WHEAT RESEARCH FINAL REPORT

Title of Research Project: Evaluating Spring Wheat Variety Performance in Organic Environments

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Abstract/Summary of Results and Conclusions:

The objective of this project was to help organic producers to identify superior varieties for their production system by surveying growers about their variety choices and by conducting replicated variety trials. Organic wheat variety trials took place on a certified organic farm in Lake County. The trial was conducted as a randomized complete block design (RCBD) with four replications of twelve varieties. Data was collected for maturity, plant height, and yield. In addition, a wheat nursery was established to screen and increase seed of over 100 discontinued or non-commercial varieties, heirloom varieties, and specialty wheat accessions.

Based on yield alone, the best hard spring wheat variety was Otis, a hard white variety. Among the soft white varieties, Alturas had the highest yield. Among the durum wheat, Kyle was the highest yielding. However, both Otis and Alturas were relatively short stature in this trial, which can be problematic in weedy fields. A number of cultural and environmental factors may have influenced the performance of the varieties of these trials, and are important to keep in mind when interpreting the results. In addition, this project was only able to evaluate a subset of potential varieties, and was only able to evaluate them at a single location this season. Future trials would allow additional varieties to be evaluated, and would allow a better understanding of how well these varieties perform under a wider range of climatic conditions.

Introduction and Objectives:

Organic wheat is a rapidly expanding specialty crop in California. According to the most recent organic survey from the USDA Economic Research Service, between 1997 and 2008 organic wheat acreage has increase 50-fold in California, from 727 acres in 1997 to 36,115 acres in 2008. The expansion of organic wheat production in California has coincided with the increased interest in local grain, with many independent bakeries and supermarkets attempting to source their wheat from regional producers.

One of the key pieces in successfully increasing the production and profitability of organic wheat on the North Coast is identifying appropriate varieties. In many ways the needs of organic producers are similar to those of conventional producers: both need reliably high yields of high quality wheat. However, organic production practices do differ from typical conventional practices and those differences will influence variety selection. For example, many organic wheat producers rely on slow-releasing forms of nitrogen such as cover crops, manure and previous legume crops. Also organic farmers rely on mechanical cultivation and crop competiveness for weed control. These differences in production practices can lead to differences in relative variety performance between conventional and organic systems. In a 2007 paper in Field Crops Research, Murphy et al. found that the highest yielding soft white wheat varieties on organic farms were different than the highest yielding varieties on conventional farms..

In 2013, with funding from the California Wheat Commission, wheat variety trials were conducted at two organic farm sites: one in Humboldt County, and one in Sonoma County. Significant differences in yield, height, lodging tendency, protein content, and rust susceptibility were found between varieties. In 2014, these trials were continued at an additional farm site in Lake County. In addition, a wheat nursery was established to screen and increase seed of over 100 discontinued or non-commercial varieties, heirloom varieties, and specialty wheat accessions.

Materials and Methods:

(1) Establish a nursery to screen and increase seed of promising varieties.

A wheat nursery was established at College of the Redwoods trial site. This nursery included a set of 57 entries planted in small 4' wide x 8' long plots. In addition, another 47 entries of material obtained from the USDA germplasm system was planted in 4' single row plots (Table 1). These plots were be used to screen and increase seed of non-commercially available material that may be useful to produce on the North Coast or to evaluate in future field trials. Material may include discontinued or non-commercial varieties, heirloom varieties, and specialty wheat such as durum, spelt and einkorn. These plots were screened for stripe rust susceptibility and will be evaluated for yield.

(2) Conduct variety trials to identify superior wheat varieties for organic farms along the North Coast

Planting date investigation

Prior to planting, the project team investigated optimum planting dates for planting wheat on the North Coast. Wheat planting dates in this region are primarily based the balance of two factors: planting early enough to ensure adequate soil moisture and precipitation, while late enough to avoid cooler fungal disease promoting conditions. In order to determine planting dates, historic climate records were examined for locations close to the trial sites, along with additional locations in the North Coast counties. Potential planting dates were calculated as the dates when, historically, 10 additional inches of rain would fall after planting. Dates and average temperatures were reported (Table 2). This information was compiled and provided to local growers as a resource.

Trial design and location

The first trial site was Clover Creek Farm in Upper Lake, Lake County. The soil is a Lupoyoma silt loam, with a previous crop of ten years of native cover crop. The trial was planted March 20th, 2014 and harvested July 30th, 2014. Two inches of irrigation were applied after planting.

In the project proposal, trials were to be grown at 3 sites. At the start of the year, four sites were identified. However, all but the Clover Creek site was abandoned for reasons discussed below.

