Use of resources in 4 cultivars of wheat in the high rainfall zone of south-eastern Australia - Protein and water soluble carbohydrates.

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Abstract

Changes in dry matter, water-soluble carbohydrates and crude protein concentration in the plant parts of 4 wheat cultivars were measured throughout the 2003-growing season in the high rainfall zone of south-western Victoria, Australia. Consistent with previous years, cultivar Silverstar produced more, but smaller grains per ear and per m^2 than to the other three cultivars. Total amounts of water soluble carbohydrates ranged from 276 g/m^2 for Brennan to 365 g/m^2 for Silverstar. Patterns of accumulation and distribution of water soluble carbohydrates appeared to be related to wheat type (spring or winter) and, in this experiment, there was no obvious relationship with grain yield. Significant differences also occurred in the magnitude and rate of accumulation of crude protein in the stems and leaves of Silverstar relative to the other cultivars. Data will be further analysed to examine relationships between crude protein, water soluble carbohydrates and soil N and moisture.

Media summary

Differences in the accumulation and partitioning of resources were detected between four wheat cultivars growing in the high rainfall zone of south-west Victoria, Australia.

Keywords

NIR, WSC, CP

Introduction

Traditionally, agriculture in south-western Victoria has been dominated by grazing industries (wool and meat production) with cropping playing only a minor role. The reason for this has been the high rate of crop failure due to severe waterlogging caused by a combination of high winter rainfall, low evaporation and impermeable subsoils. However, the recent introduction of raised bed technologies has largely alleviated waterlogging, resulting in a four fold increase in cropping area in the region over the past decade. In the absence of waterlogging, the longer growing season of south-west Victoria compared to the traditional cropping areas of the Wimmera and Mallee, offers the potential for the region to significantly contribute to grain production in the State through the use of later maturing, higher yielding cultivars. Despite conditions favouring the later maturing cultivars, yields of a very early maturing spring wheat (Silverstar), initially bred for the Mallee environment have often equalled or exceeded those of the late season wheats both in experimental plots (Riffkin *et al* 2003) and on commercial farms. This experiment was conducted to study the patterns of resource (dry matter, water soluble carbohydrates and protein) accumulation and distribution in four wheat cultivars. This data will be further analysed in relation to soil moisture and water-use. Information may then be used to help determine if high yields from Silverstar are due to a more efficient partitioning of resources into grain or due to drought avoidance associated with early maturity. Such information may also provide a better understanding of wheat growth in this environment and aide breeders in the selection of material better suited to the high rainfall environment of southern Australia.

Methods

The experiment was conducted at the Department of Primary Industries, Hamilton in south-western Victoria, Australia (37?49’S, 142?04’E). Annual rainfall for 2003 was higher than the long term average

(LTA) (728 mm for 2003 compared to 692 mm for the LTA). Much of the increased rainfall fell during the winter months (281mm compared to 235 for the LTA). The soils have strong textural contrast between surface and subsoil horizons and are generally Ferric Eutrophic, Brown Chromosols and Sodosols (Isbell 1996).

Two spring-wheats (cv Silverstar- early maturity, and Chara, mid maturity) and 2 winter-wheats (cv Brennan and Rudd, late maturity) were all direct drilled on May 7, 2003 into paddocks that, in the previous year, had been pure subclover pasture (the preferred cultural procedure for cropping in the High Rainfall Zone). Crops were sown on flat land and the plots were approximately 3.5 m wide x 100 m long. The experimental design was a randomised block, with four replicates giving a total of 16 plots. Crops were harvested at 21-day intervals, giving a total of 10 harvests for the season. Four random cuts (4 x each side of a 50 cm rod) per plot were taken at each sampling period, with samples within each plot bulked. Harvested samples were divided, with a portion oven dried at $100^{o}C$ to a constant weight to determine dry matter content. The remaining subsample was separated into leaf, stem (including leaf sheath) and ear (after emergence), depending on developmental stage, and freeze-dried. Dry weight values were recorded and combined to determine total biomass and dry weights of individual organs were calculated.

Freeze-dried samples were ground to 1.0 mm in a Cyclotec mill and crude protein (CP) and water soluble carbohydrates (WSC) for individual plant parts were determined using near infrared reflectance (NIR) spectroscopy. CP and WSC levels were predicted using equations developed through the commercial FEEDTEST laboratory.

Statistical analysis

A linear mixed model including a cubic spline of time (Verbyla *et al.* 1999) was fitted to CP and WSC to test for effects of wheat fitted as fixed effects and allowing for random blocking effects. Significant differences in grain yield, weight, numbers, ears per m^2 and harvest index were determined through ANOVA. All analyses were performed using the GenStat 5.42 statistical package (GenStat 2000).

Results and Discussion

Dry matter and yield components

The grain yield of Silverstar was lower in 2003 than in previous years (4.7 t/ha compared to 7 t/ha, mean over 3 years) and was not significantly different to the other cultivars. This was most likely due to more severe waterlogging during winter in 2003, resulting in reduced tiller survival and heads/m^2. However, trends in growth were similar to previous years with Silverstar producing significantly more, but smaller grains per ear than the other cultivars (Table 1). Grain protein concentration of Silverstar was also lower in this experiment than in previous years (9.56% compared to a three year mean of 12.6%).

