# Performance of Hard Red Winter Wheat Cultivars under Conventional-till and No-till Systems

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Conservaton tillage accounts for an increasing percentage of the U.S. crop acreage for wheat, corn, and soybean (Conservation Tillage Information Center, 1988). In North Dakota, crop production under no-till systems increased from less than 8,000 acres in 1972 to approximately one million acres in 1987, predominantly in small grains.

Reasons often cited for converting to conservation tillage are increased soil erosion control and stored soil moisture. An additional benefit associated with seeding winter wheat into standing small grain stubble in the Northern Great Plains is the protection against cold temperatures provided by trapped snow (Fowler and Gusta, 1978).

Tillage has been shown to have a significant effect on grain yield of winter wheat during years when differential winter kill is recorded, with no-till wheat often yielding significantly more than wheat produced under conventional tillage. However, in years when little or no winter injury is sustained grain yields may be similar for wheat grown under both conventional-till and no-till systems (Cox et al., 1986). Approximately 45 percent of the North Dakota winter wheat acreage was no-till in 1984 (Cox, 1985).

If wheat breeding programs were conducted under conservation tillage systems rather than conventional tillage, would different genotypes be released for commercial seed production? If so, is it necessary to carry on simultaneous programs to develop cultivars adapted for each type of tillage? These types of questions can be addressed by studying genotype X tillage interactions for gram yield of wheat.

Significant genotype X tillage interactions indicate changes in yield rank or changes in the magnitude of yield differences among genotypes between tillage methods. Hall and Cholick (1989), in a recent study conducted in South Dakota, obtained a significant genotype X tillage interaction for grain yield of hard red spring wheat. The response of 18 cultivars ranged from 12 percent greater yield under tilled conditions to 10 percent greater yield under no-till. They concluded that evaluation under no-till conditions should more effectively develop cultivars adapted to no-till production systems. Similarly, significant genotype X tillage interactions for grain yield have been found for winter wheat grown in other areas of the U.S. where winter kill is minimal (Allan, 1982).

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The objective of this experiment was to evaluate cultivar X tillage interactions for grain yield of winter wheat grown in North Dakota, and then based on the results, to make appropriate recommendations for changes in wheat breeding strategies and/or production practices.

## MATERIALS AND METHODS

Fourteen hard red winter wheat cultivars were grown under conventional-till and no-till cropping systems at each of four locations in North Dakota over five crop seasons, 1984/85 through 1988/89. The 20 year-location combinations are called environments.

The hard red winter wheat cultivars included in this study were representative of cultivars grown in the Dakotas. The relative level of winter hardiness and percentage of North Dakota winter wheat acreage planted to each cultivar are found in Table 1. Cultivars were randomly assigned within replications (RCB design), with four replications per experiment.

**Table 1. Name, origin, level of winter hardiness, and percentage of acreage planted to winter wheat cultivars.**

| Cultivar | Year of release | Origin | Winter-hardiness rating[1] | Percent of North Dakota acreage[2] | |
|---|---|---|---|---|---|
| | | | | 1984 | 1989 |
| Norstar | 1977 | Alberta | good | 17.6 | 9.2 |
| Roughrider | 1975 | ND | good | 77.5 | 61.6 |
| Agassiz | 1983 | ND | good | 0.7 | 6.4 |
| Seward | 1987 | ND | good | — | 13.0 |
| Rita | 1980 | SD | fair | — | — |
| Rose | 1981 | SD | fair | 0.5 | 0.6 |
| Norwin | 1984 | MT | fair | — | — |
| Winridge | 1981 | MT | poor | — | — |
| Redwin | 1979 | MT | poor | — | — |
| Brule | 1981 | NE | poor | — | — |
| Siouxland | 1984 | NE | poor | — | 2.3 |
| Colt | 1983 | NE | poor | — | — |
| Thunderbird | 1985 | private | poor | — | — |
| Abilene | 1987 | private | poor | — | — |

[1] Agronomy Circular No. 1 (North Dakota State Univ. Ext. Serv., 1988) and Crop Production Guide No. 1 (North Dakota State Univ. Ext. Serv., 1990).

