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**NEBRASKA AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF NEBRASKA-LINCOLN
DEPARTMENT OF AGRONOMY and Horticulture**

RELEASE OF 'ANTON' HARD WHITE WINTER WHEAT

'Anton' is a hard white winter wheat (*Triticum aestivum* L.) cultivar cooperatively developed and released in 2007 by the USDA-ARS and Nebraska Agricultural Experiment Station. Anton was released primarily for its low levels of grain and flour polyphenol oxidase (PPO). Low levels of grain PPO correlate with enhanced end-use quality, including final product color in noodle applications. Low PPO also is desirable for the establishment of a viable Great Plains hard white wheat production industry. Anton was tested under the experimental designation NW98S097.

Anton was developed using a modified bulk breeding procedure, followed by re-selection for uniformity of seed coat color. Anton was selected from the cross WA691213-27/N86L177//'Platte'. WA691213-27 is a soft white winter wheat breeding line developed by Washington State University. WA691213-27 was derived from the cross Brevor/CI 15923//Nugaines and is a sister line of the cultivar 'Dusty' (PI 486429). N86L177 (PI 559717) is a high-protein strong-gluten hard red winter wheat developed by USDA-ARS, and derived from the cross Nap Hal/'Lancer'//'Karlik 1'3/NS 622/4/'Centurk'/'GK-Tiszataj'//'Plainsman V'. Platte (P.V.P. Certificate # 9700012) is a low grain PPO hard white winter wheat developed by HybriTech Seed International, a former unit of Monsanto Company.

The final cross in the breeding of Anton was made in 1993. The F1 generation was grown in the field at Yuma, AZ in 1994, and the F2 to F3 generations were advanced using the bulk breeding method in the field at Lincoln, NE in 1995 and 1996. In 1997, Anton was selected as a single F3-derived F4 head row, grown at Lincoln, NE. In 1998, Anton was entered in an un-replicated F5 preliminary observation at Sidney, NE, with subsequent F6 and F7 generations tested in multi-location yield trials in Nebraska in 1999 and 2000. At this time, Anton was detected as being heterogeneous for red and white grain color. In 2000, ten uniformly white-grained heads were selected, and grown in single 3 m rows in the field at Yuma, Arizona. Seed harvested from these ten rows was combined, and increased. Anton then was submitted for testing in regional and state-wide trials.

Anton was evaluated in the USDA-ARS Northern Regional Performance Nursery (NRPN) in 2003 (15 environments) and 2004 (14 environments). In the 2003 NRPN, average grain yield of Anton (Table 1) did not differ significantly from average yields of 'Nuplains' and 'Nekota', but was significantly lower than that of the hard red winter wheat 'Darrell'. In the 2004 NRPN (Table 1), Anton again was significantly lower in grain yield than Darrell, not

significantly different from Nuplains, and significantly higher than Nekota. Anton also was evaluated in the University of Nebraska cultivar performance trials in 2005-2007. Compared to the three most widely-grown cultivars in Nebraska in crop year 2007, three year respective grain yields averaged over 37 rainfed environments were: Anton, 3374 kg ha⁻¹; 'Millennium', 3843 kg ha⁻¹; 'Jagalene', 3541 kg ha⁻¹; 'Wesley', 3628 kg ha⁻¹. Three-year grain yields in the Southeast and South Central Nebraska reporting districts (Table 2) of Anton did not differ significantly from Millennium, Jagalene or Wesley. In the West Central district (Table 2) mean grain yield of Anton was significantly lower than that of both Millennium and Wesley, and in the West Dryland district, grain yields of Anton were significantly lower than Jagalene. In irrigated trials over the same three year period, grain yields of Anton again were not significantly different than those of Millennium, Wesley or Jagalene (Table 2).