Table 1. Yield data for 4 wheat cultivars sown at Hamilton in 2003

	Brennan	Chara	Rudd	Silverstar	F prob	Lsd
Grain wt (mg)	38.54	36.34	35.85	32.17	0.016	3.442
Grains/ear	28.4	27.4	24.8	37.2	0.042	8.43
Grains/m^2	11722	10888	9619	13802	ns	

Yield (t/ha)	4.62	4.04	3.47	4.68	ns	
Harvest Index	0.42	0.39	0.39	0.41	ns	
Ears/m^2	402	386	379	353	nsd	
Grain CP (%)	10.91	9.68	9.28	9.59	0.032	1.068

Flowering dates were October 17 for Silverstar, October 29 for Chara, November 7 for Brennan and November 10 for Rudd. Maximum total biomass was higher for Silverstar (13.6t/ha) and Chara (11.5t/ha) compared to Brennan (9.8 t/ha) and Rudd (9.7 t/ha). Growth rates (kg/ha/day) for the spring wheats were 2-3 times higher than the winter wheats until early October (Figure 1). Slow growth rates during winter and early spring were most likely due to colder than average temperatures (June – October average 12.96^{o}C in 2003 compared to 13.84^{o}C LTA) and waterlogging.

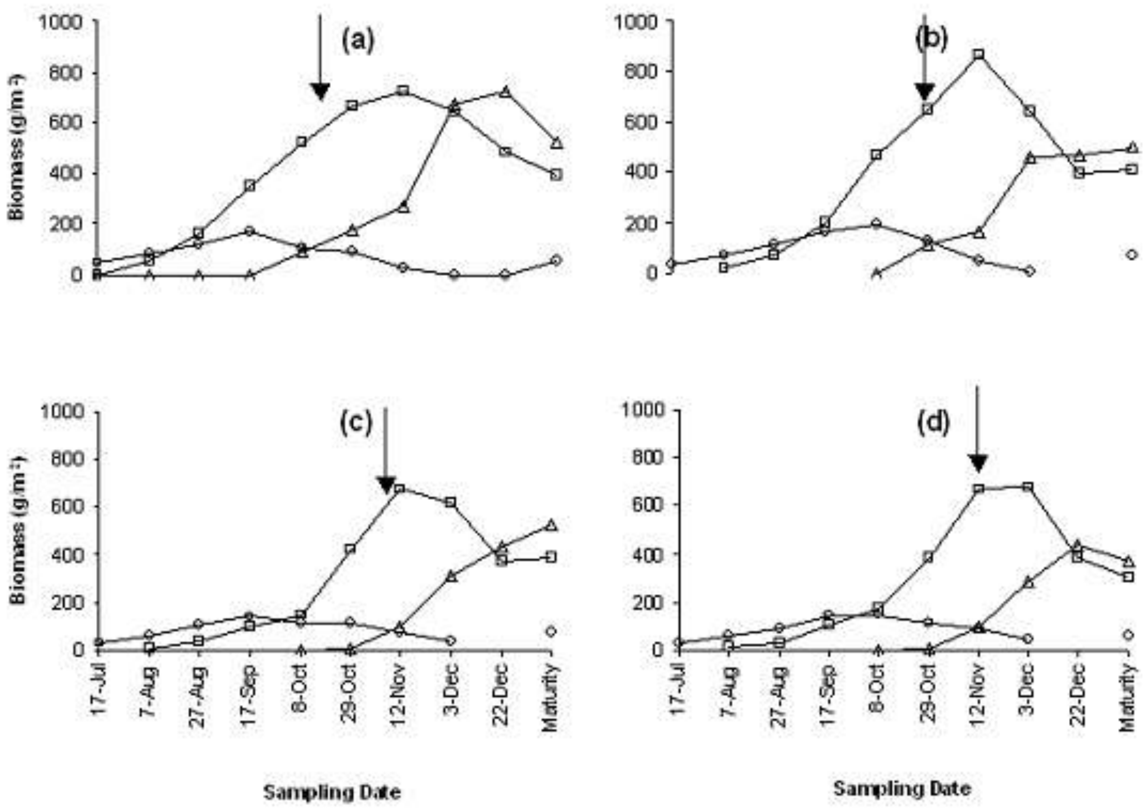
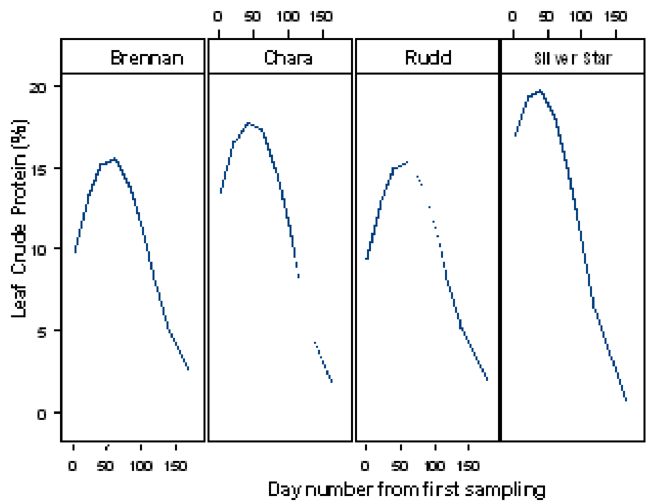


Figure 1. Dry matter (g/m2) of the stem (square), leaf (circle), and ear (triangle) for 4 wheat cultivars (a) Silverstar, (b) Chara, (c) Brennan and (d) Rudd throughout the 2003 growing season. Downward arrows indicate anthesis.