[2] North Dakota Agric Stat. Serv. (Carver et al., 1984; Wiyatt et al., 1989).

Each tillage method was treated as a separate experiment so that plots having tillage in common were grouped into larger areas (60 x 112 feet) to ensure uniformity of snow depth (Cox et al., 1986). Grain yield was determined by harvesting wheat from 40 square feet areas from each plot. Winter survival rating was a visual estimate of percentage survival determined in late April after regrowth was initiated.

Conventional till at Williston Research Center and North Central Research Center (Minot) consisted of bare fallow with the fallow period lasting approximately 13 months between harvest of a spring-sown grain and planting of winter wheat. Conventional-till plots at Langdon Research Center and Casselton were disked prior to planting to ensure that standing small grain stubble was incorporated. The Casselton location alternated between two sites (Agronomy Seed Farm and Prosper Research Site) within nine miles of each other. The distinguishing feature of conventional till, regardless of location within the state, was the lack of residue on the soil surface that would otherwise act as a snow catch. No-till involved planting directly into standing small grain or flax stubble of 4 to 12 inches in height.

Planting was done with a six-row hoe drill with openers that were 1 inch wide during the first four years of the study. The final year of the study plots were planted using a four-row, no-till offset double disk planter. Winter wheat was seeded at 1 to 1¼-inch depth in rows 12 inches apart, at the rate of 60 pounds per acre. Conventional-till and no-till plots at a location were planted on the same day during the first 20 days of September. Nitrogen fertilizer was applied at rates to achieve the following yield goals: 55 bushels per acre at Williston Research Center, 70 bushels per acre at both North Central Research Center and Prosper Research Site, 80 bushels per acre at Langdon Research Center, and 90 bushels per acre at Agronomy Seed Farm. Urea was fall applied at Langdon and spring applied at the Minot site. Ammonium nitrate was broadcast in the early spring at Williston. Anhydrous ammonia was soil incorporated in the fall at the Casselton sites.

## RESULTS AND DISCUSSION

Grain yields for conventional-till and no-till winter wheat for each of the five years are found in Table 2. Mean separation statistics could not be calculated because of heterogeneity of error variances. The first three-years no-till wheat yielded more than conventional-till wheat in all but three environments (data not shown). For these three environments, winter survival was greater than 90 percent for all cultivars regardless of tillage method.

When differential winter survival occurs, grain yields often are greater under no-till conditions because of greater stands and less winter injury (Cox et al., 1986). Differential winter survival will be defined here as a difference of 40 percent or more between the percentage survival estimates for the least winter-hardy and most winter-hardy cultivars in a trial; e.g., Colt - 45 percent survival vs. Norstar - 90 percent survival. Grain yield was greater for conventional-till wheat in six of eight environments for 1988 and 1989. Differential winter survival was recorded in four of these six environments, yet without the expected result of greater no-till yields. The effects of drought during 1988 and 1989 may have confounded the yield variation due to winter injury. The four study locations received only 40 to 64 percent of normal seasonal (April to July) precipitation in 1988 and 64 to 73 percent of normal precipitation in 1989. Available soil water at the end of April 1988 was 2.5 and 0.1 inches in other no-till plots at Minot and Williston, respectively. Conventional-till wheat yields were 150 to 330 percent greater than no-till wheat yields at these locations, perhaps because soil water stored during the 13-month fallow period added significantly to total available soil water.

The overall average yields for conventional-till wheat and no-till wheat were 36.2 and 37.3 bushels per acre, respectively (Table 2). A greater advantage for no-till production was indicated for those environments in which wheat displayed differential winter survival (12 of 20 environments).

