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CULTIVAR

Registration of 'TAM 113' Wheat

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ABSTRACT

'TAM 113' (Reg. No. CV-1081, PI 666125), a hard red winter wheat (*Triticum aestivum* L.) cultivar with experimental designation TX02A0252, was developed and released by Texas AgriLife Research in 2010. TAM 113 is an F_5–derived line from the cross TX90V6313/TX94V3724 made at Vernon, TX in 1995. Both TX90V6313 and TX94V3724 are Texas experimental lines derived from the crosses TAM 200"S"/TX78A3345-V34 and U1254-1-8-1-1/'TAM 202' (PI 561933), respectively. TAM 113 is an awned, medium maturing, semidwarf wheat with white glumes. It was released primarily for its excellent grain-yield potential in both irrigated and dryland environments of the Texas High Plains; for its resistance to leaf rust (caused by *Puccinia triticina* Eriks.), stripe rust (caused by *P. striiformis* Westend.), and stem rust (caused by *P. graminis* Pers.:Pers f. sp. *tritici* Eriks. & E. Henn.); and for its good milling and exceptional bread-baking characteristics. TAM 113 has a similar area of adaptation and grain-yield potential as 'TAM 111' (PI 631352) and 'TAM 112' (PI 643143). However, compared with TAM 111, it has better leaf rust resistance and better bread-baking qualities, and compared with TAM 112, it has better resistance to leaf and stripe rusts. TAM 113, with better milling and baking characteristics and resistance to leaf, stripe, and stem rusts, will provide a good complement to other hard red winter wheat cultivars for wheat producers in the southern Great Plains.

'TAM 113' (Reg. No. CV-1081, PI 666125), a hard red winter wheat (*Triticum aestivum* L.) cultivar with the experimental designation TX02A0252, was developed and released by Texas AgriLife Research in 2010. TAM 113 is an awned, medium-maturing, semidwarf wheat with white glumes. It has been extensively tested throughout the Great Plains, including the major wheat-growing areas of Texas, but is best adapted to the High Plains of Texas and similar areas in adjacent states. It is resistant to the prevalent races of leaf rust (caused by *Puccinia triticina* Eriks.), stripe rust (caused by *P. striiformis* Westend), and stem rust (caused by *P. graminis* Pers.: Pers f. sp. *tritici* Eriks. & E. Henn.). It has good milling and exceptional bread-baking characteristics. TAM 113 has a similar area of adaptation and grain-yield potential as 'TAM 111' (PI 631352; Lazar et al., 2004) and 'TAM 112' (PI 643143). In comparison with TAM 111, it has better bread-baking qualities and better leaf rust resistance. In comparison with TAM 112, it has better leaf and stripe rust resistance.

TAM 113 is an F_5–derived line from the cross TX90V6313/TX94V3724. The pedigree of TX90V6313 is TAM 200"S"/TX78A3345-V34. TAM 200"S" is an unreleased sib-selection of the cultivar 'TAM 200' (PI 578255; Worrall et al., 1995b). TX78A3345-V34 was selected from the cross MV61-06/TAM 105"S". The pedigree of MV61-06 could not be traced back further. TAM 105"S" is an unreleased sib-selection of cultivar 'TAM 105' (CItr 17826; Porter et al., 1980). The pedigree of TX94V3724 is U1254-1-8-1-1/'TAM 202' (PI 561933; Worrall et al., 1995a). U1254-1-8-1-1, developed from the cross TAM 200*4/TA2460, is a USDA-ARS germplasm line from the Plant Science and Entomology Research unit, Manhattan, KS. TA2460 is an *Aegilops tauschii* line with the leaf rust resistance gene *Lr41*.

Based on its excellent performance in High Plains areas from 2007 to 2011, the proposed primary area of adaptation for TAM 113 will be the High Plains of Texas and similar

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Abbreviations: SKCS, single-kernel characterization system; SRPN, Southern Regional Performance Nursery; UVT, Uniform Variety Trial; WQC, Wheat Quality Council.

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areas in the neighboring states. It will provide an option to producers in the region for a cultivar with better end-use quality and resistance to leaf, stripe, and stem rusts.

