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CULTIVAR

'TAM 112' Wheat, Resistant to Greenbug and Wheat Curl Mite and Adapted to the Dryland Production System in the Southern High Plains

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ABSTRACT

'TAM 112' (Reg. No. CV-1101, PI 643143), a hard red winter wheat (*Triticum aestivum* L.) cultivar with experimental designation TX98V9628, was developed and released by Texas A&M AgriLife Research in 2005. TAM 112 is an F_4–derived line from the cross U1254-7-9-2-1/TXGH10440 made at Vernon, TX, in 1992. U1254-7-9-2 is a USDA–ARS germplasm line from the Plant Science and Entomology Research unit, Manhattan, KS, and TXGH10440 is a sibling selection of the cultivar TAM 110. TAM 112 is an awned, medium-early maturing, semidwarf wheat with red glumes. It was released primarily for its excellent grain yield potential particularly in dryland environments of the southern Great Plains; resistance to stem rust (caused by *Puccinia graminis* Pers.:Pers. f. sp. *tritici* Eriks. & E. Henn.), powdery mildew [caused by *Blumeria graminis* (DC.) E.O. Speer f. sp. *tritici* Em. Marchal], and greenbug [*Schizaphis graminum* (Rondani)]; and good milling and bread-baking characteristics. Compared with existing hard red winter wheat cultivars at the time of release, TAM 112 is most similar to TAM 110 with respect to area of adaptation and disease and insect resistance, but it has significantly higher yield and better bread-baking characteristics than TAM 110. Licensed to Watley Seed Company for marketing, TAM 112 is currently one of the most popular hard red winter wheat cultivars adapted to the dryland production system in the Texas High Plains and similar areas in the southern Great Plains.

'TAM 112' (Reg. No. CV-1101, PI 643143), a hard red winter wheat (*Triticum aestivum* L.) cultivar with experimental designation TX98V9628, was developed and released by Texas A&M AgriLife Research in 2005 and was licensed to Watley Seed Company for marketing. TAM 112 is an awned, medium-early maturing, semidwarf wheat with red glumes. It was extensively tested throughout the Great Plains, including the major wheat-growing areas in Texas, but is well adapted to the dryland wheat production system of the Texas High Plains and similar areas in the adjacent states. The Texas wheat variety survey in 2012 indicated that 'TAM 111' (Lazar et al., 2004) and TAM 112 are currently the two most widely grown cultivars in the state, occupying 36 and 17% of the Texas High Plains acres, respectively, in 2012 (NASS, 2012). TAM 112 is also adapted to Kansas and Colorado, where it was grown on 5.1 and 3% of the wheat acres planted respectively in those two states in 2013 (NASS, 2013a,b). TAM 112 is suitable for both dual-purpose (grazing plus grain) and grain-only systems. TAM 112 carries T1AL.1RS inherited from 'Amigo' (Sebesta et al., 1995) and is resistant to stem rust (caused by *Puccinia graminis* Pers.:Pers f. sp. *tritici* Eriks. & E. Henn.), powdery mildew [caused by *Blumeria graminis* (DC.) E.O. Speer f. sp. *tritici* Em. Marchal], and greenbug [*Schizaphis graminum* (Rondani)] biotype E, I, and K. In addition, it is tolerant to *Wheat streak mosaic virus* and resistant to wheat curl mite (*Aceria tosichella* Keifer) (Price et al., 2014).

TAM 112 is an F_4–derived line from the cross U1254-7-9-2-1/TXGH10440. U1254-7-9-2, developed from the cross

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Abbreviations: SKCS, single-kernel characterization system; SRPN, Southern Regional Performance Nursery; UVT, uniform variety trial.

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‘TAM 200’ (PI 578255)/TA2460, is a USDA–ARS germplasm line from the Plant Science and Entomology Research unit, Manhattan, KS. TAM 200 was released by Texas A&M AgriLife Research in 1986 (Worrall et al., 1995). TA2460, commonly known as Tausch’s goatgrass, is an *Aegilops tauschii* line with the leaf rust resistance gene *Lr41*. TXGH10440, a sibling selection of cultivar TAM 110 (Lazar et al., 1997), carries greenbug resistance genes *Gb2*, inherited from the wheat germplasm line Amigo (Sebesta et al., 1995), and *Gb3*, inherited from the synthetic hexaploid wheat line ‘Largo’ (Joppa and Williams, 1982).

