Registration of 'Willow Creek' Forage Wheat

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ABSTRACT

'Willow Creek' forage winter wheat (*Triticum aestivum* L.) (Reg. No. CV-1032, PI 655073) was released by the Montana Agricultural Experiment Station. Awnletted cereal forages are widely used for hay production on integrated crop–livestock operations in the Northern Great Plains. Five awnletted winter wheat accessions were evaluated for forage characteristics in 1996 and 1997, and Willow Creek was selected directly from PI 306505. Willow Creek was evaluated in replicated trials for forage yield and quality, grain yield, and agronomic characteristics from 1998 through 2008. Willow Creek is an awnletted winter wheat cultivar with good performance as an annual hay crop under irrigated or rainfed conditions in Montana and Wyoming. This cultivar has excellent winterhardiness and is tall and late-maturing. Willow Creek has good forage quality characteristics suitable for use by livestock in winter maintenance diets.

'Willow Creek' forage winter wheat (*Triticum aestivum* L.) (Reg. No. CV-1032, PI 655073) was developed at Montana State University and released by the Montana Agricultural Experiment Station (MAES) in 2005. Willow Creek is a tall, awnletted, and late-maturing cultivar selected for forage production under irrigated or rainfed conditions in Montana and Wyoming. Willow Creek was derived from an awnletted accession of the Romanian cultivar Lunnija 56, designated as PI 306505 in the USDA National Small Grains Collection in 1965. PI 306505 has good cold tolerance (McVey and Busch, 1991), is tall and late-maturing, and has resistance to barley yellow dwarf virus, dwarf bunt (*Tilletia controversa*), and stripe rust (*Puccinia striiformis* var. *tritici*) (USDA-ARS NPGS, 2008b). The name *Willow Creek* refers to the village in Gallatin County, MT, where several nearby ranch cooperators participated in on-farm demonstrations of the cultivar in 2004 and 2005.

Currently, there is renewed interest in small grain forages by integrated crop–livestock producers. Early landraces of awnless or awnletted small grains were widely used in the United States for the dual purpose of grain and forage production. For hay production, livestock producers have favored awnless small grain cultivars including oat (*Avena sativa* L.), hooded or awnless barley (*Hordeum vulgare* L.), and awnletted wheat. In Montana and the Northern Great Plains, Beardless Kharkof (USDA-ARS NPGS, 2008a), 'Montana King' (Clark, 1936), and 'Newturk' (Clark et al., 1926) are examples of early landraces or cultivars of awnless wheat used for forage. Many new seed sources of "beardless" and awnletted winter wheat and triticale (× *Triticosecale* Wttm.) are appearing on the market for multiple uses as pasture, hay, and grain crops. The performance and characterization of winter wheat cultivars related to forage production have been poorly documented by the cultivar registration process, largely due to a lack of standard protocols for their evaluation.

Methods

PI 306505 was initially evaluated near Bozeman, MT, in 1996 and 1997 by the MAES winter wheat breeding program in single rep observation (SROB) nurseries as a potential source of improved winterhardiness and pest resistance.

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Abbreviations: ADG, average daily gain; CP, crude protein; DM, dry matter; HRW, hard red winter; HWW, hard white winter; ISDMD, in situ dry matter disappearance; MAES, Montana Agricultural Experiment Station; SKCS, single kernel characterization system; SROB, single rep observation.

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On the basis of visual appraisal of forage characteristics in 1997, PI 306505 (designated 97SROB-633) was among five awnless or awnletted accessions selected for improved forage potential. Both individual heads and bulk seed were harvested from each accession. Preliminary replicated forage yield evaluations established in 1998 and 1999 from the bulk seed indicated that 97SROB-633 had promising forage yield and quality characteristics. In 1999, headrows were evaluated for uniform plant height, leaf width, absence of disease, and general uniformity of heading date. Six 97SROB-633 selections were identified for further testing. All six selections, along with other awnletted lines and promising commercial cereal forage cultivars, were grown in a replicated (r = 4) forage trial in Bozeman in 2000. On the basis of forage performance results and further phenotypic evaluations in 1999, headrow selection 99H-3975 (from 97SROB-633) was identified as a most-promising forage-type winter wheat line. Seed from 99H-3975 was subsequently harvested and designated as experimental 2000FWW-26, later named Willow Creek.

