The converted lines were developed through a backcross procedure in which tall, late-maturing tropical sorghum varieties or cultivars were converted to early-maturing, combine-height sorghums. Conversion is accomplished by a crossing and backcrossing program using favorable short-day photoperiods during the winter in Puerto Rico, with selection for early, short genotypes within segregating populations under long-day, summer conditions at Chillicothe, Texas. All converted lines offered for release have received four backcrosses to the original exotic variety. The non-recurrent parent used in 24 of the converted lines was an early-maturing, 4-dwarf Martin B-line, BTx406, of U.S. origin. Three lines were converted using BTx3121 as the early-maturing non-recurrent parent. The exotic varieties are used as male parents in all crosses and backcrosses until the 3rd backcross when they are used as the females in order to recover the original cytoplasm in the converted line.

The converted lines are non-sensitive to photoperiod, will mature normally in the USA, and are generally short-statured, usually 3- or 4-dwarf in height, but occasionally 2-dwarf in height. They represent new sources of germplasm from the World Sorghum Collection and are of a height and maturity to make them readily usable in the United States and other temperate zone areas of the world. These materials should contain new sources of such desirable traits as disease and insect resistance, drought resistance, and improved grain quality, and should be useful to breeders and other sorghum researchers as germplasm sources in developing improved sorghum lines and hybrids. Table 1 gives the designation of the converted lines and information on the original exotic varieties.

Seed will be maintained and distributed by the Texas Agricultural Experiment Station at the Texas A & M University Agricultural Research and Extension Center at Lubbock, Route 3, Box 219, Lubbock, Texas 79401-9757. It will be available in germplasm quantities only. Private seed companies will be charged a fee of $200.00 for the set. Payment should be made to "Texas Agricultural Experiment Station" and should be in U.S. dollars. Genetic material of this release will be deposited with the National Plant Germplasm System, where it will be available for research purposes including development and commercialization of new varieties/cultivars. Those receiving seed are asked to agree to supply, upon request, information about breeding behavior, desirability, and usefulness of the material, and to cite it as the origin of useful derived lines.

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Stay-Green Trait Associated with Yield in Recombinant Inbred Sorghum Lines Varying in Rate of Leaf Senescence

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Introduction

Drought is the major constraint to sorghum [*Sorghum bicolor* (L.) Moench) production worldwide. To reduce the effects of late-season drought, sorghum breeders in Australia, the USA, and India, have been selecting for the non-senescence or stay-green trait. Genotypes possessing the stay-green trait maintain a greater green leaf area under post-anthesis drought than their senescent counterparts (Rosenow 1977). This has raised an important question: does maintaining green leaf area in sorghum automatically improve yield under drought? This question has concerned sorghum breeders for more than two decades, as leaves can remain green simply due to a lack of assimilate demand because the plants have small panicles (Henzell and Gillerion 1973; Rosenow et al. 1983). If this were the case, then selection for stay-green would result in lower grain yield. To better understand the physiological effects of stay-green, particularly its association with yield and lodging resistance, we studied a set of recombinant inbred lines (RILs), varying in their rate of leaf senescence, under post-anthesis drought.

Materials and methods

One hundred and sixty RILs were developed in Queensland, Australia, from a cross between two elite lines (BQL 39, senescent x BQL 41, stay-green) (Tao et al. 1997). The RILs were grown at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in southern India during the 1996 postrainy season. The experimental design was a randomized-block with two replicates. Plot size was 3 x 4 m. The soil was a shallow (<75 cm), cracking, self-mulching, Vertic Inceptisol. The experimental site was fertilized with 40 kg N ha^{-1} prior to sowing. Plots were machine-sown on 1 November 1995 in rows 0.75-m apart, giving a population density of about 7 plants m^{-2}. Emergence (50%) occurred on 5 November 1995. All RILs flowered between 59 and 73 days after emergence. The sorghum crop experienced severe post-anthesis drought. A single 1-m long row was cut from a center row of a 4-row plot on three dates: anthesis (A), mid-grain filling (A+25d), and physiological maturity (black layer). Green leaf area was measured for each plot at all harvest times with an electronic planimeter (LiCor). Grain yield, 100-grain weight, and grain number per row were also determined for all plots at maturity. Each sample was dried in a forced draft oven at 80°C for 48 h before weighing. Harvest index was derived by dividing grain yield by above-ground dry mass.

