Breeding for hard red winter wheat cultivars adapted to conventional-till and no-till systems in northern latitudes

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Summary

Conservation tillage in the Great Plains of North America has increased in recent years, in part, to control soil erosion, increase soil water storage and reduce production costs. No-till production is recommended for winter wheat (Triticum aestivum L.) in northern latitudes for the purpose of trapping snow and protecting the crop from freezing temperatures. A 5 year field study was conducted at four North Dakota locations from 1984–85 through 1988–89 to determine if significant cultivar x tillage interactions existed for grain yield of winter wheat. Fourteen hard red winter wheat cultivars were planted in both conventional-till and no-till systems. Significant cultivar x tillage interactions were obtained for grain yield from both a weighted analysis across all environments and from individual analyses of 12 of the 16 environments in which wheat survived under both tillage systems (P < 0.05). Regression of cultivar yield on mean environment yield produced b values that varied little between conventional till and no-till for 10 of the 14 cultivars. The top five yielding cultivars were the same for both tillage systems and had b values > 1.0. Although the cultivar x tillage interaction may be a result of differential winter survival rather than tillage per se, this study suggests that selection for winter wheats with superior yield performance can be conducted under either no-till or conventional-till systems.

Introduction

Conservation tillage accounts for a growing percentage of the U.S. crop hectarage for wheat (Triticum aestivum L.), maize (Zea mays L.), and soybean (Glycine max (L.) Merr.). In North Dakota alone, no-till increased from less than 3300 ha in 1972 to approximately 400,000 ha in 1987, with most of the no-till hectarage in small grain production (Conservation Tillage Information Center, 1988). Seeding winter wheat into standing small grain stubble has become a recommended practice in the Northern Great Plains because snow trapped by the stubble protects wheat seedlings from cold temperatures (Fowler & Gusta, 1978). Most plant breeding programs are conducted using conventional-till systems. The question of whether different genotypes would be selected if evaluations were performed under conservation-till systems, rather than conventional-till, has been raised for several crops. Studies have been conducted to determine the extent of cultivar x tillage interactions in wheat. Doa & Nguyen (1989) evaluated 10 winter wheat cultivars and found significant cultivar x tillage interactions in some years for several phenological events. No significant cultivar x tillage in-
interaction was observed for grain yield; however, the authors suggested that late maturing wheats may not be suitable for no-till production in the Southern Great Plains because stresses associated with no-till conditions may accelerate maturity and shorten the period of vegetative growth. Chevalier & Ciha (1986) found stresses occurring early in growth of spring wheat under no-till conditions resulted in reduced growth, and suggested the development of spring wheats for no-till production. Results of a series of winter wheat tillage studies conducted in the Pacific Northwest indicated that genotype x tillage interactions for grain yield were significant (Allan, 1982). Hall & Cholick (1989) also reported significant cultivar x tillage interactions for grain yield of hard red spring wheat in the Northern Great Plains.

Cox et al. (1986) found tillage to have a significant effect on grain yield of winter wheat during years when differential winter kill was recorded. However, in years when little or no winter injury occurs grain yields may be similar for wheat grown under both conventional and no-till systems. The objective of this study was to evaluate cultivar x tillage interactions for grain yield of winter wheat grown in northern latitudes.

Materials and methods

Hard red winter wheat cultivars were grown under conventional-till and no-till systems at each of four locations in North Dakota over five years, 1984–85 through 1988–89. Two western North Dakota locations were the Williston Research Center (48° 8’ N, 103° 45’ W) and Minot Research Center (48° 11’ N, 101° 18’ W), where conventional till consisted of bare fallow with the fallow period lasting approximately 13 months between harvest of a spring-sown grain and seeding of winter wheat. Weeds were controlled with mechanical cultivation during the fallow period. No-till involved seeding directly into standing oat (Avena sativa L.), barley (Hordeum vulgare L.) or flax (Linum usitatissimum L.) stubble of 0.1 to 0.2 m in height, with only 30 to 45 d between harvest of the previous crop and seeding of winter wheat. No-till and conventional-till plots also were grown at two eastern North Dakota locations, Langdon Research Center (48° 45’ N, 98° 20’ W) and Fargo (46° 53’ N, 97° 14’ W), with Fargo alternating between two sites. Conventional-till plots at the eastern North Dakota locations were disked prior to seeding. The no-till treatment for eastern locations was similar to that described for western locations. Continuous cropping normally is practiced at the two eastern locations and a wheat-fallow rotation normally is practiced at the western locations.

Soils at the Williston Research Center and Minot Research Center are fine-loamy, mixed, Typic Haploborolls. The Langdon Research Center is characterized by fine-loamy, mixed, Pachic Udic Haploborolls. Soil types at Fargo sites 1 and 2 are fine-silty, frigid, Aeric Calciaquolls and coarse-silty, mixed, Pachic Udic Haploborolls, respectively. Nitrogen fertilizer was applied according to soil tests.

The 14 hard red winter wheat cultivars included in this study were representative of cultivars grown in the Northern Great Plains. In 1989, the winter-hardy cultivars ‘Roughrider’, ‘Agassiz’, ‘Seward’ and ‘Norstar’ comprised 90% of North Dakota’s hectarage. Cultivar name, year of release, origin, and relative level of winter hardness are found in Table 1. Winter wheat was seeded at 25 to 40 mm depth at the rate of 67 kg ha⁻¹. Seeding occurred during the first 20 days of September. Conventional-till and no-till plots were seeded on the same day at each location.

A randomized complete block design with four replications was used. Each tillage method was treated as a separate experiment to ensure uniformity of snow depth across a tillage treatment (Cox et al., 1986). Conventional-till and no-till experiments were spaced a minimum of 6 m apart so that conventional-till plots would not be affected by drifted snow in adjacent no-till plots. In the first four years, plot area was 8.2 m² for 6-row plots and in the last year 5.5 m² for 4-row plots. Row width was 0.3 m. Grain yield per plot was determined by harvesting four rows of wheat for a harvest area of 3.6 m². Winter survival rating was a visual estimate of percentage survival determined in late April after regrowth was initiated. Differential winter