Willow Creek was evaluated for forage and grain production, forage quality, and agronomic characteristics in Montana, Wyoming, and North Dakota. All forage and grain trials were sown with small plot drills. Soil fertility was managed using soil test results and recommendations for forage or grain production relative to the site and anticipated precipitation. Plot sizes were consistent within trials and ranged from 1.0 to 2.8 m wide by 3.3 to 6.5 m long. Forage plots at most irrigated or high rainfall sites were composed of seven rows planted with 15-cm spacing. Rainfed forage and grain plots were composed of four to seven rows planted with 30- to 36-cm spacing. Weed control and other crop management practices were consistent with local procedures to optimize hay or grain production.

Replicated forage nurseries were conducted in Montana and Wyoming from 1998 through 2008. Willow Creek was grown under rainfed high-precipitation conditions at two locations near Bozeman (mean annual precipitation of 415 and 467 mm). It was also evaluated in rainfed low-precipitation conditions following crop fallow or in continuous crop at Moccasin, Three Forks, Huntley, Havre, Wibaux, Winifred, and Conrad, MT, as well as Sheridan, WY (mean annual precipitation ranging from 290 to 389 mm). The experimental design at each location was a randomized complete block (RCB) with entries replicated either three or four times. Forage trial entries included promising cultivars or lines of wheat, triticale, spelt (*Triticum aestivum* L. subsp. *spelta* L. Thell.), and barley. Trial entries and test locations varied considerably each year due to limitations in personnel or resources but were uniform within years.

Forage harvest in the trials conducted from 1998 to 2002 occurred when a majority of the entries were from anthesis to kernel milk stage (Feekes stage 10.51 to 11.1). In the 2005 to 2008 trials, winter cereal forage was harvested on multiple dates, when each entry was at the kernel watery ripe stage (Feekes 10.54). Plant height, maturity rate, flag leaf width (as an indicator of leaf width), disease prevalence, and awn characteristics of each entry were determined before forage harvest. Self-propelled forage plot harvesters or sickle mowers were used for forage harvest. At harvest, subsamples were collected for dry matter (DM) determination following drying for 96 h at 40°C.

Forage quality analyses of Willow Creek and check cultivars were conducted from 2005 through 2008, using the procedures described by Hafla et al. (2008). Forage quality parameters included DM, N and nitrate N (NO_3–N) by standard Association of Official Analytical Chemists (2000) procedures, and neutral detergent fiber, acid detergent fiber, and in situ dry matter disappearance (ISDMD) concentrations (Van Soest et al., 1991). Crude protein (CP) was estimated from the equation %N × 6.25. All forage yield and quality parameters were expressed on a 100% DM basis.

Willow Creek was evaluated for grain production in the MAES Montana Intrastate Winter Wheat Performance Trials in 2006 and 2007 (Bruckner et al., 2006, 2007). It was grown in uniform replicated trials under high-precipitation conditions (Bozeman and Kalispell) and low-precipitation rainfed conditions (Havre, Huntley, Sidney, Moccasin, and Conrad, MT; Williston, ND). Entries in both trials included 49 commercial and advanced experimental lines of hard red winter (HRW) and hard white winter (HWW) wheat. The experimental designs were consistent for each site, either an RCB design with four replications or a partially balanced lattice design with three replications (Cochran and Cox, 1957).

Entries in the MAES Montana Intrastate Winter Wheat Performance Trials were evaluated for winter survival, maturity, prevalence and severity of disease and insect pests, plant height, and other characteristics before grain harvest (Berg et al., 2008). Grain from each plot was harvested with small-plot combines. Grain yield, grain moisture, and test weight were determined for each sample. Grain samples for each cultivar at each location-year (n = 16) were submitted to the Montana State University Cereal Quality Testing Laboratory. All samples were analyzed for grain protein concentration (n = 16), and a subset (n = 4) was evaluated for milling and bread-making characteristics by methods described by Bruckner et al. (2001). Kernel hardness (n = 4) was evaluated with a single kernel characterization system (SKCS) 4100 (Perten Instruments, Segeltorp, Sweden).