End-use quality evaluations of Anton (Table 3) were conducted by the USDA-ARS GMPRC, Manhattan, KS, on samples obtained from the 2003 and 2004 NRPN, composited by agro-ecological production zone. Six samples were evaluated from this two year period. Anton displayed significantly harder kernels, longer Mixograph and bake mix times, and greater Mixograph tolerance scores than the three check cultivars. Levels of flour PPO in Anton were significantly lower than in the control cultivars, and this contributed to significantly lower changes in noodle L* (brightness values) over a 24 hour test period (Table 3). Flour PPO levels of Anton, over the 2003 and 2004 harvest seasons, were significantly lower than all other entries in the NRPN. Few additional significant differences (Table 3) in quality of Anton, relative to the controls, were noted. Grain PPO activity of Anton, evaluated from samples collected from nine locations of the University of Nebraska wheat variety trial in 2005, did not differ significantly from the low PPO cultivar Platte, and was significantly lower than that of all other white wheats in the trial (Table 4). Anton carries the high-molecular-weight glutenin subunits 2*, 7+8, and 5+10, encoded by the respective alleles *Glu-A1b*, *Glu-B1b* and *Glu-D1d*. Sprouting tolerance of Anton is similar to that of the hard white wheats 'Trego' and Nuplains, and exceeds that of the Nebraska-adapted hard white wheats 'Antelope' and 'Arrowsmith'.

Anton is moderately resistant to resistant to the following bulk cultures of wheat stem rust (caused by *Puccinia graminis* Pers.: Pers. f. sp. *tritici* Eriks & E. Henn.): TTTT, TPMK, QTHJ, QFCS, RCRS and RTQQ. Anton also is moderately resistant to resistant to leaf rust (caused by *P. triticina* Eriks) bulk cultures CBMT, MCDS, MBDS, MHDS, MCRK, THBJ. Anton is postulated as carrying the stem rust resistance gene Sr24 and the leaf rust resistance gene Lr24, plus at least one additional unidentified leaf rust resistance gene. It is moderately susceptible to Great Plains races of stripe rust (caused by *P. striiformis* Westendorp f. sp. *tritici*), but susceptible to Hessian fly (*Mayetiola destructor* Say), Russian wheat aphid [*Diuraphis noxia* (Mordvilko)] and greenbug *Schizaphis graminum* (Rondani). Anton is susceptible to field and artificial inoculations of wheat streak mosaic virus, but tolerant of natural infestations by wheat soilborne mosaic virus (WSBMV).

Anton is a semi-dwarf hard white winter wheat. The spike is oblong, erect and awned. The glumes are white, with an acuminate beak and an oblique shoulder. Seed shape is oval, with a mid-sized brush of short to medium hairs. The embryo is midsized, and the seed crease width is narrow and mid-deep. Based on data from 38 rainfed Nebraska environments (Table 1) mature plant height of Anton is 79 cm, 2 cm taller than Wesley, 2 cm shorter than Antelope and 9 cm shorter than Millennium. Lodging resistance is good, and similar to 2137 under both rainfed and irrigated conditions (Table 1). Average heading date of Anton in Nebraska, over the

2005-2007 crop years was 123 days after January 1st, three days later than Millennium and Wesley, and one day later than Antelope. Field appearance of Anton is most similar to Platte. The juvenile plant growth form is erect, coleoptile and stem anthocyanin is absent, anther color is yellow, foliage is green and the stem is hollow. The phenol reaction of Anton is polymorphic, with the following predominant results, and observed percentages: 21.4% fawn, 50.8% light-brown and 25.9% brown.

