Published online June 20, 2006

Registration of 'Deliver' Wheat

'Deliver' (Reg. No. CV-995, PI 639232) hard red winter wheat (*Triticum aestivum* L.) was released to certified seed growers with permission of the Oklahoma Agricultural Experiment Station (AES) and the USDA-ARS in 2004. Deliver, an apically awnletted cultivar, is well suited for a dual-purpose system, a grain-only system, or a hay-production–graze-out system. This range of adaptation gives producers flexibility in their management options that they currently lack with awned grain-type cultivars or awnletted forage-type cultivars. Its targeted production area extends throughout Oklahoma and the southern Great Plains except in areas limited by soil acidity and aluminum toxicity.

Deliver was selected from the single cross, OK91724/'Karl', in which Karl (Sears et al., 1991) is a hard red winter (HRW) wheat cultivar developed by the Kansas AES and USDA-ARS and released in 1988. OK91724 is a nonreleased breeding line developed by the Oklahoma AES from the cross, 'Yantar'/2*'Chisholm'. Chisholm (Smith et al., 1985) is a HRW cultivar developed by the Oklahoma AES and USDA-ARS and released in 1983. Yantar (PI 565327) is a Bulgarian cultivar with the pedigree, 'Pervenka'/'Mironovskaja 808', and was subsequently characterized for adult-plant leaf rust (*Puccinia triticina* Eriks.) resistance by Yang et al. (1990).

The F_2 and F_3 generations were advanced as bulk populations in Lahoma and Stillwater, OK. Deliver was selected from a single $F_{3:4}$ head row in 1996 on the basis of plant and head type, maturity, and seed quality at Stillwater, OK. The head-row progeny was evaluated in 1997 in a non-replicated observation nursery at Lahoma, OK and selected on the basis of fall vegetative growth habit, reactions to leaf rust, *Barley yellow dwarf virus*, and *Wheat soilborne mosaic virus*, plant height, heading date and maturity, stay-green, spike density, test weight, seed quality, and grain yield. Subsequent generations were advanced by bulk selfing in the field, with roguing of awned variants each year until 2003. Deliver was evaluated as OK98690 in replicated breeder trials from 1998 to 2003, and in the Southern Regional Performance Nursery (SRPN) in 2003. It was subsequently tested in the Oklahoma Wheat Variety Trials (OWVT) from 2003 to 2005.

Deliver is semidwarf and intermediate in plant stature relative to most HRW wheat cultivars. Its mature-plant height (85 cm in Oklahoma) is within 2 cm of 'Jagger' (Sears et al., 1997), '2174', and 'Ok101' (Carver et al., 2003). Its lodging pattern is similar to Jagger and classified as moderately susceptible. Arrival to first-hollow-stem (FHS) stage is intermediate. From 2003 to 2005 at Stillwater, OK, Deliver reached FHS stage 7 d later than Jagger (early), 2 d later than Ok101 (intermediate), and 7 d earlier than 2174 (late). Heading date of Deliver is also intermediate, or about 2 d later than Ok101 and Jagger but similar to 2174. Befitting to a dual-purpose (grazing-plus-grain) management system, Deliver avoids precocious arrival at FHS stage, while reaching the heading stage at the appropriate time. Other fitness traits of Deliver relative to a dual-purpose system include an erect to semi-erect fall growth habit which may give it the appearance of relatively high forage production, but clipping trials indicate its forage capacity is in the intermediate range of current cultivars (Edwards et al., 2005). Reaction to low-pH soils with high aluminum saturation is considered moderately susceptible (score of 4, 1 = resistant to 5 = highly susceptible) and similar to Karl (score = 4) and Chisholm (score = 3) but slightly more tolerant than the highly susceptible cultivar 'TAM 110' (score = 5).

Flag leaves of Deliver at the boot stage are blue-green, recurved, twisted, and waxy. Spikes are white-chaffed, apically awnletted, tapering, dense, and recurved at harvest-maturity. Kernels are red, hard textured, ovate, and have a narrow, shallow crease, rounded cheeks, and small germ.

Disease reactions are summarized based on field observations under natural infection in Oklahoma (2003–2005), greenhouse observations in Oklahoma (2003–2006), and cooperative evaluations in the USDA-ARS regional nursery program (2003). Deliver has adult-plant resistance to wheat leaf rust races currently present in Oklahoma (May 2005) and is postulated to carry the race-specific gene *Lr*26 (J. Kolmer, personal communication, 2004) that results in a moderately susceptible rating to leaf rust in the seedling stage. The most recent adult-plant leaf rust ratings were collected at four Oklahoma sites in 2005. Deliver produced a consistent score of 1 on a 1-to-4 scale, compared with the susceptible check cultivar, Chisholm, with a consistent score of 4. Adult plants of Deliver were rated as moderately resistant to stripe rust *(Puccinia striiformis* Westend) in Oklahoma in 2004 (similar to Chisholm) based on a mean score of 1.0 on a scale of 0 to 4, in which the susceptible check cultivar, 'Ok102', averaged 2.5. During the stripe rust epidemic in 2005, Deliver was again rated as moderately resistant based on a mean score of 0.4 across six Oklahoma sites, in which the susceptible check, Ok102 (Carver et al., 2004), averaged 3.4.

