USDA-ARS
Western Wheat Quality Laboratory

Genotype & Environment Study
6-Year Summary

1997-2002 Crop Years

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EXECUTIVE SUMMARY

This report compiles and summarizes the first six years of a study aimed at profiling the quality of the leading commercial wheat varieties and advanced experimental breeding lines in or nearing production throughout the Columbia River-PNW export region.

Grain samples were obtained from university extension trials with multiple sites (nurseries) per crop year. In these nurseries, varieties were grown side-by-side under identical management and weather conditions. Milling, baking and other end-use quality traits were determined at the USDA-ARS Western Wheat Quality Laboratory (WWQL) with the assistance of Brady P. Carter, Washington State University Wheat Quality Specialist. Statistical analyses (*t*-tests) were conducted to compare each variety against a selected "check" variety. The resultant "*t*-scores" were used to rate varieties according to their relative overall quality. Similarly, individual environments were statistically analyzed to assess both the relative contribution of this factor to quality, as well as to examine the effect of location on producing high quality grain. The aim of this study was to identify superior quality varieties and identify which regions they may be best produced in.

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Introduction

This report compiles and summarizes the first six years of a study aimed at profiling the quality of the leading commercial wheat varieties and advanced experimental breeding lines in or nearing production throughout the Columbia River-PNW export region. The Washington, Idaho and Oregon Wheat Commissions each supported financially the analysis of samples from their respective states.

Grain samples were obtained from university extension trials with multiple, individual sites (nurseries) per crop year. In these nurseries, varieties were grown side-by-side under identical management and weather conditions. Milling, baking and other end-use quality traits were determined at the USDA-ARS Western Wheat Quality Laboratory (WWQL) with the assistance of Brady P. Carter, Washington State University Wheat Quality Specialist. Statistical analyses (*t*-tests) were conducted to compare each variety against a selected "check" variety. The resultant "*t*-scores"[†] were used to rate varieties according to their relative overall quality. Check varieties were selected based on their prominence in production, extensive testing history at the WWQL, and an understanding of the relationship of the quality of the check to that of the market class or sub-class.

Individual environments were statistically analyzed using Analysis of Variance (ANOVA) to assess both the relative contribution of the environment to quality, as well as to examine the effect of 'location' on producing high quality grain. The aim of this study was to identify superior quality varieties and identify which regions they may be best produced in.

NB: Many studies of this type analyze the "genotype" effect–those differences ascribable to genetic differences among varieties, the "environmental" effects–that variation ascribable to differences among geographical locations and crop years, and the interaction of these two–the "G-by-E" (G X E). However, to conduct such a statistical analysis, replicate grain samples are required. In the present study, replication of variety samples in individual environments was foregone to contain the cost of the research. Consequently, the GXE interaction term has not been directly analyzed. Hence the name "G&E".

[†] For the ANOVA, the data for each 'test' variety is sub-setted individually along with that of the 'check' variety, using only check variety nurseries wherein the test variety being analyzed appears, *i.e.* a balanced design, and there appears <u>at least five observations of the test variety</u>. The '*t*-score' is actually the statistic, "Student's *t*" (R.G.D. Steel, J.H. Torrie and D.A. Dickey, 1997, *Principles and Procedures of Statistics: A Biometrical Approach*, 3rd ed., The McGraw-Hill Co., New York). Student's *t* is calculated by SAS using the two-tailed *t*-distribution and forcing the check variety to appear after the test variety in the analysis such that positive values of *t* indicate the test variety has a value greater than that of the check, negative values indicating that the test variety value is less than that of the check. For the individual *t*-scores (pages 10-15, no judgement has been made as to whether greater or lesser values are more or less desirable from a quality standpoint. In calculating the **Summary *t*-Scores** (pages 6-9), this judgement has been applied, changing the sign of the weighting term as appropriate (*see* page 5). For the analyses here, which represent from 5 to 39 observations (4 to 38 degrees of freedom), the value of *t* at the $P = 0.05$ probability of a numerically lager value of *t* is 2.776 to about 2.021 A description of the materials and methods used for assessing end-use quality can be found at:
http://www.wsu.edu/~wwql/php/index.php

Calculation of Summary *t*-Scores

Minimum number of observations per test variety = 5
Check Varieties: Stephens, Rely, Alpowa, WPB 926, ID377s, and Finley.

<u>Soft White Winter Wheat Varieties</u>
Grain = (test weight *0.2) + (wheat protein * -0.8)
Milling = (milling score * 0.6) + (break flour yield * 0.4)
End-product = (cookie diam. * 0.8) + (mixo. abs. * -0.2)
Overall = (grain * 0.1) + (milling * 0.4) + (end-product * 0.5)

<u>Soft White Winter Club Wheat Varieties</u>
Grain = (test weight *0.2) + (wheat protein * -0.8)
Milling = (milling score * 0.6) + (break flour yield * 0.4)
End-product = (cookie diam. * 0.6) + (mixo. abs. * -0.4)
Overall = (grain * 0.1) + (milling * 0.4) + (end-product * 0.5)

<u>Soft White Spring Wheat Varieties</u>
Grain = (test weight *0.2) + (wheat protein * -0.8)
Milling = (milling score * 0.6) + (break flour yield * 0.4)
End-product = (cookie diam. * 0.8) + (mixo. abs. * -0.2)
Overall = (grain * 0.1) + (milling * 0.4) + (end-product * 0.5)

<u>Hard Red and White Spring Wheat Varieties (Combined Analysis)</u>
Grain = (test weight *0.2) + (wheat protein * +0.8)
Milling = (milling score * 1.0)
End-product = (loaf vol. * 0.8) + (mixo. abs. * 0.2)
Overall = (grain * 0.1) + (milling * 0.3) + (end-product * 0.6)

