# Field performance of farmer-selected wheat populations in Western Canada

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## Background

Organic farming presents unique challenges that include limitations in available soil nutrients and interference from weeds. Due to the unique stresses found under organic management, selecting crop cultivars for organic crop production under organic production systems is recommended. Previous research conducted at the University of Manitoba has demonstrated that performance of spring wheat (*Triticum aestivum* L.) in organic systems is improved if the plant breeding process occurs under actual organic field conditions.

A further step in developing crop cultivars adapted to organic production systems is to involve farmers directly in the selection process through participatory plant breeding (PPB). PPB is a collaboration between researchers and farmers that aims to restore the place of farmers in the plant breeding process. In Canada the majority of cultivar development occurs under conventional management in environments that have been made homogeneous through the use of chemicals and fertilizer. Due to the more diverse nature of organic farms, involving farmers in the plant breeding process by having them conduct selection on-farm may be particularly beneficial to organic farmers.

A PPB program for spring wheat was initiated by the University of Manitoba in collaboration with Agriculture and Agri-Food Canada (AAFC) in 2011. A plant breeder made the cross and provided early generation populations to farmers located in Manitoba. After three years of on-farm selection, the farmer-selected wheat populations were returned to the University of Manitoba for further testing. In 2014, we tested all of the farmer selected populations in a common study at the Carman research station. The objective was to test field performance and quality of farmer selected wheat populations and compare them with some registered varieties. The plots were grown on the long-term organic land at Carman.

# Methods

**Part 1 – Getting farmers involved**

Early generation (F3 or 3$^{rd}$ generation) wheat populations from the organic wheat breeding program at the University of Manitoba were distributed to eight farmers located in Manitoba in 2011 (Figure 1). With input from the plant breeder and coordinator, the participating farmers chose wheat populations based on the known characteristics of the parental lines. Each farmer chose three populations and was given 5,000 seeds of each population in order to seed a 20m$^2$ area. Plots were seeded on farm using a garden seeder or by hand and selections occurred throughout the growing season based on the farmer's preferences.

Selections were made throughout the growing season by removing undesirable plants from the populations, with final selections being made at harvest. At harvest farmers selected approximately 300 spikes/population to move forward to the next generation, with the exception of one of the participating farmers who bulk harvested the plots. The selected spikes were sent to the University of Manitoba for threshing and cleaning and returned to the farmers the following spring. This process was repeated for 3 consecutive years: 2011, 2012 and 2013. In 2013, the F6, or 6$^{th}$ generation, was harvested by the participating farmers.

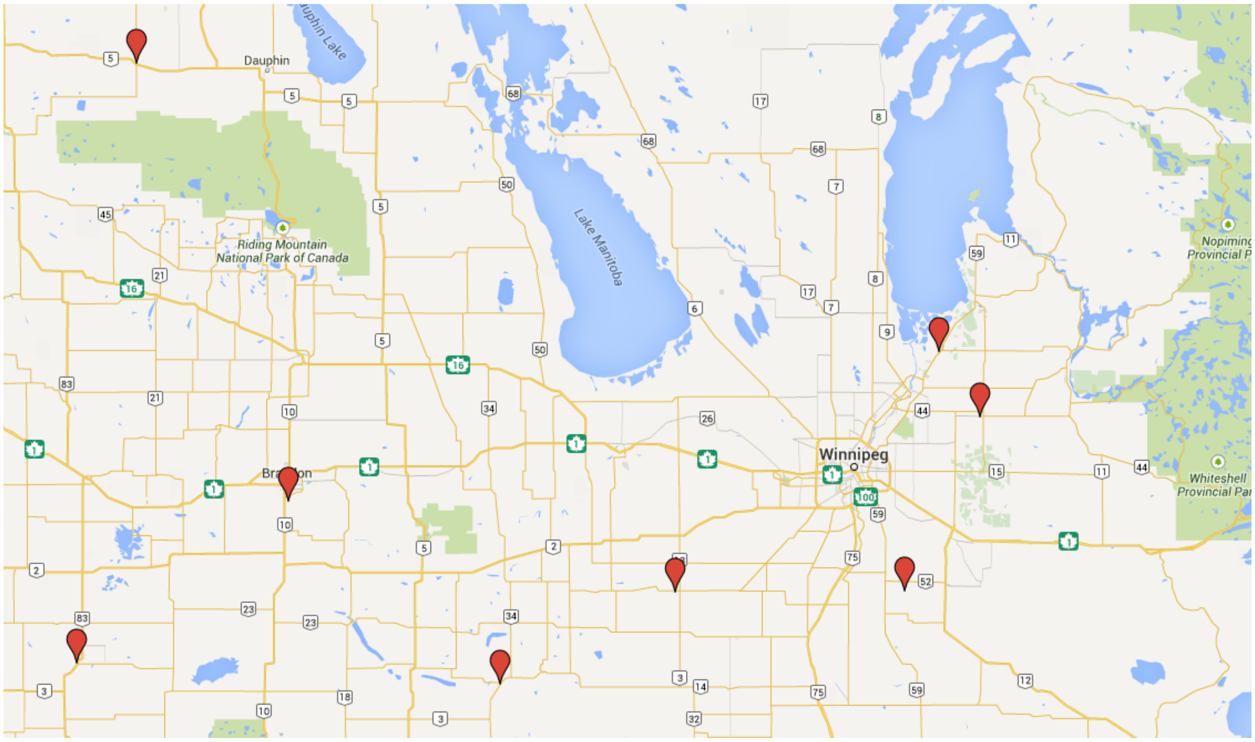


**Figure 1.** Location of the farms in the participatory wheat breeding program in 2011.

### Part 2 – The research trial

To evaluate the field performance and quality of the farmer-selected populations the F6 (6$^{th}$ generation) farmer selections were seeded in a replicated field experiment at the University of Manitoba research farm near Carman, Manitoba. Check cultivars were included in the study for comparison purposes. A complete treatment list can be found in Table 1.

