Sunflower Production Comparisons With Conventional and Reduced Tillage Systems

Edward J. Deibert

The inclusion of sunflower into crop rotations in recent years can be attributed to many factors. Farm programs encouraged a reduction in wheat acreage, and sunflower provided an alternative cash crop that would fill the void. Sunflower, a deep rooted crop, utilized deep stored soil moisture and residual nitrogen accumulations not extracted with small grain crops. Sunflower also made available a row crop adapted to the Northern Plains, previously an area of predominantly small grain cropping systems.

Introduction of sunflower, however, also accentuated soil erosion concerns since erosion under row crops is generally much higher than with close-growing small grains. To reduce this erosion potential, the sunflower crop must be placed in a crop rotation system that leaves adequate residue on the soil surface to protect the soil against both wind and water erosion.

Reduced tillage offers this alternative, but management programs that maximize production, minimize inputs and limit management problems need to be developed. Research was initiated at NDSU in 1980 to evaluate sunflower in a crop rotation system that compares reduced tillage systems with conventional tillage systems.

Plant growth, seed yield and nutrient content of sunflower were evaluated in a four-year crop rotation (barley, sunflower, barley, sugarbeet) under four tillage systems. The study was conducted at the North Dakota State University Agricultural Experiment Station at Fargo (NW22 area) on a Fargo clay soil. Primary tillage treatments consisted of conventional fall plow and three reduced tillage systems referred to as fall sweep, fall intertill and no-till.

The **Plow** treatment consisted of fall plowing after barley harvest, followed by two secondary tillage operations with a tandem disk. Later in the fall two tillage passes with a field cultivator were used to incorporate herbicide. Prior to spring planting, this treatment received two additional light tillage operations with the field cultivator. Nearly all barley residue was incorporated by this tillage system.

Sweep treatment consisted of one late fall tillage operations using a chisel plow with 12-inch shank spacing and 14-inch sweep shovels. No additional fall or spring secondary tillage was performed with direct planting in the spring. Approximately 80-85 percent of the residue, in a semi-flattened state, was retained on the soil surface.

Intertill treatment was achieved with one late fall operation using a Woods intertiller that rototills an 8-inch wide strip for each row. No additional fall or spring secondary tillage was performed. This sytem leaves two-thirds of the residue standing and one-third incorporated with direct spring planting into the tilled strips.

No-till treatment received no primary or secondary tillage. All residue was left standing with direct planting in the spring.

Tillage plots (46 ft wide by 100 ft long) were divided into subplots to compare two weed control methods, herbicides alone or herbicides plus cultivation. The herbicide treatment consisted of a fall application of granular trifluralin (Treflan) as 5G at a rate of 20 pounds per acre. Trifluralin was broadcast over the entire plot area in early October with complete incorporation on the **Plow** system, partial incorporation during tillage with the **Sweep** and **Intertill**, and no incorporation with the **No-till**. Cultivation for weed control consisted of one early cultivation with a rear mounted implement with narrow sweep shovels and cutoff knives on each side of the row. In addition, a fall burn down application of glyphosate (Roundup) at 1 quart per acre was applied to the reduce tillage plots, prior to any tillage, for control of volunteer grain and any annual, biannual or perennial weeds that emerged after harvest.

Average soil tests at the site indicated an organic matter value of 4.1 percent, a pH level of 7.7, a P level of 42 pounds per acre and a K level of 562 pounds per acre. Soil nitrate-nitrogen in the surface 2 feet ranged from 50 to 60 pounds per acre. A 100 pound per acre rate of nitrogen as ammonium nitrate (33-0-0) fertilizer was broadcast on the sunflower plots in the spring prior to any tillage or planting operations. No phosphorus or potassium fertilizers were applied.

