

“Patwin”

Origin and breeding history of the variety

1. Parentage

Patwin “UC1419” is a Hard White Spring derived from the cross **Madsen/2*Express**. Madsen (PI 511673) is a Soft White Winter wheat (SWW) developed in Washington, United States and jointly released by the USDA-ARS and the Agric. Exp. Stations of Washington, Idaho, and Oregon (Allan et al. 1989). Express is a Hard Red Spring (HRS) variety released by Western Plant Breeders (now WestBred, LLC). Both Madsen and Express have been used commercially for several years and are widely available.

2. Breeding History

2. A. Stages of election and multiplication

The original cross was made by J. Dubcovsky in experiment JD960018 and backcrossed to ‘Express’ in experiment 976043. In 1998 it was assigned the official hybrid ID CA980086. The BC₁ plants carrying the *Lr37/Yr17/Sr38* rust resistance complex were selected with molecular markers (Helguera et al. 2003) and then self pollinated and advanced to BC₁F₅.

BC₁F₂ seed was produced in experiment 98609/17-18 and used to plant experiment 98615/41-50. BC₁F₃ was planted in experiment 99051/444 and BC₁F₄ in experiment 00052/12. Patwin was first evaluated for yield as BC₁F₅ 01039/562 in a small plot single replication experiment and was harvested in bulk. Based on its excellent performance was advanced directly to Elite trials where was tested in 2002 (BC₁F₆, 02013/13) and 2003 (BC₁F₇, 03010/24) in three locations.

Half-seeds from five heads from 03010/24 were tested for high molecular weight glutenins and homozygous lines for the *Glu-D1* 5+10 allele were selected. The selected homozygous grains were planted in the greenhouse to produce BC₁F₈ seed. The BC₁F₈ seed was used to plant 18 large plots in experiment 04026/36 in the field (BC₁F₉). From these plots we harvested 1000 heads that were planted as headrows in experiment 05116/1 at Tulelake (BC₁F₁₀). We harvested 400 pounds of Breeders Seed and delivered it to the FSP in 2005 for production of Foundation Seed in 2006. In 2004 and 2005 it was tested in Regional Trials as UC1419 in eight locations under irrigation and was part of the Collaborators Quality Evaluation. In 2005 it was also grown as strip trials by Kent Brittan at four locations.

2. B. Selection criteria

The plants were selected based on observation of the plants in the field, and objective yield and laboratory data. Elite yield trials were performed at three locations and Regional Trials were performed at 10 locations during 2004 and 2005. Quality data was obtained from the California Wheat Commission Quality Laboratory for one location each year. The following criteria were used:

1. Early flowering

2. Low stature and good agronomic appearance
3. High yield potential
4. Resistance to lodging
5. White grains
6. Hard grain texture
7. High protein content
8. Strong gluten and good breadmaking quality
9. High Molecular weight subunits 5+10 (*Glu-D1*)
10. Resistance to stripe rust, leaf rust and septoria tritici blotch
11. Presence of a 2NS/2AS translocation from *T. ventricosum* carrying leaf rust resistance gene *Lr37*, stripe rust resistance gene *Yr17*, and stem rust resistance gene *Sr38*.

2. C. Characteristics by which the application variety can be distinguished from the direct parents

Differences from Madsen

Patwin is a spring variety (*Vrn-D1* allele) whereas Madsen is a winter variety (*vrn-D1* allele) that requires vernalization to flower.

Patwin has hard textured grains (deletion in Puroindoline A gene, allele *Pina-D1b*) whereas Madsen has soft textured grains (normal Puroindoline A gene, allele *Pina-D1a*)

Patwin has high molecular weight glutenin subunits 5+10 at the *Glu-D1* locus and Madsen has subunits 2+12

Differences from Express

Patwin has white grains whereas Express has red grains

2. D. Statement concerning whether the variety is uniform and stable and how many generations the variety has been observed to determine this.

- Variety Patwin is uniform for all traits as described in Exhibit C (Objective Description of Variety)
- Variety Patwin has been reproduced and judged stable for the last three generations.
- Variety Patwin was stable in all the Elite (3 locations) and Regional Trials (10 locations) during the 2004 and 2005 trials) and during the production of the Breeder's Seed in 2005 (Cal/West Seed test #05SERV-293: 99.9% pure seed) and Foundation Seed in 2006.