For other known disease reactions in the seedling stage, Deliver is resistant to septoria leaf blotch (caused by *Septoria tritici* Roberge in Desmaz.), moderately resistant to tan spot [caused by *Pyrenophera tritici-repentis* (Died.) Drechs.], and moderately susceptible to powdery mildew [caused by *Blumeria graminis* (DC.) E.O. Speer f. sp. *tritici* Em. Marchal]. Based on field reactions, it is resistant to *Wheat soilborne mosaic virus* and *Spindle-streak mosaic virus.* Deliver is susceptible to race TTKS of stem rust (*Puccinia graminis* f. sp. *tritici*) based on a 30S reaction recorded in Kenya in 2005 (B. Goates, personal communication, 2005).

Deliver is susceptible to greenbug (*Schizaphis graminum* Rondani) and Russian wheat aphid *(Diuraphis noxia* Mordivilko), and moderately resistant to Hessian fly (*Mayetiola destructor* Say) based on frequency of broken stems at harvest maturity (score of 2, 1 = resistant [2174] to 5 = highly susceptible [Jagger]). Seedling tests, however, indicate Deliver is susceptible to prevalent biotypes of Hessian fly in the southern Plains (M.S. Chen, personal communication, 2006).

Across 31 grain-only sites of the 2003 SRPN, Deliver was the eighth highest yielding entry with a mean yield of 4650 kg ha^{-1} compared with the long-term checks, TAM 107 at 4090 kg ha^{-1} and Trego at 4510 kg ha^{-1} (LSD = 290 kg ha^{-1}, $P = 0.05$). In the OWVT (41 site-years), grain yield of Deliver averaged 3410 kg ha^{-1}, compared with 3180 kg ha^{-1} for 2174 and 3510 kg ha^{-1} for Jagger (LSD = 101 kg ha^{-1}, $P = 0.05$). Test weight is a formidable trait in breeding awnletted cultivars for the southern Great Plains (Weyhrich et al., 1994). Deliver has exceeded acceptable standards with a mean hectoliter weight in the OWVT (41 site-years) of 78.7 kg hL^{-1}, compared to 77.9 kg hL^{-1} for 2174 and 76.9 kg hL^{-1} for Jagger (LSD = 1.8 kg hL^{-1}, $P = 0.05$).

Based on single-kernel characterization system (SKCS) data recorded from 27 breeder trials from 1999 to 2003, Deliver has above-average kernel size and below-average kernel hardness that mirrors one of its progenitors, Chisholm. Deliver averaged 31.9 mg kernel weight, 2.36 mm kernel diameter, and 57 for kernel hardness index. Values for Ok101, also known for its above-average kernel size and below-average kernel hardness, were 30.7 mg kernel weight, 2.37 mm kernel diameter, and 55 for kernel hardness index. From the same environments measured with the Quadromat Senior mill, Deliver performed well for straight-grade flour yield (645 g kg^{-1}) relative to the

high-yielding check, Ok101 (635 g kg^{-1}). Hence, Deliver has desirable physical quality attributes based on SKCS and experimental milling performance. Also from those 27 environments, mean wheat protein content was 120 g kg^{-1} for Deliver and 112 g kg^{-1} for Ok101.

From 27 breeder trials spanning 1999 to 2003, Deliver showed a moderately long mixograph mixing time of 7.0 min (indicative of parent Karl), an intermediate mixing tolerance score of 4.8 on a 1-to-10 (low-to-high) scale, and good dough strength based on a mixogram curve width at 2 min past peak development of 12.8 mm. Respective scores for Ok101, known for its moderate dough strength, were 5.1 min, 4.7, and 8.9 mm.

Overall milling and baking quality was rated acceptable in the 2003 evaluation program of the Wheat Quality Council. On a 0-to-6 scale (poor to excellent), mean scores across 13 collaborators were 3.60 for Deliver and 3.69 for the check cultivar, Ok102. Straight-grade flour yield of Deliver (with reference to Ok102 as the check sample) was 733 g kg^{-1} (699 g kg^{-1}) with 3.2 g kg^{-1} flour ash (4.4 g kg^{-1}). Deliver averaged 595 g kg^{-1} bake absorption (619 g kg^{-1}) and 4.0 in crumb grain score (3.3) on a 0-to-6 scale (poor to excellent). Loaf volume for Deliver averaged 97% of the loaf volume for Ok102. In summary, Deliver has above-average milling quality and average baking quality that is commensurate with its protein level.