The field experiment was replicated four times and the plot size was 2 m$^2$. Data was collected throughout the growing season on plant density, early season vigour, growth stage, leaf diseases, leaf and stem rust, fusarium head blight, crop and weed biomass, height, days to maturity, lodging, spike density, yield and harvest index. Thousand kernel weight was measured post-harvest, and a subsample of seed was analyzed for macro and micronutrients.

**Table 1**. Treatment name and pedigree (female parent/male parent) of the treatments included in the study. Farmer selected populations were selected under organic crop production as part of the participatory plant breeding (PPB) project. Check cultivars were selected under conventional crop production.

| Treatment[1] | Pedigree |
|---|---|
| ***Farmer selected populations*** | |
| BJ08-IG | BW430/BW897 |
| BJ22-IG | 3X1-134*FA0067/BW880 |
| BJ23-IG | BD94B*D0371/BW880 |
| BJ26-KS | ND04/3-21/BA51*B92 |
| BJ32-KS | BD92A*D0621/BW410 |
| BJ18-KS | BW429/BW880 |
| BJ11-CG | ACS 54608/Waskada |
| BJ08-CG | BW430/BW897 |
| BJ10-SC | ACS 54608/BW342 |
| BJ11-SC | ACS 54608/Waskada |
| BJ25-SC | ND04/3-21/BW874 |
| BJ28-MW | SD3948/BW880 |
| BJ27-MW | SD3948/97B64-F9A3 |
| BJ03-HRE | HW341/BW342 |
| BJ13-HRE | BW433/BW430 |
| BJ2-HRE | 3X1-134*FA0067/BW875 |
| BJ11-KB | ACS 54608/Waskada |
| BJ04A-KB | HW341/Vesper |
| BJ10A-KB | ACS 54608/BW342 |
| BJ05-GM | HW341/Waskada |
| BJ15-GM | BW425/BW430 |
| BJ43-GM | 3X1-134*FA0067/BW342 |
| PA00-KB-AL | Red Fife/5602 HR |
| ***Check cultivars*** | |
| AC Cadillac | Pacific*3/BW553 |
| Glenn | ND2831/Steele-ND |
| AAC Brandon | Superb/CDC Osler//ND744 |
| Carberry | Alsen/Superb |
| Unity | McKenzie*3//BW174*2/Clark |
| AC Vesper | A/HWA//*3ACBarrie/6/BW150*2//Tp/Tm/3/2*BW252/4/98A190/5/Sup |
| PT245 | Somerset/BW865 |

[1]The initials of the farmer that selected the population have been added to the population name. In some cases more than one farmer received the same population.

# Results

## Agronomic Characteristics

Days to maturity (DTM), height, lodging, yield and thousand kernel weight results for all treatments included in the field study are presented in Table 2.

**Table 2.** Days to maturity (DTM), height (cm), lodging index, yield (kg $ha^{-1}$), thousand kernel weight (TKW), and protein of all treatments included in the study.

| Treatment | DTM | Height (cm) | Lodging[1] | Yield (kg $ha^{-1}$) | TKW (g) |
|---|---|---|---|---|---|
| BJ08-IG | 98 | 102 | 3.7 | 4658 | 35.0 |
| BJ22-IG | 99 | 103 | 1.5 | 4983 | 35.2 |
| BJ23-IG | 98 | 100 | 3.0 | 4928 | 33.6 |
| BJ26-KS | 94 | 101 | 3.5 | 4622 | 31.2 |
| BJ32-KS | 96 | 99 | 3.8 | 4027 | 32.4 |
| BJ18-KS | 100 | 103 | 4.5 | 5318 | 32.1 |
| BJ11-CG | 105 | 103 | 5.3 | 4788 | 34.0 |
| BJ08-CG | 103 | 103 | 3.3 | 5095 | 33.0 |
| BJ10-SC | 100 | 92 | 2.8 | 4750 | 32.2 |
| BJ11-SC | 104 | 103 | 3.8 | 4740 | 32.6 |
| BJ25-SC | 103 | 91 | 4.5 | 4536 | 32.5 |
| BJ28-MW | 98 | 100 | 1.8 | 4834 | 33.0 |
| BJ27-MW | 95 | 96 | 3.3 | 5102 | 34.6 |
| BJ03-HRE | 98 | 93 | 3.0 | 4457 | 33.1 |
| BJ13-HRE | 99 | 104 | 4.0 | 4635 | 36.2 |
| BJ21-HRE | 99 | 94 | 1.8 | 4856 | 34.7 |
| BJ11-KB | 103 | 103 | 3.3 | 5081 | 35.6 |
| BJ04-KB | 99 | 100 | 2.8 | 4311 | 35.5 |
| BJ10-KB | 101 | 109 | 2.8 | 4716 | 34.8 |
| BJ05-GM | 100 | 99 | 2.5 | 4184 | 35.0 |
| BJ15-GM | 100 | 103 | 3.3 | 4332 | 35.6 |
| BJ43-GM | 102 | 96 | 2.5 | 4041 | 34.9 |
| PA00-KB-AL | 101 | 108 | 4.5 | 4453 | 35.0 |
| AC Cadillac | 96 | 102 | 4.5 | 4437 | 36.2 |
| Glenn | 99 | 91 | 1.3 | 4834 | 32.6 |
| AAC Brandon | 97 | 83 | 2.5 | 4272 | 37.2 |
| Carberry | 97 | 81 | 1.8 | 3315 | 33.8 |
| Unity | 98 | 98 | 3.5 | 5108 | 37.4 |
| AC Vesper | 94 | 93 | 2.0 | 5050 | 36.4 |
| PT245 | 93 | 91 | 1.0 | 3591 | 34.5 |
| *Pr > F* | *<.0001* | *<.0001* | *<.0001* | *<.0001* | *0.0449* |
| *LSD* | *4.23* | *3.60* | *1.01* | *505* | *4.9* |