All data for forage and grain yield evaluations were analyzed annually by ANOVA by the site cooperators. For multiple-location or multiple-year data analyses in this report, cultivar means were reanalyzed using Statistix 9.0 Analytical Software (Statistix, Tallahassee, FL). The models included cultivars in an RCB design with locations or years considered as blocks. Cultivars were considered as fixed effects, with location, year, and all interactions considered as random effects. The appropriate interaction term was used as the error term for F-tests of cultivars and calculation of protected least significant differences (LSD at α = 0.05) for tests among cultivar means.

Characteristics

Willow Creek is a tall, late-maturing, awnletted winter wheat with excellent forage yield potential. Under high-precipitation rainfed conditions at Bozeman, MT, in 1998 through 2008 Willow Creek had forage yields

(7.1–11.1 Mg ha^{-1}) similar to most other awnletted wheat, triticale, or spelt entries (Table 1). TRICAL 102 Brand triticale (Resource Seeds, Inc., Gilroy, CA) had higher ($P < 0.05$) forage yields than Willow Creek in 2002, 2005, and 2007. All recent forage triticale cultivars were taller and had wider flag leaves than Willow Creek wheat.

In low-precipitation rainfed trials conducted in Montana and Wyoming from 1999 through 2008, Willow Creek forage yields (4.9–9.5 Mg ha^{-1}) varied considerably depending on precipitation (Table 2). During droughty conditions in 2002, Willow Creek forage yields were comparable to other awnletted wheat, triticale, and spelt cultivars or lines (Table 2). During higher precipitation in 2007, Willow Creek forage yield was lower ($P < 0.05$) than TRICAL 102 Brand triticale and 'Boreal' triticale (Elliot Plant Breeding, http://www.elliottplantbreeding.com/).

In two trials near Bozeman, MT, in 2005 Willow Creek had higher ($P < 0.001$) forage yields than 'Haybet' (CV-215) barley (Table 3). Across trials, Willow Creek had excellent forage yield potential, superior to barley (Table 3) and other awnletted wheat lines (Tables 1 and 2) but inferior to new awnletted lines of triticale under higher precipitation (Tables 1 and 2). Appropriate head-to-head field comparisons of winter and spring cereals within the same nursery are limited. However, at research locations where both winter and spring cereal forages are grown, winter crops appear to have better forage production potential than barley (Cash et al., 2007).

Forage quality of Willow Creek has been evaluated in a limited number of trials. In replicated trials near Bozeman in 2005, Willow Creek was taller and had wider flag leaves ($P < 0.001$) than Haybet barley (Table 3). In both trials, Willow Creek and Haybet were harvested for hay at the kernel water stage (Feekes stage 11). Willow Creek had lower ($P < 0.001$) forage quality (lower CP and ISDMD) than Haybet barley. However, NO_3–N concentration of Willow Creek forage (402 mg kg^{-1}) was significantly lower ($P < 0.001$) than those of Haybet (2260 mg kg^{-1}). High nitrate accumulation by cereal forages is a significant concern for feeding pregnant ruminant livestock. These levels of NO_3–N (402 vs. 2260) correspond generally to the recommendations of "limit feed" and "avoid feeding" to pregnant cattle, respectively (Cash et al., 2002).

Hafla (2008) evaluated forage yield and quality of Willow Creek and TRICAL 102 Brand triticale hay in replicated plots or field strips near Fort Ellis, MT (Table 3). Willow Creek was shorter ($P < 0.001$) than TRICAL 102, but forage yields of the two cultivars were similar ($P > 0.05$) at hay harvest (Feekes 10.54). Despite similar fiber concentrations, Willow Creek had better ($P < 0.05$) ISDMD than TRICAL 102. These data indicate that fiber digestibility of Willow Creek forage is superior to that of TRICAL 102, but more testing is needed. The crops had different ($P < 0.01$) NO_3–N concentrations; however, all observed levels (54–692 mg kg^{-1}) in these samples were considered safe for livestock consumption (Table 3). These data are consistent with those of Marsalis et al. (2008) in New Mexico, who reported that

Table 1. Forage yield and agronomic characteristics of Willow Creek wheat cultivar compared with other awnletted winter cereal crops grown under high-precipitation conditions near Bozeman, MT, 1998–2008.