Methods

Early-Generation Population Development

The cross between the two Texas experimental lines TX90V6313 and TX94V3724 was made at Vernon, TX in 1995. The F_1 generation was grown in the greenhouse at Vernon in 1996 (year of harvest), and the F_2 generation was grown as a bulk population at Texas AgriLife Research Farm in Chillicothe, TX in 1997. The F_3, F_4, and F_5 generations were grown and harvested in bulk during 1998, 1999, and 2000, respectively, at the Texas AgriLife Research Farm in Bushland, TX. Random spikes, harvested from the F_5 population in 2000, were grown as $F_{5:6}$ headrows of approximately 1 m in length at Bushland during 2001. Both among- and within-population selection was practiced mainly based on disease resistance and visual agronomic characteristics such as uniformity, heading, plant height, straw strength, and plant type. Approximately 5% of the headrows were selected, including the one that was assigned the experimental number TX02A0252.

Evaluation and Selection of Advanced Lines

TX02A0252 was tested consecutively in the Amarillo Observation Nursery in 2002 (866 entries, 2 locations); the Amarillo Preliminary Yield Trial in 2003 (240 entries, 4 locations); the Amarillo Advanced Yield Trial in 2004 (80 entries, 6 locations); the Uniform Advanced Trial in 2005 (40 entries, 10 locations); the Texas Elite Trial in 2006 (40 entries, 18 locations) and 2007 (40 entries, 18 locations); the Southern Regional Performance Nursery (SRPN) in 2007 (50 entries, 27 locations) and 2008 (50 entries, 31 locations); the Texas Uniform Variety Trial (UVT) in 2008 (40 entries, 29 locations), 2009 (40 entries, 30 locations), 2010 (40 entries, 34 locations), and 2011 (40 entries, 37 locations); and the Wheat Quality Council (WQC) Trial in 2009. Lines were advanced based on agronomic traits, disease resistance (particularly to leaf rust and stripe rust), grain yield, grain volume weight, and end-use quality. As appropriate, additional data on disease and insect resistance from 2007 and 2008 SRPN (http://www.ars.usda.gov/Research/docs.htm?docid=11932; accessed 14 Nov. 2011) were also considered for selection. In addition, analysis with the single-kernel characterization system (SKCS) and 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 lab at College Station, TX and the USDA-ARS Hard Winter Wheat Quality Lab at Manhattan, KS.

During the evaluation and selection process, different sets of checks were used for comparison based on the known traits and response to the environments being evaluated. Among the TAM-series cultivars released by Texas AgriLife Research, 'TAM W-101' (CItr 15324; Porter, 1974) is the standard long-term check, 'TAM 110' (PI 595757; Lazar et al., 1997) is a popular cultivar resistant to greenbug [*Schizaphis graminum* (Rondani)] Biotype E, TAM 111 is currently the most widely grown cultivar in the state of Texas, and TAM 112, also resistant to greenbug Biotype E, is the second most widely grown cultivar in the state. 'Kharkof' (PI 5641), 'Scout 66' (CItr 13996), and 'TAM 107' (PI 49559; 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 the fall of 2006 by planting 48 $F_{5:12}$ headrows in Yuma, AZ. Following visual evaluation for uniformity, 4 were eliminated, and the remaining 44 rows were harvested in bulk. This seed was used by Texas Foundation Seed Service to plant 0.4 ha in the fall of 2007 to produce breeder seed, which was further planted on 4 ha in the fall of 2008 to produce foundation seed. A late spring freeze in the Rolling Plains devastated the majority of the 2008–2009 wheat crops, including the TAM 113 increase, so remnant seed from the 2007 planting was used again to plant 0.4 ha in Yuma in the fall of 2009. This seed was planted again by Texas Foundation Seed Service in the fall of 2010 to produce foundation seed.

Statistical Analysis

Statistical analyses were done with SAS version 9.1 (SAS Institute, Cary, NC). Analysis of variance for individual locations as well as combined analyses across locations and years were performed using a mixed model that had genotypes and environments as fixed factors 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 (d from 1 January) of TAM 113 (124.8 d) was similar to TAM 111 (124.3 d) but later than TAM W-101 (121.9 d) and TAM 112 (120.3 d) (Table 1). During the same period over 18 location-years, TAM 113 (64.5 cm) was similar

Table 1. Summary of grain yield and agronomic performance of TAM 113 hard red winter wheat and other check cultivars averaged across location-years from 2008 to 2011 within the Texas High Plains.