Sunflower (hybrid - Interstate 894) was planted each year at 24,000 seeds per acre in late May in 22-inch spacing using a six-row double disk flex planter. Planter units were attached to the rear bar of a double tool-bar (2 ft spacing between bars). An 18-inch notched rolling coulter was attached to the front tool-bar in line with the double-disk openers to assist wtih cutting through residue in the reduced tillage plots. Average amount of residue on the soil surface at seeding time was approximately 0, 4200, 3500 and 5000 pounds per acre for the **Plow, Sweep, Intertill** and **No-till** systems, respectively. Tillage plots were 24 rows wide (subplots 12 rows each) with two replications. Plant samples were collected early (Stage V-16) and at rayflow (Stage R-5) for plant dry matter production and nutrient uptake determination. Sunflower heads were hand harvested from two rows (20 feet) in October, dried, threshed and seed yield determined at 10 percent moisture. Oil content of dried seed was determined by nuclear magnetic resonance.

Deibert is associate professor, Department of Soil Science.

Mean air temperatures during the growing period (June through September) for this four-year study (1980 to 1983) were near normal for this location. Precipitation received during the growing period was on the average about 1 inch below normal but varied with years (1982 was 3 inches below normal and 1983 was 2 inches above normal, with 1980 and 1981 slightly below normal).

Weed control on the plots with fall application of granular trifluralin was good to excellent, even on the **No-till** treatment without incorporation (not recommended by manufacturer). Prior to initiating the sunflower study, the main weed problems were Kochia, pigweed and foxtail grasses. Kochia remained the main weed problem but only in spot areas in the reduced tillage systems where residue distribution was poor. Early cultivation did help in control of weed escapes between the row. Some Canada thistle and perennial sow thistle were initially present in the plot area but were controlled effectively by spot treatment with glyphosate. The fall application of granular trifluralin alleviated the Kochia problem at this site. Although weeds progressively became less of a problem, the combination of fall burndown and granular herbicides did not completely eliminate all weed species. Other weed species like dandelion and mustard appeared, especially on the **No-till**.

Early plant growth samples (Table 1) indicated slightly higher dry matter production and taller sunflower plants with reduced tillage (**Sweep, Intertill** and **No-till**) compared to the Plow system. This additional growth response may be partially related to soil moisture availability, which tends to be higher when residue is retained on the soil surface. The added growth may also be associated wtih less drastic fluctuation in soil temperatures found with reduced tillage compared to bare soil on the **Plow** system (very warm soil temperatures during the day and very cool soil temperatures during the night).

Since the added growth was consistant each year, there may be a relationship with photosynthate production and movement. Root growth has been shown to be restricted in some crops grown under reduced tillage, so the photosynthates produced may be diverted mainly to top growth under reduced tillage while they are transported downward in the conventional system for expanded root growth, leaving less available for top growth. The reflection of light energy from the light colored residue back to the plant may also benefit photosynthate production and explain the added growth. These are some scientific areas that need additional research to explain the different in growth obtained among tillage systems.

Nutrient concentrations (N P K) in the early plants were not greatly different among tillage systems. Nitrogen concentrations were slightly lower under reduced tillage systems but this was a dilution effect from added growth since total N uptake was highest in the three reduced tillage systems compared to the **Plow** system. No consistant relationships can be found among systems for P and K concentration of the plants at this early growth stage. However, due to added growth the uptake of P and K was much higher under the reduced tillage systems. Concentration and uptake of K in the sunflower plant was slightly higher whereas N was lower when cultivation for weed control was included as a management option.

Table 1. Early sunflower plant growth and nutrient content as influenced by conventional and reduced tillage systems. Fargo, ND.[1]

