Influence of Water Stress on Protein Concentration in *Themeda triandra* Forsk. in a Semi-Arid Climate of South Africa

I. B. Oosthuizen
University of the Orange Free State, South Africa

Hennie A. Snyman
University of the Orange Free State, South Africa

ID#01-14

INFLUENCE OF WATER STRESS ON PROTEIN CONCENTRATION IN *THEMEDA TRIANDRA* FORSK. IN A SEMI-ARID CLIMATE OF SOUTH AFRICA

I.B. Oosthuizen[1] and H.A. Snyman[1]

[1]Department of Grassland Science, PO Box 339, University of the Orange Free State, Bloemfontein, 9300, South Africa

Abstract

The objective of this study was to determine the influence of four water treatments (T1 = 75-100%, T2 = 50-75%, T3 = 25-50% and T4 = 0-25% of Field Water Capacity) on the concentration of water-soluble protein as growth reserve during three growth stages (vegetative, pipe and reproductive) in three plant parts (roots, stubble and leafs). The water-soluble protein concentration (WSPC) in the plants under the four water treatments differed ($P \leq 0.01$) among the plant parts as well as among growth stages ($P \leq 0.05$). WSPC in leafs increased ($P \leq 0.01$) with increased water stress from T1 to T4 for the pipe growth stage. For the vegetative and reproductive growth stages the WSPC increased ($P \leq 0.01$) from T1 to T2, decreased from T2 to T3 and increased again to T4 with concentration higher ($P \leq 0.01$) in T4 than T1, for the vegetative and reproductive growth stages. The WSPC in the roots differed ($P \leq 0.01$) across growth stages and water treatments. The results confirm that water-soluble protein growth reserve is influenced by the intensity of water stress and accumulation occurs with increased water stress, with the largest accumulation in the stubble.

Keywords: water treatments, water-soluble protein, growth reserve, growth stages, plant parts, translocation, accumulation

Introduction

The role and importance of growth reserves in biological processes, was a huge injection for the intense interest in this complex group of compounds. Although carbohydrate reserves play a vital role as growth reserve (Snyman *et al*., 1997), non-carbohydrate growth reserves also play a major role in the regrowth and survival of perennial grasses. Even under ideal conditions only 80% of the growth reserves utilized for regrowth is from carbohydrate reserve pools. In the first two days of regrowth after defoliation, protein growth reserves are important (Davidson & Milthorpe, 1966) and are used when carbohydrate reserves are low (Alberda, 1966). Very little is known on how water stress influences the water soluble protein growth reserves across plant parts (Busso & Richards, 1995). Although most protein determined was done as total crude protein, it can be reasoned that only water-soluble protein is most likely to be utilized as non-carbohydrate growth reserve. The aim of this investigation was to determine how water stress influences the water-soluble protein status in *Themeda triandra*, which is a dominant grass species in the semi-arid areas of South Africa.

Material and Methods

The research was conducted in a greenhouse for one season. The temperature was set at 32^0C ($\pm 2^0$C) during the day and 18^0C ($\pm 2^0$C) at night to simulate actual temperatures during these periods of mid-summer droughts. Four water treatments (T1 = 75-100% of Field Water Capacity (FWC), T2 = 50-75% of FWC, T3 = 25-50% of FWC and T4 = 0-25% of FWC) were applied. Plants were grown in pots (0.039 m^3) in a loamy fine sand soil.

All the pots were soaked with water, vacuum sucked at –20 kPa for 6 hours to reach FWC and then weighed. Three pots were dried down up to permanent wilting point and then weighed again to determine average weight increments for each water treatment. The severity of water stress was determined by leaf water potential measurements conducted at biomass harvest using a pressure bomb (Scholander *et al*., 1965), before dawn. The pressure bomb readings were –500 kPa for T1, -1250 kPa for T2, -2050 kPa for T3 and –2400 kPa for T4 respectively. Following the leaf water potential measurements the biomass samples were dried in a forced draft oven for ten days to inhibit all enzymatic activity (at 100^0C for 1 hour and then completed at 70^0C) (Smith *et al*., 1964). The plant parts were divided into stubble, leafs and inflorescence. The plant material was ground through a 40 maas sieve and analyzed for water-soluble protein using the Bradford method. Bovine gamma globulin served as standard (Bradford, 1976).

Results and Discussion

The water-soluble protein concentrations (WSPC) in plants under the four water treatments differed ($P \leq 0.01$) across plant parts as well as across growth stages ($P \leq 0.05$).

