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BREEDING SPRING WHEAT FOR ORGANIC AGRICULTURE

Final Research Report W2009-52

INTRODUCTION

Interest in crop breeding and agronomic research for organic production is growing in Canada and the United States. The selection of cultivars for low-input and/or organic environments has not been a priority of past breeding programs. Banziger and Cooper (2001) suggested that cultivars developed through formal crop breeding have not been adopted for low-input conditions because few programs have focused on low-input conditions.

Trials conducted under conventional management have questionable applicability to organic agriculture. Several studies have reported differences in the performance of wheat cultivars in organic and conventional management systems with some cultivars better suited to organic management in northern North America (Carr et al. 2006; Mason et al. 2007; Nass et al. 2003).

Murphy et al. (2007) reported selecting for yield under organic management resulted in genotypic ranks different from conventional management. Przystalski et al. (2008) suggested that selection of cultivars should be conducted under conditions which closely match commercial organic farms and should include traits important to organic farmers.
The objective of the study was to determine if selection results would differ between the two management systems.

WHAT WAS DONE?

A population was created from a cross between the Canadian spring wheat cultivar AC Barrie and the CIMMYT spring wheat cultivar Attila. AC Barrie was the most commonly grown spring wheat cultivar on the Canadian Prairies in the 1990s. Attila is an awned semi-dwarf bread wheat cultivar widely grown in Southeast Asia. The population consisted of 79, F4 derived F6 genotypes.

The experimental study was conducted from 2005 to 2007 at the University of Alberta Edmonton Research Station (ERS). The conventionally managed site was less than 1 km from the organically managed site. In keeping with the station's crop rotation, different areas of each site were used in subsequent years. Plots were seeded with 250 seeds m^{-2} in a randomized complete block design within management system.

Data recorded for each plot included early season vigour, plant height, number of spikes m^{-2}, grain yield, kernels $spike^{-1}$, harvest index, grain protein, weed biomass, days from seeding to anthesis, and physiological maturity.

Breeding lines grown under conventional management (cr. T. Reid)

WHAT HAPPENED?

On average, AC Barrie and Attila yielded less grain with greater protein content under organic than under conventional management (Table 1). In the organic system AC Barrie had 28% greater yield, was 17 cm taller, and had 5% greater protein content than Attila.

Table 1: Least square means of AC Barrie and Attila and the population derived from a cross between the two, grown under organic and conventional management in Edmonton, AB Canada from 2005 to 2007, for 17 agronomic traits.

Variable	AC Barrie		Attila		Diff Between Parents		Population Mean		SE of Diff
	Conv[a]	Org	Conv	Org	Conv	Org	Conv	Org	
Grain Yield (t ha^{-1})	4.54*	2.68*	4.83**	2.09**	-0.29	0.59*	3.88*	1.85*	0.67
Spikes m^{-2}	536	322	414	336	122*	-14	454	343	83
Plant Height (cm)	86	84	71	67	15*	17**	76	74	7.2
Kernels spike^{-1}	31	28	39**	32**	-8**	-4	40	32	3.0
Harvest Index (%)	45	45	49	42	-4	3	47	42	2.3
Grain Protein (%)	14.1**	15.2**	12.8**	14.4**	1.3**	0.8**	13.0	14.8	0.58
Weed Biomass (g)	0	10	1**	20**	-1	-10	1*	13*	3.5
Early Season Vigour	4	4	3	3	1	1*	3	3	0.1
Days to Anthesis	59	53	58	53	1	0	59	53	3.3
Days to Maturity	90	90	95	90	-5	0	94	92	3.5
Grain Fill Duration	32*	37*	37	37	-5*	0	35	39	3.9

*,** Significant at P = 0.05 and P = 0.01 respectively.
[a] Conv: Conventionally managed system; Org: Organically managed system.

In the conventional system AC Barrie had 30% more spikes m^{-2}, was 15 cm taller and had a 10% greater protein content than Attila.

When the population was grown in conventionally managed trials it yielded, on average, double the amount of grain with less recorded weed biomass than organic trials (Table 1). No other traits differed statistically between the systems.

Direct selection in each management system (10% selection intensity) resulted in 50% or fewer lines selected in common for four traits including: grain yield, grain protein, spikes m^{-2}, and grain fill duration (Table 2). If the top yielding 8 lines (10 %) of the population were selected from each management system (based on our results) 3 lines would be in common. Selecting the top 12 (15%) and 16 (20%) lines based on yield resulted in 7 and 8 lines in common, respectively. This suggests that selecting in the two management systems would result in large differences between systems for lines retained for further yield trials in a breeding program. The difference in the relative ranking of lines between systems was also large for other agronomically important traits (Table 2; Figure 1).