[1]1-9 rating scale, with 1 given to plots with erect stems and 9 given to plots with plants that are flat on the ground.

Farmer selected populations compared to conventionally selected checks

To compare the farmer selected populations to the conventionally selected checks treatments were combined and analyzed as two groups: farmer selected populations and conventionally selected checks.

*Early Season Vigour*

Early season vigour was visually rated and took into account the general health and appearance of the plants, row cover and tolerance to harrowing (Figure 1). There were significant differences in early vigour across treatments, and as a group the farmer selected populations displayed significantly greater early vigour than the conventionally selected varieties (Figure 2A).

**Figure 1.** A treatment with poor early season vigour (left) compared to a treatment with good early season vigour (right).

*Leaf Disease*

Leaf disease was measured at heading and plant maturity by visually estimating the percent of the flag leaf surface area that showed symptoms of disease. There were significant differences between treatments at maturity, but not at heading. When analyzed as a group there were no significant differences between the farmer selected populations and the conventionally selected check varieties (Figure 2B).

*Plant height*

As a group the farmer selected populations were significantly taller than the conventionally selected check varieties. The average height of the farmer selected populations was 9 cm taller than the conventionally selected check varieties (Figure 2C).

*Days to maturity*

There were significant differences across treatments for days to maturity. As a group the farmer selected populations matured four days later than the conventionally selected check varieties (Figure 2D); however, there were large differences in days to maturity between treatments.