<u>Hard White Spring Wheat Varieties (Separate Analysis)</u>
Grain = (test weight *0.2) + (wheat protein * +0.8)
Milling = (milling score * 1.0)
End-product = (loaf vol. * 0.5) + (L24 Alkaline Noodle Color * 0.5)
Overall = (grain * 0.05) + (milling * 0.3) + (end-product * 0.65)

<u>Hard Red and White Winter Wheat Varieties</u>
Grain = (test weight *0.2) + (wheat protein * +0.8)
Milling = (milling score * 1.0)
End-product = (loaf vol. * 0.8) + (mixo. abs. * 0.2)
Overall = (grain * 0.1) + (milling * 0.3) + (end-product * 0.6)

Soft White Winter Wheat Variety Summary *t*-Scores

Variety	Grain	Milling	End-Product	Overall	By Rank	Overall
ALBION	0.07	-4.76	-1.05	-2.42	BRUNDAGE96	5.17
ARS96105	-1.72	-0.68	0.11	-0.39	LEWJAIN	2.49
BASIN	1.94	-3.19	2.24	0.04	ID17113A	2.28
BEAMER	1.95	-0.64	-0.76	-0.44	FINCH	2.23
BRUNDAGE96	2.40	3.29	7.23	5.17	ROD	1.44
CASHUP	1.37	-1.13	3.10	1.24	CASHUP	1.24
DAWS	-0.23	-2.25	-9.22	-5.53	HILL81	1.22
ELTAN	1.55	1.52	0.53	1.03	HUBBARD	1.13
FINCH	3.72	1.78	2.28	2.23	ID576	1.03
GT123-64	-0.63	-2.08	-0.39	-1.09	ELTAN	1.03
HILL81	0.15	3.19	-0.15	1.22	MJ-9	0.31
HUBBARD	1.05	0.87	1.37	1.13	ID9134302A	0.25
ID17113A	0.09	3.88	1.43	2.28	WA7916	0.07
ID576	0.86	1.21	0.92	1.03	BASIN	0.04
ID9134302A	4.09	1.04	-1.15	0.25	STEPHENS	0.00
LAMBERT	-0.09	2.71	-2.56	-0.21	MOHLER	-0.12
LEWJAIN	0.88	1.94	3.25	2.49	LAMBERT	-0.21
MACVICAR	1.13	-1.30	-3.32	-2.07	WA7918	-0.28
MADSEN	-2.03	-0.13	-4.33	-2.42	ARS96105	-0.39
MJ-4	0.11	0.25	-4.43	-2.10	BEAMER	-0.44
MJ-9	-0.36	2.64	-1.42	0.31	GT123-64	-1.09
MOHLER	1.94	0.68	-1.18	-0.12	TUBBS	-1.83
OR2010010	-1.27	-3.75	-1.50	-2.38	MACVICAR	-2.07
ROD	5.14	1.57	0.59	1.44	MJ-4	-2.10
STEPHENS	0.00	0.00	0.00	0.00	OR2010010	-2.38
TUBBS	1.77	-1.21	-3.05	-1.83	ALBION	-2.42
WA7916	0.22	0.02	0.08	0.07	MADSEN	-2.42
WA7917	-1.28	-4.35	-4.32	-4.03	WEATHERFORD	-2.44
WA7918	0.38	-0.64	-0.13	-0.28	WA7917	-4.03
WEATHERFORD	-1.33	-1.93	-3.07	-2.44	WPB470	-4.84
WPB470	0.70	-6.08	-4.96	-4.84	DAWS	-5.53

Soft White Winter Club Wheat Variety Summary *t*-Scores

Variety	Grain	Milling	End-Product	Overall	By Rank	Overall
ARS98237	3.49	3.23	3.49	3.39	CHUKAR	3.71
BRUEHL	-0.23	-1.16	2.38	0.70	HILLER	3.61
CHUKAR	0.31	4.87	3.47	3.71	ARS98237	3.39
CODA	-0.87	2.30	-2.16	-0.24	EDWIN	2.22
EDWIN	2.23	3.31	1.34	2.22	TRES	0.76
HILLER	0.08	4.65	3.47	3.61	BRUEHL	0.70
RELY	0.00	0.00	0.00	0.00	TEMPLE	0.01
ROHDE	-2.11	-6.24	-2.80	-4.11	RELY	0.00
TEMPLE	0.52	1.75	-1.49	0.01	CODA	-0.24
TRES	0.40	0.99	0.64	0.76	ROHDE	-4.11

Soft White Spring Wheat Variety Summary *t*-Scores

Variety	Grain	Milling	End-Product	Overall		By Rank	Overall
ALPOWA	0.00	0.00	0.00	0.00		VANNA	8.19
ALTURAS	0.59	5.74	2.70	3.70		EDEN	6.68
BZ698-31	-1.13	2.02	4.05	2.72		ZAK	5.70
CALORWA	-2.18	-0.07	2.76	1.13		JUBILEE	5.57
CENTENNIAL	0.07	2.77	-0.05	1.09		WA7905	5.07
CHALLIS	3.04	3.34	5.15	4.21		CHALLIS	4.21
EDEN	3.15	7.29	6.90	6.68		WA7883	3.90
EDWALL	-4.45	0.77	2.68	1.21		ALTURAS	3.70
FIELDER	-1.13	1.80	2.69	1.95		WA7906	3.66
ID556	-1.55	-0.68	3.28	1.21		WHITEBIRD	3.61
JUBILEE	-1.45	7.93	5.08	5.57		WA7921	3.36
PENAWAWA	-2.33	-5.36	0.94	-1.91		BZ698-31	2.72
POMERELLE	-1.26	0.32	4.32	2.16		POMERELLE	2.16
SPRITE	-2.46	4.63	0.29	1.75		WAKANZ	2.01
VANNA	-0.77	5.96	11.77	8.19		FIELDER	1.95
WA7877	-1.20	1.29	2.53	1.66		SPRITE	1.75
WA7883	-2.32	4.18	4.92	3.90		WA7877	1.66
WA7905	0.33	6.84	4.60	5.07		WAWAWAI	1.24
WA7906	-0.54	3.26	4.82	3.66		ID556	1.21
WA7921	-0.14	4.13	3.45	3.36		EDWALL	1.21
WAKANZ	-3.06	-0.30	4.87	2.01		CALORWA	1.13
WAWAWAI	-5.04	2.23	1.71	1.24		CENTENNIAL	1.09
WHITEBIRD	-1.07	4.43	3.89	3.61		ALPOWA	0.00
ZAK	-1.37	3.21	9.12	5.70		PENAWAWA	-1.91