Primary Fall Tillage System[2]	Weed Control Method[3]	Plant Height	Plant Dry Matter	Nutrient Concentration N	P	K	Total Nutrient Uptake N	P	K
		inches	lb/acre	%			lb/acre		
Plow	H	21	1120	3.94	.48	4.79	44	5.4	54
	H+C	21	1040	3.82	.49	4.98	40	5.1	52
	Ave	21	1080	3.88	.48	4.88	42	5.2	53
Sweep	H	23	1310	3.78	.49	4.54	50	6.4	59
	H+C	23	1220	3.73	.47	5.12	46	5.7	62
	Ave	23	1260	3.76	.48	4.84	48	6.0	61
Intertill	H	23	1280	3.88	.49	4.83	50	6.3	62
	H+C	22	1200	3.82	.55	5.29	46	6.6	63
	Ave	23	1240	3.85	.52	5.07	48	6.4	63
No-till	H	24	1340	3.81	.45	5.09	51	6.0	68
	H+C	23	1290	3.64	.45	5.16	47	5.8	66
	Ave	23	1320	3.72	.45	5.06	49	5.9	67
Average	H	23	1310	3.85	.48	4.81	50	6.3	63
	H+C	22	1230	3.75	.49	5.11	46	6.0	63

[1]Data are the average of the three years sampled (1980, 1981, 1983). Samples collected at vegetative stage (V-16).

[2]Tillage system: Plow = plow, disk twice, field cultivate twice in the fall, field cultivate and plant in spring; Sweep = one fall tillage with chisel plow with sweeps and plant in spring; Intertill = one pass in fall with Woods intertiller that tills an 8-inch strip for each row and plant in spring; No-till = no-tillage and plant directly into standing stubble.

[3]Weed control: H = a fall application (October) of trifluralin at 20 lb/acre as 5G. Complete or partial incorporation of granular herbicide on all tillage systems except no-till; C = one early cultivation for additional weed control with rear mounted cultivator.

Sunflower dry matter production at rayflower (R-5) was again much higher on the three reduced tillage systems compared to the **Plow** system (Table 2). Plant height was similar among systems. Dry matter was not greatly affected by weed control method, although at this growth stage the cultivated (H+C) plots tended to be slightly higher than when only herbicides were used. This may be associated with the slightly better weed control.

Nitrogen concentration in the plants was highest with the **Plow** system but again that is a dilution effect associated with the difference in growth since total uptake of N, with small variations, was similar among systems. Sunflower cultivated for weed control, on the average, contained more N in the plant, which may be associated with enhanced N mineralization in the soil and thus slightly higher levels of uptake.

Again, P and K concentrations in the plant were not influenced by tillage systems, but due to added growth, more P and K were found in the reduced tillage plants compared to those grown on the **Plow** system. Cultivation, on the average, also enhanced the uptake of these two nutrients in all systems except the **Intertill**.

Plant populations at harvest (Table 3) were slightly lower on the three reduced tillage systems. This difference is mainly associated with rodent damage and not seed emergence. Gophers tended to dig up more seeds and rabbits tended to cut off more plants on the reduced tillage plots compared to the plow system. The difference is more evident in the **Intertill** as rodents tended to follow or prefer the narrow tilled strip in the residue in which the sunflower was planted.

Average seed yield was lower on the **Plow** system compared to the three reduced tillage systems. The lower yield is related to moisture stress and the lower storage of non-growing season moisture in the soil profile with the bare **Plow** plots compared to the additional 1 to 2 inches of moisture stored with the reduced tillage systems. This was more evident in 1982 when growing season precipitation was below normal and the **Plow** system yielded 700 pounds per acre less than the three reduced tillage systems. The difference in systems is also evident by comparing seed weights. The reduced tillage systems had higher seed weights, indicating less moisture stress during the seed filling period. Seed oil content on the hybrid (Interstate 894) used in this study was not influenced by tillage or weed control method. Oil yield was much higher with reduced tillage as a result of much higher yields.

Nutrient content of the seed (Table 4) followed similar patterns observed at the two plant sample times. Concentration of N P K in the seed was not substantially different among tillage systems. Cultivation for weed control tended to increase the levels but at a lesser degree than observed with the plants. Uptake of N P K in the seed, as a result of higher yields, was highest in the reduced tillage systems. Some 48, 11 and 15 pounds per acre of N, P, and K were removed yearly from each system with seed harvest.

