1989

Ear stem ratios in the breeding populations. Characterization of early vigour in wheat cultivars.

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SUMMARY OF EXPERIMENTAL RESULTS 1989

A. Ear:stem ratios in the breeding populations
B. Characterization of early vigour in wheat cultivars

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A. Ear:Stem Ratios in the Breeding Populations

Experiments:

1. Ear:stem ratios in F_2 lines - Wongan Hills 1988.
2. Ear:stem ratios in F_3 lines - Wongan Hills and South Perth 1989.

The above experiments were done in association with Dr B. Whan, Department of Agriculture.

Introduction

Experiments with old and modern wheat cultivars (Siddique et al. 1989a) indicated that improvement in harvest index and grain number per ear in modern cultivars was due to a greater proportion of the shoot dry matter produced before anthesis being allocated to the ear. At anthesis modern cultivars had a higher ear:steam ratio and more competent florets per spikelet. Differences in ear:stem ratio were detected soon after terminal spikelet stage, when the ear weighed less than 1 mg.

A major finding was the positive correlation between harvest index and ear:stem ratio at anthesis. This suggests that harvest index is decided as early as terminal spikelet stage and ear:stem ratio provides a better selection criteria than harvest index, since it is unaffected by stress in the post-anthesis period. In the pre-anthesis period moisture stress is less frequent in this environment and ear:stem ratio measures the potential of a genotype. Post-anthesis moisture stress (a common feature in this environment) affects the grain growth and this reduces the harvest index. Thus harvest index of genotypes of different maturity may be differentially affected, reducing the efficacy of selection. The main aims of this project are two-fold:

(i) Study and identify lines varying in ear:stem ratio within material from WADA's wheat breeding programme and to study its implication for grain yield improvement.

(ii) Study the genetics and physiology determining ear:stem ratio.

Methods

Ear:stem ratio F_2 lines

F_2 lines from 40 crosses from Dr Whan's yield improvement programme were sown in plots of two rows x 30 m at Wongan Hills on June 6, 1988. Fourteen of the crosses which have the greatest uniformity of life cycle were selected for ear:stem ratio studies (Table 1). At anthesis (the lower florets in the central spikelets have nearly exerted anthers) fifty plants per plot were taken at random for ear:stem ratio studies. The number of ear bearing tillers were counted and plants were tagged with a cross/plant number. The main shoot (largest) with a cross/plant number were removed. The rest of the plant i.e. tillers were left to fill grain, which were harvested at maturity for grain. The measurements made on the main shoot were: total stem length, stem dry matter (excluding leaves and leaf sheaths) and ear dry matter. Ear:stem ratio was calculated as the ratio of ear dry matter/stem dry matter at anthesis.

Ear:Stem Ratio F_3 Lines

In 1989 nine croses from the fourteen original crosses (Table 2 and 3) were selected on the basis of parental genotypes and the mean ear:stem ratio of F_2 lines. From each cross fifty F_2 plants were selected and the the F_3 seeds from each plant were sown at Wongan Hills and South Perth as a 1.5 m row in six row plots. One row per plot was sown as a parental cultivar as control. The experiments were sown on June 7 at Wongan Hills and June 21 at South Perth. Normal cultural and management practices were followed for both experiments. The South Perth plots received irrigation (overhead sprinklers) as and when required.

At anthesis five plants per each F_3 line and parents were selected and the following measurements were made:

(i) date of anthesis and tiller number per plant;
(ii) main stem lenth (ground to collar);
(iii) main stem dry matter (excluding leaves and leaf sheath);
(iv) main stem ear dry matter.

Ear:stem ratio was calculated as mentioned before. The plots were harvested and grains were retained for F_4 studies.

Results

Experiments with F_2 lines from fourteen crosses in 1988 at Wongan Hills indicated a range of ear:stem ratios at anthesis (Table 2). Anthesis in these lines ranged from 96 to 110 days. Analysis of 1989 experiments also indicated a range of ear:stem ratio at anthesis in F_3 lines (Table 3).

Ear:stem ratio at anthesis was poorly corelated with days to anthesis or tiller number. There was a strong negative linear relationship ($P<0.01$) between ear:stem ratio and stem length in all crosses, except W87-072. However, there were substantial variation (low and high ear:stem ratios) within the same height class.

In general there was good correlation between ear:stem ratios at Wongan Hills and South Perth among F_3 lines and between F_2 and F_3 lines. This suggests that ear:stem ratio is less affected by environment. Preliminary analysis of ear:stem ratio data in the F_3 lines using Residual Maximum Likelihood programme indicates high heritability (Table 4).

Conclusion

The results so far indicate a range of ear:stem ratios in the crosses examined. The study also suggests that ear:stem ratio has high heritability. Further studies are in progress to evaluate ear:stem ratio in the F_4 lines in selected crosses and also to establish relationship between ear:stem ratio, grain yield and harvest index.

Reference

Siddique, K.H.M., Kirby, E.J.M. and Perry M.W. (1989a). Ear:stem ratio in old and modern wheat varieties; Relationship with improvement in number of grains per ear and yield. Field crops Res. 21, 59-78.