The relationships between stay-green, grain yield, and yield components were investigated by a series of phenotypic correlations between:

- Grain yield and both grain number m^{-2} and grain size
- Green leaf area at anthesis and both grain number m^{-2} and grain size
- Green leaf area at A+25d and both grain yield and harvest index
- Grain size and relative rate of leaf senescence.

Only data from plots with 100% seed set were used to develop these relationships, thereby preventing any confounding effect of variable seed set on leaf senescence.

The relative rate of leaf senescence was calculated from the slope of the linear decline over time from anthesis (A) to maturity (M) of green leaf area, relative to green leaf area at A, expressed as loss of relative green leaf area (%) per day:

$$[(1-\mathrm{GLAM}/\mathrm{GLAA})^{*}\ 100]/\text{days from A to M}$$

where: GLAM = green leaf area at maturity (cm^{-2} m^{-2});
GLAA = green leaf area at anthesis (cm^{-2} m^{-2}).

Results and discussion

Grain yield under the prevailing post-anthesis stress conditions was correlated with both grain number (r = 0.723***, Fig. 1) and grain size (r = 0.339***, Fig. 2), although grain number was the primary determinant of yield, accounting for 52% of the variation in yield. Grain numbers were correlated with green leaf area at anthesis (r=0.424***, Fig. 3). Therefore, green leaf area at the beginning of the grain-filling period was positively related to potential grain yield.

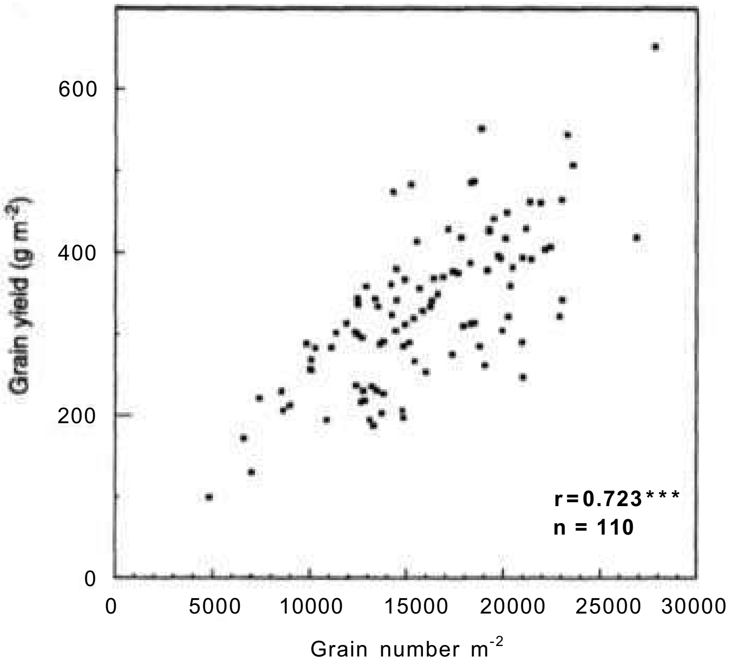

Figure 1. Relationship between grain yield and number m^{-2} in a set of 160 recombinant inbred lines (RILs) from the cross between BQL 39 (senescent) and BQL 41 (stay-green), grown during the 1995/96 postrainy season at Patancheru, India.