Hard Red and White Spring Wheat Variety Summary *t*-Scores

Variety	Grain	Milling	End-Product	Overall
BUTTE86	0.85	2.63	-3.25	-1.08
BZ998-477W	-4.19	6.42	-4.29	-1.07
CO1955W	-1.96	2.12	-2.92	-1.31
CO1963W	-2.36	2.20	-1.83	-0.67
EXPRESS	-0.66	-4.58	0.51	-1.14
GMBR2306	-5.79	3.02	-4.86	-2.59
GMBR7030	-4.40	0.95	-2.48	-1.64
HANK	-1.87	4.06	-0.71	0.60
HOLLIS	-0.88	5.63	0.36	1.82
ID377S	-4.84	-1.35	-7.15	-5.18
ID545	-1.69	1.54	0.57	0.63
JEFFERSON	-1.81	14.29	-3.15	2.22
KLASIC	0.12	3.45	1.49	1.94
LOLO	-2.80	1.08	-3.08	-1.80
MACON	-4.16	6.22	-0.84	0.95
ML455	-7.53	4.99	-3.96	-1.63
NW#10	-1.20	-2.63	-0.57	-1.25
PLATA	-2.48	5.31	0.93	1.90
PRISTINE	-0.16	6.90	-2.75	0.40
SAXON	-2.34	0.71	-1.63	-1.00
SCARLET	-3.77	6.52	-1.58	0.63
SEEDEXHR	-3.68	0.08	-4.06	-2.78
SPILLMAN	-3.35	5.67	-1.18	0.66
SX1501B	-17.80	1.81	-5.92	-4.79
SX1502B	-2.17	2.37	-0.82	0.00
SX1503B	-5.02	-2.46	-6.58	-5.19
TARA2002	-2.15	6.66	0.88	2.31
WA7839	0.09	4.00	0.04	1.23
WA7894	-2.80	1.25	-0.18	-0.01
WA7914	-2.48	2.33	-2.39	-0.98
WA7925	-2.70	3.87	-0.26	0.73
WA7931	-4.42	4.21	-2.07	-0.42
WINSOME	-9.19	3.30	-4.27	-2.49
WPB926	0.00	0.00	0.00	0.00
WPB936	-1.95	4.70	0.08	1.26
ZEKE	-3.39	6.47	-3.19	-0.31

Variety	Overall
TARA2002	2.31
JEFFERSON	2.22
KLASIC	1.94
PLATA	1.90
HOLLIS	1.82
WPB936	1.26
WA7839	1.23
MACON	0.95
WA7925	0.73
SPILLMAN	0.66
ID545	0.63
SCARLET	0.63
HANK	0.60
PRISTINE	0.40
SX1502B	0.00
WPB926	0.00
WA7894	-0.01
ZEKE	-0.31
WA7931	-0.42
CO1963W	-0.67
WA7914	-0.98
SAXON	-1.00
BZ998-477W	-1.07
BUTTE86	-1.08
EXPRESS	-1.14
NW#10	-1.25
CO1955W	-1.31
ML455	-1.63
GMBR7030	-1.64
LOLO	-1.80
WINSOME	-2.49
GMBR2306	-2.59
SEEDEXHR	-2.78
SX1501B	-4.79
ID377S	-5.18
SX1503B	-5.19

Hard White Spring Wheat Variety Summary *t*-Scores

Variety	Grain	Milling	End-Product	Overall	By Rank	Overall
BZ998-477W	-0.83	2.95	0.24	0.84	MACON	2.48
CO1955W	-1.59	0.48	-3.23	-1.79	ML455	2.09
CO1963W	-0.70	1.68	-4.64	-1.96	WA7931	0.97
GMBR7030	-0.77	-0.33	-7.85	-4.18	LOLO	0.84
ID377S	0.00	0.00	0.00	0.00	BZ998-477W	0.84
KLASIC	1.51	4.08	-6.91	-1.93	WINSOME	0.28
LOLO	0.26	2.56	0.04	0.84	ID377S	0.00
MACON	-1.39	6.97	1.34	2.48	PLATA	-0.49
ML455	-2.92	6.77	1.28	2.09	CO1955W	-1.79
PLATA	-0.14	5.29	-4.10	-0.49	KLASIC	-1.93
WA7931	-3.02	5.24	0.01	0.97	CO1963W	-1.96
WINSOME	-3.63	4.53	-0.72	0.28	GMBR7030	-4.18

