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WHEAT PRODUCTION SYSTEMS FOR SOUTHWESTERN NORTH DAKOTA

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Only a brief description of data analyses are provided for the two experiments described in this project. Interested readers are asked to contact the author for additional information. Results of both these experiments are summarized in three manuscripts in various stages of development for publication.

Abstract

The wheat-black fallow rotation has been used extensively as a production strategy for spring wheat in western North Dakota and throughout the Great Plains. Economic inefficiencies and other problems associated with this rotation suggest that alternatives are needed. The objectives of this research were to determine: (I) how cultivar selection, seeding rate adjustments, and tillage practices affect wheat yield, kernel crude protein (CP) concentration, and kernel weight in a wheat-fallow sequence; and (ii) how wheat yield and kernel quality were affected by a wheat-summer fallow (WSF) rotation compared with continuous wheat (WW). To do this, plots were established in 1993 in which five wheat cultivars were seeded at 500 000, 1 000 000, and 1 500 000 pure live seed (PLS)/acre in conventional- (<5% wheat stubble after planting), reduced- (30-50% wheat stubble after planting), and no-tillage seedbeds following the fallow period in a wheat-fallow sequence. Cultivar selection affected wheat yield, kernel CP concentration and kernel weight ($P < .05$). Seeding rate affected wheat yield but not kernel CP concentration or weight. Tillage did not affect wheat yield, kernel CP concentration, or kernel weight, nor were interactions between tillage, seeding rate, and/or cultivar significant. Five semidwarf and five conventional height cultivars were seeded following fallow and wheat in a separate experiment. Cropping system (WSF, WW) and cultivar affected wheat yield and kernel weight, but only cultivar selection affected kernel CP concentration. A crop system x cultivar interaction did not exist for grain yield, kernel CP concentration, or kernel weight. Results of these experiments support extrapolation of wheat cultivar ranking for yield, kernel CP concentration, and kernel weight from tilled to reduced- or

no-tilled environments, and from WSF to WW cropping systems.

Introduction

The WSF rotation has been used extensively as a production strategy for spring wheat in western North Dakota and throughout the Great Plains. There are several benefits that the summer fallow period provides: organic nitrogen can be mineralized, weeds can be controlled mechanically, soil water recharge can occur, and crop loss risk can be minimized (Smika, 1970). Along with these benefits have come costs, including the formation of saline seeps, uncontrolled wind and water erosion, and reduced soil nutrient levels over time (Halvorson and Black, 1974). Moreover, the idling of productive land in a WSF rotation has raised economic efficiency questions (Ali and Johnson, 1981), particularly when the Freedom to Farm Act is considered. Alternatives to WSF must be developed for the long-term viability of wheat production in North Dakota.

The objectives of this project were to:

1. Identify how cultivar selection and seeding rate adjustments affect spring wheat performance across a wheat-fallow rotation in conventional-, reduced-, and no-tillage environments.
2. Determine if wheat cultivar ranking for wheat yield, kernel CP concentration, and kernel weight changes in a WSF compared with a WW cropping system.

Objective 1

Hard red spring wheat commonly is sown after fallow in the Southwest Crop Reporting District (Anonymous, 1997). Several cultivars are sown each year, depending on seed costs, seed availability, and other factors. The cultivars vary in agronomic performance, depending on the environmental factors present during their growth and development. Changes in tillage alter the environment in which crop plants grow, and a cultivar x tillage interaction has been demonstrated when wheat has been rotated with other crops (Ciha, 1982). A cultivar x tillage interaction has not been considered in a wheat-fallow rotation, even though knowledge of this interaction would aid producers in selecting cultivars best suited to their fallow management strategies. It also is unknown if seeding rates should be adjusted according to the cultivar and tillage system used. Knowledge of the cultivar x tillage, seeding rate x tillage, seeding rate x cultivar, and cultivar x tillage x seeding rate interactions might result in more efficient spring wheat production in reduced- and no-tillage environments.

Objective 2

Spring wheat cultivars respond differently in contrasting environments. It is unclear how wheat yield, kernel CP concentration, kernel weight, and selected phenotypic characteristics are influenced by crop system. North Dakota producers need this information as they explore alternatives to black fallow in a WSF rotation. Presence of a cropping system x cultivar interaction may help explain why crop yields vary in regions of the state where rotations differ.

Materials and Methods

Objective 1

Data were collected in 1995, 1996, 1997, and 1998 from plots established under dryland management in 1993 at Dickinson. Plots were arranged in a randomized complete block design in a split split-plot arrangement. Tillage comprised main plots, seeding rate comprised subplots, and spring wheat cultivar comprised sub-subplots. Tillage systems included: (1) conventional-tillage (spring discing and leveling with a cultivator and culti-harrow until less than 5% of residue remained at the soil surface at planting); (2) reduced-tillage (leveling with a cultivator in an attempt to maintain between 30% to 50% of residue at planting); and (3) no-tillage (direct sowing into standing stubble). Subplots consisted of seeding rates of 500 000, 1 000 000, and 1 500 000 PLS/acre. Sub-subplots consisted of 2 conventional height (AC Minto, Amidon) and 3 semidwarf (Bergen, Grandin, Norm) hard red spring wheat cultivars representing a range of genotypes and phenotypes presently grown in the northern Great Plains Region.

