Barley Cultivar Performance Following Corn in Clean- and No-Till Systems

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SUMMARY

Tillage is being reduced in dryland cropping regions. Our objective is to determine if tillage systems impacts barley cultivar ranking for yield and grain quality traits. Six barley cultivars were compared for grain yield, test weight, and kernel plumpness under clean- and no-till management in southwestern North Dakota during 2009. Grain yield ranged from 86 bu/acre for the 6-rowed cultivar Stellar-ND to 121 bu/acre for the 2-rowed cultivars Conrad and Pinnacle ($P < 0.05$). Grain test weight ranged from 46 lb/bu for Stellar-ND to 50 lb/bu for Conrad and another 2-rowed cultivar, Conlon. Fewer plump kernels were produced by Conlon than all other cultivars. Tillage had no or minimal effect on grain yield and quality. Similarly, tillage did not affect barley cultivar rank for any grain trait. These results suggest that barley cultivar rank is unchanged as tillage is reduced, but additional data are needed to verify this preliminary observation.
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INTRODUCTION

Tillage is declining in western North Dakota and other dryland cropping regions (Carr et al., 2003a). Previous research at the NDSU Dickinson Research Extension Center indicated that cultivar rank was unchanged for grain yield and quality when tillage was reduced in a wheat-fallow system (Carr et al., 2003a, 2003b). Grain yield also was unaffected by tillage in that study (Carr et al., 2003a). Grain yield and quality were enhanced under no-till compared with clean-till when cropping intensity was increased from crop-fallow to crop-crop in a subsequent study (Carr et al., 2006). This suggests that cultivar rank may be affected by tillage system when crops are grown annually. The objective of this research is to determine if barley cultivar rank changes across contrasting tillage systems in a barley-corn rotation.

MATERIALS AND METHODS

Three 2-rowed (Conlon, Conrad, and Pinnacle) and three 6-rowed (Lacey, Stellar-ND, and Tradition) barley cultivars were established in no-till and clean-till plots in a field where corn previously was grown. A barley-corn rotation was selected because of interest in determining if fusarium head blight would become a problem when these two crops are grown in a 'tight' 2-yr rotation in western North Dakota. Tillage plots were maintained as described previously (Carr et al., 2006). Soil surface coverage by previous crop cover and barley stand counts were determined as described elsewhere (Carr et al, 2006). Days to heading were recorded for plants in each plot, as was plant height at physiological maturity. Grain yield was determined by harvesting each plot. A subsample was used for determination of grain test weight, kernel weight.

Plots were arranged in a randomized complete block in a split plot arrangement. Tillage system comprised whole plots and barley cultivar comprised subplots. Tillage by barley cultivar combinations were replicated three times. Data were analyzed using PROC GLM from SAS for balanced data.

RESULTS AND DISCUSSION

Over 70% of the soil surface was covered by previous crop residue in no-till plots, compared with less than 10% in clean-till plots (Table 1). However, no impact was detected on barley stand establishment by surface residue coverage. Barley heading date, plant height, and spike density were unaffected by tillage system. Grain yield averaged over 100 bu/acre and test weight over 48 lb/bu, regardless of tillage system. There was a statistically significant advantage in kernel weight when barley was grown in clean-till plots (9726 kernels/lb) compared with no-till plots (9999 kernels/lb), as well as in kernel plumpness (clean-till = 98.5% and no-till = 97.9%), although the practical impacts of these small differences are limited.

