Variety Performance Under Reduced Tillage Systems

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No-till, also referred to as direct drill, zero, reduced, and minimum tillage, is a cropping system with much appeal, especially for the conservation of soil, our most valuable natural resource. Some of the first scientific direct drill research was initiated in England (David et al, 1975). In the US, the first research was conducted in the early sixties in Kentucky (Phillips and Young, 1973) with row crops.

The early zero till research was summarized in Advances in Agronomy in 1973. Up to that time, very little research had been done with small grains, but references were made that 56 percent of the trials favored conventional till over zero till when growing barley and oats (Baeumber and Bakermans, 1973).

Early research in North Dakota involved the Williston, Langdon , and North Central (Minot) branch stations and the soil science department. The first published data from this research indicated that no-till wheat yields were equal or slightly greater than wheat planted with conventional spring tillage (Deibert et al, 1978).

Early data reported from Langdon showed that yield of wheat and barley under no-till averaged 34.8 and 43.6 bushels per acre while wheat and barley grown by the conventional farming methods averaged 33.5 and 42.0 bushels per acre (Nowatski, 1980). Yield data at Willston (French and Riveland, 1984) and Minot (Hoag and Thompson, 1986) were recorded on hard red spring wheat (HRSW) from a tillage trial that compares fallow, continuous no-till, and continuous conventional till systems. Unpublished results at Williston over a seven-year period showed a yield advantage of fallow over no-till of 14 percent and over conventional till of 17 percent. At Minot, over a nine-year period, the yield advantage of fallow was 30 percent over no-till and 26 percent over conventional till.

Limited data have made reference to variety response or interaction with tillage systems like no-till. Phillips and Young (1973) indicated that some soybean varieties performed more favorably under no-till when compared to conventionally tilled soil. No data have been published on the interaction of small grain varieties with no-till.

No-till has increased in North Dakota from practically no acreage in 1977 to 654,000 acres in 1985 (Lessiter, 1986). This would account for approximately 3.5 percent of the cropped acres in 1985. With this growing interest in no-till, more research data are needed in all aspects of production. This article will report on variety and tillage interaction results at the North Central Experiment Station near Minot.

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METHODS

The North Central Experiment Station at Minot serves a 12 county area in north central North Dakota. The main soil type at the station is a Williams loam which is the most typical soil type found in the area. The average annual rainfall is 16.5 inches, however, the average for the last ten years has been 17.7 inches.

An evaluation of HRSW, durum, barley and oat varieties on three different tillage systems was conducted from 1982 through 1986. Plantings were conducted on a conventional fallow system, a conventional recrop system and a no-till recrop system. Stubble on the continuous recrop system was not worked until spring, which allowed additional snowtrap, thus giving the potential for additional stored soil moisture for crop production. All tillage systems were fall soil tested and spring fertilized. Liquid fertilizer was surface applied, based on soil tests for yield goals of 70 bushel wheat and durum, 100 bushel barley and 130 bushel oats per acre.

Fallow and conventional tilled recrop systems were spring disced or cultivated, then rototilled and packed prior to seeding. The no-till recrop system was established on first year no-till in each of the five years tested. Recrop systems were generally planted on flax ground, except in 1984 (durum ground) and 1983 (no-till planting on HRSW ground).

HRSW, durum, barley and oats were seeded at a rate of one million live seeds/acre. The conventional tilled recrop and fallow systems were seeded with a double disc opener press drill plot seeder. No-till was seeded with a plot seeder having a single disc cutting colter followed by a slot shoe used for seed placement.

Broadleaf and grassy weeds were controlled with herbicides as needed. All three tillage systems were treated with the same chemicals, except no-till, which had an additional preemergence Roundup burn down treatment.

Crop varieties were evaluated for heading date, plant height, and disease infestation during the growing season. All plots were straight cut harvested with a self-propelled plot combine. Test weight, grain protein and kernel plumpness (barley only) were determined on all varieties.

RESULTS AND DISCUSSION

Yield, test weight, protein, heading date, plant height and leaf diseases of HRSW, durum, barley and oat varieties were studied on fallow, conventional tilled and no-till recrop

systems over a five-year period, 1982-86. An adjusted value was calculated for each variety trait for equal comparison since all varieties were not planted in every year. The values were calculated using the following equation:

$$\frac{\text{Sum of the variety trait} \times \text{base mean (trait average for all varieties in all years)}}{\text{Sum of the traits yearly averages in the years the variety was planted.}}$$

Only those varieties which were not grown in all years have adjusted values. Trait values of varieties planted every year remain unchanged. This procedure was used in order to compare varieties tested in three or four of the five years with varieties tested in all five years.