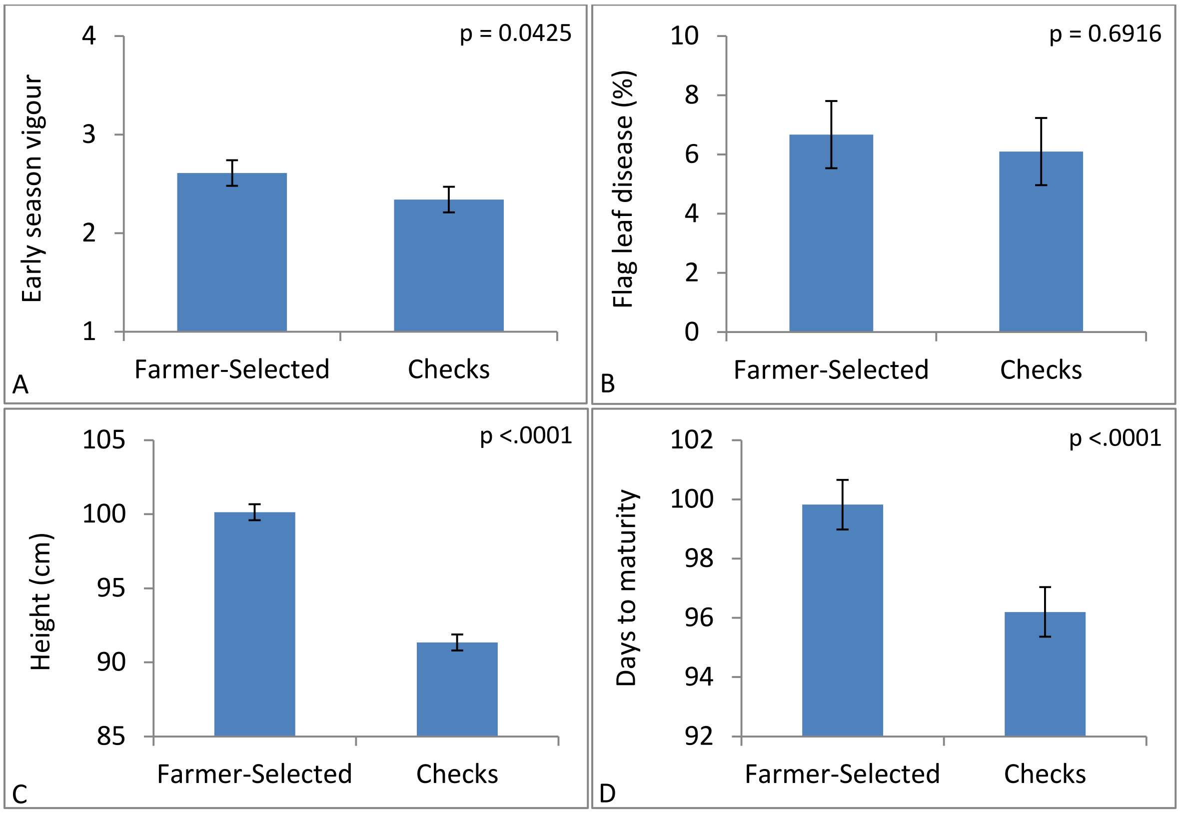


**Figure 2.** Farmer selected populations compared to the conventionally selected check varieties for: **A)** early season vigour (visually rated with a 1-4 rating scale with 4 being the most vigourous), **B)** percent of flag leaf showing symptoms of leaf disease, **C)** plant height, and **D)** days to maturity. A P value of <0.05 indicates a significant difference between the famer-selected populations and conventionally selected check varieties.

*Lodging*

Lodging was rated using a 1-9 rating scale with a rating of 1 given to plots with completely erect stems and 9 to plots with plants that are flat on the ground (Figure 3). There were significant treatment differences in lodging and as a group the farmer selected populations lodged more than the conventionally selected checks (Figure 4A). On average, the farmer selected populations received a lodging rating of 3, while the conventionally selected checks were rated as a 2 (Figure 3).

**Figure 3.** Wheat plots at the time lodging was evaluated. Plots with a lodging rating of 1 (left), 3 (middle), and 5 (right).

*Yield*

There were significant yield differences between treatments. As a group the farmer selected populations yielded significantly higher than the conventionally selected checks (Figure 4B). On average the farmer selections yielded 3 bu $ac^{-1}$ greater than the conventionally selected check varieties.

*Thousand kernel weight*

There were significant differences in thousand kernel weight across treatments, but there was no significant difference between the farmer selected populations and the conventionally selected checks (Figure 4C).

*Kernel number per unit area of land*

Kernel number per unit of land is a measure used by plant breeders and crop physiologists to better understand the yield potential of cereal crops. It is generally accepted that yield of cereal crops like rice, wheat, and oats are limited by the seed number per unit area of land. Results of this work show that there were significant differences in kernel number per unit area of land across treatments. On average, the farmer selected populations had 700 more kernels $m^{-2}$ than the conventionally selected checks (Figure 4D). This result demonstrates that farmers were indeed increasing the yield potential compared to the conventionally bred varieties – an exciting development.

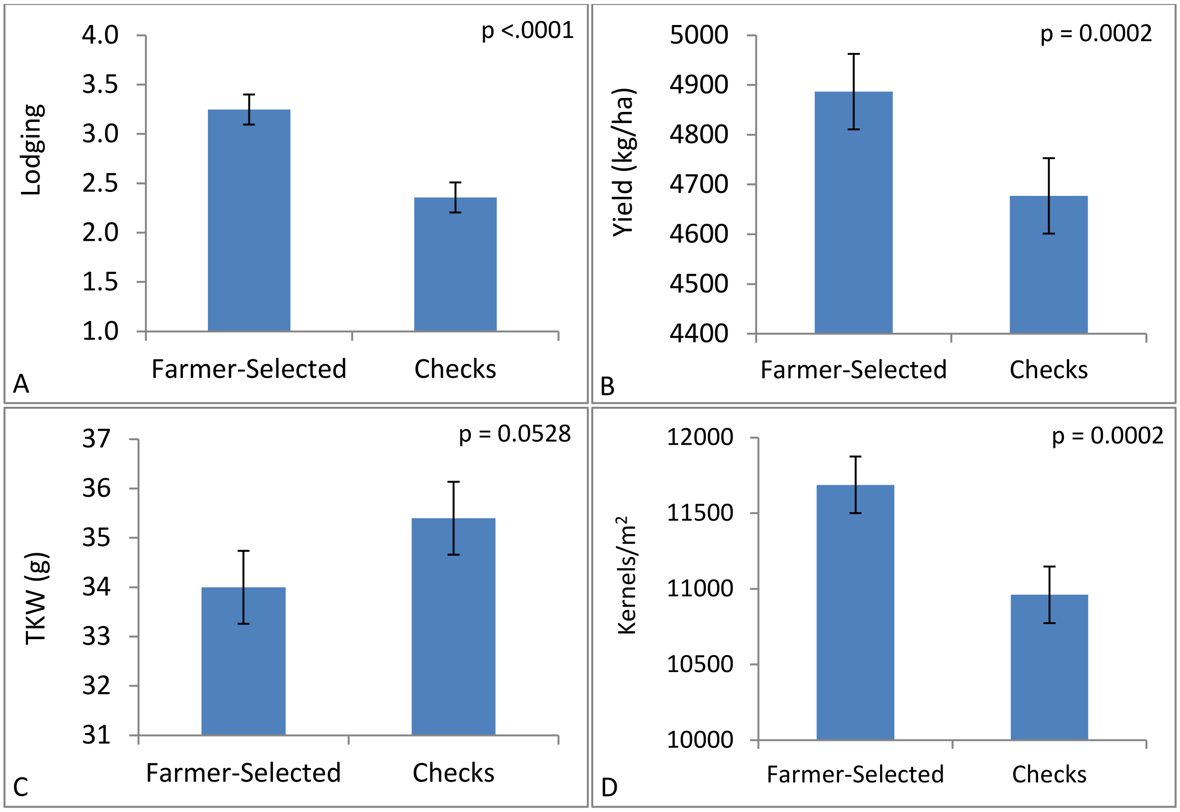


**Figure 4.** Farmer selected populations compared to the conventionally selected check varieties for: **A)** lodging (1-9 rating scale with a higher number indicating more lodging), **B)** yield (kg/ha), **C)** thousand kernel weight (TKW), and **D)** kernel number per unit area. A P value of <0.05 indicates a significant difference between the famer-selected and conventionally selected check varieties.