Barley cultivar selection did not affect plant stand (Table 1). In contrast, Conlon headed 3 to 6 days earlier than other cultivars included in the study. Plant height was similar among all cultivars except for Conrad, which was 4 to 5 inches shorter. Over 50 reproductive spikes/ft^2 were counted in plots of each 2-rowed cultivar included in the study, compared with fewer than 35 for the three 6-rowed cultivar. This may explain why 2-rowed cultivars generally produced more grain than 6-rowed cultivars in this study. Average grain yield of Conlon, Conrad, and Pinnacle were 105, 121, and 121 bu/acre, respectively, compared with an average grain yield of 87, 86, and 97 bu/acre, respectively, for the 6-rowed cultivars Lacey, Stellar-ND, and Tradition (LSD = 12). With the exception of Tradition, 2-rowed cultivars also produced grain with a heavier test weight than 6-rowed cultivars. Heavier kernel weight was produced by Conlon and Pinnacle than any 6-rowed cultivar, but no advantage in kernel weight occurred between Conrad and 6-rowed cultivars. Conrad also produced a relatively low number of plump kernels (96%) compared with other cultivars (98-99%).

Cultivar ranking was unaffected by tillage system for any trait considered in this field experiment (data not presented). Cultivar selection may not be impacted by the tillage reductions that are occurring across cropping systems in western North Dakota. However, additional research is needed to validate the preliminary results generated from this study in 2009.

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Table 1. 2009 Tillage System and Barley Tillage Study, NDSU Dickinson Research Extension Center[1]

	Surface Cover	Plant count	Days to heading	Plant height	Spike density	Grain Yield	TW	Kernels	
Tillage system	-%-	-no./ft^2-	-d-	-in-	-no./ft^2-	-bu/ac-	-lb/bu-	-no./lb-	-% plump-
Conventional	8	19	55	30	42	107	48.7	9726	98.5
No-till	73	16	56	29	40	99	48.4	9999	97.9
LSD 0.05	57	NS	NS	NS	NS	NS	NS	84	0.1
Barley cultivars									
Conlon	41	17	52	30	51	105	50	8841	99
Conrad	45	18	58	26	56	121	50	10,297	96
Lacey	-	19	55	30	24	87	49	10,621	98
Pinnacle	-	17	56	31	51	121	48	8439	98
Stellar-ND	-	18	56	30	30	86	46	10,272	99
Tradition	-	19	55	30	32	97	49	10,702	99
LSD 0.05	NS	NS	1	2	11	12	1	360	0.9

Crop Cultivar Performance Testing Under Organic Management in Southwestern North Dakota

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SUMMARY

Small-grain and field pea cultivar performance testing was done in fields transitioning to certified organic management in 2009. Thirteen hard red spring wheat and six field pea cultivars were compared for grain yield and other selected traits in separate studies. The cultivar Howard produced 61 bu/acre and more grain than other cultivars in the spring wheat study, except for Coteau and Stoa. CDC Mozart averaged 43 bu/acre and more grain than Cruiser and Majoret in the field pea study. Seven emmer treatments representing different seed lots and cultivars were compared in a third field study. Grain yield averaged almost 3600 lb/acre with no difference detected across emmer treatment (P > 0.05). These results indicate that grain yield of hard red spring wheat, emmer, and field pea can exceed 40 bu/acre under dryland management when grown in fields transitioning to certified organic management in southwestern North Dakota.
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INTRODUCTION

Cultivar adaptation studies are valued highly and encouraged by organic farmers and their proponents (Sooby et al., 2007). Previous research suggests that crop cultivars developed and selected in environments managed conventionally are adapted to environments managed organically (Carr et al., 2006), but recent studies indicate that cultivars suited to organic farming methods should be developed and selected under organic management (Mason et al., 2007; Murphy et al., 2007). Research is needed that identifies crop species and cultivars that are adapted to organic farming methods in North Dakota, as well as traits (e.g., rapid emergence; Sooby et al., 2007) that those species and cultivars possess which explain their adaptation to organic environments. Crop cultivar comparison efforts were established under organic management in a field transitioning to certified organic production in 2009 so that superior performing cultivars could be identified.

MATERIALS AND METHODS

The 2009 growing season began much later than is typical. As a result, small-grain and field pea cultivar comparison studies were not established until late May and not harvested until late August (field pea) or early September (emmer and spring wheat).

