	5.0	3.0	2.8	0.5	0.2	0.5	7.0	1.8	2.8
$LSD_{0.05}$*	NS†	NS	NS	NS	NS	NS	NS	NS	NS
Herbicide Bandwidth									
Wide	5.1	3.2	2.6	0.4	0.0	0.3	6.0	1.4	2.1
Narrow	5.5	3.8	3.6	0.6	0.4	0.7	7.9	2.1	3.5
$LSD_{0.05}$	NS	NS	NS	NS	0.3	0.3	0.6	0.4	0.5
Uncultivated Treatments									
Broadcast herbicide	1.1	1.6	1.2	0.1	1.5	1.0	3.9	4.9	8.3
No-herbicide control	6.0	8.4	8.7	0.2	3.0	3.4	9.8	9.4	10.0

* $LSD_{0.05}$ is least significant difference at 0.05 probability level.
† NS is treatments not statistically significantly different.

significantly lower in wide-band herbicide treatments than in narrow-band herbicide treatments after cultivation and late in the season. The no-herbicide control had a greater weed population than all other treatments after cultivation and late in the season. At a confidence level of $\alpha = 0.10$, before cultivation, the broadcast treatment had fewer weeds than the narrow band, control, and sweep treatments.

In 1997, climatic conditions were generally favorable for weed growth during late May and June and greater weed populations were present throughout the season. Weed populations were significantly lower in wide-band herbicide treatments than in narrow-band herbicide treatments after cultivation and late in the season. Before cultivation the broadcast treatment had a significantly lower weed population than the control, sweep, narrow, and smith fin treatments. After cultivation and late in the season, weed population was significantly lower in the wide, point-and-share, and sweep treatments than in the broadcast treatment. Weed population was greater in the no-herbicide control treatment than in all other treatments after cultivation and late in the season. At a confidence level of $\alpha = 0.10$, weed population late in the season was significantly lower in the point-and-share and sweep treatments than in the smith fin treatment. Also at this expanded confidence interval, weed populations in the smith fin treatment after cultivation and in the narrow treatment both after cultivation and late in the season were less than in the broadcast treatment.

Visual Weed Cover

In 1995, no differences were detected in visual weed cover of cultivated plots among cultivator styles or between herbicide bandwidths (table 3). The wide bandwidth treatment did have less visual weed cover than the narrow bandwidth treatment late in the season at a confidence level of $\alpha = 0.10$. Contrasting the uncultivated treatments with cultivated treatments, the control treatment had greater visual weed cover than all other treatments after cultivation and late in the season. The broadcast treatment had less visual weed cover than all other treatments throughout the season.

In 1996, visual weed cover was less in the wide-band treatment than in the narrow-band treatment after cultivation and late in the season. After cultivation, visual weed cover was less in all cultivated treatments than in the broadcast treatment. Late in the season, visual weed cover in the wide-band treatment was still less than in the broadcast treatment. At a confidence level of $\alpha = 0.10$, all cultivator-style treatments had less late-season visual weed cover than the broadcast treatment. The control treatment had greater visual weed cover than all other treatments after cultivation and late in the season.

In 1997, visual weed cover was less in the wide-band treatment than in the narrow-band treatment throughout the growing season. The broadcast treatment had less visual weed cover than all other treatments before cultivation, but greater visual weed cover than all cultivated treatments after cultivation and late in the season. The no-herbicide control had greater visual weed cover than all other treatments throughout the season.

Ground Cover

In 1995, percent groundcover after cultivation was less for the point-and-share cultivator treatment than other cultivator styles and greater for the wide band herbicide treatment than the narrow band herbicide treatment (table 4). After cultivation, both uncultivated treatments had greater groundcover than all cultivated treatments.

In 1996, although trends were similar to 1995, no statistical differences were measured in groundcover among cultivator styles or between herbicide bandwidths. After cultivation, the broadcast treatment had greater groundcover than the point-and-share treatment. The no-herbicide control treatment had greater groundcover than the point-and-share treatment, the sweep treatment, and the wide-band treatment.