E) Statement concerning whether there are genetic variants that are to be expected during normal maintenance of the variety, the description of the variants, and their frequency

- Variety Patwin shows the following variant frequency: Plants 1 to 1.5 heads taller or shorter have been found with a frequency lower than one in 1000 plants. Red

grains have been observed with a frequency lower than 1 in 1000. Depending on herbicide applications and environmental conditions, branched spikes can be observed with a frequency of less than 1 in 1000 plants.

References

Allan R.E., C.J. Peterson, G.L. Rubenthaler, R.F. Line, D.E. Roberts. 1989. Registration of Madsen wheat. *Crop Science* 29:1575.

Helguera M., I.A. Khan, J. Kolmer, D. Lijavetzky, L. Zhong-qi, J. Dubcovsky. 2003. PCR assays for the *Lr37-Yr17-Sr38* cluster of rust resistance genes and their use to develop isogenic hard red spring wheat lines. *Crop Science* 43:1839-1847

Statement of Distinctiveness

Patwin “UC1419” is a Hard White Spring variety. It is a short stature wheat variety (93.3 ± 1.9 cm) that does not differ significantly in height from Blanca Grande (95.1 ± 1.5 cm) and Clear White (96.3 ± 1.8 cm, $P = 0.20$, see Appendix D, Table 1).

Patwin can be easily differentiated from its hard red spring parent Express by the white color of the seeds. It differs from its white soft winter parent by its spring growth habit and by the presence of hard texture seeds.

Patwin is more similar to the two Hard White Spring varieties ‘Clear White’ and ‘Blanca Grande’ currently grown in California. The following characteristics can be used to differentiate Patwin from these varieties:



Figure 1. Wax in Patwin

In Davis Patwin flowers approximately 7 days later than Clear White and 11 days later than Blanca Grande ($P < 0.05$ using Tukey pair-wise comparisons, see Appendix D, Table 2). Wax is abundant on the surfaces of leaves, glumes, stems and peduncles in mature Patwin plants (Figure 1). Wax is not present or is not as abundant in Blanca Grande and Clear White.

Patwin has yields similar to Blanca Grande in both the Sacramento (based on 14 year-locations) and San Joaquin Valleys (based on 9 year-locations), but significantly higher yields than Clear White ($P < 0.05$, see Appendix D, Table 3) in both Valleys.

Patwin and Blanca Grande have high polyphenol oxidase (PPO) activity whereas Clear White has low PPO activity (Figure 2).

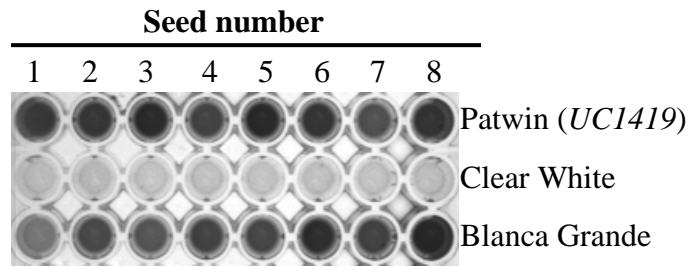


Figure 2. Noodle quality. PPO test for 8 grains from each variety

Patwin has high grain protein content (13.5 ± 0.3 % protein), which is similar to Blanca Grande (13.3 ± 0.4 %, $P > 0.05$) but significantly higher than Clear White (12.9 ± 0.2 %, $P < 0.05$, see Appendix D, Table 4).

Patwin has significantly harder grain texture (78.3 ± 2.3) than Clear White (67.6 ± 2.6) or Blanca Grande (62.0 ± 1.9) ($P < 0.05$, see Appendix D, Table 5).

Patwin has similar Thousand Kernel Weight (38.7 ± 1.5 g) to Clear White (37.0 ± 1.0 g) but significantly smaller than Blanca Grande (46.9 ± 1.0 g, $P < 0.05$, see Appendix D, Table 6).

Patwin has high Loaf Volumes (910 ± 11 cc), which are not significantly different from Blanca Grande (941 ± 14 cc, $P > 0.05$) but that are significantly larger than those observed for Clear White (855 ± 16 cc, $P < 0.05$, see Appendix D, Table 7). All three varieties have similar flour extraction rates (Appendix D, Table 8).