The size of the individual plots was to be reduced this year to from the 8' x 100' plots used in 2013 to 4' x 50' by using a 3pt vineyard drill for planting. Replicated plots were planted at Nelson Ranch in Mendocino and Clover Creek Farm in Lake County using that drill. Although the drill was tested on a hard surface before planting the plots, the seed delivery rate was very erratic in the field. The plantings at Nelson Ranch came

up sparse, uneven and with immediate heavy weed competition. That planting was abandoned. The planting at Clover Creek Farm was better than Nelson Ranch, though still irregular. Stand counts were taken throughout the plots to use as a potential covariate in the analysis of yield, but found to be non-significant (see below in Results). The third site at Open Field Farm near Petaluma was abandoned after a rain event revealed that the location was poorly drained and impossible to prepare for any timely planting. The forth site, to be planted last, was College of the Redwoods in Humboldt County. Based on the poor performance of the vineyard drill, the plan was made to switch back to the larger drill used in 2013. However, because of a series of mechanical breakdowns and pressure of other farming priorities it was not possible to haul the drill from Lake County back to College of the Redwoods before the window for spring planting closed.

The trial at Clover Creek Farm was conducted as a randomized complete block design (RCBD) with four replications of twelve varieties (Figures 1-3). Each plot contained one variety and was 4 feet wide by 50 feet long. Plots were harvested in cooperation with the University of California Small Grains Regional Testing Program.

Materials

The twelve varieties included in the trials are listed in Table 3.

Varieties were selected for inclusion in the trial based on: yield potential under organic coastal management, rust resistance, protein, lodging resistance, weed competiveness, and quality.

They were selected based on recommendations by:

- Kent Brittan and Lee Jackson, University of California Cooperative Extension;
- Michael Flowers, Oregon State University;
- Kevin Murphy and Steven Jones, Washington State University;
- and area farmers

Evaluation

Initial Stand Density – At approximately two weeks after planting, we recorded the average number of plants per row foot based on a five 5' samples.

Stripe Rust Incidence – At approximately the time of heading, we intended to record stripe rust incidence as a percentage of leaf area affected. However, no significant incidence of stripe rust was found at Clover Creek Farm; therefore this trait was not measured.

Relative Maturity – We measured relative maturity approximately two weeks after the first varieties begin to yellow from maturity. Maturity was based on the progress of senescence on a 1-9 scale relative to the varieties in the trial at that site, with 1 representing the earliest maturing plot and 9 representing the latest maturing plot.

Lodging – We intended to measure lodging at harvest as a visual rating on a 1 to 9 scale, with 1 being the entire plot on the ground, and 9 being no lodging. However, no lodging was observed in the trial at Clover Creek Farm; therefore this trait was not measured.

Plant Height – We measured plant height in inches at harvest based on a visual average of the plot average height from soil surface to the maximum height of the plants, and noted degree of variation.

Yield – We measure yield in pounds for each plot.

Moisture, Test Weight, and Protein – Grain from trial plots is still being cleaned and subsamples will sent to the California Wheat Commission Laboratory for analysis of these traits.

Data Analysis

For each of the traits measured, data was analyzed separately using a mixed model analysis where varieties are considered fixed effects and replicates considered random effects. Analysis of variance

(ANOVA) was used to test if there are significant differences between varieties. If significant differences (at $p<0.05$) were found, the Tukey's honestly significant difference (HSD) procedure was used to separate varieties. Because of the variable stand counts between plots, models were analyzed which included stand counts as a covariate. However, adding stand counts to the model did not improve the model's performance and they were subsequently dropped.

Outreach

A field day was conducted at the College of the Redwoods wheat nursery site. This took place on September 12th. Fifteen people attended the field day. In addition, a detailed report will be released after the quality analysis is complete. This report will be similar in format to the report released in 2013, found here: https://seedalliance.org/publications.

Budget: The budget, with proposed and actual line-item expenses, is shown in Table 4. Because the project team failed to complete replicated trials at all of the proposed sites, the team felt that funds should be spent very carefully and reserved with the intention to request an extension from the California Wheat Commission. This extension would allow the project team to complete research in additional sites in 2015 with the same original funding. These unspent funds are listed as a line item in Table 4.

Results:

Analysis of Variance (Table 5)

Significant differences between varieties were seen at both locations for relative maturity, plant height and yield. Stripe rust and lodging did not occur at the Clover Creek site.