RESULTS AND DISCUSSION

The late seeding is reflected in the later-than-average first-flower (field pea) and heading (spring wheat) dates that were observed (Tables 1 and 2). Date of first flower was similar among the six field pea cultivars that were compared. In contrast, differences occurred between spring wheat cultivars for heading date. ‘Thatcher’, ‘Waldon’, ‘Glenn’, and Howard were among the first cultivars to reach the heading growth stage, while ‘Red Fife’ and ‘Vesta’ were among the last. Lodging generally did not occur among spring wheat cultivars at physiological maturity, with the exception of Kota (lodging score = 4.5 on a scale of 0 to 9 where 0 = no lodging and 9 = completely flattened). In contrast, all emmer treatments had lodging scores greater than 5.0 (Table 3). Field pea lodging scores are not reported.

Field pea plant height ranged from 21 inches for Majoret to 27 inches for DS Admiral (Table 1). Differences between cultivars were not detected in the spring wheat study, with plant height averaging 35 inches (Table 2). Similarly, emmer plant height averaged 36 inches with no differences detected across treatments (Table 3).

CDC Mozart field pea produced a grain yield average of 43 bu/acre, compared with 37 bu/acre for Cruiser and 35 bu/acre for Majoret (Table 1). Both Cruiser and Majoret are green cotelydon-type field pea cultivars, whereas CDC Mozart is a yellow cotyledon-type field pea cultivar. However, CDC Striker is a green cotyledon-type pea cultivar that produced comparable amounts of grain (40 bu/acre) to that produced by CDC Mozart

Grain yield ranged from 61 bu/acre for Howard to 44 bu/acre for Thatcher in the spring wheat study (Table 2). Howard is a modern spring wheat cultivar developed and released by the Agricultural Experiment Station at North Dakota State University in 2006. Thatcher is an old spring wheat cultivar released in 1935. Coteau (released in 1978) and Stoa (released in 1984) still are grown on some organic farms, and both cultivars produced yield levels comparable to the grain yield produced by Howard. Glenn, released in 2005, was the most widely grown cultivar in North Dakota in 2009. Glenn produced an average grain yield of 55 bu/acre in the study. Other cultivars producing grain yield levels comparable to those produced by Glenn included Red Fife (widely grown in the late 19th century), Mida (released in 1944), Chris (relased in 1965), Waldron (released in 1969), along with Coteau and Stoa. In contrast, the old cultivars Marquis (released iin 1910), Kota (released in 1921), Thatcher (released in 1935), and Vesta (released in 1942) produced less grain than either Glenn or Howard.

Emmer grain yield averaged 3574 lb/acre, with little variation across the seven treatments that were compared (Table 3). Similarly, differences were not detected between emmer treatments for any growth trait that was evaluated, as well as grain test weight.

Plans are underway to expand cultivar performance testing under organic management at the Dickinson Research Extension Center in 2010 and beyond. This research will aid farmers in selecting cultivars that are adapted to organic farming conditions in western parts of the state.

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Table 1. 2009 Organic field pea trial, NDSU Dickinson Research Extension Center[1]

Cultivar	Cotelydon type	Plant population -1000/acre-	First flower -July-	Plant Height -in-	Grain yield -bu/acre-	Grain test weight -lb/bu-	Seed weight -g/100 seed-
CDC Golden	YELLOW	617	7	25	41	64.7	2067
CDC Mozart	YELLOW	585	6	20	43	64.5	1899
CDC Striker	GREEN	694	7	25	40	65.4	1832
Cruiser	GREEN	602	7	24	37	64.0	2272
DS Admiral	YELLOW	479	7	27	40	65.2	1866
Majoret	GREEN	536	7	21	35	63.8	2132
Mean		586	7	24	39	64.6	2,011
C.V. (%)		10	7	4	7	1	4
LSD (0.05)		84	NS	1.6	4	1	126

[1]Planting date: 20 May; Harvest date: 25 August; Previous crop = Gazelle spring rye

