

Registration of 'Judee' Wheat

G. R. Carlson, J. E. Berg, K. D. Kephart, D. M. Wichman, P. F. Lamb, J. H. Miller, R. N. Stougaard, J. L. Eckhoff, N. R. Riveland, D. L. Nash, W. E. Grey, Y. Jin, J. A. Kolmer, X. Chen, G. Bai, and P. L. Bruckner*

ABSTRACT

'Judee' (Reg. No. CV-1084, PI 665227) hard red winter (HRW) wheat (*Triticum aestivum* L.) was developed and released by the Montana Agricultural Experiment Station in September 2011. Judee has the pedigree 'Vanguard'/'Norstar'/'Judith' dwarf selection/3/'NuHorizon'. Judee was developed using a modified bulk-breeding method and selected as an F_{5,6} headrow. Judee was tested under the experimental number MTS0713 from 2007 to 2011 in Montana. Quality was evaluated in multilocation Montana trials since 2007. Judee is a solid-stem, high-yielding HRW wheat line with medium to high test weight, medium maturity, reduced height (*Rht-B1b*), medium to high grain protein, and acceptable milling and baking quality. Judee 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.

'Judee' (Reg. No. CV-1084, PI 665227) hard red winter (HRW) wheat (*Triticum aestivum* L.) was developed and released by the Montana Agricultural Experiment Station in 2011. Judee was named in honor of long-term Montana Agricultural Extension agent, entomologist, and research colleague, Judee T. Wargo. Judee was released for its combination

G.R. Carlson and P.F. Lamb, Northern Agricultural Research Center, 3710 Assiniboine Rd., Havre, MT 59501-8412; J.E. Berg, D.L. Nash, W.E. Grey, and P.L. Bruckner, Dep. of Plant Sciences and Plant Pathology, Montana State Univ., Bozeman, MT 59717-3140; K.D. Kephart, Southern Agricultural Research Center, 748 Railroad Hwy., Huntley, MT 59037; D.M. Wichman, Central Agricultural Research Center, 52583 US Hwy 87, Moccasin, MT 59462; J.H. Miller, Western Triangle Agricultural Research Center, 9546 Old Shelby Rd., Conrad, MT 59425; R.N. Stougaard, Northwestern Agricultural Research Center, 4570 Montana 35, Kalispell, MT 59901; J.L. Eckhoff, Eastern Agricultural Research Center, 1501 N. Central, Sidney, MT 59270; N.R. Riveland, Williston Research Extension Center, 14120 Hwy. 2, Williston, ND 58801; Y. Jin and J.A. Kolmer, USDA-ARS, Cereal Disease Lab., 1551 Lindig St., St. Paul, MN 55108-6052; X. Chen, USDA-ARS, P.O. Box 646430, Pullman, WA 99164-6430; and G. Bai, USDA-ARS, Hard Winter Wheat Genetics Research Unit, 4008 Throckmorton Hall, Manhattan, KS 66506. Received 13 July 2012.
*Corresponding author (bruckner@montana.edu).

Abbreviations: HRW, hard red winter; LY, location years; NRPN, Northern Regional Performance Nursery.

Published in the Journal of Plant Registrations.
doi: 10.3198/jpr2012.07.0015crc
Received 13 July 2012. Registration by CSSA.
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5585 Guilford Rd., Madison, WI 53711 USA

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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 because the 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.

Methods

Pedigree and Breeding History

Judee resulted from the single cross 93X312E14/'NuHorizon' made in the year 2000. 93X312E14 is an unreleased solid-stem Montana experimental line with the pedigree 'Vanguard' (PI 593891; Carlson et al., 1997)/'Norstar' (CI 17735; Grant, 1980)/'Judith' (PI 584526; Taylor et al., 1995) dwarf selection. NuHorizon (PI 619198) is a hollow-stem, semi-dwarf, hard white winter cultivar. The F₁ population was grown in the second cycle of the 2000 greenhouse. F₂ seed was grown as a space-planted population (00X14) at Fort Ellis in 2001 under stem rust (caused by *Puccinia graminis* Pers.:Pers. f. sp. *tritici* Eriks. & E. Henn) selection pressure and with selection for stem solidness. The F₃, F₄, and F₅ bulk populations were grown at Fort Ellis, MT; Loma, MT; and Loma in 2002, 2003, and 2004, respectively, using a modified bulk-breeding method, with mass selection for survival, reduced plant height, favorable head morphology, stem solidness, and kernel plumpness. One hundred heads selected from the F₅ population grown at Loma in 2004 were grown as F₆ headrows at Fort Ellis in 2005. Headrow 00X14E59 was selected based on evaluation of stem solidness and visual criteria for uniformity, productivity, and acceptable agronomic

type and harvested in bulk. 00X14E59 was subsequently tested in the 2006 Sawfly Observation Nursery grown at Bozeman, Havre, North Havre, and Fort Ellis, MT.

