Proposal for Release of Hard Red Winter Wheat Candidate Cultivars:
OK05526-RHf
OK05212

Prepared by

Brett F. Carver

and the

OSU Wheat Improvement Team

Brett Carver	*Wheat Breeding, Team Leader*	**Jeff Edwards**	*Information Exchange*
Kris Giles	*Entomology*	**Bob Hunger**	*Pathology*
Art Klatt	*Germplasm Development*	**Patricia Rayas-Duarte**	*Cereal Chemistry*
Tom Royer	*IPM*	**Liuling Yan**	*Molecular Genetics*

Dep. of Plant and Soil Sciences
Dep. of Entomology and Plant Pathology
Dep. of Molecular Biology and Biochemistry
Oklahoma State University
Stillwater, OK 74078

OK05526-RHf

Graze n Grain Breeding System

OK05212

Acknowledgments

The OSU Wheat Improvement Team gratefully acknowledges the generous and continual support of the

Oklahoma Agricultural Experiment Station
Oklahoma Cooperative Extension Service
OSU's Office of Intellectual Property Management
Oklahoma Wheat Commission
and the
Oklahoma Wheat Research Foundation

The development and release of these cultivars embraces OSU's land-grant commitment to public service, technology transfer, and economic development.

The WIT also acknowledges the following individuals who supported the development and characterization of OK05526-RHf and OK05212:

Wayne Whitmore	Connie Shelton	Tina Johnson	Melanie Bayles
Jeff Wright	Shuwen Wang	Rima Thapa	Jana Morris
Ming Chen	Richard Chen	Paul St. Amand	Guihua Bai
Richard Austin	Brian Olson	Tilin Fang	Jay Ladd
Ray Sidwell	Lawrence Bohl	Craig Chestnut	Erich Wehrenberg
Bobby Weidenmaier	Jared Johnson	Roger Osburn	Roger Gribble
Mike Hogg	Scott Null	Monte Tucker	Kevin Johnson

Experimental Designation

OK05526-RHf

OK05212

Both are Hard Red Winter (HRW) wheat (see Exhibit 1 for USDA-GIPSA confirmation of class), *Triticum aestivum* L.

Proposed Names

OK05526-RHf, '**Ruby Lee**'

OK05212, '**Garrison**'

See Exhibit 2 for clearance granted by the USDA, Marketing and Regulatory Programs, Seed Regulatory & Testing Branch.

Origination and Breeding Procedure

Two candidate HRW cultivars are submitted for consideration, as each candidate fulfills a different genetic gap in current varietal choices. Candidate OK05212 was derived from crosses directed by Dr. Edward L. Smith, former wheat breeder and Wheat Genetics Chair in Agriculture until 1998. The other candidate, OK05526-RHf, originated in the Wheat Genetics project previously directed by Dr. Brett F. Carver. Upon Dr. Smith's retirement, materials from both projects were combined according to generation of inbreeding and selection history, under the direction of Dr. Carver.

Parentage

OK05526-RHf was produced from a single cross according to the pedigree, KS94U275/OK94P549. KS94U275 was a Kansas State University experimental line developed cooperatively with USDA-ARS, having the pedigree KS90WGRC10 sib/KS92WGRC16. OK94P549 was developed by Oklahoma State University, after originating in the former hard winter wheat breeding program of Pioneer Hi-Bred International, Inc. It has the pedigree HBY756A/Siouxland//2180. Respective origins of the parents in this pedigree were Pioneer Hi-Bred, University of Nebraska-Lincoln, and Pioneer Hi-Bred/Kansas State University. Single-plant selections were eventually made from the pureline OK94P549, one of which was released as 'Endurance'.

OK05212 was produced from a three-way cross with the pedigree, OK95616-1/'Hickok'//KS84063-2W. OK95616-1 was an Oklahoma State University experimental line with the pedigree, TXGH13622/'2180'. KS84063-2W was later released by Kansas State University as 'Betty', which according to its 1998 registration with the Crop Science Society of America, was believed to have resulted from an outcross with 'Jagger'. Hence Jagger is likely a grandparent, not a parent, of this candidate cultivar.

Breeding history –OK05526-RHf and OK05212

Line development, selection, and testing. The F_2, F_3, and F_4 generations were advanced through the OSU ***Graze***n***Grain*** breeding system in harvest years 2000, 2001, and 2002 (Exhibit 3). Bulked seed progeny were harvested from populations managed for dual-purpose

production either at the Expanded Wheat Pasture Unit (EWPU) near Marshall, OK or at Stillwater, OK. In either location, actual stocking rates and grazing periods were invoked consistent with farmer practice. Bulk population evaluation also occurred at grain-only sites at Lahoma, Altus, and/or Ft. Cobb, but breeder seed was strictly harvested from the dual-purpose sites. The ***Graze***n***Grain*** breeding system imposes selection within populations for grazing tolerance, non-precocious first-hollow-stem development, and tolerance to barley yellow dwarf (BYD) virus, Hessian fly, and other conditions that may sporadically appear with early planting. From the F_4 population subjected to grazing, about 100 heads were selected from plants with appropriate earlier maturity and shorter stature, and the head-row progenies were evaluated the following year.

OK05526-RHf and OK05212 each traced to a single $F_{4:5}$ head row selected in 2003 based on plant height (no taller than 'Ok101'), straw strength, maturity (no later than 'Thunderbolt'), spike density, spike size, uniformity of phenotype at harvest maturity, kernel size and kernel size consistency, kernel color (lack of yellow berry phenotype), and kernel morphology indicative of acceptable test weight. In 2004, the bulk progeny of each selected head row was evaluated in the Dual-Purpose Observation Nursery (DPON) using an augmented experimental design at Stillwater (simulated dual-purpose environment) and at Lahoma (grain-only environment). Each progeny surpassed subjective and non-subjective criteria used in selection, including but not limited to forage accumulation and regrowth throughout the vegetative phase, spring recovery following final forage removal in early March, timing of winter dormancy release, heading date, whole-canopy and flag-leaf stay-green, foliar disease resistance (primarily stripe rust, but also BYD, leaf rust, and septoria leaf blotch), grain yield, test weight, lodging tolerance, shattering tolerance, and multiple quality traits associated with hard wheat milling and baking quality.

OK05212 and the original line from which OK05526-RHf was reselected, OK05526, were first entered into replicated yield trials during harvest year 2005. Until 2010, OK05212 and OK05526 appeared with *n* experimental lines (or varieties in the case of variety trials) in the following replicated yield trials in Oklahoma and surrounding states:

2005	Replicated Yield Trials 1, RYT1	*n* = 218
2006	Replicated Yield Trials 2, RYT2	*n* = 43
2007	Oklahoma Elite Trial 1, OET1	*n* = 26
2008	Oklahoma Elite Trial 2, OET2	*n* = 14
2009	Oklahoma Elite Trial 3, OET3	*n* = 21
2009	Southern Regional Performance Nursery, SRPN	*n* = 46 (OK05212 only)
2010	OET3	*n* = 20
2010	SRPN	*n* = 48
2010	OSU Wheat Variety Trials, WVT	*n* = variable
2010	Uniform Variety Trial, UVT (TX)	*n* = 32

Breeder-seed advancement. Production of breeder seed beyond the $F_{4:6}$ head row progeny stage occurred in separate nurseries but parallel to the testing nurseries listed above (equivalent generations of inbreeding). Contrary to the testing nurseries dedicated to combine harvest, the breeder-seed nurseries were established strictly for visual monitoring of uniformity

and for hand-harvest to minimize, if not virtually eliminate, seed contamination from neighboring lines. These nurseries were established at field laboratories operated by the Oklahoma Agricultural Experiment Station at Stillwater, OK and/or Goodwell, OK.

Breeder seed of OK05212 was advanced through continuous bulk-selfing without reselection, and is a F_4-derived line in the F_{12} generation as of the 2010 harvest ($F_{4:12}$). Immediately following a breeder-seed increase of 350 lb during the 2009 harvest, the decision was made to place OK05212 under foundation seed increase. Sufficient OK05212 breeder seed was provided to Oklahoma Foundation Seed Stocks, Inc. (OFSS) in Fall 2009 to plant 4.2 acres. A second generation of foundation seed production is currently in progress (2010-2011) using foundation seed harvested in 2009, with the expected production of >2000 bu foundation seed. OK05212 was observed to be highly uniform and stable for four generations (2007-2010). Variants observed in the final breeder-seed increase at Goodwell, OK in 2010 included plants that were slightly taller (<4 in.), under irrigation, at a frequency <0.005%.

Breeder seed of OK05526 was advanced by bulk-selfing to the $F_{4:9}$ generation in 2007, at which time greenhouse evaluation of single F_9 plants revealed segregation for resistance to Hessian fly (data provided by Ming Chen, USDA-ARS), and the line in the field was also observed for a low degree of segregation in chaff color, i.e., plants with white glumes at a frequency of 0.2%. Thus, among 13 plants identified with seedling resistance to Hessian fly, one representative F_9 plant with red glumes was harvested to re-continue the breeder-seed increase. The reselection, OK05526-RHf, was subsequently observed to be indistinguishable from OK05526, except the reselection showed no segregation in chaff color in the field for all subsequent generations. Breeder seed of OK05526-RHf was advanced through continuous bulk-selfing without reselection, and is a F_9-derived line in the F_{12} generation as of the 2010 harvest ($F_{9:12}$). While breeder-seed increase proceeded with the reselection, continued field testing occurred with the original line.

Immediately following the 2010 harvest, the decision was made to place OK05526-RHf under foundation seed increase. About 210 lb. of OK05526-RHf breeder seed was provided to Oklahoma Foundation Seed Stocks, Inc. (OFSS) in Fall 2010, and foundation seed production is currently in progress (2010-2011) on about 3.5 acres near McCloud, OK. OK05526-RHf was observed to be highly uniform and stable for three generations (2008-2010).

Description and Performance

This section will focus on agronomic and quality data from the past five crop years (2006-2010), during which the two candidates were tested in the same designed nursery with relevant and contemporary check cultivars. Two principal sources of data were used to assess agronomic and end-use quality performance: i) OSU breeding nurseries across Oklahoma (primarily the OET series of nurseries), and ii) the Oklahoma State University WVT.

OK05212 will be positioned to overtake acreages of Endurance and other older varieties with similar maturity patterns (relatively late maturity), especially where those cultivars suffer yield reductions due to foliar disease susceptibility. However, for the purpose of establishing distinctness in the application for U.S. Plant Variety Protection, OK05212 resembles Duster in vegetative and reproductive plant type, kernel characteristics, and to some extent, targeted range of environments, but not in pedigree.

OK05526-RHf will be positioned in a more restricted manner, with no specific varietal displacement intended, but to provide a contemporary choice with top-end yield potential in environments where grain yield is maximized by intensive management. Given similar developmental patterns and season-long appearance, OK05526-RHf should be compared with OK Bullet for the purpose of establishing distinctness in the PVP application. Lastly, data for Endurance was occasionally provided where comparison to a later maturing cultivar or a cultivar with minimal acceptability for quality would be appropriate.

The nursery mean reported in each table of this proposal reflects the mean performance of *all* checks and breeder lines selected and advanced for further testing from a particular nursery; hence the nursery mean provided may not equal the mean of the entries shown in a given table. The "top LSD group" was determined from the entry in a given nursery with the highest value (or lowest, if more desirable) among all entries, and not necessarily the entry shown in a given table with the highest (or lowest) value. "Average" levels of performance indicate a certain candidate performed similar to the mean of the nursery in which it was tested. For some of the end-use quality comparisons, values highlighted in blue indicate superiority of the candidate cultivar relative to a specified check; those in red indicate the check out-performed the candidate.

Grain yield performance and areas of adaptation

Overview of testing environments. Statewide breeding nurseries during the primary evaluation period, 2006-2010, reflected extremes in environmental conditions, ranging from a season-long, severe drought period in harvest year 2006 to above-average rainfall patterns in each of the two subsequent years. Additionally, severe disease pressure occurred in 2007, 2008, and 2010, headlined by powdery mildew, leaf rust, and Xanthomonas infection in 2007, severe leaf rust pressure in north central Oklahoma and High Plains virus (and possibly barley yellow dwarf virus) in the panhandle in 2008, and severe stripe rust pressure in 2010 (and 2005) from southwest Oklahoma to north central Oklahoma. Stripe rust was present in only trace amounts in isolated areas of the state in 2007 and 2008. Unusually late freeze events further confounded yield comparisons in 2007 and 2009 due to wide genetic variability in circumvention or recovery, though many test locations in 2007 could not be harvested. This extreme variability in year-to-year environmental conditions forces interpretation of yield responses within years. For example, cultivars now considered sensitive to leaf rust and the new race(s) of stripe rust, such as OK Bullet, have not shown the same yield superiority in more recent years as they did before 2007 (Table 1).

Grain yield comparisons in breeding nurseries. Both OK05526 and OK05212 placed in the top-yielding group in four of the past five years (Table 1). Hence both candidates offer strength in yield potential and yield stability. They were able to hold their top-tier positions in a nursery (OET3) that features continued incorporation of experimental lines with better yielding ability. OK05526 suffered a significant decline in yield in 2009, as its earlier dormancy release patterns made it more vulnerable to the April freeze event. OK05212 either recovered from or circumvented the spring freeze event better than most experimental lines and check cultivars tested, finishing with the highest yield of all entries in the 2009 OET3. This performance history, combined with differential maturity patterns, indicates that years which favor later maturity

might favor OK05212 (e.g., 2009), whereas years that favor early maturity might favor OK05526 (e.g., 2006, 2008).

OK05212 resembles Endurance in maturity pattern, plant type, and dual-purpose capability. Merit for OK05212 should thus be based on its superiority to Endurance, not to OK05526. OK Bullet remained a very competitive cultivar for yield performance until leaf rust in 2008, and stripe rust in 2010, began to erode some of its yield advantage. Without more observations, neither experimental can be considered a "breakaway" type from Duster based purely on mean statewide yield performance. One needs to examine the environment-specific trends to see where definite advantages come into view.

Site- or system-specific yield comparisons. Both candidates demonstrated good adaptation to southwestern, north central, and irrigated-panhandle sites, with OK05212 showing superiority in dryland-panhandle environments (Table 2). Harvest years 2006 and 2008 at Lahoma allowed the superior yield potential of OK05526 to stand out in north central Oklahoma. OK05212 was the better performer over Endurance in the majority of single site-year comparisons, including dual-purpose managed sites.

For an earlier maturity type, it is noteworthy that OK05526 exceeded all other varieties or experimental lines in its ability to match Duster in dual-purpose yield in wheat variety trials at the Wheat Pasture Unit, either in 2010 (58 bu/ac) or in the past two years combined (35 bu/ac; data provided by J. Edwards, 2010). This trend was corroborated by yield data collected in an artificial dual-purpose production system by the Noble Foundation at two sites near Ardmore, OK in 2010. OK05526 ranked first (81 bu/ac) or second (60 bu/ac) for grain yield in those trials, following forage removal. At one of those sites, it placed in the highest yielding group for season-long forage production. OK05526's ability to produce biomass in the fall and recover from grazing in the spring make dual-purpose production a legitimate secondary option.

Despite OK05526 showing an intermediate adult-plant reaction to stripe rust, it still performed in the top-yielding group in 2005 and 2010 in the southwest where disease pressure was heavy, and in 2008 at Lahoma where stripe rust (and leaf rust) pressure was moderate. The 2010 Lahoma site would have also provided a barometer for yielding ability in the presence of heavy stripe rust infection, but other factors (hail damage included) confounded the data. Whereas OK05526 cannot be claimed to be resistant to previous (predominately PST100) and current races of stripe rust, it does exhibit an effective level of tolerance that has yet to severely or even moderately impact its yield (discussed further in Disease reaction section). As with Duster and Endurance, lack of complete resistance still warrants close monitoring of OK05526 in commercial fields, with the option of fungicide application offering a potentially legitimate expense.