Breeding lines grown under organic management (cr. T. Reid)

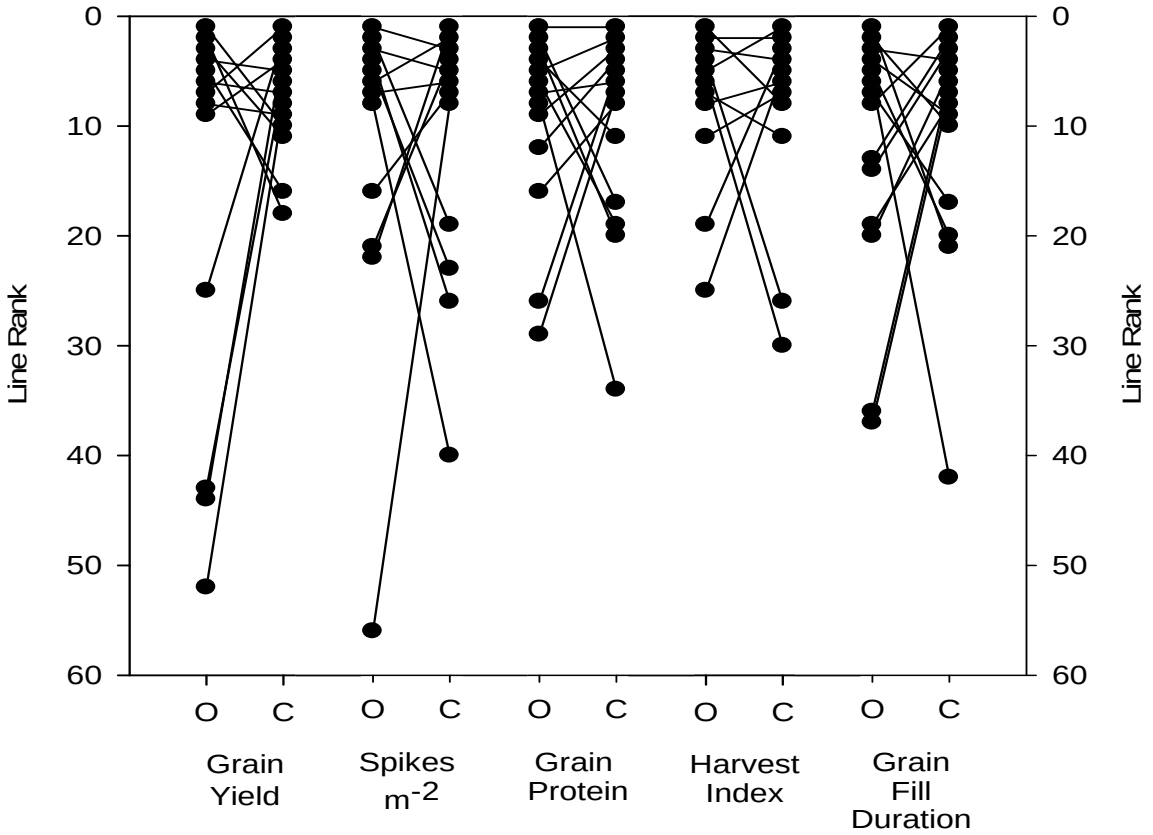

Figure 1: Genotypic ranks changes observed in the top 10% lines ranked under each management system (O: Organic; C: Conventional) for five traits measured in both systems. Rank was assigned according to the desired direction of selection (e.g. rank one for grain yield was the highest yielding)

Table 2: The number of lines in common at three selection intensities, for 14 agronomic traits in a population derived from a cross between AC Barrie and Attila grown under organic and conventional management in Edmonton, AB Canada from 2005 to 2007.

	Lines selected in common		
Trait	10%[a] (8)[b]	15% (12)	20% (16)
Grain Yield	3	7	8
Spikes m^{-2}	4	7	10
Plant Height	7	9	14
Kernel $Spike^{-1}$	6	12	13
Harvest Index	5	7	12
Grain Protein	3	6	13
Weed Biomass	7	10	12
Early Season Vigour	7	9	12
Days to Anthesis	6	11	14
Days to Maturity	7	11	6
Grain Fill Duration	2	4	10

[a] **Selection intensity applied within each system**

[b] **Maximum number of lines selected from the population of 79 lines at the given selection intensity (10, 15, 20 %)**

THE BOTTOM LINE

Selection in conventionally managed land for the purposes of developing cultivars for organic production does not result in the same genotypes being selected for each system for all traits. Based on the results of this study, we believe the selection of spring wheat cultivars for organic production systems should be done on organically managed land.

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Graduate Student Todd Reid, standing in the middle of one of his breeding experiment locations at the University of Alberta, Edmonton Research Station (cr. M. Iqbal)

CREDITS

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