Hard Red and White Winter Wheat Variety Summary *t*-Scores

Variety	Grain	Milling	End-Product	Overall	By Rank	Overall
BLIZZARD	-0.38	0.75	-1.03	-0.43	PILLAR	0.40
BOUNDARY	0.01	-3.61	-3.50	-3.18	FINLEY	0.00
BUCHANAN	-2.90	-2.20	-1.74	-1.99	HATTON	-0.42
COLUMBIA1	0.59	-7.82	-2.69	-3.90	BLIZZARD	-0.43
ESTICA	-5.99	-8.17	-7.39	-7.48	WESTON	-0.63
FINLEY	0.00	0.00	0.00	0.00	MORELAND	-1.79
GARY	-1.04	-3.58	-2.97	-2.96	BUCHANAN	-1.99
HATTON	0.87	-2.29	0.30	-0.42	Q1824	-2.59
MORELAND	0.20	-3.82	-1.10	-1.79	NUHORIZON	-2.91
NUFRONTIER	0.06	-2.26	-3.79	-2.94	NUFRONTIER	-2.94
NUHORIZON	1.16	-8.37	-0.86	-2.91	GARY	-2.96
PILLAR	7.03	-6.95	2.97	0.40	BOUNDARY	-3.18
Q1824	-0.77	-5.92	-1.23	-2.59	WANSER	-3.37
Q542	-0.03	-8.17	-2.55	-3.98	RESIDENCE	-3.71
RESIDENCE	-1.94	-1.87	-4.93	-3.71	COLUMBIA1	-3.90
SEMPER	-2.12	-3.33	-4.54	-3.93	SEMPER	-3.93
SYMPHONY	0.09	-11.19	-3.70	-5.57	Q542	-3.98
WANSER	-0.96	-5.02	-2.95	-3.37	SYMPHONY	-5.57
WESTON	2.88	-7.73	2.33	-0.63	ESTICA	-7.48

Soft White Winter Wheat Variety *t*-Scores

Variety	N	Test Weight	NIR Hard.	Wheat Protein	Single Hard.	Kernel Weight	Break Flour Yield	Flour Yield	Flour Ash	Milling Score	Flour Protein	Flour Swelling Volume	Flour RVA	Mixo. Abs.	Cookie Diameter
ALBION	23	-1.27	-3.34	-0.40	5.05	-17.06	-1.71	-8.69	-1.48	-6.79	-0.57	2.23	0.70	-0.44	-1.42
ARS96105	6	-4.75	-3.72	0.96	-6.91	-3.66	5.64	-1.30	4.30	-4.90	0.68	.	.	0.71	0.32
BASIN	16	3.73	-3.64	-1.49	1.72	-13.54	1.18	-9.48	-1.68	-6.10	-2.09	2.16	1.67	-1.33	2.47
BEAMER	26	4.41	-1.85	-1.33	4.25	-11.01	1.18	-0.41	-1.99	-1.86	-0.02	0.00	1.29	-0.32	-1.03
BRUNDAGE96	29	3.67	-1.45	-2.08	-3.04	-15.88	9.19	-1.55	-0.65	-0.64	-1.39	-1.75	-1.65	-1.19	8.74
CASHUP	25	2.15	-5.01	-1.18	-0.61	-10.78	2.62	-4.80	-0.30	-3.63	-1.41	2.65	6.21	-2.94	3.14
DAWS	10	6.12	0.56	1.82	2.74	-8.39	-0.14	-4.39	0.56	-3.65	0.92	-0.21	3.20	0.38	-11.43
ELTAN	33	1.41	-3.54	-1.59	-1.45	-12.65	6.06	-6.45	-4.80	-1.51	-0.36	-0.39	2.73	3.23	1.47
FINCH	29	4.28	2.08	-3.58	1.77	-15.92	7.78	1.19	3.97	-2.22	-3.05	-1.52	-4.95	0.06	2.87
GT123-64	12	0.98	-2.38	1.03	2.22	-4.28	-0.11	-3.62	-0.77	-3.39	0.64	.	.	0.86	-0.27
HILL81	21	3.45	-0.44	0.67	3.88	-16.18	4.99	3.08	0.85	1.99	1.63	-1.20	-2.75	0.81	0.02
HUBBARD	24	5.19	0.11	-0.01	2.68	-11.50	4.22	-3.46	-1.24	-1.37	0.15	-1.03	-0.13	0.65	1.87
ID17113A	12	1.85	-0.13	0.35	1.15	-13.98	6.69	1.22	-0.60	2.01	0.43	.	.	0.12	1.82
ID576	5	4.30	-0.98	0.00	0.57	-9.18	2.66	-0.82	-1.45	0.24	-0.43	.	.	-0.14	1.12
ID9134302A	8	0.64	2.50	-4.95	10.65	-4.95	5.89	1.99	3.92	-2.19	-0.15	.	.	1.33	-1.11
LAMBERT	25	1.32	2.83	0.44	1.36	-2.72	3.13	0.91	-2.87	2.43	-0.18	-1.06	-0.36	-1.42	-3.56
LEWJAIN	21	2.34	-0.50	-0.51	-2.22	-15.76	4.59	-0.78	-1.23	0.18	-0.24	-1.94	-0.91	1.76	4.50
MACVICAR	21	1.30	-0.96	-1.09	8.00	-3.54	0.27	-3.82	-1.95	-2.34	-1.98	-0.67	4.98	-0.20	-4.20
MADSEN	39	0.72	3.44	2.72	9.62	-17.18	4.49	-2.45	1.93	-3.21	3.89	-2.27	-2.31	1.19	-5.12
MJ-4	12	-5.85	1.26	-1.60	7.15	-11.89	4.60	0.72	2.87	-2.65	-1.38	.	.	0.30	-5.46
MJ-9	12	-1.90	-2.15	-0.03	-3.54	-11.56	5.43	-1.86	-4.01	0.78	-0.34	.	.	-0.36	-1.87
MOHLER	14	2.90	-1.91	-1.70	4.01	-6.85	5.01	-1.01	0.89	-2.20	-0.42	.	.	-0.40	-1.58
OR2010010	6	-0.90	4.96	1.36	7.83	-2.32	-3.40	-4.99	-0.31	-3.99	1.68	.	.	1.92	-1.40
ROD	28	-1.92	2.34	-6.91	6.62	-13.28	3.44	-2.50	-2.80	0.33	-5.52	-0.87	-1.06	0.42	0.84
STEPHENS	41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TUBBS	17	-2.32	4.15	-2.79	12.71	-6.30	0.87	-4.19	1.06	-2.60	-2.41	-3.67	.	-0.51	-3.94
WA7916	6	-0.20	0.40	-0.33	2.57	-5.97	3.45	-2.14	0.96	-2.26	-1.02	.	.	-0.25	0.04
WA7917	6	-3.14	-1.34	0.82	2.23	-11.00	-3.56	-11.29	-2.09	-4.87	-1.15	.	.	-0.25	-5.46
WA7918	5	-0.33	-1.09	-0.56	-3.68	-5.03	2.43	-1.97	1.83	-2.68	-0.83	.	.	-1.17	-0.46
WEATHERFORD	20	1.99	4.47	2.16	10.70	-8.42	0.29	-2.43	2.02	-3.41	2.13	-0.95	-2.43	0.91	-3.61
WPB470	23	12.83	-1.14	2.33	3.21	-3.54	-5.15	-8.93	0.29	-6.70	3.33	0.02	7.18	3.02	-5.44