Hard Red Spring Wheat

The average HRSW yield tended to be highest on fallow and lowest on no-till recrop (Table 1). Yields on fallow averaged 7 percent more than conventional recrop and 13 percent more than no-till recrop even though fertility and yield goals were equal. Top yielding varieties on fallow also were best yielding on recrop so variety by tillage interaction was not significant. Only tillage × year × variety interactions were significant for HRSW yield.

The average test weight of HRSW within each tillage system was not significantly different (Table 1). Individual varieties responded differently to the tillage systems with Butte and Coteau having test weight of 0.8 and 0.9 pounds per bushel higher, respectively, on fallow than on no-till crop. Walera's test weight was 1.4 pounds per bushel higher on no-till recrop than the fallow system. Other variety test weights were not influenced by tillage system.

HRSW varieties planted on fallow headed two to four days later than wheat planted on conventional or no-till recrop (Table 2). Varieties planted on no-till recrop tended to head slightly later than wheat planted on conventional recrop. This may partly be explained by slower growth associated with the cooler soil temperature which generally occurs in a no-till system (not documented in this study). Variety heading dates were significantly different when averaged over tillage systems.

HRSW plant height was not statistically different among tillage systems, however, plant height on fallow averaged 3 to 4 inches taller than on recrop (Table 2). Tillage system influenced conventional height varieties more than semidwarf varieties. Conventional height varieties grew even taller on fallow relative to their height on recrop than did the semidwarf varieties. HRSW protein and leaf diseases, such as

Table 1. Tillage system influence onf grain yield (1982-1986) and test weight (1983-86) of ten HRSW varieties.

	Grain Yield			Test Weight		
Variety	Fallow	Conv-Till	No-till	Fallow	Conv-Till	No-till
	bu/A			lb/bu		
Alex	53	49	45	59.7	59.9	59.6
Butte	52	49	44	60.8	60.5	60.0
Coteau	49	47	44	59.0	58.9	58.1
Len	52	46	45	58.7	58.8	58.6
Marshall	56	51	47	58.4	59.4	58.5
Solar	55	52	49	58.4	59.4	58.6
Stoa	55	51	50	59.5	58.9	58.8
Walera	55	53	50	57.9	58.9	59.3
Wheaton	56	50	49	58.4	57.8	58.1
2369	56	53	51	60.5	60.3	59.8
Average	54	50	47	59.1	59.2	59.0

Table 2. Tillage system influence on days to heading and plant height of ten HRSW varieties (1982-1986).

	Days to Heading			Plant Height		
Variety	Fallow	Conv-Till	No-till	Fallow	Conv-Till	No-till
	number			inches		
Alex*	61	58	59	38	33	34
Butte*	57	55	56	36	32	32
Coteau*	63	59	60	38	33	34
Len	61	58	59	32	28	29
Marshall	62	59	60	30	26	27
Solar	63	60	60	31	27	29
Stoa*	60	57	58	37	31	34
Walera	64	60	61	31	27	29
Wheaton	61	58	58	30	26	27
2369	60	57	58	30	27	29
Average	61	58	59	33	29	30

*Conventional height

tan spot and leaf rust, were not influenced by tillage system (Data are not presented).

Durum

Durum yield averaged over variety and years was 8 percent greater on fallow than on no-till or conventional recrop. Yield of conventional recrop and no-till recrop averaged 48 bushels per acre while fallow averaged 52 bushels per acre (Table 3). All durum varieties yielded more when planted on fallow than on recrop except Rolette durum. Rolette durum fallow yield was low compared to other variety yields on fallow but was equal to their conventional and no-till recrop yields. Lloyd durum was consistantly the top yielding variety in each tillage system when averaged over years.

Test weight of Cando, Coulter and Lloyd was 0.5 pound per bushel lower on no-till than on fallow (Table 3). Other variety test weights were not influenced by tillage system. The fallow system averaged 0.5 pound per bushel greater test weight than the no-till system, but the difference was not significant.