Means (Table 6)

Stand count did not vary significantly between varieties; therefore means are not reported. Foisy was the latest to mature, while Alturas, Canus, Hollis, Lassik, and Otis were the earliest. Foisy was the tallest variety, averaging 42.8 inches, while Alturas was the shortest, averaging 21 inches. Yield was highest for Otis, at 2419 pounds per acre. Yield was lowest for Foisy, at 1069 pounds per acre.

Discussion, Conclusions and Recommendations:

The primary objective of the variety trials was to identify superior varieties for organic farms on the North Coast. Based on yield alone, the best hard spring wheat variety was Otis, a hard white variety. Among the soft white varieties, Alturas had the highest yield. Among the durum wheat, Kyle was the highest yielding. However, both Otis and Alturas were relatively short stature in this trial, which can be problematic in weedy fields.

A number of cultural and environmental factors may have influenced the performance of the varieties of these trials, and are important to keep in mind when interpreting the results. The first factor was the low and variable stand counts. The analysis showed no significant difference in stand counts between varieties; however, it is very conceivable that some varieties were favored in these conditions that would not have performed as well in a denser planting.

This project was only able to evaluate a subset of potential varieties, and was only able to evaluate them at a single location this season. Future trials would allow additional varieties to be evaluated, and would allow a better understanding of how well these varieties perform under a wider range of climatic conditions.

List of cultivars and accessions grown in College of the Redwoods nursery

Ent#	Name	Type
1	Abruzzi	Rye
2	Fourez	Rye
3	Merced	Rye
4	WAMV 0748	Hard Red Winter Wheat
5	WAMV 9563	Hard Red Winter Wheat
6	WAMV 2202	Hard Red Winter Wheat
7	WAMV 8162	Hard Red Winter Wheat
8	WAMV 5116	Hard Red Winter Wheat
9	WAMV 6558	Hard Red Winter Wheat
10	WAMV 9612	Hard Red Winter Wheat
11	WAMV 8973	Soft White Winter Club Wheat
12	Spanish	Spelt
13	Swiss	Spelt
14	Eaton	White Winter Wheat
15	Odessa	Hard Red Winter Wheat
16	Gold Coin	White Winter Wheat
17	Sol	Winter Wheat
18	Hopi Trigo	Wheat
19	AGS-104	Rye
20	Streaker	Oat
21	Hulless	Oat
22	Turkey Red	Hard Red Winter Wheat
23	Turkey Red (spring habit?)	Hard Red Winter Wheat
24	Supreme	Hard Red Spring Wheat
25	Defiance	Hard Red Spring Wheat
26	Marquis	Hard Red Spring Wheat
27	Red Bobs	Hard Red Spring Wheat
28	Surprise	Hard Red Spring Wheat
29	Ladoga	Hard Red Spring Wheat
30	Reliance	Hard Red Spring Wheat
31	Champlain	Hard Red Spring Wheat
32	Komar	Hard Red Spring Wheat
33	Mida	Hard Red Spring Wheat
34	Ceres	Hard Red Spring Wheat
35	Thatcher	Hard Red Spring Wheat
36	Stoa	Hard Red Spring Wheat
37	Spinkcota	Red Spring Durum Wheat
38	Selkirk	Hard Red Spring Wheat
39	Canthatch	Hard Red Spring Wheat
40	Garnet	Hard Red Spring Wheat
41	Reward	Hard Red Spring Wheat
42	Ethiopian Hulless	Barley
43	WAMV 0486	Hard Red Spring Wheat
44	WAMV 2083	Hard White Spring Wheat
45	Childham Blanca	White Spring Wheat
46	Baart	Semihard White Spring Wheat
47	Hard Red Calcutta	Hard Red Spring Wheat
48	Canoco	Durum Wheat
49	Pacific Bluestem	Hard White Spring Wheat
50	Blanca Fuerte	Hard White Spring Wheat
51	Lucille	Emmer
52	Vernal	Emmer
53	ND Common	Emmer
54	Debra	Emmer
55	TM23	Einkorn
56	PI 538722	Turkish Einkorn
57	Ladoga	Hard Red Spring Wheat
58	PI 167526	Turkish Einkorn
59	PI 355491	Italian Einkorn
60	PI 352364	Iranian Emmer
61	PI 297830	Ethiopian Emmer
62	PI 428160	Turkish Einkorn
63	PI 428151	Italian Einkorn
64	PI 273982	Ethiopian Emmer
65	PI 355504	Italian Emmer
66	PI 319869	Turkish Emmer
67	PI 191098	Spanish Einkorn
68	PI 307984	Moroccan Einkorn
69	PI 254163	Iranian Emmer
70	PI 352362	Italian Emmer
71	PI 298582	Ethiopian Emmer
72	PI 352363	Italian Emmer
74	PI 193882	Ethiopian Emmer
75	PI 191097	Spanish Einkorn
76	PI 387777	Ethiopian Emmer
77	PI 387791	Ethiopian Emmer
78	PI 470739	Turkish Emmer
79	PI 532304	Omani Emmer
80	PI 532305	Omani Emmer
81	PI 532306	Omani Emmer
82	PI 584654	Italian Einkorn
83	PI 606325	Turkish Emmer
84	PI 276001	Spanish Emmer
85	PI 167625	Turkish Einkorn
86	PI 387277	Ethiopian Emmer
87	PI 225332	Iranian Emmer
88	PI 10474	German Einkorn
89	PI 225164	Greek Einkorn
90	PI 94648	Italian Emmer
91	PI 94674	Georgian Emmer
92	PI 352361	Italian Emmer
93	PI 94626	Turkish Emmer
94	PI 275999	Spanish Emmer
95	PI 94624	Iranian Emmer
96	PI 427959	Iraqi Einkorn
97	PI 427927	Iraqi Einkorn
98	PI 355487	Italian Emmer
99	PI 355488	Italian Emmer
100	PI 276000	Spanish Emmer
101	PI 362699	Bosnian Emmer
102	PI 374685	Bosnian Emmer
103	PI 384333	Ethiopian Emmer
104	PI 197481	Ethiopian Emmer