Table 1. List of crosses and their pedigrees used for ear:stem ratio studies

Line code	Pedigree
W87-203	Eradu/Martonvasar 13T
W87-116	79W:783/Hazera 2154
W87-241	Schomburg/Tai Shan 1
W87-022	Eradu/V763-17
W87-152	Schomburg/Yu Mai 7
W87-072	SA42/V763
W87-437	Kulin/URY-GU-530-86W
W87-410	Kulin/U-KL-496-86W
W87-073	TFQ113/SA42
W87-114	Kulin/Hazera 2145
W87-131	772:832/V979-28
W87-123	79:783/Kansu No. 32
W87-121	Schomburg/Kansu No. 32
W87-076	V763/Pato Argentina

Table 2. Days to anthesis and ranges and means among F_2 selections for ear:stem ratio at Wongon Hills, 1988

Line code	Days to anthesis	Ear:stem ratio		
		Mean	Min.	Max.
W87-203	110	0.53	0.37	0.71
W87-116	104	0.47	0.30	0.68
W87-241	110	0.51	0.35	0.68
W87-022	96	0.44	0.36	0.56
W87-152	110	0.55	0.31	1.02
W87-072	96	0.42	0.31	0.71
W87-437	96	0.48	0.29	0.73
W87-410	96	0.53	0.40	0.92
W87-073	96	0.41	0.31	0.62
W87-114	96	0.52	0.33	0.74
W87-131	104	0.47	0.33	0.61
W87-123	110	0.39	0.27	0.52
W87-121	110	0.40	0.29	0.54
W87-076	96	0.48	0.35	0.64

Table 3. Means and ranges among F_3 selections for ear:stem ratio at Wongan Hills (WH) and South Perth (SP), 1989

Line code	Ear:stem ratio					
	Mean		Min.		Max.	
	WH	SP	WH	SP	WH	SP
W87-203	0.57	0.60	0.40	0.45	0.83	0.93
W87-131	0.64	0.66	0.47	0.51	0.75	1.01
W87-072	0.60	0.59	0.47	0.49	0.75	0.73
W87-410	0.64	0.69	0.51	0.49	0.96	1.30
W87-121	0.50	0.43	0.38	0.33	0.79	0.66
W87-152	0.68	0.60	0.46	0.36	1.08	1.30
W87-022	0.54	0.56	0.44	0.43	0.66	0.78
W87-114	0.66	0.69	0.41	0.43	0.98	1.20
W87-241	0.60	0.52	0.44	0.36	0.78	0.74

Table 4. Heritabilities among F_3 selections for ear:stem ratio at South Perth (SP) and Wongan Hills(WH) in 1989

Line code	Heritability (h^2)	
	SP	WH
W87-203	0.854	0.814
W87-131	0.796	0.665
W87-072	0.570	0.683
W87-241	0.822	0.604
W87-410	0.896	0.504
W87-121	0.886	0.801
W87-152	0.894	0.856
W87-022	0.738	0.788
W87-114	0.830	0.855

B. Characterization of early vigour in wheat cultivars

Trial number: 89WH54
File number: Ex6108

This trial was done in association with Kerry Regan (CSIRO, Dryland Crops and Soils Reseach Programme, Western Australia).

Introduction

Large area of wheat crops (48%) are grown on light textured soils in Western Australia. Since these soils have large quantity of water stored well below 1 m (Hamblin Tennant, 1987) crops should be able to support post-anthesis grain growth without any haying off, provided roots can reach and extract water from this lower depths. Thus main strategy on these soils should be to maximize the crop growth and dry matter production in the pre-anthesis period as opposed to the optimum dry matter prouction on fine textured soils (Fischer, 1979).

Cultivars with increased crop growth rates and canopy development in winter could improve the dry matter production and water use efficiency through both higher transpiration efficiencies and more rapid shading of soil surface (Siddique et al. 1990b). Recent studies by Whan et al. (unpublished) in Western Australia suggests that cultivar differences exists for early vigour and dry matter production when comparing commercial cultivars with some introduced genotypes. However, very little information is available on the traits associated with the early vigour and dry matter production of these cultivars in this environment. The present study therefore examines the characters associated with early vigour and high dry matter production in a set of commercial cultivars and introduced genotypes.

Methods

A field study was done at Wongan Hills, in the central wheat belt. The study included five introduced genotypes, two advanced breeding lines from WADA's breeding programme and eight commercially grown cultivars (Table 1). The introduced genotypes were selected due to their relatively high growth rates and dry matter production measured in preliminary experiments (Whan et al., unpublished data). The experiment was sown on June 7,1989. A randomized block experimental design was used with cultivars randomized within four replications. Plot size was 1.42 m wide (eight rows, 17.5 cm apart) x 40 m long. The seeding depth was approximately 3.0 cm. Normal cultural and management practices were followed for the experiment.

Aspects studied included crop establishment, phenology, above ground dry matter, leaf number, canopy coverage, leaf area index and light interception.

