CARBOHYDRATE RESERVES OF PERENNIAL GRASSES: EFFECT OF DROUGHT AND DEFOLIATION INTENSITY

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ABSTRACT
The carbohydrate reserves of six perennial grasses were measured during exposure to drought and defoliation over spring-summer and summer-autumn seasons. Of the six species assessed, tall fescue (*Festuca arundinacea*) and perennial ryegrass (*Lolium perenne*) had the highest level of reserves while wallaby grass (*Danthonia richardsonii*) had the lowest levels. The results indicate that during the spring-summer period drought intensity had a greater effect on plant reserves than defoliation intensity. However, defoliation had a greater effect on reserves during the summer-autumn period. It is suggested that tiller reserves may be most affected when drought is moderate and defoliation is severe.

KEYWORDS
Plant reserves, drought, defoliation, perennial grasses

INTRODUCTION
Drought is one of the factors which reduces the life of perennial grass pastures on the Northern Tablelands of NSW, Australia. Water deficit is the environmental stress which most limits plant growth and development (Hsiao, 1973). Over-grazing during a drought may result in extensive loss of perennial grass species from pastures. Water soluble carbohydrates (WSC) play an important role in survival when plants are under temperature or moisture stress (Alberda, 1966). This paper describes tiller WSC data collected during a larger experiment to determine the responses of perennial grasses to drought and defoliation.

METHODS
Six perennial grass species were planted at 25 plants m^{-2} into 1 m^2 plots in the field in December, 1993. The grasses included four introduced species: *Lolium perenne* cv. Victorian; *Phalaris aquatica* cv. Sirosa; *Dactylis glomerata* cv. Porto and *Festuca arundinacea* cv. Demeter, and 2 Australian native species: *Microlaena stipoides* cv. Shannon and *Danthonia richardsonii* cv. Taranna. Plots were defoliated at two intensities, moderate and severe, using a lawn mower. The severe defoliation represented a heavily grazed pasture. The moderate defoliation represented a well managed pasture based on a level of residual biomass within the ‘pasture management envelope’ described by Kemp (1991).

Three simulated rainfall regimes were applied: Non-stress (rain applied equivalent to pan evaporation x 0.8), 40-percentile rainfall (drought which occurs 4 years in 10) and 10-percentile rainfall (drought which occurs 1 year in 10). The rainfall regimes determined from historical rainfall records simulated a typical distribution in both frequency and volume. Rain was excluded from the trial area using an automatic rain-out shelter. The trial consisted of two blocks, each being assessed for six months of either spring-summer (1 September - 29 February) or summer-autumn (1 December - 31 May). The experiment was conducted 1994-96. The WSC results from 1994-95 are detailed in this paper.

Plant tillers, excluding roots were collected from each plot for carbohydrate analysis. The tillers were collected around mid-day, the same day as the harvest. In 1994-95 the tillers were collected monthly and, due to their small size, the samples were bulked to form 2-monthly samples. All tillers removed from the plants for analysis were in the vegetative growth stage. While in the field, the tillers were stored in an insulated cooler. The samples were then heated in a microwave oven to prevent enzyme degradation, dried in an oven at 50 ½C, then ground using a 1 mm sieve.

Percentage WSC (WSC%) of the samples was determined using a Near-Infrared Spectrophotometer (NIR) over the range 400 - 2500 nm. The NIR was calibrated and validated using a total hydrolysable reducing sugars autoanalyser method (Olson, pers. comm.).

RESULTS
Spring-Summer. In December/January the two drought treatments had a significantly higher WSC% than the non-stress moisture treatment (data not shown). There was a decline in WSC% between December/January and February/March of approximately 20% for all species except M. *stipoides* which increased by 6%. Figure 1 shows the significant moisture-species interaction in February/March. There were no significant differences in WSC% between moisture treatments for F. *arundinacea* and D. *glomerata*. Differences for the other species were inconsistent but the drought treatments tended to have similar or higher WSC% than the non stressed treatment. There was a significant defoliation-species interaction at both sample times. In general the moderate defoliation had greater reserves than the severe defoliation, although they were only significant in F. *arundinacea* and M. *stipoides* in February/March (data not shown).

Summer-Autumn. There was no effect of moisture on WSC during the summer-autumn period, however there was a moisture-species interaction in April, 1995 (data not shown). For all species with the exception of D. *richardsonii*, the WSC% was greater in the 40-percentile rainfall than the 10-percentile rainfall treatment. There were no significant differences between the three moisture treatments in *P. aquatica*, *M. stipoides* and D. *richardsonii.*

The WSC content increased for all species during the first 4 months of the experimental period; but declined at the last harvest with the exception of *L. perenne* and *P. aquatica*. Figure 2 shows the temporal response in WSC% for three of the species underfor severe and moderate defoliation. There was a significant defoliation effect from February/March and a significant species-defoliation interaction in April. The moderate defoliation had higher levels of WSC than the severe defoliation treatment. In April, the moderate defoliation treatment had significantly more reserves than the severe defoliation for all species with the exception of F. arundinacea (Figure 2). While *F. arundinacea* had the highest WSC of the six species it was also least affected by the defoliation intensities imposed. *D. richardsonii* was the most affected by defoliation intensity with the severe defoliation having less than 40% of the WSC of the moderate defoliation treatment plots in April (Figure 2).

DISCUSSION
Height and frequency of defoliation affect WSC levels after cutting (McKell, et al, 1966). Volenec (1986) reported a drop in reserves by 50% of their initial concentrations four days after defoliation, with a return to their initial concentrations after 24 days. In this study, moisture stress was more severe in spring-summer than in summer-

autumn. The results show that moisture had the greatest effect on WSC% in spring-summer, and defoliation had the greatest effect in summer-autumn. Low soil moisture stops regrowth so that repeated defoliation has less impact on tiller reserves. If growth can occur, but is insufficient to replenish regrowth after defoliation then reserves may decline through repeated defoliation. We suggest that tiller reserves may be most affected when drought is moderate and defoliation is severe.

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Figure 1

Percent water soluble carbohydrate of six perennial grass species at three moisture regimes, averaged over two defoliation intensities in February/March 1995 during the spring-summer experimental period (P=0.001). Fa: *Festuca arundinacea,* Dg: *Dactylis glomerata,* Lp: *Lolium perenne,* Pa: *Phalaris aquatica,* Ms: *Microlaena stipoides,* Dr: *Danthonia richardsonii.*

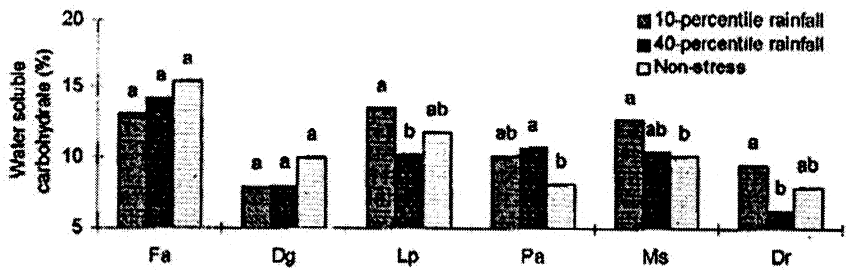

Figure 2

Percent water soluble carbohydrate of three perennial grass species at two defoliation intensities, averaged over three moisture regimes during the 1994-95 summer-autumn season. 5%LSDs are shown. Dr: *Danthonia richardsonii,* Ms: *Microlaena stipoides,* Fa: *Festuca arundinacea.*