Recent yield comparisons from the OSU WVT. Inclusion of candidate cultivars and other experimental lines in the OSU Wheat Variety Trials (WVT) allows comparisons with other contemporaries besides Endurance, Duster, and OK Bullet. In 2009, OK05526 performed in the top yielding group listed in Table 3 (212 was not tested), despite significant visible damage suffered from the April freeze. In 2010, both candidates performed second only to Duster, which was in a yield class of its own. Averaged across 11 sites, OK05526 and OK05212 were at least 3 bu/ac superior to Fuller, Jagger, Doans, and TAM 203, but similar to Endurance and Jackpot. Interestingly, OK05526 does not carry the same level of resistance to stripe rust as

OK05212, but OK05526 maintained the same mean yield as OK05212 in 2010. This could be explained, in part, by higher intrinsic yield of OK05526 that might be more clearly distinguished if protected with timely foliar fungicide application.

Test weight performance

One to two years of WVT testing indicate that OK05212 has average test weight, whereas OK05526 has above-average test weight (Table 3). In 2010, OK05212 exceeded Endurance by almost 1 lb/bu, but was still 1 lb/bu lower than OK05526. More observations were collected in breeding nurseries from 2006 to 2010 (Table 4), where both candidates placed between Endurance (average test weight) and OK Bullet (superior test weight). Across 28 site-years, test weight of OK05526 was almost 1 lb/bu less than OK Bullet, but 0.6 lb/bu better than Endurance. Across the same environments, OK05212 was similar to Endurance but 1.5 lb/bu inferior to OK Bullet. Either candidate should easily exceed 60 lb/bu when conditions allow reasonable expression of test weight, but these data indicate that OK Bullet holds its test weight better than either candidate in poorer environments.

Disease reactions

Both candidates provide a broad spectrum of foliar disease resistance, though OK05526 might be considered slightly inferior due to weaker protection against stripe rust and septoria leaf blotch (Exhibit 4). Comparing seedling ratings with field reactions, OK05212 apparently has adult-plant resistance (APR) to leaf rust, and expression levels can vary depending on the year (Table 5). We have yet to determine with certainty that the APR in OK05212 is conferred by gene *Lr34*, because the available gene markers produced inconsistent results at three key sites in the coding region of *Lr34* (E11, E12, and E22). The susceptible allele is often found at E12, but the resistant allele is consistently found at the critical E22 site. Gene *Lr34* confers durable non-specific resistance to multiple races of the leaf rust pathogen. Symptoms of leaf rust may be found on OK05212 during the later grain-filling stages, usually during the last week of May in north central Oklahoma. OK05526 on the other hand, has exhibited seedling or all-stage resistance to leaf rust, with only one exception in 2008. In four of the past five years, OK05526 was rated resistant to leaf rust in Oklahoma. Gene postulations based on seedling reactions place *Lr39/41* in OK05526 (consistent with its pedigree) and *Lr17* in OK05212, but additional APR genes must be involved as these genes in isolation do not provide adequate protection.

OK05212 is best noted for its high level of stripe rust resistance expressed in Oklahoma environments, having held up to the new race(s) that appeared throughout the Great Plains in 2010. It is this trait which elevates OK05212's standing as a candidate for release.

On the contrary, field reaction to stripe rust for OK05526 is best described as intermediate in Oklahoma (Table 5). Tests conducted by USDA-ARS in northern Kansas (R. Bowden, personal communication, 2010) indicate even greater symptom expression or susceptibility. A peculiar characteristic of OK05526 in breeder nurseries is that its specific reaction can fluctuate widely in direct proportion to the level of inoculum present in adjacent plots. Also peculiar to OK05526's stripe rust response was its high yield expression throughout the Great Plains in 2010 SRPN, with an overall rank of 4th out of 48 entries across 15 sites in TX,

OK, KS, and NE, despite widespread occurrence of stripe rust at many of those sites. Furthermore, in the 2010 OET3, OK05526 achieved the highest large-kernel fraction value (LKF of 81%) among six check cultivars and the best experimental lines in the nursery. An attribute of keen interest to millers, LKF can be sharply reduced to unacceptable levels proportional to disease susceptibility. Nevertheless, OK05526 maintained unusually high LKF values in the presence of stripe rust. Duster, resistant to stripe rust in 2010, averaged 52% LKF across the same sites.

Both OK05212 and OK05526 are resistant to the WSBMV/WSSMV complex, and they both provide an effective level of resistance to BYD virus, based on limited data collected in 2010 (Exhibit 4) and on additional data (not shown) collected in 2008. Dual infections of High Plains virus vectored by the wheat curl mite and BYDV occurred that year at Goodwell, and both candidates were given a score of 1.5 on a scale of 0 to 4, with Endurance and Duster given scores of 1.0 and 2.0, respectively. The reactions to BYDV are especially noteworthy because BYD is a disease more or less present across Oklahoma in any year, especially in early-planted grazed systems. Reactions to powdery mildew were generally acceptable, with slightly better adult-plant resistance in OK05212. Our most reliable data for tan spot and septoria reactions were produced in 2010 and 2011. OK05212 excels in resistance to septoria leaf blotch, whereas OK05526 excels in resistance to tan spot.

Other agronomic characteristics

Stay-green. An additional indicator of overall protection against foliar pathogens can be gleaned from ratings of green-leaf duration, or stay-green. Both OK05212 and OK05526 have shown relatively good stay-green ratings compared with other desirable cultivars such as Billings (Table 5). The better (lower) stay-green scores for OK05212 may be confounded by its later maturity; nevertheless overall leaf hygiene for OK05212 is outstanding and comparable to Billings.

Insect reactions. Both OK05526 and OK05212 are susceptible to all biotypes of greenbug and Russian wheat aphid. Their reaction to bird-cherry oat aphid is unknown.

With its susceptibility, OK05212 should not be chosen for production where Hessian fly infestation is a recurring problem (Table 6). Other resistance options exist, and they continue to be released. One option could be OK05526, which has shown effective field tolerance similar to Centerfield and Duster, based on reproductive inhibition of the fly in adult stages. Reduced support of Hessian fly reproduction could be considered a component of plant resistance. Seedling tests in the greenhouse revealed segregation of susceptible and resistant types in OK05526. Its reselection OK05526-RHf, the actual line placed under seed increase, has been confirmed for more uniform resistance (Table 6), though additional tests suggest the resistance expressed in the greenhouse may be temperature-sensitive (M. Chen, personal communication, 2010).

Acid-soil tolerance. OK05526 and OK05212 also have highly contrasting reactions to acidic soils (pH<4.5). At best OK05526 can be classified as an intermediate type based on visual ratings (Table 7), and the only yield data available (Table 8) indicates no statistically better tolerance than Fuller in 2010. OK05212 on the other hand exhibits the same tolerance level as Duster. Averaged across two nurseries in a farmer's field east of Enid, grain yields of OK05212

and Duster were 56 and 54 bu/ac in 2010, whereas yields of OK05526 and Fuller were 36 and 32 bu/ac (Table 8). OK05212 is thus highly recommended in environments where liming is not a feasible option, whereas caution would be advised for planting OK05526 in soils with pH <5.5, especially in the absence of an in-furrow phosphorous application at sowing. Neither candidate was positive for the SSR marker, *WMC0331*, linked to a major quantitative trait locus on chromosome 4DL associated with aluminum tolerance (personal communication, Guihua Bai, USDA-ARS, Manhattan, KS). Hence, OK05212 must contain other gene(s) contributing to its high level of aluminum tolerance.

Dual-purpose characteristics. OK05212 and OK05526 appear to produce ample fall forage biomass. Their visual ratings were consistently better than the arbitrarily preset value of 3 representing intermediate or average production on a 1-to-5 scale (Table 9). Both candidates have a semi-erect to erect juvenile growth habit, but they are easily distinguished in the field by the finer texture, or narrower leaves, of OK05212. Canopy presentation of OK05212 resembles Duster, while that of OK05526 resembles OK Bullet, OK Rising, and Jagalene.

Hand-clipped biomass data taken from the 2009-2010 Wheat Variety Trials suggest that OK05526 may have higher forage production potential than OK05212. OK05526 ranked in the highest yield grouping at 2520 lb/ac (dry forage), whereas OK05212 ranked in the lowest grouping at 1840 lb/ac (data provided by J. Edwards). A second year of clipping data is needed to better account for environmental factors that can highly influence cultivar ranking for this trait. The clipping data is not inconsistent with visual differences in canopy texture.

Data from 2009-2010 breeding nurseries indicate OK05212 may not recover from grazing as well as Endurance and Duster (Table 9), but more data in production fields are needed for validation. Recovery from continuous forage removal in a simulated dual-purpose system—as monitored in the 2010 and 2011 DPON (data not shown)—does not reveal any weakness of either OK05526 or OK05212.

Maturity. OK05526 and OK05212 represent divergent reproductive developmental patterns. Visual ratings of winter dormancy release (Table 10) place OK05526 as moderately early (similar to Billings) and OK05212 as moderately late (similar to Endurance). Actual data of first-hollow-stem (FHS) arrival do not necessarily show as much separation between the candidates, but more data should be collected before declaring any particular pattern. What is certain is their genotype for key developmental genes, according to data provided by Liuling Yan. OK05212's allele composition for genes *VRN-A1*/*PPD-D1*/*VRN-D3* (segregating BBB, BAB) is generally associated with a relatively late phenotype throughout reproductive development; OK05212 shows segregation for two alleles with opposite effect at the *PPD-D1* locus. OK05526's genotype (BBA) is generally associated with intermediate winter dormancy release, early heading date, and intermediate maturity. Both of the expected phenotypes match well with field observations. Genotypes BAB and BBA have relatively low frequency among current OSU elite, experimental lines. Genotype BBB is most frequent and is found in cultivars Endurance and Duster.

OK05526 consistently reached the heading stage 3 days earlier than OK05212 and is only one day later than Billings. Heading date of OK05212 was most similar to Endurance from 2006 to 2010. Expected heading dates at Stillwater, Lahoma, and Goodwell, OK for OK05526 are April 21, April 23, and May 3. A line that shows a larger differential in heading date between Goodwell and Stillwater may be more sensitive to unusually warm temperature events that

promote early flowering. This differential would be expected to be lower for photoperiod-sensitive genotypes, or if determined at more northerly latitudes.

Shattering tolerance. Ratings for shattering were taken only where significant expression occurred (e.g., scores of ≥ 2 for shattering-susceptible cultivars such as Overley). From a total of nine readings during the period 2006 to 2010, both candidates can be classified as moderately resistant to shattering (Table 12). Each has shown significant shattering loss in only one year during this 5-yr period. Neither came close to resembling the shattering patterns of Overley, but they cannot be placed in the same tolerance category as Duster, Billings, and Pete.

Plant height and lodging. OK05526 and OK05212 differ in plant stature, with OK05526 being one of the taller experimental lines in the OSU wheat improvement program. In environments which allow greater expression of height, OK05526 will exceed 90 cm (Table 13). It is no shorter than OK Bullet, also known for taller stature. OK05212 is similar to Duster, and is limited in height expression by its relatively later maturity. Both candidates are non-*Rht8* genotypes (data provided by G. Bai, USDA-ARS), but it is not yet clear which dwarfing allele is present in OK05526 at *Rht1-B1* or *Rht2-D1*. OK05212 has the dwarfing allele at *Rht1-B1*. From the 2010 SRPN (data not shown), OK05526 was 8.3 cm taller than TAM 107 and 10.8 cm shorter than Scout 66 (wild-type allele at both *Rht* loci). OK05212 was only 3.6 cm taller than TAM 107, but 15.5 cm shorter than Scout 66.

All candidates are intermediate to OK Bullet and Duster in lodging resistance, averaging about 2 on a scale of 1 (tolerant) to 5 (susceptible) (Table 14). However, OK05212 tends to be more sensitive in environments most conducive to lodging, and has shown tendency for brackling with excessive moisture immediately prior to physiological maturity (as observed in 2007, Table 14). In most environments, all candidates will show reasonably good lodging resistance and straw strength.

Milling quality

Kernel hardness, a distinguishing characteristic for both candidates, falls within a lower but acceptable range of values recommended for hard winter wheat (>60, Table 15). This level was similar to Endurance. Flour yields were no different from OK Bullet, although the latter has much higher kernel hardness values. The flour yields of OK05526 and OK05212 would have been equivalent if not for the unexplainably low flour yield for OK05212 in 2007.

In contrast to their similar hardness scores, OK05526 and OK05212 differed widely in kernel size. OK05212 has below-average kernel weight (28 mg) and kernel diameter (2.3 mm) (both similar to Duster), whereas OK05526 showed unusually high kernel weight (34 mg) and diameter (2.6 mm) (Table 15). The larger kernel size may potentially translate to higher flour extraction on a commercial scale, but we were unable with our experimental mill to detect a difference. OK05526 consistently ranked in the top tier of experimental lines for either kernel weight or kernel diameter. OK05212 was consistently in the lower tier along with Duster, but again, both candidates were consistently in the top tier for grain yield, even in the kernel-filling challenged conditions following the late winter freeze of 2009.

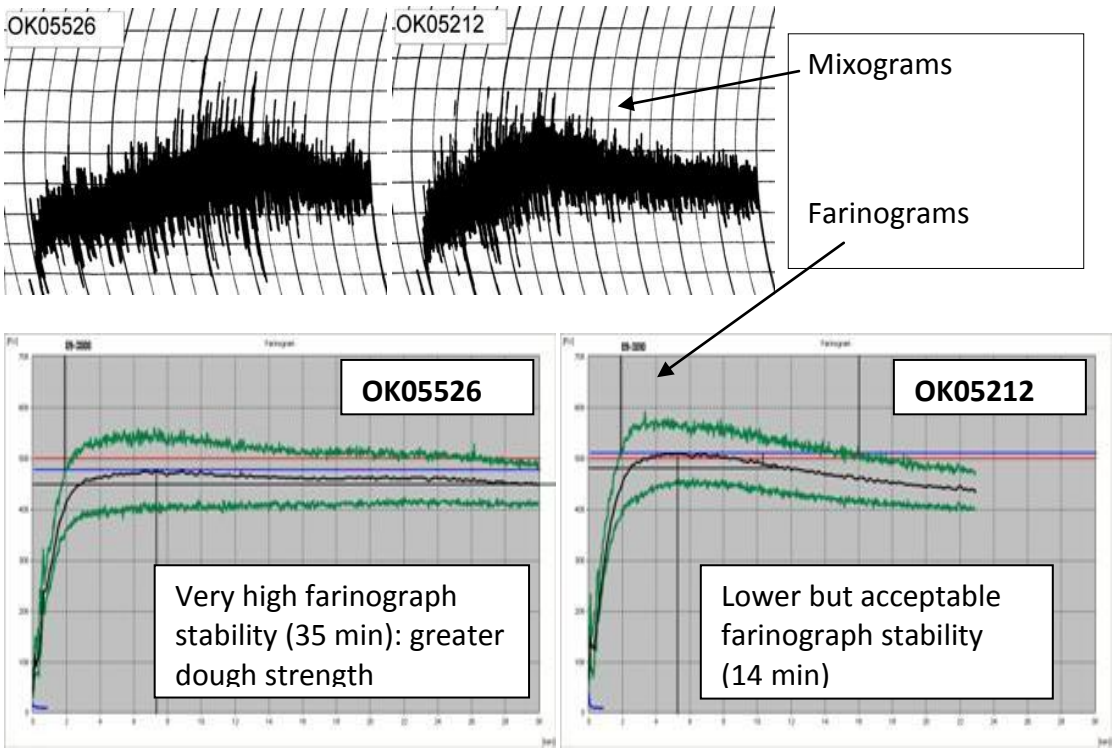
Baking quality

Protein content. Wheat and flour protein contents were well within the acceptable and class-appropriate range for hard winter wheat. OK05526 and OK05212 produced above-average protein content from 2006 to 2010, with a 5-yr mean for wheat protein of 12.6 to 12.8%, or about one-half percentage unit below the high protein cultivar, OK Bullet (Table 15). Wheat-to-flour protein loss was about normal, or 1.6%. Replacement of Endurance with the equivalent maturity type of OK05212 should have an overall favorable impact of about one-half percentage point on crop protein content.