Compared with existing hard red winter wheat cultivars at the time of release, TAM 112 is most similar to TAM 110 with respect to area of adaptation, drought tolerance, and disease and insect resistance, but it has significantly higher yield and better bread-baking characteristics than TAM 110. A recent study on the physiological basis for drought tolerance in wheat indicates that TAM 112 and TAM 111, the predominant cultivars in the Texas High Plains, have higher yield due to increased biomass production and higher water-use efficiency than TAM 110 and ‘TAM 105’ (Porter et al., 1980), the most popular cultivars until 2005 (Xue et al., 2014). With increasing popularity in recent years, TAM 112 has provided a good option to producers in the region for a cultivar with resistance to greenbug and wheat curl mite, improved end-use quality, and excellent grain and forage yield, particularly under dryland production system in the High Plains of Texas and similar areas in the southern Great Plains.

Methods

Early Generation Population Development

The cross between U1254-7-9-2-1 and TXGH10440 was made at Vernon, TX, in 1992. The F_1 generation was grown in the greenhouse at Vernon in 1993 (year of harvest). The F_2, F_3, and F_4 generations were grown and harvested in bulk during 1994, 1995, and 1996, respectively, at the Texas A&M AgriLife Research Farm in Chillicothe, TX. Random spikes, harvested from the F_4 population in 1996, were grown as $F_{4:5}$ head rows of approximately 1 m in length at Chillicothe in 1997. Both among- and within-population selection was practiced mainly on the basis of disease resistance and visual agronomic characteristics such as uniformity, heading, plant height, straw strength, and plant type. Approximately 5% of the head rows were selected, including the one that was assigned the experimental number TX98V9628.

Evaluation and Selection of Advanced Lines

TX98V9628 was tested consecutively in various observation nurseries and preliminary yield trials from 1998 to 2000; the uniform advanced trial in 2001; the Texas Elite trial in 2002 and 2003; the Southern Regional Performance Nursery (SRPN) in 2002 and 2003; the Texas Uniform Variety Trial (UVT) from 2004 to present; and the Wheat Quality Council Trial in 2006. Lines were advanced based on agronomic traits (mainly maturity, height, and straw strength), reaction to disease and insect (particularly to leaf rust caused by *Puccinia triticina* Eriks., stripe rust caused by *P. striformis* Westend., and greenbug), grain and forage yield, grain volume weight, and end-use quality. As appropriate, additional data on disease and insect resistance from 2002 and 2003 SRPN (USDA–ARS, 2014a) were also considered for selection. Adult plant (field) reactions to leaf and stem rust were scored using the standard scale of either 0 to 9 or a combination of severity and infection types. Seedling reactions were scored using a scale of 0 to 4. In addition, analysis with the single-kernel characterization system (SKCS) and/or small-scale milling and bread-baking evaluations were performed according to approved methods of the American Association of Cereal Chemists (AACC, 2000) in the cereal quality laboratory at College Station, TX, and the USDA–ARS Hard Winter Wheat Quality Laboratory at Manhattan, KS.

TAM 112 was last evaluated as an experimental line in 2004 and as a check since 2005 in the statewide UVT (randomized complete block design, 40 entries, three replications). Starting in 2008, it has become an increasingly popular cultivar under the dryland production system in the Texas High Plains and similar areas in the southern Great Plains, and, as appropriate, we present here the yield and ancillary data, in most cases, from 2008 to 2011. During the evaluation and selection process, different sets of checks were used for comparison based on the known reaction to the traits and environments being evaluated. Among the TAM-series cultivars released by Texas A&M AgriLife Research, ‘TAM W-101’ (Porter, 1974) is the standard long-term check, TAM 110 is a popular cultivar resistant to greenbug Biotype E, TAM 111 is currently the number-one cultivar in the state of Texas, and ‘TAM 113’ (Rudd et al., 2013) is the most recent release targeting the Great Plains. ‘Kharkof’ (PI 5641), ‘Scout 66’ (CItr 13996), and ‘TAM 107’ (Porter et al., 1987) are the long-term standard checks used in the USDA–ARS coordinated SRPN.

