Small-Grain Cultivar Selection for Organic Systems

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Research Summary

The criteria used for the development and selection of modern small grain cultivars is based on performance in environments where synthetic fertilizers and biocides are applied to minimize nutrient deficiencies and pests. Cultivar performance in these environments may not be applicable to organic environments where synthetic fertilizers and biocides are not used. Our objective is to identify small grain cultivars from existing germplasm that are adapted to organic environments. Sixteen seed lots representing fourteen spring wheat cultivars, fifteen seed lots representing thirteen oat cultivars, and five seed lots representing five barley cultivars were sown in replicated and randomized, small-plot adaptation trials in a certified organic field approximately 25 mi east of Dickinson near Richardton, North Dakota. Crop development and weed biomass data were collected. An organic seed lot of the hard red spring wheat cultivar Stoa produced equal or greater amounts of grain compared with other spring wheat cultivars ($P < 0.05$) . 'Glupro' produced grain with the highest protein content while grain with a test weight greater than 60 lb/bu was produced by 'BacUp', 'Gunner', 'Ingot', and 'Parshall'. Leonard and Sesqui were among the highest yielding oat cultivars, while the hull-less cultivar Buff produced grain with the heaviest test weight among oat cultivars. Comparable amounts of grain were produced by the barley cultivars Conlon, Drummond, Lacey, and Robust. The barley cultivar Legacy produced relatively poor yields in 2002.

Introduction

North Dakota leads the nation in organic production of small grains. However, limited efforts by crop scientists have been made at identifying small grain cultivars adapted to organic environments in the state or even the nation. Recently, efforts have been made to identify and develop winter wheat cultivars that are adapted to organic farming environments by conducting adaptation trials in certified organic fields. Our objective is to identify small grain cultivars that are adapted to organic environments in southwestern North Dakota. This effort is part of a larger project with the objective of identifying small grain cultivars that are adapted to organic environments in both North Dakota and Minnesota.

Materials and Methods

A limited comparison of spring wheat cultivars was done in a certified organic field on a commercial farm southeast of Richardton, ND, in 2001. This effort was expanded to include fourteen hard red spring wheat cultivars in 2002. Seed lots produced under conventional and organic management were included for two of the fourteen cultivars, so there were sixteen treatments (14 cultivars + 2 'extra' seedlots) in the spring wheat adaptation study. Thirteen cultivars with seed lots produced under conventional and organic management for two of the cultivars were included in an oat adaptation study in 2002. Five cultivars were compared in a barley adaptation study in the same field that the wheat and oat adaptation studies were located in.

Cultivar and seed lot treatments in each of the three adaptation studies (spring wheat, oat, barley) were arranged in a randomized complete block with cultivar treatments replicated four times. The plots were established using a small-plot planter after the seedbed was prepared by the participating organic farmer using standard practices on his farm.

Wheat and barley were sown at 1.6 million pure live kernels/acre (approximately 41 live kernels/ft^2) and oats at 1.4 million pure live kernels/acre (approximately 32 live kernels/ft^2) in 6 by 27 ft plots. Data on crop emergence and stand, seedling vigor, grain yield, test weight, kernel weight, and protein concentration were collected from each wheat plot. These same data except for protein concentration also were collected from each barley and oat plot. Crop and weed biomass data were collected from three of the four plots for each cultivar. The data were analyzed statistically so differences in agronomic performance between cultivars could be identified.

Results and Discussion

Wheat

Seed lots of the cultivars Parshall and Waldron produced equal or greater numbers of seedlings compared with other cultivars on both dates when seedlings were counted (Table 1). Conversely, fewest seedlings were produced by the seed lot of Stoa

produced under conventional management. There was an average decline in the number of seedlings counted on 7 June compared with 30 May of almost 10% across cultivar treatments. The self-thinning that occurred suggests that a planting rate of 1.6 million PLS/acre may be too heavy for spring wheat at this location.

Seedlings of Parshall, Gunner, and Coteau were among the most vigorous of the cultivars that were included in the study (Table 1). However, only Parshall produced grain yield that was among the largest produced by any cultivar. Grain yield produced in plots established using the organic seed lot of Stoa exceeded yield in plots established with other cultivars except Parshall and Reeder. Conversely, yield in plots established with a seed lot of Glupro was lower than plots established with other cultivars except for BacUp and Red Fife.