Cultivar	Grain yield		Grain volume weight	Heading date	Plant height
	HPI†	HPD‡			
	—— kg ha^{-1} ——		kg m^{-3}	d after 1 Jan.	cm
TAM 113	4032	2082	763	124.8	64.5
TAM W-101	3539	1778	752	121.9	61.5
TAM 111	4374	2008	761	124.3	66.3
TAM 112	4251	2121	764	120.3	65.2
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.

in height to TAM 112 (65.2 cm), taller than TAM W-101 (61.5 cm), and shorter than TAM 111 (66.3 cm). Anecdotal observations indicate that TAM 113 has a straw strength similar to that of TAM 111 and stronger than that of TAM 112. Significant lodging and shattering occurred on some cultivars at three of the High Plains irrigated location-years, but almost none were observed on TAM 113, TAM 111, and TAM 112. An estimate of winter hardiness is generally obtained from northern state participants in the SRPN, but no differential winter-kill was reported in either 2007 or 2008. There was also no winter-kill report on TAM 113 from any locations in Texas during 4 yr of testing (2008–11).

TAM 113 is semierect during the juvenile plant growth stage and is green at the boot stage. It lacks anthocyanin in both the coleoptile and stem. The anthers are yellow. TAM 113 has a waxy bloom with hollow stem internodes, erect and twisted flag leaves, and erect peduncles. It has an oblong, middense (laxidense), and inclined spike with white glumes at maturity. The glumes are medium in length and width with an oblique shoulder and an acuminate beak of medium width. TAM 113 is awned and has hard, red kernels of oval shape with a medium-size germ, rounded cheeks, and noncollared medium brush.

The plant uniformity of TAM 113 was stable during the last five generations of seed purification and increase (small increase strips at Bushland in 2007 [year of harvest]; seed purification at Yuma, AZ in 2008; breeder seed increase at Vernon, TX in 2009 or again at Yuma in 2010; and foundation seed multiplication at Vernon in 2011). Variants, which were 10 to 15 cm taller with white or red glume color, were observed at a low frequency (<0.01%) and were removed during the initial stages of seed increase. These variants may occur in future generations of seed increase at a similarly low percentage (<0.01%).

Disease and Insect Resistance

Based on natural field infection during various stages of testing over the years (2007 to 2011) across a wide range of environments, TAM 113 has been consistently resistant to leaf and stripe rust (Table 2). The severity of leaf rust for TAM 113 ranged from a trace (t) to 20% with almost all resistant or moderately resistant reaction types in contrast to a severity of 100% with susceptible reaction types for TAM 111 and TAM 112. When TAM 113 was included in the SRPN in 2007 and 2008, it was evaluated for various diseases and insects under the USDA regional testing program. 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 113 showed resistance (infection types ranging from 0; to ; on a scale of 0–4, where 0 = immune, ; = hypersensitive chlorotic or necrotic flecks, and 4 = susceptible) to the most prevalent races of leaf rust—MLDSB, THBJ, MHDS, and TGBG—and was postulated to have the gene *Lr24* for leaf rust resistance. Since it has shown good adult-plant resistance at various locations throughout Texas, where *Lr24* virulence is known to occur, it must possess additional seedling or adult-plant resistance genes, or both (SRPN molecular marker data indicated *Lr34* might be present; data not shown). TAM 113 showed resistance to the prevalent races of stripe rust during the natural epidemics in 2007 and 2010 (Table 2). Tests have shown that the natural epidemics in 2010, observed particularly at College Station and Castroville, TX, were due to a new race that had not previously been detected in the Great Plains. Many wheat cultivars, such as 'Jagger' (PI 593688; Sears et al., 1997) and 'Jagalene' (PI 631376), that showed resistance in previous years were susceptible to this new race in 2010. Both TAM 113 and TAM 111 showed resistance not only to this new race but also to the prevalent races of 2007 and 2009 (Table 2).