Line Selection and Evaluation

In 2007, 00X14E59 was designated MTS0713 and tested in the Montana Sawfly Yield Trial at five locations, distinguishing itself for outstanding yield performance. From 2007 through 2011, MTS0713 was evaluated in the Sawfly nursery (total 19 location-years [LY]), from 2008 through 2011, MTS0713 was evaluated in the Montana Intrastate Trial planted at eight locations (total 27 LY, 5 sites lost, Berg et al., 2012) and from 2009 through 2011, MTS0713 was evaluated in the Montana Off-Station Nursery planted at 14 to 16 on-farm locations (total 41 LY). Quality has been evaluated in multilocation Montana trials since 2007. In 2010, MTS0713 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>; accessed 20 Dec. 2011).

The Montana Intrastate Trial consisted of 49 entries 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 ground to top of 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. Coleoptile length was determined under controlled growth-room conditions at Bozeman.

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 and Sawfly Trials from 2007 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 Judee was initiated in 2009, when 105 F₅-derived F₁₀ headrows were grown at Bozeman with selection for stem solidness and visual uniformity and 78 linerows bulked as a source of breeder seed. In 2010, Breeder seed of Judee was increased at Yuma, AZ and the Bozeman Post Farm. Foundation seed of Judee was grown at Bozeman and Havre and allocated to seed growers of Montana in the fall of 2011.

Characteristics

Botanical and Agronomic Characteristics

Judee has winter growth habit and semierect juvenile plant growth. Foliage at boot stage is dark 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 Judee is lax, oblong, and recurved with white glumes at maturity. Kernels are red, intermediate in size, and hard textured.

Judee is an awned, solid-stem, semi-dwarf HRW wheat. Judee has medium maturity, 170.6 d heading from 1 January, which is similar to 'CDC Falcon' (PI 619610) and slightly earlier than the predominant Montana solid-stem cultivars, 'Genou' (PI 640424; Bruckner et al., 2006) and 'Rampart' (PI 593889; Bruckner et al., 1997; Table 1). Judee is semidwarf (*Rht-B1b*) and medium short (81 cm,

Table 1. Mean performance of Judee and check cultivars in 87 Montana environments, 2007–2011.

| Cultivar | Grain yield | Volume weight | Winter survival | Heading date | Plant height | Lodging | Stripe rust | Grain protein | Coleoptile length |
|---------------------|---------------------|--------------------|-----------------|---------------|--------------|---------|-------------|-----------------------|-------------------|
| | kg ha ⁻¹ | kg m ⁻³ | % | d from 1 Jan. | cm | % | % severity | g 100 g ⁻¹ | cm |
| Judee | 4172 | 780 | 32 | 170.6 | 81 | 15 | 5 | 12.5 | 9.4 |
| CDC Falcon | 4125 | 768 | 49 | 170.4 | 77 | 6 | 25 | 12.4 | 7.1 |
| Genou | 3763 | 771 | 31 | 171.3 | 90 | 26 | 29 | 12.6 | 10.4 |
| Rampart | 3655 | 773 | 24 | 171.2 | 89 | 30 | 15 | 13.1 | 10.9 |
| LSD (0.05) | 141 | 4 | 8 | 0.4 | 1 | 14 | 11 | 0.2 | 0.8 |
| No. of environments | 87 | 87 | 4 | 48 | 88 | 8 | 10 | 87 | 2 |

$n = 88$), 4 cm taller than CDC Falcon, and about 10 cm shorter than Genou and Rampart. The coleoptile length of Judee under controlled conditions is 9.4 cm, longer than that of CDC Falcon and slightly shorter than that of Genou. Straw strength of Judee is good. Judee is solid stemmed, averaging 20.1 on the 5 (hollow) to 25 (solid) stem solidness scale, which is significantly more solid than Genou (18.2) but less solid than Rampart (21.4) (Table 2). The winterhardness of Judee is medium to low, which is similar to Genou's (Table 1).

Judee has been genetically uniform and stable across three generations of seed increase. Judee contains tall plant variants at a frequency of less than 5 per 10,000 plants and dark chaff variants at a frequency of less than 2 per 10,000 plants.