Even more impressive was the sedimentation volumes for both candidates, which well exceeded the volume for OK Bullet (Table 15). The higher volumes, which were adjusted for any differences in flour protein content, reflect greater swelling properties of a flour suspension and can be indirectly related to bread loaf volume.

Dough quality. Information on mixograph properties provides breeders with a cursory view of dough strength, a key component of baking quality. With several measurements over years and locations, the mixograph can be highly effective in predicting baking quality from straight-dough formulations. Specifically, the mixograph measures the resistance, or tolerance, to mixing of a flour-water dough sample. From a time-course drawing, the mixograph curve, or mixogram, rises to a peak as the gluten-starch complex develops with mixing and then falls as it degrades with further mixing. The rate at which the curve rises and falls provides a measure of mixing tolerance, often quantified as *mixograph stability*, for which higher values indicate lower tolerance and dough strength (greater rate of rise and fall). The narrowing of the curve after the peak also provides a measure of mixing tolerance, and is typically measured about two minutes beyond the time at which a dough reaches peak development (two minutes past peak). Aside from environmental deviations, a very short mixing time (< 3 minutes) coupled with high mixograph stability value (>10) and low curve width (< 10 mm) is indicative of poor mixing tolerance and dough strength. Note that mixograph stability is inversely related to farinograph stability, estimated by the time in minutes for which the farinograph curve remains above a standardized base level. Higher, but not excessive, values of stability (10 to 18 minutes) are desirable, because they indicate greater mixing tolerance and the capacity to withstand longer fermentation times during commercial processing.

Both candidates were within the norm for all mixograph properties, indicating they exhibit desirable dough strength. Slight superiority might be given to OK05526, as it produced a wider mixogram (17.2 mm vs. 15.0 mm for OK05212) after peak dough development (Table 17). Mixing time tended to be 1.5 min longer for OK05526 (5.0 min vs. 3.5 min for OK05212) but within the acceptable range. Superior dough strength for OK05526 is manifested in the following mixograms (upper) and farinograms (lower) from 2009 using multi-location composite flour samples of each candidate (data provided by R. Chen, USDA-ARS, Manhattan, KS). OK05526 produced a wider mixograph curve and a lower rate of descent after the peak.



Contrary to predominant selection patterns in HRW breeding programs, OK05526 and OK05212 contained the HMW-GS *Glu-D1* subunit pair 2+12, which is generally thought to confer less desirable dough characteristics compared with subunit pair 5+10, by far the more frequent *Glu-D1* subunit among OSU advanced lines (data provided by P. Rayas-Duarte; Table 18). The disparate *Glu-D1* subunit identity for OK05212 in 2009 is likely in error, because marker analysis of this line in the 2010 SRPN confirmed the presence of alleles *Glu-D1-Dx2* and *Glu-D1-Dy12* (data provided by G. Bai, USDA-ARS, Manhattan, KS). OK05526's LMW-GS subunit composition cannot yet be resolved given the highly inconsistent results from two years. OK05212 had the LMW-GS *Glu-A3c* allele, which is the most common allele in the literature. The LMW subunits c, g, and c (*Glu-A3*, *-B3*, and *-D3*, respectively) present in OK05212 are also present in the cultivar Jagalene, which is considered a good reference in terms of end-use properties.

To better approximate the forces exerted on dough during the extensional phases of processing (i.e., following dough mixing), dough samples of OK05526 and OK05212 were subjected to uniaxial extension tests using the TA Texture Analyzer (essentially a rheometer). Two attributes were measured: the maximum force required to extend the dough (resistance, or dough strength) and the distance to which the dough could be extended before breakage. Ideally, a flour destined for pan production needs moderate to good gluten strength combined with good extensibility. OK05526 showed the ideal set of parameters by producing the highest values for extensibility and resistance combined (Table 19). Further, its gluten index value, which quantifies the ratio of large-to-small gluten aggregates in a dough sample, was among the highest among all experimental lines tested in each year. Larger aggregates are typically related to higher dough strength, though differences may be difficult to detect given that

gluten index measurements were originally designed to discriminate among dough samples from divergent hardness classes (i.e., soft vs. hard). Although OK05526 and OK05212 generally met or exceeded acceptable thresholds for each attribute in Table 19, OK05526 warrants further examination for its potentially exceptional combination of strength and extensibility.

Experimental baking. Four consecutive years of experimental baking using the straight-dough method did not reveal any serious weaknesses for either candidate (Table 20). The only separation of OK05526 and OK05212 occurred in loaf volume, with OK05526 usually producing higher volume by a mean of 5%. Bake absorption and visual characteristics, such as crumb grain and texture, were acceptable for both candidates and similar to the high-quality check cultivar, Billings.

Results reported in the remaining two tables were derived from external evaluations by USDA-ARS in two years differing widely in wheat protein content: 2008 with low protein (Table 21) and 2009 with normal protein (Table 22). Conclusions drawn from this analysis are not substantively different from those already made from our own internal evaluations. The larger kernel size of OK05526 was confirmed as was its high farinograph stability.

Quality profiles

OK05526 has slightly above-average test weight patterns and exceptional test weight potential, coupled with unusually large kernel size; good straight-grade flour yield at an acceptable flour ash content and excellent bran separation based on cumulative ash curves (provided in the 2009 WQC evaluation); and below-average kernel hardness, which may be favorably linked to its excellent flour refinement pattern. With appropriate fertilization practices, OK05526 will exceed 12% in wheat protein with normal wheat-to-flour protein loss. Dough strength is above-average, as manifested in appealing mixograms (5.0 min mix time, 17.2 mm curve width at 2 min past the peak, and 3.3 mixing tolerance on a 0-to-6 scale), farinograms (5.2 min peak time and 27 min stability), and alveograms (0.70 P/L ratio and 263 W value). Straight-dough bake mixing time is medium-long or about 5 minutes. Bake absorption, assuming normal wheat protein patterns, should exceed 60%, and pup loaf volume should exceed 850 cc. Crumb grain, texture, and color are acceptable; moreover, visual attributes of baking quality are indistinguishable from OK Bullet and Billings, two HRW cultivars with an established record of excellent baking quality. OK05526 has the HMW glutenin subunits 2*, 7+8, 2+12 (*Glu-A1*, *-B1*, and *–D1*, respectively).

OK05212 shows average test weight patterns, but below-average kernel size that is commensurate with its later maturity; average straight-grade flour yield at an acceptable flour ash content; and below-average kernel hardness based on either ground particle size or resistance to crushing. With appropriate fertilization practices, OK05212 will exceed 12% in wheat protein with normal wheat-to-flour protein loss. Dough strength is average, as manifested in mixograms of 3.5 min mix time, 15 mm curve width (2 min past peak), and 2.9 mixing tolerance (0-to-6 scale), farinograms of 3.8 min peak time and 12 min stability, and alveograms of 0.63 P/L ratio and 242 W value. Straight-dough bake mixing time is short or about 2.7 minutes. Bake absorption, assuming normal protein patterns, should exceed 61%, and pup loaf volume should easily exceed 850 cc. Crumb grain is about 4 on a 0-to-6 scale; overall visual attributes of baking quality are indistinguishable from Billings but possibly inferior

to OK Bullet, two HRW cultivars with an established record of excellent baking quality. OK05212 has the HMW glutenin subunits 1, 7+8, 2+12 (*Glu-A1*, *-B1*, and *–D1*, respectively).

Both genotypes are non-carriers of any wheat-1RS rye translocation. Other translocations are unknown or untested.

Summary Justification

OK05526-RHf

With the exception of Billings and Pete, which were released by the OAES in 2009, most OSU wheat cultivars fall into a maturity range of intermediate (Duster) to moderately late (Endurance). OK05526-RHf thus fills a maturity niche in cultivar choice currently addressed outside of the OSU wheat improvement program. OK05526-RHf provides an early-maturity option with a level of winter-hardiness similar to Endurance and equivalent or superior to other cultivars from more northern locales (K. Campbell, 2010, personal communication), and with top-end yield potential that merits a management scheme designed to maximize yield expression.

Its high yield potential is matched with quality traits exceeding expectations of millers for kernel size and bran separation, and exceeding expectations of bakers for reliable dough strength at a desirable level of protein. While this unique combination of yield potential and quality may be found in Billings, OK05526-RHf provides an alternative genetic background and a level of grazing tolerance—combined with Hessian fly and BYDV tolerance—that is expected to exceed Billings. Though more regional testing is needed, OK05526-RHf would be expected to move more northward in its range of adaptation than Billings. Finally, OK05526 represents a significant step forward by the WIT in achieving tan spot resistance. Duster is also considered resistant, but its physiological leaf spotting pattern produces symptoms similar to tan spot. OK05526 shows neither blemish.

OK05212

The cultivar Endurance was released by the OAES in 2004 and brought significant improvement in grain yield and dual-purpose capability to the southern Great Plains. Endurance will likely continue to command acreage in central and northwest areas of Oklahoma, especially where dual-purpose producers lean their priorities and interests toward beef production. At equivalent maturity, OK05212 offers vast improvement over Endurance in grain-only production environments, and in a grain-focused dual-purpose environment.

Grain yielding ability of OK05212 should exceed Endurance by 5 to 10% across a wide range of production environments (grain-only and dual-purpose). The superior yielding ability of OK05212 is most noticeable where late winter freeze events severely interrupt reproductive development of early-maturity cultivars such as many Jagger derivatives, Billings, and Pete. Endurance has this capability too, but it is even more apparent in OK05212. Specific traits for which OK05212 offers improvement, if not a garrison of protection, over Endurance are 1) superior resistance to stripe rust, spindle-streak mosaic virus, and septoria leaf blotch, 2) even better yielding ability in low-pH soils, 3) improved test weight stability, and 4) improved protein content and mixing tolerance in the complete absence of any wheat-1RS rye translocation. OK05212 may provide a similar level of protection to BYDV as Endurance.

OK05212 extends very well geographically and edaphically in dryland as well as water-logged soil environments. This plasticity, and ability to distinctively fulfill a late-maturity option in cultivar choice exercised by an individual producer, provides ample justification for its release. Wheat producers in the southern Plains are continually reminded to diversify their operations with a reasonable range of plant maturities as a risk-averse strategy to cope with unpredictable micro-climate change.

Probable Area of Adaptation and Limitations

OK05526-RHf

In regional uniform testing in 2010, OK05526 showed superior yielding ability at Bushland, TX with supplemental irrigation, Chillicothe, TX, and Winfield, KS. In the 2010 OSU WVT, it performed exceptionally well in northeastern Oklahoma. The primary range of adaptation for OK05526-RHf should extend across Oklahoma, and Its secondary range of adaptation should extend further north into Kansas and Nebraska. With excellent top-end yield potential, OK05526-RHf would be the first cultivar released by OSU targeted for intensive management schemes, a practice that is coming into vogue in the Great Plains. OK05526-RHf should also be the first OSU HRW cultivar to be recommended for contract production to ensure 1) direct delivery of enhanced end-use value to millers and bakers and 2) direct value capture by producers. These expectations would not necessarily demand vast acreages of OK05526-RHf production but instead place demand on Oklahoma's prized wheat acreage.

Chronic infection of stripe rust or severe soil acidity would present the greatest risks for OK05526-RHf, as it appears to offer no more innate protection than either Endurance for stripe rust (especially to race PST100) or Fuller for acidic soils. Intensive management schemes for which OK05526-RHf would be targeted should feature a foliar fungicide for protection against stripe rust, and soil pH should be appropriately managed. Additionally, with the elevated emphasis on grain production, OK05526-RHf would not be positioned necessarily for dual-purpose systems. Risks associated with this misdirection would be relatively low, however, because OK05526-RHf has the built-in insurance of above-average ability to be grazed and adaptation to early-planted management systems.

OK05212

OK05212 is widely adapted across Oklahoma and surrounding states, especially Texas and Kansas. Its later maturity would naturally favor a more northward progression of adoption. OK05212 is susceptible to Hessian fly, and thus it should not be planted in areas with a history of severe Hessian fly infestation. In Oklahoma, OK05212 may also show modest signs of leaf rust infection during the final stages of grain filling. Otherwise, it retains exceptional leaf hygiene. With very limited examination, OK05212 was observed to be preferentially and severely grazed under experimental dual-purpose conditions. In commercial conditions this choice would not be expressed, unless OK05212 is blended with another less preferred cultivar(s) or planted in contiguous wheat pastures featuring other cultivars.

Varietal Replacement: OK05526-RHf

Cultivar	Anticipated superior attribute of OK05526-RHf justifying replacement
Endurance	Yielding ability in the absence of late winter freeze events
	Test weight
	Kernel size
	Hessian fly resistance
	Tan spot resistance
	Dough strength and overall baking quality
	Earlier maturity
Duster	Yield responsiveness
	Kernel size and associated milling attributes

Varietal Replacement: OK05212

Cultivar	Anticipated superior attribute of OK05212 justifying replacement
Endurance	Higher yield potential
	Test weight stability
	Stripe rust resistance
	Spindle-streak wheat mosaic virus resistance
	Septoria leaf blotch resistance
	Yielding ability in highly acidic soils
Duster	Kernel size
	Stripe rust and septoria resistance

Seed Production Plan and Status

Breeder seed will be maintained by the OSU wheat breeding project, whereas foundation seed will be maintained by OFSS. Production of more than 2000 bushels foundation seed of OK05212 is expected in 2011 from multiple locations in Oklahoma. About 300-400 bushels foundation seed of OK05526-RHf should be produced in 2011 from a single location.

Certification Classes

Certification classes of seed production recognized for each line should be Foundation, Registered, and Certified.

Proposed Method of Release

Both candidates should be protected under U.S. Plant Variety Protection, with the Title

V option. Both should be released through Oklahoma State University's wheat cultivar licensing program. Application for plant variety protection will be filed within one year of date of first commercial sale of seed.

Cooperating Scientists

Evaluation of both candidate cultivars was accomplished through OSU's Wheat Improvement Team, as well as breeders throughout the Great Plains associated with the Hard Winter Wheat Performance Nursery Program. They represent state Agricultural Experiment Stations, the USDA-ARS, and private companies. Special assistance was provided by Ming Chen, Lab Director and Research Entomologist, USDA-ARS and Dept. of Entomology, Kansas State Univ., and by Richard Chen with the USDA-ARS Hard Winter Wheat Quality Laboratory. Others assisting in the development or release of these cultivars were credited at the beginning of this report.

Draft: 12/30/10
Final: 2/4/11

Table 1. Grain yield comparisons in replicated breeding nurseries varying from 2 to 10 environments per year.

Entry	2005-A	2005-B	2006	2007	2008	2009	2010	2006-2010
	- - - - - - - - - - bu/ac [a] - - - - - - - - - -							
OK05526	45	--	53	63	51	37	49	**51**
OK05212	--	61	49	63	48	47	49	**51**
Endurance	49	--	48	--	--	43	45	**--**
Duster	--	--	--	--	--	45	52	**--**
OK Bullet	--	--	53	65	45	41	41	**49**
LSD (0.05)	*14*	*7*	*4*	*11*	*6*	*4*	*tba*	--
Winfield							‡	
Cherokee						‡	‡	
Lahoma		‡	‡		‡	‡	‡	
Kingfisher						‡	‡	
Coyle or Marshall - DP					‡	‡	‡	
Coyle - GO					‡	‡		
Ft. Cobb		‡	‡	‡		‡		
Sweetwater					‡	‡		
Granite/Hobart/Altus	‡		‡	‡	‡	‡	‡	
Goodwell-irrigated	‡			‡	‡	‡	‡	
Goodwell-dryland					‡[b]	‡	‡	
Stillwater			‡					

[a] Means highlighted in yellow were within one LSD value of the highest yielding entry in a given nursery.