Black and Bauer (1990) studied the relationship between grain yield and plant production for several winter wheats grown in the Northern Great Plains. They found grain yield did not begin to decrease significantly until plant stand was reduced by more than 45 percent from an initial planting rate of 0.89 million viable seeds per acre. This suggests that differences in grain yield between conventional-till and no-till wheat should not be confounded by winter survival when winter kill is less than this amount.

The ranking of cultivars for yield differed between conventional-till and no-till systems (Table 3). This suggests the presence of significant cultivar X tillage interactions,

**Table 2. Average grain yields for winter wheats grown under conventional-till and no-till conditions for each of five years, 1985-89.**

| Tillage | 1985 | 1986 | 1987 | 1988 | 1989 | Average 1985-89 | Locations with diff. winter survival[1] |
|---|---|---|---|---|---|---|---|
| | bu/A | | | | | | |
| Conventional | 7.9 | 34.6 | 44.2 | 18.0 | 54.0 | 36.2 | 36.3 |
| No-till | 45.1 | 44.9 | 42.4 | 13.2 | 43.0 | 37.3 | 39.9 |
| Number of locations with diff. winter survival | 3 | 3 | 1 | 2 | 3 | | |

[1]Winter wheat in 12 of 20 locations displayed differential winter survival in at least conventional-till plots. Differential winter survival is defined as a difference of 40 percent or more in the percentage winter survival estimates of the most winter-hardy and least winter-hardy cultivars.

which in fact were obtained for 13 of 17 environments. The cultivars can be grouped into three classes based on their average yield and b values. A b value of 1.0 would be produced if each increment increase in average grain yield (average of all cultivars in a trial) was matched by an equal yield increase for a specific cultivar. A b value less than 1.0 indicates that a cultivar produced smaller increments of yield gain as environments became progressively more productive. Cultivars having low average yield and b < 1.0 constitute the first class. These cultivars (Norwin, Redwin, Winridge and Colt) are poorly adapted for production in North Dakota regardless of tillage method.

The intermediate class can be described as including cultivars with mean yield similar to the overall average yield (36.2 and 37.3 bushels per acre for conventional-till and no-till, respectively) and b values fluctuating around 1.0.

Culitvars in the intermediate class have been of interest to North Dakota producers because under the right environmental conditions and little winter kill they have the potential to yield as much or more than the winter-hardy cultivars. For example, in 1988 yields of Abilene and the winter-hardy cultivars Agassiz and Seward were similar under no-till conditions at Langdon (Table 4), whereas conventional-till wheat yields at Langdon closely reflected the winter survival for each cultivar. The correlation between winter survival and grain yield was 0.9. However, the correlation between the yields of cultivars grown under conventional till and no-till was only 0.46, suggesting that cultivar recommendations would differ for the two tillage systems. Therefore, less winter-hardy cultivars released by agencies in the Central Great Plains should be evaluated under no-till conditions in North Dakota so that their yield potentials are more accurately measured.

The less winter-hardy cultivars Arapahoe, Thunderbird, Siouxland and Bighorn accounted for 5 percent of the North Dakota winter wheat acreage in 1990. The results from this study indicate this class of cultivars will perform well under no-till conditions. Of course, the production of less winter-hardy cultivars is contingent on adequate snow cover, which occurred during the critical months of December through February for the five crop seasons of this study.

Five cultivars, Seward, Brule, Norstar, Agassiz and Roughrider, had the highest yields under both conventional till and no-till (Table 3). These cultivars also had b values > 1.0 indicating they produced increasingly more grain in higher yield environments as compared to cultivars with b values < 1.0. All of these cultivars except Brule were developed for production in the Northern Great Plains and released because of their adaptation to harsh winter conditions. Although Brule previously had been rated as having a poor level of winterhardiness (Table 1), its superior performance in this study was probably the result of its high yield potential and average survival of 55 percent in conventional-till plots (Table 3). Black and Bauer's (1990) research suggests that grain yields may not be reduced drastically even at 55 percent survival. Brule should be grouped with Rita and Rose as having fair survival.