Table 2. 2009 Organic hard red spring wheat trial, NDSU Dickinson Research Extension Center[1]

Cultivar	Approximate Year of Release	Heading date -July-	Lodging Score 0-9	Plant height -in-	Grain yield -bu/acre-
Red Fife	1885	16	0.3	33	51
Marquis	1910	15	0.8	37	49
Kota	1921	15	4.5	37	45
Thatcher	1935	10	0.3	35	44
Vesta	1942	16	3.8	33	47
Mida	1944	12	2.3	37	51
Acadia	1951	11	1.0	36	52
Chris	1965	13	1.3	34	51
Waldron	1969	10	0.0	35	51
Coteau	1978	15	0.0	35	57
Stoa	1984	11	0.3	35	56
Glenn	2005	10	0.0	35	55
Howard	2006	10	0.0	33	61
Mean		13	1.12	35	52
C.V. (%)		8	72	6	7
LSD (0.05)		1	1	NS	5

[1]Planting date: 20 May; Harvest date: 02 September; Lodging: 0 = no lodging, 9 = completely flat;
Previous crop = Gazelle spring rye

Table 3. 2009 Organic emmer trial, NDSU Dickinson Research Extension Center[1,2]

	Days to	Plant	Lodging	Test	Grain
	heading	height	score	weight	yield
Cultivar	-d-	-in-	0-9	-lb/bu-	-lb/acre-
Bowman	60	36	5.8	34.4	3617.5
Common H	60	36	5.5	36.0	3639.1
Common M	60	36	5.3	33.8	3236.7
Common R	60	35	6.3	35.3	3599.5
Lucille	61	37	5.5	33.6	3607.4
Common ND	60	36	6.0	35.3	3691.1
Red Vernal	61	36	6.0	33.1	3629.6
Mean	60	36	5.8	34.5	3574.4
CV %	0.5	1.9	25.0	4.7	9.9
LSD (0.05)	0.4	NS	NS	NS	NS

[1]Planting date: 20 May; Harvest date: 02 September; Lodging: 0 = no lodging, 9 = completely flat; Previous crop = Gazelle spring rye

[2]H, M, R, and ND refer to different seed lots of common emmer

Dickinson Natural Products Weed Control Efficacy Study

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SUMMARY
Herbicides generally are prohibited from use in organic management systems. However, a small number of products incorporating naturally-occurring active ingredients are permitted under the USDA National Organic Program. These herbicides could be an important tool for organic farmers and, for that reason, a study was conducted to determine the efficacy of five different herbicide treatments on controlling grass and broadleaf weeds in southwestern North Dakota in 2009: Green Match (active ingredient [a.i.] = lemongrass oil), Matratac AG (a.i. = clove oil), Racer (a.i. = ammonium nonanoate), and vinegar (20% acetic acid). All products were applied in plots arranged in a randomized complete block design prior to seeding hard red spring wheat (cv. FBC Dylan). Treatment blocks were replicated four times. Weed control was rated at 1, 7, 14, 21, and 42 days after application. Grain yield was determined when wheat reached physiological maturity. Visual ratings indicated that all herbicides controlled weeds compared with weedy plots where no herbicide was applied ($P < 0.05$). Wheat yield was enhanced from 44 to 61%, depending on the herbicide treatment. Results of this preliminary study suggest herbicides or products having herbicidal activity do have potential in organic management systems, but caution is urged since many are not cleared for use as herbicides in field crops in North Dakota. The one exception in this study was Green Match, which could be used for weed control in wheat during 2009.

INTRODUCTION
The National Organic Program along with organic certification groups emphasize preventative and cultural measures for weed control. However, oftentimes tillage is relied upon heavily for weed control on many organic farms. Unfortunately, the deleterious impacts of excessive tillage on soil structure, organic matter content and humus formation are well known. Recent interest in reduced- or conservation-till, organic farming systems has kindled interest in natural products that might provide organic farmers with a burn-down herbicide option. There are few products that are registered under the USDA National Organic Standards for use as herbicides. These herbicides typically use naturally-occurring substances for weed control, such as clove and garlic oils, soap salts or acids. Little research has been conducted to determine their efficacy in controlling weeds in North Dakota or neighboring states.