[b] Yield recorded in 2008 at Goodwell-dryland, but not included in the across-years analysis.

Table 1
Grain yield by year
Breeding trials

Table 2. Grain yield comparisons (bu/ac) in replicated breeding nurseries at key regional testing sites in the state, or in a dual-purpose management system.

	Altus/Hobart/Hobart (Southwest)							
Entry	2005-A	2005-B	2006	2007	2008	2009	2010	2006-10
OK05526	58	--	56	30	44	29	57	**43**
OK05212	--	--	55	37	33	31	54	**42**
Endurance	52	--	53	--	--	25	47	**--**
Duster	--	--	--	--	--	34	56	**--**
OK Bullet	--	--	59	42	54	32	37	**45**
LSD(0.05)	*10*	--	*5*	*8*	*14*	*7*	*7*	

	Lahoma (North Central)							
Entry	2005-A	2005-B	2006	2007	2008	2009	2010	2006-10
OK05526	--	--	74	--	74	48	24	**55**
OK05212	--	64	65	--	69	52	34	**55**
Endurance	--	--	64	--	--	47	24	**--**
Duster	--	--	--	--	--	44	32	**--**
OK Bullet	--	--	66	--	58	51	21	**49**
LSD(0.05)	--	*9*	*7*	--	*8*	*4*	*6*	

	Goodwell-irrigated (Panhandle)							
Entry	2005-A	2005-B	2006	2007	2008	2009	2010	2007-10
OK05526	32	--	--	113	38	82	72	**76**
OK05212	--	--	--	113	47	86	70	**79**
Endurance	46	--	--	--	--	87	66	**--**
Duster	--	--	--	--	--	76	82	**--**
OK Bullet	--	--	--	115	43	78	69	**76**
LSD(0.05)	*10*	--	--	*16*	*8*	*8*	*12*	

	Goodwell-dryland (Panhandle)							
Entry	2005-A	2005-B	2006	2007	2008	2009	2010	2007-10
OK05526	51	--	--	60	16	30	61	**42**
OK05212	--	--	--	82	20	44	61	**52**
Endurance	59	--	--	--	--	43	58	**--**
Duster	--	--	--	--	--	42	60	**--**
OK Bullet	--	--	--	36	18	31	61	**37**
LSD(0.05)	*1 rep only*	--	--	*1 rep only*	*4*	*5*	*8*	

	Dual-purpose						
	2008		2009		2010		
Entry	Coyle	Sweet-water	Coyle	Sweet-water	Marshall	Sweet-water	2009-10
OK05526	53	39	16	26	45	42	**32**
OK05212	50	32	30	37	40	47	**39**
Endurance			24	36	40	37	**34**
Duster			28	39	52	35	**39**
OK Bullet	42	33	26	39	30	34	**32**
LSD(0.05)	5	6	*4*	*6*	*7*	*tba*	

Means highlighted in yellow were within one LSD value of the highest yielding entry in a given nursery.

Table 2
Grain yield by state region

Table 3. Grain yield and test weight of OK05526 and OK05212 versus several contemporary varieties tested in the OSU Wheat Variety Trials in 2009 and 2010 (data provided by Jeff Edwards).

	2009 (14 sites)		**2010** (11 sites)	
Entry	Yield	Test weight	Yield	Test weight
	bu/ac	lb/bu	bu/ac	lb/bu
Endurance	41	55.6	44	55.6
TAM 203	39	54.5	36	55.9
Duster	38	55.5	49	57.6
Santa Fe	38	56.0		
Doans	36	58.2	41	59.0
OK05526	**36**	**56.9**	**45**	**57.5**
OK05212	*not tested in 2009*		**44**	**56.5**
Jagalene	35	56.5		
Deliver	34	56.8		
Fuller	34	55.9	41	57.0
OK Bullet	33	57.3		
Shocker	32	55.0		
Jagger	32	55.2	38	56.0
Jackpot	31	55.6	44	57.1
Overley	31	56.0		
LSD (0.05)	6	1.2	2	0.6

Means highlighted in yellow were in the statistically highest yielding group for the given varieties in each year.

Table 4. **Test weight** comparisons from 5 years of statewide breeder trials with 3 to 9 environments per year.

Entry	2006 Mean (*n* =4)	2006 Min	2006 Max	2007 Mean (*n* =3)	2007 Min	2007 Max	2008 Mean (*n* =5)	2008 Min	2008 Max	2009 Mean (*n* =9)	2009 Min	2009 Max	2010 Mean (*n* = 7)	2010 Min	2010 Max	5-yr mean (*n* =28)	Deviation from Endurance[a]	Deviation from OK Bullet[a]
	lb/bu			lb/bu			lb/bu			lb/bu			lb/bu			lb/bu		
OK05526	**62.2**	**61**	**63**	**59.3**	**55**	**62**	**58.9**	**56**	**64**	**57.0**	**54**	**61**	**58.4**	**54**	**63**	**58.7**	**0.6**	**-0.9**
OK05212	**61.5**	**61**	**62**	**58.6**	**53**	**62**	**58.1**	**55**	**63**	**56.4**	**53**	**59**	**58.2**	**54**	**62**	**58.1**	**0.1**	**-1.5**
Endurance	61.4	61	62	--	--	--	--	--	--	56.5	53	61	57.8	54	61	--	0.0	-2.0
OK Bullet	63.0	62	64	59.1	55	62	58.3	54	63	58.9	56	61	59.6	56	62	59.6	2.0	0.0
Trial mean	61.9	61	63	57.4	52	61	58.0	54	63	57.1	55	60	58.4	55	62	58.3	0.6	-1.3
LSD (0.05)	0.6			2.4			0.8			0.7			*tba*					
No. of sites<58 lb/bu	0			1			3			6			3			13		
No. of sites<56 lb/bu	0			1			1			4			2			8		

[a] Positive deviations indicate the corresponding entry is superior to Endurance or to OK Bullet, whichever the comparison made.

Table 4
Test weight
Breeding trials

Table 5. Consensus **foliar disease** reactions from field and greenhouse environments, 2005-2010. More detailed data located in Exhibit 4.

		Leaf rust					Stripe rust			Viruses						
			Adult-plant[a]					Adult-plant[b]							Green-leaf duration[d]	
Year	Entry	Seedling	Oklahoma average	Lahoma Early	Lahoma Late	Hunger (Stillwater)	USDA Seedling	Oklahoma average	USDA	WSBMV	WSSMV[c]	Powdery mildew *adult*	Tan spot *seedling*	Septoria *seedlin* g	Early	Late
			(0-4)	----(0-4 or 1-4)----		(1-9)	(0-9)	(0-4)				(0-4)	(1-4)	(1-9)	-------(1-9)-------	
2010	**OK05526**	**R**	**1**	**NA**	**NA**	**NA**	**8**	**1.3**	**85% (8/2)**	**R**	**R**	**1**	**R**	**S**	NA	**6.8**
	OK05212	**S**	**1.5**				**8**	**0.0**	**2% (1)**	**R**	**R**	**1**	**I**	**R**	on 1-9	**4.0**
	Endurance	S	1.0				NA	0.8	60% (5)	R	MS	0	**S**	**S**		6.5
	OK Bullet	Rseg	3.5					0.5	30% (8)	R	R	1	I	S		7.5
	Duster	MR	0.0					0.0	30% (5)	R	R	0	R	S		6.2
	Billings	MR	1.0					0.3	1% (2)	MR	R	3	S	S		4.7
	Fuller	Rseg	0.5					1.5	20% (8)	MR	MR	1	S	S		6.8
2009	**OK05526**	**MR**	**0.5**	**1**	**3**	**1**	**8**	**NA**	**70% (8)**	**R**	**R**	**1**	**NA**	**NA**	**4.5**	**7.8**
	OK05212	**S**	**0.7**	**1**	**--**	**4**	**6**		**2% (2)**	**R**	**R**	**0**			**4.0**	**5.0**
	Endurance	S	0.5	1	1	1	NA		50% (6)	R	I	0			5.0	5.7
	OK Bullet	S	3.0	3	4	5			2% (2)	I	R	2			4.5	5.7
	Duster	R	0.0	0	0	1			70% (4)	R	R	0			4.5	6.7
	Billings	MR	0.0	0	0	1			2% (2)	R	I	2			4.5	7.3
	Fuller	S	0.3	0	--	1			1% (1)	R	R	1			4.0	7.0
2008	**OK05526**	**S**	**NA**	**0.0**	**0.0**	**1**	**8**	**0.0**	**90% (8)**	**R**	**R**	**NA**	**3.9**	**NA**	**4.5**	**8.0**
	OK05212	**S**		**0.0**	**0.5**	**2**	**6**	**0.0**	**5% (3)**	**R**	**R**		**3.0**		**5.0**	**7.5**
	Endurance	S		0.5	1.0	1	6	0.0	50% (6)	R	S?		4.0		5.0	6.0
	OK Bullet	MS		0.0	1.5	4	6	0.0	10% (6)*	R	R		3.0		5.0	7.5
	Duster	R		0.5	0.5	1	7	0.0	70% (6)	R	R		4.0		6.0	7.0
	Billings	MR		0.0	0.0	1	4	0.0	5% (2)	R	S?		4.0		4.0	6.5
	Fuller	MR		0.0	0.5	1	6	0.0	10% (6)	R	R		4.0		4.0	5.5
2007	**OK05526**	**MR**	**0.3**	**0**	**1**	**1**	**MS**	1	**NA**	**R**	**R**	**2**	**1.3**	**--**	**3.0**	**5.0**
	OK05212	**MS**	**1.0**	**2**	**4**	**1**	**S**	0		**R**	**R**	**0**	**2.5**	**5.2**	**4.0**	**7.0**
	Endurance	S	0.8	1	1	1	S	0		R	S	0	3.0	6.3	5.0	6.5
	OK Bullet	Rseg	0.8	1	3	2	I	0		R	R	2	3.0	4.5	3.0	7.0
	Duster	R	0.5	1	0	1	S	0		R	R	1	3.6	6.4	4.0	6.5
	Billings	MR	0.3	0	2	1	MS	0		R	R	1	3.0	6.3	3.0	7.0
2005	**OK05526**	**R**	**NA**	**NA**	**1**	**NA**	**NA**	**1.5**	**NA**	**R**	**NA**	**NA**	**NA**	**NA**	**6.0**	**NA**
	OK05212	**S**			**3**			**0.0**		**IC**					**3.5**	
	Ok101	MS			2			3.0		MS	MS				7.0	

Readings collected by B. Carver and R. Hunger; USDA reactions to stripe rust provided by Robert Bowden, USDA-ARS, Manhattan, KS. APR = adult-plant resistance

[a] Leaf rust reaction recorded on a 0 (highly resistant) to 4 (very susceptible) scale, except in 2005, 2006 (1-to-4 scale).

[b] OSU stripe rust reactions recorded in the field at Lahoma (2008), Goodwell (2007), and multiple locations in 2005 and 2010; for USDA adult-plant readings, 'sdlg' indicates that seedling resistance is likely expressed in the adult plant; x% (y) indicates % severity of given infection type on scale of 1 (resistant type) to 9 (highly susceptible type), flag leaf, early milk stage; * indicates segregating reaction. Note race change in 2010 in the field.

[c] IC = inconsistent ratings (resistant to susceptible) among assays.

[d] Green-leaf duration values are derived as the mean of multiple ratings taken in the OET in several Oklahoma environments during mid to late grain-fill.

Table 6. **Hessian fly** reaction in the field (yellow) using reproductive inhibition as a quantitative indicator of field tolerance, and in the greenhouse (green) based on qualitative response of seedlings to the Great Plains biotype (greenhouse data provided by Ming Chen, USDA-ARS, Manhattan, KS; field data provided by Kris Giles).

Entry	2007 [a]	2008	2009 Seedling OET3	2009 Seedling RGON	2010	2009 field
	- - - - - - - - - - % resistant plants - - - - - - - - - -					flies/tiller
OK05526	**62**	**4**	**29**	**47**	**22**	**0.8**
OK05526-RHf	**--**	**--**	**--**	**--**	**88**	**--**
OK05212	**0**	**0**	**0**	**5**	**0**	**7.8**
Endurance	4	11	0	NA	0	5.5
OK Bullet	0	4	7		0	4.9
Centerfield	0	61	89		84	0.4
Duster	33	93	90		80	0.0
Billings	0	0	0		0	4.6
Field trial range						0.0 - 7.9
Field trial mean						3.2
LSD (0.05)						2.6

[a] 2007 assay may have been contaminated with a more virulent biotype

Table 7. **Acid-soil tolerance** field ratings (0-5 scale) collected from OET nurseries conducted at Enid, OK, 2005-2010, pH<4.5.

Entry	Year	Juvenile	Early adult	Adult	**Consensus rating**
OK05526	2005	3	4	4	
	2006	4	3	2	
	2007	--	4	2	
	2008	3	3	2	
	2009	4	3	2	
	2010	4	4	3	
	Mean	**3.5**	**3.6**	**2.5**	**I**
OK05212	2005	4	3	2	
	2006	2	3	3	
	2007	--	3	2	
	2008	0	0	0	
	2009	0	0	2	
	2010	1	1	1	
	Mean	**1.3**	**1.7**	**1.7**	**T**
OK05511	2005	4	4	3	
	2006	3	1	0	
	2007	--	3	3	
	2008	2	4	1	
	2009	2	3	2	
	2010	3	4	2	
	Mean	**2.9**	**3.1**	**1.9**	**I**
OK Bullet	2005	3	3	1	
	2006	11	2	2	
	2007	--	4	3	
	2008	1	1	1	
	2009	2	3	3	
	2010	2	3	3	
	Mean	**3.7**	**2.6**	**2.2**	**MT**
Duster	2005	2	3	1	
	2006	2	2	2	
	2007	--	1	1	
	2008	1	2	1	
	2009	0	1	1	
	2010	1	2	1	
	Mean	**1.2**	**1.9**	**1.1**	**T**
Endurance	2005	2	2	1	
	2006	2	2	3	
	2007	--	2	1	
	2008	2	2	1	
	2009	1	1	1	
	2010	1	2	1	
	Mean	**1.5**	**1.7**	**1.3**	**T**
Fuller	2008	3	4	4	
	2009	4	5	4	
	2010	4	4	4	
	Mean	**3.8**	**4.3**	**3.9**	**S**

n =1 to 3 observations per entry-year

Table 8. **Acid soil tolerance** measured in 2010 as visual scores from 0 (highly tolerant) to 5 (highly susceptible) and as grain yield in replicated trials of the OET and Texas-Oklahoma UVT at Enid , OK (pH<4.5).

	Adult plant visual rating			Grain yield	
Entry	OET	UVT	Visual tolerance rating	OET	UVT
	(0 - 5)			bu/ac[a]	
OK05526	**3.0**	**2.3**	**Intermediate**	**34**	**38**
OK05212	**1.0**	**0.3**	**Highly Tolerant**	**55**	**57**
Duster	0.7	0.0	Highly tolerant	56	51
Endurance	0.7	0.7	Tolerant	47	44
Billings	1.7	0.3	Tolerant	44	53
Jackpot	1.7	1.0	Tolerant	55	55
OK Bullet	3.0	2.7	Intermediate	37	29
Fuller	4.0	2.0	Susceptible	29	34
TAM 203	5.0	4.7	Very susceptible	20	24
Trial mean	**2.4**	**1.7**		41	43
LSD (0.05)	1.3	1.2		8	9

[a] Means highlighted in yellow were within one LSD value of the highest yielding entry in a given nursery.

