High Salinity Effects on the Components of Relative Growth Rate in Rhodes Grass

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ID # 06-04

HIGH SALINITY EFFECTS ON THE COMPONENTS OF RELATIVE GROWTH RATE IN RHODES GRASS

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Abstract

Rhodes grass (*Chloris gayana* Kunth), is widely cultivated in the semiarid tropics and favored for its salt tolerance. Nevertheless, productivity decreases significantly under saline conditions, especially in tetraploid cultivars. The purpose of this work was to explore, in tetraploid cultivar Boma, the physiological causes for the observed salt-associated growth reduction. The effects of high salinity (200 mM NaCl) on the components of relative growth rate were analyzed in greenhouse experiments. An early reduction in leaf area expansion was observed, which later resulted in decreased dry matter accumulation. Plant leafiness was reduced by effects both on dry matter allocation to photosynthetic organs and, more significantly, on leaf surface expansion. This caused reductions in the number of tillers, and afterwards, stolons. Photosynthetic production was altered later than leaf area expansion, indicating, as has been seen in other species, that the main effect of salinity was a limitation of leaf growth.

Keywords: *Chloris gayana*, Rhodes grass, salinity, vegetative growth, tillering, stolons, photosynthesis

Introduction

Chloris gayana, Rhodes grass, a C_4 species widely cultivated in the semiarid tropics, is known for its ability to withstand dry conditions, soil salinity and light frost (Bogdan, 1977). Diploid and tetraploid cultivars are used, the latter are more productive but also less salt tolerant (Taleisnik, *et al.*, 1997, Pérez *et al.*, 1999). The purpose of this work was to explore, in tetraploid cultivar Boma, the physiological causes for the observed growth reduction under salinity. The approach was to analyze how the various components of relative growth rate (RGR) (Hunt, 1978) are affected by high salinity. This analysis can indicate the relative contribution of alterations in photosynthetic production, leaf expansion and dry matter allocation, to the observed salinity-associated growth reductions. In stoloniferous grasses in the vegetative phase, leaf area is determined by individual leaf size, number of leaves per tiller, tiller density (Lemaire and Chapman, 1996); and stolon elongation. These variables were also considered in the present study.

Material and Methods

Trials were carried out in a greenhouse, in the summer, and repeated twice. *Chloris gayana cv*. Boma plants were cultivated in sand irrigated with Hoagland solution, and one-month old plants were gradually salinized to 200 mM NaCl, controls were not salinized. Then, for a period of 81 days, five plants per treatment were harvested at regular intervals. Dry weight was determined in shoots and roots, tillers and stolons were counted, and leaf area was measured with a LI-COR area meter. Photosynthesis was measured with a CID portable apparatus. RGR and its components were calculated from weight and area data (Hunt, 1978).

RGR and NAR (net assimilation rate) are calculated as average values for an interval, and thus, were not statistically analyzed. However, the analysis of the repeated measures of Log W (dry weight) can estimate the significance of differences in RGR’s, so, this parameter and all the others, were subject to ANOVA followed by Tukey´s test.

Results and Discussion

In these trials, the most conspicuous effect of high salinity on Rhodes grass growth was an early reduction in LA expansion (Table 1), and, later decreased dry matter accumulation. This result was expected, as LA expansion is one of the most salt-sensitive aspects of plant growth (Greenway and Munns, 1980) and similar effects have been reported for many plants, including halophytes (see, for example, Shennan, *et al.*, 1987). Reduced leaf expansion, which delays leaf appearance rate, in turn delayed tillering, which depends primarily on it (Davies, 1974).

Since tiller and stolon development were delayed by the salt treatment, there were less stolons in salinized plants (Table 1), and, as could be expected, had less nodes ($P<0.001$). However, mean internode length was not affected by salinity. This suggests that plants growing in saline areas would eventually reach the same land cover index as in non-saline soil, provided stolons were able to develop viable roots. We have observed that rooting itself is not hampered by salinity in this species (García Seffino et al., unpublished); however, root development is negatively affected and restricted to the upper layers of soil (McQueen Mason *et al*., 1998).

The rate of plant growth was highest in the 15-28 day interval and then decreased (Table 2). Drastic reductions in growth rate by salinity occurred only after two months of treatment, along with effects on the net assimilation rate (NAR), which estimates the gain in dry weight per unit leaf area. Photosynthesis rates were lower in salinized plants by day 61; indicating effects on NAR reflected changes in photosynthesis rates.