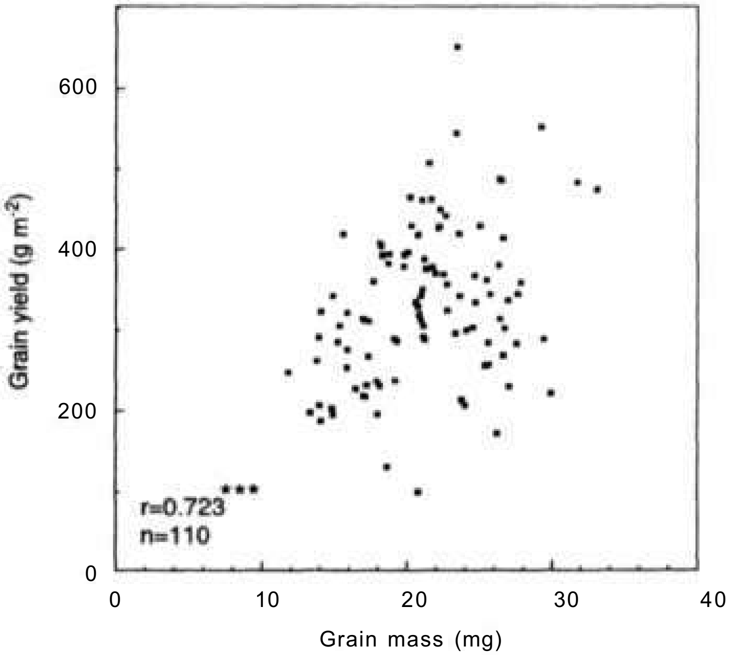

Figure 2. Relationship between grain yield m^{-2} and grain mass in a set of 160 recombinant inbred lines (RILs) from the cross between BQL 39 (senescent) and BQL 41 (stay-green), grown during the 1995/96 postrainy season at Patancheru, India.

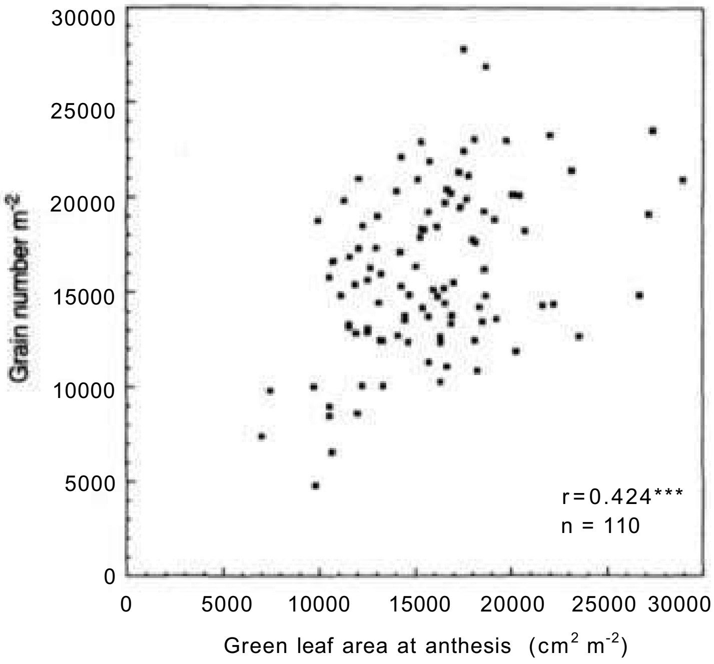

Figure 3. Relationship between green leaf area at anthesis and grain number m^{-2} in a set of 160 recombinant inbred lines (RILs) from the cross between BQL 39 (senescent) and BQL 41 (stay-green), grown during the 1995/96 postrainy season at Patancheru, India.

Grain size was a secondary yield determinant and was independent of green leaf area at anthesis. It was, however, correlated with the relative rate of leaf senescence during the grain-filling period (r = -0.632***, Fig. 4), such that reducing the rate of leaf senescence from 3 to 1% loss of leaf area per day resulted in doubling grain size from about 15 to 30 mg. Stay-green thus had a major positive benefit on filling the grains that were set.