Seed purification began in 2004. Seed harvested from the advanced yield trials at Lincoln, NE in 2004 was planted in an unreplicated strip plot at Yuma, AZ. In the fall of 2005, seed from Yuma, AZ was used to plant a breeder seed increase near Hemingford, NE. In 2006, a Foundation Seed increase was planted by the Nebraska Foundation Seed Division. Anton has been stable and uniform since 2000. The Nebraska Foundation Seed Division University of Nebraska-Lincoln, Lincoln, NE 68583 will have foundation seed available to qualified certified seed enterprises in 2008. The U.S. Department of Agriculture will not have seed for distribution. The seed classes will be Breeder, Foundation, Registered, and Certified. Anton will be submitted for plant variety protection under P.L. 10577 with the certification option. Small quantities of seed for research purposes may be obtained from Dr. Robert Graybosch, USDA-ARS, Department of Agronomy and Horticulture, University of Nebraska-Lincoln, 68583 for at least 5 yr from the date of this release according to the provisions of the Wheat Worker's Code of Ethics (Annual Wheat Newsletter, 1995). A seed sample has been deposited in USDA-ARS National Center for Genetic Resources Preservation and in the USDA-ARS National Small Grains Collection, Aberdeen ID and seed is freely available to interested researchers.

Table 1. Agronomic performance of Anton compared to control cultivars in the 2003 and 2004 Northern Regional Performance Nursery.

2003				
Cultivar	Grain yield, kg/ha	Volume weight, kg/hl	Days from 1/1 to heading	Plant height, cm
Region	mean	mean	mean	mean
Darrell	4406	75.0	162	88
Nuplains	4059	76.9	163	80
Nekota	4066	75.2	159	81
Anton	3795	73.9	162	79
I.s.d. (0.05)	365			
no. locations	14			
2004				
Darrell	4894	76.5	156	81
Nuplains	4308	78	158	71
Nekota	4021	76	153	74
Anton	4374	76	157	71
I.s.d. (0.05)	130			
no. locations	15			

Table 2. Agronomic performance of Anton relative to control cultivars in rainfed and irrigated environments, University of Nebraska cultivar performance trials, 2005-2007.

Cultivar	Southeast					South Central				
	Yield kg/ha	Test weight kg/hl	Protein g/kg	Lodging %	Plant Height cm	Yield kg/ha	Test weight kg/hl	Protein g/kg	Lodging %	Plant Height cm
2137	4492	76.5	113	2	85	3699	70.6	121	35	88
2145	4492	77.3	118	1	82	4055	70.2	131	33	83
Antelope	4143	74.7	118	5	89	3477	68.9	134	34	86
Anton	4022	76.6	121	2	86	3477	69.3	134	32	82
Arapahoe	4499	75.5	119	8	95	3477	69.9	134	35	90
Jagalene	4223	76.5	116	7	87	3497	69.0	125	33	85
Mace	4257	75.1	118	4	83	3450	69.9	132	33	85
Millennium	4667	77.3	117	3	94	3833	70.7	128	37	94
Nuplains	3820	74.8	115	1	82	2690	68.9	134	33	83
Overland	5165	78.8	116	2	91	4055	70.3	128	36	92
Scout66	3450	72.0	121	42	102	2710	71.2	132	38	97
Wahoo	4378	72.6	114	10	92	3410	68.6	130	35	90
Wesley	4391	74.4	117	1	84	3679	66.3	125	33	84
average of all entries*	4385	76.0	117	8	90	3490	69.5	129	35	88
l.s.d. (0.05)	753	4.0	4	18	7	612	3.5	5	3	7

Cultivar	West Central					West Dryland				
	Yield kg/ha	Test weight kg/hl	Protein g/kg	Lodging %	Height cm	Yield kg/ha	Test weight kg/hl	Protein g/kg	lodging %	Height cm
2137	3652	74.3	119	9	81	2966	75.3	103		71
2145	3463	75.1	127	10	76	2636	76.6	113		66
Antelope	3416	74.7	125	8	80	2831	76.0	110		70
Anton	3241	73.8	127	4	77	2757	76.5	110		70
Arapahoe	3497	73.7	126	9	87	2818	75.6	110		74
Jagalene	3436	75.6	125	9	80	3006	77.4	105		69
Mace	3632	74.0	125	9	77	2818	74.7	109		69
Millennium	3921	76.4	125	6	88	2952	76.5	110		75
Nuplains	2912	74.4	126	7	76	2757	78.7	111		66
Overland	4075	76.1	122	8	86	3181	77.0	105		75
Scout66	3080	76.4	125	37	99	2724	76.5	106		85
Wahoo	3874	72.5	123	10	85	3013	74.6	103		73
Wesley	3652	73.7	123	9	75	2791	73.9	115		66
average of all entries*	3618	74.8	124	11	84	2946	76.2	107		73
l.s.d. (0.05)	410	1.7	5	10	4	229	1.7	6		5

