Registration of 'Bearpaw' Wheat

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ABSTRACT

'Bearpaw' (Reg. No. CV-1083, PI 665228) hard red winter (HRW) wheat (*Triticum aestivum* L.) was developed and released by the Montana Agricultural Experiment Station in September 2011. Bearpaw is of unknown pedigree, derived from a composite of five crosses made to the same F_1 male sterile parent in 1999: Dominant male sterile (DMS)/'Rampart'//'Pronghorn'/3/2*Rampart, DMS/Rampart//Pronghorn/3/Rampart/4/MTW9806, DMS/Rampart//Pronghorn/3/Rampart/4/'Nuplains', DMS/Rampart//Pronghorn/3/Rampart/4/MT9513, DMS/Rampart//Pronghorn/3/Rampart/4/MT98113. Bearpaw was developed using a modified bulk-breeding method and selected as an $F_{5:6}$ headrow. Bearpaw was tested under the experimental number MTS0721 from 2007 to 2011 in Montana. Quality has been evaluated in multilocation Montana trials since 2007. Bearpaw is a high-yielding, solid-stem, semidwarf (Rht-B1b) HRW wheat cultivar with medium maturity, medium to high test weight and grain protein, and acceptable milling and baking quality. Bearpaw was released for its host-plant resistance to wheat stem sawfly (*Cephus cinctus* Nort.) conditioned by stem solidness, along with short stature and improved yield potential relative to existing solid-stem cultivars adapted to Montana.

'Bearpaw' (Reg. No. CV-1083, PI 665228) hard red winter (HRW) wheat (*Triticum aestivum* L.) was developed and released by the Montana Agricultural Experiment Station in 2011. Bearpaw's name denotes the Bears Paw Mountains south of Havre, MT and the Northern Agricultural Research Center, where the cultivar was derived, selected, and tested during its development. Bearpaw was released for its combination of stem solidness, short stature, and high yield potential and its excellent performance in production environments of north-central Montana infested with wheat stem sawfly (*Cephus cinctus* Nort.). Wheat stem sawfly is the major biotic limitation to wheat production in Montana, reducing kernel weight and grain yield and increasing harvest losses since stems lodge after mature larvae girdle the stem base (Morrill et al., 1992). Solid stems provide resistance due to antibiosis whereby larvae are unable to survive in the stem.

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Abbreviations: DMS, dominant male sterile; HRW, hard red winter; LY, location years; MAES, Montana Agricultural Experiment Station; NRPN, Northern Regional Performance Nursery.

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Methods

Pedigree and Breeding History

Bearpaw is of unknown pedigree, derived from a composite of five crosses made to the same F_1 male sterile parent in 1999: Dominant male sterile (DMS)/'Rampart'//'Pronghorn'/3/2*Rampart,DMS/Rampart//Pronghorn/3/Rampart/4/MTW9806, DMS/Rampart//Pronghorn/3/Rampart/4/'Nuplains', DMS/Rampart//Pronghorn/3/Rampart/4/MT9513, DMS/Rampart//Pronghorn/3/Rampart/4/MT98113. The DMS was a 'Taigu' DMS stock (Bing-Hua and Jing-Yang, 1986) in a hard red spring wheat background obtained from Westbred in 1996. Rampart (PI 593889; Bruckner et al., 1997) is a solid-stem HRW wheat released by the Montana Agricultural Experiment Station (MAES) in 1996. Pronghorn (PI 593047; Baenziger et al., 1997) is a hollow-stem HRW cultivar released by Nebraska in 1996. Nuplains (PI 605741) is a semidwarf, hollow-stem,

hard white winter cultivar developed by the USDA-ARS, Lincoln, NE in 1998. MTW9806 ('Redwin' [CItr 17844]/'Rio Blanco' [PI 531244]//'NuWest' [PI 586806]), MT9513 (NuWest/MT8030), and MT98113 ('Judith' [PI 584526]/MT8764) are unreleased hollow-stem experimental wheat lines developed by the MAES. The composite F_1 population was grown at Fort Ellis, MT in 2000. The F_2, F_3, F_4, and F_5 bulk populations were grown at Bozeman, Fort Ellis, Loma, MT and Loma from 2001 to 2004, respectively, using a modified bulk-breeding method with mass selection for winter survival, reduced plant height, favorable head morphology, stem solidness, and kernel plumpness. Heads (111) selected from the F_5 population grown at Loma in 2004 were grown as F_6 headrows at Bozeman in 2005. Headrow 99X96cE107 was selected based on evaluation of stem solidness and visual criteria for uniformity, productivity, and acceptable agronomic type and harvested in bulk. 99X96cE107 was subsequently tested in the 2006 Sawfly Observation Nursery, which was grown at Bozeman, Havre, North Havre, and Fort Ellis.

