Comparison of selecting spring wheat in conventional and organic environments

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INTRODUCTION

In 2005 over 530,000 ha of land in Canada was dedicated to organic crop production, with wheat accounting for the largest portion at 75,816 ha (Macey 2006). Organic production systems represent a different soil and weed environment that is largely not considered in existing Canadian wheat breeding programs. Due to increased crop stresses of organic management, cultivar performance may be affected to the extent where breeding specifically for organic environments is recommended (Mason and Spaner 2006) and where response to selection can be expected to be maximized (Ceccarelli 1994). There is some evidence suggesting that organic environments are sufficiently different to warrant breeding programs that specifically target organic cropping systems as significant genotype x environment interactions have been detected (Murphy et al. 2007). However, measuring the impact of selection environment on eventual outcomes has not been well studied due to lack of appropriate plant germplasm that offers the same genetic potential but also reflects the specific adaptations that result from the novelty of the selection environment. Understanding the value of directly selecting for the target environment is also important to justify the additional effort that this requires.

Comparing selection environments requires identification of superior breeding lines that are representative of each environment but also derived from the same source populations. The design of such an experiment should be geared to detect the impact of the selection environments and to detect the interaction between organic and conventional selection and testing environments that would be expected to exist if these two environments favour different genotypes.

Since 2004, an organic breeding project has been operating which has been based on starting selection in organic breeding nurseries utilizing the same sources of F2 seed generated for the Canada Western Red Spring (CWRS) breeding program operated at the Cereal Research Centre, Winnipeg. A result of this has been the identification of superior lines from the same populations in two selection environments. This material provides an exceptional opportunity to investigate the outcomes of these potentially distinct growing environments.

A project has been initiated where the same populations, selected in both conventional and organic environments are compared for agronomic performance in both types of environments.

MATERIALS AND METHODS

Populations from seven crosses were identified where there were at least four F2:6 or F3:6 lines remaining from each cross selected in respective conventional and organic environments (Table 1, Figure 1). Conventional materials were grown in breeding nurseries which were exposed to artificially induced epidemics of leaf rust, stem rust, and Fusarium head blight. F3 and F5 generations were grown in contra-season nurseries in New Zealand. Organic breeding nurseries were dependent on naturally occurring disease infection. All lines used to develop the population bulks and check cultivars were increased together to provide a uniform seed source for this experiment. Lines contributing to a bulk were mixed on an equal weight basis. These bulks were used as treatments grown in three-replicate randomized complete block experiments with two locations in each production environment. Five modern CWRS cultivars and the heritage variety Red Fife were used as check cultivars. Agronomic, disease and quality traits were evaluated.

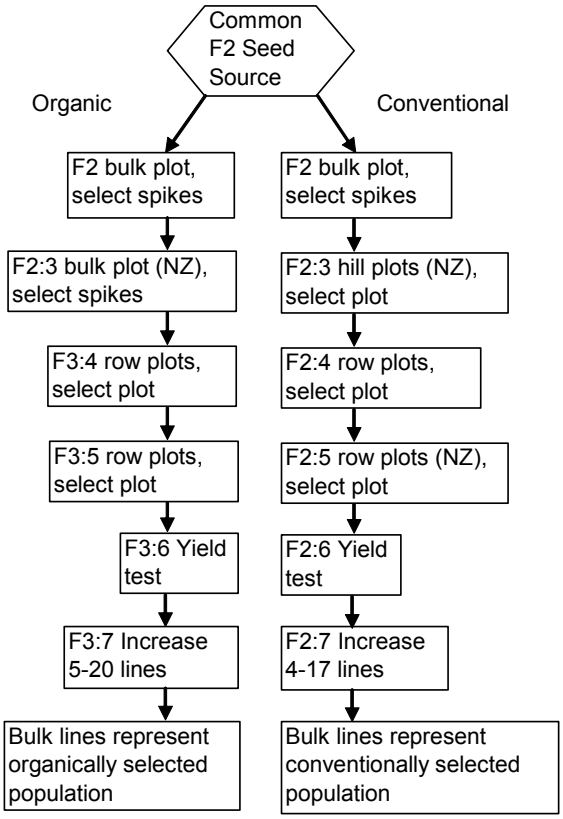

Figure 1. Selection procedure used to identify superior lines for organic and conventional selection environments.

