## Conclusions

- Little winter durum wheat is grown anywhere in the world, but the crop might have some potential in Kansas.
- Of 50 experimental lines of winter durum wheat evaluated, many were resistant to leaf rust and lodging, had desirable agronomic traits, and produced high yields of grain.
- For winter durum wheat to become a successful crop in Kansas, improvement is needed in winter hardiness, earlier maturity, and quality of the grain for pasta and other products.
- If a program is undertaken to develop winter durum as a crop for the state, many years will be needed to combine all the attributes into improved varieties and determine the optimum agronomic practices for production.

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# EVALUATION OF WINTER DURUM WHEAT FOR KANSAS

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Durum wheat (*Triticum durum* L.) is an important crop for making pasta, bulgur, couscous, and other products. Annual productions are approximately 100 million bushels in the U.S. and 1200 million bushels in the world. Nearly all of this is spring durum, which is planted mostly at the end of winter and harvested in the summer, but some is planted in the autumn in areas where the climate is mild.

Yields of durum compare favorably with yields of bread wheat in the U.S. During the past 10 years, yields averaged approximately 37 bu/a for durum, 33 bu/a for spring wheat, and 39 bu/a for winter wheat. In addition, growers often receive a higher price for durum wheat than for other classes. From 1989 to 1998, durum sold for an average of about \$5.00/bu, hard red spring wheat for \$4.30/bu, and hard red winter wheat for \$4.00/bu.

Many of the agronomic characteristics of durum wheat are inferior to those of the hard red winter (HRW) wheat grown in Kansas. Yields of spring durum varieties are often lower than those of HRW wheats, which become established in autumn, rapidly resume growth in the spring, and ripen before the onsets of drought and high temperatures in the summer. The few experimental lines of winter durum that have been available for evaluation often lacked adequate cold hardiness to survive Kansas winters and also matured later than HRW wheat varieties. However, durum wheat is reportedly more tolerant to drought than HRW wheat and may have an advantage in areas where precipitation is low.

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The availability of advanced experimental lines and improved varieties of winter durum from wheat research programs in the U.S. and overseas, the several advantages of durum wheat, and the need to diversify agriculture prompted a reassessment of the crop's adaptation to Kansas conditions. The objective of this study was to evaluate grain yield and other agronomic characteristics of improved winter durum lines and varieties and compare them with popular varieties of HRW wheat in the state.

## Procedures

Sixteen advanced winter durum lines from Oregon State University, 10 lines from the CIMMYT wheat program in Turkey, 7 varieties from Romania, 10 varieties from Hungary, and 7 varieties from the Ukraine were evaluated at Hutchinson and Manhattan during the 1998-99 season. Five HRW wheat varieties (Karl 92, Ike, Jagger, TAM 107, and 2137) were grown in separate experiments at the same locations for comparisons.

The soil at the South Central Experiment Field at Hutchinson was Clark-Ost complex, 0 to 1% slope, fine loamy mixed thermic, typic Calciustalls, and that at the North Agronomy Research Farm at Manhattan was Reading silt loam, 0 to 1% slope, fine mixed mesic, typic Arqiudalls. Fertilizer was applied before planting to provide 70 lbs/a N and 27 lbs/a P at Hutchinson and 90 lbs/a N and 27 lbs/a P at Manhattan.

Wheat was seeded at the rate of 90 Ibs/a at both locations. Entries were planted in 5-ft-long, single-row plots on 21 October 1998 at Hutchinson and on 25 October 1998 at Manhattan. The experiments were arranged in randomized complete block designs with two replications at both locations. Production practices recommended for HRW wheat were used for both classes. Glean herbicide was applied at the rate of 0.35 oz/a on 26 January 1999 at Hutchinson and on 2 February 1999 at Manhattan.

Observations were made on seedling emergence during the autumn of 1998 and on plant survival, heading and maturation dates, lodging and leaf rust reactions, height and spike lengths, grain and biomass yields, and grain yield components during the spring of 1999. Leaf rust infection was rated on a scale of 1 (no rust) to 9 (complete infection). Plant height was measured from the soil surface to the top of the main spikes at maturity. Spike number, spike length, and spikelets per spike were determined 1 week before harvest.

All entries were harvested on 5 July 1999 at Hutchinson and on 1 July 1999 at Manhattan. Plants were cut near the soil surface, dried at 122°F for 72 hours, and weighed for total biomass. The grain was threshed with a plot thresher and weighed, and yields were adjusted to 12% moisture content. Harvest index was calculated as the ratio of grain yield to total biomass of the dried samples. Kernel weight was measured by counting and weighing 1000 kernels of each sample.