Entry	Crop year								Plant height	Flag leaf width
	1998	1999	2000	2002	2005	2006	2007	2008		
	Forage DM yield[†]								Mean (SE)[‡]	
	Mg ha^{-1}								cm	mm
Willow Creek wheat[§]	9.7	11.1 ab[¶]	8.9 ab	7.2 bc	7.1 bc	9.8 a	7.2 c	10.9 ab	123 (9)	16 (1)
2000 FWW-25 (PI 262578) wheat	10.5	11.5 a	9.7 a	7.5 bc		11.6 a	7.5 bc		95 (11)	15 (1)
97SROB-639 (PI 94487) wheat	10.4	10.5 ab	7.0 ab	7.2 bc					125 (15)	19 (1)
97SP-30 wheat	9.0	9.0 c	5.8 b	6.1c	6.5 c				96 (12)	20 (1)
97SP-316 wheat	10.4	10.3 b	6.6 ab	7.4 bc					114 (15)	17 (1)
Newturk (CV-245) wheat			8.4 ab					10.8 ab	113 (15)	15 (1)
Frostat triticale			8.8 ab	8.2 b	12.2 ab	9.6 a			157 (12)	19 (1)
TRICAL 102 Brand triticale				10.0 a	13.4 a	10.7 a	8.8 ab	11.6 a	152 (10)	18 (1)
Winterness triticale				8.8 ab					145 (–)	16 (–)
Windrift triticale					9.7 bc	10.6 a	7.3 c	7.5 b	153 (11)	20 (1)
Frank spelt					6.9 bc	7.5 b			114 (15)	18 (1)
2005SFOB-48 wheat						11.1 a	9.0 a	8.9 ab	114 (12)	19 (1)
Boreal triticale							9.4 a		171 (–)	21 (–)
Yellowstone (CV-1012) awned wheat								8.3	85 (–)	16 (–)
$LSD_{0.05}$	NS	1.1	3.6	1.7	3.5	2.1	1.3	3.6		
CV%	16.2	6.2	26.8	14.6	26.7	15.0	10.4	15.4		

[†]Values are dry matter (DM) forage yields from replicated trials at Bozeman (1999– 2005) and Fort Ellis (2006– 2008), with mean annual long-term precipitation of 414 and 467 mm, respectively. Annual precipitation was 400, 366, 320, 345, 369, 425, 446, and 470 mm, respectively for the 1998–2008 trials. The 1999 trial received 76 mm of preplant irrigation in September 1998.

[‡]Values are the mean and standard error for plant height and flag leaf width for the years tested.

[§]97SROB-633 (Willow Creek progenitor) was evaluated in 1998 to 2000; Willow Creek (99H3975, 2000FWW-26) was grown in subsequent trials.

[¶]Values within a column followed by the same letter are not significantly different at the $\alpha = 0.05$ probability level by protected least square difference (LSD).

Table 2. Forage yield of Willow Creek wheat cultivar compared with other awnletted winter cereal crops grown under rainfed conditions at low-precipitation sites in Montana and Wyoming, 1999–2008.

Entry	Crop year						
	1999	2000	2002	2005	2006	2007	2008
	Forage DM yield[†]						
	Mg ha^{-1}						
Willow Creek wheat[‡]	6.6 ab[§]	6.2 ab	4.9	5.7 abc	6.8	9.5 b	7.9
FWW-25 (PI 262578) wheat	6.6 ab	5.7 abc	5.2		6.6	9.9 b	
97SROB-639 (PI 94487) wheat	7.0 a	5.7 abc	5.4				
97SP-30 wheat	3.5 e	4.7 c	4.6	4.4 c			
97SP-316 wheat	5.4 cd	5.5 bc	5.0				
Newturk (CV-245) wheat	5.5 bcd	5.5 bc					7.0
SP 949 spelt	6.1 abc	6.6 ab					
Frostat triticale		6.8 a	4.9	6.8 ab	6.1		
TRICAL 102 Brand triticale			4.9	6.8 ab	7.2	12.3 a	8.6
Winterness triticale			5.2				
Windrift triticale				7.1 a	6.3	11.1 ab	8.1
Frank spelt				4.8 bc	6.4		
2005SFOB-48 wheat						11.6 ab	8.1
Boreal triticale						12.2 a	
Yellowstone (CV-1012) awned wheat							7.9
$LSD_{0.05}$	1.2	1.2	NS	2.0	NS	2.2	NS
CV%	10.3	15.6	12.7	22.8	13.1	10.8	14.2
Locations	3	5	4	4	5	3	4