How do farmer selections shape a population?

Having more than one farmer make selections in the same population provides a unique opportunity to see how the person making the selections in their particular selection environment influences the population. While the populations started out the same, the characteristics of these populations shifted over the three year period of on-farm selection.

There were three populations that were distributed to more than one farmer. Results showed that these populations were similar in terms of yield and amount of leaf disease. There were, however, differences in early season vigour, height, days to maturity, and lodging (Figure 8).

*Early season vigour*

There were significant differences in early season vigour in the population BJ11, with BJ11 selected by farmer SC (BJ11-SC) having greater early season vigour than BJ11 selected by farmer KB (BJ11-KB) (Figure 8A). Differences in early season vigour between the same population selected by two different farmers are likely due to the selection environment since this is a characteristic that has not been directly selected for. Farmer-selected populations with greater early season vigour may have had greater weed competition early in the growing season during the on-farm selection period, which would have resulted in collecting seed from the most vigourous plants. The treatment with greater early season vigour may have also been a better quality seed sample which may have resulted in faster germination, or the population may have been more tolerant to harrowing.

*Height*

The population BJ10 had significant height differences between treatments selected by two different farmers (Figure 8B), with BJ10 selected by farmer KB (BJ10-KB) measuring 17 cm taller than BJ10 selected by farmer SC (BJ10-SC) (Figure 5). In general, the farmer selected populations were taller than the conventionally selected check varieties, but comparing the individual farmer selections shows how much of an influence the person making selections has on a population in just three years. The height difference between the farmer selections is likely due to the farmers' preference for taller or shorter wheat.

**Figure 5.** The population BJ10-SC (left) measuring 92 cm tall compared to BJ10-KB (right) at 109 cm.

*Days to maturity*

There was a significant difference in days to maturity in the population BJ08 (Figure 8C), with BJ08 selected by farmer IG (BJ08-IG) reaching maturity in 98 days, while BJ08 selected by farmer CG (BJ08-CG) reached maturity in 103 days (Figure 6). The five day difference in days to maturity between these two populations may be explained by the selection environment. BJ08-IG was selected in the Brandon area, which on average has a 10 day shorter frost free period than Carman, Manitoba where BJ08-CG was selected. What happened in this case is that the farmer from the shorter season region actually produced a wheat “variety” that reaches maturity faster than the farmer from the longer season region. This is a good example of how genetically diverse populations can be tailored to the environment where they will be grown, and the importance of farmer involvement in the early plant breeding process.

**Figure 6.** The population BJ08-IG (left) reached maturity in 98 days compared to BJ08-CG (right) which reached maturity in 103 days.

*Lodging*

There were significant differences in the amount of lodging in population BJ11 (Figure 8D), with BJ11 selected by farmer CG (BJ11-CG) lodging more than BJ11 selected by farmers SC (BJ11-SC) and KB (BJ11-KB) (Figure 7). Differences in the amount of lodging between farmer selections may be due to a combination of the selection environment and the person making the selections. Soils that are very high in fertility tend to result in greater issues with lodging, and when the entire population is lodged it is difficult to make selections. If some lodging occurs within a population during the three years of on-farm selection the person making selections may be able to select spikes from plants that have stronger stems.

