Grazing effects on the retranslocation of assimilates during grain filling of wheat

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Abstract

An experiment was conducted within a commercially sown winter wheat crop (cv. EGA Wedgetail) to analyse the effects of stocking rate (dry sheep equivalent, DSE) and grazing duration on the storage and post-anthesis retranslocation of non-structural carbohydrates (NSC) and nitrogen (N). Grazing significantly reduced grain yields, accumulated biomass and grains m^{-2} only at the highest grazing intensity. Grazing reduced the size of the vegetative organs at anthesis and thus their capacity to store reserves. However, the ability to draw on these reserves during grain fill was unaffected by grazing. It was apparent that as grazing intensity increased grain growth was increasingly supported by post-anthesis assimilation.

Keywords

Wheat, grazing, non-structural carbohydrates, NSC, nitrogen, N, remobilisation

Introduction

Dual-purpose wheat is increasingly being utilised in the cropping zone of southern Australia. Previous experimental work has usually focused on the accumulation and remobilisation of assimilates in ungrazed spring wheats, with important responses to climate (Bidinger *et al.*, 1977; Palta *et al.*, 1994 and Blum, 1998), cultivar (McCaig *et al.*, 1982), and fertiliser (van Herwaarden *et al.*, 1988). Grazing reduces anthesis biomass but its affect on the post-anthesis retranslocation of reserves is unknown. The aim of this study was to identify how grazing management modifies the storage and post-anthesis retranslocation of non-structural carbohydrates (NSC) and nitrogen (N), with respect to the rate and duration of grain filling.

Materials and methods

An experiment was conducted in a commercial winter wheat crop (cv. EGA Wedgetail) at Cookardinia, in southern New South Wales. With the aid of temporary fencing, three grazing treatments were imposed: ungrazed, moderate intensity (599 DSE.days) and high intensity (1169 DSE.days). Sequential dry matter harvests (9-10 days), from anthesis to maturity, were separated into grain, ear (excluding grain), leaf, sheath and stem (excluding sheath), oven dried at 70?C, and ground in a Cyclotec mill with a 0.5 mm sieve. Stem NSC were extracted using de-ionised water in a shaking water bath at 30?C for 2 hours (Bonnett G.D. and Incoll, 1993), filtered, with NSC levels determined using a flow injection analyser (Lachat Instruments, USA) and glucose standards. Nitrogen content in the grain and non-grain parts was analysed by near infrared reflectance spectroscopy (NIRS) with spectra regressed against reference samples whose N content was determined using a combustion analyser. Approximately one week after physiological maturity fifty random tillers were taken from each plot to estimate yield components. Grain yield was calculated from a machine harvest and expressed at 12 % moisture content. Sub-samples were taken to determine grain N.

Results and discussion

Grazing reduced grain yield, the effect being most significant at high grazing intensity (Table 1). Grazing lowered biomass at anthesis and maturity and significantly reduced grains m^{-2} at the heaviest grazing intensity (Table 1). Furthermore, maturity biomass and grains m^{-2} explained most of the variation in grain yield (r^2 = 0.91 and 0.92 for each, respectively).

The capacity to store NSC in the stem at anthesis was reduced by grazing only at a high intensity, but as a proportion of dry weight the levels were similar regardless of grazing treatment (38, 42 and 35% for the ungrazed, moderate and high intensity treatments, respectively). The retranslocation of stem NSC was complete around 36 - 40 days after anthesis (DAA) for the ungrazed and moderate intensity treatments, however most retranslocation occurred by 27 - 30 DAA for the high intensity grazing. The 'loss' of stem stored NSC constituted 38% of grain yield for the ungrazed and moderate intensity treatments, but only 28% of yield for the high intensity grazing (Table 1).

Table 1. Effect of grazing on the growth, stem non-structural carbohydrates (NSC), vegetative nitrogen (N) and grain yield of winter wheat in southern NSW. Least significant difference (LSD) reported at *P*=0.05.

	Anthesis				Maturity					
Grazing	Date	Biomass ($g\ m^{-2}$)	NSC ($g\ m^{-2}$)	Crop N ($g\ m^{-2}$)	Biomass ($g\ m^{-2}$)	NSC ($g\ m^{-2}$)	Veg. N ($g\ m^{-2}$)	Grain N ($g\ m^{-2}$)	Yield ($g\ m^{-2}$)	Grains m^{-2}
ungrazed	14 Oct.	1317	226	15.4	1519	8.0	4.9	13.4	581	14677
moderate	18 Oct.	1187	226	15.9	1462	8.2	4.7	12.5	575	14749
high	27 Oct.	941	142	12.0	1186	6.9	3.9	11.8	482	11990
LSD	*1.74*	*141*	*38*	*2.4*	*67*	*ns*	*0.9*	*ns*	*27*	*956*

The contribution to final grain N from that stored in the vegetative parts at anthesis was 79, 90 and 70% for the ungrazed, moderate and high intensity grazing, respectively (Table 1). Therefore additional grain N must have been supplied by retranslocation from the roots or from post-anthesis uptake from the soil. The assumption, based on the figures presented in previous research (Simpson *et al.,* 1983), is that for the ungrazed and moderate intensity treatments the extra N found in the grain could have originally been stored in the roots at anthesis. However, the much larger discrepancy found in the high intensity treatment could not be explained by retranslocation from the roots alone and thus post-anthesis uptake of N from the soil is more likely to be a factor after heavy grazing.

Irrespective of grazing treatment the ability to draw upon stored reserves was similar. That is, reserves stored within the vegetative plant parts at anthesis were almost completely exhausted by maturity with only minor differences in between grazing treatments. However, as grazing lowered anthesis biomass and the quantity of stored reserves (particularly after high intensity grazing), post-anthesis assimilation apparently contributed an increasing proportion of final grain yield. Hence, conditions which limit or, conversely, extend the period of photosynthesis will have a greater affect on grain yield under grazed than ungrazed conditions.

Conclusions

Delayed flowering caused by grazing results in grazed crops filling grain over a much shorter period with higher mean temperatures and lower water supply. Therefore grain yield after grazing will be more responsive to post-anthesis climatic conditions than in grain-only crops. The uptake of soil N after anthesis was found to be greater after heavy grazing. Hence, post-grazing N management is more important for the accumulation of grain protein than in a moderately grazed or ungrazed crop.

Acknowledgements

This project was supported by funding from the E.H. Graham Centre for Agricultural Innovation and the Grains Research and Development Corporation

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