Seed Purification and Increase

Seed purification and increase started in fall 2003 by planting 150 $F_{4:11}$ head rows in Yuma, AZ. Following visual evaluation for uniformity, 15 were eliminated and the remaining 135 were harvested individually. Samples of 10 seeds from each of these 135 lines were planted in the greenhouse and evaluated for resistance to greenbug biotype E following the procedures previously described by Weng and Lazar (2002). Two of the 135 lines tested showed susceptibility to greenbug and were discarded. The remaining 133 lines were uniformly resistant to greenbug and hence the remnant seed of those 133 lines were blended together. This bulk seed was used by Texas Foundation Seed Service to plant 1.2 ha in fall 2004 to produce breeder seed, which was further planted in fall 2005 to produce foundation seed.

Statistical Analysis

Statistical analyses were performed with SAS version 9.3 (SAS Institute, 2011). Analysis of variance for individual locations and combined analyses across locations and years were performed using a mixed model that had genotypes and environments as fixed and replications within environments as random factors. Assumptions for ANOVA over environments were checked and met. Values for LSDs at $P = 0.05$ were used to compare means among entries.

Characteristics

Agronomic and Botanical Description

Based on 7 location-years from 2008 to 2011, the average heading date (day of year) of TAM 112 (120.3 d) was earlier than all the three checks (Table 1). During the same period over 18 location-years, the average height of TAM 112 (65.2 cm) was taller than that of TAM W-101 (61.5 cm) and similar to that of TAM 111 (66.3 cm) and TAM 113 (64.5 cm). The straw strength of TAM 112 is generally less than TAM 113, TAM 111, TAM 110, and TAM 107, particularly under a high input irrigated production system. Winter survival notes obtained from the SRPN cooperators in the northern states of South Dakota, Iowa, and Nebraska indicate that the winter hardiness of TAM 112 is similar to TAM 107. This would be adequate for the southern Great Plains as there has been no winter-kill report on TAM 112 from any locations in Texas throughout selection and testing history.

TAM 112 is semierect during the juvenile plant growth stage and is blue-green at the boot stage. It has anthocyanin pigment in the coleoptile but that is not visible in the stem. The anthers are purple. TAM 112 has waxy flag leaves that are erect and twisted at boot stage. It has hollow stem internodes and erect peduncles. It has a tapering, middense (laxidense), and inclined spike with red glumes at maturity. The glumes are medium in length and width. It has an elevated shoulder of medium width and an acuminate beak. TAM 112 is awned and has hard, red kernels of ovate shape with a medium-size germ, rounded cheeks, and noncollared short brush.

Plant uniformity of TAM 112 was stable during several generations of seed purification and increase. A variant, 10 cm taller with the same glume color, was observed at a low frequency (<0.05%) and was removed during the initial stages of seed increase. This variant may occur in future generations of seed increase at a low percentage (<0.05%).

Disease and Insect Resistance

Based on natural field infection during various stages of testing over the years (2007–2011) across a wide range of environments, TAM 112 is susceptible to stripe rust and leaf rust (Table 2). It was susceptible to stripe rust at the time of release in 2005 and has stayed the same since then. Based on its pedigree and gene postulation by the USDA–ARS Cereal Disease Laboratory (USDA–ARS, 2014b), TAM 112 carries the leaf rust resistance gene *Lr41*, inherited from the *Aegilops tauschii* line TA2460. This gene was effective until 2003, and TAM 112 showed good level of resistance with scores ranging from 20R–MR to 20S (where R = resistant, MR = moderately resistant, and S = susceptible) or with a rating of 1 in a scale of 0 to 9 (0 = immune or no sign of infection, 1 = resistant, 9 = susceptible) (Table 3). However, beginning in 2003 and increasing in prevalence in 2004, leaf rust races virulent to *Lr41* have become dominant across Texas. Since then, TAM 112 has been susceptible to leaf rust scoring as high as 100S in 2010 and 2011 at Castroville, TX (Table 2). When TAM 112

Table 1. Summary of grain yield and agronomic performance of TAM 112 hard red winter wheat and other check cultivars averaged over location-years from 2008 to 2011 within Texas High Plains.

Cultivar	Grain yield		Grain volume weight	Heading date	Plant height
	HPI†	HPD‡			
	kg ha^{-1}		kg m^{-3}	day of year	cm
TAM 112	4251	2121	764	120.3	65.2
TAM W-101	3539	1778	752	121.9	61.5
TAM 111	4374	2008	761	124.3	66.3
TAM 113	4032	2082	763	124.8	64.5
Mean	4048	1997	760	122.8	64.4
LSD (0.05)	144	84	5	0.8	1.2
Location-years	11	17	23	7	18

† HPI, High Plains irrigated.

