2010 UNL ORGANIC WINTER WHEAT BREEDING REPORT

Excerpts From: Improving Wheat Varieties For Nebraska, 2010 State Breeding And Quality Evaluation Report To The Nebraska Wheat Development, Utilization And Marketing Board

Added analysis: by Ibrahim Salah El Bastyoni regarding differences among organic and conventional testing environments.

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Summary

Our long-term goal is to develop small grains cultivars and cropping systems that will improve the profitability and competitiveness of organic producers. Our approach is to: 1. Grow winter wheat in state variety trials at four organic locations; 2. Use a targeted organic breeding effort complete with end-use quality, nutrient quality evaluations, and soil fertility trials at two locations; and 3. Conduct cover crop research at two locations. Our outreach efforts included conferences and web-based materials to explain wheat breeding and variety selection, and to involve organic producers in research planning and on-farm evaluation. Our research revealed that it is inappropriate to use data from conventional testing to recommend lines for organic production or cultivar release decisions. Nitrogen top-dressing trials revealed the need to tailor recommendations to each cultivar. Selecting and testing lines under organic production practices in different ecological regions is also needed. Several experimental wheat lines have been outperforming most released varieties for yield and bread quality. We identified lines suited for organic production (NE04424, NE05425 and NW03681), lines suited for conventional production, and lines suitable for both production systems (e.g. McGill, Pronghorn, NW03666 and NE06469). Several other lines with excellent potential require more testing in the Organic State Variety Trials to confirm yield and quality stability. In the future, our breeding efforts will focus on using state-of-the-art, non-transgenic breeding technologies (genomic selection, marker-assisted breeding, and high throughput phenotyping) to synergistically improve organic and conventional wheat breeding.
**a. Planting and Harvesting**

Organic State Variety yield trials, with 21 varieties and 15 experimental lines, were conducted at Mead, Clay Center, Sidney (HPAL) and Concord (HAL). NIN, Triplicate and Duplicate nurseries, with the same entries as in the conventional trials, were conducted at Mead and Sidney. Clay Center was no-till planted after soybeans on Oct. 5 and harvested July 14. Mead was no-till planted into soybeans October 15 and harvested July 22 and 23. HAL was planted after oats/clover on September 18 and harvested July 10. HPAL was planted after fallow on September 17. Combine equipment failure at Sidney after the OSVT harvest on July 16 resulted in a drawn-out harvest for NIN, TRP and DUP nurseries with some harvested July 22 and the rest harvested on July 26 after rain. The NIN and TRP nurseries were further compromised by blue mustard infestation resulting from atypical rainfall. Sidney yield data for NIN and TRP (reported earlier in this annual report) was not reliable enough for selection decisions. Seed was retained from all nurseries and locations for quality tests.

**b. Organic State Variety Trials**

Western Nebraska-- top 50% winter wheat lines for grain yield of those entered in 2010 Organic State Variety Trial (HPAL), ranked in order of cumulative z-score for grain yield (†):

<table>
<thead>
<tr>
<th></th>
<th>2008 to 2010 yield</th>
<th>z-score</th>
<th>yield rank</th>
<th>2009 to 2010 yield</th>
<th>z-score</th>
<th>yield rank</th>
<th>2010 yield</th>
<th>z-score</th>
<th>yield rank</th>
<th>cumulative z-scores for yield†</th>
</tr>
</thead>
<tbody>
<tr>
<td>NW07505</td>
<td>76.4</td>
<td>1.5</td>
<td>4</td>
<td>72.4</td>
<td>0.7</td>
<td>9</td>
<td>76.6</td>
<td>1.5</td>
<td>2</td>
<td></td>
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<tr>
<td>WAHOO</td>
<td>55.5</td>
<td>1.4</td>
<td>3</td>
<td>58.9</td>
<td>1.7</td>
<td>1</td>
<td>72.4</td>
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<tr>
<td>OVERLAND</td>
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<td>1.5</td>
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<td>54.2</td>
<td>0.4</td>
<td>13</td>
<td>76.8</td>
<td>1.5</td>
<td>2</td>
<td>1.1</td>
</tr>
<tr>
<td>NW03681</td>
<td>50.1</td>
<td>-0.3</td>
<td>11</td>
<td>57.7</td>
<td>1.4</td>
<td>2</td>
<td>79.3</td>
<td>2.0</td>
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<td>1.0</td>
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<tr>
<td>SNOWMASS</td>
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<td>EXPEDITION</td>
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<td>73.9</td>
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<td>MILENNIUM</td>
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<td>NE04424</td>
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<td>NE06469</td>
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<td>NE01481 (MCGILL)</td>
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<tr>
<td>NURSERY MEAN</td>
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<tr>
<td>C.V.</td>
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<tr>
<td>L.S.D.</td>
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</tbody>
</table>