[†]Values are forage dry matter (DM) yield means from replicated trials following summer fallow at Moccasin (8 yr), Three Forks (2 yr), Huntley (4 yr), Havre (2 yr), Wibaux (1 yr), Winifred (1 yr) and Conrad (1 yr), MT; Sheridan, WY (3 yr); and Moccasin continuous crop (6 yr). Long-term average precipitation at these sites is 389, 292, 335, 310, 353, 359, 290, 384, and 389 mm, respectively. During the trial years, precipitation was lowest in 2002 (228–308 mm), and highest in 2007 (325–423 mm).

[‡]97SROB-633 (Willow Creek progenitor) was evaluated in 1999 and 2000; Willow Creek (99H3975, 2000FWW-26) was grown in subsequent trials.

[§]Values within a column followed by the same letter are not significantly different at the $\alpha = 0.05$ probability level by protected least square difference (LSD).

Table 3. Summary of forage performance and quality data of Willow Creek wheat cultivar compared with other cereal crops grown under high-precipitation rainfed conditions from 2005 to 2008 near Bozeman, MT.

Entry (Feekes maturity at harvest)[†]	Forage yield	Plant height	Flag leaf width	Forage quality				
				CP[‡]	NDF	ADF	ISDMD	NO_3–N
	Mg ha^{-1}	cm	mm	%				mg kg^{-1}
2005 Bozeman and Fort Ellis								
Willow Creek wheat hay (11)	9.6	134	16	10.3	56.8	33.7	56.8	402
Haybet (CV-215) barley hay (11)	7.0	107	11	15.6	53.0	34.0	66.8	2260
Significance of *F*-test[§]	***	***	***	***	NS[#]	NS	***	***
2006–2008 Fort Ellis								
Willow Creek wheat hay (10.54)	7.9	120	17	11.1	63.9	39.9	57.8	523
TRICAL 102 Brand triticale hay (10.54)	8.8	147	18	9.8	59.0	36.4	51.9	241
Significance of *F*-test[¶]	NS	***	NS	NS	NS	NS	*	**

*$\alpha = 0.05$ level of probability.

**$\alpha = 0.01$ level of probability.

***$\alpha = 0.001$ level of probability.

[†]Trials in 2005 and 2007 were replicated forage plots; 2006 and 2008 data were from replicated field strips where forage yield was determined by hand-harvesting 1-m^2 quadrats of wheat and triticale (Hafla, 2008).

[‡]Forage quality analyses were conducted at Montana State University Livestock Nutrition Center using cited methods, and values are reported on a 100% DM basis: crude protein (CP, estimated by %nitrogen[N] × 6.25), neutral detergent fiber (NDF), acid detergent fiber (ADF), in situ dry matter disappearance (ISDMD, 48 h), and nitrate N (NO_3–N) (Hafla 2008).

[§]*P* > F for cultivar effects in ANOVA where the location × cultivar MS were used as the error term.

[¶]*P* > F for cultivar effects in ANOVA where the year x cultivar MS were used as the error term.

[#]NS, not significant.

winter triticale had superior forage production than winter wheat, but wheat generally had better forage quality than triticale.