In 1997, no statistical differences were measured in residue or green cover among cultivator styles or between herbicide bandwidths; however, at an expanded confidence interval of $\alpha = 0.10$ the wide band herbicide treatment had less green cover than the narrow band herbicide treatment before cultivation. Before cultivation the broadcast treatment had greater residue cover than the point-and-

Table 4. Groundcover (%)

Treatment	1995		1996		1997			
	Groundcover				Residue Cover		Green Cover	
	Before Cultivation	After Cultivation	Before Cultivation	After Cultivation	Before Cultivation	After Cultivation	Before Cultivation	After Cultivation
Cultivator Style								
Smith fin	77	77	40	48	45	64	13	14
Sweep	77	77	38	43	46	66	14	10
Point-and-share	73	73	37	41	40	61	16	14
$LSD_{0.05}$*	NS†	4	NS	NS	NS	NS	NS	NS
Herbicide Bandwidth								
Wide	77	77	38	43	44	61	11	12
Narrow	75	74	39	45	43	66	17	14
$LSD_{0.05}$	NS	3	NS	NS	NS	NS	NS	NS
Uncultivated Treatments								
Broadcast herbicide	74	88	38	51	50	34	9	34
No-herbicide control	77	95	39	55	44	6	17	85

* $LSD_{0.05}$ is least significant difference at 0.05 probability level.
† NS is treatments not statistically significantly different.

share treatment and less green cover than the control or narrow band treatment. After cultivation, all cultivated treatments had greater residue cover and less green cover than the broadcast treatment. Increases in residue cover after cultivation in cultivated treatments were the result of dead weed vegetation. The no-herbicide control treatment had less residue cover and more green cover than all other treatments after cultivation.

Soil Movement

In 1995, soil movement was quite variable, and no statistical differences among treatments were distinguishable (table 5). Negative soil movement values indicate that soil at the base of the dowel was lower at the time of measurement than at the time of placement. This lower level may have resulted from soil movement away from the dowel or soil settling after placement.

In 1996, the point-and-share and sweep cultivator styles moved more soil into the row than did the smith fin style. All cultivated treatments had more soil in the row than either of the uncultivated treatments.

In 1997, the point-and-share cultivator style moved more soil into the row than other cultivator styles. Unexpectedly, more soil was moved into the row in the wide band herbicide treatment than in the narrow band herbicide treatment. More soil was moved into the row in all cultivated treatments (smith fin treatment at $\alpha = 0.10$ level) than in either uncultivated treatment.

Table 5. Soil movement, cm (in.)

Treatment	Soil Movement 1995		1996		1997	
Cultivator Style						
Smith fin	–4.9	(–1.9)	1.6	(0.6)	1.1	(0.4)
Sweep	0.3	(0.1)	2.8	(1.1)	1.9	(0.7)
Point-and-share	1.1	(0.4)	3.5	(1.4)	3.0	(1.2)
$LSD_{0.05}$*	NS†	NS	0.7	(0.3)	1.1	(0.4)
Herbicide Bandwidth						
Wide	–2.5	(–1.0)	2.8	(1.1)	2.6	(1.0)
Narrow	0.8	(0.3)	2.5	(1.0)	1.4	(0.6)
$LSD_{0.05}$	NS	NS	NS	NS	0.9	(0.4)
Uncultivated Treatments						
Broadcast herbicide	–0.7	(–0.3)	0.3	(0.1)	0.1	(0.0)
No-herbicide control	–0.9	(–0.4)	–0.1	(–0.0)	–0.1	(–0.0)

* $LSD_{0.05}$ is least significant difference at 0.05 probability level.
† NS is treatments not statistically significantly different.

Corn Population

In 1995, corn plant population was not statistically different among cultivator styles or between herbicide bandwidth treatments (table 6). Corn population in the no-herbicide control treatment was greater before cultivation than in the point-and-share, smith fin, or wide herbicide band treatments. After cultivation, population in the control treatment was greater than population in the point-and-share and narrow herbicide band treatments.

In 1996, corn population before cultivation was greater in the wide herbicide band treatment than in the narrow herbicide band treatment. Also before cultivation, more corn plants were present in the broadcast treatment than in the narrow-band treatment or the smith fin treatment. After cultivation no statistical differences in plant population were detected.

After cultivation in 1997, corn population in the sweep cultivator treatment was less than the population in other cultivator styles and in both uncultivated treatments. A stronger-than-desirable crosswind during cultivation and the wider dimensions of the sweep as compared to other cultivator styles resulted in wing tips of the sweep operating close to the corn plants. If the travel path of the cultivator varied from the row direction more at the 16.9 km/h (10.5 mph) travel speed used in 1997, this may have increased injury to the crop by the cultivator.