Protein content was higher for grain produced by Glupro compared with other cultivars (Table 1). BacUp and Coteau also produced grain with a relatively high percentage of protein.

Gunner, Ingot, and BacUp produced grain with a heavier test weight compared with many cultivars included in the study (Table 1). Conversely, relatively heavy individual kernels were produced by Red Fife, among the lowest yielding cultivars included in the study.

Plants in plots established with seed lots of AC Cadillac, Chris, Glupro, and Red Fife were among the tallest in the study (Table 1). There is a belief among some organic growers that taller crop plants are more competitive with weeds than shorter plants, but this belief is not supported by comparing crop plant stature (Table 1) and weed dry matter (Table 2). For example, grass weeds produced less than 215 lb DM/acre in Walworth plots compared with 429 lb DM/acre in Chris plots, even though crop plants in Chris plots were taller than those in Walworth plots.

Differences in plants grown from the seed lots of Parshall produced under conventional and organic management generally did not exist for any crop or weed trait that was measured (Tables 1 and 2). Conversely, agronomic performance of plants grown from the seed lot of Stoa produced under organic management generally was superior to plants grown from the seed lot produced under conventional management.

Oats

An organic seed lot of the cultivar Hytest produced equal or greater numbers of seedlings compared with other cultivars (Table 3). Hytest seedlings grown from seed lots produced under both conventional and organic management also were more vigorous than seedlings of most other cultivars. However, less grain was produced by Hytest than by the cultivars Leonard, Richard, and Otana. Both the test weight and kernel weight of grain produced by Hytest were among the heaviest of grain produced by any hulled cultivar in the study; grain test weight for Buff was heavier but Buff produces a hull-less kernel or groat. Differences in weed DM production were not detected across oat cultivars in this study (Table 4). Weeds appeared to be less competitive when Triple Crown was grown compared with many other oat cultivars (Table 42), but grain yield was lower for Triple Crown compared with other oat cultivars (Table 3).

More seedlings become established for the cultivar Hytest when a seed lot produced under organic management was planted compared with a seed lot produced under conventional management (Table 3). Plants were taller on 7 June and at physiological maturity in plots where the conventional seed lot was used. No differences in grain yield, test weight, or kernel weight were detected between plots established with the two difference seed lots for Hytest. However, more grain was produced when a seed lot produced under conventional management was used for the cultivar Otana compared with a seed lot produced under organic management. These data demonstrate the impact that seed lot differences can have on agronomic performance of a small grain cultivar.

Barley

The cultivar Conlon produced seedlings in equal or greater numbers that were more vigorous than seedlings produced by other cultivars (Table 5). Height also was greater for Conlon seedlings than for seedlings produced by some of the other barley cultivars. Only the cultivar Legacy produced less grain than Conlon, but grain test weight and kernel weight for Conlon were superior compared with the other cultivars. Weed DM production was similar across the five barley cultivars (data not presented).

Conclusions/Implications of Research

Readers are cautioned to not infer too much from these adaptation studies until additional data are collected. However, some trends have begun to emerge by comparing results of the field studies in 2002 with preliminary efforts in 2001. Grain yield for Stoa and Parshall wheat was equal or superior to yield of other cultivars in both years. However, grain protein content for both cultivars was below the average for the adaptation studies in 2001 and 2002. Conversely,

protein content for grain produced by the cultivar Coteau was relatively high in both years. Weed DM production was less than 500 lb/acre in many plots in both 2001 and 2002, suggesting that heavy weed pressure may not occur when small grain adaptation trials are moved onto certified organic fields.

Readers are reminded that the spring wheat and oat adaptation studies that were located near Richardton also were located at one other site in North Dakota, and at two sites in Minnesota. This experiment will be repeated at four locations for two more years. The authors believe that results of these studies can be used to identify commercial small grain varieties that are adapted to organic farms in western Minnesota and across North Dakota.

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Table 1. Performance of fourteen different organic wheat cultivars in southwestern North Dakota in 2002.