Cattle feeding trials have been conducted with Willow Creek wheat and other cereal forages in Montana (Todd et al., 2007) and North Dakota (Stamm et al., 2006). The cereal forages were fed to weaned steers (~310 kg initial bodyweight) in high roughage backgrounding diets. Chopped hay or silage of each treatment was fed ad libitum in replicated pens ($r = 4$ pens; 5 steers per pen). The treatment diets were balanced for CP and energy by the addition of rolled barley grain and a protein supplement (32%) to isolate the effects of the different forage sources. In both trials, Willow Creek wheat resulted in acceptable levels of feed intake and calf growth over the 2-mo feeding period (1.1 kg head^{-1} d^{-1} average daily gain, ADG). Willow Creek hay resulted in lower ($P < 0.05$) ADG than 'Robust' barley (CV-184) hay and silage but had similar results compared with 'Loyal' oat hay at Hettinger, ND (Stamm et al., 2006). In the feeding trial at Bozeman, MT, steers fed Willow Creek hay and silage had lower ($P < 0.05$) ADG than those fed Haybet or 'Hays' barley hay (Todd et al., 2007). Data from these feeding trials confirm that Willow Creek has good feeding characteristics in livestock diets but is slightly inferior to barley forage in growth rations.

Willow Creek produces significantly lower grain yields than most modern semidwarf HRW and HWW cultivars (Table 4). In the MAES Montana Intrastate Winter Wheat

Performance Trials, 96 and 80% of the cultivars or lines had significantly ($P < 0.05$) higher grain yields than Willow Creek in 2006 and 2007, respectively (Bruckner et al., 2006, 2007). Willow Creek had lower ($P < 0.05$) test weights than most winter wheat cultivars, including the widely adapted cultivars Tiber (CV-775) and Genou (CV-986). Grain protein of Willow Creek (14.5%) was higher than most entries, likely because of its low grain harvest index of Willow Creek (data not presented).

Table 4. Agronomic performance of Willow Creek wheat cultivar compared with select hard red winter wheat cultivars grown in uniform grain trials from 2006 to 2007 in Montana and North Dakota[†].

Cultivar	Grain yield	Test weight	Grain protein	Heading date	Plant height	Winter survival	Stripe rust symptoms
	kg ha^{-1}	kg m^{-3}	%	Julian day	cm	——— % ———	
Willow Creek	3437 c[‡]	766 b	14.5 a	166 a	123 a	68 a[§]	4 a[¶]
Yellowstone (CV-1012)	5121 a	777 ab	12.6 c	158 b	87 c	63 ab	5 a
Genou (CV-986)	4444 b	790 a	13.3 b	157 b	91 c	48 c	44 b
Tiber (CV-775)	4428 b	793 a	13.2 bc	159 b	98 b	55 bc	43 b
$LSD_{0.05}$	526	18	0.6	2	5	12	16
CV (%)	16.7	3.2	6.5	1.7	7.3	7.0	33.9
Location-years	16	16	16	16	16	2	2

[†]Data were from replicated trials at seven Montana locations (Bozeman, Havre, Sidney, Kalispell, Moccasin, Huntley, and Conrad) and Williston, ND (Bruckner et al., 2006, 2007).

[‡]Values within a column followed by the same letter are not significantly different at the $\alpha = 0.05$ probability level by protected least square difference (LSD).

[§]Visual ratings of percent survival in spring stands at Sidney, MT, and Williston, ND, in 2006.

[¶]Visual ratings of percentage infection by indigenous races of *Puccinia striiformis* var. *tritici* at Bozeman and Kalispell in 2006.

In grain trials, Willow Creek was the tallest and latest-maturing cultivar or line tested (Table 4), requiring delayed or multiple harvest dates at several sites. At high-rainfall sites (Bozeman and Kalispell), Willow Creek was 130 and 147 cm tall in 2006 and 2007, respectively (Bruckner et al., 2006, 2007). At the same sites, Willow Creek heading dates (Feekes stage 10.5) were 11 and 10 d later than the trial averages. Despite the height of Willow Creek, the incidence of lodging has been low in seed production fields. Willow Creek has excellent winterhardiness and resistance to stripe rust (caused by local races of *P. striiformis* var. *tritici*) similar to those of 'Yellowstone' (CV-1012) winter wheat (Table 4). Grain yield and milling and baking characteristics of this cultivar are poor (Berg et al., 2008).