‡ HPD, High Plains dryland.

Table 2. Resistance to leaf and stripe rust of TAM 112 hard red winter wheat and other check cultivars evaluated from 2007 to 2011 at various locations in Texas.†

Cultivar	Leaf rust							Stripe rust			
	2007		2008		2009	2010	2011	2007	2009	2010	
	Bus	Cas	Cas	Mc†	Cas	Cas	Cas	Bus	RvilleKS‡	Cas	CS
TAM 112	tS§	tMS	40S	tR	30–80S	100S	100S	80S	90MS	70S	60S
TAM W-101	20S	20MS	40S	10MR	30S	40SMS	30MS	70S	95S	20MS¶	50S
TAM 111	40S	30MS	40S	15MR	40S	100S	90S	tR	2R	tR	R
TAM 113	tS	tR	20MS	tR	5R	10R	tR	10MR	15R	tR	tR

† Locations in Texas: Bus, Bushland; Cas, Castroville; McG, McGregor; CS, College Station.

‡ Inoculated field nursery at Rossville, KS.

§ Field scores: severity in percentage of flag-leaf area infected (t, trace) and reaction (infection type) in the field at soft dough stage. S, susceptible; MS, moderately susceptible; MR, moderately resistant; R, resistant.

¶ TAM W-101 was particularly late maturing in this trial, and the stripe rust had not fully developed at the time readings were taken.

was included in the SRPN in 2002 and 2003, it was evaluated for various diseases and insects under the cooperative USDA regional testing program (USDA–ARS, 2014a). Based on the seedling leaf rust evaluation conducted by the USDA–ARS Cereal Disease Laboratory, St. Paul, MN, following the procedures described previously by Kolmer (2003), TAM 112 showed resistance to leaf rust races KFBJ, THBJ, and MCDS (Table 3).

Based on the 2002 and 2003 SRPN data on seedling stem rust evaluation at the Cereal Disease Laboratory, TAM 112 is resistant or moderately resistant to the most prevalent races of stem rust. In seedling tests with multiple stem rust races following the procedures described by Jin et al. (2007), TAM 112, with postulated gene *Sr24* and T1AL.1RS, showed resistance (infection types ranging from 1 to 2= on a 0–4 scale, where 0 = immune or no sign of infection, 1 = resistant, 4 = susceptible) to all the races of U.S. origin (Table 4). T1AL.1RS has been associated with resistance to powdery mildew, leaf rust, stem rust, and greenbug biotype C (Delwiche et al., 1999). TAM 112 was recently documented to have tolerance to *Wheat streak mosaic virus* and resistance to wheat curl mite (Price et al., 2014).

Studies performed with seedling inoculations in the past indicated that TAM 112 is resistant to the three most prevalent greenbug biotypes, E, I, and K (data not presented). Based on its pedigree and reaction to greenbug, TAM 112, like TAM 110, has the greenbug resistance genes *Gb2*, inherited from the wheat germplasm line Amigo, and *Gb3*, inherited from the synthetic hexaploid wheat line Largo. Severe natural infestations of greenbug occurred in the wheat trial plots at Etter, TX, in 2002. TAM 112 along with TAM 110 and other experimental lines and cultivars thought to carry the gene *Gb3* were the only ones that survived the severe damage from greenbug at this location (Fig. 1).

Table 3. Seedling and adult plant leaf rust scores of TAM 112 hard red winter wheat and other check cultivars evaluated in the 2002 and 2003 Southern Regional Performance Nursery at the USDA–ARS Cereal Disease Laboratory, St. Paul, MN,† Brookings, SD, Stillwater, OK, and Castroville, TX.

Cultivar	Seedling reaction to leaf rust isolates‡						Adult plant resistance (field)§				
	2003					2002	2003		2002		
	THBJ	MCDS	TNRJ	KFBJ	Stillwater, OK	Stillwater, OK	St. Paul, MN	Brookings, SD	St. Paul, MN	Stillwater, OK	Castroville, TX
TAM 112	;	;1-	3+	0;	R	R	20S	MS	20R-MR	1	tMS
Kharkof	33+	3+	3+	3	S	S	30MS	S	60S	3	80S
Scout 66	33+	3+	3+	2+/3+	S	S	20MS	S	80S	6	80MR-MS
TAM 107	33+	;2	3+	;0	S	S	20–30MS	S	60S	9	100S

† Complete dataset can be found at USDA–ARS (2014a).