Soft White Winter Club Wheat Variety *t*-Scores

Variety	N	Test Weight	NIR Hard.	Wheat Protein	Single Kernel Hard.	Single Kernel Weight	Break Flour Yield	Flour Yield	Flour Ash	Milling Score	Flour Protein	Mixo. Abs.	Cookie Diameter	Cake Volume
ARS98237	6	-1.12	-0.46	-4.64	-0.04	-9.51	8.52	0.06	0.35	-0.29	-3.04	-3.81	3.27	.
BRUEHL	18	-3.73	-3.59	-0.65	-3.44	6.76	-0.52	-1.00	2.06	-1.59	-0.54	1.58	5.02	-0.21
CHUKAR	18	-2.32	-0.14	-0.97	-3.39	-0.56	5.14	3.41	-3.56	4.69	-1.55	-0.09	5.72	0.35
CODA	22	7.24	3.69	2.90	13.14	-1.01	1.26	2.34	-1.75	3.00	2.62	3.41	-1.32	.
EDWIN	18	8.04	1.91	-0.78	0.43	-1.34	-0.12	5.02	-2.36	5.59	1.02	2.03	3.59	-0.15
HILLER	21	-9.46	-3.39	-2.47	-4.96	1.51	5.35	8.15	0.78	4.19	-3.36	0.72	6.27	.
RELY	34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
ROHDE	22	6.33	4.12	4.22	12.99	1.07	-11.00	-5.84	-1.91	-3.06	4.07	5.84	-0.78	.
TEMPLE	22	3.30	1.47	0.17	0.59	4.06	2.18	3.21	0.55	1.46	0.92	5.68	1.31	.
TRES	10	2.02	0.52	0.00	2.60	-1.29	0.82	1.75	0.00	1.10	0.14	-0.41	0.80	.

Soft White Spring Wheat Variety *t*-Scores

Variety	N	Test Weight	NIR Hard.	Wheat Protein	Single Hard.	Kernel Weight	Break Flour Yield	Flour Yield	Flour Ash	Milling Score	Flour Protein	Flour Swelling Volume	Flour RVA	Mixo. Abs.	Cookie Diameter
ALPOWA	32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ALTURAS	12	-3.48	-2.08	-1.61	1.35	-3.52	8.48	9.11	4.07	3.91	-1.07	1.69	2.00	0.06	3.39
BZ698-31	12	-3.89	2.13	0.44	7.86	-5.16	1.07	6.35	2.69	2.65	0.98	3.67	6.42	-1.41	4.71
CALORWA	20	-4.63	1.48	1.57	3.70	-11.34	3.25	0.04	3.90	-2.29	2.32	.	.	-3.20	2.65
CENTENNIAL	5	-1.99	1.23	-0.58	1.24	-6.44	0.47	6.01	-0.30	4.31	-0.87	8.28	1.29	-1.67	-0.48
CHALLIS	14	-5.86	1.40	-5.27	-1.51	0.42	2.20	4.96	3.36	4.10	-4.42	9.23	7.50	-2.46	5.82
EDEN	9	-0.27	5.28	-4.01	3.96	-11.46	5.43	9.59	-1.93	8.53	-3.60	.	.	-5.20	7.33
EDWALL	20	-15.11	3.00	1.78	-0.48	-0.75	0.49	2.54	1.61	0.96	0.37	11.93	3.72	-2.21	2.80
FIELDER	5	-2.27	-1.37	0.84	0.99	-2.12	3.04	2.23	0.37	0.97	0.39	.	.	-1.07	3.09
ID556	5	1.64	2.40	2.35	3.17	-5.72	-1.05	0.29	1.20	-0.44	2.87	.	.	-0.75	3.91
JUBILEE	12	-2.29	2.14	1.24	5.26	-7.37	11.30	6.57	-2.48	5.69	1.24	-0.10	-5.00	-0.04	6.34
PENAWAWA	20	-4.69	-4.44	1.74	-4.96	-3.55	-3.31	-2.08	6.35	-6.73	2.00	6.68	6.99	-2.11	0.65
POMERELLE	10	-7.67	-1.13	-0.34	3.60	-11.71	1.93	1.51	4.15	-0.76	-0.84	-1.44	-4.45	-1.67	4.98
SPRITE	5	-3.44	1.61	2.21	-1.43	-4.28	3.65	4.83	-1.06	5.28	1.16	3.35	-0.16	-4.03	-0.65
VANNA	15	-7.31	1.00	-0.87	-11.61	-2.57	7.99	5.29	0.56	4.61	-0.25	-2.81	-4.35	-2.52	14.08
WA7877	14	-6.42	-1.88	-0.10	-2.35	-1.66	1.50	1.36	1.32	1.15	-0.23	7.01	4.00	0.04	3.17
WA7883	17	-3.97	-2.44	1.91	-0.72	0.71	3.30	7.85	2.88	4.77	2.21	7.63	5.00	-0.03	6.14
WA7905	12	-3.18	-1.67	-1.21	-3.57	1.88	6.59	6.93	-2.07	7.01	-1.66	-0.50	-4.59	-2.98	5.01
WA7906	8	-1.82	-1.06	0.22	0.88	1.70	3.85	3.89	-0.79	2.86	-0.52	.	.	-3.02	5.27
WA7921	8	-3.53	-0.50	-0.71	-1.05	2.26	6.15	5.75	0.90	2.79	-0.72	.	.	-1.39	3.96
WAKANZ	15	-7.02	1.55	2.07	2.85	-3.03	-0.43	2.60	4.79	-0.21	2.61	2.10	-7.11	-3.63	5.18
WAWAWAI	23	1.91	3.02	6.78	2.61	8.13	-1.52	3.12	-3.22	4.73	5.15	-6.07	-7.26	0.99	2.39
WHITEBIRD	10	-1.10	6.84	1.06	7.37	-11.54	5.85	3.69	-1.20	3.48	0.43	-2.23	-9.36	-1.41	4.51
ZAK	32	-5.43	2.49	0.36	-1.62	1.41	4.39	7.15	5.34	2.42	0.16	-6.87	-12.54	-1.83	10.94

