

Participatory Plant Breeding

Another Season's Promise – by Martin Entz

Winter is loosening its grip on Canadians - though the arrival of spring appears particularly slow in the eastern part of the country. But the warming days signal that the growing season will soon be upon us. For some of you, this may be your 40th crop; for others, perhaps only your 3rd. All of us, young and old, share a love and respect for the land and its bounty. This common bond brings us together in anticipation of “another season’s promise”.

This is the 5th year of the farmer participatory plant breeding program. When we started, I wondered if farmers would be interested in getting involved in seed variety development. I recognize that spring is a busy time, and having additional tasks at planting time - like seeding small amounts of seeds in a nursery - can be problematic. But the response has been overwhelming. In 2015, over 50 farmers from coast to coast will be involved in selecting wheat, oat and potato varieties for their organic farms. In addition, several farmers are involved in organic carrot seed production in BC, and in Quebec organic farmers are developing corn varieties for both animal and human uses. Wow!

Eleven farmers started selecting wheat in 2011. Last summer, we had the opportunity to examine the fruits of their 3 consecutive years of selection by growing all the farmer selected varieties in the same field plot at Carman, Manitoba. Some results of this exciting work are being shared in this newsletter issue. What the work shows is that farmers do indeed have a great influence on the variety characteristics - and the overall conclusion of the work is that farmer breeding works!

I want to end by acknowledging the many people who help make this program a success. Thanks to the Canadian plant breeders who continue to share their parental material with us. Thanks to Anne Kirk for making unique wheat and oat crosses and for keeping the project organized. Thanks to the Bauta regional coordinators for helping us stay connected with participating farmers. Thanks to Mrs. Bauta for her generous financial support - without it this work could not proceed. And thanks to USC Canada for being such a great organization to partner with. Finally, a very special thanks to you, the farmers.



Farms growing wheat, oat, and potato populations in 2015

Milling and baking quality of farmer selected wheat

In 2014 wheat populations that had been selected by Manitoba farmers for three generations were evaluated for agronomic performance in a replicated trial at our organic research farm in Carman. Thanks to generous support from Organic Alberta the milling and baking quality of the top performing populations was evaluated.

Composite samples of eight farmer-selected populations and three check varieties were analyzed for milling and baking quality at the Canadian International Grains Institute (CIGI). The check varieties were included for comparison purposes. Carberry and Glenn were chosen as weak and strong gluten checks, respectively. Red Fife was included due to general interest in its baking characteristics under an industrial process. Treatments were analyzed for protein content, falling number, dough strength, and baking quality.

Protein content of the farmer-select populations and modern check varieties ranged from 14.2-16.2%, with most farmer-selected populations reporting protein content similar to that of Carberry and Glenn (Table 1). Red Fife had a protein content of 13.3%, 2% lower than the check varieties (Table 1).

Falling number measures enzyme activity to assess sprout damage in the wheat kernel. A higher falling number indicates low alpha-amylase activity while a low falling number indicates high alpha-amylase activity. This is an important measurement since enzyme activity affects product quality. High enzyme activity results in too much sugar and too little starch, which results in sticky dough and poor texture of the finished product. Five of the eight farmer-selected populations measured had a falling number above 300, indicating no sprout damage in the grain (Table 1). The farmer-selected populations BJ08-IG, BJ11-SC, and BJ11-KB, and the check varieties Carberry and Red Fife had falling number values ranging from 250-300, indicating some sprout damage (Table 1).

Farinographs measure flour water absorption and dough strength. Absorption is measured as the amount of water required to form the dough and center the curve over the line. Stability time is the length of time the dough maintains maximum consistency and indicates dough strength. Flour with weak gluten has lower water absorption and shorter stability time than strong gluten flour. None of the farmer-selected populations had stronger dough strength than Glenn, the strong gluten check. With the exception of BJ08-IG, BJ11-KB, and BJ27-MW, the farmer selected populations had dough strength similar to that of Carberry. Red Fife had low water absorption and a short stability time, indicating weak gluten strength (Table 1).

The Canadian short process baking test was used to assess the suitability of the farmer selections and checks to an industrial baking system. The farmer-selections BJ28-MW, BJ18-KS, and BJ08-CG had a loaf volume similar to that of Carberry and Glenn, while BJ08-IG and BJ11-SC had a loaf volume similar to Red Fife (Table 1). Loaf volume may be correlated to protein concentration, gluten content, and gluten network development. In 2015 the farmer selected populations will be evaluated for bread making quality by a small scale bakery.

The majority of the farmer selected populations tested have good quality characteristics and are similar to registered Canadian Western Red Spring varieties. Since this breeding program starts with good quality parents it is not surprising that those quality characteristics would be retained.