Cultivar	Dryland State Average					West Irrigated				
						Yield kg/ha	Test weight kg/hl	Protein g/kg	Lodging %	Height cm
2137	3702	74.2	114	9	81	5669	75.3	106	5	77
2145	3662	74.8	122	8	77					
Antelope	3467	73.6	122	12	81	5683	76.2	115	6	78
Anton	3374	74.0	123	4	79	5662	76.1	114	0	76
Arapahoe	3573	73.7	122	15	86					
Jagalene	3541	74.6	118	12	80	5763	75.7	116	11	76
Mace	3539	73.4	121	10	79	5777	73.8	115	4	76
Millennium	3843	75.2	120	7	88	5582	76.2	113	14	86
Nuplains	3045	74.2	122	7	77	5494	76.5	115	9	76
Overland	4119	75.6	118	7	86	5736	75.5	113	11	83
Scout66	2991	74.0	121	44	96					
Wahoo	3668	72.1	118	12	85					
Wesley	3628	72.1	120	7	77	5831	74.7	119	4	73
average of all entries*						5804	75.7	114	8	78
l.s.d. (0.05)						343	1.4	6	10	3

Table 3. End-use quality attributes of Anton compared to check cultivars from the 2003 and 2004 Northern Regional Performance Nursery.

Cultivar	Kernel weight (mg)	Grain hardness score	Grain protein concentratio n g/kg)	Flour milling yield (g/kg)	Flour ash content (g/kg)	Flour PPO†	Δ L‡	Δ a‡	Δ b‡
Nekota	32.3	64.8	131	65.9	3.1	0.509	-10.157	1.025	1.335
Nuplains	28.5	73.4	135	66.7	3.3	0.473	-10.717	1.100	1.923
Darrell	30.8	74.5	134	67.2	3.5	0.424	-10.705	1.055	2.750
Anton	29.4	80.3	136	65.0	4.0	0.162	-9.028	0.838	3.637
l.s.d. (0.05)	2.0	6.1	ns	ns	ns	0.091	-0.575	ns	0.965

Cultivar	Flour protein concentration g/kg)	Mixograph water absorption (g/kg)	Mixograph time (min)	Mixograp h tolerance (0-6)	Bake water absorption (g/kg)	Bake mix time (min)	Crumb score (0-5)	Loaf volume (ml)
Nekota	111	631	3.3	3	631	4.4	3	883
Nuplains	115	638	2.7	2	624	3.4	4	917
Darrell	115	639	3.8	4	632	5.3	3	878
Anton	116	642	4.4	5	649	6.5	3	883
l.s.d. (0.05)	ns	ns	0.6	1.0	ns	1.0	ns	ns

†PPO = polyphenol oxidase activity defined as a change of 0.001 absorbance unit (AU)/min/mL

Noodlemaking Properties - Change in alkaline noodle color over 24 hrs by Minolta colorimeter

Table 4. Mean grain polyphenol oxidase (PPO) of Anton relative to additional hard white winter wheats from nine locations of the 2005 University of Nebraska wheat variety trial.

Line or cultivar	Grain PPO†
Platte	0.335
Anton	0.351
Antelope	0.733
NW97S139-1	0.774
Trego	0.786
Nuplains	0.799
NP-02	0.824
NW99L7068	0.899
L.S.D. (0.05)	0.092

†PPO = polyphenol oxidase activity defined as a change of 0.001 absorbance unit (AU)/min/mL

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