Hard Red and White Spring Wheat Variety *t*-Scores

Variety	N	Test Weight	NIR Hard.	Wheat Protein	Single Kernel Hard.	Single Kernel Weight	Flour Yield	Flour Ash	Milling Score	Flour Protein	Mixo. Abs.	Bread Baking Water Abs.	Bread Baking Loaf Volume	Bread Baking Crumb Ranking
BUTTE86	20	2.96	13.43	0.32	8.90	-9.84	0.94	-3.22	2.63	0.10	1.64	1.20	-4.47	1.88
BZ998-477W	5	-1.26	2.21	-4.92	-8.22	2.86	1.06	-4.28	6.42	-6.05	-1.66	-0.46	-4.95	2.14
CO1955W	5	8.54	2.53	-4.59	10.26	-10.06	-0.30	-4.22	2.12	-4.58	-1.92	-1.35	-3.17	2.14
CO1963W	5	1.78	-0.85	-3.39	0.09	-3.91	-0.09	-4.35	2.20	-3.25	-2.32	-3.44	-1.71	1.18
EXPRESS	12	2.57	4.48	-1.47	11.75	-9.64	-7.15	1.71	-4.58	0.67	1.30	1.34	0.31	0.56
GMBR2306	10	0.44	4.68	-7.35	4.15	-2.87	0.36	-4.13	3.02	-6.67	-2.23	-1.75	-5.52	1.66
GMBR7030	5	4.70	6.48	-6.68	4.73	-4.47	-0.05	-2.07	0.95	-6.12	-3.51	-1.13	-2.22	0.78
HANK	15	0.67	1.02	-2.51	-0.80	5.53	6.34	-2.20	4.06	-2.36	0.24	1.44	-0.95	0.60
HOLLIS	13	1.62	-0.04	-1.50	-3.45	0.11	4.37	-4.80	5.63	-0.83	-0.02	0.19	0.46	-2.52
ID377S	32	3.32	2.00	-6.88	7.64	-9.66	-4.70	-3.38	-1.35	-6.48	-4.97	-4.64	-7.70	6.01
ID545	5	0.96	6.89	-2.35	4.20	2.49	2.70	-0.52	1.54	-2.48	-0.20	0.82	0.76	-3.21
JEFFERSON	20	7.47	3.33	-4.13	3.77	-5.96	10.99	-9.12	14.29	-3.55	-1.50	-1.61	-3.56	2.21
KLASIC	5	2.82	-4.95	-0.56	-3.77	-3.02	2.29	-3.30	3.45	-0.10	-3.31	-3.43	2.69	-0.49
LOLO	15	2.69	2.06	-4.17	2.01	-2.50	-1.40	-3.44	1.08	-3.74	-2.47	-2.35	-3.23	1.81
MACON	12	0.94	0.09	-5.44	0.93	-3.95	5.90	-4.30	6.22	-5.48	-5.86	-3.31	0.42	0.00
ML455	21	-2.27	1.63	-8.85	1.97	-3.59	5.05	-2.88	4.99	-8.25	-5.75	-5.04	-3.51	2.38
NW#10	10	-11.70	0.44	1.43	2.50	-0.56	-3.25	0.68	-2.63	1.41	0.45	0.55	-0.82	1.92
PLATA	10	4.12	1.20	-4.13	-2.78	-6.26	3.59	-4.93	5.31	-3.00	-1.57	-2.86	1.55	-0.51
PRISTINE	5	7.03	6.00	-1.96	0.79	13.70	3.84	-4.88	6.90	-2.98	-3.95	-2.93	-2.45	3.21
SAXON	5	-0.24	11.45	-2.86	5.13	-4.25	6.65	0.92	0.71	-2.09	0.12	0.40	-2.07	1.63
SCARLET	23	-0.24	2.17	-4.65	1.88	-2.91	3.99	-6.73	6.52	-3.44	0.44	0.26	-2.08	0.00
SEEDEXHR	5	-1.82	0.63	-4.15	6.37	-9.35	-1.28	-1.39	0.08	-3.85	-2.29	-1.86	-4.50	2.99
SPILLMAN	19	-3.40	3.92	-3.34	5.23	-3.26	6.89	-1.13	5.67	-3.14	-0.50	-1.10	-1.35	1.45
SX1501B	5	-0.96	1.92	-22.01	5.78	-4.33	1.36	-1.91	1.81	-21.74	-15.24	-2.77	-3.59	5.10
SX1502B	5	-2.43	2.38	-2.10	4.06	-9.87	3.75	-1.09	2.37	-1.51	0.00	0.16	-1.02	0.49
SX1503B	5	-4.39	-27.20	-5.18	-12.73	-4.43	-6.41	-1.46	-2.46	-7.09	-7.78	-7.50	-6.28	6.67
TARA2002	28	0.27	-2.78	-2.76	-2.70	-0.42	3.01	-6.87	6.66	-2.55	-0.50	-0.31	1.23	-0.75
WA7839	15	6.05	-2.04	-1.40	-7.86	1.39	-0.12	-6.49	4.00	-1.54	-2.63	-2.57	0.71	-0.23
WA7894	8	0.27	6.95	-3.57	5.46	-2.66	1.42	-0.81	1.25	-3.42	0.17	0.86	-0.27	-0.68

