Plant Characteristics associated with wheat yield in the High Rainfall Zone of southern Australia

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Abstract

A significant increase in crop production in the High Rainfall Zone of southern Australia over recent years has highlighted the potential of the region to contribute significantly to the National grains industry. However, low crop harvest indices suggest a poor conversion of light, water and nutrients to grain indicating that potential yields are not being realised. To ensure that yields are optimised, information relating to crop growth and plant characteristics suited to the region need to be identified. A wheat experiment was sown on raised beds at Hamilton, Victoria in 2005 with three wheat cultivars and two sowing times to generate different growth patterns and demand for resources. Differences in grain yield and harvest indices were partly explained by differences in water-use efficiency, reduced number of grains per spike and per spikelet and grains per m^2. The unsown area of the furrows also possibly contributed to poor resource conversion efficiency. Adequate soil moisture and good grain size suggest that low harvest indices were not due to the effects of 'haying-off'.

Key Words

Wheat, grain yield, harvest index (HI), water-use, raised beds

Introduction

Based on our knowledge of crop growth, it is estimated that wheat in the south-west of Victoria, in an average year, if supplied with enough light, water and temperature may yield 12 t/ha. Crops are currently yielding only about one third of this value with the majority of energy captured being converted to straw. This experiment aims to provide advice to growers and breeders on the plant characteristics related to higher yields and greater resource conversion efficiencies in the High Rainfall Zone (HRZ) of southern Australia.

Methods

Three wheat cultivars, an early and a mid spring type (Glover and Chara) and a mid winter-type (Wylah) were sown at two sowing times, April and May on raised beds at Hamilton in 2005. The experimental design was a randomized complete block with 4 replicates giving 24 plots. There were two beds per plot (beds were 1.7 m wide, furrow to furrow, 8 rows per bed and 15 cm row spacing). Plots were 15 m long, for a total plot area of 102 m^2. Plots were maintained free of weeds and disease. Crop biomass was determined every 21-28 days throughout the growing season using oven-dried (60^{o}C) quadrat cuts (0.5m^2). At each period, soil moisture was also determined to 180 cm depth at 20 cm intervals using a neutron moisture meter (NMM). The lower limit for soil moisture was determined from NMM readings taken from plots covered with rain exclusion tents from anthesis to crop harvest. The upper limit was determined from the sum of the mean-maximum soil moisture at each depth for each plot during the growing season. At harvest, (December 13 and 28) grain yield and yield characteristics (components and spike morphology) were determined from hand harvest cuts from two-0.5m^2 quadrats per plot. Calculations for yield and biomass included area of the furrow. Biomass, yield, soil moisture and climatic data was used to calculate water-use efficiency (WUE).

Results and Discussion

Annual rainfall was 541 mm with 423 mm falling between April and December, lower than the long-term average (691 and 590 mm respectively). There were significant differences in yield between cultivars and for sowing time but no significant cultivar by time of sowing interactions. Grain yields from Glover were significantly lower (4.6 t/ha) than Chara and Wylah (5.9 t/ha and 5.7 t/ha respectively) (Table 1).

Low harvest indices (0.38-0.42) and WUE for grain (9.5 – 18.0 kg/ha/mm) and biomass (24.9 – 43.3 kg/ha/mm) provide evidence for inefficient resource capture particularly in the April sown crops. Biomass and yield calculations included the unsown area of the furrows and possibly contributed to the overall poor resource conversion efficiency. For Glover, poor conversion of resources into grain could in part be explained by low grain number per spikelet resulting in fewer grains per spike and grains per m^2. Causes of spikelet sterility in Glover were not obvious. Despite flowering earlier (up to 12 days), minimum temperatures encountered around flowering for Glover were not lower than experienced by the other the cultivars. The reduced number of grains per spike between cultivars/sowing times was not compensation for difference in the number of spikes per m^2 as this component did not vary significantly. A common cause of low grain yield relative to total biomass is the effect of ‘haying off’. This is generally caused by rapid vegetative growth followed by terminal drought (van Herwaarden et al 1998a). High grain weights (37.0 to 44.1 mg, Table 1) and adequate soil moisture during the grain fill period (Figure 1) make haying off an unlikely reason for poor resource conversion in this year.

Table 1. Grain yield, weight, HI, water-use efficiency (WUE) and spike characteristics of 3 cultivars sown in April and May at Hamilton in 2005.

Treatment	Grain Yield (t/ha)	Grain Wt (mg)	HI	WUE Grain kg/ha/mm	WUE DM kg/ha/mm	Grains/ Spikelet	Grains/ Spike	Grains/m^2
Chara	5.9	41.5	0.42	14.1	33.9	2.74	34.6	20415
Glover	4.6	41.7	0.38	11.2	29.1	2.23	20.6	12042
Wylah	5.7	39.3	0.41	14.9	36.6	2.44	30.4	19368
Lsd (P=0.05)	0.84	ns	0.020	ns	ns	0.297	7.02	1655.1
April	4.9	42.5	0.40	11.0	27.8	2.51	27.1	15733
May	5.9	39.1	0.41	15.8	38.7	2.43	29.9	18816
Lsd (P=0.05)	0.006	2.48	ns	2.87	7.49	ns	ns	1351.4

Chara April	5.5	44.1	0.41	11.8	28.7	2.75	31.0	17499
Glover April	4.2	41.9	0.39	9.5	24.6	2.31	18.7	10498
Wylah April	5.0	41.6	0.40	11.8	29.9	2.49	31.6	19203
Chara May	6.4	38.8	0.42	16.4	39.1	2.74	38.1	23331
Glover May	5.0	41.5	0.38	12.9	33.6	2.14	22.5	13585
Wylah May	6.4	37.0	0.41	18.0	43.3	2.40	29.3	19533
Lsd (P=0.05)	ns	ns	ns	ns	ns	ns	ns	2340.6

HI = Harvest Index, WUE = Water Use Efficiency

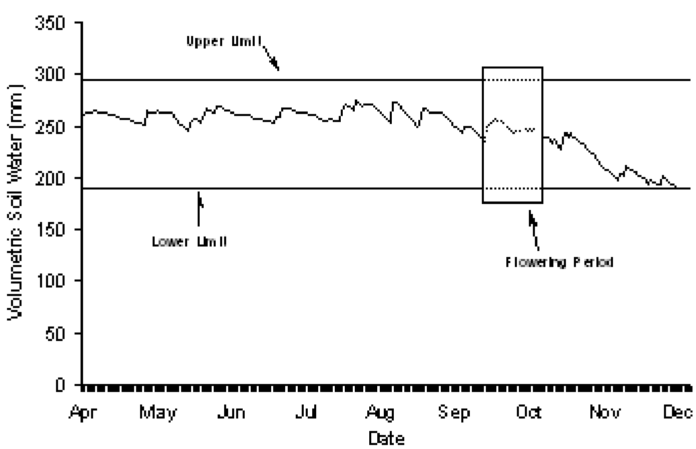

Figure 1. Seasonal volumetric soil water content (wavy line), upper and lower limits and flowering period for wheat sown at Hamilton in 2005. Seasonal soil water is the mean of 6treatments (3 cultivars x 2 times of sowing).

Conclusion

Wheat yields and resource capture efficiencies were below what is regarded as potential for this environment. Cultivars differed in their ability to convert resource to grain and appeared to be in part due to fewer grains per spike(let)and grains per m^2. The potential loss of yield due to the unsown furrows needs to be better understood so plant types suited to raised beds can be identified. Investigations are continuing to better understand the plant characteristics associated with improved conversion of resource to grain in this environment.

References

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