The maximum green leaf area per plant generally occurs about 10 days before anthesis in sorghum (Borrell et al. 2000a) and is an important determinant of green leaf area at maturity, since it sets the initial 'benchmark' of green leaf area per plant. It is from this benchmark that leaf area declines according to the onset and rate of senescence, thereby determining the amount of green leaf area at any point during the grain-filling period, and ultimately at maturity. Leaf area at mid-grain filling (A+25d) is a potentially useful single integrator of both of these factors, and an important determinant of grain yield in terminal stress environments for two reasons. Firstly, leaf area at mid-grain filling reflects differences in grain numbers at anthesis due to the variation in leaf area production prior to anthesis (Fig. 3), and secondly, it reflects reduced senescence rates that result in enhanced grain filling (Fig. 4). It is not surprising then, that green leaf area at mid-grain filling was related to both grain yield (r=0.643***, Fig. 5) and harvest index (r = 0.308**, Fig. 6). This is an important finding, suggesting that the association between high grain sink/source ratio and senescence under water-limited conditions reported by Henzell and Gillieron (1973), Duncan et al. (1981), Rosenow et al. (1983), and Tangpremsri (1989) is not necessarily always the rule.

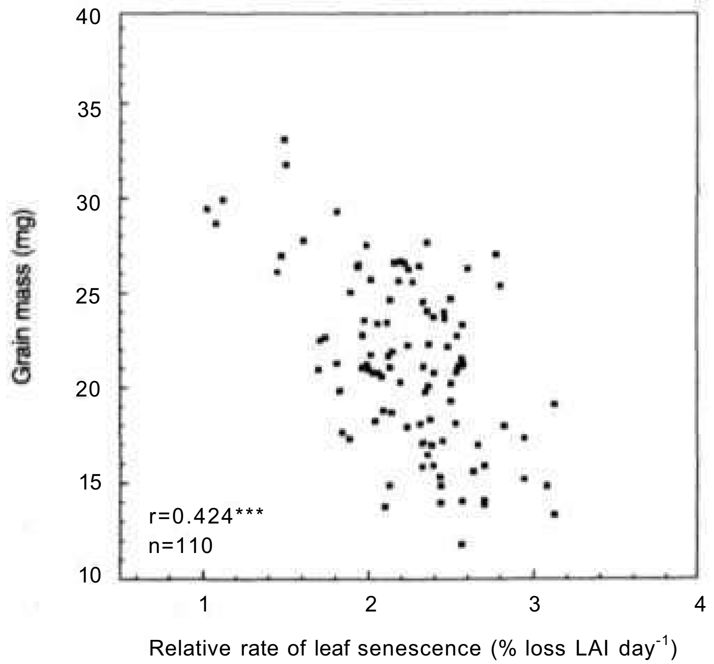

Figure 4. Relationship between the relative rate of leaf senescence and grain mass in a set of 160 recombinant inbred lines (RILs) from the cross between BQL 39 (senescent) and BQL 41 (stay-green), grown during the 1995/96 postrainy season at Patancheru, India.