**Figure 7.** The population BJ11-KB (left) had a lodging rating of 3, while BJ11-CG (right) had a lodging rating of 5.

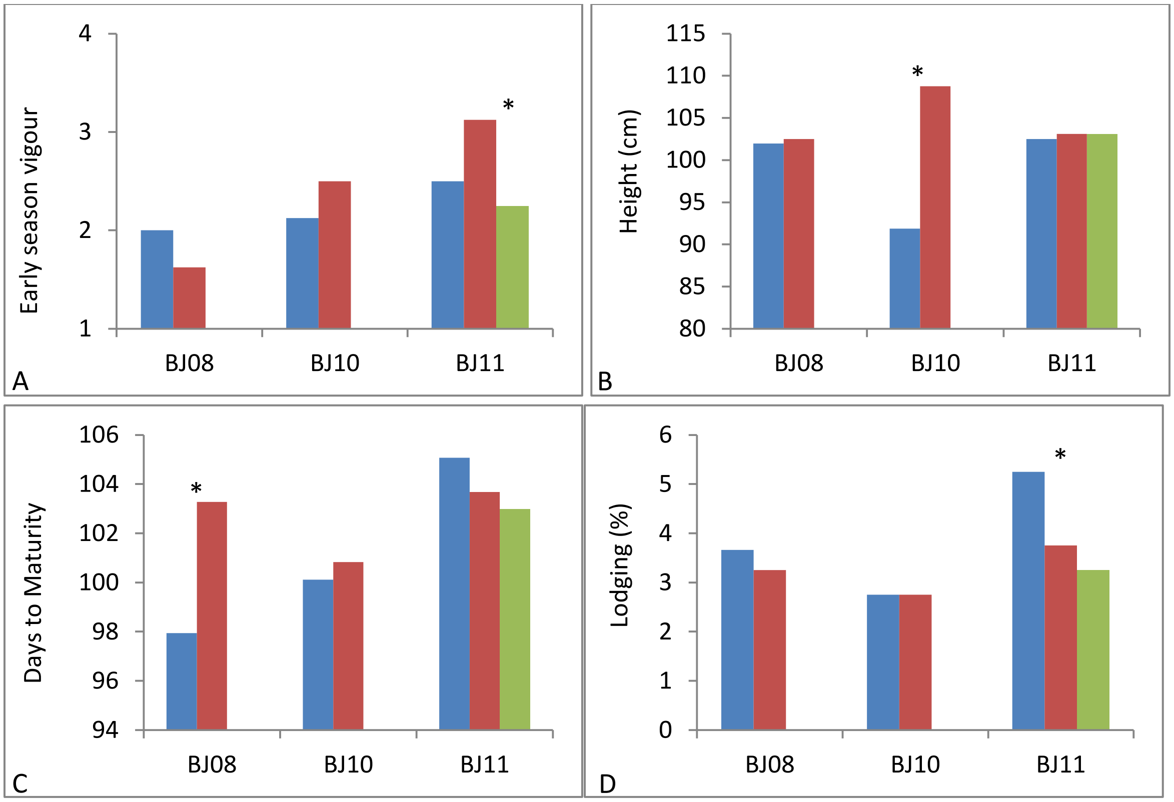


**Figure 8.** Comparison of populations selected by different farmers for: **A)** early season vigour (visually rated with a 1-4 rating scale with 4 being the most vigourous), **B)** height (cm), **C)** days to maturity, **D)** lodging (1-9 rating scale with a higher number indicating more lodging). From left to right the populations shown in each figure are BJ08-IG, BJ08-CG, BJ10-SC, BJ10A-KB, BJ11-CG, BJ11-SC, and BJ11-KB. An asterisk (*) over bars within the same population indicates that there is a significant difference between treatments within that population.

**Grain nutrient analysis**

After harvest, all farmer-selected and commercial check varieties were analyzed for macro and micronutrients.  Grain nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), zinc (Zn), iron (Fe), manganese (Mn), and boron (B) concentrations for all treatments can be found in Table 3. There were no significant differences among varieties for sulfur (S) and copper (Cu) concentrations.  It was interesting to observe that wherever differences were detected, the farmer selected populations that had significantly greater concentrations of nutrients than the commercial varieties (eg., Ca, Zn, Fe and Mn)  (Table 4).

Greater concentrations of Ca, Zn, Fe and Mn in the farmer-selected populations may be due to the selection environment, the genetics of the populations, or a combination of both.  Conducting selections on organically managed land may have resulted in an improved ability of the root to uptake mineral nutrients, or improved the ability of the plant to allocate mineral nutrients to the grain.  Conducting selections in an environment with lower levels of available phosphorus may have improved the ability of these populations for form a symbiotic relationship with arbuscular mycorrhizal fungi (AMF), which not only improves uptake of P, but also of Cu and Zn.

**Table 3.** Total nitrogen (N), protein, phosphorus (P), potassium (K), calcium (Mg), zinc (Zn), iron (Fe), manganese (Mn), and boron (B) grain concentration of all treatments included in the study.