Weather conditions were generally favorable for production of winter wheat during the 1998-99 season. Temperatures were above the long-term means at both locations, particularly during the winter. Precipitation from September through June was approximately 4.7 in. above the mean at Hutchinson and 15.7 in. above the mean at Manhattan. Much of the excess precipitation occurred during the critical jointing through maturation stages of wheat from April through June.

## Results

All 50 durum lines and varieties and the five HRW wheat varieties emerged and formed full stands during autumn (data not shown). However, during winter, several durum lines were injured at Hutchinson, and one durum line was killed and five durum lines were injured at Manhattan. None of the HRW wheats was injured at either location. The durum wheats headed over a 5- to 6-day period, and the HRW wheats over a 3- to 4-day period. Although the durum lines headed about 7 to 10 days later than the HRW wheats, they matured only 3 to 4 days later, so their grain-filling duration was nearly 1 week shorter.

Leaf rust on durum ranged from none to complete or nearly complete infection at Hutchinson (Table 1) and Manhattan (Table 2). Infection on the HRW wheats, in contrast, ranged from moderate to severe at Hutchinson and mild to moderate at Manhattan. Neither the durum wheats nor the HRW wheats lodged significantly at either location (data not shown).

The durum wheats were considerably shorter than the HRW wheats at both locations (Tables 1 and 2). At Hutchinson, all the durum wheats were shorter than the HRW wheats, whereas some overlapping of heights of the two classes occurred at Manhattan. On the other hand, spike length was greater for all the durums than for all the HRW wheats at both locations.

Spike density was low for some durums, because winter injury reduced the plant stands (Tables 1 and 2). All the HRW wheats had excellent stands at maturity and produced over twice as many spikes as the durum wheats at Manhattan. However, all durums formed more spikelets than the HRW wheats at both locations, probably because they had longer spikes.

Total plant biomass was high for durum wheats at Hutchinson, except for lines that were injured by cold (Table 1). At Manhattan, where injury was more severe, both the range and mean amount of plant biomass were low (Table 2). The HRW wheats produced slightly less biomass at Hutchinson but nearly twice as much biomass at Manhattan compared to the durum wheats.

Grain yield of the durum wheats ranged widely at both locations, reflecting differences in winter injury, maturity, and other traits of the lines (Tables 1 and 2). Mean grain yield of all the durum lines equaled that of the HRW wheat varieties at Hutchinson but was only about one-half of the mean HRW wheat yield at Manhattan. At both locations, however, the highest durum yields equaled or exceeded the highest HRW wheat yields. Harvest indices of the durum lines reflected the variation in grain yields. The mean harvest index of the durum wheats was low, but some lines had high values at both locations. Harvest indices of the HRW wheats were usually high and varied over a small range.

Kernel weights of most durum lines were high at Hutchinson (Table 1) but were low at Manhattan (Table 2). However, some lines had heavy kernels at both locations, which was unexpected because of their late maturity. Kernel weights of the HRW wheats varied over a small range and differed only slightly between the two locations.

A large number of durum lines had promising attributes for important agronomic traits at Hutchinson (Table 1). Spike density and harvest index were the only desirable traits that were low in many of the lines. At Manhattan, spike density, kernel weight, and grain yield were frequently unfavorable (Table 2). At both locations, however, some durum lines had all the components for excellent grain yields: high spike density, numerous spikelets per spike, and heavy kernels.

## Discussion

Winter durum wheats exhibited several defects that must be corrected before the crop can be successful in Kansas. However, some of the lines performed well, particularly at Hutchinson, giving promise that production of durum wheat in the state is feasible. A concerted effort to eliminate the undesirable traits and combine the desirable traits into single varieties by breeding could result in a crop that is as well adapted to Kansas as HRW wheat.

The most important defects in the durum lines tested were their susceptibility to winter injury and late maturity. The susceptibility to winter injury is disturbing, because it occurred in a year that was mild at both Manhattan and Hutchinson. Normal low temperatures undoubtedly would have caused considerably more injuy. However, the wide range in winter survival among the lines indicated that considerable genetic variability exists in winter durum to improve its cold hardiness by breeding.

