ORGANIC FARMING RESEARCH FOUNDATION

Project Report Summary

BREEDING WHEAT VARIETIES FOR ORGANIC FARMING SYSTEMS

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Development of wheat varieties for organic farmers

From the mid-1950's on, most wheat in the U.S. has been selected and bred for high-input agricultural conditions. These conditions include the common use of artificial fertilizers and chemical herbicides and fungicides, practices that are not allowed under certified organic standards. Traits specifically adapted to and useful for organic wheat production may have been lost from the gene pool of modern wheat varieties due to the intensive chemical management common in current wheat-breeding programs. In response, we have initiated a breeding program that focuses on selection under certified organic production systems and incorporates parental material from historical wheat varieties grown before the widespread use of modern day chemicals.

Field crops such as wheat present organic growers with unique challenges in managing weeds, pests and fertility. Successful cereal production requires varieties that are highly adapted to local climatic conditions and disease pressures. This is true for both conventional and organic production systems, but there are aspects of organic production that may make the ideotype required different from conventional systems.

There is great potential for improving the characteristics of cereals that will make them superior for use in organic production. In spite of the fact that organic wheat production is increasing rapidly, there has to date been little attention paid by public wheat breeders to evaluate and develop cultivars adapted specifically to organic production systems.

Objectives

The primary objectives we would like to answer with this research are:

- Are the best varieties in conventional farming systems the best varieties in organic farming systems?"
- Do varieties grown pre-1950's contain genes that could prove beneficial to organic wheat farmers?
- Will wheat lines bred under a low-input organic environment be better adapted to these conditions and result in varieties particularly well suited to organic farming systems?

Organic spring wheat nursery at WSU Spillman Farm, July 2006

Methods

Comparison of wheat variety performance in organic and conventional systems: Trials were developed to test differences in yield and test weight between organic and conventional systems. Randomized complete block designs with four replicates of 35 soft white winter wheat genotypes were grown in paired organic and conventional systems at five locations and evaluated in 2002-03 and 2004-05. The 35 genotypes represent the most promising lines in the WSU winter wheat breeding program each year and have been selected entirely in conventional systems. The organic and conventional nurseries were located in similar microclimatic conditions with comparable soil properties. The conventional nurseries were treated according to standard agricultural practice, including the use of crop-protection chemicals and inorganic fertilizer. The organic nurseries were located on certified organic ground and treated according to the regulations set by the USDA National Organic Program.

Mineral content studies of historical and modern wheats and evaluation of wheats under low-input conditions: A randomized complete block design nursery of 63 spring wheat varieties (56 historical, 7 modern) was grown in Pullman, Washington in 2004 and 2005. The historical varieties were

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Project Notes

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Project locations: Spillman Agronomy Farm, Pullman, WA; Lind Dryland Research Station, Lind, WA; DeLong Farm, St. John, WA; Jorgensen Brothers Ranch, St. Andrews, WA (all locations farmed under certified organic conditions)

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selected randomly from a larger group of spring wheat varieties that were widely grown in the Pacific Northwest region of the U.S. from 1842 to 1965. The seven modern varieties were among the most widely grown spring wheat cultivars in Washington State in 2003. Thirty-seven varieties were in the soft white market class, twenty varieties were in the hard red market class, four varieties were in the hard white market class and two varieties were in the soft red market class. There were three replicates of each variety in 2004 and four replicates of each variety in 2005. The nurseries were fertilized with PerfectBlend® fertilizer at the rate of 6.05 kg/ha each of N, P, and K, drilled with the seed at planting. No fungicidal or insecticidal seed treatments were used. This management practice was intended to reflect low-input wheat production in the Pacific Northwest.