Days to heading of durum varieties followed a similar trend among tillage systems. All varieties headed later on fallow (Table 4), but differences were not significant.

Plant height of the varieties tended to be tallest on fallow and shortest on conventional recrop. Semidwarf varieties Cando and Lloyd varied in height 1 to 2 inches among tillage systems while conventional height varieties varied 3 to 4 inches. Since fertility was equal with all tillage systems, soil moisture may have influenced the plant height.

Leaf spot ratings were taken on durum varieties in 1982-83 and 1985-86. Leaf spot, primarily tan spot infestations, was heaviest on durum varieties planted on fallow (Table 5). The fallow system produced a taller and more dense growth which provides a better environment for disease progression. Medora durum tan spot ratings, 3.9 on a scale of 0-9, were significantly lower than all other varieties tested when ratings were averaged over years and tillage systems.

Grain protein content of the durum seed did not vary significantly among tillage systems (Table 5). Protein content for Coulter was 0.5 percent greater on no-till than fallow while Medora was 0.8 percent greater on fallow than no-till. Protein content averaged for each tillage system varied only 0.2 percent between fallow and the conventional recrop system.

Table 3. Tillage system influence on grain yield (1982-86) and test weight (1983-86) of nine durum varieties.

	Grain Yield			Test Weight		
Variety	Fallow	Conv-Till	No-till	Fallow	Conv-Till	No-till
	bu/A			lb/bu		
Cando*	52	50	48	60.3	59.8	59.3
Coulter	52	47	48	60.0	59.0	59.1
Lloyd*	54	50	50	60.0	60.0	59.4
Medora	52	48	47	60.1	60.2	60.0
Monroe	51	48	48	60.0	59.9	59.5
Rolette	47	46	48	60.9	61.2	60.9
Rugby	53	49	46	60.9	60.5	60.3
Vic	52	49	50	60.6	60.1	60.0
Ward	54	48	47	60.2	60.3	59.7
Average	52	48	48	60.3	60.1	59.8

*Semi-dwarf

Table 4. Tillage system influence on plant height and days to heading of nine durum varieties (1982-1986).

	Days to Heading			Plant Height		
Variety	Fallow	Conv-Till	No-till	Fallow	Conv-Till	No-till
	number			inches		
Cando*	62	60	60	28	27	26
Coulter	61	59	59	37	33	35
Lloyd*	62	60	60	28	27	27
Medora	61	58	59	37	33	35
Monroe	58	57	57	35	32	33
Rolette	58	56	56	37	33	34
Rugby	61	58	59	37	35	36
Vic	60	58	59	37	34	36
Ward	60	58	58	38	34	35
Average	60	58	59	35	32	33

*Semi-dwarf

Barley

Barley yields averaged 5 percent higher on fallow than conventional recrop and 7 percent higher on fallow than no-till recrop (Table 6). Hazen and Azure yields were greater than other varieties regardless of tillage system. Glenn and Morex barley yields were lowest in all three tillage systems compared to the other varieties.

Barley varieties tended to head later on fallow compared to recrop with the exception of Bowman, which headed the same time in all tillage systems (Table 6).

Barley varieties were 2 to 5 inches taller when planted on fallow than on recrop with the exception of Bowman barley even though fertility was equal on all tillage systems (Table 7). Bowman plant height was not influenced by tillage system, 27 inches whether planted on fallow or no-till. Four of six barley varieties tested tended to be 1 inch taller on no-till recrop than conventional recrop; however, this difference was not significant.

Barley kernel plumpness was signficantly greater when planted on no-till or conventional till recrop than when

Table 5. Tillage system influence on leaf.spot (1982-83, 85-86) and grain protein content (1984-86) of nine durum varieties.

	Leaf Spot Rating			Protein		
Variety	Fallow	Conv-Till	No-till	Fallow	Conv-Till	No-till
	(0-9)+			%		
Cando*	7.2	6.0	5.9	13.7	13.8	14.0
Coulter	7.1	6.3	5.8	14.7	14.8	15.2
Lloyd*	7.2	6.2	6.0	14.2	14.2	14.2
Medora	4.7	3.7	3.2	15.5	15.2	14.7
Monroe	6.8	6.1	6.1	15.1	14.8	14.8
Rolette	7.2	6.4	6.1	15.7	15.3	15.3
Rugby	6.4	5.6	5.7	15.2	14.7	14.9
Vic	6.7	6.2	5.6	15.3	15.2	15.4
Ward	6.4	5.6	5.8	15.6	15.3	15.3
Average	6.6	5.8	5.6	15.0	14.8	14.9

*Semi-dwarf
+0 = none, 9 = severe

Table 6. Tillage system influence on grain yield and days to heading of six barley varieties (1982-86).

