An investigation of the adaptation of seleci ed cimmyt wheat germplasm to water limiting environments in Queensland

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Generally yield improvement of genotypes by plant breeding proceeds without a physiological understanding of the basis of improvement. Interpretimg genotype adaptation to agricultural environments on a physiological basis relies upon firstly identifying the environmental factors initiating the differences in performance among the genotypes and secondly the development of an analytical framework for investigating the physiological basis of differences in genotypic adaptation. Characterisation of environments for water availability has been previously comsidered for four Queensland emvironments in which water availability was manipulated by use of rain out shelters and irrigation'. This paper considers the value of grain number and graim size measurements and the differences between genotypes in patterns of performance for these characters over these four envirommemts as a preliminary step in resolving physiological reasons for differences im gemotypic adaptatiom.

Methods

Twelve advanced CIMMYT wheat genotypes and three check cultivars, also of CIMMYT parentage, Hartog, Banks and Kite,were growm in four environments, low (LROS), medium (MROS), high (HROS), and irrigated (IRRIG) at Gatton, Queensland during 1988. Water availability was manipulated by use of irrigation and rain out shelters (ROS). Two of these environments were characterised using midday leaf water potential (LWP) meaurements as experiencing severe water stress prior to anthesis, reducing grain yield, while the two remaining environments suffered no yield reducing water stress at anthesis (Table 1). Pooled analyses of variance were conducted for graim yield, grain number per square metre and graim size (200 grain weight). Differences in genotype grain yield patterns of performance over environments were considered in terms of grain number (GN) and grain size (GS) inter.relations.

Results and discussion

Genotype main effect differences were significant ($P<0.05$) for grain yield, GN and GS. However genotype by environment (GxE) interactiom was significant ($P < 0.05$) for only grain yield and GS. Grain yield differences between genotypes were positively related to GN both within and averaged over environments ($P<0.01$) (Table 1). GS was positively related to grain yield ($P<0.05$) in only two environments, the lowest yielding environment where GN was severely reduced and in the fully irrigated environment where grain setting ability was maximised (Table 1). These results suggest firstly that the ability of the genotypes to set grains underwater limiting and non.limiting conditions was the major determinant of grain yield differences between genotypes and secondly that the relative ability of these genotypes to set grains was constant over these envirromments. This provided information on the timing of water stress events and the way in which they effected grain yield in terms of grain set and grain fillimg. In the emvironmemts where pre.anthesis stress was encountered the graim setting ability of the genotypes was reduced (Table 1). Therefore grain setting ability of the genotypes under water stress would have a large influence on yield performamce of the gemotypes. Comsidering differences between genotype grain yield response patterns in this way is viewed as a useful preliminary framework for investigating differences in grain yield adaptation. From here the contribution of underlying physiological processes, relationships and mechanisms to grain yield performance may be assessed through their influence om GN or GS. This is fundamentally a holistic approach to investigating differences in genotypic adaptatiom, working back from grain yield differences expressed between gemotypes, attempting to find a basis for these differences. This would be a useful complementary approach to the study of physiological mechanisms and their role in genotypic adaptation and may provide insight to the nature of genotypic improvement through plamt breeding.

Table 1. Treatments and correlation coefficients between grain yield and yield components for 15 genotypes in 4 envs, with env mean pre.anthesis midday LWP and grain yield and yield component measurements.

Environment	Irrig Timing	G Yield vs GN	G Yield vs GS	LWP (MPa)	GN (m^{-2})	GS (g./200gr)	G Yield (t/ha)
LROS	1 sowing	0.88^{**}	0.61^{*}	-2.31	6705	7.0	2.37
MROS	1 sowing, 1 mid-till	0.78^{**}	0.31	-1.91	8008	7.3	2.92
HROS	1 sowing, 2 mid-till	0.72^{**}	0.42	-1.43	11141	7.5	4.15
IRRIG	every 2 weeks	0.84^{**}	0.55^{*}	-1.55	11453	7.6	4.34
Mean over 4 envs		0.76^{**}	0.49^{*} LSD 5%	0.09	651	0.2	0.25

1. Cooper M., Woodruff D.R. amd Byth D.E. (1989). Identification and characterisation of water limiting environments within the Queensland wheat production system. This volume.