WSPC in leafs increased ($P \leq 0.01$) with increased water stress from T1 to T4 for all the growth stages (Fig 1). For all the water treatments, the highest WSPC in leafs occurred during the pipe growth stage. For T1 and T2 the WSPC in leafs were higher ($P \leq 0.01$) in the vegetative than in the reproductive growth stage. This is in line with the results of research done by Van Rensburg (1976). For T3 and T4, the protein concentration in leafs was higher ($P \leq 0.01$) in the pipe stage than for the vegetative and reproductive growth stages.

The WSPC in the stubble was higher ($P \leq 0.01$) under T4 than T1 for vegetative, pipe and reproductive growth stages (Fig 1). For the pipe growth stage, WSPC increased steadily from T1 to T4. In the vegetative and reproductive growth stages, WSPC in the stubble increased from T1 to T2, then declined again from T2 to T3 and increased again from T3 to T4. A possible explanation for the similar trend of protein concentration variation in stubble, in the vegetative and reproductive growth stages, can be that the plants in the reproductive growth stage were harvested after seed formation was completed, thus causing them to behave much like being in the vegetative growth stage. This phenomenon is amplified in the fact that there was no difference in leaf WSPC in the vegetative and reproductive growth stages under T3 and T4. For T1 and T2 the protein concentration in the stubble was higher ($P \leq 0.01$) for the vegetative and reproductive growth stage, than for the pipe growth stage. This corresponds with results of Van Rensburg (1976). For T4 the WSPC in the stubble were higher ($P \leq 0.01$) for the reproductive growth stage than for the vegetative and pipe stages. The results show that when the plant is under water stress, and is in the vegetative or pipe growth stage where growth reserves are translocated upwards for leaf elongation and the beginning of seed formation, it is less prepared for the survival of draught, regarding its protein growth reserves.

The WSPC in the roots, for the vegetative growth stage, increased ($P \leq 0.01$) from T1 to T2, decreased again to T3 and then increased again to T4 ($P \leq 0.01$) (Fig 2). In the pipe growth stage, WSPC increased from T1 to T2 ($P \leq 0.01$), stabilized from T2 to T3 and decreased to T4 ($P \leq 0.05$). This decrease can be explained by the continued increase ($P \leq 0.01$) in the protein concentration of leafs and stubble from T1 to T4 through translocation of the protein growth reserves during the pipe growth stage. In the reproductive growth stage the WSPC in roots decreased from T1 to T2, increased from T2 to T3 and decreased again from T3 to T4 ($P \leq 0.01$). As the plant developed severe water stress in T4, protein growth reserves were likely translocated to the stubble serving as the main storage organ explaining this decrease from T3 to T4 in the reproductive growth stage.

The increase of water-soluble protein in roots, stubble and leafs with increased intensity of water stress, prepared the plant to survive prolonged periods of draught and severe defoliation. In areas where mid summer droughts are more the rule than the exception, the results of irresponsible severe defoliation of water stressed plants can play a determining role in the rate of regrowth of forage plants after good rains.

References

Alberda, T. (1966). The influence of reserve substances on dry matter production after defoliation. Proceedings of the 10th International Grassland Congress. 140-147.

Busso, C.A. and Richards J.H. (1995). Drought and clipping effects on tiller demography and growth of two tussock grasses in Utah. Journal of Arid Environments. **29**: 239-251.

Bradford, M.M. (1976). A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein utilizing the principle of protein-dye binding. Analytical Biochemistry. **72**: 248-254.

Davidson, J.K. and Milthorpe F.L. (1966). The effect of defoliation on the carbon balance in Dactylis glomerata. Annals of Botany. **30**: 185-198.

Scholander, P.F., Hammel H.T., Bradstreet E.D. and Hemmingsen E.A. (1965). Sap pressure in vascular plants. Science. **148**: 339-346.

Smith, D., Paulsen G.M. and Raguse C.A. (1964). Extraction of total available carbohydrated from grass and legume tissue. Plant Physiology. **39**: 960-962.

Snyman, H.A., Venter W.D. and Van Rensburg W.L.J. (1997). Transpiration and water-use efficiency in response to water stress in *Themeda triandra* and *Eragrostis lehmanniana*. South African Journal of Botany. **63**: 55-59.

Van Rensburg, W.L.J. (1976). *Groeireserwes by Themeda triandra Forsk.* Ph.D.-Proefskrif. Departement Plantkunde. U.O.V.S. Bloemfontein.