MATERIALS AND METHODS
The 2009 growing season began much later than is typical. Cool temperatures prevented early emergence of summer annual weeds and delayed the onset of regrowth by winter annual weeds. Seeding was delayed much later than is recommended so that annual weeds would emerge or resume growth before treatments were applied. A decision was made to seed on 15 June, much later than is recommended, even though the weed population was lower than anticipated. Hard red spring wheat (cv. FBC Dylan) was seeded at 90 lb PLS/acre using a John Deere 750 grain drill in rows 15 cm apart.

All treatments were applied using a hooded bicycle-type sprayer with a 7.5-ft boom and 8004 nozzle tips at a rate of 150 gallons per hectare (60 gpa) on 18 June, beginning at 8:30 AM and ending at 10 AM, under partly cloudy skies and at a relative humidity of 55%. Wind speed during the application period achieved a maximum velocity of 2.7 mph. Treatments were applied in 10 by 20 ft plots that were arranged in a randomized complete block and replicated four times. An unsprayed 5-ft border separated adjacent plots within each block.

Above-ground weed biomass was collected from a 0.25-m^2 area in each plot on 17 June and separated into grass and broadleaf weed samples. The weed population was low and consisted predominately of common lambsquarters, kochia, Russian thistle, and dandelion for broadleaf species, and green foxtail and barnyardgrass for grass species. Weed samples were dried at 130^{o}F until a constant weight was reached, and then weighed. Weights were reported as g/m^2. A second biomass sample was collected on 19 June, approximately 24 hr after the treatments were applied, following the same procedure.

A visual efficacy rating (% control) was given by comparing the density and necrosis of weeds in the center of each plot to the 5-ft untreated area separating adjacent plots by three individuals independently at 1, 7, 14, 21, and 42 days after treatments were applied. A mean was computed from the three ratings each date by plot combination and recorded. Plot centers were marked by flags but otherwise not identified to minimize bias during the rating process. The lack of identifying plot treatments explains how the mean visual efficacy rating did not = 0 for most dates in weedy check plots (refer to Table 1).

Above-ground crop and weed biomass samples were collected from a 0.25-m^2 area on 13 August. Biomass collection occurred as described earlier. Cool weather delayed grain harvest until 18 September, when grain yield was determined by harvesting the cener 8.7-m^2 (93-ft^2) area in each plot using a research harvester.

Data were analyzed using the PROC ANOVA procedure available from SAS. Results of the analyses are summarized in Tables 1 and 2.

RESULTS

It was observed, beginning approximately 7 days after the application of the treatments, that purslane was present at varying populations in plots; very few if any plants occurred in some plots while there appeared populations >4 plants/0.1-m^2 in the untreated border area separating plots, outside the study elsewhere in the field, and in at least one plot in each of the four blocks of treatments included in the study. This observation suggested varying levels of soil activity on this weed species since no purslane was observed before or within a few days after the treatments were applied.

Differences in grass and broadleaf weed biomass were not detected between plots receiving herbicide treatments and the weedy check plots where no herbicide treatment was applied just prior and shortly after the treatments were applied (Table 1). However, visual weed ratings indicated weeds were controlled in plots receiving all herbicide treatments compared with weedy check plots. Differences in visual weed ratings between plots receiving different herbicide treatments generally were not detected, except at 14 days after seeding FBC Dylan wheat (i.e., 15 days after herbicide application) when weed control appeared superior in plots receiving the Green Match treatment compared with Racer.

Differences in grass and broadleaf weed biomass were not detected in plots receiving herbicide treatments and weedy check plots when the wheat crop reached physiological maturity (Table 2). However, more biomass was produced by wheat in plots where herbicides were applied compared with weedy check plots, except when Racer was used. Less wheat biomass was produced in plots receiving the Racer treatments than in plots where Green Match and Vinegar were applied.