Willow Creek is suitable for forage production in Montana and Wyoming under rainfed or irrigated conditions. Willow Creek should not be planted with the intent of a dual-purpose hay or grain crop (dependent on market or forage conditions) due to its low grain yield and quality. Early vegetative growth of Willow Creek in the spring is lighter green in color and more lax than semidwarf wheat cultivars; however, from jointing to the boot stage, Willow Creek has a faster rate of biomass accumulation than standard wheat cultivars (data not presented). Willow Creek wheat and TRICAL 102 Brand triticale had excellent recovery following spring grazing, and these crops are very adaptable to a pasture-hay system in Montana under rainfed conditions (Hafla, 2008).

Willow Creek is an awnletted cultivar suitable for feeding as long stem hay, similar to other available awnletted cereal forages. Seventy-six percent of Willow Creek plants have rudimentary tip awns (avg. = 6.2, SE = 0.2 per spike) from 6 to 19 mm in length, comparable to those in photographs of PI 306505 (USDA-ARS NPGS, 2008b) and Newturk (USDA-ARS NPGS, 2008c). Heads at grain maturity are 93% tan to amber, 5% white and <2% red, and the chaff is white. Willow Creek is a HRW wheat cultivar, with tan grain kernels similar to PI 306505. Grain texture of Willow Creek is hard with an SKCS hardness index of 77.2, which is similar to Yellowstone (77.3) and Genou (79.9).

Willow Creek has gained rapid acceptance by livestock producers in Montana due to several distinct advantages. The forage yield potential of Willow Creek is excellent, making it an ideal forage option for livestock producers in crop rotations with alfalfa (*Medicago sativa* L.). Since 2000, forage production levels of cereal hays grown under rainfed conditions in Montana (2.2–3.4 Mg ha^{-1}) were comparable to those of alfalfa (2.0–3.1 Mg ha^{-1}) (http://www.nass.usda.gov/Statistics_by_State/Montana/Publications/crops/grhayayp.htm; verified 3 Apr. 2009). Winter cereals including Willow Creek generally produce higher forage yields than spring barley at the same site. Further, winter cereals grown under continuous cropping often have higher forage production than alfalfa and perennial grasses at low-precipitation rainfed sites (Cash et al., 2007). For example, during droughty conditions at Moccasin, MT, in 2002, forage yields of Willow Creek wheat and TRICAL 102 Brand triticale (avg. 5.0 Mg ha^{-1}) were numerically higher than the trial means of forage barley (4.1 Mg ha^{-1}) and 2-yr stands of alfalfa (1.9 Mg ha^{-1}) (Cash et al., 2007). Autumn planting is a significant benefit for many livestock operations. The late maturity of Willow Creek is an advantage, because this cultivar can be harvested for hay in early July after the first cutting of alfalfa, coinciding with ideal hay drying conditions. Despite having inferior forage quality compared to barley, Willow Creek hay has a good balance of CP and energy for growth rations or winter maintenance diets for pregnant cattle and sheep. Nitrate–nitrogen concentrations were lower in Willow Creek wheat compared with Haybet barley; however, more data are needed to confirm a reduced level of nitrate risk. Many new seed sources of awnletted winter triticale or wheat are being marketed as annual forage crops. Some winter triticale cultivars have forage yields superior to Willow Creek; however, little published information exists on their forage quality and feeding characteristics. Also, there currently is some resistance to growing winter triticale by producers and seed dealers in Montana near winter wheat grain production areas due to potential contamination issues. Forage yield, adaptation, winterhardiness, forage quality, and animal performance have been documented for Willow Creek, and reliable seed sources of this cultivar are now available.

Availability

Initial Breeder seed of Willow Creek was grown in 2001 in a 0.25-ha irrigated field near Willow Creek, MT. Foundation class seed has been produced annually since 2004. Willow Creek wheat was reviewed by the MAES Variety Release Committee in 2005 and released by MAES as an unprotected public cultivar with no restrictions. Foundation seed is distributed by the MAES Foundation Seed Program Director, MSU, Bozeman, MT 59717-3150 (406-994-5687, http://plantsciences.montana.edu/FoundationSeed/default.htm). It is requested that appropriate recognition be given if Willow Creek contributes to research or development of new breeding lines or cultivars. Small quantities of seed for research purposes may be obtained from the corresponding author.

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