	Plant Counts			Plant Heights						Test
Variety	May 30	June 7	Vigor[1]	May 30	June 7	PM[2]	Kernels	Protein	Yield	Weight
	------ plants/acre---------			----------inches---------- -			-no./lb-	-%-	bu/ac	-lbs/bu-
Stoa -O[3]	1,567,715	1,339,996	1.8	3.7	5.4	25.4	18,278	15.0	31.5	58.4
Parshall-C	1,410,842	1,280,283	1.9	3.9	5.9	23.8	17,537	15.0	29.6	60.8
Reeder	984,756	864,318	2.3	4.3	5.9	21.9	18,053	14.9	29.1	59.1
Parshall-O	1,360,238	1,163,894	1.5	4.1	5.4	23.8	17,894	14.8	29.2	60.8
Gunner	1,316,718	1,113,290	1.5	3.9	5.4	24.9	20,328	15.1	28.4	61.0
Alsen	1,156,809	990,828	2.3	3.7	5.3	21.9	17,854	15.8	27.5	59.5
Walworth	1,119,362	1,019,166	1.9	4.1	5.6	22.3	18,873	15.5	27.5	58.3
Ingot	1,037,384	1,053,577	2.1	4.3	5.7	24.8	18,069	14.7	27.3	61.0
Waldron	1,487,760	1,434,120	1.9	4.2	5.5	26.9	18,041	14.3	26.5	57.5
Coteau	1,294,453	1,279,271	1.4	4.0	5.3	24.0	18,719	16.0	25.0	56.4
AC Cadillac	1,126,447	959,454	1.9	4.5	5.8	26.1	17,745	15.9	23.4	59.3
Stoa-C	666,962	647,732	3.8	3.1	5.3	25.9	16,826	14.2	23.4	54.4
Chris	1,133,532	1,057,625	2.6	4.3	5.5	27.9	21,141	15.4	23.1	57.8
BacUp	1,225,631	1,187,172	2.5	4.1	5.4	23.2	18,672	16.3	21.1	61.0
Red Fife	1,265,102	1,165,918	2.3	4.3	5.3	30.3	16,148	14.2	20.2	56.1
Glupro	1,029,287	898,729	2.6	4.0	5.5	27.5	18,151	18.9	18.2	54.6
Trial Mean	1,198,937	1,090,961	2.1	4.0	5.5	25.0	18,271	15.4	25.7	58.5
C.V. %	13.7	16.1	14.2	5.9	3.8	5.1	4.8	4.2	7.9	1.4
LSD .05	233,232	249,648	0.4	0.3	0.3	1.8	1,258	0.9	2.9	1.2

[1]1 = high vigor; 5 = low vigor.
[2]PM = physiological maturity.
[3]O = organic; C = conventional.

Table 2. Above-ground wheat and weed biomass in plots of different spring cultivars in 2002.

Variety	Biomass			Crop Competitiveness[1]
	Crop Dry Matter	Broadleaf Weed Dry Matter	Grass Weed Dry Matter	
	---------- lbs/acre----------			-% Control-
AC Cadillac	2,560	12	197	51
Alsen	2,205	30	350	35
BacUp	2,242	91	386	44
Chris	2,004	62	429	44
Coteau	2,558	61	254	49
Glupro	2,265	29	341	41
Gunner	2,494	30	214	55
Ingot	2,519	33	214	46
Parshall-O	2,417	68	295	46
Parshall-C	2,741	63	219	35
Red Fife	1,998	32	359	48
Reeder	2,031	33	304	38
Stoa-C	1,180	66	901	18
Stoa-O	2,624	47	290	58
Waldron	2,607	9	288	51
Walworth	2,902	89	213	53
Trial Mean	2,334	47	328	44
C.V. %	12.3	112.5	39.8	25.7
LSD .05	478	NS	218	16

[1]Visual rating of the ability of crop to compete with weeds compared with a check (no crop) control.

Table 3. Performance of thirteen different organic oat cultivars in southwestern North Dakota in 2002.