Figure 3: Comparison between Blanca Grande, Clear White and Patwin for leaf damage produced by stripe rust and Septoria Tritici Blotch, Davis May 8 2006

No significant differences in stripe rust reactions were observed between these varieties in 2004 and 2005 (Appendix D, Table 9). However, during the 2005-2006 growing season the stripe rust resistance present in Blanca Grande was overcome whereas the resistance in Patwin and Clear White remained effective. Analysis of the four replications at the UC Davis Elite trials (Appendix D, Table 10.1) showed significantly higher levels

of final flag leaf stripe rust infection in Blanca Grande ($62.5\% \pm 1.6$) relative to Patwin ($0.5\% \pm 0.2$) or Clear White ($8.8\% \pm 0.8$). Similar results were observed in the individual Regional trials at Colusa (Table 10.2) and Kern (Table 10.3).

Patwin also exhibited the lowest levels of flag leaf infection with septoria tritici blotch ($8\% \pm 3\%$, Appendix D, Table 11) of the three CA HWS varieties. The differences were significant with Clear White ($46\% \pm 12\%$) but not with Blanca Grande ($23\% \pm 10\%$).

In summary, Patwin presents significant yield increases and septoria resistance over Clear White and improved resistance to stripe rust relative to Blanca Grande (Figure 3).

Therefore its release will benefit the California wheat growers. Patwin maintains the high quality breadmaking standard established by Express and Blanca Grande.

Additional description and statistical analyses

The data from Tables 1-8 obtained are from the Elite trials (2003-2005) and the Regional Performance Tests (2004-2004) performed by the UCD breeding program and by Dr. L. Jackson. Regional trials results are published in the 2004-2005. "Regional barley, common and durum wheat, triticale, and oat performance tests" in California, Agronomy Progress Report, UC Davis).

For statistical analysis Year/Location combinations were used as blocks and the Year/Location * Variety interaction was used as an estimate of the error term. This is a more stringent criterion to detect significant differences than the separate analysis of individual locations. Homogeneity of variances was confirmed for all tests by Levene's test and normality was tested with Shapiro-Wilk test. Patwin was compared with Blanca Grande and Clear White that are the most similar HWS varieties from California.

The California Wheat Commission Quality Laboratory, Woodland, CA, provided all the breadmaking quality analyses.

In summary, Patwin presents significant yield increases over Clear White and improved resistance to stripe rust relative to Blanca Grande. Therefore its release will benefit the CA wheat growers. Patwin maintains the high quality breadmaking standard established by Blanca Grande.

Table 1. Height in cm.

Year/location	B. Grande	Clear White	Patwin
Butte-04-Reg.	99	99	91
Colusa-04-Reg.	94	99	94
Davis-04-Reg.	91	97	94
Delta-04-Reg.	91	91	89
Madera-04-Reg.	89	79	79
Kings-04-Reg.	99	99	97
Kern-04-Reg.	99	99	99
Butte-05-Reg.	97	104	97
Colusa-05-Reg.	86	97	94
Davis-05-Reg.	107	102	102
Delta-05-Reg.	99	97	104
Fresno-05-Reg.	89	89	97
Kings-05-Reg.	94	94	84
Kern-05-Reg.	97	104	86
Average	95.1	96.3	93.3
Standard error of the mean	1.5	1.8	1.9

RCBD (environments) P= 0.1962
LSD LSD=3.4. All NS.
Tukey HSD= 4.1. All NS
Levene (= variances) 0.76
Shapiro Wilk (Normality) 0.06

Table 2. Heading date at Davis, days after March 1st.

Year/location	B. Grande	Clear White	Patwin
Davis-04-Reg.	20	28	32
Davis-05-Reg.	31	33	41
Davis-04-Elite	19	21	31
Davis-05-Elite	30	35	40
Average	25	29	36
Standard error of the mean	3.2	3.1	2.6

RCBD (environments) P= 0.0003
LSD LSD=2.93. All different
Tukey HSD= 3.67. All different
Levene (= variances) 0.69
Shapiro-Wilk (Normality) 0.38

Table 3. Yield data (lb/ac) in the Sacramento and San Joaquin valleys.