Table 2: Calculated planting dates and temperatures based on historical averages of 10 inches of rain falling after planting and before July 1

Planting dates for Hayfork where 10 inches of rain are expected to fall before July 1
Weather data set date range: 07/01/99 to 06/30/13
Number of missing years in range: 0

	TypeOfYear	PlantingDate	AverageLow	AverageHigh	AverageDaily
1	Driest 10%	01-06	30.0	48.5	35.95
2	Driest 25%	01-26	31.0	46.5	36.45
3	Average	02-23	30.5	50.0	39.45
4	Wettest 25%	03-14	32.0	61.0	44.20
5	Wettest 10%	03-17	32.0	59.5	46.00

Planting dates for Eel River Camp where 10 inches of rain are expected to fall before July 1
Weather data set date range: 07/01/02 to 06/30/13
Number of missing years in range: 0

	TypeOfYear	PlantingDate	AverageLow	AverageHigh	AverageDaily
1	Driest 10%	02-02	37.0	59	46.1
2	Driest 25%	02-26	39.0	54	45.5
3	Average	03-26	40.0	62	49.1
4	Wettest 25%	04-04	37.0	64	48.7
5	Wettest 10%	04-18	41.5	66	53.8

Planting dates for Cooksie where 10 inches of rain are expected to fall before July 1
Weather data set date range: 07/01/86 to 06/30/13
Number of missing years in range: 3

	TypeOfYear	PlantingDate	AverageLow	AverageHigh	AverageDaily
1	Driest 10%	02-08	38.5	48.5	43.25
2	Driest 25%	03-12	36.5	46.5	42.20
3	Average	03-28	35.5	48.5	41.25
4	Wettest 25%	04-13	39.0	50.5	42.90
5	Wettest 10%	05-19	40.0	55.5	48.15

Planting dates for Laytonvile where 10 inches of rain are expected to fall before July 1
Weather data set date range: 07/01/03 to 06/30/13
Number of missing years in range: 1

	TypeOfYear	PlantingDate	AverageLow	AverageHigh	AverageDaily
1	Driest 10%	02-20	37	57	43.7
2	Driest 25%	02-26	35	57	44.7
3	Average	03-29	36	57	46.5
4	Wettest 25%	04-12	40	62	48.8
5	Wettest 10%	05-05	42	71	56.2

Planting dates for Konocti where 10 inches of rain are expected to fall before July 1
Weather data set date range: 07/01/96 to 06/30/13
Number of missing years in range: 0

	TypeOfYear	PlantingDate	AverageLow	AverageHigh	AverageDaily
1	Driest 10%	01-01	39.5	53	47.1
2	Driest 25%	01-15	42.0	56	48.0
3	Average	02-18	38.0	53	44.7
4	Wettest 25%	02-28	39.0	57	46.2
5	Wettest 10%	03-21	41.0	58	48.5

Planting dates for High Glade where 10 inches of rain are expected to fall before July 1
Weather data set date range: 07/01/98 to 06/30/13
Number of missing years in range: 5

	TypeOfYear	PlantingDate	AverageLow	AverageHigh	AverageDaily
1	Driest 10%	01-01	30.5	43.0	37.50
2	Driest 25%	01-24	38.5	45.5	40.70
3	Average	02-20	32.0	41.5	35.15
4	Wettest 25%	03-02	31.5	51.0	38.05
5	Wettest 10%	03-20	30.0	49.0	39.00