†Z-score is the standard deviation from the average for the entries listed. The cumulative z-scores (the average of z-scores in the other columns) give a greater weight to yield for the current year (2010), and elevates new top-performing entries, such as NW07505, Snowmass, Expedition and NE05496, while retaining lines that performed very well in previous years such as Antelope and Hatcher.
Eastern Nebraska--top 50 % winter wheat lines for grain yield of those entered in 2010 Organic State Variety Trial (Mead, HAL, and Clay Center), ranked in order of cumulative z-score for grain yield (†):

<table>
<thead>
<tr>
<th>ID</th>
<th>2008 to 2010 yield</th>
<th>z-score</th>
<th>rank</th>
<th>2009 to 2010 yield</th>
<th>z-score</th>
<th>rank</th>
<th>2010 yield</th>
<th>z-score</th>
<th>rank</th>
<th>cumulative z-scores for yield†</th>
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<td>1.4</td>
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<td>1.1</td>
<td>4</td>
<td>1.8</td>
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<td>NW07505 (W)</td>
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<td>47.5</td>
<td>0.8</td>
<td>9</td>
<td>1.0</td>
</tr>
<tr>
<td>WAHOO</td>
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<td>52.7</td>
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<tr>
<td>GOODSTREAK</td>
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<td>53.6</td>
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<td>9</td>
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<tr>
<td>NW03666 (W)</td>
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<td>48.2</td>
<td>0.9</td>
<td>6</td>
<td>0.8</td>
</tr>
<tr>
<td>OVERLAND</td>
<td>47.6</td>
<td>0.8</td>
<td>8</td>
<td>50.3</td>
<td>1.4</td>
<td>3</td>
<td>47.2</td>
<td>0.7</td>
<td>10</td>
<td>0.7</td>
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<tr>
<td>SNOWMASS (W)</td>
<td>49.4</td>
<td>0.2</td>
<td>9</td>
<td>51.8</td>
<td>0.6</td>
<td>9</td>
<td>50.3</td>
<td>1.4</td>
<td>3</td>
<td>0.7</td>
</tr>
<tr>
<td>EXPEDITION</td>
<td>52.9</td>
<td>0.9</td>
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<td>0.6</td>
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<tr>
<td>NE0548</td>
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<td>7</td>
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<td>8</td>
<td>46.3</td>
<td>0.5</td>
<td>14</td>
<td>0.6</td>
</tr>
<tr>
<td>NE01481 (MCGILL)</td>
<td>51.3</td>
<td>0.5</td>
<td>10</td>
<td>44.2</td>
<td>0.0</td>
<td>21</td>
<td>47.1</td>
<td>0.7</td>
<td>11</td>
<td>0.2</td>
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<tr>
<td>NE05425</td>
<td>48.5</td>
<td>-0.4</td>
<td>17</td>
<td>44.2</td>
<td>0.0</td>
<td>21</td>
<td>45.4</td>
<td>0.3</td>
<td>15</td>
<td>0.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ENTRY</th>
<th>Leaf Spotting (Scale 1-9)</th>
<th>Maturity (days)</th>
<th>Protein (13% moisture basis)</th>
<th>Grain Yield (bu/ac)</th>
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</thead>
<tbody>
<tr>
<td>WESLEY</td>
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<td>1.0</td>
<td>0.83</td>
<td>10.4</td>
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<tr>
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<td>10.2</td>
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<td>0.73</td>
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<td>DANBY (W)</td>
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<td>3.7</td>
<td>1.15</td>
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<tr>
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<tr>
<td>L.S.D.</td>
<td>0.3</td>
<td>0.3</td>
<td>0.14</td>
<td>2.7</td>
</tr>
</tbody>
</table>

### c. Varietal protein response to top-dressed nitrogen

For the second year, top-dressing trials within the Organic State Variety Trials at Haskell Ag Lab provided positive results for protein response. Twenty pounds per acre nitrogen from an approved organic liquid fertilizer were applied in a split treatment at jointing and boot stages. Leaf spotting diseases increased in most plots, but to varying degrees; and yield response was highly varied. Half of the 36 lines increased protein content by more than 0.7 % on a 12 % moisture basis. Of those lines, twelve increased to above an 11.5% protein content threshold that would position them for a higher value market. Some of the increased protein content may be attributed to lower grain yield. However, five varieties increased in both protein content and yield (shown below). Based on yields and quality data, of these five, only McGill and SD07165 are of commercial interest.
**d. Milling and Bread Baking Quality**