The adapted cultivars (Seward, Norstar, Agassiz and Roughrider) were among the highest yielding cultivars regardless of tillage. This would suggest experimental lines developed for intended production in northern latitudes can be effectively evaluated using only a single tillage system for testing. If this is correct, testing under no-till conditions should be considered because it is possible to evaluate both less winter-hardy cultivars and adapted genotypes without the added cost of additional tests in other tillage systems.

**Table 3. Average grain yields, regression coefficients for grain yield and percentage winter survival of 14 hard red winter wheat cultivars tested in 20 environments.**

| Cultivar | Conventional till | | | No-till | | |
|---|---|---|---|---|---|---|
| | Grain yield | | Winter survival | Grain yield | | Winter survival |
| | bu/A | b[1] | % | bu/A | b[1] | % |
| Seward | 44.1 | 1.21 | 69 | 44.4 | 1.23 | 93 |
| Brule | 39.2 | 1.12 | 55 | 40.6 | 1.07 | 90 |
| Norstar | 39.3 | 1.05 | 74 | 39.8 | 1.20 | 97 |
| Agassiz | 39.8 | 1.07 | 60 | 39.6 | 1.05 | 94 |
| Roughrider | 39.3 | 1.09 | 71 | 39.3 | 1.10 | 96 |
| Rita | 37.4 | 1.04 | 56 | 38.2 | 1.11 | 90 |
| Rose | 35.8 | 0.97 | 57 | 37.9 | 0.95 | 92 |
| Siouxland | 36.6 | 1.08 | 50 | 37.7 | 1.02 | 87 |
| Abilene | 38.4 | 1.09 | 51 | 36.5 | 0.98 | 89 |
| Thunderbird | 34.6 | 1.06 | 47 | 35.6 | 0.86 | 81 |
| Norwin | 34.2 | 0.94 | 58 | 35.0 | 0.92 | 92 |
| Redwin | 30.6 | 0.74 | 48 | 34.9 | 0.88 | 89 |
| Winridge | 29.0 | 0.80 | 42 | 32.1 | 0.84 | 86 |
| Colt | 29.0 | 0.75 | 36 | 31.2 | 0.78 | 80 |
| LSD (0.05)[2] | 4.4 | | 7 | 4.5 | | 5 |

[1] Regression of cultivar mean on environment mean.

[2] Cultivar differences larger than this value would be expected due to random environmental effects only once in 20 repetitions of this experiment.

**Table 4. Grain yield and winter survival for 14 winter wheats under conventional-till and no-till conditions at Langdon, 1988.**

| Cultivar | Convention till | | No-till | |
|---|---|---|---|---|
| | Yield | Winter surv.[1] | Yield | Winter surv. |
| | bu/A | % | bu/A | % |
| Norstar | 45.0 | 92.5 | 28.9 | 100 |
| Seward | 43.2 | 88.8 | 32.8 | 100 |
| Agassiz | 36.6 | 81.3 | 31.2 | 100 |
| Rita | 32.0 | 45.0 | 26.4 | 100 |
| Brule | 31.7 | 67.5 | 32.7 | 100 |
| Norwin | 31.1 | 76.3 | 28.6 | 100 |
| Roughrider | 29.5 | 87.5 | 26.2 | 100 |
| Rose | 29.3 | 63.8 | 28.0 | 100 |
| Redwin | 21.9 | 40.0 | 28.7 | 100 |
| Winridge | 21.3 | 31.3 | 29.6 | 100 |
| Thunderbird | 18.7 | 50.0 | 28.2 | 100 |
| Abilene | 17.3 | 25.0 | 31.4 | 100 |
| Colt | 11.9 | 17.5 | 25.0 | 100 |
| Siouxland | 11.1 | 20.0 | 26.4 | 100 |
| LSD (0.05)[2] | 9.5 | 18.8 | NS | — |

[1] Conventional-till wheat displayed differential winter survival.

[2] Cultivar differences larger than this value would be expected due to random environmental effects only once in 20 repetitions of this experiment.

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