Late maturity is undesirable in wheat because hot, dy conditions during the last days of June shorten the grain-filling period, shrivel the kernels, lower the test weight, and reduce the grain yield. Unfortunately, the winter durum lines were uniformly late and had little genetic variability for maturity, so improving the maturity by breeding would be slow and difficult. The high kernel weight of some of the lines probably resulted from their superior resistance to drought and heat. Because of this excellent resistance to environmental stress, winter durum varieties might not have to mature as early as adapted HRW wheat varieties in order to be productive.

Many of the other traits of the winter durum lines were favorable for production of the crop in Kansas. The plant height and resistance to lodging indicated that winter durum can be grown at high plant density and with high rates of nitrogen fertilizer where moisture is available. The long spikes with numerous spikelets and large kernels suggested that the yield potential is high. These traits probably resulted in the good yields that were obtained from lines that had not been selected for adaptation to Kansas conditions. The high amount of total biomass indicated that winter durum might be used for pasture as well as for grain production. The low incidence of leaf rust in some of the lines suggested that they were resistant to present races of one of the most important diseases of wheat in Kansas.

Numerous traits that were not considered in the present study must be evaluated before winter durum wheat can be recommended for production in Kansas. Resistance to the many diseases besides leaf rust that affect wheat, resistance to common insects, and quality of the grain for making pasta and other products must be determined. If durum wheat appears to be feasible for Kansas, several decades may be needed to combine all the essential traits into improved varieties for production by the state's growers. Additional research will be needed to determine the crop's agronomic requirements, such as planting date, seeding rate, and fertilizer rate, and the optimum areas of the state for production. Winter durum wheat may be a promising crop, but fulfillment of its promise is many years away.

**Table 1. Agronomic and physiological characteristics of winter durum wheat lines and hard red winter (HRW) wheat varieties at Hutchinson, Kansas during 1998-99.**

| Agronomic traits | Durum wheat | | HRW wheat | | Number of durum lines showing promise |
|---|---|---|---|---|---|
| | Range | Mean | Range | Mean | |
| Leaf rust (1-9)† | 1-9 | 5.9 | 6-9 | 7.1 | 31 |
| Plant height (in) | 28-37 | 33 | 38-41 | 40 | 23 |
| Length of spike (in) | 2.7-3.9 | 3.1 | 2.3-3.5 | 2.4 | 49 |
| Spike number (no/yd$^2$) | 80-648 | 425 | 505-592 | 554 | 9 |
| Spikelets per spike (no/spike) | 18.3-23.0 | 20.6 | 12.1-13.3 | 12.8 | 49 |
| Total biomass (lb/a) | 2315-23619 | 15552 | 10836-13247 | 11895 | 44 |
| Grain yield (bu/a) | 10.0-118.6 | 82.9 | 63.3-78.6 | 71.7 | 37 |
| Harvest index | 0.19-0.40 | 0.30 | 0.37-0.41 | 0.40 | 5 |
| Kernel weight (mg) | 25.7-41.5 | 32.7 | 24.8-28.8 | 27.3 | 46 |

†1 = no infection, 9 = complete infection.

**Table 2. Agronomic and physiological characteristics of winter durum wheat lines and hard red winter (HRW) wheat varieties at Manhattan, Kansas during 1998-99.**

| Agronomic traits | Durum wheat | | HRW wheat | | Number of durum lines showing promise |
|---|---|---|---|---|---|
| | Range | Mean | Range | Mean | |
| Leaf rust (1-9)† | 1-8.5 | 5.1 | 2-4 | 2.4 | 13 |
| Plant height (in) | 27-37 | 32 | 37-40 | 39 | 26 |
| Length of spike (in) | 2.7-3.8 | 3.1 | 2.2-2.4 | 2.2 | 49 |
| Spike number (no/yd$^2$) | 23-431 | 260 | 392-626 | 547 | 2 |
| Spikelets per spike(no/spike) | 17.4-23.9 | 20.8 | 11.9-12.6 | 12.2 | 49 |
| Total biomass (lb/a) | 473-10692 | 5753 | 8171-13589 | 10815 | 15 |
| Grain yield (bu/a) | 1.8-67.6 | 29.0 | 42.8-64.2 | 57.0 | 8 |
| Harvest index | 0.18-0.48 | 0.30 | 0.31-0.38 | 0.33 | 18 |
| Kernel weight (mg) | 18.6-35.9 | 28.6 | 26.9-31.8 | 29.1 | 3 |

†1 = no infection, 9 = complete infection.