RESULTS AND DISCUSSION

The operation of the breeding nurseries in both selection environments was similar for selection intensity relative to check cultivars for agronomic, and disease traits. There were several differences between how the two selection programs were implemented. The F2 spikes selected in the organic program were bulked and grown as a plot in New Zealand where spikes were again selected. Only the conventional material was tested for flour yield and dough strength using a mixograph in the F2:4. The conventional material was grown in irrigated disease nurseries whereas the organic nurseries were rainfed. The year in which selection occurred differed between selection environments for some generations as using contra-season nurseries is not applicable for organic selection. Thus selection for a trait may be more or less effective in some years. Standard plot management techniques were used including herbicide application in conventional selection nurseries and in-plot harrowing for weed control in organic nurseries at the 4-5 leaf stage. The lines forming the population bulks were successful in meeting similar above-ground selection criteria for agronomic traits and resistance to leaf and stem rust. Reaction to FHB has yet to be assessed.

Table 1. Composition of organic (ORG) and conventional (CON) population bulks and field leaf rust ratings in 2007.

Name	Parentage	No. in bulk	Leaf rust rating
McKenzie	Columbus/Amidon		0 R
Superb	Grandin*2/AC Domain		30 MS
AC Barrie	Neepawa/Columbus//BW90		40 MS
5602HR	AC Barrie/Norpro		1 R
Waskada	BW278/2*BW252		20 MS
Red Fife	Reselection from Ukrainian Introduction		10 S
BC07-ORG	98B25-AS6D01/ND744	20	R
BC07-CON	98B25-AS6D01/ND744	17	R
BC10-ORG	98B25-AG3C7/ND744	13	SEG
BC10-CON	98B25-AG3C7/ND744	12	SEG
BC11-ORG	98B25-DF2B04/ND744	5	SEG
BC11-CON	98B25-DF2B04/ND744	8	SEG
BC23-ORG	98B34-T4B/98B26-N1C01	16	R
BC23-CON	98B34-T4B/98B26-N1C01	10	R
BC37-ORG	97B64-E9B5/96B32-AN3C	7	SEG
BC37-CON	97B64-E9B5/96B32-AN3C	8	SEG
BC41-ORG	BW301/Alsen//94B18-G1E1/9606-EJ03B	6	R
BC41-CON	BW301/Alsen//94B18-G1E1/9606-EJ03B	5	R
BC42-ORG	BW301/Alsen//94B18-G1E1/9606-EJ03B	5	SEG
BC42-CON	BW301/Alsen//94B18-G1E1/9606-EJ03B	4	SEG

Of the tests grown in 2007, one of the two conventional sites was abandoned due to poor establishment. Thus an initial investigation of the interaction between selection and growing environments will not be possible until further test sites are grown in 2008. The data presented are means from two organically managed locations and one conventionally managed. Least significant differences were calculated only when significant treatment effects occurred. Of the traits studied to date, no differences in lodging resistance, maturity or kernel weight were observed (Table 2). Significant differences were noted for height and grain protein concentration. The organically selected material was 2 cm taller and had 0.4% higher grain protein concentration than the conventionally selected material. The organically selected material showed only a numerically higher yield than the conventionally selected populations, but was significantly higher than the check group. The poorer performance of the checks was large attributable to AC Barrie and Red Fife. McKenzie yielded as high as the highest yielding bulk population. Testing in additional environments may improve our ability to detect differences in yield potential. The leaf rust ratings in 2007 (Table 1) showed that both selection environments resulted in similar outcomes for each population for this trait. Little difference between the two selection environments was noted for flour yield and dough strength as measured by mixograph (data not shown).

Table 2. Comparison seven populations selected in organic and conventional environments with agronomic and quality traits.

	Selection Environment						
Trait	Organic	Conventional	Checks	F-stat	F-prob	SED	LSD
Height (cm)	99.0	97.4	100.6	4.07	0.019	1.118	2.2
Lodging (1-9)	1.95	2.17	2.08	0.89	0.413	0.1661	
Maturity (1-5)	3.62	3.79	3.41	2.40	0.094	0.1741	
Yield (kg/ha)	2587	2472	2359	4.73	0.010	72.95	143.0
Kernel weight (mg)	30.6	30.0	30.3	1.30	0.274	0.3778	
Grain Protein (%)	16.7	16.3	16.0	12.84	<0.001	0.1389	0.3

This experiment is being broadened in 2008 to add six locations which will provide data to investigate the presence of interactions between selection and growing environments: significant interactions would suggest that direct selection for organic and conventional growing conditions is important. Eleven additional populations have been identified for conducting similar comparisons, and the organically selected versions of these will be available for testing in 2010.

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