Extended Leaf Height

In 1995, extended leaf height was not statistically different except late in the season when corn plants were taller in the broadcast treatment than all other treatments (table 7). In 1996, plants in the wide herbicide band treatment were taller than plants in the narrow-band treatment before and after cultivation. No plant height

Table 6. Corn population, plants/ha (plants/a)

Treatment	1995 Before Cultivation	1995 After Cultivation	1996 Before Cultivation	1996 After Cultivation	1997 Before Cultivation	1997 After Cultivation
Cultivator Style						
Smith fin	60,000	59,800	61,800	65,900	64,200	58,700
	(24,300)	(24,200)	(25,000)	(26,700)	(26,000)	(23,800)
Sweep	60,800	60,400	64,000	67,400	65,200	43,200
	(24,600)	(24,400)	(25,900)	(27,300)	(26,400)	(17,500)
Point-and-share	60,000	59,400	64,800	66,800	63,700	54,000
	(24,300)	(24,000)	(26,200)	(27,000)	(25,800)	(21,900)
$LSD_{0.05}$*	NS†	NS	NS	NS	NS	9,600
	NS	NS	NS	NS	NS	(3,900)
Herbicide Bandwidth						
Wide	60,000	60,000	65,800	67,600	65,100	52,100
	(24,300)	(24,300)	(26,600)	(27,400)	(26,300)	(21,100)
Narrow	60,500	59,700	61,200	65,800	63,700	51,900
	(24,500)	(24,200)	(24,800)	(26,600)	(25,800)	(21,000)
$LSD_{0.05}$	NS	NS	3,100	NS	NS	NS
	NS	NS	(1,300)	NS	NS	NS
Uncultivated Treatments						
Broadcast herbicide	60,000	60,000	67,800	67,900	58,500	56,600
	(24,300)	(24,300)	(27,400)	(27,500)	(23,700)	(22,900)
No-herbicide control	63,200	62,700	65,100	67,100	62,300	62,300
	(25,600)	(25,400)	(26,300)	(27,200)	(25,200)	(25,200)

* $LSD_{0.05}$ is least significant difference at 0.05 probability level.
† NS is treatments not statistically significantly different.

Table 7. Extended leaf height, cm (in.)

Treatment	1995 Before Cultivation	1995 After Cultivation	1995 Late Season	1996 Before Cultivation	1996 After Cultivation	1996 Late Season	1997 Before Cultivation	1997 After Cultivation	1997 Late Season
				Cultivator Style					
Smith fin	102.1 (40.2)	139.3 (54.8)	203.9 (80.3)	42.9 (16.9)	98.4 (38.7)	164.3 (64.7)	43.0 (16.9)	108.3 (42.6)	153.1 (60.3)
Sweep	104.7 (41.2)	150.1 (59.1)	208.9 (82.2)	43.4 (17.1)	95.9 (37.8)	171.7 (67.6)	42.0 (16.5)	102.3 (40.3)	142.7 (56.2)
Point-and-share	114.8 (45.2)	145.9 (57.4)	205.2 (80.8)	42.8 (16.9)	94.7 (37.3)	155.7 (61.3)	43.3 (17.0)	122.9 (48.4)	164.5 (64.8)
$LSD_{0.05}$*	NS† NS	NS NS	NS NS	NS NS	NS NS	NS NS	NS NS	NS NS	16.3 (6.4)
				Herbicide Bandwidth					
Wide	104.3 (41.1)	143.2 (56.4)	208.6 (82.1)	44.8 (17.6)	99.4 (39.1)	173.1 (68.1)	42.5 (16.7)	113.3 (44.6)	165.8 (65.3)
Narrow	110.1 (43.3)	147.1 (57.9)	203.4 (80.1)	41.2 (16.2)	93.3 (36.7)	154.7 (60.9)	43.0 (16.9)	109.1 (43.0)	141.0 (55.5)
$LSD_{0.05}$	NS NS	NS NS	NS NS	2.3 (0.9)	5.2 (2.0)	NS NS	NS NS	NS NS	13.3 (5.2)
				Uncultivated Treatments					
Broadcast herbicide	107.0 (42.1)	146.7 (57.8)	225.0 (88.6)	43.9 (17.3)	99.8 (39.3)	172.6 (68.0)	44.4 (17.5)	129.5 (51.0)	184.7 (72.7)
No-herbicide control	108.0 (42.5)	140.3 (55.2)	202.6 (79.8)	42.6 (16.8)	94.3 (37.1)	158.7 (62.5)	41.6 (16.4)	98.5 (38.8)	102.3 (40.3)

* $LSD_{0.05}$ is least significant difference at 0.05 probability level.
† NS is treatments not statistically significantly different.

differences were statistically significant when contrasted with uncultivated treatments.

