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NITROGEN OR WATER LIMITATION TO GRASSLAND GROWTH DURING A MODERATE DRY SEASON IN THE HUMID TROPICS

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Abstract

The aim of this work was to compare the effects of nitrogen and water shortage on grassland production during a moderate dry season in a tropical humid environment. The results of two experiments carried out in Guadeloupe (FWI) have shown that during dry spells, the reduction in growth of natural grasslands based on Angleton grass (*Dichantium aristatum)* is more easily corrected by nitrogen fertiliser application than by irrigation. This shows that it is not the availability of water, but that of nitrogen, which is limiting the primary production of Angleton grass, stands. This result is less clear for a pasture based on Pangola grass (*Digitaria decumbens*), a species introduced to improve forage production. Research experience in the field of water-plant-weather relations in a humid or sub-humid tropical environment cannot be extrapolated to animal production systems based on natural grasslands. The productivity of this forage resource is much more dependant on nitrogen availability, during periods of low rainfall or when water soil reserve is low.

Keywords: fertilisation, irrigation, production, natural grasslands, Angleton grass, Pangola

Introduction

In topical humid/sub-humid regions it is recognised that the main factor limiting plant growth is the poor availability of nutrient elements, particularly nitrogen (MacDicken, 1990). In the French West Indies, considerable research effort has been invested in the management of irrigation water for agriculture. Theses efforts have accompanied the development of a fairly intensive style of agriculture geared towards exported products. Intensification of production has also been proposed for perennial forage crops based on introduced species (Salette, 1970) intended to replace natural grasslands. Nevertheless, most cattle and goat production is still carried out on these natural grasslands. This resource, rarely studied until now, has been exploited in recent studies (Boval *et al*., 1996). The object of this work is to analyse, for a humid/sub-humid environment, the relative importance of nitrogen and water stress on the growth of herbaceous plant canopies during the dry season, and to consider the need for research into management of herbage production in traditional livestock systems.

Materials and Methods

Two experiments were carried out in Guadeloupe (FWI) during the dry season of two years. I- In 1987, at Godet (in the north of Grande Terre), the dynamics of regrowth of sward based on *Dichantium aristatum* were studied over two months (January-February). The factorial effects of irrigation and nitrogen fertiliser levels were studied using a fully randomised experimental design with four replications (3 m^2 plots). Weekly samplings (0.18 m^2 per replicate) were made on four treatments - N0W0, N0W1, N1W0 and N1W1, where N0 and N1 represent applications of 0 and 150 kg $N.ha^{-1}$ in the form of NH_4NO_3, W0 means no irrigation and W1 is supplementary sprinkler irrigation sufficient to satisfy a daily PET of 5 mm. Total rainfall during the two months was 97.5mm which is close to the mean value. The sampled biomass was oven-dried at 90ºC to constant weight. II- In 1996, at Gardel (in the east of Grande Terre) the development of plots of *D. aristatum* and *Digitaria decumbens* cut regularly at intervals of 14, 21 and 28 days of regrowth was measured while applying the same treatments as those for the Godet experiment. The nitrogen application in N1 was about 3 kg per hectare and per day of growth. The study was made during the month of April by measurements of biomass and stolon morphogenesis (length, number of green leaves) and of the canopy (height) with the aim of describing the morphological adaptation of these species to defoliation frequency. The extended length of tillers (Boval *et al*. 2000), used in this work is the mean of nine determinations made for each species, date and treatment on basic plots of 9 m^2. This variable is positively correlated with the total aerial biomass of the canopy. Analysis of variance of the data was carried out using STATISTIX software.

Results and discussion

The growth of *D. aristatum* in the four treatments is shown in Figure 1. A nitrogen effect is apparent (cf. N1W0 and N0W0) which is much greater ($P<0.01$) than that of water (cf. N0W1 and N0W0). It is evident that the single application of irrigation water has not significantly increased the production of the pasture during the studied regrowth. On the other hand, the single application of nitrogen has resulted in three times the growth of biomass over a 50-day period. After this stage, growth on the N1 treatment was obscured by the flowering of the canopy, which took place in the short-day season (November-April). The growth rate on N1W1 during the linear growth phase (between days 10 and 50 of regrowth) was about 130 $kg.ha^{-1}$, which might be regarded as being the potential production of the species during the short-day season. At this time flowering limits the growth of *D. aristatum* independently of any nutrient and/or water stress. The response of this species to a single application of nitrogen may be explained by its capacity to extract water from deeper soil layers, thanks to its root system which is well developed and adapted to the environment (Y-M Cabidoche, personal communication, 1988). This property would enable it to make use of the fertiliser nitrogen solubilised by the low rainfall of this season and the heavy dew which is due to the high humidity of the atmosphere combined with lower night temperatures. Figure 2 compares *Dichanthium* with Pangola for extended tiller length measurements of the canopy. The curves represent values obtained for the three defoliation intervals subjected to nitrogen and irrigation treatments, rather than the actual growth dynamics. For *Dichanthium* the same type of response is observed as in the first experiment, i.e. a larger effect of nitrogen than of water on the canopy height for all the regrowth ages studied. A different situation is shown by the data obtained for Pangola grass. For this species the response to the two factors is similar, and their additive effect is very clear. This illustrates the dependence of Pangola grass on irrigation, due to its poor adaptation to moderate or temporary water stress conditions in this environment. Whenever an introduced forage species is used to replace the natural vegetation it is essential to bring in also the fertilisation and irrigation practices for pastures. The failure of Pangola grass to be generally adopted in Guadeloupe must be largely attributed to this limitation. Moreover, it has been demonstrated that the productive potential of *Dichanthium* and its response to nitrogen fertilisation are similar to those of *Digitaria decumbens* (Cruz *et al*., 1989; Cruz and Schemoul, 1991). In the absence of irrigation Pangola pastures are recolonised by Angleton grass, whatever fertilisation practices are adopted. The adaptation of this species to moderate water stress leads us to conclude that for animal production systems based on natural grasslands in the humid/sub-humid tropics: i) research needs on the mineral nutrition of grasslands and on the forage-animal interactions should be given precedence over irrigation studies; ii) care should be exercised when using methods and advice on the use of irrigation water coming from research carried out on species which are less well adapted to the frequent conditions of moderate water stress in this environment.