Loc./Yr./trial	Blanca Grande	Clear White	Patwin
Sacramento (14 year/loc)			
Davis-03-elite	5950	4890	6360
Davis-04-elite	7389	6200	6719
Davis-05-elite	4763	4452	5644
Colusa-03-elite	5850	5590	7210
Colusa-04-elite	7462	6513	6660
Colusa-05-elite	5300	5280	5950
Davis-04-reg.	6200	5530	6080
Davis-05-reg.	5340	4260	5460
Colusa-04-reg.	7090	6760	6450
Coluse-05-reg.	4920	5520	6380
Butte-04-reg.	5030	4600	5360
Butte-05-reg.	4640	4330	5320
Delta-04-reg.	3230	4390	3310
Delta-05-reg.	4990	4950	5230
Mean	5582	5233	5867
SE	314.3	221.0	254.3
San Joaquin (9 year /loc)			
Kings-03-elite	7700	6790	6760
Kings-04-elite	6657	5409	6619
Kings-05-elite	4690	3960	4640
Madera-04-reg.	3770	3390	3520
Fresno-05-reg.	5470	5230	4830
Kings-04-reg.	5250	5410	5740
Kings-05-reg.	4720	4370	5050
Kern-04-reg.	7470	5500	6020
Kern-05-reg.	5880	5780	5760
Mean	5734	5093	5438
SE	441.5	342.4	343.8
General AVERAGE	5642	5178	5699

Sacramento

RCBD (environments) P= 0.0078
 LSD LSD= 380.41. Patwin = BG but > CW (0.05)
 Tukey HSD= 459.87. Patwin = BG but > CW (0.05)
 Levene (= variances) P= 0.48
 Shapiro-Wilk (Normality) P= 0.75

San Joaquin

RCBD (environments) P= 0.017
 LSD LSD= 417.5 Patwin = BG but > CW (0.05)
 Tukey HSD= 508.1. Patwin = BG but > CW (0.05)
 Levene (= variances) P= 0.53
 Shapiro-Wilk (Normality) P= 0.81

Both Valleys combined

RCBD (environments) P= 0.0009
 LSD LSD= 282.6. Patwin = BG but > CW (0.05)
 Tukey HSD= 340.1. Patwin = BG but > CW (0.05)
 Levene (= variances) P= 0.27
 Shapiro-Wilk (Normality) P= 0.66

Table 4. Grain Protein Content (%) at 12% humidity (14 year-location).

Year/location	Blanca Grande	Clear White	UC1419
Butte-04-reg.	9.8	12.2	11.8
Colusa-04-reg.	12.6	11.6	12.7
Davs-04-reg.	13.5	12.4	13.7
Delta-04-reg.	15.0	13.1	14.6
Madera-04-reg.	14.4	13.5	14.4
Kings-04-reg.	15.1	12.8	13.7
Kern-04-reg.	13.9	13.0	14.0
Butte-05-reg.	14.5	13.5	14.3
Colusa-05-reg.	11.7	12.1	12.7
Davis-05-reg.	14.1	13.7	13.7
Delta-05-reg.	13.0	12.0	13.7
Fresno-05-reg.	10.9	11.3	11.2
Kings-05-reg.	14.8	14.8	14.4
Kern-05-reg.	13.5	13.0	14.2
Mean	13.3	12.9	13.5
SE	0.4	0.2	0.3

RCBD (environments) P= 0.0146
 LSD LSD=0.4918. Patwin = BG but > CW (0.05)
 Tukey HSD=0.5945. Patwin = BG but > CW (0.05)
 Levene (= variances) P= 0.1353
 Shapiro-Wilk (Normality) P= 0.1363

Table 5. Hardness (NIR)

Year/location	Blanca Grande	Clear White	Patwin
Davis-03-elite	69	72	80
Colusa-03-elite	64	69	75
Davis-04-elite	62	72	79
Colusa-04-elite	68	72	82
Kings-04-elite	60	71	84
Kings-04-reg.	61	71	83
Davis-05-elite	50	54	67
Colusa-05-elite	54	50	64
Kings-05-elite	66	74	85
Kings-05-reg.	66	71	84
Mean	62.0	67.6	78.3
SE	1.9	2.6	2.3

RCBD (environments) P= <0.0001
LSD LSD= 2.726. All different
Tukey HSD= 3.312. All different
Levene (= variances) P= 0.6776
Shapiro-Wilk (Normality) P= 0.291