	Grain Yield			Days to heading		
Variety	Fallow	Conv-till	No-till	Fallow	Conv-Till	No-till
	bu/A			number		
Azure	84	81	77	59	57	57
Bowman	80	77	75	57	57	57
Glenn	75	72	70	57	55	56
Hazen	83	79	78	59	57	58
Morex	77	73	72	59	56	57
Robust	81	75	73	59	57	58
Average	80	76	74	58	57	57

Table 7. Tillage system influence on plant height (1982-86), kernel plumpness and test weight (1984-86) of six barley varieties.

	Plant Height			Kernel Plumpness			Test Weight		
Variety	Fallow	Conv-till	No-till	Fallow	Conv-till	No-till	Fallow	Conv-till	No-till
	inches			%			lb/bu		
Azure	31	29	29	71	86	84	47.3	47.0	47.0
Bowman	27	26	27	93	95	93	51.2	50.1	50.3
Glenn	32	27	28	78	90	88	47.7	47.5	47.6
Hazen	32	29	29	76	89	89	47.2	47.2	47.3
Morex	33	29	30	69	88	90	47.0	47.5	47.5
Robust	32	28	29	81	90	88	49.1	48.1	48.0
Average	31	28	29	78	90	89	48.2	47.9	48.0

planted on fallow (Table 7). Plumpness with Bowman remained constant whether planted on fallow or no-till recrop. However, all other varieties had 10 to 19 percent more plump kernels on recrop than fallow. Morex was 69 percent plump on fallow and 90 percent plump on no-till recrop, the greatest range compared to all other varieties. Tillage, variety, and tillage × variety interactions were all significant.

Test weight of Bowman and Robust barley tended to be higher on fallow than recrop while Morex showed the reverse with 0.5 pound per bushel higher on a recrop than fallow. Generally, the test weight of the other varieties were not influenced by tillage system.

Leaf disease and grain protein content were not influenced by tillage systems (data not present).

Oat

The average no-till recrop oat yield was 14 percent less than fallow (Table 8). This significant yield difference was greater with oats than HRSW, durum or barley. All oat varieties seeded on fallow averaged 10 or more bushels per acre than yields on no-till except with the Moore variety. Yield of Moore was 17 bushels per acre lower than Dumont on fallow and 1 bushel lower than Dumont on no-till. It appears the Moore variety was not influenced by tillage system while Dumont appeared to be quite responsive to tillage system; however, the variety × tillage interaction was not significant. High yield potential varieties like Dumont and Fidler average 18 to 23 bushel/acre more on fallow than no-till, yet these varieties were also among the top yielding varieties on no-till.

Test weight of Dumont, Moore and Porter were more than 1 pound per bushel heavier on fallow than on no-till recrop (Table 8). All other variety test weights were generally not influenced by tillage system. Test weight among varieties was significantly different while differences among tillage systems and variety × tillage interactions were not significant.

All oat varieties, like the HRSW, durum and barley varieties, headed earliest on conventional recrop and latest on fallow (Table 8). Five of the eight varieties headed one to two days later when planted on no-till recrop compared to the conventional recrop planting. Cooler soil temperature on the no-till system may have caused the delayed heading. The variety by tillage interaction was significant.

Protein content of Otana, Kelsey and Harmon tended to be greater on no-till than on conventional till while Dumont tended to have the greatest protein content on fallow rather than on recrop, although data were not significant (Table 9). Protein content of most varieties tended to be higher when planted on no-till recrop than when planted on conventional recrop, except Moore, which averaged 0.5 percent more on

Table 8. Influence of tillage system on yield (1982-86), test weight (1983-86), and days to heading (1982-86) of eight oat varieties.