‡ Seedling infection types: 0 = immune response, no sign of infection; 1 or R = resistant with small uredinia surrounded by necrosis; 2 = small uredinia surrounded by chlorosis; 3 = moderate size uredinia without necrosis or chlorosis; 4 or S = susceptible with large uredinia without necrosis or chlorosis; + = uredinia larger than normal; – = uredinia smaller than normal; ; = hypersensitive chlorotic or necrotic flecks; / = heterogeneous, the predominant type listed first. At Stillwater OK, seedling leaf rust reaction (R = resistant; S = susceptible) was determined using a bulk mixture of *Puccinia triticina* spores collected from Oklahoma and Texas.

§ Adult plant resistance scores: severity in percentage of flag-leaf area infected (t, trace) and reaction (infection type) at soft dough stage; S = susceptible; MS = moderately susceptible; MR = moderately resistant; R = resistant. Scale of 0–9 at Stillwater OK: 0 = immune, no sign of infection; 1 = resistant; 9 = susceptible.

Table 4. Seedling and adult plant stem rust scores of TAM 112 hard red winter wheat and other check cultivars evaluated in 2002 and 2003 Southern Regional Performance Nursery at the USDA–ARS Cereal Disease Laboratory, St. Paul, MN.†

Cultivar	Seedling reaction to stem rust isolates‡						APR (field)§	Postulated genes/1RS¶
	2002							
	TTTT	TPMK	RTQQ	QTHJ	RRTS	PTHS	St. Paul MN	
TAM 112	2=	2=	2=	2=	1	2=	5R	*Sr24*/1AL.1RS
Kharkof	S	S	S	S	0?	S	60S	?
Scout 66	S	S	;	2	S	S	tMR	*Sr17*
TAM 107	2=	0	1	2 =	2=	1	60S	*Sr6*,*Sr17*,*Sr24*/1AL.1RS
	2003							
	TTTT	TPMK	RTQQ	QTHJ			St. Paul MN	
TAM 112	1+	1+	1+	1+			20MR	1AL.1RS
Kharkof	4	4	4	23+			30MRMS	
Scout 66	33+	3+	3+	2+3+			10MRMS	
TAM 107	2	1	1	22-			30MR	1AL.1RS

† Complete dataset can be found at USDA–ARS (2014a).

‡ Seedling infection types: 0 = immune response, no sign of infection; 1 = small uredinia surrounded by necrosis; 2 = small uredinia surrounded by chlorosis; 3 = moderate size uredinia without necrosis or chlorosis; 4 = large uredinia without necrosis or chlorosis; + = uredinia larger than normal; – = uredinia smaller than normal with visible sporulation and = with no visible sporulation; ; = hypersensitive chlorotic or necrotic flecks; / = heterogeneous, the predominant type listed first.

§ APR, adult plant resistance. Field scores: severity in percent of flag-leaf area infected (t, trace) and reaction (infection type) at soft dough stage; S = susceptible; MS = moderately susceptible; MR = moderately resistant; R = resistant. Scale of 1–9 at Stillwater OK: 1 = resistant and 9 = susceptible.

¶ ? = unable to make gene postulation.

Additional data on disease and insect resistance from 2002 and 2003 SRPN indicated that TAM 112 is highly resistant to powdery mildew, tolerant to *Wheat streak mosaic virus*, and moderately resistant to *Barley yellow dwarf virus* but susceptible to *Wheat soilborne mosaic virus* and Hessian fly [*Mayetiola destructor* (Say)] Great Plains biotype.

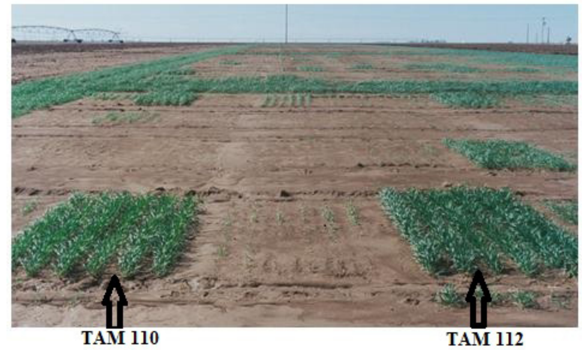

Fig. 1. Field resistance of hard red winter wheat cultivars TAM 112 and TAM 110 to greenbug under natural infestation in the replicated yield trial at Etter, TX, 2002.