Late in the 1997 season plants in the point-and-share treatment were taller than plants in the sweep treatment. Also, late-in-the season plants in the wide-band treatment were taller than plants in the narrow-band treatment. After cultivation, plants in the broadcast treatment were taller than plants in the control and sweep treatments and at an expanded confidence interval of $\alpha = 0.10$, taller than plants in the smith fin treatment. At a confidence interval of $\alpha = 0.10$, plants in the point-and-share treatment are taller after cultivation than plants in the control treatment. Late-in-the season, plants in all treatments were taller than those in the control treatment, and plants in the broadcast treatment were taller than plants in all other treatments except the wide-band treatment.

Grain Yield and Moisture Content

In 1995, grain yield or moisture content at harvest did not differ between herbicide bandwidths or among cultivator styles (table 8). Grain yield of the no-herbicide control treatment was less than all other treatments. Grain moisture of the control treatment was higher than all treatments except the sweep cultivator style and narrow herbicide bandwidth. No difference was measured for grain yield between the broadcast herbicide treatment and the treatments using the sweep or wide herbicide band; however, broadcast treatment yield was greater than the yield in other treatments. No difference was measured for grain moisture content at harvest between the broadcast treatment and the wide band and point-and-share treatments, but grain in the broadcast treatment was drier than grain in other treatments.

In 1996, grain yield of the wide-band treatment was greater than that of the narrow-band treatment. Yield of the control treatment was less than that of all other treatments. Grain yield of the broadcast treatment was not statistically different than the yield of the cultivated treatments.

In 1997, grain yield was quite low apparently as a result of a mid-season drought and a nutrient deficiency. Topsoil was quite dry, and noticeable yellowing of the corn leaf margins during the period from pre-pollination through most of the grain-filling period indicated a potassium deficiency. Grain yield of the wide-band treatment was greater than that of the narrow band treatment. Grain yield of the broadcast treatment was greater than yield in the narrow-band treatments. Yield of the control treatment was less than that of all other treatments. Although not statistically significant, grain yield in each cultivator style treatment using a wide band was numerically greater than yield in the broadcast treatment.

Grain yield of the combination of sweep cultivator style and wide herbicide band had the best three-year average yield of cultivated treatments. Yields for this combination were 7.75 Mg/ha (123 bu/a), 6.02 Mg/ha (96 bu/a), and 2.71 Mg/ha (43 bu/a) in 1995, 1996, and 1997, respectively. Comparing the broadcast treatment to the treatment using a combination wide herbicide band at planting and single cultivation with a sweep cultivator style, crop profits would have been greater the first year for the broadcast strategy, but greater the second and third years for the cultivation strategy.

Table 8. Grain yield, Mg/ha (bu/a), and moisture content (%)

Treatment	1995 Grain Yield		1995 Grain Moisture	1996 Grain Yield		1996 Grain Moisture	1997 Grain Yield	
				Cultivator Style				
Smith fin	7.25	(115)	17.4	5.84	(93)	19.2	2.04	(33)
Sweep	7.60	(121)	17.5	5.65	(90)	19.1	2.33	(37)
Point-and-share	7.22	(115)	17.3	5.37	(86)	19.5	2.50	(40)
$LSD_{0.05}$*	NS†	NS	NS	NS	NS	NS	NS	NS
				Herbicide Band				
Wide	7.54	(120)	17.3	5.89	(94)	19.2	2.94	(47)
Narrow	7.17	(114)	17.5	5.35	(85)	19.3	1.63	(26)
$LSD_{0.05}$	NS	NS	NS	0.37	(6)	NS	0.47	(7)
				Uncultivated Treatments				
Broadcast herbicide	8.31	(132)	16.8	6.08	(97)	19.1	2.63	(42)
No-herbicide control	5.55	(88)	17.9	4.31	(69)	19.6	0.10	(2)

* $LSD_{0.05}$ is least significant difference at 0.05 probability level.
† NS is treatments not statistically significantly different.