Table 6. Thousand Kernel Weight

Year/location	Blanca Grande	Clear White	Patwin
Davis-03-elite	44.9	40.5	42
Colusa-03-elite	48.7	30.2	44.7
Davis-04-elite	49.4	37.8	39.7
Colusa-04-elite	50.2	37.6	38.5
Kings-04-elite	48.8	37.5	32.1
Kings-04-reg.	49.3	38.3	38.8
Davis-05-elite	43.1	34.5	41.5
Colusa-05-elite	49.6	41.5	43.9
Kings-05-elite	43.9	34.3	31.6
Kings-05-reg.	41.1	38.0	34.6
Mean	46.9	37.0	38.7
SE	1.0	1.0	1.5

RCBD (environments) P= <0.0001
LSD LSD= 3.30. **Patwin = CW but < BG (0.05)**
Tukey HSD= 4.01. **Patwin = CW but < BG (0.05)**
Levene (= variances) P= 0.2573
Shapiro-Wilk (Normality) P= 0.2787

Table 7. Loaf volume

Year/location	Blanca Grande	Clear White	Patwin
Davis-03-elite	925	815	925
Colusa-03-elite	890	750	895
Davis-04-elite	955	915	965
Colusa-04-elite	1000	845	900
Kings-04-elite	995	885	950
Kings-04-reg.	940	880	850
Davis-05-elite	980	895	900
Colusa-05-elite	895	800	870
Kings-05-elite	950	885	920
Kings-05-reg.	880	880	925
Mean	941	855	910
SE	13.7	16.3	11.0

RCBD (environments) P= <0.0001
LSD LSD= 31.8. Patwin = BG but > CW (0.05)
Tukey HSD= 38.6. Patwin = BG but > CW (0.05)
Levene (= variances) P= 0.4130
Shapiro-Wilk (Normality) P= 0.387

Table 8. Flour yield

Year/location	Blanca Grande	Clear White	Patwin
Davis-03-elite	67.8	68.7	66.9
Colusa-03-elite	67.9	65.4	67.1
Davis-04-elite	70.4	74.0	69.3
Colusa-04-elite	70.5	72.9	67.5
Kings-04-elite	71.6	71.9	65.6
Kings-04-reg.	67.2	69.8	69.3
Davis-05-elite	65.6	65.1	68.7
Colusa-05-elite	65.4	70.3	68.9
Kings-05-elite	64.5	63.2	62.9
Kings-05-reg.	66.6	64.9	61.9
Mean	67.8	68.62	66.81
SE	0.8	1.2	0.8

RCBD (environments) P= 0.1776
LSD LSD= 1.95. NS differences
Tukey HSD= 2.37. NS differences
Levene (= variances) P= 0.09
Shapiro-Wilk (Normality) P= 0.9849

Table 9. Stripe rust 04-05. Average % final infection of the flag leaf.

Year/location	Blanca Grande	Clear White	Patwin
Davis-04-reg	0	12	1
Kern-04-reg	1	22	0
Colusa-04-elite	1	3	0
Kings-04-elite	12	22	7
Butte-05-reg	0	9	0
Davis-05-reg	2	1	0
Colusa-05-elite	7	0	0
Davis-05-elite	10	0	0
Mean	4.1	8.6	1.0
SE	1.5	2.9	0.8

RCBD (environments) P= 0.06 (log(x+1))
 LSD LSD= 1.1 **Patwin** lower CW but not BG
 Tukey HSD=1.34. **NS differences** with BG
 Levene (= variances) P= 0.11
 Shapiro-Wilk (Normality) **P= 0.0007**

Table 10. Stripe rust 2006 all four replications (% final infection of the flag leaf)
10.1 Davis Elite 2006

Block	Blanca Grande	Clear White	Patwin
1	60	10	0
2	70	10	1
3	60	10	0
4	60	5	1
Mean	62.5	8.8	0.5
SE	1.6	0.8	0.2

RCBD (environments) P= <0.0001 (x+0.5)^0.3)
 LSD LSD= 0.278 **Patwin** < CW< BG
 Tukey HSD=0.3485. **Patwin** < CW< BG
 Levene (= variances) P= 0.28
 Shapiro-Wilk (Normality) P= 0.05

10.2 Colusa Regional 2006

Block	Blanca Grande	Clear White	Patwin
1	96	0	0
2	96	4	0
3	92	15	0
4	100	0	1
Mean	96.0	4.8	0.3
SE	1.0	2.2	0.2