Table 9. **Dual-purpose adaptive traits** collected from three to four years of early-planted breeding nurseries established for grazing.

	Fall forage rating[a]								**Fall growth habit**[b]								**Grazing recovery (visual)**[c]		
	Breeder nurseries						TX-OK UVT		Breeder nurseries					UVT					
Entry	2006 3 sites	2008 Coyle-1	2008 Coyle-2	2009 Coyle	2010 Marshall	2010 Granite	2009 Coyle	2010 Granite	2006 2 sites	2008 Coyle	2009 Coyle	2010 Marshall	2010 Granite	2009 Coyle	2010 Granite	Con-sensus	2006 Sweetwater	2008 Coyle	2010 Marshall
	(1 - 5)								(1 - 4)								(1 - 5)		
OK05526	**2.3**	**1.3**	**1.7**	**2.3**	**3.0**	**3.0**	**2.7**	**2.7**	**2.0**	**1.7**	**2.0**	**2.0**	**2.7**	**2.3**	**2.7**	**SE**	**1.5**	3.0	1.3
OK05212	**1.7**	**1.7**	**1.7**	**2.3**	**2.0**	**1.0**	**--**	**2.0**	**2.0**	**1.3**	**2.0**	**1.7**	**2.3**	**--**	**2.7**	**SE**	**1.5**	3.0	2.7
Endurance	3.3	2.7	2.7	2.7	3.0	3.0	2.3	3.3	2.5	3.0	3.0	2.0	3.0	2.7	3.0	SP	1.0	1.7	1.0
OK Bullet	1.3	1.3	1.3	1.7	2.3	3.0	1.7	3.7	1.0	1.0	1.3	1.0	2.7	1.0	2.0	E	2.5	3.3	3.3
Duster	--	3.0	3.3	1.0	2.3	2.0	2.3	3.7	--	2.0	2.0	2.0	3.0	2.0	3.3	SE	--	2.3	1.3
Billings	--	2.3	2.0	2.7	4.0	1.0	4.0	1.7	--	2.3	3.3	3.0	3.0	4.0	4.0	SP	--	3.0	1.0
Fuller	--	3.3	4.7	5.0	3.0	3.0	5.0	3.0	--	4.0	4.0	2.0	3.7	4.0	3.0	P	--	3.0	1.3
Trial mean	2.6	2.1	2.1	2.3	2.8	2.5	2.6	3.1	2.3	2.0	2.3	2.1	2.9	2.2	2.9	--	1.7	2.7	1.8
LSD (0.05)	--	1.1	1.2	1.1	1.0	1.3	1.1	1.2	--	0.8	0.5	0.6	0.7	0.5	0.6	--	0.9	1.1	1.3

[a] Forage ratings taken on scale of 1 (best) to 5 (worst) at Lahoma and Goodwell (irrigated and dryland nurseries) during late fall, 11 Oct. 2007 (2008 Coyle - 1) and 16 Nov. 2007 (2008 Coyle - 2), 30 Oct. 2008 (2009 Coyle), 19 Nov. 2009 (2010 Marshall), 17 Nov. 2009 (2010 Granite).

[b] Growth habit rated as 1 (erect, E), 2 (semi-erect, SE), 3 (semi-prostrate, SP), and 4 (prostrate, P) during the mid-vegetative period.

[c] Grazing recovery ratings taken on scale of 1 (best) to 5 (worst) 2-3 weeks after grazing termination.

Table 10. Relative ratings for winter dormancy release statewide, actual measurements of first hollow stem (FHS) stage collected at Stillwater (by Jeff Edwards), and genotypes at key developmental loci (identified by Liuling Yan).

	Dormancy Release (visual)[a]				First hollow stem		Allele identity[b]
Entry	2006	2008	2009	2010	2009	2010	*VRN-A1/PPD-D1/VRN-D3*
	- - - - - - - (1 - 5) - - - - - -				d of yr		
OK05526	1.0	2.0	2.5	2.8	63	76	BBA
OK05212	4.0	3.3	3.5	3.3	--	78	BBB/BAB
Endurance	3.5	3.8	4.0	4.3	67	76	BBB
Duster	2.5	2.8	3.0	3.2	66	76	BBB
OK Bullet	3.0	2.5	2.5	3.3	61	70	BAA
Billings	2.0	3.5	2.5	2.2	56	66	BBB
Fuller	--	2.8	1.5	3.0	58	66	BAA
Mean	3.4	3.4	3.0	3.2	62	72	--

[a] Visual scale represents gradually delayed dormancy release relative to the nursery evaluated, ranging from 1 (very early) to 5 (very late). Measured at Lahoma in 2006, Hobart and Goodwell in 2008, Lahoma and Goodwell in 2009, and Granite and Goodwell in 2010.

[b] Genotype designations correspond to the same allele found in Jagger (A) or 2174 (B). Jagger alleles at *VRN-A1* and *VRN-D3* accelerate development, whereas the Jagger allele at *PPD-D1* delays it. Alleles for 2174 have opposite effect for each gene. Allele identity for OK05526 determined by assaying multiple plants of OK05526-RHf.

Table 11. **Heading date** recorded at three Oklahoma locations in four of the past five years (2006 to 2010).

	Stillwater (ST)[a]						Lahoma (LA)[a]						Goodwell irrigated (GD)[a]						Average	
Entry	06	07	08	09	10	M	06	07	08	09	10	M	06	07	08	09	10	M[b]	Diff.[c]	ST, LA, GD
	d after 31 March																			
OK05526	**12**	**21**	**22**	NA	**29**	**21**	**15**	**20**	**28**	NA	**28**	**23**	**23**	**34**	**37**	**39**	**40**	**33**	**12**	**26**
OK05212	**16**	**22**	**24**		**33**	**24**	**19**	**24**	**31**		**29**	**26**	**28**	**36**	**37**	**41**	**42**	**36**	**12**	**28**
Endurance	16	22	26		30	**24**	19	24	31		30	**26**	28	37	38	40	41	**36**	**13**	**28**
Duster	13	22	25		33	**23**	17	24	31		30	**26**	27	40	39	40	42	**37**	**14**	**29**
OK Bullet	16	21	23		33	**23**	17	25	29		30	**25**	29	36	36	41	42	**36**	**13**	**28**
Billings	13	11	21		28	**18**	15	20	28		28	**22**	26	35	37	40	40	**34**	**16**	**25**
Fuller	--	--	21		33		--	--	29		29		--	--	37	37	41	**39**		
Trial mean	**15**	**23**	**24**		**32**	**23**	**18**	**25**	**29**		**24**	**24**	**28**	**36**	**37**	**39**	**41**	**36**		
LSD (0.05)	--	--	--			--	--	2	1			--	--	1	1	1		--		

[a] Single-replicate data taken at Stillwater; two replicates from Lahoma and Goodwell-irrigated.

[b] Each entry x site mean (M) does not include 2009 data.

[c] Diff. = mean heading date at Goodwell irrigated minus the mean heading date at Stillwater.

Table 12. **Shattering loss ratings** collected on a non-linear scale of 0 (no shattering) to 4 (spike disarticulation) across Oklahoma from 2005 to 2010 (no significant shattering in 2009), with environments ordered from lowest mean shattering potential to highest.

	Shattering potential and environment code								
	Low			Moderate				High	
Entry	06AL	07HB	07GDD	05AL	06LA	07LA	10GD	08LA	08GD
OK05526	**0**	**2**	**1**	**1**	**0**	**1**	**0**	**1.0**	**1**
OK05212	**0**	**0**	**0**	**--**	**0**	**0**	**1**	**1.0**	**2**
Overley	0	2	2	3	1	3	--	2.5	3
Big Max	--	1	3	--	--	3	--	--	--
Endurance	0	0	0	1	1	1	2	0.0	1
Jagalene	0	0	0	1	1	0	--	--	--
OK Bullet	0	0	0	0	0	0	1	0.0	0
Duster	0	0	0	0	0	1	1	0.0	0
Billings	0	0	0	0	0	0	0	0.0	0
Trial mean	0.1	0.3	0.4	0.5	0.5	0.7	0.8	1.1	1.1
LSD (0.05)								0.7	

Potential grain yield loss due to shattering rated as 0 (no apparent loss), 1 (minimal loss, <5%), 2 (significant loss, 5-30%), 3 (severe shattering with potential loss of 30-70%), or 4 (spike disarticulation).

Environment code indicates Altus (AL), Goodwell irrigated (GD), Goodwell dryland (GDD), Lahoma (LA), Ft. Cobb (FC), and Hobart (HB) in years 2005 (05) to 2010 (10).

Table 13. **Plant height** measured from 2008 to 2010 in replicated trials of the OET, nonreplicated observation nurseries at Stillwater, and the OSU Wheat Variety Trials (variety trial data provided by Jeff Edwards).

	2008	2009		2010	2010
Entry	ST	Lahoma	Goodwell-irrigated	Wheat Variety Trials[a]	SRPN[b]
		- - - - - - - - - - - cm - - - - - - - - - - -			
OK05526	**94**	**52**	**64**	**82**	**84**
OK05212	**77**	**49**	**63**	**76**	**79**
Endurance	86	48	65	78	--
OK Bullet	86	53	66	82	--
Duster	83	48	62	76	--
Billings	86	48	59	75	--
Fuller	86	45	58	78	80
TAM 107					75
Scout 66					94
Trial mean	87	47	61	--	81
LSD (0.05)		5	7		

LSD reported for only those trials with replicated data.

[a] Data collected from single replicates of variety trials at Kingfisher, Lahoma, Lamont, Marshall dual-purpose, and Marshall grain-only.

[b] Data collected from single replicates of 18 trials conducted throughout the Great Plains region.

Table 14. **Lodging ratings** collected on a scale of 1 (resistant) to 5 (highly susceptible) across Oklahoma from 2005 to 2010, with environments ordered from lowest lodging potential to highest. OSU Wheat Variety Trial data in 2010 provided by Jeff Edwards.

	Lodging potential and environment code											
	Low					Moderate			High			
Entry	08LA	08GD	09GD	05GD	06AL	09CK	05AL	07GD	07LA	07FC	07HB	10WVT
OK05526	**2.0**	**1**	**1.5**	**2.5**	**3**	**1.0**	**2**	**2.0**	**1.5**	**1.5**	**2.0**	**3.0**
OK05212	**1.5**	**2**	**2.0**	**--**	**1**	**1.3**	**--**	**1.0**	**4.5**	**3.0**	**3.5**	**2.0**
Endurance	1.5	2	1.5	1.0	1	1.3	2	2.5	3.0	2.5	3.5	3.0
OK Bullet	1.5	1	1.5	1.0	2	1.0	2	1.0	1.0	2.0	2.5	2.0
Duster	2.0	2	2.5	3.0	2	2.7	2	3.5	5.0	3.5	4.5	3.0
Trial mean	1.3	1.3	1.7	1.7	1.7	1.9	2.1	2.0	2.9	2.9	3.4	--
LSD (0.05)	0.6	--	1.1	0.8	--	1.0	--	1.2	0.9	0.6	1.0	

Environment code indicates Altus (AL), Cherokee (CK), Goodwell irrigated (GD), Lahoma (LA), Ft. Cobb (FC), Hobart (HB) in years 2005 (05) to 2007 (07), and Wheat Variety Trial (WVT) locations Alva, Cherokee, and Marshall grain-only.

Table 15. **Milling characteristics**, based on single-kernel characterization system (SKCS) and near-infrared (NIR) analysis, taken from the 2006-2010 breeding trials in 3 to 7 environments. Data provided by C.E. Shelton, OSU Wheat Quality Laboratory.

	Hardness index												SKCS																	
	NIR						SKCS						Kernel weight						Kernel diameter						Flour yield					
Entry	06	07	08	09	10	M	06	07	08	09	10	M	06	07	08	09	10	M	06	07	08	09	10	M	06	07	08	09	10	M
													-------mg-------						-------mm-------						---------%---------					
OK05526	**72**	**62**	**57**	**61**	**69**	**64**	**63**	**52**	**49**	**63**	**62**	**58**	**34.9**	**36.7**	**33.3**	**30.0**	**32.6**	**33.5**	**2.53**	**2.70**	**2.49**	**2.72**	**2.76**	**2.64**	**68.8**	**65.2**	**62.0**	**60.8**	**61.0**	**63.6**
OK05212	**72**	**59**	**58**	**58**	**68**	**63**	**68**	**59**	**57**	**67**	**67**	**64**	**30.6**	**28.8**	**26.9**	**25.0**	**27.4**	**27.7**	**2.21**	**2.10**	**2.05**	**2.42**	**2.47**	**2.25**	**68.2**	**57.8**	**61.6**	**61.7**	**61.9**	**62.2**
Endurance	78			63	72		68			66	69		31.5			28.0	28.6		2.27			2.61	2.60		67.5			62.8	61.5	
OK Bullet	88	81	76	77		**81**	77	71	73	80		**75**	33.8	32.5	28.9	28.2		**30.9**	2.52	2.56	2.32	2.67		**2.52**	69.6	64.6	62.2	61.8		**64.6**
Duster				72	80					82	80					24.8	26.8					2.55	2.57					61.3	61.9	
Trial mean	**79**	**67**	**66**	**67**	**74**	**71**	**69**	**63**	**61**	**72**	**70**	**67**	**33.4**	**30.7**	**29.5**	**27.7**	**30.0**	**30.3**	**2.44**	**2.36**	**2.29**	**2.63**	**2.66**	**2.48**	**68.0**	**62.6**	**61.3**	**61.0**	**61.3**	**62.8**
LSD (0.05)	6	5	5	3	*tba*		5	5	4	3	*tba*		1.2	3.3	1.3	1.4	*tba*		0.07	0.19	0.07	0.05	*tba*		1.5	3.1	2.2	0.5	*tba*	
Target range	>60						>60						>29.0						>2.20						>62.0					

Data from 2005 not included because the experimentals were tested in different pairs of environments.

Number of environments in each year were 4 (2006), 3 (2007), 6 (2008), and 7 (2009, 2010).

Where highlighted, a given entry was significantly worse than (red) or better than (blue) OK Bullet. Comparison not available for 2010.

Table 16. **Protein content** from near-infrared analysis and protein quality based on **sedimentation volume** adusted for flour protein, taken from the 2006-2010 breeding trials in 3 to 7 environments. Data provided by C.E. Shelton, OSU Wheat Quality Laboratory.

	Wheat protein (12% mb)						Flour protein (14% mb)						Adusted sedimentation volume					
Entry	06	07	08	09	10	M	06	07	08	09	10	M	06	07	08	09	10	M
	- % -												- - - - - - - - - - mL - - - - - - - - - -					
OK05526	**13.0**	**12.5**	**11.6**	**13.1**	**13.6**	**12.8**	**11.6**	**11.0**	**10.2**	**11.6**	**11.9**	**11.3**	**NA**	**7.8**	**8.2**	**7.3**	**7.4**	**7.7**
OK05212	**12.7**	**12.4**	**12.2**	**12.7**	**13.2**	**12.6**	**11.3**	**11.1**	**10.8**	**11.3**	**11.7**	**11.2**		**6.8**	**6.8**	**7.4**	**6.7**	**6.9**
Endurance	12.4			12.1	12.8		10.6			10.2	11.0					6.8	6.3	
OK Bullet	13.1	14.0	12.8	12.7		**13.2**	11.2	12.4	11.2	10.9		**11.4**		5.1	6.1	6.1		**5.8**
Duster				12.3	13.0					10.4	11.1					6.2	6.3	
Trial mean	**12.5**	**12.6**	**11.9**	**12.9**	**13.3**	**12.6**	**10.7**	**11.1**	**10.3**	**11.2**	**11.6**	**11.0**		**6.2**	**6.9**	**7.0**	**6.6**	**6.7**
LSD (0.05)	0.9	1.4	0.4	0.4	*tba*		1.0	1.5	0.4	0.5	*tba*			1.1	0.5	0.6	*tba*	
Target range	> 12.0%						> 10.5%						higher values					

Number of environments per year were 4 (2006), 3 (2007), 6 (2008), and 7 (2009, 2010).