Based on the 2007 and 2008 SRPN data on seedling stem rust evaluation at the Cereal Disease Laboratory, TAM 113 is highly resistant to the most prevalent race, QFCSC, of the stem rust pathogen in Texas and the United States. In seedling tests with multiple stem rust races following the procedures described previously by Jin et al. (2007), TAM 113, with a postulated gene *Sr24*, exhibited resistance (infection types ranging from ;1- to 2 on a scale of 0–4, where 0 = immune, ; = hypersensitive chlorotic or necrotic flecks, and 4 = susceptible) to all the races of U.S. origin as well as to the race TTKSK (Ug99, of Kenyan origin) (Table 3). Moderately high infection types were observed when TAM 113 was tested against race TTKST, a race in the TTKS lineage that is virulent on plants containing *Sr24* (Jin et al., 2008), indicating that *Sr24* is present. TAM 113 also showed an excellent adult-plant resistance (score of 0–5R) in the field stem rust nursery in St. Paul, MN (Table 3), where it

Table 2. Resistance to leaf and stripe rust of TAM 113 hard red winter wheat and other check cultivars evaluated from 2007 to 2011 at various locations in Texas.[†]

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

[†]Locations in Texas: Bus, Bushland; Cas, Castroville; Els, Ellis County; Lul, Lulling; McG, McGregor; CS, College Station. 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; semicolon (;), hypersensiteve chlorotic or necrotic flecks.

[‡]Inoculated field nursery at Rossville, KS.

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

Table 3. Seedling leaf rust and stem rust scores of TAM 113 hard red winter wheat and other check cultivars evaluated in 2007 and 2008 Southern Regional Performance Nursery at the USDA-ARS Cereal Disease Laboratory, St. Paul, MN.[†]

Cultivar	Seedling reaction to leaf rust races									Postulated genes[‡]
	2007									
	MLDSB	THBJ	MJBJ	KFBJ	MHDS	MFPSC	TNRJ	TGBG	MCRK	
TAM 113	;	;	3+	33+	0;	3+	3+	;	0;	*Lr24*
Kharkof	3+	3+	3+	3+	3+	3+	3+	3+	3+	—
Scout 66	3+	3+	3+	3+	;2	3+	3+	;12–	3+	?
TAM 107	3+	3+	3+	3+	3	3+	3+	;/;2/3+	3+	*Lr14a*
	2008									
	MLDS	THBJ	MJBJ	KFBJ	MHDS	MFPS	TDBJ	TDBG		
TAM 113	0;	;	3+	3+	;	3+	3+	x		*Lr24*
Kharkof	3+	3+	3+	3+	3+	3+	3+	3		—
Scout 66	2+3	3	3+	3+	3+	3+	3+	X		*Lr14a*
TAM 107	3+	33+	3+	3+	3+	3+	3+	3+		—

Cultivar	Seedling reaction to stem rust races							APR (field)[§]	Postulated genes[‡]
	2007								
	QFCSC	QTHJC	RCRSC	RKQQC	TPMKC	TTTTF	TTKSK (Ug99)		
TAM 113	2	2/S	;1/2–	2	2	;2	;1+	5R	*Sr24+*
Kharkof	S	S	S	S	S/;	S	S	40S	—
Scout 66	2+	S	S	S	S	S	2+/S	20MR-MS	—
TAM 107	2/2+	2	2/2++	2/;1	2/S	2/S	2	TMR	1A.1R
	2008								
	QFCSC	QTHJC	RCRSC	RKQQC	TPMKC	TTTTF	TTKSK (Ug99)		
TAM 113	;1–	2	2–	2	2	2	;2–	0	*Sr24*
Kharkof	3/2	S	S	S	S	S	S	10MS/50S	—
Scout 66	2+	2	S	S	S	S	S	20MS	—
TAM 107	2–	2	2–	;1/2	2	2	2+/S	10MR-MS	1A.1R

[†]Complete dataset can be found at http://www.ars.usda.gov/Research/docs.htm?docid = 11932 (accessed 14 Nov. 2011). 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; semicolon (;) = hypersensitive chlorotic or necrotic flecks. A range of infection types is indicated by more than one infection type, with the predominant type listed first.

[‡]Postulated genes: ? = unable to make gene postulation; + = has an unidentified resistance gene.