Wheat yield was greater in plots were herbicides were applied compared with the weedy check plots (Table 2). These results demonstrate that all herbicides evaluated at Dickinson in 2009 did control weeds compared with weedy check plots. This work will be expanded and continue in 2010.

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Table 1. Pre-treatment application (PRE) and Post-treatment application (POST) weed biomass and visual weed ratings (percent visual weed control) at 1, 7, 14, 21, and 42 days after seeding (DAS) for six natural products at the North Dakota State University, Dickinson Research Extension Center in 2009.

	PRE		POST		Visual Weed Control				
	g/m2				-%-				
Treatment	Grass	Broadleaf	Grass	Broadleaf	1 DAS	7 DAS	14 DAS	21 DAS	42 DAS
Green Match	70	5	65	0	39	26	40	27	39
Matratec AG	43	3	16	3	23	29	33	27	26
Matratec AG + Act90	38	19	13	3	28	33	37	35	38
Racer	65	8	40	0	36	23	18	20	23
Vinegar (20%)	30	11	8	0	49	44	59	68	52
Weedy check	51	8	105	0	0	2	6	2	2
Mean	42	8	35	1	25	22	28	26	26
CV %	77	238	162	358	47	47	39	37	36
P-value	0.68	0.48	0.32	0.6	0.003	0.006	0.0006	<0.0001	0.0002
LSD (0.05)	NS	NS	NS	NS	21	19	19	17	16

Table 2. Crop, grass weed, and broadleaf weed biomass, and hard red spring wheat grain yield following the application of six natural products at the North Dakota State University, Dickinson Research Extension Center in 2009.

	Rate[1]	Biomass (g/m2)			Wheat grain yield	
Treatment	-%-	Crop	Grass	Broadleaf	kg/ha	Bu/acre
Green Match	14	487	32	65	1982	29
Matratec AG	8	404	83	41	1720	26
Matratec AG + Act90	8	397	85	43	1799	27
Racer	6	338	122	76	1717	26
Vinegar (20%)	100	464	150	29	1953	29
Weedy check	-	236	238	73	1238	18
Mean		332	101	47	1487	22
CV %		18	80	73	15.7	15.7
P-value		0.002	0.10	0.48	0.019	0.19
LSD (0.05)		108	NS	NS	411	6

[1]Number indicates percent of total product (active ingredient plus inerts) in solution applied at a rate of 60 gallons per acre.

Status Report of Cover Crop Studies at the NDSU Dickinson Research Extension Center.

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SUMMARY

Considerable interest in cover crops exists because of the benefits to soil quality, pest suppression, and subsequent crop performance that can result when cover crops are incorporated into rotations with grain, seed, forage, and/or industrial crops. Several cover crops studies are underway at the Dickinson Research Extension Center. Hairy vetch, winter rye, and winter wheat planted alone and in cereal/legume combinations are being compared for their impact on weeds and subsequent performance of buckwheat, corn, and pinto bean after cover crops are disked, undercut, and rolled/crimped. The impact of winter rye and hairy vetch cover crops on soil biological, chemical, and physical properties, soil water content, weed growth, and subsequent crop performance is being compared in a separate study when cover crops are disked and rolled/crimped. Five spring-seeded (fababean, spring rye, spring triticale, sudangrass, and a 4-crop mixture) and five fall-seeded (Austrian winter pea, hairy vetch, winter rye, winter triticale, and a 4-crop mixture) cover crop treatments are being compared for impacts on soil water content, soil quality, and subsequent crop performance when cover crops are disked, undercut, rolled/crimped, and mowed in a third study. Buckwheat, corn, flax, dry bean, and spring wheat performance is being compared after seeding into rolled and crimped spring rye, hairy vetch, and winter rye cover crops. These four studies are ongoing and results will be reported as studies are completed, beginning in 2010.