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'USU-Apogee' Wheat - Registration

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INTRODUCTION 'USU-Apogee' is a full-dwarf hard red spring wheat (Triticum aestivum L.) (NSSL Reg. no. 331390.01; PI 592742) cultivar developed for high yields in controlled environments. USU-Apogee was developed by the Utah Agricultural Experiment Station in cooperation with the National Aeronautics and Space Administration and released in April 1996. NASA is interested in improved food crops for bioregenerative life support systems in space.

Apogee is the point in an orbit farthest from the earth. USU-Apogee is a shorter, higher yielding alternative to 'Yecora Rojo' and 'Veery-10', the short field cultivars previously selected for use in controlled environments (Bugbee and Salisbury, 1988). USU-Apogee (45-50 cm tall, depending on temperature) is 10 to 15 cm shorter than Yecora Rojo and 2 to 5 cm shorter than Veery-10. USU-Apogee was also selected for resistance to the calcium-induced leaf tip necrosis that occurs in controlled-environments.

PEDIGREE USU-Apogee originated from the cross 'Parula'/'Super dwarf', both of which were obtained from the CIMMYT germplasm collection in 1984. Parula has the pedigree:
FKN/3/2*FCR//'KenyaAD '/GAB054/4/'Bluebird'/'Chanate';
where FKN = 'Frontana'/'Kenya58'//'Newthatch'.

Parula was selected for its small leaf size. Super dwarf has the CIMMYT germplasm number CMH79.481-1Y-8B-2Y-2B-0Y; and the pedigree:
T. sphaerococcum/2*H-567.71/3/'Era' /'Sonora64'//2*Era.

Super Dwarf was selected for its dwarf stature (25 cm tall).

SELECTION Single head selections were made in the F2 to F4 generations for short height (less than 0.5-m tall), vertical tillering habit, reduced tillering, and small leaves. The segregating dwarf-lines tended to have plagiotropic (horizontal) tillers, which cause undesirable interplant competition in communities. For the same reason, the formation of secondary tillers is an undesirable trait at high planting densities in optimal environments (Donald, 1968; 1979). Small leaves are often more photosynthetically efficient than large leaves and 2 small leaves may be better than one large leaf (Morgan et al., 1990; LeCain et al., 1989; Bhagsari and Brown, 1986).

Mass selections were made in the F5 to F8 generations. All selections were made in a CO2-enriched temperature-controlled greenhouse that had 350 µmol m-2 s-1 of supplemental lighting from high pressure sodium lamps. The photoperiod was 24-h (continuous light). The root-zone was a hydroponic soilless medium watered twice daily with nutrient solution. Continuous cultivation made it possible to evaluate 3 to 4 generations per year. Yields in this environment are typically double that of the best irrigated field yields (about 16 Mg ha-1; 240 bushels per acre).

Yield evaluations, in the near-optimal conditions of the CO2-enriched greenhouse, were begun in the F5 generation in 1988. USU-Apogee was tested under the designation CPL-20-1-41. Mice got into the greenhouse prior to harvest in the F8 generation and attacked all six replicate plots of USU-Apogee. No other plots were damaged. Selective seed consumption by mice among field breeding lines has occurred previously at Utah State University, and may be caused by subtle differences in volatile compounds among lines. USU-Apogee had the least leaf tip necrosis, but had considerable variability for plant height, so 67 single heads selected from the F9 generation were grown as head rows. Additional selections were made in the next six generations (F10 to F15) for short height and high yield. In the F16 generation, 100 heads were selected and grown as head rows. After roguing off-type and nonuniform rows, the remaining 90 F16-derived lines were harvested and bulked as Breeder seed.

UNIQUE PROPERTIES USU-Apogee is resistant to the severe leaf tip chlorosis that occurs in wheat under rapid growth conditions, particularly continuous light. This chlorosis (caused by a calcium-deficiency) can kill the top 30% of the flag leaf. The problem is severe in Veery-10 and also occurs in Yecora Rojo. Calcium deficiencies, such as tip burn in lettuce and blossom end rot in tomatoes, are common in controlled-environment crop production because Ca has low phloem mobility and is thus not sufficiently translocated to rapidly growing meristems. Foliar Ca applications and increased root-zone Ca are not effective because they do not reach the meristematic leaf tissue. USU-Apogee has significant rates of guttation during dark periods and guttation occurs even during the light period when the stomates are partly closed by elevated CO2. Significant amounts of Ca can be translocated by guttation. The segregating lines with the smallest leaves had the least chlorosis. Measurements indicated adequate calcium in the top 30% of small leaves (0.4% Ca), but inadequate amounts (0.05% Ca) in large leaves. USU-Apogee has smaller flag leaves (11 to 20 cm long, depending on temperature) than Yecora Rojo and Veery-10 (20 to 30 cm long).

USU-Apogee has an extremely rapid development rate. Heads emerge 23 days after seedling emergence in continuous light with a constant 25 C temperature. Heads of Yecora Rojo and Veery-10 emerge about 6 days later under these conditions. In field conditions, USU-Apogee heads about 3 days earlier than Yecora Rojo and 6 days earlier than Veery-10.

YIELD COMPARISONS The yield advantage of USU-Apogee is greatest in conditions favorable to a rapid development rate (warm temperatures, 23 C). The yield of Yecora Rojo and Veery-10 are similar, so most of our studies compared USU-Apogee to Veery-10. USU-Apogee out-yielded Veery-10 by an average of 29±2% in 2 studies at 23 C (60 day life cycle), but by an average of 13±10% in 3 studies at 17 C (95-day life cycle). USU-Apogee outyielded Veery-10 by 8% in a replicated study in a growth chamber under high light (1200 µmol m-2 s-1; 24-h photoperiod; 51.8 mol m-2 d-1, equivalent to full sunlight at the summer solstice). USU-Apogee outyielded Veery-10 by 15±3% in replicated field trials in 1994 and 1995, and outyielded Yecora Rojo by 14% in 1995. The yield of USU-Apogee was 160% of Super Dwarf in the 1995 field trial. In 1995, the field yield was 100.1% of the yield of Fremont, an adapted semi-dwarf Utah wheat cultivar. Neither Veery-10 nor Yecora Rojo are specifically adapted to

Utah field conditions.

USU-Apogee differs significantly from Veery-10 in the relative contribution of yield components. Heads per m2 and seeds per head are approximately 25% higher in USU-Apogee, and mass per seed is about 25% less. The harvest index is 5 to 15% higher than that of Veery-10.

BREADMAKING PROPERTIES **Breadmaking quality was evaluated by the USDA-ARS Western Quality Wheat Laboratory at Pullman, WA. Milling and Baking tests indicated that USU-Apogee has similar quality to Veery-10 and slightly lower quality than Yecora Rojo. Breeder seed of USU-Apogee will be maintained by the Crop Physiology Laboratory at Utah State University.**

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