Planting dates for Boonville where 10 inches of rain are expected to fall before July 1
Weather data set date range: 07/01/91 to 06/30/13
Number of missing years in range: 0

	TypeOfYear	PlantingDate	AverageLow	AverageHigh	AverageDaily
1	Driest 10%	01-08	42	56	47.60
2	Driest 25%	01-28	37	57	46.05
3	Average	02-17	39	58	46.70
4	Wettest 25%	03-18	42	63	50.50
5	Wettest 10%	03-30	41	64	50.95

Planting dates for Santa Rosa where 10 inches of rain are expected to fall before July 1
Weather data set date range: 07/01/92 to 06/30/13
Number of missing years in range: 0

	TypeOfYear	PlantingDate	AverageLow	AverageHigh	AverageDaily
1	Driest 10%	01-01	40.0	54	46.30
2	Driest 25%	01-08	41.0	55	47.40
3	Average	02-03	44.0	59	49.90
4	Wettest 25%	02-21	44.0	57	49.00
5	Wettest 10%	03-13	44.5	64	52.45

Planting dates for Big Rock where 10 inches of rain are expected to fall before July 1
Weather data set date range: 07/01/05 to 06/30/13
Number of missing years in range: 0

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   TypeOfYear PlantingDate AverageLow AverageHigh AverageDaily
1  Driest 10%        01-01       42.0        51.5        46.60
2  Driest 25%        01-27       44.5        56.0        48.45
3     Average        02-17       44.0        60.0        49.60
4 Wettest 25%        03-11       42.0        58.5        48.75
5 Wettest 10%        03-20       43.5        54.5        48.65


Planting dates for Olema Valley where 10 inches of rain are expected to fall
before July 1
Weather data set date range: 07/01/06 to 06/30/13
Number of missing years in range: 0

   TypeOfYear PlantingDate AverageLow AverageHigh AverageDaily
1  Driest 10%        01-22         39          54         47.4
2  Driest 25%        02-03         36          61         46.2
3     Average        02-23         34          55         47.7
4 Wettest 25%        03-16         39          58         51.8
5 Wettest 10%        03-25         42          58         50.5
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Table 3: Selected wheat varieties for 2014 organic wheat replicated trials

Variety	**Type**
Alturas	Soft White Spring
Canus	Hard Red Spring
Durum-Iraq	Durum
Foisy	Soft White Spring
Fortissimo	Durum
Fortuna	Hard Red Spring
Hollis	Hard Red Spring
Khorasan	*Triticum turanicum*
Kyle	Durum
Lassik	Hard Red Spring
Otis	Hard White Spring
Red Fife	Hard Red Spring

Table 4: Line-item budget for 2013 organic wheat trials

Line Item	**Budgeted**	**Actual**
Labor: John LaBoyteaux	2,200.00	1,250
Labor: Jared Zystro	2,800.00	2,200
Seed	600	58.46
Custom Harvest	1,500.00	
Travel	1,800.00	348.88
Supplies & Materials	1100	900
Total	**10,000.00**	**4,757.34**
Unspent		**5,242.66**

Table 5: Analysis of Variance (ANOVA) for Clover Creek Farm trial location for traits evaluated

	Stand count	Stripe rust incidence	Relative maturity	Plant height	Lodging	Yield
Variety	N/A	N/A	**	**	N/A	*

*,** Significant at the 0.05 and 0.01 probability levels, respectively

Table 6: Means of traits evaluated at Clover Creek Farm trial location

Entry	**Yield (lbs / acre)**	**Height (in)**	**Maturity (1-9)**
Alturas	2356ab	21g	5.3d
Canus	1414cd	32.8e	5d
Durum-Iraq	1310cd	38bc	7.3b
Foisy	1069d	42.8a	8.8a
Fortissimo	1619abcd	26.5f	6c
Fortuna	1867abcd	33de	5.8c
Hollis	2051abc	38.5b	5d
Khorasan	1400cd	33.8de	6c
Kyle	1892abcd	35.8bcd	5.8c
Lassik	1551bcd	35de	5d
Otis	2419a	23.5g	5d
Red Fife	1299cd	35.5cde	7b
AVE	1688	33	6.0
LSD	481	2.94	0.47
CV	0.41	0.19	0.19

Figure 1: Clover Creek Farm trial planting

Figure 2: Clover Creek Farm trial prior to harvest

Figure 3: Clover Creek Farm trial during harvest