Field Performance

In 87 LY of testing in the Montana Winter Wheat Intra-state, Off-Station, and Sawfly Nurseries, the average yield of Judee (4172 kg ha⁻¹) was high, similar to the yield of CDC Falcon, but 11 and 14% higher, respectively, than that of the predominantly grown solid-stem cultivars, Genou and Rampart (Table 1). Although Judee has improved yield potential relative to solid-stem genotypes, Judee is not recommended for environments with low levels of wheat stem sawfly since its yield potential is approximately 10% lower than Montana's predominant hollow-stem cultivar 'Yellowstone' (PI 643428; Bruckner et al., 2007; current data, Berg et al., 2012). The volume weight of Judee (780 kg m⁻³) was medium to high relative to other cultivars. The grain protein content of Judee 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, the grain yield of Judee was 10% and 14% higher than Genou and Rampart, respectively (Table 2). Cutting by wheat stem sawfly of Judee (16%) was intermediate compared with Genou (21%) and Rampart (8%), all of which were significantly lower than the susceptible CDC Falcon.

Disease and Insect Resistance

Judee is resistant to wheat stem sawfly and susceptible to Russian wheat aphid (*Diuraphis noxia* Mordvilko) and Hessian fly [*Mayetiola destructor* (Say)]. Judee is susceptible to stem rust based on field and seedling evaluations conducted at Bozeman, MT using races TLMK and QFCS and seedling stem rust evaluations conducted by the USDA-ARS Cereal Disease Lab from 2008 to 2010. Judee is susceptible to leaf rust (caused by *P. tritricina* Eriks.) based on screening evaluations in the 2010 NRPN. Judee is resistant to stripe rust (caused by *P. striiformis* Westend. f. sp. *tritici* Erik) based on field observations in Montana (Table 1) and screening at Pullman and

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

| Cultivar | Stem solidness | Sawfly-infested environments | |
|---------------------|-------------------|------------------------------|----------------|
| | | Grain yield | Sawfly cutting |
| | 5–25 [†] | kg ha ⁻¹ | % |
| Judee | 20.1 | 3984 | 16 |
| CDC Falcon | 6.8 | 3931 | 35 |
| Genou | 18.2 | 3608 | 21 |
| Rampart | 21.4 | 3494 | 8 |
| LSD (0.05) | 0.7 | 161 | 9 |
| No. of environments | 37 | 13 | 13 |

[†]5 = hollow; 25 = completely solid.

Mount Vernon, WA. Based on DNA marker analysis of the 2010 NRPN, Judee carries diagnostic markers for *Sr2*, *sbm1*, 1RS:1AL, and *Rht-B1b* (data not shown).

End-Use Quality

Based on experimental milling with a Brabender Automat Mill, the flour yield of Judee is intermediate to that of CDC Falcon and Rampart, with relatively low flour ash content and medium flour protein (Table 3). Judee has intermediate dough-mixing characteristics with medium mixing tolerance, water absorption, and mixing time. Judee has excellent loaf volume, similar to Rampart. Judee has relatively high polyphenol oxidase content and average to poor Asian noodle brightness and color stability (data not shown). The 1RS:1AL rye translocation carried by Judee does not appear to affect quality detrimentally.

Availability

The Montana Agricultural Experiment Station will maintain breeder seed of Judee. U.S. Plant Variety Protection for Judee will be sought. A research fee will be assessed on all sales of registered and certified seed. All seed requests should be sent to the corresponding author during the period of 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.

Table 3. Average milling and baking quality attributes of Judee and check cultivars in 25 Montana winter wheat yield trials, 2007–2011.

| Cultivar | SKCS [†] grain hardness | Flour yield | g 100 g ⁻¹ | | Baking mix time | Water absorption | Loaf volume |
|------------|----------------------------------|-------------|-----------------------|-----------|-----------------|------------------|-------------|
| | | | Flour protein | Flour ash | | | |
| CDC Falcon | 66.6 | 65.0 | 10.8 | 0.43 | 10.2 | 71.3 | 1038 |
| Genou | 74.2 | 68.8 | 11.6 | 0.42 | 11.7 | 73.3 | 1068 |
| Judee | 75.8 | 66.9 | 11.2 | 0.41 | 9.1 | 72.0 | 1111 |
| Rampart | 75.5 | 69.6 | 12.2 | 0.42 | 11.1 | 74.4 | 1111 |
| LSD (0.05) | 2.3 | 0.6 | 0.3 | 0.01 | 1.3 | 0.8 | 25 |

[†]Single-kernel characterization system.

Acknowledgments

Judee was developed with financial support of the Montana Agricultural Experiment Station, the Montana Wheat and Barley Committee, and Hatch project MONB00298. The authors wish to acknowledge the technical assistance of Ron Ramsfield, Jackie Kennedy, and Harvey Teslaa.

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