Where highlighted, a given entry was significantly worse than (red) or better than (blue) OK Bullet. Comparison not available for 2010.

Table 17. Gluten strength based on **mixograph characteristics** measured on samples taken from the 2006-2010 breeding trials in 3 to 7 environments. Data provided by C.E. Shelton, OSU Wheat Quality Laboratory.

	Mixing time						Mixing tolerance rating						Mixogram curve width						Mixogram stability					
Entry	06	07	08	09	10	M	06	07	08	09	10	M	06	07	08	09	10	M	06	07	08	09	10	M
	---------- min ----------						---------- 0-6 ----------						---------- mm ----------											
OK05526	**6.1**	**4.5**	**4.0**	**5.2**	**5.1**	**5.0**	**2.7**	**3.0**	**3.3**	**3.4**	**3.9**	**3.3**	**14.7**	**17.7**	**18.6**	**17.5**	**17.3**	**17.2**	**10.7**	**10.0**	**8.2**	**7.2**	**6.4**	**8.5**
OK05212	**3.5**	**3.3**	**3.7**	**3.3**	**3.6**	**3.5**	**2.7**	**1.7**	**3.3**	**3.3**	**3.7**	**2.9**	**10.7**	**11.6**	**16.7**	**18.4**	**17.8**	**15.0**	**12.1**	**10.7**	**8.8**	**7.8**	**6.3**	**9.1**
Endurance	4.0			3.6	4.4		1.7			3.0	3.4		7.0			17.6	17.2		10.8			7.1	7.4	
OK Bullet	4.4	4.5	4.6	4.5		**4.5**	2.0	2.0	3.3	3.9		**2.8**	8.8	12.1	18.1	18.1		**14.3**	14.4	13.5	6.7	5.1		**9.9**
Duster				4.1	5.4					4.0	4.4					18.7	18.3					4.7	2.6	
Trial mean	**4.0**	**3.8**	**3.9**	**4.2**		**4.0**	**2.3**	**1.9**	**3.2**	**3.3**		**2.7**	**9.7**	**11.6**	**15.5**	**18.5**		**13.8**	**11.6**	**11.0**	**7.6**	**8.1**		**9.6**
LSD (0.05)	0.5	1.7	0.6	0.4	*tba*		0.7	1.3	0.9	0.7	*tba*		2.2	5.7	3.8	4.0	*tba*		4.2	4.5	3.1	2.4	*tba*	
Target range	3 - 6 min						≥ 2.5						≥ 10 mm						< 10					

Number of environments in each year were 4 (2006), 3 (2007), 6 (2008), and 7 (2009, 2010).

Where highlighted, a given entry was significantly worse than (red) or better than (blue) OK Bullet. Comparison not available for 2010. Statistical comparisons were not highlighted for mixing time, as an intermediate value of about 4 minutes is preferred.

Table 18. **High-molecular weight** (HMW) and **low-molecular weight** (LMW) glutenin subunit composition of seed samples collected from breeder-seed increase nurseries in 2008 and 2009. Data provided by P. Rayas-Duarte, OSU Cereal Chemistry Laboratory.

	HMW glutenin subunits						**LMW** glutenin subunits					
	2008			2009			2008			2009		
Entry	*Glu-A1*	*Glu-B1*	*Glu-D1*	*Glu-A1*	*Glu-B1*	*Glu-D1*	*Glu-A3*[a]	*Glu-B3*[b]	*Glu-D3*[c]	*Glu-A3*[a]	*Glu-B3*[b]	*Glu-D3*[c]
OK05526	**2***	**7+8**	**2+12**	**2***	**7+8**	**2+12**	**a**	**d**	**b**	**d**	**g**	**a**
OK05212	**1**	**7+8**	**5+10**	**1**	**7+8**	**2+12**	**c**	**g**	**c**	**c**	**g**	**c**
Endurance	2*	6*+8*	5+10	2*	6*+8*	5+10	c	i	a	a/c?	i	a
OK Bullet	1	17+18	5+10	1	17+18	5+10	a	e	b	a/c?	h	b
Duster	2*	7+8	5+10	2*	7+8	5+10	a	i	e	a/c?	h	a
Billings	1	7+9	5+10	1	7+9	5+10		e		e	g	a
Fuller	1	7+8	5+10	1	7+8	5+10	a	f	d	a/c?	f	c

[a] Decreasing order of expected dough strength: d, b, c, f, a, e

[b] Decreasing order of expected dough strength: b=d=g=m, h, a, c

[c] Decreasing order of expected dough strength: d=f, e, a=c=b

Expectations originally published in *Wheat:Science and Trade*

Table 19. Gluten quality and micro-extensibility based on glutomatic and texture analyzer assays of statewide composite samples of grain produced in 2007 and 2008. Data provided by Patricia Rayas-Duarte, OSU Cereal Chemistry Laboratory.

		TA Texture Analyzer[a]						Glutomatic[b]	
Year	Entry	Maximum resistance (Rmax*1000)	Extensibilibity at maximum resistance (Emax)	Extensibilibity at rupture (Erup)	Extensibility difference (Erup - Emax)	Rmax/Emax	Total work required to extend the dough (Area x 10^{-3})	Gluten index	Wet gluten content (14% mb)
		mN	cm	cm	cm			- - - - - - - % - - - - - - -	
2007	**OK05526**	**212**	**11.7**	**12.7**	**1.0**	**18.1**	**157**	**99.2**	**27.9**
	OK05212	**145**	**9.7**	**10.9**	**1.2**	**14.9**	**93**	**85.5**	**32.2**
	Mean (*n* =49)	166	10.7	11.6	0.9		113	89.8	29.2
	Min	90	8.7	9.3	**0.5**		78	58.4	24.1
	Max	244	14.6	15.7	**1.2**		173	99.8	35.3
2008	**OK05526**	**282**	**9.4**	**10.4**	**1.1**	**30.1**	**174**	**99.6**	**22.3**
	OK05212	**204**	**9.1**	**11.1**	**2.0**	**22.4**	**135**	**97.9**	**24.8**

[a] Resistance = Rmax, or the maximum resistance of the dough as it is extended (just before breakage). Extensibility measured as the distance a dough sample can be extended at maximum resistance or at rupture.

[b] Gluten index = ratio of large-to-small gluten aggregates.

Table 20. Baking characteristics of grain samples composited (Comp) from three to seven environments each year from 2007 to 2009 or from single sites. Data provided by C.E. Shelton, OSU Wheat Quality Laboratory.

	Bake absorption								Loaf volume								Visual - total						
Entry	07[a] Comp	08[a] Comp	09[a] Comp	09[b] GD	09[b] LA	10[b] GD	10[b] LA	Mean [c]	07[a] Comp	08[a] Comp	09[a] Comp	09[b] GD	09[b] LA	10[b] GD	10[b] LA	Mean [c]	07[a] Comp	08[a] Comp	09[a] Comp	09[b] GD	09[b] LA	10[b] GD	10[b] LA
	---------- % ----------								---------- cc ----------								(0 - 65)		- - - - - - - - - (0-11) - - - - - - - - - -				
OK05526	**67.0**	**63.0**	**65.0**	**66.0**	**65.0**	**63.0**	**65.5**	**64.9**	**875**	**815**	**858**	**975**	**918**	**795**	**885**	**867**	**53.0**	**7**	**7.0**	**8**	**7**	**7.5**	**7.5**
OK05526-RHf						**64.5**								**825**								**7.5**	
OK05212	**66.0**	**63.0**	**64.0**	**66.0**		**65.0**	**65.0**	**64.8**	**825**	**800**	**800**	**875**		**800**	**840**	**823**	**51.0**	**6**	**6.0**	**8**		**7.5**	**7.5**
OK Bullet	65.5	64.0	64.0	65.0	63.0				950	888	845	900	850				51.5	8	9.0	8	8		
Endurance			63.0			62.5					810			810					7.5			7.5	
Duster			63.0	64.0	64.0		65.0				790	780	850		760				7.0	7	8		7.0
Billings			64.0	65.0	65.0	62.5	67.0				875	720	968	790	885				7.0	7	8	7.5	7.5
Trial mean	**65.6**	**63.0**	**64.1**	**65.2**	**64.7**	**64.0**	**65.3**	**64.5**	**878**	**820**	**838**	**863**	**911**	**782**	**845**	**838**	**50.6**	**7**	**7.0**	**7.3**	**7.6**	**7.5**	**7.4**
Target range	>63.0								>850								>50 on 0-65 scale, >7 on 0-11 scale						

[a] Composite grain samples collected from 3, 6, and 7 Oklahoma environments in 2007, 2008, and 2009, respectively.

[b] Single samples collected from breeder-seed increase nurseries at Lahoma (LA) or Goodwell (GD) (irrigated) in 2009 and 2010. OK05212 and OK05511 were not grown at Lahoma in 2009.

Table 21. Complete quality profile for composite samples of grain produced in 6 to 8 Oklahoma environments in 2008. Data provided by Richard Chen, Hard Winter Wheat Quality Laboratory, USDA-ARS, Manhattan, KS.

Category	Trait	Unit	OK05526	OK05212	OK Bullet	Endurance	Duster	Billings	Fuller	Sample mean
										n=13
Protein content	**Wheat (14% mb)**	**%**	11.1	11.6	13.0	11.9	11.7	12.5	13.0	**12.5**
	Flour (14% mb)	**%**	9.7	10.1	11.1	10.4	10.3	11.1	11.2	**10.8**
Milling quality	**Test weight**	**lb/bu**	59.7	59.3	59.7	58.0	59.3	60.0	59.5	**59.5**
	SKCS TKW	**g**	32.3	27.5	29.2	28.0	25.7	34.0	30.4	**29.4**
	SKCS Diameter	**mm**	2.79	2.54	2.72	2.61	2.59	2.78	2.77	**2.69**
	SKCS Hardness		53	59	74	57	72	65	60	**64**
	NIR Hardness		47	44	75	53	66	59	51	**62**
	Flour yield	**%**	71.0	68.9	72.4	69.5	72.2	70.0	69.6	**70.5**
	Flour ash (14% mb)	**%**	0.40	0.38	0.49	0.44	0.44	0.39	0.42	**0.43**
Mixograph & bake	**Absorption (mixo)**	**%**	59.2	59.8	61.5	59.2	60.0	61.5	61.6	**60.7**
	Mix time	**min**	3.0	2.6	3.7	2.5	3.0	3.2	4.1	**3.3**
	Mixing tolerance	**0-6**	4	3	3	1	2	3	4	**2.6**
	Bake absorption	**%**	59.7	60.0	59.7	58.9	59.4	61.4	60.8	**59.8**
	Bake mix time	**min**	4.3	3.9	4.3	3.5	4.3	5.0	4.7	**4.3**
	Crumb grain	**0-6**	3.0	3.2	4.0	3.5	4.0	3.0	4.0	**3.5**
	Crumb color		sl yell	dull	crmy	dull	crmy	dull	crmy	
	Loaf volume (LV)	**cc**	800	820	905	870	800	910	850	**866**
	Specific LV	**cc/g**	5.5	5.6	6.2	5.9	5.4	6.2	5.7	**5.9**
	LV regression		72.4	71.5	73.9	76.1	67.7	74.9	66.8	**71.8**
	Falling no. (est.)	**sec**	326	334	323	309	327	238	346	**311**
RVA	**Peak 1**		235	236	215	187	164	92	227	**195**
	Trough 1		163	156	145	129	96	34	167	**124**
	Breakdown		72	81	70	59	69	58	60	**71**
	Final Viscosity		289	276	258	244	187	81	291	**227**
	Setback		126	120	113	115	91	46	125	**103**
	Peak Time	**min**	6.3	6.3	6.3	6.1	6.0	5.2	6.3	**6.1**
Farinograph	**Absorption**	**%**	55.3	55.7	57.1	54.7	54.6	57.4	57.4	**56.3**
	Peak time	**min**	3.0	2.2	6.2	5.5	2.7	3.3	7.7	**5.3**
	Stability	**min**	17.8	10.1	15.3	11.9	10.8	14.2	24.5	**14.7**
	Tolerance index		13	19	18	26	18	21	7	**20**
Alveograph	**P value**	**mm**	83	68	64	59	68	86	75	**65**
	L value	**mm**	96	117	120	99	109	100	124	**115**
	P/L		0.86	0.58	0.53	0.60	0.62	0.86	0.60	**0.58**
	W value		295	263	263	192	248	304	326	**252**

Table 22. Complete quality profile for composite samples of grain produced in 7 Oklahoma environments in 2009. Data provided by Richard Chen, Hard Winter Wheat Quality Laboratory, USDA-ARS, Manhattan, KS.

Category	Trait	Unit	OK05526	OK05212	OK Bullet	Endurance	Duster	Billings	Fuller	Sample mean
										n=14
Protein content	**Wheat (14% mb)**	**%**	13.3	12.8	12.8	11.7	12.4	13.7	13.3	**12.6**
	Flour (14% mb)	**%**	12.0	11.7	11.5	10.5	11.1	12.1	12.0	**11.3**
Milling quality	**Test weight**	**lb/bu**	57.0	56.9	57.8	57.1	57.4	57.8	58.1	**57.9**
	SKCS TKW	**g**	31.0	25.4	26.4	28.8	24.1	28.1	27.7	**28.4**
	SKCS Diameter	**mm**	2.71	2.40	2.54	2.61	2.47	2.57	2.60	**2.6**
	SKCS Hardness		63	67	83	67	83	75	67	**73**
	NIR Hardness		45	54	74	52	65	67	49	**60**
	Flour yield	**%**	70.1	69.9	68.2	68.9	68.7	67.7	67.1	**68.9**
	Flour ash (14% mb)	**%**	0.43	0.41	0.48	0.45	0.46	0.43	0.44	**0.46**
Mixograph & bake	**Absorption (mixo)**	**%**	62.9	62.5	62.1	58.5	62.4	63.2	62.9	**61.0**
	Mix time	**min**	4.9	2.8	3.9	2.5	3.7	3.4	5.1	**3.4**
	Mixing tolerance	**0-6**	3	2	3	1	3	3	3	**2.3**
	Bake absorption	**%**	60.5	63.1	60.9	59.8	62.7	62.8	62.9	**61.4**
	Bake mix time	**min**	5.6	3.5	4.7	3.5	4.9	5.0	6.0	**4.5**
	Crumb grain	**0-6**	4.0	4.8	4.0	5.0	4.5	5.0	4.0	**4.1**
	Crumb color		creamy	creamy	creamy	creamy	creamy	creamy	creamy	
	Loaf volume (LV)	**cc**	935	920	985	915	905	970	930	**916**
	Specific LV	**cc/g**	6.4	6.1	6.7	6.2	5.9	6.5	6.2	**6.2**
	LV regression		70.6	70.9	80.3	80.6	74.3	73.3	70.0	**73.9**
Farinograph	**Absorption**	**%**	56.7	58.1	57.7	55.9	57.2	59.4	58.0	**57.2**
	Peak time	**min**	7.4	5.3	6.5	7.8	5.7	6.5	16.7	**7.9**
	Stability	**min**	35	14	20	13	16	26	30	**20**
	Tolerance index		11	22	10	30	25	13	7	**19**
Alveograph	**P value**	**mm**	63	66	74	67	72	93	71	**70**
	L value	**mm**	89	98	115	104	118	110	79	**98**
	P/L		0.71	0.67	0.64	0.64	0.61	0.85	0.90	**0.74**
	W value		231	221	291	232	283	358	233	**245**
Extensigraph	**Area under curve (30 min)**	**cm^2**	139	105	108	74	116	130	98	**102**
	Max resistance to ext (30 min)	**BU**	747	489	558	380	593	670	580	**522**
	Ext at max resist (30 min)	**mm**	147	162	149	148	151	154	131	**151**
	Max resist/Ext (30 min)		5.1	3.0	3.8	2.6	3.9	4.4	4.4	**3.5**
	Area under curve (60 min)	**cm^2**	178	144	157	124	165	179	133	**147**
	Max resistance to ext (60 min)	**BU**	998	732	889	776	914	997	999	**858**
	Ext at max resist (60 min)	**mm**	129	157	144	129	146	142	105	**136**
	Max resist/Ext (60 min)		7.8	4.7	6.2	6.0	6.3	7.0	9.6	**6.4**

Exhibit 1

USDA-GIPSA Wheat Classification
Breeder seed, Goodwell, OK; 2010 harvest
2 pages

Proposal for Release of Plant Materials

Hard Red Winter Wheat Cultivars

OK05526-RHf
OK05212

UNITED STATES DEPARTMENT OF AGRICULTURE
GRAIN INSPECTION, PACKERS AND STOCKYARDS ADMINISTRATION
TECHNICAL SERVICES DIVISION
BOARD OF APPEALS AND REVIEW

BREEDER REQUEST FOR WHEAT CLASSIFICATION EVALUATION

1. Contact Name	2. Contact Phone Number
Brett F.Carver	(405) 744-9580

3. Organization/Company Name
Oklahoma State University

4. Mailing Address
368 Ag Hall, Stillwater, OK 74078-6028

5. Variety ID Submitting	6. Quantity submitted (grams)
OK05526-RHf	1 lb

7. Variety Parentage (optional)

8. Intended Class
Hard Red Winter

Mail Sample and form to: USDA, GIPSA, TSD, Board of Appeals and Review
10383 N. Ambassador Drive
Kansas City, MO 64153

FOR BOARD OF APPEALS AND REVIEW USE ONLY:

The wheat variety sample submitted for classification evaluation was examined to determine whether kernel morphology would present any potential marketing problems in the current visual classification system. Individual kernels were examined to determine if the profiles are uniform and consistent with the characteristics normally associated with the intended marketing class. If not, efforts were made to identify dominant distinguishing features that could assist inspectors in properly and consistently classifying the variety.