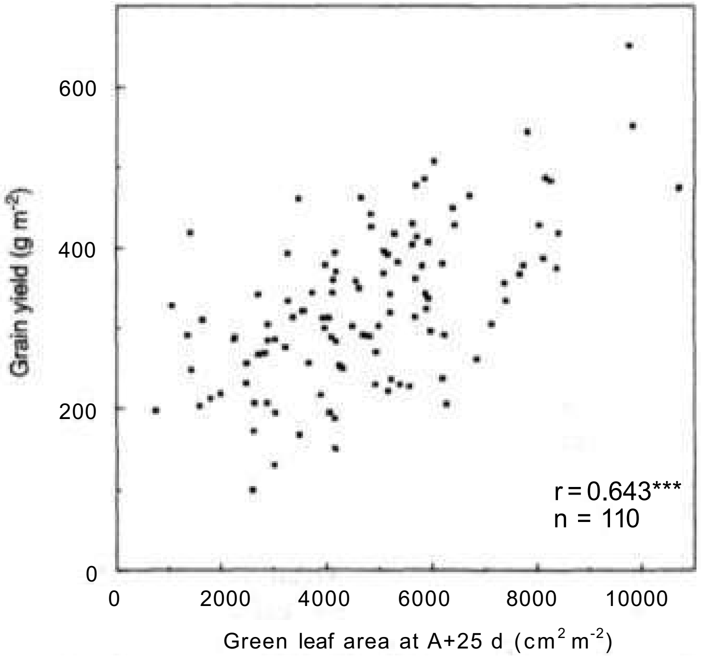

Figure 5. Relationship between green leaf area at 25 days after anthesis and grain yield m^{-2} in a set of 160 recombinant inbred lines (RILs) from the cross between BQL 39 (senescent) and BQL 41 (stay-green), grown during the 1995/96 postrainy season at Patancheru, India.

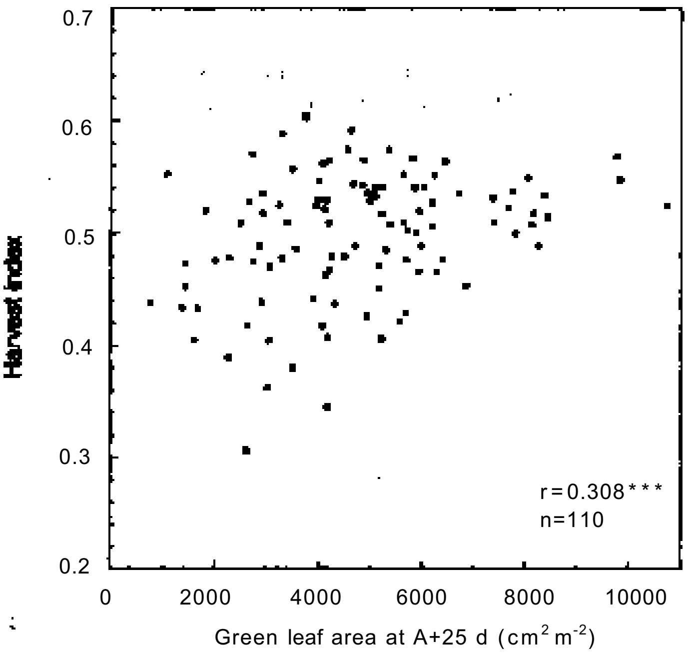

Figure 6. Relationship between green leaf area at 25 days after anthesis and harvest index in a set of 160 recombinant inbred lines (RILs) from the cross between BQL 39 (senescent) and BQL 41 (stay-green), grown during the 1995/96 postrainy season at Patancheru, India.

Our study indicates that leaves do not stay green only because of a small sink demand. Rather, as documented in earlier studies, they stay green under post-anthesis drought because of higher leaf nitrogen status (Borrell and Hammer 2000) and transpiration efficiency (Borrell et al. 2000c), resulting in maintenance of photosynthetic capacity and, ultimately, higher grain yield and lodging resistance (Borrell et al. 2000b).

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Pollen Grain Production in Male-Fertile Lines of Sorghum

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Introduction

Sorghum [*Sorghum bicolor* (L.) Moench] is one of the most important cereal crops in Mexico. In 1997 it was sown on approximately 1.5 million ha. Ergot [*Claviceps africana* (Frederickson, Mantle, & de Milliano)] is a new disease in the Americas. In Mexico, it was first seen on the coast, or in the coastal region of the Gulf of Mexico in 1997 (Diario Oficial 1997) in fields of commercial hybrid sorghum; by the end of the year the disease was present throughout most of the country where sorghum is grown.