Grain Yield

Based on 17 location-years on High Plains dryland environments in Texas from 2008 to 2011, grain yield of TAM 112 (2121 kg ha^{-1}) was similar to that of TAM 113 (2082 kg ha^{-1}) and significantly higher than that of TAM 111 (2008 kg ha^{-1}) and TAM W-101 (1778 kg ha^{-1}) (Table 1). During the same period over 11 location-years on High Plains irrigated environments, grain yield of TAM 112 (4251 kg ha^{-1}) was similar to that of TAM 111 (4374 kg ha^{-1}) and significantly higher than that of TAM W-101 (3539 kg ha^{-1}) and TAM 113 (4032 kg ha^{-1}). In a recently published study on genetic gain in Great Plains comparing yield of 30 wheat cultivars across 22 location-years, TAM 112 was in the highest-yielding group and in the highest yield stability group (Battenfield et al., 2013). TAM 111 and TAM 112 are currently the most widely grown cultivars in the Texas High Plains and have been nearly always among the top 10 highest-yielding entries every year in the UVT. During the same 4 yr, from 2008 to 2011, TAM 112 was also tested at various locations in other regions of Texas (see Texas Wheat Regions Map [Texas A&M University, 2010, p. 7])). The performance of TAM 112 with respect to grain yield was average to below average in the Rolling Plains, Blacklands, and South Texas locations (UVT data available at Texas A&M University, 2014).

Forage Yield

The 2004 to 2009 yield trials at Claude, TX, were grazed until late February; the grain yield data from UVT at that location (data not shown) indicated that TAM 112 withstands grazing as well as currently grown cultivars. Compared with TAM 110, the then most popular cultivar in Texas High Plains, TAM 112 had similar yields in 2005, 2006, 2007, and 2008 but significantly higher yields in 2004. Compared with TAM 111, TAM 112 had similar grain yields after grazing in 2004, 2006, 2007, and 2009; significantly higher yield in 2008; and significantly lower yield in 2005. Additionally, forage trials conducted at Overton, TX, in 2003 and 2004 indicated that TAM 112 had similar forage yield to that of 'Lockett' (PI 604245), the awnletted wheat released in 1998 by Texas A&M AgriLife Research mainly for forage. The fall and winter forage production (clippings through February) of TAM 112 was particularly good in both years, yielding in the top-performing group for most of the clipping dates (data not shown). The aforesaid data indicate that TAM 112, like 'TAM 401' (Rudd et al., 2012) and TAM 113, can be used in a dual-purpose (grazing plus grain) system.

End-Use Quality Evaluation

Based on 23 location-years, the average grain volume weight of TAM 112 (764 kg m^{-3}) was significantly higher than that of TAM W-101 (752 kg m^{-3}) and similar to that of TAM 111 (761 kg m^{-3}) and TAM 113 (763 kg m^{-3}) (Table 1). The average kernel weight and kernel size of TAM 112, as determined by SKCS analysis in the cereal quality laboratory at College Station over 10 location-years, were similar to that of TAM 111 and TAM 113 but significantly lower than that of TAM W-101 (Table 5). Based on 15 location-years, the flour protein content (14% moisture basis) of TAM 112 was also similar to that of TAM 111 and TAM 113 but significantly lower than that of TAM W-101 (Table 5). The single-kernel hardness index score of TAM 112 was 74.2 (kernels with a score of >50 are categorized as "hard"), which was similar to that of the checks. Mixograph and bread-baking evaluation conducted by the USDA–ARS Hard Winter Wheat Quality Laboratory at

Table 5. Grain characteristics of TAM 112 hard red winter wheat and other check cultivars evaluated by the cereal quality laboratory at College Station, TX, averaged over location-years, 2008 to 2011.