Line Selection and Evaluation

In 2007, 99X96cE107 was designated MTS0721 and tested in the Montana Sawfly Yield Trial at five locations. From 2007 through 2011, MTS0721 was evaluated in the Sawfly nursery (total of 19 location-years [LY]), in 2008, MTS0721 was evaluated in the Montana Advanced Nursery (5 LY), from 2009 through 2011, MTS0721 was evaluated in the Montana Intrastate Trial planted at eight locations (total 22 LY, Berg et al., 2012), and from 2010 through 2011, MTS0721 was evaluated in the Montana Off-station Nursery planted at 14 to 16 on-farm locations (total 30 LY). Quality has been evaluated in multilocation Montana trials since 2007. In 2010, MTS0721 was an entry in the USDA Northern Regional Performance Nursery (NRPN) planted at approximately 20 sites across the Northern Great Plains (http://www.ars.usda.gov/Research/docs.htm?docid=11932; verified 12 June 2012).

The Montana Intrastate and Advanced Trials consisted of 49 and 36 entries, respectively, planted in lattice or randomized complete block designs with three replications. The Montana Off-Station Nursery consisted of 24 entries planted in on-farm trials with three replications. The Montana Sawfly Trial consisted of 49 entries planted in two replications. Plot size, row number, and row spacing varied by location as a result of the different plot-seeding equipment used. The seeding rate in all trials was approximately 2.15 million kernels ha^{-1}. Grain yield, volume weight, plant height (distance from the ground to the top of the spike excluding awns), and grain protein were measured in all harvested trials. Days to heading (50% of heads in plots completely visible) were recorded at most on-station trials. Winter survival (% plants surviving), lodging (% plants lodged), sawfly cutting (% stems cut by wheat stem sawfly), and stripe rust (% severity) were recorded in environments where there was differential expression for these traits. Stem solidness was determined in selected environments using five stems per plot pulled randomly near crop maturity. Five internodes per stem were cross-sectionally cut and visually rated on a quantitative scale of 1 to 5, where 1 designates a hollow (normal) stem and 5 designates a solid stem. Internode scores were summed for each stem to result in a 5 (hollow) to 25 (completely solid) stem solidness score.

Milling and baking characteristics were determined by the Montana State University Cereal Quality Laboratory using methods approved by the American Association of Cereal Chemists (2000). Grain protein was determined with an Infratec 1225 Grain Analyzer. Kernel hardness was determined with a single-kernel characterization system (SKCS-4100, Perten Instruments). Composite grain samples harvested from various locations of the Montana Intrastate Trial from 2009 to 2010 were milled on a Brabender Automat mill and the flour then used to determine bake absorption, mix time, and loaf volume (AACC method 10-10B).

Analysis of variance was conducted on data from individual environments and across environments with SAS version 9.2 (SAS Institute, Cary, NC). Mean comparison of traits using a protected LSD (P = 0.05) test was made to identify significant differences among genotypes. The genotype × environment mean square was used as an error term to calculate the LSD statistic.

Seed Purification and Increase

Purification and increase of Bearpaw was initiated in 2009, when 117 F_6–derived F_{10} headrows were grown at Bozeman with selection for stem solidness and visual uniformity and 86 linerows were bulked as a source of breeder seed. In 2010, breeder seed of Bearpaw was increased at Yuma, AZ and the Bozeman Post Farm. Foundation seed of Bearpaw was grown at Bozeman and Havre and allocated to seed growers of Montana in the fall of 2011.

Characteristics

Botanical and Agronomic Characteristics

Bearpaw has a winter growth habit and semierect juvenile plant growth. The foliage at the boot stage is green with recurved, twisted flag leaves. Coleoptiles are white and anthers are yellow. The stem lacks anthocyanin and waxy bloom, and is solid stemmed. The head of Bearpaw is mid-dense, oblong, and inclined, with white glumes at maturity. Kernels are red, intermediate in size, and hard textured.

Bearpaw is an awned, solid-stem, semidwarf HRW wheat. Bearpaw has medium maturity, 170.4 d heading from 1 January, similar to 'CDC Falcon' (PI 619610) and 1 d earlier than the predominant Montana solid-stem cultivars, 'Genou' (PI 640424; Bruckner et al., 2006) and Rampart (Table 1). Bearpaw is semidwarf (*Rht-B1b*) and medium short (81 cm, n = 69), 3 cm taller than CDC Falcon and 9 to 10 cm shorter than Genou and Rampart. Bearpaw is solid stemmed, averaging 21.8 on the 5 (hollow) to 25 (solid) stem solidness scale, which is significantly more solid than Genou (18.2) and similar to Rampart (21.5) (Table 2). The winterhardiness of Bearpaw is medium to low, similar to Genou (Table 1).

Bearpaw is an F_5–derived line. Bearpaw has been genetically uniform and stable across three generations of seed increase. Bearpaw contains tall plant variants at a

Table 1. Mean performance of Bearpaw and check cultivars in 69 Montana environments, 2007–2011.