RCBD (environments) P= <0.0001
 LSD LSD= 9.01 **Patwin** = CW< BG
 Tukey HSD=11.3. **Patwin** = CW< BG
 Levene (= variances) P= 0.18
 Shapiro-Wilk (Normality) P= **0.0004**

10.3 Kern Regional 2006

Block	Blanca Grande	Clear White	Patwin
1	50	1	0
2	15	1	1
3	10	1	4
4	15	0	0
Mean	22.5	0.8	1.3
SE	5.8	0.2	0.6

RCBD (environments) P= <0.009 (x+0.5)^0.5
 LSD LSD= 2.01 **Patwin** = CW < BG
 Tukey HSD=2.52. **Patwin** = CW < BG
 Levene (= variances) P= 0.19
 Shapiro-Wilk (Normality) P= **0.0075**

Blanca Grande shows significantly higher levels of stripe rust infection than Patwin or Clear White in all three environments.

Table 11. Septoria tritici 2004-2005. Average % final infection of the flag leaf.

Year/location	Blanca Grande	Clear White	Patwin
Davis-04-elite	0	15	0
Davis-05-elite	70	96	4
Colusa-04-elite	0	22	3
Colusa-05-elite	30	57	12
Davis-04-reg	1	4	1
Colusa-04-reg	3	30	7
Mean	17.3	37.3	4.5
SE	9.0	10.7	1.4

RCBD (environments) P= 0.005. Transformation (x+0.05) ^0.3
 LSD LSD= 0.68. **Patwin**= BG and both < CW
 Tukey HSD= 0.84 **Patwin**= BG and both < CW
 Levene (= variances) P= 0.15
 Shapiro-Wilk (Normality) P= 0.17

Table 12. Septoria 2006 all four replications (% final infection of the flag leaf)

12.1 Colusa Regional 2006

Block	Blanca Grande	Clear White	Patwin
1	0	70	15
2	0	30	0
3	1	40	0
4	1	70	0
Mean	1	53	4
SE	0.3	10.3	3.8

RCBD (environments) P= 0.0004. Transformation $(x+0.05)^{0.5}$
 LSD LSD= 1.9233. **Patwin**= BG and both < CW
 Tukey HSD= 2.4116 **Patwin**= BG and both < CW
 Levene (= variances) P= 0.25
 Shapiro-Wilk (Normality) P= **0.0044**

12.2 Davis regional 2006

Block	Blanca Grande	Clear White	Patwin
1	0	30	2
2	1	15	0
3	0	30	0
4	1	2	0
Mean	0.5	19.3	0.5
SE	0.3	6.8	0.5

RCBD (environments) P= 0.0088. Transformation $(x+0.05)^{0.1}$
 LSD LSD= 0.19. **Patwin**= BG and both < CW
 Tukey HSD= 0.24 **Patwin**= BG and both < CW
 Levene (= variances) P= 0.27
 Shapiro-Wilk (Normality) P= **0.007**

Clear White shows significantly higher levels of stripe rust infection than Patwin or Blanca Grande in the two environments where septoria tritici was detected in 2006.

E. Area of adaptation and primary use

Patwin performs well agronomically in all areas where it has been evaluated in California and has good quality characteristics for bread making. Patwin appears to be well suited for the San Joaquin and Sacramento Valley where it shows high yield potential under irrigation. Patwin combines a high yield potential with excellent bread making quality and resistance to the major pathogens found in California. Its primary use is for bread production.

F. Procedure for maintaining stock seed classes

The Department of Plant Sciences, UCD will maintain Breeders seed. Foundation seed will be produced and distributed by the Foundation Seed program of the University of California, Davis. The California Crop Improvement Association will provide certification services. New Breeders seed will be produced as needed from head-row progenies obtained from the original Breeders Seed lot. Increases of Foundation Seeds from Foundation seed are allowed for three cycles. Also Registered and Certified Seeds can be produced from Registered and Certified seed three cycles. After the third cycle, new foundation seed will be produced from the original breeder seed to maintain seed purity.



Characteristics to assist field inspectors

The most characteristic aspects of Patwin are its later flowering time relative to Clear White and Blanca Grande, and its improved resistance to septoria and stripe rust. Presence of wax in the leaves, glumes, stems and peduncles differentiates this variety from Blanca Grande and Clear White. Grains can be distinguished from Blanca Grande by their smaller size and harder texture.