[§]Adult plant resistance (APR) evaluation from inoculated field nursery at St. Paul, MN.

was inoculated with a composite of U.S. stem rust races (QFCSC, QTHJC, RCRSC, RKQQC, and TPMKC) following the adult-plant evaluation procedures described by Rouse et al. (2011).

Additional data on disease and insect resistance from the 2007 and 2008 SRPNs indicated that TAM 113 might have some tolerance to acid soils but that it is susceptible to *Wheat soilborne mosaic virus*, greenbug biotype E, Russian wheat aphid [*Diuraphis noxia* (Mordvilko)] biotype 1, and Hessian fly [*Mayetiola destructor* (Say)] Great Plains biotype. Based on natural field infection over the years, it is also susceptible to powdery mildew (caused by *Blumeria graminis* f. sp. *tritici*). Data on resistance to *Wheat streak mosaic virus* is not available.

Grain Yield

Based on 17 location-years on High Plains dryland environments in Texas from 2008 to 2011, the grain yield of TAM 113 (2082 kg ha^{-1}) was similar to that of TAM 111 (2008 kg ha^{-1}) and TAM 112 (2121 kg ha^{-1}) but was significantly higher than that of TAM W-101 (1778 kg ha^{-1}) (Table 1). During the same period over 11 location-years on High Plains irrigated environments, the grain yield of TAM 113 (4032 kg ha^{-1}) was significantly higher than that of TAM W-101 (3539 kg ha^{-1}) but was significantly lower than that of TAM 111 (4374 kg ha^{-1}) and TAM 112 (4251 kg ha^{-1}). TAM 111 and TAM 112 are currently the two most widely grown cultivars in the Texas High Plains and have been almost always among the top five highest-yielding entries every year in the UVT. During the same 4 yr, from 2008 to 2011, TAM 113 was also tested at various locations in other regions of Texas (Texas Wheat Regions Map available on p. 7 at http://varietytesting.tamu.edu/wheat/docs/2010/Wheat%20Binder.pdf; accessed 14 Nov. 2011). The performance of TAM 113 with respect to grain yield was average in the Rolling Plains and below average in the Blacklands and South Texas locations (UVT data available at http://varietytesting.tamu.edu/wheat/index.htm; accessed 14 Nov. 2011).

Forage Yield

The 2007 yield trials at Claude, TX were grazed until late February, and the grain yield data from Texas Elite trial at that location indicated that TAM 113 withstands grazing as well as currently grown cultivars. The average grain yield of TAM 113 (6148 kg ha^{-1}) was not significantly different than that of TAM 111 (5946 kg ha^{-1}). Additionally, forage trials conducted at five locations across Texas in 2010 indicated that TAM 113 has above-average forage production and regrowth after clipping (data available at http://variety-testing.tamu.edu/wheat/docs/forageTrials/2010/Forage%20Pub.pdf; accessed 14 Nov. 2011), and the dual-purpose wheat trials conducted in Oklahoma indicated good grain yield after grazing (Brett Carver, personal communication, 2010). The data cited above indicates that TAM 113, like 'TAM 401' (PI 658500; Rudd et al., 2012), 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 113 (763 kg m^{-3}) was significantly higher than that of TAM W-101 (752 kg m^{-3}) but was similar to that of TAM 111 (761 kg m^{-3}) and TAM 112 (764 kg m^{-3}) (Table 1). The average kernel weight and kernel size of TAM 113, as determined by SKCS analysis in the cereal quality lab at College Station over 10 location-years, were similar to that of TAM 111 and TAM 112 but significantly lower than that of TAM W-101 (Table 4). Based on 15 location-years, the flour protein content (14% moisture basis) of TAM 113 was also similar to that of TAM 111 and TAM 112 but significantly lower than that of TAM W-101 (Table 4). The single-kernel hardness index score of TAM 113 was 67.5 (kernels with a score of >50 are categorized as "hard"), which was similar to that of the checks. Grain samples (1 kg each) of TAM 113 and other check cultivars harvested from Bushland, TX in 2007–2009 were sent to the USDA-ARS Hard Winter Wheat Quality Lab at Manhattan, KS for mixograph and bread-baking characteristics evaluation (complete evaluation protocols can be found on p. 4–7 at http://www.ars.usda.gov/SP2UserFiles/place/54300510/2010%20RPN.pdf; accessed 14 Nov. 2011). Based on 3 location-years, TAM 113 had a significantly larger loaf volume, longer bake mix time, stronger mixing tolerance, and higher milling yield and ash content than that of TAM 111 (Table 5). In addition, the grain samples (82 kg each) of TAM 113 and TAM 111 (check) harvested from the WQC increase strips at Bushland, TX in 2009 were sent to the WQC for bread-baking characteristics evaluation. Compared with TAM 111, TAM 113 had a significantly longer bake mix time, higher crumb-grain scores, finer crumb texture, improved crumb color scores, and larger loaf volume (Table 6). The overall baking quality score of TAM 113 (4.21) was significantly higher than that of TAM 111 (3.17) on a scale of 0 to 6, where 0 = very poor, 3 = average, and 6 = excellent (Table 6).