Cultivar	Grain yield	Volume weight	Winter survival	Heading date	Plant height	Lodging	Stripe rust	Grain protein
	kg ha^{-1}	kg m^{-3}	%	d from 1 Jan.	cm	%	% severity	g 100 g^{-1}
CDC Falcon	4240	770	67	170.6	78	2	26	12.2
Bearpaw	4206	772	53	170.4	81	10	29	12.4
Genou	3870	771	51	171.4	91	12	31	12.5
Rampart	3823	775	41	171.4	90	15	17	13.1
LSD (0.05)	155	4	ns	0.4	1	ns	11	0.2
No. of environments	69	69	2	39	69	7	9	68

frequency of less than 2 per 10,000 plants and dark chaff variants at a frequency of less than 4 per 10,000 plants.

Field Performance

In 69 LY of testing in the Montana Winter Wheat Intrastate, Off-Station, and Sawfly Nurseries, the average yield of Bearpaw (4206 kg ha^{-1}) was high, similar to the yield of CDC Falcon, but 9% and 10% higher, respectively, than that of the predominantly grown solid-stem cultivars, Genou and Rampart (Table 1). Although Bearpaw has an improved yield potential relative to that of the solid-stem genotypes, Bearpaw is not recommended for environments with low levels of wheat stem sawfly since its yield potential is approximately 12% lower than that of Montana's predominant hollow-stem cultivar 'Yellowstone' (PI 643428; Bruckner et al., 2007; current data, Berg et al., 2012). The volume weight of Bearpaw (772 kg m^{-3}) was similar to that of other cultivars. The grain protein content of Bearpaw is lower than Rampart's but similar to Genou's and CDC Falcon's.

In 13 north-central Montana environments where significant cutting by wheat stem sawfly was observed, grain yield of Bearpaw was 3% and 6% higher than Genou and Rampart, respectively (Table 2). Cutting by wheat stem sawfly of Bearpaw (9%, n = 11) is intermediate to Genou (20%) and Rampart (6%), all significantly lower than susceptible CDC Falcon (Table 2).

Disease and Insect Resistance

Bearpaw is resistant to wheat stem sawfly and susceptible to Russian wheat aphid (*Diuraphis noxia* Mordvilko) and Hessian fly [*Mayetiola destructor* (Say)]. Bearpaw is resistant to the prevalent races of stem rust (caused by *Puccinia graminis* Pers.:Pers. f. sp. *tritici* Eriks. & E. Henn) and UG99 (Sr36) based on field (Kenya) and seedling evaluations conducted by the USDA-ARS Cereal Disease Lab from 2008 to 2010. Bearpaw is susceptible to leaf rust (caused by *P. triticina* Eriks.) and stripe rust (caused by *P. striiformis* Westend. f. sp. *tritici* Erik). Based on DNA marker analysis of the 2010 NRPN, Bearpaw carries diagnostic markers for *Al-4DL*, *Sr2,* and *Rht-B1b* (data not shown).

End-Use Quality

Based on experimental milling with a Brabender Automat Mill, the flour yield of Bearpaw is intermediate to that of CDC Falcon and Rampart, with relatively low flour ash content and medium flour protein (Table 3). Bearpaw has intermediate dough-mixing characteristics with medium mixing tolerance, water absorption, and mixing time. Bearpaw has relatively low loaf volume, similar to CDC Falcon. Bearpaw has relatively high polyphenol oxidase content and average to poor Asian noodle brightness and color stability (data not shown).

Availability

The Montana Agricultural Experiment Station will maintain breeder seed of Bearpaw. Application for U.S. Plant Variety Protection for Bearpaw has been made. A research fee will be assessed on all sales of registered and certified seed. All seed requests should be sent to the corresponding

Table 2. Mean stem solidness and performance of Bearpaw and check cultivars in 13 Montana environments infested with wheat stem sawfly, 2007–2011.

		Sawfly-infested environments	
Cultivar	Stem solidness	Grain yield	Sawfly cutting
	5–25[†]	kg ha^{-1}	%
CDC Falcon	6.8	3944	33
Bearpaw	21.8	3756	9
Genou	18.2	3635	20
Rampart	21.5	3548	6
LSD (0.05)	0.7	181	11
No. of environments	33	11	11

[†]5 = hollow; 25 = completely solid.

Table 3. Average milling and baking quality attributes of Bearpaw and check cultivars in eight Montana winter wheat yield trials, 2009–2010.

Cultivar	SKCS[†] grain hardness	Flour yield	Flour protein	Flour ash	Baking mix time	Water absorption	Loaf volume
		g 100 g^{-1}			min	g 100 g^{-1}	cm^3
Bearpaw	74.1	68.7	11.1	0.40	7.9	72.1	1000
CDC Falcon	66.6	65.8	10.6	0.43	9.4	70.0	1024
Genou	72.9	68.8	11.3	0.41	11.3	72.3	1051
Rampart	71.8	69.9	12.1	0.41	11.8	74.0	1109
LSD (0.05)	3.5	1.1	0.4	0.01	1.9	1.4	40

[†]Single-kernel characterization system.

author during the period of protection by Plant Variety Protection. Seed of this release is deposited in the National Plant Germplasm System, where it will be available after the expiration of the Plant Variety Protection for research purposes, including development and commercialization of new cultivars. It is requested that appropriate recognition be made if this germplasm contributes to the development of new germplasm or cultivars.

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