Key Results

- **Our most important result was that the highest yielding varieties in conventional systems are not the highest yielding varieties in organic systems**. There were highly significant genotype and system interactions for yield between systems in four of five locations. This suggests that indirect selection would be considerably less efficient than direct selection for both yield and test weight. Indirect selection in this case refers to selection for yield in one system when the target environment is the other system.
- **Results showed robust genetic independence for yield and moderate genetic independence for test weight** in 35 genotypes between organic and conventional systems, indicating a need for separate breeding programs for the distinct crop management systems.
- **We found significant variation in weed suppression ability** among 63 spring wheat cultivars tested. We found particular cultivars that are better adapted to weed competition than to repeated harrowing and vice versa.
- Assessment of historical and modern spring wheat varieties under "low input" conditions demonstrated that while modern varieties had significantly higher yields than the historical varieties, **some varieties from the 1930s and 1940s are high yielding under these conditions and might contain potential for improvement.** Mean yield for the modern varieties was 1915 ± 242 kg/ha while mean yield for historical varieties was 1090 ± 79 kg/ha. Two historical varieties, Canus and Spinkota, ranked 3 and 4 respectively out of 63, may contain traits that are particularly suited to organic conditions.
- **Under low-input agronomic conditions, highly significant differences among the 63 wheat varieties were found for yield and for mineral content of eight nutrients** (Table 1). For seven of the eight minerals tested, the historical varieties had significantly higher grain mineral content than the modern varieties. Only Ca showed no significant difference between the historical and modern era. Highly significant variation exists among wheat varieties for mineral content of each nutrient, indicating the potential for genetic improvement.

Other data of interest include results of tests for dwarf bunt resistance in our wheat cultivars and breeding lines. Dwarf bunt is of particular concern to organic farmers as currently the pathogen is controlled using fungicidal seed treatments that are not available for use by organic farmers. **Three breeding lines of particular interest show genetic resistance to dwarf bunt.**

Additionally, our population selection for superior emergence properties has received strong natural selection over the past three years in the form of significant soil crusting and low soil moisture. We had the "good" fortune to have severe soil crusting at the Lind Experiment Station. Even the farm manager of the Lind station was sure that "nothing will emerge through that crust." But **some breeding lines had as high as 80% emergence through a thick soil crust.** Not all breeding lines emerged as well, but we definitely will advance the seed from the plants that survived such harsh natural selection.

Conclusions

With crop varieties bred in and adapted to the unique conditions inherent in organic systems, organic agriculture will be better able to realize its full potential as a high-yielding alternative to conventional agriculture. These results tell us that breeding for organic agriculture should be conducted in certified organic fields. It also illustrates the point that yield in organic systems has not been optimized and will not be fully optimized until breeding and selection occurs within these organic systems. ❧

Table 1. Mineral content in historical and modern wheat varieties. Mineral content is given in mg/kg dry weight ± standard error for all minerals except Se, which is given in ug/kg. Data are means from 2004-2005 trials at Spillman Farm in Pullman, WA. A significant negative value in the grain yield/mineral content correlation column indicates that increased yield was correlated with decreased concentration of that mineral.

Mineral	Mineral Content			Grain Yield/ Mineral Content Correlation
	Historical 1842 - 1965)	Modern (2003	% Change	
Ca	421.98 ± 10.90	398.49 ± 16.12	- 6	- 0.41 ***
Cu	4.76 ± 0.13	4.10 ± 0.23	- 16 ***	- 0.17 ***
Fe	35.73 ± 1.00	32.31 ± 1.75	- 11 **	0.05 ns
Mg	1402.62 ± 21.01	1307.6 ± 25.63	- 7 ***	- 0.35 ***
Mn	49.98 ± 1.22	46.75 ± 3.14	- 7 *	- 0.17 **
P	3797 ± 55.65	3492 ± 119.25	- 9 ***	- 0.25 ***
Se	16.17 ± 1.74	10.75 ± 2.73	- 50 *	- 0.38 ***
Zn	33.85 ± 0.92	27.18 ± 1.88	- 25 ***	- 0.06 ns

*, **, ***: P = <0.05, 0.01 and 0.0001, respectively
NS = not significant