References

Boval M., Peyraud J-L. and Xandé A. (2000). Influence du parcage nocturne et du fractionnement de la surface à pâturer sur l'ingestion de génises créoles conduites à l'attache. Ann. Zoot. **45**:219-231.

Cruz P., Alexandre G. and Baudot H. (1989). Cinétique de la croissance foliaire et stolonifère d'un peuplement de *Digitaria decumbens* au cours de la repousse. *Proc. XVIth Int. Grassl. Congress*; Nice, France, 4-11 Octobre 1989; 499-500.

Cruz P. and Schemoul E. (1991). Potentiel de production des prairies naturelles a base de *Dichanthium sp* en Guadeloupe. *Proc. IVth Int. Rang. Congress*; Montpellier, France, 22-26 Avril 1991, 360-363.

MacDicken K.G. (1990). Agroforestry management in the humid tropics. Pages 98-149 in K.G. MacDicken & N.T. Vergara, eds. Agroforestry: Classification and management. John Willey & Sons, New York, N.Y.

Salette J. (1970). Les cultures fourragères tropicales et leurs possibilités d'intensification. Fourrages, **43**: 91-107.

Figure 1

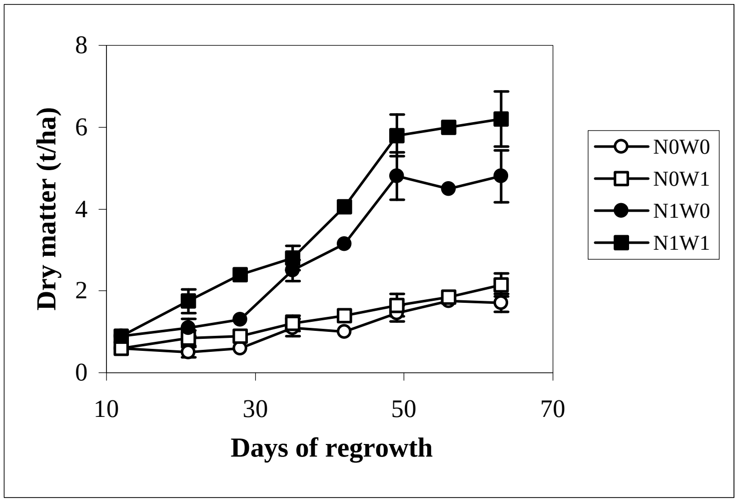

Figure 1- Biomass development of a *Dichanthium* stand during a regrowth cycle. Bars indicate standard errors.

Figure 2

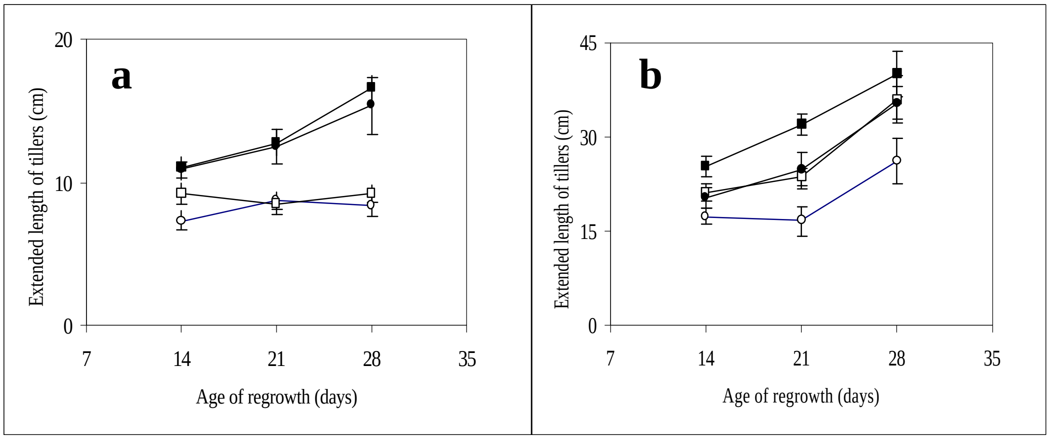

Figure 2 - Extended length of tillers of *Dichanthium aristatum* (2a) et *Digitaria decumbens* (2b) at different ages of regrowth. Bars indicate confidence intervals (α= 0.05). (Symbols are the same than Figure 1).