Cultivar	SKCS† kernel weight	SKCS kernel size	SKCS kernel hardness	Flour protein‡
	mg	mm	1–100§	g kg^{-1}
TAM 112	28.0	2.53	74.2	140.1
TAM W-101	31.6	2.65	66.9	148.7
TAM 111	28.0	2.51	67.9	140.0
TAM 113	27.3	2.50	67.5	138.0
Mean	28.7	2.54	69.1	141.6
LSD (0.05)	0.9	0.04	ns¶	3.1
Location-years	10	10	10	15

† Single-kernel characterization system.

‡ 14% moisture basis.

§ Scores greater than 50 indicate hard kernels.

¶ ns, not significant.

Table 6. Milling and baking characteristics of TAM 112 hard red winter wheat and other check cultivars evaluated by USDA–ARS Hard Winter Wheat Quality Laboratory, Manhattan, KS,† across 6 location-years from 2003 to 2007 in Texas High Plains.

Cultivar	Chemical				Mixograph			Bake		
	Wheat		Flour							
	Protein‡	Milling yield	Ash‡	Protein‡	Water absorption	Peak time	Tolerance	Water absorption	Mix time	Loaf volume
	%				%	min	0–6§	%	min	cm^3
TAM 112	14.2	68.7	0.42	12.6	64.7	4.3	4.0	64.6	5.3	983
TAM 110	13.0	69.8	0.40	11.6	62.8	2.8	2.3	61.6	3.7	920
TAM 111	13.5	69.8	0.39	12.0	63.5	2.9	2.3	62.3	3.6	873
Mean	14.1	69.5	0.42	12.6	64.5	3.5	2.1	63.2	4.2	927
LSD (0.05)	0.7	ns	ns	0.7	1.4	0.6	1.1	1.2	0.9	51

† Complete evaluation protocols can be found on p. 4–7 at Chen and Seabourn (2010).

‡ 14% moisture basis.

§ Resistance of dough to overmixing. Score: 0 = unsatisfactory; 6 = outstanding.

Table 7. Comparison of cooperater-evaluated bread-baking characteristics of TAM 112 hard red winter wheat and TAM 111 as determined by the Wheat Quality Council† from the grain samples harvested at Bushland, TX, in 2006.

Bread-baking traits	Number of observations	TAM 112	TAM 111
Bake mix time‡	13	4.12a§	2.77b
Mixing tolerance¶	12	3.17a	2.63a
Crumb grain¶	13	3.32a	3.18a
Crumb texture#	13	3.83a	3.38a
Crumb color††	13	4.88a	4.08a
Loaf volume¶	13	4.92a	3.38b
Overall baking quality¶	13	4.04a	3.50b

† Data extracted from Wheat Quality Council (2006).

‡ Bake mix time (min) score: 0 = very short; 3 = average; 6 = very long.

§ Values within a row followed by the same letter are not significantly different at the $p = 0.05$ probability level.

¶ Mixing tolerance, crumb grain, loaf volume, and overall baking quality scores: 0 = very poor; 3 = average; 6 = excellent.

Crumb texture score: 0 = very harsh; 3 = smooth; 6 = silky.

†† Crumb color score: 0 = gray; 3 = dull; 6 = bright white.

Manhattan, KS (complete evaluation protocols can be found in Chen and Seabourn, 2010, p. 4–7) on 2003 and 2004 Texas Wheat Variety Trials from Bushland irrigated location indicated that TAM 112 had significantly stronger mixing and baking strength compared with TAM 111 and TAM 110 as measured by longer mix times, higher stability, and larger loaf volumes (Table 6). Bread-baking characteristics evaluation conducted by the Wheat Quality Council in 2006 indicated that TAM 112 had significantly longer bake mix time and larger loaf volume but similar crumb texture, crumb grain, and crumb color scores to that of TAM 111 (Table 7). The overall baking quality score of TAM 112 (4.04) was significantly higher than that of TAM 111 (3.50) on a scale of 0 to 6, where 0 = very poor, 3 = average, and 6 = excellent (Table 7).

Availability

Proposed seed classes include breeder, foundation, registered, and certified seed. TAM 112 was submitted for U.S. Plant Variety Protection (PVP) under Public Law 91-577 with the Certification Only option and a PVP certificate has been issued (Certificate No. 200600274). Small quantity of seed for research purpose may be obtained from the corresponding author for at least 5 years from the date of this publication abiding by the Wheat Workers' Code of Ethics (Annual Wheat Newsletter, 1995).

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