Sodium, chloride and potassium allocation in an annual sweetclover (*Melilotus segetalis*) from the Guadalquivir salt marsh in southwest Spain

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Abstract

Annual sweetclover (*Melilotus segetalis* (Brot.) Ser. plants from the Guadalquivir salt marsh (S.W. Spain) were grown in a glasshouse, on sandy soil with nutrient solution and four salt treatments (0, 10, 50 and 100 mM NaCl). Plants (five replicates per treatment and age) were harvested at 50, 90 and 120 days after germination. Sodium, chloride and potassium were determined for each plant in leaves, stems and roots.

Total dry weight reduction with salinity was associated with increasing levels of sodium and chloride in plants and decreasing potassium uptake.

Introduction

Salt-affected soils cover about 15 million ha in the Mediterranean Basin (Le Houerou, 1986). High levels of salinity reduce plant growth and may be lethal due to the combined effects of a high external osmotic pressure, which limits water uptake, a high internal concentration of toxic ions, mainly sodium and chloride, and the imbalance in nutrient uptake (Greenway and Munns, 1980).

This study is part of a broader project aimed at evaluating forage genetic resources for salt-affected areas under Mediterranean climate (Marañón *et al.*, 1989b). We study the response to NaCl salinity of a *Melilotus segetalis* population from the Guadalquivir salt marsh (S.W. Spain). Dry weight and mineral elements (Na, Cl and K) allocation were measured in plants grown in a glasshouse under different salt treatments.

Methods

Seeds of *Melilotus segetalis* (annual legume) were

collected in June 1987 from a salt marsh grassland in the Guadalquivir delta (see description of site no. 3 in Marañón *et al.*, 1989a), and stored in paper bags at room temperature.

The experiment was carried out in a glasshouse during January–June 1988. Seeds were sown in pots of 10-L volume filled with a calcareous sandy soil, watered bi-daily with a 20% Hoagland solution no 2 (Benton Jones, 1982) and three salt treatments, adding 10, 50 and 100 mM NaCl. Plants were harvested at 50, 90 and 120 days after germination, and separated into roots, stems, leaves and reproductive output (flower buds, flowers and fruits).

Plant materials were overdried at 70°C for at least 48 hours, ground to powder, ashed, and digested with HCl. Sodium and potassium concentrations were measured by flame spectrophotometry (Comité Inter-Instituts, 1969), and chloride by thiocyanate colorimetry (Florence and Farrar, 1971).

Plant growth parameters (absolute and relative growth rates, specific absorption and utilization rates) were calculated according to Hunt (1982), for the control and the three salt treatments.

Results and discussion

Salinity and plant growth

Total dry weight of *Melilotus* plants at the reproductive stage (120 days after germination) decreased with salinity, 83% and 38% of control for 50 and 100 mM NaCl respectively (Table 1). The reduction was lower in shoots than in roots, but no clear trend was found in leaf weight ratio (Table 1).

Changes in dry weight allocation with age and salinity are shown in Figure 1. It is remarkable that the reproductive effort increased with salinity, from 18% (control) to 39% (100 mM NaCl).

Therefore, salt-affected plants, compared to control, were smaller in size, allocating relatively less to roots and stems but more to reproduction.

The salt treatments caused a reduction in absolute growth rate, from 2.7 to 1.0 g/week, as well as in relative growth rate, from 0.5 to 0.4 g/g week (values for the period between 50 and 120 days after germination). Despite this growth reduction, it is worth mentioning that *Melilotus* plants grown under relatively high salinity levels (100 mM NaCl) attained up to 10.4 g of total dry weight, with a relative growth rate of 0.43, supporting the potential value of this ecotype as a forage genetic resource for salt-affected soils.

Table 1. Growth analysis of *Melilotus segetalis* plants grown in a glasshouse under four NaCl salinity treatments. Derived quantities were calculated between 50 and 120 days (growth rates) and 50–90 days (mineral absorption and utilization rates). Values are means of 5 replicates

Quantity	Salinity treatments (mM NaCl)			
	0	10	50	100
Height (cm)	78.20	79.60	68.30	61.80
Total dry weight (g)	27.13	18.80	22.60	10.36
Root-shoot ratio	0.24	0.20	0.19	0.17
Leaf weight ratio	0.09	0.06	0.12	0.10
Absolute growth rate (g/week)	2.70	1.86	2.25	1.02
Relative growth rate (g/g week)	0.53	0.47	0.52	0.43
Sodium absorption rate (mg/g week)	5.95	16.05	42.80	42.04
Potassium absorption rate (mg/g week)	107.35	65.33	73.02	44.19
Sodium utilization rate (mg/mg week)	690.55	64.67	38.02	22.49
Potassium utilization rate (mg/mg week)	21.42	18.05	24.62	25.92

Fig. 1. Absolute allocation of dry weight to roots (black), stems (vertical lines), leaves (open) and reproduction (stippling) in *Melilotus segetalis* grown in a glasshouse with 0 (I), 10 (II), 50 (III) and 100 (IV) mM NaCl treatments. Values are means of five replicates.

Fig. 2. Absolute allocation of potassium, sodium and chloride to roots (black), stems (vertical lines) and leaves (open), in *Melilotus segetalis* plants (120 days after germination) grown under four NaCl salt treatments. Values are means of five replicates.

Mineral allocation and salt tolerance

The absolute content of potassium per plant decreased with salinity, from 359.4 to 64.2 mg (82% reduction), for control and 100 mM NaCl respectively (Fig. 2). Despite this general trend, the proportional leaf allocation of potassium at 50 mM NaCl treatment was higher than in the control.

Sodium and chloride absolute allocations showed a similar pattern (Fig. 2), increasing with salinity up to 50 mM NaCl but decreasing for the 100 mM NaCl treatment. Comparing the relative contents of sodium and chloride between plants grown at 50 and 100 mM NaCl treatments, we observe that these increased in roots and stems, but slightly decreased in leaves. However, due to the drastic reduction in total biomass (55.9%), the absolute allocation of both elements decreased (Fig. 2).

The specific absorption rate, that is, the rate of nutrient uptake per unit weight of root (Hunt, 1982), increased for sodium (7 fold) and decreased for potassium (2.4 fold) along the salinity gradient (Table 1).

On the other hand, the rate of dry weight increment per unit of absorbed nutrient, the 'specific utilization rate' (Hunt, 1982) was relatively constant for potassium, 18–26 mg/mg

week, and decreased strongly (30.7 times) for sodium (Table 1).

Potassium uptake seems to act as a limiting factor for plant growth in saline environments (Kafkafi, 1984). When the amount of sodium cations increases in the external root medium, they compete and replace potassium cations in the root influx. The ability to withdraw sodium and to retranslocate potassium is crucial for salt tolerance (Jechske, 1984).

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