A passion for new varieties

Stephen Fox, a Canadian wheat breeder

In his Canada Western Red Spring breeding program at the Agriculture and Agri-Food Canada Cereal Research Centre located in Winnipeg, Stephen Fox oversees in the neighborhood of 12,000 3-4 m^2 yield plots and about 35000 nursery rows every year across Western Canada. He collects data to identify new wheat varieties that will provide better yields, be more resistant to diseases and insects and will improve Canadian agricultural productivity.

People that grow, sell and buy Canadian wheat have many suggestions to improve the cultivars that are grown. As a researcher, Stephen Fox designs his breeding program to address these objectives. Building a breeding program takes time, as it consists of 8 to 12 generations of Material. Fox makes crosses and looks at segregating populations, with each generation being 50% more inbred than the last; after the 7^{th} generation, the new line is adequately inbred and represents a potential new cultivar. However, 6 more years of testing are typically required to identify a new cultivar suitable for registration. "Once this happens, the seed grower can start multiplying a cultivar for commercial use," explains Fox.

The multiplication of the seed requires 3 more years of time and investment before it is ready to go on the market. If the new variety is not performing as well as expected, that investment is lost and cannot be recouped. So, Fox works hard to ensure that the data used to make the decision to register a variety is of good quality.

"I measure my success based on variety surveys: if farmers grow my varieties, then I must be doing a good job. This is more important to me than counting the number of my scientific publications. I am proud when farmers grow my varieties. I like that."

In 2004, after attending an organic field day seminar organized by Dr. Martin Entz, Stephen Fox decided to try breeding cultivars for organic production. The agroecology of organics is different; there is restricted nutrient availability, the microflora of the soil is different and weed pressure is a big constraint. Seven years later, and now having an organically based wheat breeding program with all of the generations in place (F2 to F9), Fox provides his genetics and breeding know-how to identify varieties that are adapted to organic growing conditions. But, so far, Fox cannot confirm that organic lands are different enough to warrant breeding for it specifically. "Lots of things are the same between conventional and organic

breeds; it is not an easy task to determine what is different. We are chasing physiological features of cultivars that make them better suited to organic production rather than conventional, but we don't yet really know what those features are."

The breeding program will hopefully generate crops providing high yields under organic management. Then, it will be possible to study why they are adapted, and what features these plants have that the conventionally bred cultivars do not have.

"Some of the conventional varieties are very appropriate for organic production, some other ones are not. The factors that condition for adaptation to the more stressful organic growing conditions are not really understood at this time" confirms Fox.

Fox observes that some plant traits may be appreciated differently between conventional and organic crop production systems. As an example, shorter plants are preferred in conventional agriculture as these tend to be more resistant to lodging while supporting heavy spikes. In organic situations, taller plants may be more appropriate because they may be more competitive with weeds, while tending to grow less tall due to nutrient stresses.

Some organically grown cultivars tend to tolerate weed competition, while others do not. Why some weeds can help keep the crop standing or pull it down is also not clear. There is a greater diversity of microflora in organic soil, but how these organisms directly impact the plant and its yield performance is not clear, though some varieties may be better able to support synergistic fungi-plant associations.

But Fox is patient. "I happen to run a fairly big wheat breeding program; having material at various locations helps to protect the program from losing material all together and ensures getting an adequate amount of data to make good decisions each year. Breeding programs function by generating a lot of segregating material; you look at it and decide which lines you want to keep. Typically you throw approximately 80% of your breeding program away every year because you are supported by good data that allow you to make those decisions. You have to have this good information to make progress."

A breeding program struggles when pertinent information cannot be obtained. If the weather is too dry, then assessment of disease resistance cannot be done; if a location is heavily wind damaged, lodging resistance cannot be estimated; frosted grain cannot be used to make grain quality decisions. Having multiple test locations helps to avoid these obstacles, while also providing additional opportunities to see specific plant stress conditions that are difficult to create in a breeding nursery environment.

"The worst case outcome for breeding organic wheat would be to find out that the conventional and organic environments don't differ; if you finally argue that they are the same, I will only have done more wheat breeding which isn't so bad" says Fox, who is the activity leader of the *Organic cereal crop breeding* project research of the Organic Science Cluster, managed by OACC. However, he believes that in the process of creating novel breeding materials for organic

agriculture, these materials will be useful in demonstrating adaptation to organic production and will provide the basis for research projects to elucidate what these adaptation factors are.

Organic management also imposes some limitations on how breeding program can operate. AAFC has a winter nursery in New Zealand that is used by conventional breeding programs to grow an additional generation each year, thus speeding the rate at which breeding can be done. However, organic breeding material cannot be sent to other countries, because seeds have to be treated with a pesticide to prevent transfer of seed borne diseases in order to enter most countries. And, if the seed was transferred to a contra season environment, organic producers at those locations will not want to grow imported treated seeds on their organic land.

Being ecosensitive, Fox is planning to implement a carbon neutral system in his house in Winnipeg to supplement water and heating; he also plans to build a rain collector and has been composting for years. Using fewer resources makes sense to him, as well as using them wisely.

He is dreaming of being the best wheat breeder in Western Canada and of the Winnipeg Jets winning the Stanley Cup. Then, Canada would offer the best wheat variety to feed its hockey players. With his great dedication to his work, maybe we could suggest Fox develop breeding programs for hockey players – we already have Kane wheat. And one of the Jets star players is named Evander Kane….

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