1. BAR Classification	2. Average Hardness Index
Hard Red Winter	55 (06-20-39-35-02)

3. BAR Comments:
Visually a good HRW. Concerned about Hardness readings 6% Soft and 20%Semisoft.

Please note, this assessment applies only to the quantity of wheat submitted and does not apply to any other identified lots. Also, the effect of environment on kernel characteristics may be significant and necessitate re-evaluation.

If or when the variety is released, please submit a minimum of 4,000 grams to the Board of Appeals and Review so that type samples can be distributed to wheat inspection offices to serve as a reference and ensure proper classification.

Name, Title, and Phone Number of Responsible Official:	Date:
David Lowe, Chairman (816) 891-0421	01/03/2011

Signature
David Lowe

Rev. 0712010

UNITED STATES DEPARTMENT OF AGRICULTURE
GRAIN INSPECTION, PACKERS AND STOCKYARDS ADMINISTRATION
TECHNICAL SERVICES DIVISION
BOARD OF APPEALS AND REVIEW

BREEDER REQUEST FOR WHEAT CLASSIFICATION EVALUATION

1. Contact Name	2. Contact Phone Number
Brett F.Carver	(405) 744-9580

3. Organization/Company Name
Oklahoma State University

4. Mailing Address
368 Ag Hall, Stillwater, OK 74078-6028

5. Variety ID Submitting	6. Quantity submitted (grams)
OK05212	1 lb

7. Variety Parentage (optional)

8. Intended Class
Hard Red Winter

Mail Sample and form to: USDA, GIPSA, TSD, Board of Appeals and Review
10383 N. Ambassador Drive
Kansas City, MO 64153

FOR BOARD OF APPEALS AND REVIEW USE ONLY:

The wheat variety sample submitted for classification evaluation was examined to determine whether kernel morphology would present any potential marketing problems in the current visual classification system. Individual kernels were examined to determine if the profiles are uniform and consistent with the characteristics normally associated with the intended marketing class. If not, efforts were made to identify dominant distinguishing features that could assist inspectors in properly and consistently classifying the variety.

1. BAR Classification	2. Average Hardness Index
Hard Red Winter	60 (05-14-35-46-01)

3. BAR Comments:
Visually a good HRW. Concerned about Hardness readings 5% Soft and 14%Semisoft.

Please note, this assessment applies only to the quantity of wheat submitted and does not apply to any other identified lots. Also, the effect of environment on kernel characteristics may be significant and necessitate re-evaluation.

If or when the variety is released, please submit a minimum of 4,000 grams to the Board of Appeals and Review so that type samples can be distributed to wheat inspection offices to serve as a reference and ensure proper classification.

Name, Title, and Phone Number of Responsible Official:	Date:
David Lowe, Chairman (816) 891-0421	01/03/2011

Signature
David Lowe

Rev. 07/2010

Exhibit 2

Variety Name Clearance
USDA, Seed Regulatory and Testing Branch
2 pages

Proposal for Release of Plant Materials

Hard Red Winter Wheat Cultivars

OK05526-RHf
OK05212

United States Department of Agriculture
Agricultural Marketing Service
Livestock and Seed Program
Seed Regulatory and Testing Branch
801 Summit Crossing Place, Suite C
Gastonia, North Carolina 28054
704-810-7264, FAX 704-852-4189
www.ams.usda.gov/seed

October 28, 2010

Mr. Brett Carver
Oklahoma State University
368 AG Hall, Dept. of Plant and Soil Sciences
Stillwater, Oklahoma 74078

Dear Mr. Carver:

In response to your inquiry concerning variety names, we have checked our variety name database and have found the following:

Name Cleared: 'Ruby Lee' for common wheat has been cleared, however please be advised that there is an older variety of common wheat named 'Ruby.'

We are no longer doing Trademark searches on proposed variety names. The Trademark database can be accessed via the Internet at the following web site: "www.uspto.gov". Because there is no variety registration system, we cannot assure you that these names are free of conflicts. Moreover, our clearance confers no legal precedence.

We are happy to help you in this matter. **Please inform us about your new variety releases, including the kind, release date, and experimental designation(s) of the new varieties. Also, please indicate which names you decline to use so that they may be returned to the pool of available names.**

Thank you.

Sincerely,

Kevin Robinson
Seed Marketing Specialist

United States Department of Agriculture
Agricultural Marketing Service
Livestock and Seed Program
Seed Regulatory and Testing Branch
801 Summit Crossing Place, Suite C
Gastonia, NC 28054-2193
704-810-8871, FAX 704-852-4109
http://www.ams.usda.gov/seed

December 4, 2008

Mr. Brett Carver
Oklahoma State University
368 AG Hall, Dept. of Plant and Soil Sciences
Stillwater, Oklahoma 74078

Dear Mr. Carver:

In response to your inquiry concerning variety names, we have checked our variety name database and have found the following:

Names Cleared: 'Pete' and 'Garrison' for common wheat have been cleared.

We are no longer doing Trademark searches on proposed variety names. The Trademark database can be accessed via the Internet at the following web site: "tess2.uspto.gov". Because there is no variety registration system, we cannot assure you that these names are free of conflicts. Moreover, our clearance confers no legal precedence.

We are happy to help you in this matter. **Please inform us about your new variety releases, including the kind, release date, and experimental designation(s) of the new varieties. Also, please indicate which names you decline to use so that they may be returned to the pool of available names.**

Thank you.

Sincerely,

Kevin Robinson
Seed Marketing Specialist

Exhibit 3

Selection History
1 page

Proposal for Release of Plant Materials

Hard Red Winter Wheat Cultivars

OK05526-RHf
OK05212

Selection path for OK05526, OK05526-RHf, and OK05212 from 1997 to 2011. Population or entry numbers appear in italics.

Year	Nursery, NID	Location	OK05526	OK05526-RHf	OK05212
2011	OET3, 93	Statewide		*10*	*8*
	SRPN	Statewide	Terminate OK05526; shift to resln	--	--
	TX-OK UVT, 98	Statewide		--	*17*
	BSI, 96	Goodwell		*7*	*6*
	WQC, 97	Lahoma		*6*	*2*
	Wheat Var. Trials	Statewide		*5*	*18*
	OFSS			3.5 bu	UL
2010	OET3, 93	Statewide	*12*		*16*
	SRPN	Statewide	*7*		*8*
	TX-OK UVT, 98	Statewide	*18*		*20*
	BSI	Goodwell	*9606*	*11BSI-526, 1496 025*	*9608*
	WQC, 97	Lahoma	*5*		*17*
	Wheat Var. Trials	Statewide	16 sites		15 sites
	OFSS		~18 bu, Guymon		Yr 1 ~5 bu, Perkins
2009	OET3, 93	Statewide	*17*		*21*
	RGON		*113*		*117*
	SRPN	Statewide	--		*19*
	TX-OK UVT, 98		*18*		--
	BSI, 96	Goodwell	*6*		*13*
	WQC, 97	Lahoma	*8*		--
	Wheat Var. Trials	Statewide	14 sites		--
	Obsn, 109	Stillwater	--	*199-200*	227-228 (RHf2)
2008	OET2, 93	Statewide	*9*		*15*
	RGON		*28*		*34*
	08G IB15		↑	*215 005*	
2007	OET1, 91	Statewide	*18*		*29*
	07G IB11		--	→ *212 007*	
2006	RYT2, 81	Statewide	*34*		*29*
2005	RYT1, 72	Central	--		*12*
	RYT1, 75	West	*26*		--
2004	DPON, 66-67	ST, LA	*67 209*		*66 567*
2003	Head Rows	Stillwater	*1162049*		*1161078*
2002	Bulks, F4	ST2200DP, Lahoma, FC	*1154003*		*1157009*
2001	Bulks, F3	Marshall, Lahoma, AL	*2044009*		*2047001*
2000	Bulks, F2	Marshall, Lahoma	*2034035*		*2037051*
1999	F1 bulk	Greenhouse	*99G1314*		*99G1190*
1998	XBs	Greenhouse	*98cx337*		*98x128a*
1997	XBs	Greenhouse	--		*97x400a*

Exhibit 4

Disease reaction summary
Compiled by Dr. Bob Hunger
9 pages

Proposal for Release of Plant Materials

Hard Red Winter Wheat Cultivars

OK05526-RHf
OK05212

Division of Agricultural Sciences and Natural Resources

Department of Entomology and Plant Pathology
127 Noble Research Center
Oklahoma State University
Stillwater, OK 74078-3033

04 Jan 2011

Dr. Brett Carver
Department of Plant & Soil Sciences
Oklahoma State University
Stillwater, OK 74078

Dear Dr. Carver:

Below are summary statements describing the reactions of **OK05526/OK05526-RHf**, and **OK05212** to the wheat soilborne mosaic (WSBM)/wheat spindle streak mosaic (WSSM) complex, the rusts (leaf, stripe and stem), powdery mildew, septoria leaf blotch, tan spot, barley yellow dwarf and other diseases as available. The observations used to determine these reactions are presented on the attached pages. Testing of these two lines is also being done this season, which may further delineate disease reactions.

OK05526/OK05526-RHf

WSBM/WSSM complex: Results from field trials indicate that OK05526/OK05526-RHf is resistant to the WSBM/WSSM complex. A few values from ELISA indicated presence of WSSMV, but observations and values from ELISA over multiple years in field trials demonstrate resistance to both viruses.

Leaf rust: OK05526/OK05526-RHf has generally expressed seedling and adult plant resistance to wheat leaf rust caused by *Puccinia triticina*. However, the seedling reaction in 2011 (3, 3, 3) on three reps may have occurred due to a race shift in 2010. The bulk inoculum used in 2011 tests was collected from the field (LAH) from multiple genotypes in spring, 2010. This collection may represent a shift to races with greater virulence on OK05526/OK05526-RHf, which also was observed on Fuller (Lr17 + 41). Testing in 2010 was conducted using a bulk collection from 2008. There also is indication of increased susceptibility in the field in 2010 (Castroville-TX @ 80S and 60S and Wichita-KS @ 4 on a 1-9 scale) compared to readings in 2008 and 2009 in the field.

Stripe rust: Field ratings in the Plains states and elsewhere indicate an intermediate level of resistance to stripe rust. Seedling (greenhouse) testing in Washington indicates OK05526/OK05526-RHf is susceptible to races of stripe rust (*P. striiformis*) in the Pacific Northwest, although high temperature, adult plant resistance is expressed.

Stem rust: Based on tests conducted in Minnesota, OK05526/OK05526-RHf is moderately susceptible to susceptible to races of *P. graminis* f. sp. *tritici* present in the U.S., and susceptible to Ug99 (TTKSK).

Powdery mildew: Based on seedlings assays conducted in the greenhouse and field observations, OK05526/OK05526-RHf has an intermediate to resistant reaction to powdery mildew.

Tan spot & septoria: Based primarily on greenhouse testing, OK05526/OK05526-RHf is resistant to tan spot, but is susceptible to septoria leaf blotch.

Fusarium head blight: Limited observations indicate OK05526/OK05526-RHf is moderately susceptible to susceptible to Fusarium head blight (scab)

Barley yellow dwarf: Observations indicate that OK05526/OK05526-RHf has a moderately high level of resistance to BYDV compared to other varieties grown in the southern Great Plains.

Wheat streak mosaic virus: Limited results from the Oklahoma panhandle indicate that OK05526/OK05526-RHf has an intermediate reaction to wheat streak mosaic.

OK05212

WSBM/WSSM complex: OK05212 is resistant to the WSBM/WSSM complex as indicated by observations in field trials over multiple years.

Leaf rust: Adult plants of OK05212 show an intermediate reaction to wheat leaf rust in the field. Seedlings most consistently show a moderately susceptible to susceptible reaction to wheat leaf rust.

Stripe rust: Observations/testing of OK05212 indicate a moderately resistant to resistant reaction to stripe rust in the Central Plains, but susceptibility to races in the Pacific Northwest.

Stem rust: Observations/testing in Minnesota and Kenya indicate that OK05212 has intermediate resistance to most races of *P. graminis* f. sp. *tritici* in the U.S. and to Ug99 (TTKSK).

Powdery mildew: Field observations have indicated an intermediate to resistant reaction to powdery mildew although seedlings of OK05212 show a susceptible reaction when tested in the greenhouse.

Tan spot & septoria: Based primarily on greenhouse testing, OK05212 is resistant to tan spot and shows an intermediate reaction to septoria.

Fusarium head blight: Observations indicate OK05212 is moderately resistant to Fusarium head blight.

Barley yellow dwarf: OK05212 is moderately resistant to BYDV compared to other varieties grown in the southern Great Plains.

Triticum mosaic: OK05212 is susceptible to Triticum mosaic virus.

Please contact me if clarification or additional information is needed.

Sincerely,

Dr. Bob Hunger
Professor & Extension Wheat Pathologist

Summary of Disease Reactions* of OK05526 and OK05212

Disease	OK05526	OK05212
Soilborne mosiac/spindle streak complex	R	R
Wheat leaf rust	MR	I
Wheat stripe rust	I	MR-R
Wheat stem rust	MS	I
Powdery mildew	I	I
Tan spot**	R	R
Septoria leaf blotch**	S	I
Fusarium head blight (scab)**	S	MR
Barley yellow dwarf virus**	MR	MR
Wheat streak mosaic virus**	I	NI
Triticum mosaic virus**	NI	S

*Disease reactions defined as:

R=resistant
MR=moderately resistant
I=intermediate
MS=moderately susceptible
S= susceptible
NI=no information

**Resistant reactions to these diseases can be overcome by extremely favorable environments in conjunction with heavy inoculum/infestation levels.