	Grain Yield			Test Weight			Days to Head		
Variety	Fallow	Conv-till	No-till	Fallow	Conv-till	No-till	Fallow	Conv-till	No-till
	bu/A			lb/bu			number		
Dumont	121	111	98	34.5	33.4	33.2	61	60	60
Fidler	120	103	102	32.8	32.2	32.5	63	60	61
Harmon	113	104	99	34.0	33.7	34.0	62	60	60
Kelsey	117	101	100	34.6	34.2	33.9	60	57	58
Moore	104	101	97	35.4	34.9	34.2	60	58	59
Otana	117	99	97	34.9	33.5	34.5	61	59	60
Porter	114	99	97	35.7	34.1	34.5	62	59	59
Steele	108	92	93	33.0	33.2	32.8	59	57	59
Average	114	101	98	34.3	33.6	33.7	61	59	59

Table 9. Influenced of tillage systems on grain protein content (1984-86), plant height (1982-86) and crown rust infestation (1982-83, 1985-86) of eight oat varieties.

	Protein			Plant Height			Crown Rust Infestation		
Variety	Fallow	Conv-till	No-till	Fallow	Conv-till	No-till	Fallow	Conv-till	No-till
	%			inches			%		
Dumont*	12.8	11.4	11.9	41	34	36	0	0	0
Fidler*	12.0	11.7	11.9	39	33	33	0	0	0
Harmon	12.0	11.7	12.7	43	37	38	12	3	3
Kelsey	11.1	11.8	12.6	40	34	36	7	2	2
Moore	12.9	13.2	12.4	40	36	36	1	1	1
Otana	11.8	11.8	12.5	41	35	37	16	8	3
Porter	13.1	12.6	13.0	39	33	31	4	2	2
Steele*	13.9	13.6	13.7	40	35	36	0	0	0
Average	12.4	12.2	12.6	40	35	35	5	2	1

*Resistance to crown and stem rust.

conventional recrop than no-till recrop. Variety differences in protein content were significant.

Oat varieties grew 4 to 8 inches taller on fallow than on recrop. Average height for fallow was 5 inches taller than the two recrop systems. Dumont and Otana varieties tended to be the tallest when planted on fallow, where as Harmon and Moore tended to be tallest on conventional recrop and Harmon and Otana on no-till recrop. However, differences were not significant (Table 9).

Crown rust infested the oats in all years except 1984. Light infestations occurred in 1982-83 and heavy infection occurred in 1985-86 (data not presented). Crown rust ratings, 0 to 100 percent, were based on percent of flagleaf covered with rust pustules (Table 9). Dumont, Fidler and Steele oat varieties are resistant to crown and stem rust and their ratings were 0. Oat varieties which carried crown rust tended to have higher ratings on fallow than recrop. Varieties planted on fallow were taller and had a more dense canopy which provided a better environment for rust infection. Generally the rust infection on varieties planted recrop were not influenced by the conventional or no-till system, except Otana which had a higher rust rating on conventional than no-till recrop. Otana carried more rust than all other varieties tested.

SUMMARY

This five-year study with HRSW, durum, barley and oats planted on fallow, conventional and no-till recrop systems at the North Central Experiment Station at Minot indicated that varieties planted on fallow tended to yield more, head later, grow taller and have a slightly heavier disease infestation, regardless of crop tested, compared to conventional or no-till recrop. Additional stored soil moisture may account for these responses since fertility levels were essentially equalized among systems.

HRSW, durum, barley and oat grain yields averaged only 13 percent, 8 percent, 8 percent and 14 percent, respectively, more on fallow than no-till recrop. HRSW varieties which averaged at least 10 percent higher yield on fallow than no-till recrop were: Butte (15 percent), Coteau (10 percent), Len (13 percent), Marshall (16 percent), Solar (11 percent) and Wheaton (13 percent). Durum varieties which average 10 percent or more yield on fallow than no-till recrop were Medora (10 percent), Rugby (13 percent) and Ward (13 percent). All oat varieties, except Moore, had 10 percent or greater grain yields on fallow than no-till recrop. The crop varieties which averaged top yields on fallow and on no-till were Stoa, Solar and 2369 HRSW; Lloyd and Vic durum; Azure and Hazen barley and Fidler oats.

Generally HRSW, durum, barley and oats planted on fallow produced test weights equal to or greater than test weights on no-till. Walera HRSW and Morex barley were exceptions, as better test weights were produced on no-till. Grain protein was not influenced significantly by tillage system regardless of crop or variety tested. Most barley varieties planted on recrop produced a higher percentage of plump kernels than barley planted on fallow; however, the Bowman variety had similar kernel plumpness among tillage systems.

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