HRS & HWS, cont.												Bread Baking		
Variety	N	Test Weight	NIR Hard.	Wheat Protein	Single Kernel Hard.	Single Kernel Weight	Flour Yield	Flour Ash	Milling Score	Flour Protein	Mixo. Abs.	Water Abs.	Loaf Volume	Crumb Ranking
WA7914	5	3.47	0.61	-3.97	2.38	-2.46	1.11	-2.63	2.33	-2.69	-4.68	-2.77	-1.82	2.45
WA7925	8	3.18	2.66	-4.17	5.12	-5.05	3.35	-2.62	3.87	-2.60	0.49	1.18	-0.45	-0.55
WA7931	7	3.16	4.22	-6.32	2.34	-1.88	7.23	-1.50	4.21	-4.95	-1.92	-1.17	-2.11	2.65
WINSOME	15	0.92	8.23	-11.72	13.54	-12.69	2.32	-2.85	3.30	-9.07	-2.65	-1.99	-4.67	3.67
WPB926	33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WPB936	9	1.54	-1.73	-2.82	0.16	2.77	0.82	-2.95	4.70	-1.46	1.21	0.55	-0.20	-1.00
ZEKE	10	-1.69	-3.65	-3.81	-2.63	0.71	3.72	-5.65	6.47	-2.95	1.51	1.45	-4.37	1.00

Hard White Spring Wheat Variety *t*-Scores

													Bread Baking			Alkaline Noodle Color Brightness		
Variety	N	Test Weight	NIR Hard.	Wheat Protein	Single Kernel Hard.	Single Kernel Weight	Flour Yield	Flour Ash	Milling Score	Flour Protein	Flour RVA	Mixo. Abs.	Water Abs.	Loaf Vol.	Crumb Rank.	0 Hr	24 Hr	Change
BZ998-477W	5	-1.02	0.43	-0.78	-4.06	3.59	1.05	-1.74	2.95	-1.52	-6.31	-0.89	-0.20	0.31	0.78	-0.38	0.17	0.84
CO1955W	5	1.12	-0.38	-2.27	1.82	0.27	-0.09	-1.32	0.48	-2.88	-6.08	-2.83	-1.09	-1.01	0.67	-0.54	-5.45	-3.45
CO1963W	5	0.31	-3.04	-0.95	-0.90	-0.29	0.06	-3.14	1.68	-1.45	-5.53	-0.61	-1.29	0.51	0.34	0.95	-9.79	-7.81
GMBR7030	5	0.57	4.51	-1.10	0.36	0.50	0.09	1.05	-0.33	-1.72	-1.94	-1.37	-1.50	1.43	0.00	-4.15	-17.13	-11.48
ID377S	34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
KLASIC	5	-2.64	-6.13	2.55	-4.41	1.80	3.83	-3.03	4.08	3.80	1.91	0.34	0.34	5.70	-4.71	-3.45	-19.51	-22.90
LOLO	15	1.12	1.39	0.05	-4.08	5.74	2.01	-1.86	2.56	-0.38	1.39	1.74	1.69	-0.49	-0.62	1.61	0.57	-0.71
MACON	14	-1.45	-2.84	-1.37	-2.75	2.49	5.84	-3.37	6.97	-1.67	-10.47	-2.10	-0.71	4.46	-3.24	-1.42	-1.78	-0.42
ML455	21	-4.82	1.38	-2.44	-4.07	5.71	7.02	-0.10	6.77	-2.20	-10.78	-0.83	-0.36	3.70	-3.29	-0.51	-1.15	-1.61
PLATA	10	1.06	-0.77	-0.44	-4.83	1.93	3.06	-2.60	5.29	-0.21	-6.82	0.61	-0.17	4.46	-1.92	-3.69	-12.65	-11.10
WA7931	9	1.83	2.30	-4.23	-1.02	0.51	9.04	0.20	5.24	-2.87	-2.99	-1.21	-0.37	1.92	0.00	-2.82	-1.91	0.00
WINSOME	15	-0.66	8.13	-4.37	6.19	-1.90	4.27	-0.26	4.53	-4.27	-9.32	0.76	2.68	-1.68	1.38	3.32	0.25	-2.76