Crop and fallow phases of each tillage system were both maintained each yr. As a result, 50% of the space allocated for plots was not planted in any year (i.e., fallow plots). Mechanical cultivation was used to control weeds in fallow plots in the conventional-tillage system. Two herbicide applications and a light cultivation were used in fallow plots in the reduced-tillage system. Non-incorporated herbicides were used in fallow plots in the no-tillage system. Post-emergent herbicides were used during the crop phase in all tillage systems to control weeds.

Main plots were 4500 square feet (90 by 50 ft). There were 6 main plots per replicate and four replicates in the experiment. Sub-subplot dimensions were 50 by 6 ft.

Plant nutrients were supplied as needed for a grain yield goal of 40 bu/acre, based on soil test results.

Variables measured on each cropped plot included: number of plants at emergence, plant height, grain yield, 1000 kernel weight, grain volume weight, and kernel CP concentration. Number of tillers at the 6.0 to 7.0 leaf stage were counted, as were the number of heads that had developed on wheat plants at physiological maturity.

Objective 2

The experiment was arranged in a randomized complete block design in a split-plot arrangement. Cropping system comprised main plots and consisted of WSF and WW. Five conventional-height hard red spring wheat cultivars (AC Minto, Amidon, Butte 86, Sharp, Stoa) and five semidwarf cultivars (2371, Bergen, Grandin, Hi Line, Norm) comprised subplots treatments.

Both phases of the WSF cropping system were established in plots along with the WW plot in 1993 and maintained each yr. Wheat yield, kernel CP concentration, and kernel weight were determined from data collected in 1995, 1996, and 1997.

Main plots were 1680 square feet. There were three main plots per replicate (two for the WSF rotation and one for continuous wheat). There were four replicates. Subplot dimensions were 6 by 28 ft.

Wheat plant height, grain yield, kernel CP concentration, and kernel weight were determined for each plot.

Data from experiments described under objectives 1 and 2 were analyzed using a computer-driven statistical program. Only preliminary statistical analyses of wheat yield, kernel CP concentration, and kernel weight will be discussed in this report.

Results and Discussion

Objective 1

Wheat yield, kernel CP concentration, and kernel weight were affected by cultivar selection (Table 1). Seeding rate affected wheat yield but not kernel CP concentration or weight. Tillage failed to affect wheat yield, kernel CP concentration, and kernel weight. No interactions existed between tillage, seeding rate, and/or cultivar for wheat yield, kernel CP concentration, or kernel weight.

Objective 2

Wheat yield and kernel weight were affected by cropping system (Table 2). Cropping system did not affect kernel CP concentration. Wheat yield, kernel CP concentration, and kernel weight were affected by cultivar selection. A cropping system x cultivar interaction did not exist for wheat yield, kernel CP concentration, or kernel weight.

Conclusion/implications of Research

Objective 1

Data collected over a 4-yr period suggest that the relative ranking of wheat cultivars for yield, kernel CP concentration, and kernel weight is unaffected by changes in tillage practices and seeding rates under conditions similar to those encountered in this experiment. These preliminary data suggest that wheat cultivar recommendations apply across tillage systems.

Objective 2

The ranking of wheat cultivars for yield, kernel CP concentration, and kernel weight does not change across WSF and WW cropping systems, under conditions similar to those encountered during this experiment. These preliminary data suggest that wheat cultivar recommendations apply across wheat-fallow and continuous wheat production systems.

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Table 1. Analysis of variance of contrasting seeding rates and hard red spring cultivars across conventional-, reduced-, and no-tillage environments for yield, kernel crude protein (CP) concentration, and kernel weight in a wheat-fallow rotation experiment located at Dickinson, ND, during four-years (1995-98).

Source of Variation	Wheat yield	Kernel CP concentration	Kernel weight
	kg/ha	g/kg	g/1000 kernels
Tillage (T)	NS[1]	NS	NS
Year (Y) x T	*	NS	*
Seeding rate (SR)	*	NS	NS
Y x SR	NS	NS	*
T x SR	NS	NS	NS
Y x T x SR	NS	NS	NS
Cultivar (C)	*	*	*
T x C	NS	NS	NS
SR x C	NS	NS	NS
T x SR x C	NS	NS	NS
Y x T x SR x C	NS	NS	NS

[1]NS = not significant at the *P* < 0.05 level; * = significant at the *P* < 0.05 level.

Table 2. Analysis of variance of contrasting cultivars for wheat grain yield, kernel crude protein (CP) concentration, and kernel weight across wheat-summer fallow and continuous wheat cropping systems during 1994-1997.

Source of Variation	Wheat yield	Kernel CP concentration	Kernel weight

	kg/ha	g/kg	g/1000 kernels
Cropping system (CS)	*[1]	NS	*
Year (Y) x CS	*	NS	NS
Cultivar (C)	*	*	*
Y x C	*	*	*
CS x C	NS	NS	NS
[1]* = significant at the *P* < 0.05 level; NS = Not significant at the *P* <0.05 level.			

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