Disease Reactions of OK05526/OK05526-RHf

Wheat Soilborne Mosaic Virus (WSBMV)/Wheat Spindle Streak Mosaic Virus (WSSMV)

Year/location	Symptoms (1-4)	ELISA WSBMV	ELISA WSSMV
2010 NID 93 #12; STW	1 1 1 2	0.00 0.00	3.00 0.26
2010 SRPN #07; STW	1 1 1 2 1 2	0.13 0.11 0.16	1.48 1.08 2.13
2010 SRPN #07; MAS	positive for sbm1 marker		
2010 NID 98 #18; STW	2 1		
2010 STW Var-demo	1 1	0.11	0.12
2009 NID 93 #17; STW	1 1 1 1	0.14 (0.45)	3.00 (0.17)
2009 RGON #113; STW	1 1 2 1 1 2	0.15	3.00
2009 NID 98 #18; STW	1 2 1 1	0.13	2.99
2008 NID 93 #09; STW	1 1 1 1	0.14 (0.15)	0.13 (0.14)
2008 RGON #28; STW	1 2 2 1 1 1	0.09	0.33
2007 NID 91 #18; STW	2 2 1 2	0.12 (0.36)	0.13 (0.16)
2006 NID 81 #34; STW	1	0.13 (0.41)	0.19 (0.34)
2005 NID 75 #26; STW	1 1		

*Number in parentheses is the pos/neg threshold (mean of Hawk + three SDs).

Leaf Rust

Year/location	Seedling	Field
2011 NID 93 #10	3 3 3	
2010 NID 93 #12; STW	; (2P3) 0 0 (1P3)	
2010 SRPN #07; STW	; (1P3) ; ;	
2010 NID 98 #18; STW	; ; ;	
2010 SRPN #07; CDL	0; 0 3 0; ; 0; 3 ; (postulated to have Lr39/41)	
2010 SRPN #07; MAS	Hetero-Lr34	
2010 SRPN #07; Castro-TX		80S 60S (tr-100S)
2010 SRPN #07; Wichita-KS		4 (range of 1-9 on a 0-9 scale)
2010 Var trial @ APA		No Lr; 2 (Yr) 1 4 (Yr) 2 [Yr as high as 8]
2009 NID 93 #17; STW	X;3	1 [@ STW (1-9; range of 1-7)]
2009 RGON #113; STW	0	50S [@ Castroville, TX; Tr-R-90S)
2009 NID 98 #18; STW	1P-3+	
2008 NID 93 #09; STW	3 3 3	
2008 RGON #28; STW	X;3=	10MS (@ Castroville, TX; Tr-100S)
2007 NID 91 #18; STW	X;3= X;3= X;3-	
2006 NID 81 #34; STW	3-	
2005 NID 75 #26; STW	;	

Disease Reactions of OK05526/OK05526-RHf

Stripe Rust

Year/location	Seedling	Field
2010 SRPN #07; WA (8 races):	8 8 8 8 8 (4-20C)	3,3,3 3,3,4 2,3,3 (10-30C) = HTAP possible
2010 SRPN #07 @ Kenya:		30MS (27-29 Sep; 0-40MS)
2010 SRPN #07; Castro-TX		6 (range of 0-8 on a 0-9 scale)
2010 SRPN #07; Laurel Spr.-NC		7 (range of 0-8) 50% (range of 0-70)
2010 SRPN #07; Ft. Collins-CO		5 (range of 1-9)
2010 SRPN #07; Wichita-KS		4 (range of 1-8)
2010 SRPN #07; Rossville-KS		5 (range from 2-8) 40% (1-90)
2010 SRPN #07; WA (5 locations)		5-60 5-30 8-100 3-20 8-20
2010 UVT @ College Station-TX		40S (27-Mar; R–90S) 60S (02-Apr; R-100S)
2010 Var trial @ APA		No Lr; 2 (Yr) 1 4 (Yr) 2 [Yr as high as 8]

		Severity	Inf type	Grn leaf
2009 RGON #113 @ Rossville, KS.....	8 (2-9)	80 (0-100)	7 (1-8)	0 (0-75)
2009 RGON #113 @ NC.....	3 (IT; 0-9) 10 (%; 0-100)			
2008 RGON #28 @ KS	8 (2-8)			

Stem Rust (TTKSK underlined)

2010 SRPN #07 @ CDL-MN	22+ S 2 S/2 S 2+3- S 2 2 S (9 U.S. races & TTKSK)	
2010 SRPN #07 @ Kenya (field)	10MS (29 Sep; 0-10S) 20MS (13 Oct; 0-40MS) 60MS (27 Oct; 0;-90S)	
2010 SRPN #07; MAS	Positive for Sr2	
2009 RGON #113 @ CDL-MN	S ;3 2+ 2- (bulk & 3 U.S. races)	
2009 RGON #113 @ Kenya (field)	S S (TTKSK)	
2008 RGON #28 @ CDL-MN	S (U.S. bulk)	
2008 RGON #28 @ Kenya	S S (TTKSK)	90S 90S (field 0-90S)
2008 RGON #28 @ CDL-MN.....	40MS-S (field; 0-80S)	

Other Diseases

Powdery mildew:

2010 Var-demo @ STW	0 (0-4; range of 0-3)
2010 NID 93 #12 (sdlng)	4 (0-4)
2010 SRPN #07; Castro-TX	3 (range of 0-6 on a 0-9 scale)
2010 SRPN #07; Wichita-KS	9 (1-9 on a 0-9 scale)
2009 NID 93 #17; STW	+ (0 to +++)
2009 NID 98; STW	++
2008 NID 93 #09; STW	++ ++ ++
2007 NID 91 #18; STW	++ ++ ++

Disease Reactions of OK05526/OK05526-RHf
Other Diseases

Tan spot:

2011 NID 93 #10 (29 sdlngs)	14.55 (%)	2.18 (0-9)		
Red Chief (32 sdlngs)	3.08 (%)	0.46 (0-9)	TMP 64 (28 sdlngs)	41.16 (%) 5.95 (0-9)
Karl 92 (32 sdlngs)	14.83 (%)	2.22 (0-9)	TAM 105 (45 sdlngs)	58.77 (%) 8.80 (0-9)
2174 (24 sdlngs)	20.56 (%)	3.08 (0-9)		

2010 NID 93 #12; STW 1.78 0.22 (nine plants)
% infection 1st/2nd leaves; TAM 105 (315 plants)=28.12/7.37; Red Chief=1.31/0.14

2008 NID 93 #09; STW 3.9 (1-4)
2007 NID 91 #18; STW 1.3 (1-4)

Septoria:

2010 SRPN #07; Wichita-KS 6 (1-9 on a 0-9 scale)
2010 NID 93 #12; STW 46.9% [Newton (sus; 129 sdlngs)=28.0; 2137 (res; 100 sdlngs)=16.4]

Fusarium head blight:

2010 SRPN #07; Columbia-MO 53% (0-75%; avg = 33%)

2008 RGON #28 @ SD Inc=102.2 (72.8-102.9)
Sev=61.8 (20.5-85.5)
Index=62.5 (18.8-85.2)

Wheat streak mosaic virus:

2009 Hooker WW Var Trial 3 2 3 3 (avg=2.75) [scale of 0-5; range = 1.00-4.00]

Barley yellow dwarf virus:

2010 Var trial @ LAH (8 reps - % plot area incidence)
Res (5 entries) = 12% Sus (6 entries) = 89% 5526 = 28%
2010 Var-demo @ STW 10% (early planted; range of 10-70% leaf incidence)
30% (late planted; range of 10-90% plot area affected)

Disease Reactions of OK05212

Wheat Soilborne Mosaic Virus (WSBMV)/Wheat Spindle Streak Mosaic Virus (WSSMV)

Year/location	Symptoms (1-4)	ELISA WSBMV	ELISA WSSMV
2010 NID 93 #16; STW	1 1 1 2	0.00 0.68	0.00 0.83
2010 SRPN #08; STW	1 1 1 2 1 1	0.11 0.13 0.15	0.09 0.09 0.12
2010 NID 98 #20; STW	1 1		
2010 STW Var-demo	1 1	0.12	0.12
2010 SRPN #08; USDA-ARS markers	Positive for SBM1		
2009 NID 93 #21; STW	1 1 1 1	0.14 (0.45)	0.16 (0.17)
2009 RGON #117; STW	1 1 1 1 1 1	0.14	0.15
2009 SRPN #19; STW	1 1 1 1 1 1	0.13 0.13 0.15	0.14 0.15 0.15
2009 SRPN #19; Win, KS	1.0 (mean of 3 reps)		
2008 NID 93 #15; STW	1 1 1 1	0.09 (0.15)	0.10 (0.14)
2008 RGON #34; STW	1 1 1 1 1 1	0.10	0.10
2007 NID 91 #29; STW	1 1 1 1	0.13 (0.36)	0.12 (0.16)
2006 NID 81 #29; STW	1	0.13 (0.41)	0.19 (0.34)
2005 NID 72 #12; STW	3 3	No data	No data

*Number in parentheses is the pos/neg threshold (mean of Hawk + three SDs).

Leaf Rust

Year/location	Seedling	Field
2011 NID 93 #08	3 3 X3;	
2011 NID 98 #17	; ; X;1 (1p3)	
2010 NID 93 #16; STW	3 3 3	
2010 SRPN #08; STW	3=C 3=C 3-	
2010 NID 98 #20; STW	3= X;1 X;1	
2010 SRPN #08; CDL (8 races)	; 2+3 ; ; 3+ 0; 3+ ;1- (postulated Lr17)	
2010 SRPN #08; Castro-Tx		60S 60S (tr-100S)
2010 SRPN #08; Wichita-KS		4 (range of 1-9 on a 0-9 scale)
2010 SRPN #08; MAS	Positive for Lr19	
2009 NID 93 #21; STW	3+	4 (1-9; range of 1-7)
2009 RGON #117; STW	3	
2009 RGON #117; Castroville, TX		20MS
2009 SRPN #19; STW	3+ 3-C	2 2 1 (1-7)
2009 SRPN #19; CDL-MN	2 3+ 3+ 23 ; ; ; ; [8 U.S. Races – Postulated 17, +]	
2009 SRPN#19; Castroville, TX (2 reps)		50MS (tR-R-80S) 30MS (tR-80S)
2008 NID 93 #15; STW	3+ 3+ 3+	
2008 RGON #34; STW	3+	

Disease Reactions of OK05212

Leaf Rust

Year/location	Seedling	Field
2008 RGON #34; Castroville, TX		5MR (tR-80S)
2007 NID 91 #29; STW	X;3- X;3- X;3=	
2006 NID 81 #29; STW	3+	
2005 NID 72 #12; STW	3	

Stripe Rust

Year/location	Seedling	Field
2010 SRPN #08; Kenya (field)		01S (29-Sep; 0-40MS)
2010 SRPN #08; Castro-TX		0 (range of 0-8 on a 0-9 scale)
2010 SRPN #08; Laurel Spr.-NC		0 (range of 0-8) 0% (0-70% range)
2010 SRPN #08; Ft. Collins-CO		1 (1-9 range on a 0-9 scale)
2010 SRPN #08; Wichita-KS		4 (1-8 range on a 0-9 scale)
2010 SRPN #08; Rossville-KS		2 (range of 0-9) 1% (0-90% range)
2010 UVT @ College Station-TX		30S (27-Mar; R–90S) 20S (02-Apr; R-100S)
2010 SRPN #08; WA (5 locations)		8-60 8-20 8-100 8-100 8-20
2010 SRPN #08; WA (sdlng)	2,8 8 8 8 8 (4-20C)	8,8,8 8,8,8 8,8,8 (10-30C) no HTAP
2009 RGON #117; Rossville, KS	6 (0-9)	1 1 35 [Sev IT GLA]
2009 RGON #117; NC		2 10 [IT %)
2009 SRPN #19; Rossville, KS	6 (0-9)	1 1 40 [Sev IT GLA]
2009 SRPN #19; NC		2 10 [IT Sev check=9 100]
2009 SRPN #19; WA	S to 5 races (grnhse)	8 100 @ Pullman [2-8 1-100]
		8 10 @ Mt. Vernon [2-8 2-80]
		8 10 @ Walla-Walla [0-8 0-90]
2008 RGON #34; KSU		7 (using 0-9 scale – range of 3-8)

Stem Rust (TTKSK underlined)

2010 SRPN #08; CDL-MN	2++ S 2 2/; ;1 S S/2; 2- 2 - 2-- 2 - 2+ (14 races)
2010 SRPN #08; Kenya (field)	; (29-Sep; 0-10S) 05RMR (13-Oct; 0-25MSS) 50S (27-Oct; 0;-90S)
2009 RGON #117; CDL-MN	S (US bulk) S 0 2- 2+ S 2+ 2+ 2 10S 30MSS (Kenya 1R-70S)
2009 SRPN #19; CDL-MN	S S 2- 22+ ;3- 2++ S/;2 2+ 0 2 (10 U.S. races)
2009 SRPN #19; Kenya	S S 20S (0-70S) 30MS (5R-70S)
2008 RGON #34; CDL-MN	S (US bulk) ;/S S/; S S S 2+/S
	40S (0-80S – field @ MN)
2008 RGON #34; Kenya	60S (1R-90S)

Disease Reactions of OK05212
Other Diseases

Powdery mildew:

2010 Var-demo @ STW	0 (0-4; range of 0-3)
2010 NID 93 #16 (sdlng)	4 (0-4)
2010 SRPN #08; Castro-TX	4 (range of 0-6 on a 0-9 scale)
2010 SRPN #08; Wichita-KS	1 (range of 1-9 on a 0-9 scale)
2009 NID 93 #21; STW	+ (- to +++)
2008 NID 93 #15; STW	4 3 3 (1-4)
2007 NID 91 #29; STW	3+ 3+ 3+

Tan spot:

2011 NID 93 #08 (31 sdlngs)	6.87 (%)	1.03 (0-9)		
Red Chief (32 sdlngs)	3.08 (%)	0.46 (0-9)	TMP 64 (28 sdlngs)	41.16 (%) 5.95 (0-9)
Karl 92 (32 sdlngs)	14.83 (%)	2.22 (0-9)	TAM 105 (45 sdlngs)	58.77 (%) 8.80 (0-9)
2174 (24 sdlngs)	20.56 (%)	3.08 (0-9)		

2010 NID 93 #16; STW	13.9 6.44 (nine plants) % infection 1st/2nd leaves TAM 105 (315 plants)=28.12/7.37; Red Chief=1.31/0.14
2008 NID 93 #15	3.0 (1-4; avg of 15 sdlngs)
2007 NID 91 #29	2.5 (1-4; avg of 15 sdlngs)

Septoria:

2010 NID 93 #16; STW	16.0% [Newton (sus; 129 sdlngs)=28.0; 2137 (res; 100 sdlngs)=16.4]
2010 SRPN #08; Wichita-KS	4 (range of 1-9 on a 0-9 scale)
2007 NID 91 #29	5.2 (1-9) [Newton (sus; 30 sdlngs)=8.57; 2137 (res; 29 sdlings)=1.48]

Fusarium head blight:

2010 SRPN #08; MAS	Positive for 3BS-unknown allele
2010 SRPN #08; Columbia-MO	11% (0-75% range; average = 33%)
2008 RGON #34; SDSU	97.2 68.3 65.7 [Inc (82.2-102.9) Sev (20.5-85.0) Index (18.8-85.2)]

Barley yellow dwarf virus:

2010 Var trial @ LAH (8 reps - % plot area incidence)	
	Res (5 entries) = 12% Sus (6 entries) = 89% 5526 = 33%
2010 Var-demo @ STW	20% (early planted; range of 10-70% leaf incidence)
	40% (late planted; range of 10-90% plot area affected)

Triticum mosaic virus:

2010 SRPN #08; Hayes-KS	7 dpi = 1.5 (range of 1.0-4.0)
	14 dpi = 8.5 [range of 4.3 (Mace) – 8.5]