| Treatment | Total N | Protein[1] | P | K | Ca | Mg | Zn | Fe | Mn | B |
|---|---|---|---|---|---|---|---|---|---|---|
| | ----------------------------------- % ----------------------------------- | | | | | | ----------------- ppm ----------------- | | | |
| BJ08A-N-IG | 3.11 | 17.1 | 0.40 | 0.289 | 0.032 | 0.191 | 45.1 | 65.3 | 52.3 | 0.29 |
| BJ22A-N-IG | 2.72 | 14.9 | 0.37 | 0.306 | 0.028 | 0.181 | 39.2 | 56.9 | 58.7 | 0.31 |
| BJ23A-N-IG | 2.90 | 15.9 | 0.42 | 0.311 | 0.028 | 0.196 | 41.2 | 62.4 | 55.2 | 0.31 |
| BJ26A-N-KS | 3.02 | 16.6 | 0.38 | 0.305 | 0.038 | 0.190 | 43.8 | 57.0 | 55.3 | 0.31 |
| BJ32A-N-KS | 3.10 | 17.0 | 0.38 | 0.275 | 0.035 | 0.198 | 43.0 | 60.8 | 56.8 | 0.28 |
| BJ18A-N-KS | 2.93 | 16.1 | 0.41 | 0.303 | 0.033 | 0.195 | 41.3 | 62.0 | 58.0 | 0.30 |
| BJ11A-N-CG | 3.06 | 16.8 | 0.38 | 0.295 | 0.030 | 0.188 | 40.3 | 56.8 | 50.5 | 0.30 |
| BJ08A-N-CG | 3.06 | 16.8 | 0.36 | 0.288 | 0.030 | 0.180 | 41.0 | 57.8 | 55.0 | 0.29 |
| BJ10A-N-SC | 3.04 | 16.7 | 0.37 | 0.275 | 0.043 | 0.205 | 48.3 | 54.8 | 60.8 | 0.28 |
| BJ11A-N-SC | 2.87 | 15.8 | 0.34 | 0.268 | 0.035 | 0.185 | 39.5 | 52.3 | 54.8 | 0.27 |
| BJ25A-N-SC | 3.07 | 16.9 | 0.38 | 0.280 | 0.040 | 0.198 | 46.8 | 56.0 | 61.8 | 0.28 |
| BJ28A-N-MW | 2.68 | 14.7 | 0.38 | 0.305 | 0.038 | 0.193 | 41.5 | 59.0 | 59.0 | 0.31 |
| BJ27A-N-MW | 2.98 | 16.4 | 0.36 | 0.280 | 0.033 | 0.195 | 39.3 | 55.0 | 51.0 | 0.28 |
| BJ03A-N-HRE | 3.08 | 16.9 | 0.38 | 0.263 | 0.033 | 0.198 | 45.8 | 50.3 | 59.8 | 0.26 |
| BJ13A-N-HRE | 3.11 | 17.1 | 0.38 | 0.288 | 0.035 | 0.193 | 41.3 | 54.3 | 52.8 | 0.29 |
| BJ21-N-HRE | 3.12 | 17.1 | 0.39 | 0.318 | 0.038 | 0.203 | 39.8 | 57.5 | 59.5 | 0.32 |
| BJ11A-N-KB | 2.86 | 15.7 | 0.36 | 0.290 | 0.035 | 0.193 | 42.3 | 57.0 | 58.8 | 0.29 |
| BJ04A-N-KB | 3.08 | 16.9 | 0.38 | 0.288 | 0.025 | 0.188 | 42.5 | 52.8 | 56.5 | 0.29 |
| BJ10A-N-KB | 2.93 | 16.1 | 0.41 | 0.288 | 0.035 | 0.198 | 45.5 | 63.3 | 58.5 | 0.29 |
| BJ05-N-GM | 3.10 | 17.0 | 0.39 | 0.278 | 0.028 | 0.185 | 42.5 | 52.3 | 57.3 | 0.28 |
| BJ15A-N-GM | 3.01 | 16.5 | 0.39 | 0.283 | 0.033 | 0.190 | 44.8 | 57.0 | 55.0 | 0.28 |
| BJ43A-N-GM | 3.10 | 17.0 | 0.37 | 0.285 | 0.033 | 0.190 | 40.5 | 54.0 | 57.5 | 0.29 |
| PA00-KB-AL | 2.86 | 15.7 | 0.39 | 0.318 | 0.035 | 0.193 | 47.3 | 61.0 | 57.3 | 0.32 |
| Cadillac | 3.04 | 16.7 | 0.39 | 0.300 | 0.030 | 0.185 | 43.8 | 50.5 | 52.3 | 0.30 |
| BW487 | 3.04 | 16.7 | 0.35 | 0.283 | 0.030 | 0.183 | 36.3 | 55.8 | 47.3 | 0.28 |
| Red Fife | 2.62 | 14.4 | 0.37 | 0.328 | 0.035 | 0.175 | 42.0 | 58.0 | 47.0 | 0.33 |
| Glenn | 2.96 | 16.3 | 0.41 | 0.295 | 0.033 | 0.213 | 46.3 | 56.8 | 58.8 | 0.30 |
| AAC Brandon | 2.89 | 15.9 | 0.33 | 0.283 | 0.033 | 0.183 | 34.8 | 52.5 | 48.5 | 0.28 |
| Carberry | 3.06 | 16.8 | 0.38 | 0.288 | 0.035 | 0.195 | 37.3 | 56.5 | 50.8 | 0.29 |
| Unity | 2.94 | 16.1 | 0.36 | 0.268 | 0.025 | 0.183 | 38.5 | 54.3 | 47.3 | 0.27 |
| Vesper | 2.87 | 15.8 | 0.39 | 0.283 | 0.033 | 0.193 | 46.3 | 58.3 | 66.0 | 0.28 |
| PT245 | 3.02 | 16.6 | 0.40 | 0.333 | 0.023 | 0.180 | 42.5 | 48.8 | 50.8 | 0.33 |
| *Pr>F* | *0.0013* | *0.0013* | *0.0001* | *<.0001* | *<.0001* | *0.0076* | *<.0001* | *<.0001* | *<.0001* | *<.0001* |
| *LSD* | *0.2456* | *1.348* | *0.0331* | *0.0266* | *0.007* | *0.0164* | *4.1205* | *4.9559* | *6.5236* | *0.03* |

**Table 4.** Ranges and mean seed mineral nutrient concentrations of the 32 treatments. Means and contrasts of the farmer selected populations and conventionally selected check cultivars for seed mineral nutrient concentrations.

| | Total N | P | K | S | Ca | Mg | Zn | Fe | Mn | Cu | B |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | % | | | | | | ppm | | | | |
| Range | 2.62 - 3.12 | 0.33 - 0.42 | 0.26-0.33 | 0.16-0.18 | 0.02-0.04 | 0.18-0.21 | 34.8-48.3 | 48.8-65.3 | 47-66 | 3.3-4.8 | 0.26-0.33 |
| Mean | 2.98 | 0.38 | 0.29 | 0.17 | 0.03 | 0.19 | 42.20 | 56.40 | 55.30 | 3.87 | 0.29 |
| **Means** | | | | | | | | | | | |
| Farmer-selected | 2.99 | 0.38 | 0.29 | 0.17 | 0.033 | 0.19 | 42.7 | 57.2 | 56.6 | 3.8 | 0.29 |
| Conventional checks | 2.97 | 0.38 | 0.29 | 0.17 | 0.030 | 0.19 | 41.3 | 53.9 | 53.5 | 4.0 | 0.29 |
| Difference between farmer selections and conventional checks? | no | no | no | no | yes | no | yes | yes | yes | no | no |

Populations that were distributed to more than one farmer were compared to see if the different selection environments resulted in differences in the grain nutrient concentration. There were no significant differences in total grain N, Mg, Zn, and B concentrations between populations selected by different farmers. There were, however, differences in grain P, K, Ca, Fe and Mn concentrations (Figure 9).