Results from the study indicated that fall application of granular herbicides, in this case trifluralin, was a viable means for controlling the weeds encountered in these three reduced tillage crop rotation systems. A change in annual weed species to something like mustard may eventually re-

Table 2. Sunflower plant growth and nutrient content at rayflower as influenced by conventional and reduced tillage systems. Fargo, ND[1]

Primary Fall Tillage System[2]	Weed Control Method[3]	Plant Height	Plant Dry Matter	Nutrient Concentration			Total Nutrient Uptake		
				N	P	K	N	P	K
		inches	lb/acre	%			lb/acre		
Plow	H	65	6680	2.56	.34	3.72	171	22.7	248
	H+C	64	7360	2.71	.34	3.88	199	25.0	286
	Ave	65	7020	2.64	.34	3.80	185	23.9	267
Sweep	H	63	7380	2.26	.31	3.72	167	22.9	275
	H+C	62	8530	2.26	.33	4.00	193	28.1	341
	Ave	63	7960	2.27	.32	3.86	180	25.5	308
Intertill	H	63	8570	2.21	.31	3.68	189	26.6	315
	H+C	67	7980	2.38	.33	3.82	190	26.3	305
	Ave	65	8270	2.30	.32	3.75	190	26.5	310
No-till	H	63	7440	2.49	.36	3.70	185	26.8	275
	H+C	66	7700	2.49	.34	3.78	192	26.2	291
	Ave	65	7570	2.49	.35	3.74	188	26.5	283
Average	H	64	7520	2.38	.33	3.70	179	24.8	278
	H+C	65	7890	2.46	.34	3.87	194	26.8	305

[1]Data are the average of the two years sampled (1981 and 1983). Samples collected at stage R-5.

[2]Tillage system: Plow = plow, disk twice, field cultivate twice in the fall, field cultivate and plant in spring; Sweep = one fall tillage with chisel plow with sweeps and plant in spring; Intertill = one pass in fall with Woods intertiller that tills an 8-inch strip for each row and plant in spring; No-till = no-tillage and plant directly into standing stubble.

[3]Weed control: H = a fall application (October) of trifluralin at 20 lb/acre as 5G. Complete or partial incorporation of granular herbicide on all tillage systems except no-till; C = one early cultivation for additional weed control with rear mounted cultivator.

quire a switch to another granular herbicide to control this specie. Cultivation to control weeds did improve weed control but did not necessarily increase yields. Although cultivation aeriates the soil and increases N mineralization, it may also cause root pruning and dry out the soil, which may limit yields. Nutrient uptake by the sunflower crop was not restricted with reduced tillage. Once weeds were controlled, the sunflower plant performed similarly among tillage systems except in dry years (low growing season precipitation) when the reduced tillage systems out produced the conventional system as a result of non-growin season stored soil moisture. In an area where moisture is the most important factor limiting yield, the added moisture available to the sunflower crop, via retention of residue on the soil surface during the non-growing season period, should not be ignored in planning a crop management or rotation system that includes sunflower.

Although the information presented gives some insight into sunflower growth as influenced by tillage systems, there still is a need to evaluate the interaction of hybrids with tillage systems. Some research work is currently underway in this area.

Table 3. Sunflower population, seed yield, seed weight, and oil content as influenced by conventional and reduced tillage systems. Fargo, ND[1]

Primary Fall Tillage System[2]	Weed Control Method[3]	Harvest Population	Seed Yield	Seed Weight	Seed Oil Content	Oil lb/acre
		plants/acre	lb/acre	grams/1000	%	lb/acre
Plow	H	20780	1630	37.2	43.4	640
	H+C	20300	1740	37.3	43.5	688
	Ave	20540	1680	37.2	43.4	664
Sweep	H	20390	2070	37.9	44.5	829
	H+C	18710	1810	39.0	43.0	704
	Ave	19550	1940	38.5	43.8	767
Intertill	H	16830	2100	44.9	42.9	809
	H+C	17230	2150	44.7	42.7	829
	Ave	17030	2120	44.8	42.8	819
No-till	H	19400	1860	41.4	44.1	743
	H+C	19900	2030	41.1	43.9	802
	Ave	19650	1950	41.3	44.0	773
Average	H	19350	1920	40.3	43.7	755
	H+C	19030	1930	40.5	43.3	756

[1]Data are the average of three years (1980, 1982, 1983). Low seed yields (less than 200 lb/acre) were obtained in 1981 due to Midge damage and data not included.