Results

Table 2 shows the above ground dry matter data at weekly intervals from 26 to 61 days after sowing (DAS). There were differences in ($P<0.05$) in dry matter production between cultivars at all sample times. Three of the introduced genetypes (CEP8058, Kansu No. 32 and V979-28) had consistently high dry matter than other cultivars. Although there was 6-24% improvement in dry matter during this period, the difference between highest producing introduced genotype and commercial cultivar was only significant at 61DAS. These results are consistent with that of Whan et al. (unpublished) and this difference is considered sufficient to use in the breeding programme for improvement in early vigour and dry matter production (Whan, pers.com).

Analysis of phenology data shows that (data not presented) the above differences in dry matter were not associated with phenological development.

Detailed early growth measurements were made at 54 DAS when cultivars had approximately 6 leaves on the main stem. Dry matter (gm^2) was poorly correlated with leaf number and tiller number (Table 3). However, green area index, ground cover and light interception were highly correlated with dry matter. In this study early vigour score (visual scoring) was also highly correlated with dry matter.

Conclusion

The study suggests that cultivar difference exists for early growth and dry matter production. Improved early vigour and high dry matter production was associated with greater leaf size, green area index and light interception. Ground cover estimates (using photographic technique, see Siddique et al. 1989b) or by visual scoring can be used to screen germplasm for early vigour and high dry matter. However when the differences in early vigour are small, visual scoring is an inadequate method for selecting high dry matter cultivars.

References

Fisher, R.A. (1979). Growth and water limitation to dryland what yield in Australia: a physiological framework. J. Aust. Inst. Agric. Sci. 45, 83-94.

Hamblin, A.P. and Tennant, D. (1987). Root length density and water uptake in cereals and grain legumes: How well are they correlated? Aust. J. Agric. Res. 38, 513-27

Siddique, K.H.M, Belford, R.K, Perry, M.W. and Tennant D. (1989b). Growth, development and light interception of old and modern wheat cultivars in a mediterranean type environment. Aust. J. Agric. Res. 40, 473-87.

Siddique, K.H.M; Tennant, D; Perry M.W. and Belford, R.K. (1990b). Water use and water use efficiency of old and modern wheat cultivars in a mediterranean type environment. Aust. J. Agric. Res. 41(3) in press.

Table 1. List of cultivars used in the experiment and their origin

Cultivar	Origin
Commercial cultivars	
Aroona	South Australia
Bass	Queensland
Egret	New South Wales
Gamenya	New South Wales
Gutha	Western Australia
Halberd	South Australia
Kulin	Western Australia
Tincurrin	Western Australia
Advanced breeding lines	
79W:783*	Western Australia
79W:793	Western Australia
Introductions	
CEP8058	Rhodesia
Ji Mai 14	China
Kansu No. 32	China
TFQ 113	-
V979-28	Israel

* Released in 1989 as a new cultivar "Reeves".

Table 2. Above ground dry matter (gm^2) produced between 26 and 61 days after sowing for wheat cultivars at Wongan Hills 1989

Cultivar	Days after sowing					
	26	33	40	47	54	61
Aroona	1.75	3.26	6.37	14.8	33.3	58.2
Bass	1.62	3.09	5.90	12.5	30.5	45.1
Egret	1.32	2.23	4.22	8.7	18.6	38.0
Gamenya	1.48	2.48	5.34	12.7	31.9	52.7
Gutha	1.35	3.08	6.13	14.6	34.7	57.0
Halberd	1.78	3.36	6.74	17.2	35.8	57.7
Kulin	1.70	2.98	5.78	14.0	29.6	46.3
Tincurrin	1.43	2.57	5.45	12.3	27.1	52.0
79W:783	1.61	3.05	5.49	12.1	30.1	43.6
79W:793	1.52	2.66	5.18	11.2	26.1	44.1
CEP8058	1.83	3.16	7.15	18.5	40.2	70.8
Ji Mai 14	1.48	3.01	6.43	15.9	30.4	55.3
Kansu No. 32	2.10	3.67	7.32	16.2	37.7	65.0
TFQ 113	1.50	2.58	5.26	13.2	31.0	59.3
V979-28	1.64	3.03	6.63	18.3	39.8	71.6
LSD (P = 0.05)	0.43	0.86	1.61	4.1	7.9	12.5

Table 3. Correlation co-efficients between above ground dry matter and other characters measured for 15 cultivars, 54 days after sowing at Wongan Hills 1989

Character	1	2	3	4	5	6	7
1. Dry matter (g/m^2)	-	-	-	-	-	-	-
2. Plant no./ m^2	0.3228	-	-	-	-	-	-
3. Leaf no. on main steam	0.0027	0.0392	-	-	-	-	-
4. Tiller no.	-0.0842	0.0423	0.2875	-	-	-	-
5. Green area index	0.9101**	0.2674	0.0588	-0.0087	-	-	-
6. Light inter- ception (%)	0.5216*	0.3675*	-0.1308	-0.2716	0.3569*	-	-
7. Ground cover (%)	0.6564**	0.3556*	0.028	0.000	0.589**	0.387*	-
8. Early vigour score	0.649**	0.2676	-0.0183	-0.1791	0.6467**	0.452*	0.2154

* P < 0.01.
** P < 0.001.