Discussion

Comparing cultivator styles within the six factorial combinations of cultivator treatment, few differences were measured in cultivator style. In the third year, use of the sweep resulted in less corn population after cultivation and shorter plants than did the point-and-share sweep late in the season. Some crop injury may have occurred this third year when the sweep (wider than the other cultivator styles) was operated at a speed of 16.9 km/h (10.5 mph) in a noticeable crosswind. Although the wider sweep might be expected to perform better than other cultivator styles with the narrower herbicide bandwidth, because interactions between cultivator style and herbicide bandwidth were not significant the data did not support this conclusion. Possibly due to the flatter rake angle, the smith fin and sweep treatments left more ground cover than the point-and-share treatment the first year. The second year, the smith fin moved less soil into the row than other treatments, and during the third year both the smith fin and sweep moved less soil than did the point-and-share treatment. Although weed population was greater late in the first season in the sweep treatment than the broadcast treatment, grain yields were not statistically different. Corn yield differences among cultivator styles were not significant; however, yields compared to a broadcast treatment were different during the first year except for the sweep style.

Comparing wide and narrow herbicide bands within the six factorial cultivated treatments, weed management and crop conditions were generally improved by using the wide band. During the first year, there were fewer weeds before cultivation and a greater amount of ground cover after cultivation in the wide-band treatment. During the second and third years weed population and visual weed cover in the wide-band treatment was less after cultivation and late in the season than in the narrow-band treatment. Also during the second and third years, grain yield was greater, and during parts of the season corn population and/or extended leaf height were greater in the wide-band treatment than in the narrow-band treatment.

Contrasting cultivated treatments to the broadcast herbicide without cultivation treatment, visual weed cover was generally less in the cultivated treatments for two of three years. Visual weed cover was greater in the cultivated treatments during the first year; however, it was less after cultivation in the cultivated treatments during the third year. In the second year, visual weed cover after cultivation was less in all cultivated treatments after cultivation than in the broadcast treatment. Weed cover continued to be less in the wide-band cultivated treatment than in the broadcast treatment late in the season. During the third year both after cultivation and late in the season, weed populations were less in the wide-band, point-and-share, and sweep treatments than in the broadcast treatment. Grain yields in the cultivated treatments were statistically similar to that in the broadcast treatment during the second and third years with the exception of the narrow-band treatment during the third year. Grain yield of the sweep and wide-band herbicide treatments during the first year was statistically similar to that of the broadcast treatment. Average corn yield was greatest during the first two years in the broadcast treatment. In the third year, broadcast treatment yield was less than all cultivated treatments using a wide herbicide band, but greater than those using a narrow herbicide band. To have the best chance of maintaining corn yield and reducing weed pressure compared to a broadcast herbicide only strategy, the data suggest using a wide herbicide band and perhaps considering use of a conventional cultivator sweep. Crop injury should be monitored by the operator at high travel speed (16.9 km/h or 10.5 mph). This is particularly important with a crosswind present. A narrower soil-engaging tool may be substituted to reduce crop damage. A guidance system may help also to reduce operator fatigue on field-sized areas.

As expected, weed population and visual weed cover after cultivation and late in the season were greater and grain yield was less in the uncultivated no-herbicide control treatment than in other treatments.

CONCLUSIONS

Data from this experiment support the following conclusions for a single high-speed cultivation strategy in no-till corn production:

- A 38-cm (15-in.) herbicide band treatment had fewer weeds, less visual weed cover, and generally greater yield, extended leaf height, and corn population than did a 19 cm (7.5 in.) band.
- Few differences were noted comparing cultivator styles. Weed management and grain yield were as good or better with the traditional low-crown sweep as other styles. Its wider cutting width (56 cm or 22 in.) in 76 cm (30 in.) rows resulted in a lower corn population, however, when operated at 16.9 km/h (10.5 mph) with a crosswind.
- Weed population and visual weed cover after cultivation and late in the season were greater and corn grain yield was less in a no-herbicide, uncultivated control treatment.
- To maintain corn yield with a single cultivation strategy as compared to a broadcast only strategy, it is recommended to use a 38-cm (15-in.)-wide herbicide band. Cultivator style is less significant. Crop injury should be monitored as operational speed increases.

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