[2]Tillage system: Plow = plow, disk twice, field cultivate twice in the fall, field cultivate and plant in spring; Sweep = one fall tillage with chisel plow with sweeps and plant in spring; Intertill = one pass in fall with Woods intertiller that tills an 8-inch strip for each row and plant in spring; No-till = no-tillage and plant directly into standing stubble.

[3]Weed control: H = a fall application (October) of trifluralin at 20 lb/acre as 5G. Complete or partial incorporation of granular herbicide on all tillage systems except no-till; C = one early cultivation for additional weed control with rear mounted cultivator.

Table 4. Nutrient content of sunflower seed as influenced by conventional and reduced tillage systems. Fargo, ND[1]

Primary Fall Tillage System[2]	Weed Control Method[3]	Nutrient Concentration			Total Nutrient Uptake		
		N	P	K	N	P	K
		—%—			—lb/acre—		
Plow	H	2.84	.60	.84	41	8.8	12
	H+C	2.85	.61	.86	43	9.6	13
	Ave	2.85	.60	.85	42	9.2	13
Sweep	H	2.60	.56	.82	49	10.4	15
	H+C	2.93	.61	.86	47	9.7	14
	Ave	2.76	.59	.84	48	10.1	15
Intertill	H	2.82	.70	.92	54	13.2	17
	H+C	2.93	.67	.86	56	12.9	16
	Ave	2.87	.69	.89	55	13.0	17
No-till	H	2.69	.62	.81	45	10.4	14
	H+C	2.72	.62	.83	49	11.3	15
	Ave	2.71	.62	.82	47	10.9	14
Average	H	2.74	.62	.85	47	10.7	15
	H+C	2.86	.63	.86	49	10.9	15

[1]Data are the average of three years (1980, 1982, 1983). Low seed yields (less than 200 lb/acre) were obtained in 1981 due to Midge damage and data not included.

[2]Tillage system: Plow = plow, disk twice, field cultivate twice in the fall, field cultivate and plant in spring; Sweep = one fall tillage with chisel plow with sweeps and plant in sprining; Intertill = one pass in fall with Woods intertiller that tills an 8-inch row and plant in spring; No-till = no tillage and plant directly from standing stubble.

[3]Weed control: H = a fall application (October) of trifluralin at 20 lb/acre as 5G. Complete or partial incorporation of granular herbicide on all tillage systems except no-till; C = one early cultivation for additional weed control with rear mounted cultivator.

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Recent advances in technology, coupled with our current crop surpluses, have switched our thinking away from applied research with more emphasis being placed on basic or specific single variable research. Basic research has a purpose and may serve as a guide for further advances in applied research. However, the advances in basic resarch can only be considered successful when the results are evaluated against all possible interactions within the system. This evaluation or applied research phase is the necessary link with the producer.

Biotechnology and computerized plant growth models are being proposed as a means to achieve further gains in production efficiency. Initial advances in biotechnology in areas like gene splicing and the transfer of symbiotic nitrogen-fixation to major crops may only require a relatively short time. However, evaluation and transfer of the advances into the system may require considerably longer. The modeling approach has the potential for more rapid influx into the system, but still requires both basic and applied research to develop and test the capability of the model in the production system. The trend toward more reduced tillage in current cropping systems suggests the need for model development in this area. Models that show merit for specific tillage or cropping systems will provide a new management or decision-making tool for the producer.

Researchers need to concentrate on the systems approach when developing future research goals or projects in modeling or biotechnology. Rapid advances in agricultural research will depend on a willingness to accept the multidisciplinary systems approach that places emphasis on some advanced form of reduced tillage. The systems approach must also be supported by a strong research (basic and applied) and education program capable of attracting and inspiring scientists in all areas of agricultural crop production.