Table 4. Grain characteristics of TAM 113 hard red winter wheat and other check cultivars evaluated by the Cereal Quality Laboratory at College Station, TX averaged over location-years from 2008 to 2011.

Cultivar	SKCS†			Flour protein‡
	Weight	Size	Hardness	
	mg	mm	score§	g kg^{-1}
TAM 113	27.3	2.50	67.5	138.0
TAM W-101	31.6	2.65	66.9	148.7
TAM 111	28.0	2.51	67.9	140.0
TAM 112	28.0	2.53	74.2	140.1
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 >50 indicate hard kernels.

Availability

Proposed seed classes will include Breeder, Foundation, Registered, and Certified. TAM 113 has been submitted for U.S. Plant Variety Protection (PVP) under Public Law 91-577 with the Certification Only option. Small quantity of seed for research purpose may be obtained from the corresponding author for at least 5 yr from the date of this publication abiding by the Wheat Workers' Code of Ethics (Annual Wheat Newsletter, 1995). Seed of TAM 113 has been deposited

Table 5. Milling and baking characteristics of TAM 113 hard red winter wheat and other check cultivars evaluated by the USDA-ARS Hard Winter Wheat Quality Laboratory, Manhattan, KS across three location-years from 2007 to 2009 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 113	14.3	70.8	0.45	12.9	63.8	3.7	3.0	63.2	5.3	965
TAM 110	13.9	68.5	0.41	12.8	64.2	3.3	3.0	63.5	4.5	958
TAM 111	14.4	68.8	0.38	13.3	65.3	3.3	2.3	65.3	4.6	887
Mean	14.2	69.4	0.42	13.0	64.4	3.5	2.8	64.0	4.8	937
LSD (0.05)	ns	1.2	0.04	ns	ns	ns	0.5	ns	0.6	22

†Complete evaluation protocols can be found on p. 4–7 at http://www.ars.usda.gov/SP2UserFiles/place/54300510/2010%20RPN.pdf (accessed 14 Nov. 2011).

‡14% moisture basis.

§Resistance of dough to overmixing: 0 = unsatisfactory; 4 = satisfactory; 6 = outstanding.

Table 6. Summary of bread-baking characteristics of TAM 113 hard red winter wheat and TAM 111 (check) as determined by the Wheat Quality Council from the grain samples harvested at Bushland, TX in 2009.†

Bread-baking traits	No. of observations	TAM 113	TAM 111
Bake mix time (min)‡	17	4.41a§	3.68b
Mixing tolerance¶	16	4.28a	3.94a
Crumb grain¶	17	3.99a	3.09b
Crumb texture#	17	4.19a	3.26b
Crumb color††	17	3.88a	2.87b
Loaf volume¶	17	4.50a	2.75b
Overall baking quality¶	17	4.21a	3.17b

†Extracted from the 60th Report on Wheat Quality Hard Winter Wheat Technical Board of the Wheat Quality Council (complete evaluation protocol and the report at http://www.wheatqualitycouncil.org; accessed 14 Nov. 2011).

‡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.

¶0 = very poor; 3 = average; 6 = excellent.

#0 = very harsh; 3 = smooth; 6 = silky.

††0 = gray; 3 = dull; 6 = bright white.

with the National Plant Germplasm System, where it will be available for distribution upon expiration of Plant Variety Protection, 20 yr after the date of publication.

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