III. CONTRIBUTIONS

ITEMS FROM ARGENTINA

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Harvest index. The alter ego of grain yield under terminal drought stress.

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In a plant-breeding program, gene effects, genotypic variability, and the selection environment are factors that influence the heritability of the improved character. Concerning the biological determinants and as selection and gene recombination cycles elapse, the allelic variability tends to decrease. In the selection environment, low heritability estimates usually are obtained under stress conditions, consequently the response to selection is less than that obtained in nonstress conditions. However, a particular environment can be a stress for one attribute or character and not stress another. Our objective was to measure the response to divergent selection for grain yield in wheat and triticale grown under terminal drought. The study was conducted at the Experimental Farm of the College of Agriculture (Córdoba National University) Córdoba, Argentina. Crops were grown under rain-fed conditions, stored soil moisture, and direct seeding. The experimental material consisted of S_0 progenies of wheat and triticale derived from two recurrent selection programs.

During 2008, the C_9S_0 (wheat) and C_6S_0 (triticale) progenies were evaluated and divergently selected with respect to grain yield/plot according to a selection intensity of 1.554. The experimental units were one-row plots without replications, 1.3 m in length, spaced at 0.20 m, and with a seeding rate of 100 kernels/m^2. Systematic controls were used in order to adjust for environmental heterogeneity. In addition to grain yield, aerial biomass, harvest index, and spike number/plot also were measured. During 2009, the 20 S_1-derived families for each species (ten per each high and low group) were evaluated using 5-m, one-row plots spaced 0.20 m apart at seeding rate of 250 kernels/m^2. Completed randomized designs with two replications were used. The S_1-derived family traits measured on a plot basis were grain and biological yield (g/m^2), spike number (n/m^2), 1,000-kernel weight (g), harvest index (%), and grain number (n/m^2). An S_1 evaluation of available soil-water content to a depth of 2.0 m was measured gravimetrically. Soil samples were taken at seeding (DC 0.0), flag leaf sheath extending (DC 4.1), physiological maturity (DC 9.5), and harvest maturity. The amount of rainfall during the crop cycle was 52 mm (26 mm of effective precipitation). Correlations were computed between grain yield and the other agronomic traits measured during the S_0 and S_1 evaluations. The DGC test was used for comparing the mean differences between the high and low groups of the S_1-derived families.

Significant and positive associations in the wheat germ plasm were found between grain yield and harvest index (S_0 r = 0.49; S_1 r = 0.48), grain yield and aerial biomass (S_0 r = 0.97; S_1 r = 0.74), grain yield and spike number (S_0 r = 0.90; S_1 r = 0.65), and aerial biomass and spike number (S_0 r = 0.92; S_1 r = 0.73). For triticale, the analyzed variables also showed positive and significant relationships between grain yield and harvest index (S_0 r = 0.55; S_1 r = 0.68), grain yield and aerial biomass (S_0 r = 0.91; S_1 r = 0.89), grain yield and spike number (S_0 r = 0.92; S_1 r = 0.53), and aerial biomass and spike number (S_0 r = 0.83; S_1 r = 0.61). Significant differences between the high and low group mean values were observed for harvest index in both species. The amount of available soil water varied from 268.4 mm (81% of field capacity or FC) at DC 0.0; 90.0 mm (27% of FC) in wheat, and 59.0 mm (17.8% of FC) in triticale at DC 4.1; 7.1 mm (2.1% of FC) in wheat and 12.2 mm (3.8% of FC) in triticale at DC 9.5; and 3.6 mm (1% of FC) in wheat and 0.0 mm (0% of FC) in triticale at harvest maturity. Both species extracted soil water below the -1,500 kPa (wilting point or WP), with evapotranspired water amounts of 21.7 mm and 17.6 mm in wheat and triticale, respectively. As physiologically expected, a nonsignificant, direct response to selection for grain yield was balanced by a significant response for harvest index, one its physiological components. In both SR programs, harvest index was the only grain yield component that showed significant response and heritability estimates along the last four cycles in wheat (C_6 to C_9) and two cycles in triticale (C_5 and C_6). Independent of the cycles of SR elapsed, harvest index showed enough genetic variability for further genetic improvement. The 78% of available water depletion at the beginning of the critical period and the terminal drought stress in both cereals did not affect with the same intensity the phenotypic expression of the analyzed traits. In summary, an taking into account previous results, harvest index shows us an alternative way to interpret grain yield improvement under marginal conditions of cultivation.

Straw production and water use under direct seeding.

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The monsoon regime of the central region of Argentina is the main constraint for the wheat production in this area, where winter crops grow and develop with scarce amount of precipitation and depend on stored soil moisture at sowing. Effective use of water implies maximum soil moisture for transpiration, which also involves reduced nonstomatal transpiration and minimal water loss by soil evaporation. The presence of straw mulch has a positive impact on suppressing evaporation and, consequently, greater carbon sequestering is a priority. The objectives of this study were to evaluate the influence of seeding date on straw production and quantify the corresponding water use. Three commercial cultivars and three experimental lines were grown under rainfed and direct seeding conditions at Córdoba (Argentina) in 2009. The late-flowering genotypes were sown on 1 May, intermediate on 12 May, and early on 21 May. The different sowing dates were used in order to diminish the risk of frost damage after spike emergence. Completely randomized blocks designs with three replications were used. Plot size was '1.0 m x 5.0 m' with a row spacing of 0.2 m. A seeding rate of 250 seed/m^2 was used. A gravimetrical method was used in order to quantify (0–200 cm) the available soil water content. At sowing, the available stored soil moisture was 233 mm (late genotypes), 239 mm (intermediate genotypes) and 223 mm (early genotypes). Grain and straw yield, harvest index, water-use (WU), water-use efficiency for grain (WUEg) and straw (WUEs) production, intercepted radiation in flowering (Ei), and percentage soil water at harvest for every 0.2-m depth interval were determined. Data was analyzed with the INFOSTAT statistical package.

The late-flowering genotypes showed the highest mean value for straw production (7,189.7 kg DM/ha) with significant differences for the intermediate and early genotypes (5,854.7 kg DM/ha and 5,654.3 kg DM/ha, respectively). Higher straw production was associated to a significant and increased WU (283.6 mm in the late genotypes versus 258.6 mm in the early genotypes) and WUEs (25.35 kg DM/mm in the late genotypes versus 20.85 kg DM/mm and 21.87 kg DM/mm for the intermediate and early genotypes, respectively). For grain yield, nonsignificant differences were noted between materials with different biological cycles. The straw of the late, experimental genotypes had a higher C:N ratio and lignin percentage than those for the corresponding intermediate and early genotypes. The percentage of soil moisture content at harvest differed significantly between commercial (9.2%) and experimental (9.41%) genotypes and late (8.98%), intermediate (9.32%), and early (9.61%) flowering materials. Significant statistical differences also were observed between the 0–40 cm (8.70–8.83%), 40–180 cm (9.18–9.63%), and 180–200 cm (9.92%) soil profiles. In all cases, the wheat crop used water below -1,500 kPa of suction (10.3–13.5%). For intercepted radiation at flowering, the Ei of the early genotypes (83.95%) was significantly higher than those measured for the late (75.33%) and intermediate (68.30%) genotypes.

In conclusion, the use of late-flowering genotypes sequestered more carbon in terms of straw production, captured more water, and used it most efficiently. In addition, under rainfed conditions, with crops grown on stored soil moisture and the use of no-till practices such as direct seeding, water uptake by wheat surpassed the physical estimate of the permanent wilting point.