	Plant Counts			Plant Heights				
Variety	May 30	June 7	Vigor[1]	May 30	PM[2]	Kernels	Yield	Test Weight
	--------plants/acre---------			--------inches-------		-no./lb-	-bu/ac-	--lbs/bu--
AC Assiniboia	1,220,571	1,145,677	1.6	3.3	23.3	13,374	50.7	28.9
Buff	1,095,072	1,050,541	2.1	3.3	22.5	18,304	34.0	45.5
Ebeltoft	1,333,924	1,315,706	1.4	3.2	22.2	14,390	49.2	27.3
HiFi	1,171,991	1,122,399	1.9	3.5	24.8	15,589	44.7	25.8
Hytest-C[3]	1,191,220	1,126,447	1.3	3.8	29.2	13,379	48.7	36.7
Hytest-O	1,438,168	1,313,682	1.0	3.8	26.8	13,655	46.1	37.3
Leonard	1,395,661	1,356,190	1.5	3.4	25.1	15,091	55.8	32.6
Morton	1,157,822	1,102,157	1.6	3.5	27.0	15,227	48.2	31.3
Otana-C	1,244,861	1,142,640	1.9	3.1	27.0	15,711	54.6	32.5
Otana-O	908,849	914,922	2.9	3.1	27.4	15,280	49.5	32.7
Richard	939,212	914,922	2.0	3.8	24.9	15,500	54.7	32.3
Sesqui	1,113,290	1,033,336	1.9	3.3	23.7	15,888	51.8	34.1
Triple Crown	1,279,271	1,212,474	1.8	3.7	23.1	20,973	28.8	15.5
Wabasha	1,270,163	1,171,991	1.8	3.1	23.5	16,563	48.7	35.3
Youngs	1,249,921	1,184,136	1.8	3.2	25.8	13,251	51.3	29.4
Trail Mean	1,200,666	1,140,481	1.8	3.4	25.1	15,487	47.8	31.8
CV %	11.7	12.1	20.8	5.5	4.2	6.0	6.7	4.0
LSD .05	207,346	207,939	0.5	0.3	1.5	1,333	5.0	1.8

[1]1 = high vigor; 5 = low vigor.
[2]PM = physiological maturity.
[3]O = organic; C = conventional.

Table 4. Above-ground crop and weed biomass in plots of different oat cultivars in 2002.

Variety (Source)	July Biomass: Crop Dry Matter	July Biomass: Broadleaf Weed Dry Matter	July Biomass: Grass Weed Dry Matter	Crop Competitiveness[1]
	----------lbs/acre----------			% Control
AC Assiniboia	2,433	61	112	66
Buff	2,571	104	222	65
Ebeltoft	2,957	48	154	74
HiFi	2,590	49	141	75
Hytest-C	2,720	26	161	58
Hytest-O	2,446	33	129	61
Leonard	3,066	37	190	70
Morton	2,899	50	269	64
Otana-C	2,812	24	182	68
Otana-O	2,711	65	383	65
Richard	2,569	42	197	66
Sesqui	2,897	31	245	60
Triple Crown	2,619	34	138	83
Wabasha	2,779	28	227	64
Youngs	3,006	29	175	71
Trial Mean	2,738	44	195	67
C.V.%	13.1	83.6	44.9	9.0
LSD .05	NS	NS	NS	9

[1]Visual rating of the ability of crop to compete with weeds compared with a check (no crop) control.

Table 5. Performance of five organic barley cultivars in southwestern North Dakota in 2002.

Variety	Plant Counts			Plant Height				
	May 30	June 7	Vigor[1]	May 30	PM[2]	Kernels	Yield	Test Weight
	------- plants/acre-------			---------inches---------		no./lb	-bu/ac-	---lbs/bu---
Conlon	1,332,912	1,185,148	1.3	3.7	18.8	11,450	47.1	42.7
Drummond	896,704	793,472	2.6	3.3	19.9	14,512	43.0	40.2
Lacey	1,196,281	1,068,758	1.9	3.7	18.8	16,013	46.8	37.3
Legacy	1,024,227	916,946	2.6	3.2	19.4	14,259	38.0	39.8
Robust	1,137,580	991,840	2.1	3.6	19.9	15,046	45.8	39.0
Trial Mean	1,117,541	991,233	2.1	3.5	19.3	14,256	44.1	39.8
C.V. %	16.3	13.8	20.8	6.3	3.7	4.8	9.1	2.6
LSD .05	280,558	210,045	0.7	0.3	NS	1,057	6.2	1.5

[1]1 = high vigor; 5 = low vigor.
[2]PM = physiological maturity.