Hard Red and White Winter Wheat Variety *t*-Scores

Variety	N	Test Weight	NIR Hard.	Wheat Protein	Single Kernel Hard.	Single Kernel Weight	Flour Yield	Flour Ash	Milling Score	Flour Protein	Mixo. Abs.	Bread Baking Water Abs.	Bread Baking Loaf Volume	Bread Baking Crumb Ranking
BLIZZARD	3	-0.37	0.50	-0.38	-2.10	-2.46	2.95	0.46	0.75	1.11	-0.86	-0.86	-1.07	2.00
BOUNDARY	12	-4.09	1.58	1.03	1.54	2.44	-5.85	0.11	-3.61	0.39	-1.64	-0.38	-3.97	4.53
BUCHANAN	17	-7.04	1.38	-1.87	1.42	-3.89	-3.28	0.08	-2.20	-2.84	-2.86	-2.98	-1.46	2.38
COLUMBIA1	9	-4.16	-5.91	1.78	-1.85	-4.46	-9.01	3.53	-7.82	3.43	-3.39	-5.30	-2.52	2.27
ESTICA	17	-17.05	-2.88	-3.22	-0.51	0.30	-3.10	9.82	-8.17	-4.04	-8.46	-3.69	-7.12	7.26
FINLEY	27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GARY	9	-3.36	1.51	-0.46	2.46	-1.59	-5.36	-1.00	-3.58	-1.24	-1.81	-1.07	-3.26	4.64
HATTON	17	2.17	5.06	0.54	5.05	-9.57	-1.98	1.40	-2.29	0.40	0.34	0.28	0.29	-0.17
MORELAND	9	-4.14	0.97	1.29	2.74	-6.46	-6.60	1.49	-3.82	1.33	-1.51	-0.83	-1.00	0.48
NUFRONTIER	9	0.84	-0.31	-0.13	5.60	-10.36	-4.43	-2.46	-2.26	0.00	-1.89	-2.48	-4.26	2.53
NUHORIZON	8	1.92	0.45	0.97	2.62	-4.42	-2.68	6.30	-8.37	0.71	-1.09	-1.15	-0.80	-0.36
PILLAR	7	-5.29	1.14	10.11	0.23	0.91	-7.58	3.53	-6.95	8.22	4.64	5.01	2.55	0.28
Q1824	10	-4.83	-7.23	0.25	-0.01	-10.40	-8.63	0.41	-5.92	-0.77	-5.06	-4.96	-0.27	0.43
Q542	23	-5.53	-3.01	1.34	2.91	-7.44	-7.25	6.21	-8.17	0.19	-3.78	-5.34	-2.24	2.01
RESIDENCE	9	-3.97	0.71	-1.43	4.14	-0.93	-0.80	1.93	-1.87	-1.31	-3.73	-4.06	-5.23	4.91
SEMPER	9	-7.30	0.88	-0.82	2.77	-2.38	-2.44	3.00	-3.33	-1.88	-3.16	-7.74	-4.88	6.00
SYMPHONY	17	-6.45	-11.22	1.72	1.51	-4.69	-12.17	2.32	-11.19	1.84	-4.32	-3.99	-3.55	5.20
WANSER	17	-3.91	-1.07	-0.22	-4.11	-9.49	-4.29	1.48	-5.02	0.00	-2.60	-3.14	-3.04	2.26
WESTON	26	0.06	-8.63	3.59	-11.97	7.75	-9.09	1.27	-7.73	3.39	1.55	2.54	2.53	-1.10

Organization and Description of the Files on CD-ROM

WWQL TDIFF 6 Year Summary.xls	Summary *t*-scores, Excel spreadsheet (1 tab)
WWQL TDIFF 6 Year.xls	*t*-scores, Excel spreadsheet (6 tabs)
G&E Variety List 97-02.xls	Tabulation of varieties and locations by crop year, Excel spreadsheet (4 tabs)
Report 6-Year G&E.wpd	*This report*, Word Perfect 10 document
Report 6-Year G&E.pdf	*This report*, Adobe Acrobat

🗀 **G&E Data & Program Files**

🗀 **Raw Data Output** — 4 files, raw data output from SAS, ASCII

- HS DATA OUPUT.lst
- HW DATA OUTPUT.lst
- SS DATA OUPUT.lst
- SW DATA OUPUT.lst

🗀 **SAS GLM Code by Variety** — 136 files, SAS ANOVA GLM program code, ASCII

- HS TDIFF xxxxxxx.SAS, where xxxxxxx = the variety name
- HW TDIFF xxxxxxx.SAS, where xxxxxxx = the variety name
- HWS TDIFF xxxxxxx.SAS, where xxxxxxx = the variety name
- SS TDIFF xxxxxxx.SAS, where xxxxxxx = the variety name
- SW CLUB TDIFF xxxxxxx.SAS, where xxxxxxx = the variety name
- SW TDIFF xxxxxxx.SAS, where xxxxxxx = the variety name

🗀 **SAS GLM Output by Variety** *136 files, SAS ANOVA GLM output, ASCII

HS TDIFF xxxxxxx.lst, where xxxxxxx = the variety name
HW TDIFF xxxxxxx.lst, where xxxxxxx = the variety name
HWS TDIFF xxxxxxx.lst, where xxxxxxx = the variety name
SW TDIFF xxxxxxx.lst, where xxxxxxx = the variety name

*These files contain the *t*-tests for variety means, and Duncan's Multiple Range Test mean comparisons for individual environments.

🗀 **SAS Permanent Data Sets** 24 files, permanent SAS data sets

gxeNNhs.sas7bdat, where NN = crop year
gxeNNhw.sas7bdat, where NN = crop year
gxeNNss.sas7bdat, where NN = crop year
gxeNNsw.sas7bdat, where NN = crop year

🗀 **Location-Zone Coding** 6 files, SAS program code for location-year environments, includes Idaho and Oregon locations, ASCII

G&E_NN.sas, where NN = crop year

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