Thirty-nine organic wheat varieties, composited from Mead and Sidney locations, were analyzed for single kernel characteristics, milling properties, protein content, ash content, rheological dough strength, and bread production in the UNL Wheat Quality Lab. To increase our level of confidence for making direct comparisons between the lines for mixing and baking quality, changes were made in the mixograph protocol and sample preparation. The mixograph method was changed from a constant absorption basis to an absorption adjusted for protein content and mixing type. The sampling method was changed to provide samples with nearly equivalent protein contents. Since soil fertility has not been uniform in our organic plots, the grain protein has been known to fluctuate widely among reps. Therefore, grain protein content was measured for each entry in each rep for each location. Then samples were blended to obtain $11.9 \pm 0.1\%$, except for four higher protein lines between 12.1 and 12.4 %. In the past, it was necessary to consider the protein quality as defined as the ratio between quality scores and protein content. As an indication of how well we met the goal, the flour protein content ranged from 9.6 to 10.6 % (after removing anomalous values for NW07505 of 11.2% and Danby of 11.0 %) with a standard deviation among SVT entries in 2010 of 0.27, compared to 0.63 in 2009 and 0.74 in 2008.

Of the top 15 for bread score this year, eight were also in the top 15 last year: NW03666, NE01481 (MCGILL), PRONGHORN, NE04424, NE02558, NW03681, NE07569, and NE05425. Three lines—NE05548, ALLIANCE AND DARREL—had the lowest bread scores for the nursery. In the past, Alliance was thought to bake poorly because of its low protein content. This year the flour protein content of Alliance was only slightly less than the nursery average. Six entries were flagged for having extremely long peak mixograph mixing times (greater than nine minutes). These six entries were in the top ten for bread score (4.9 or greater on a scale of 1-6). Of these six, NW03666, MILLENNIUM and NE05425 had the top crumb scores for the nursery. MCGILL had the best loaf volume, slice area, and exterior score. NW03666 had the top baking absorption (63% compared to 61.9% nursery average), but had an extremely long baking mix time of 15.4 minutes. Unlike for conventional markets, where long mix times are avoided because of excessive equipment wear, long mix times may be favorable for making whole wheat bread (which dominates organic wheat markets) to compensate for the effect of sharp bran particles on dough development. When comparing 2010 results with 2008 and 2009 organic results and multiple years of data from conventional trials in regional nurseries (USDA tests), the rejection of DANBY and OVERLAND for the organic bread market was again supported in 2010. However, if Danby is top-dressed to increase protein content (as indicated in the above table), it is possible that Danby would be adequate for the organic bread market. On the other hand, GOODSTREAK, which was rejected in previous years, was adequate this year. ARROWSmith baked well this year, whereas in previous years the range was from good to very poor. The long-term poor milling of Antelope was confirmed this year. Whereas, milling for NE01481 (MCGILL) was not a concern in 2010 as it had been in previous years.

**e. Grain Yield differences among testing environments for NTN and NIN nurseries**

Biplot analyses for Nebraska Triplicate Nurseries (NTN or TRP) and Nebraska Interstate Nurseries (NIN) revealed differences among all locations and between organic and conventional systems, indicating a need for using all environments for making selections among lines to be retained for further testing. The following tables show vectors and lengths for two abstract principle components that distinguish yield differences among locations. The following scatter graphs show a poor yield correlation between organic and conventional lines at two locations in 2010.
Suffixes for NIN10 and TRP10 (NTN) in the diagrams indicate the following locations:

A—Alliance (Box Butte County)
CC—South Central Ag Lab (SCAL in Clay County)
L—Havelock Farm at Lincoln (Lancaster County)
MC—McCook County
M—Conventional plots near Mead at ARDC (Ag Research and Development Center, Saunders County)
NP—near North Platte at WCAL (West Central Ag Lab)
S—Conventional plots near Sidney at HPAL (High Plains Ag Lab, Cheyenne County)
SO—Organic plots near Sidney at HPAL (High Plains Ag Lab, Cheyenne County)

Yield comparisons between conventional and organic trials for 60 NIN nurseries in 2010.

**f. Promising Lines for Potential Release for Organic Production**

Germplasm selections for potential release are focused on quality traits for bread, with a secondary emphasis on yield. Several experimental wheat lines have been outperforming most released varieties for yield and bread quality. Two exemplary lines, NW03681 and NE04424, were discontinued from the conventional breeding program, but continue to show promise in the organic sector. Also discontinued from the conventional program, NE05425, with its strong gluten, has promise for the whole wheat bread market. NW03681 is a white complement to the red phenomenon, HATCHER, in the western part of the state, with a similar high yield in most years and excellent baking quality. However, neither line can be planted deep when topsoil is dry, because of short coleoptiles. Among long-coleoptile, good bread quality lines, NE06469 may replace lower-yielding Buckskin, the predominant organic variety in western Nebraska.