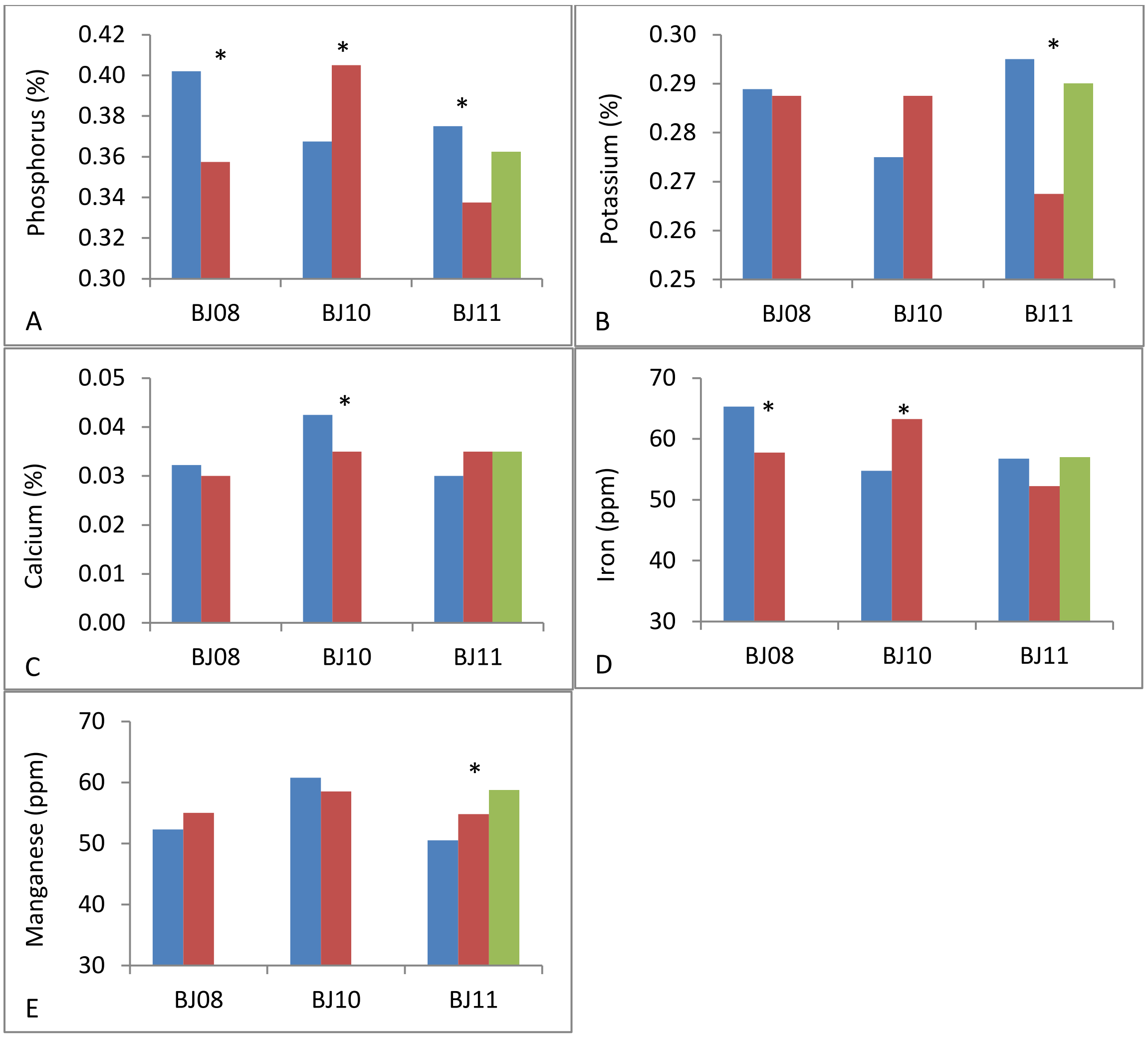


**Figure 9.** Comparison of populations selected by different farmers for: **A)** phosphorus (P), **B)** potassium (K), **C)** calcium (Ca), **D)** iron (Fe), and **E)** manganese (Mn) concentration in the grain. From left to right the populations shown in each figure are BJ08-IG, BJ08-CG, BJ10-SC, BJ10A-KB, BJ11-CG, BJ11-SC, and BJ11-KB. An asterisk (*) over bars within the same population indicates that there is a significant difference between treatments within that population.

## What can we take away from this study?

The 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 Ca, Zn, Fe and Mn 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.

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.

The fact that grain P status varied among farmer selected populations indicates 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. This will be a focus on a new research project.

Since the start of the participatory wheat breeding program the on-farm breeding project has expanded to include oat and potato and takes place on farms across Canada. The results of this 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.

## Acknowledgements

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