Photosynthetic decline under saline conditions has been widely documented, and kinetic analyses have shown that the effect may often be preceded by reductions in leaf area extension (Munns, 1993, nevertheless, see Romero and Marañon, 1994, who report that in *Melilotus segitalis*, long-term responses to low salinity were associated to reductions in NAR, even when increased LA was observed). Roots of Rhodes grass growing under saline conditions accumulate a high concentration of soluble and reserve carbohydrates, and triglycerides (Arias *et al.*, 1997), which also suggests that the source of carbohydrates may have been less affected than growth, as has often been reported (see Nilsen and Orcutt, 1996 and references therein).

As plants grew, the ratio of assimilatory surface to dry matter (LAR) decreased, and the early effects of salinity on LA development were reflected on the LAR. In salinized plants, LAR was reduced by effects both on dry matter allocation (LWR) and on specific leaf area (SLA), but the latter was more significant. After the initial effect, differences in LAR between control and salinized plants were not statistically significant, possibly reflecting plant adaptation to stress.

In *Chloris gayana* pastures established in saline areas, the proportion of dead leaves is significantly higher than in non-saline soils (Pérez *et al*., 1999). So, both reduced LA expansion and an increased proportion of dead leaves may be important causes of the reduced productivity of this halophytic species under saline conditions.

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Table 1: Effect of high salinity (200 mM NaCl) on dry weight (DW) accumulation, leaf area (LA), tillers and stolons per plant in *C. gayana*. Different letters within a column indicate significant differences at P<0.05 (ANOVA followed by Tukey´s test).

Condition	Days from the beginning of the salt treatment	Dry Weight (g)	Log. DW	Leaf Area (cm^2)	Log LA	Tillers/plant	Stolons/plant
Control	0	0.04 a	0.58 a	10.24 a	0.99 a		
	15	0.47 a	1.66 b	93.09 a	1.96 c	2.1 a	
	28	7.88 a	2.89 d	885.72 b	2.94 ef	6.0 bc	2.4 ab
	47	24.40 b	3.37 e	1616.82 c	3.19 fg	6.2 bcd	5.0 bc
	61	41.39 c	3.59 e	2389.00 d	3.37 gh	9.0 cd	6.4 c
	81	42.47 c	3.61 e	3218.80 e	3.50 h	9.6 cd	6.4 c
Salinized	15	0.32 a	1.48 b	37.05 a	1.54 b	1.5 a	
	28	2.40 a	2.36 c	232.98 a	2.34 d	2.0 a	1.0 ab
	47	7.09 a	2.83 d	484.40 ab	2.67 e	3.4 ab	3.2 ab
	61	8.63 a	2.88 d	432.80 ab	2.59 de	2.4 a	3.0 ab
	81	9.77 a	2.98 d	401.40 ab	2.59 de	2.2 a	2.6 ab

Table 2: Effect of high salinity (200 mM NaCl) on relative growth rates (RGR), net assimilation rate (NAR), leaf area ratio (LAR), leaf weight ration (LWR) and specific leaf area (SLA) in *C. gayana* plants. Different letters within a column indicate significant differences at P<0.05 (ANOVA followed by Tukey´s test).

Condition	Days from the beginning of the salt treatment	RGR (d^{-1})	NAR (x 1000) ($g\ cm^{-2}\ d^{-1}$)	LAR ($cm^2\ g^{-1}$)	LWR	SLA ($cm^2\ g^{-1}$)
Control	0			259.90 e	0.54 e	480.75 d
	15	0.072	0.264	201.20 d	0.50 e	404.89 c
	28	0.088	0.653	113.13 c	0.36 bc	315.82 b
	47	0.031	0.369	66.23 a	0.26 a	262.35 b
	61	0.016	0.267	62.01 a	0.31 abc	222.88 a
	81	0.001	0.300	77.80 abc	0.31 abc	272.49 b
Salinized	15	0.060	0.265	118.27 c	0.43 d	277.35 b
	28	0.063	0.608	98.01 bc	0.39 d	251.73 b
	47	0.029	0.370	68.76 ab	0.30 ab	232.21 ab
	61	0.006	0.105	51.13 a	0.34 bcd	156.56 a
	81	0.003	0.056	40.78 a	0.28 abc	152.67 a