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Table 1. Protein content (%), falling number (sec), flour water absorption (%), stability of dough (min), and loaf volume (cm³) of the eleven treatments analyzed for baking quality.

Variety ¹	Protein content (%)	Falling number (sec)	Farinograph		Loaf Volume (cm ³)
			Absorption (%)	Stability (min)	
BJ08-IG	16.2	290	62.9	6.8	947
BJ18-KS	15.4	345	64.6	8.3	1064
BJ08-CG	15.8	307	63.5	7.5	1067
BJ11-SC	15.1	267	62.8	7.5	959
BJ28-MW	14.2	381	62.5	7.5	1043
BJ27-MW	15.4	414	64.2	6.5	1015
BJ21-HRE	16.2	327	64.7	7.8	1009
BJ11-KB	14.7	272	61.9	6.5	996
Glenn	15.3	331	64.6	9.8	1041
Carberry	16	290	64.3	7.6	1045
Red Fife	13.3	268	57.5	2.3	967

¹The initials of the farmer that selected the population have been added to the population name.

The overall results of this study indicate that farmer selected populations are better adapted to organic crop production than conventionally selected varieties. As a group the farmer selected populations displayed greater early vigour, higher yield, and increased concentrations of certain micronutrients (calcium, zinc, iron, and manganese) in the grain than the conventionally selected checks. There was no difference in leaf disease between the farmer selected populations and the conventionally selected checks indicating that the farmer selected populations have a good level of disease resistance. As a group the farmer selected populations were significantly taller than the conventionally selected checks and matured later. The milling and baking quality results indicate that the majority of the farmer selected populations tested have quality characteristics similar to registered Canadian Western Red Spring varieties.

This study highlights the large influence that the individual farmer and the selection environment have on shaping a population. Three years of on-farm selection had a significant impact on agronomically important characteristics such as days to maturity, lodging and height, as well as the nutrient density of the grain. The characteristics of the populations changed depending on the selection environment and the preferences of the person making selections, showing that a population can be tailored to the growing environment and needs of an individual farmer. Grain phosphorus (P) status varied among farmer selected populations indicating that there is potential to select for organic wheat types that are able to capture soil P, even when soil available P levels appear low.

The results of this Manitoba based pilot project show the positive impact of involving farmers in plant breeding and the gains that can be made by just three years of on-farm selection.

The complete report can be found on the Natural Systems Agriculture website:

<http://www.umanitoba.ca/outreach/naturalagriculture/ppb.html>

Seeding your wheat and oat populations

Planting a small amount of wheat or oat seed under field conditions can seem like a challenge to farmers that are new to this project. Farmers participating in this project have been using various techniques to plant their populations, and have found that it really isn't that difficult or time consuming.

Garden seeder

A garden seeder works well for planting small amounts of seed, and I have heard comments from many farmers that it was much easier to plant using a garden seeder than they thought it would be.

Some people use the beet seed wheel, while others have had success using the popcorn wheel. To achieve the correct seeding rate it may be necessary to run over each row twice with a garden seeder.

Seeding at a consistent depth can be a challenge, especially when seeding on uneven ground. To create a smooth seedbed and to ensure straight rows some farmers have run their empty air seeder over the area where they plan to plant their PPB plots, then follow the seeder marks with the garden seeder.

Modify a planter

Some farmers have experimented with modifying a planter or press-drill to be able to plant small quantities of seed.

If you are thinking about planting these populations using field equipment keep in mind that it can be difficult to achieve uniform seeding density.

In order for a small amount of seed to go through the roller it may be necessary to insert a plastic spacer to reduce the distance between the bottom of the seed box and the roller.



Garden seeder used to seed oat plots



Plots seeded using a garden seeder



Plots seeded following air seeder furrows

What's new?

We have been developing new potato, wheat, and oat populations based on your feedback and parental suggestions. Duane Falk is developing new genetic diversity for the potato breeding program and will have populations to distribute to farmers in spring 2016.

Duane harvested true potato seed in the fall of 2014, planted it in the greenhouse and harvested mini-tubers this winter. These mini-tubers will be planted on his farm this spring and the tubers produced will be sent to farmers in the spring of 2016 for selection.

This winter was also busy for the wheat and oat program with new crosses being made in the fall and an F1 seed increase this winter. The F1 seed increase will be harvested in a couple of weeks and the F2's will be planted at our organic research farm in Carman. These populations will be sent to farmers as F3's in spring 2016.



Mini-tubers from Duane's true potato seed grow out. Look at all of that diversity!



F1 wheat plants from four different crosses. The parents used in these crosses were suggested by farmers from across Canada.

Thank you for your participation in this exciting project!



Martin Entz



Anne Kirk