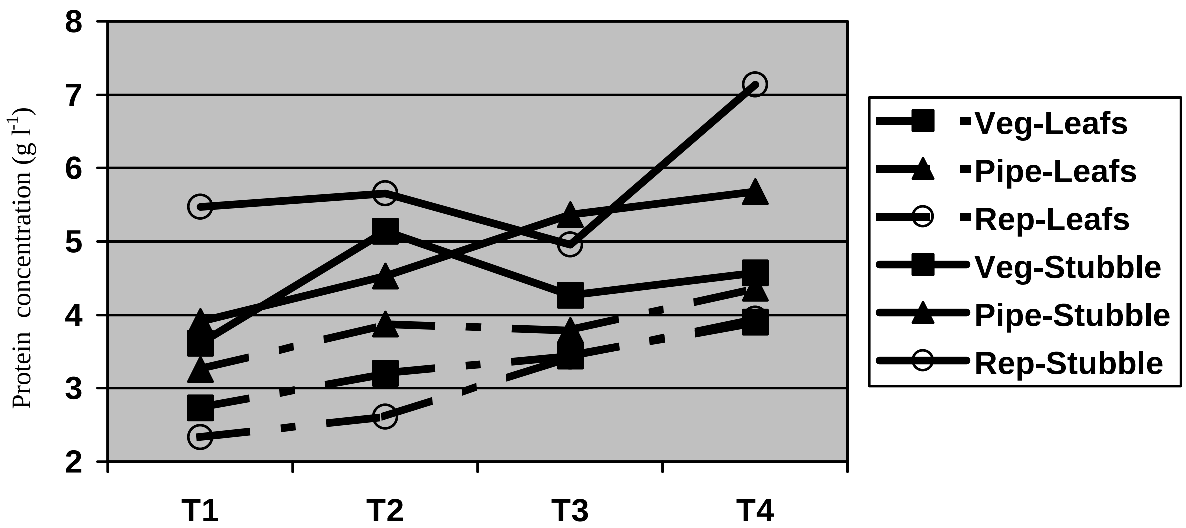

Figure 1 - Protein concentration in leafs and stubble under T1, T2, T3 and T4 for the vegetative, pipe and reproductive growth stages.

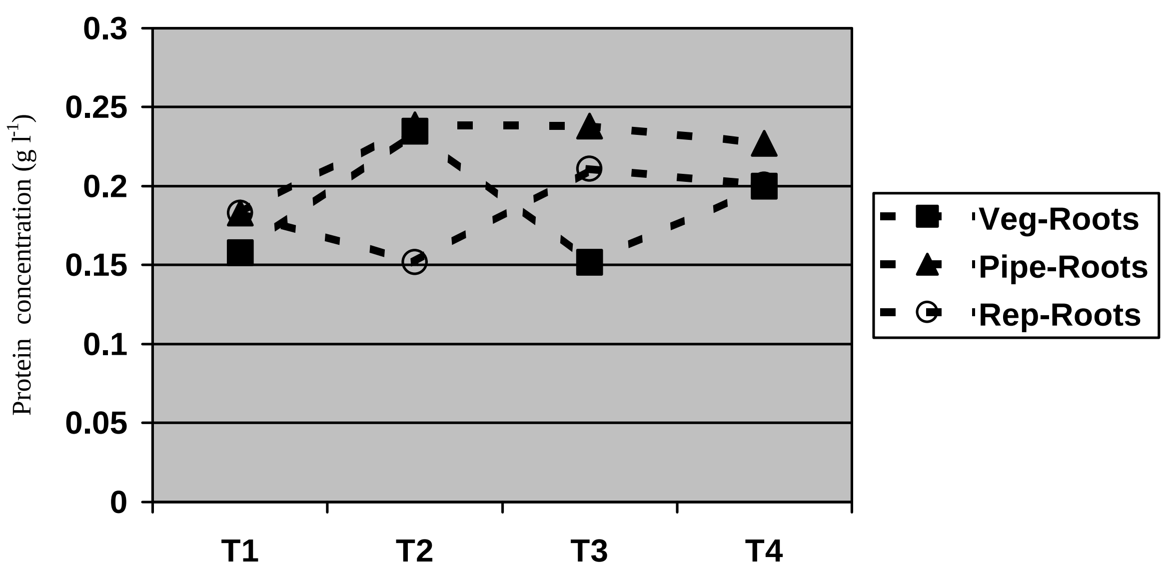

Figure 2 - Protein concentration in roots under T1, T2, T3 and T4 for the vegetative, pipe and reproductive growth stages.