Seed of Deliver has been deposited in the National Plant Germplasm System, where it will be available for research purposes, including development and commercialization of new cultivars. Appropriate recognition is requested if this release contributes to the development of a new breeding line or cultivar. Authorized seed classes are Breeder, Foundation, Registered, and Certified. Foundation seed may be obtained through Foundation Seed Stocks, Dep. of Plant and Soil Sciences, Oklahoma State Univ., Stillwater, OK 74078. The Oklahoma Agricultural Experiment Station will maintain Breeder seed. The U.S. Department of Agriculture will have no seed for distribution. Application for U.S. Plant Variety Protection (Title V) is pending.

B.F. Carver,* R.M. Hunger, E.L. Smith,
A.R. Klatt, J.T. Edwards, D.R. Porter,
P. Rayas-Duarte, J. Verchot-Lubicz, B.C. Martin,
E.G. Krenzer, and B.W. Seabourn

Acknowledgments

Deliver was developed with financial support of the Oklahoma Wheat Research Foundation, the Oklahoma Wheat Commission, and state project OKLO1426.

References

Carver, B.F., E.G. Krenzer, R.M. Hunger, D.R. Porter, E.L. Smith, A.R. Klatt, J. Verchot-Lubicz, P. Rayas-Duarte, A.C. Guenzi, G. Bai, and B.C. Martin. 2004. Registration of 'Ok102' wheat. Crop Sci. 44:1468.

Carver, B.F., E.L. Smith, E.G. Krenzer, R.M. Hunger, D.R. Porter, A.R. Klatt, J. Verchot-Lubicz, P. Rayas-Duarte, A.C. Guenzi, B.C. Martin, and G. Bai. 2003. Registration of 'Ok101' wheat. Crop Sci. 43:2298.

Edwards, J., R. Austin, B. Carver, and R. Kochenower. 2005. Fall forage production by winter wheat varieties in Oklahoma. PT 2005–4. Oklahoma State Univ., Coop. Ext. Serv., Stillwater, OK. (Available online at http://www.wheat.okstate.edu/vtr/index.htm) (Verified 24 Apr. 2006).

Sears, R.G., E.G. Heyne, T.J. Martin, T.S. Cox, L.E. Browder, D.L. Wetzel, M.D. Shogren, L. Bolte, S. Curran, J. Lawless, M. Witt, and W. Heer. 1991. Registration of 'Karl' wheat. Crop Sci. 31:1386.

Sears, R.G., J.M. Moffatt, T.J. Martin, T.S. Cox, R.K. Bequette, S.P. Curran, O.K. Chung, W.F. Heer, J.H. Long, and M.D. Witt. 1997. Registration of 'Jagger' wheat. Crop Sci. 37:1010.

Smith, E.L., O.G. Merkle, H.T. Nguyen, D.C. Abbott, and G.H. Morgan. 1985. Registration of 'Chisholm' wheat. Crop Sci. 25:367.

Weyhrich, R.A., B.F. Carver, and E.L. Smith. 1994. Effects of awn suppression on grain yield and agronomic traits in hard red winter wheat. Crop Sci. 34:965–969.

Yang, T., S. Wenhua, and S. Kequan. 1990. Monosomic analyses of stripe rust and leaf rust resistance genes in winter wheat varieties Luqiyu and Yantar. Euphytica 48:83–86.

B.F. Carver, E.L. Smith (retired), A.R. Klatt, J.T. Edwards, B.C. Martin, and E.G. Krenzer (retired), Dep. of Plant and Soil Sciences, Oklahoma State Univ., Stillwater, OK 74078; R.M. Hunger and J. Verchot-Lubicz, Dep. of Entomology and Plant Pathology, Oklahoma State Univ., Stillwater, OK 74078; D.R. Porter, USDA-ARS Plant Science Res. Lab., Stillwater, OK 74075; P. Rayas-Duarte, Dep. of Biochemistry and Molecular Biology, Oklahoma State Univ., Stillwater, OK 74078; B.W. Seabourn, USDA-ARS Grain Marketing and Production Res. Ctr., 1515 College Ave., Manhattan, KS 66502. Registration by CSSA. Received 11 Jan. 2006. *Corresponding author (bfc@okstate.edu).

doi:10.2135/cropsci2006.01-0016CRC
Published in Crop Sci. 46:1819–1820 (2006).