Relative concentrations of CP and WSC throughout the growing season of the four cultivars had not been measured in previous experiments. Similar yields between cultivars in 2003 made it difficult to relate WSC and CP (concentrations and distribution) to grain yield.

Protein (magnitude and rate of accumulation) in the stems and leaves of Silverstar throughout the growing season were significantly different to the other cultivars (Figure 2a and b). Maximum amounts of total WSC (sum of individual plant parts) ranged from a mean of 276 g/m^2 for Brennan to 365 g/m^2 for Silverstar. Amounts and the patterns of distribution of WSC throughout the growing season appeared to be related to wheat type (spring or winter) rather than grain yield with the spring wheats (Silverstar and Chara) accumulating more WSC than the winter wheats (Brennan and Rudd) (Figure 2c). The proportion of WSC in the stem around anthesis was between 0.42 (Silverstar) and 0.46 (Rudd). These values were higher than those reported in the U.K., 0.2-0.3 (Austin *et al* 1977) and 0.29-0.39 (Foulkes *et al*, 1998) and those reported as a percentage of the total above-ground biomass in studies in Australia, 15-20% (van Herwaarden *et al.* 2003). Further analysis will be conducted to explain possible reasons for higher values. Protein and WSC results will also be further analysed in relation to soil moisture and soil N.

(a)



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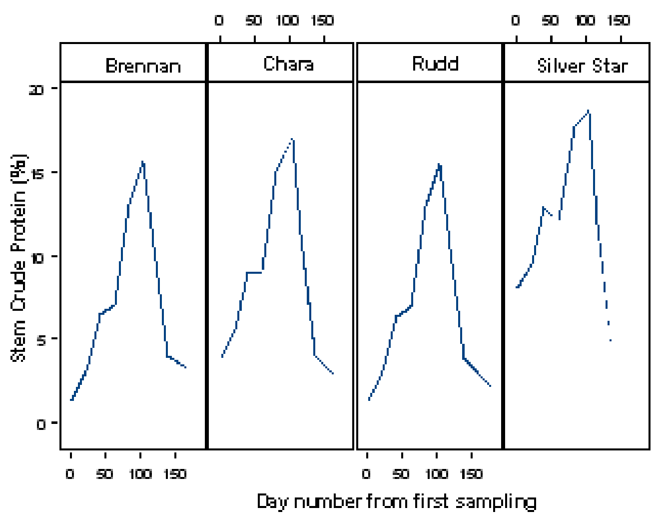

(c)

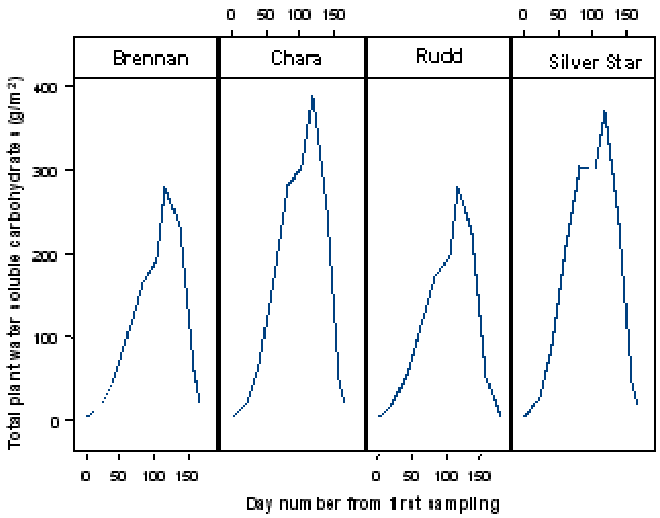

Figure 2. Crude Protein concentrations (%) in the leaf (a) and stem (b) and total plant water soluble carbohydrates (g/m^2) (c) for 4 cultivars, Brennan, Chara, Rudd and Silverstar throughout the 2003 growing season.

Conclusion

Preliminary data and analysis indicates that the wheat cultivars in this experiment accumulated and partitioned resources differently. This may be due to differences between individual cultivars or wheat types (spring and winter). However, in this experiment there was no clear association with resource allocation and grain yield. Additional data will be collected and further analysis conducted to test possible associations between WSC and CP levels and water-use and soil N. This will help determine if Silverstar allocates resources more efficiently than other cultivars or if high yields are achieved through drought avoidance as a result of early maturity. The experiment will continue in 2004.

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