Influence of nutrient loading during crop production on outplanting performance and drought reactions of *Rosa majalis*

James Wanjiku, Heike Bohne

Leibniz Universität, Institut für Zierpflanzen- u. Gehölzwissenschaften, Abteilung Baumschule, Herrenhäuser Straße 2, D-30419 Hannover.
james@baum.uni-hannover.de, bohne@baum.uni-hannover.de

Introduction

Generally, nursery culture involves production of transplantable plants through application of fertilizer to supply sufficient nutrients to achieve desired morphological features. This so-called conventional fertilization often leads to decreasing internal nutrient concentrations at later stages of development due to growth dilution. To overcome this problem, a new cultural practice was evolved to produce seedlings of high quality with increased internal nutrient concentration known as nutrient loading. Nutrient loading is achieved by increasing external supply either through conventional method or through exponential loading where external nutrient supply is increased to relative growth requirements. Nutrient loading has been demonstrated to be beneficial to some plant species. However, outplanting performance under stress conditions such as drought has not been tested. We therefore conducted an experiment to evaluate how nutrient loaded plants perform under drought conditions.

Objectives

Based on the above outline, we chose *Rosa majalis.* J. Herrm., an important ornamental and landscaping plant, to investigate whether it can be loaded and evaluate the effects of nutrient loading on some physiological reactions and selected osmoprotectants (sucrose, proline) to drought.

We also investigated whether

- these osmoprotectants vary among the two nutrient loading techniques
- there are relations between sucrose and proline concentration and drought tolerance

Methods

One year old seedlings of *Rosa majalis* were potted into 3 L containers using peat as the growing media fertilized with a multinutrient fertilizer under three fertilization regimes with regard to nitrogen: 0.8 g N/L (conventional = K8), 2.4 g N/L, (conventional loading = K24) and 2.4 g N/L (exponential loading = E24). Conventional fertilization was carried out using a slow release fertilizer, while a liquid fertilizer was used for exponential loading. At the end of the nursery phase, nutrient analyses and morphological characterizations were done. Thereafter, the plants were outplanted and one year later potted into 7 L containers using soil as the substrate. The plants were subjected to drought under controlled conditions in a greenhouse by completely withdrawing irrigation. Control plants were irrigated by ebb and flow irrigation. Control plants and stress plants were arranged in a completely randomized design with 6 plants per treatment. During the drought period, physiological reactions (stomatal conductance, predawn water potential, relative water content, chlorophyll fluorescence) were measured in intervals, at the end of the drought period samples were taken for the analysis of sucrose and proline. Drought period was terminated when 50 % of the plants in each treatment had severely wilted.

Results

Effects of nutrient loading on growth and N-, P-, K- concentration and content

Table 1: General comparison of the fertilization treatments, end of nursery phase

Parameter	Conventional non loading (K8)	Conventional loading (K24)	Exponential loading (E24)
Growth and dry matter	Large	Small	Large
N (concentration / content)	↓/↑	↑/↓	↑/↑
P (concentration/content)	↓/↑	↑/↓	↑/↑
K (concentration/content)	↑/↑	↓/↓	↓/↑

↑ = high concentration or content   ↓ = low concentration or content

Fig. 1: Morphological outlook of *Rosa majalis* at the end of nursery phase in October 2010

Effects of nutrient loading on some physiological reactions during drought

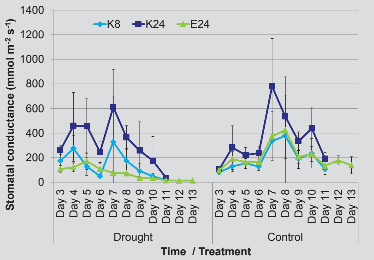

Fig. 2: Stomatal conductance of differently fertilized *Rosa majalis* in the nursery during the greenhouse drought period (August, 2011); (Fertilization in the nursery: K8: conventional = 0.8 g N L^{-1}; K24: conventional loading = 2.4 g N L^{-1}; E24: exponential loading = 2.4 g N L^{-1}). Mean ± standard deviation; n = 6.

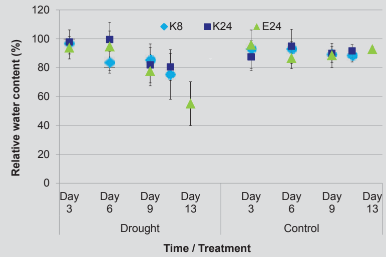

Fig.3: Relative water content of differently fertilized *Rosa majalis* in the nursery during the greenhouse drought period (August, 2011); (Fertilization in the nursery: K8: conventional = 0.8 g N L^{-1}; K24: conventional loading = 2.4 g N L^{-1}; E24: exponential loading = 2.4 g N L^{-1}). Mean ± standard deviation; n = 3 (day 3 to day 9); n = 6 (day 10 and 13).

Effects of nutrient loading on selected osmoprotectants at the end of drought

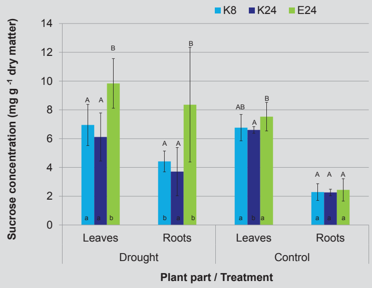

Fig. 4: Sucrose concentration (mg g^{-1}) in leaves and roots of loaded and non loaded *Rosa majalis* grown in the greenhouse drought period (August, 2011) (Fertilization in the nursery: K8: conventional = 0.8 g N L^{-1}; K24: conventional loading = 2.4 g N L^{-1}; E24: exponential loading = 2.4 g N L^{-1}). Mean ± standard deviation; n = 6. Different letters show significant differences: capitals between fertilization treatments and lower case between drought and control. Tukey test, $p \leq 0.05$

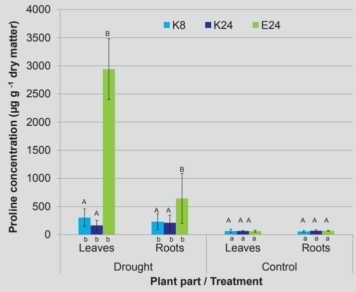

Fig. 5: Proline concentration (µg g^{-1}) of loaded and non loaded *Rosa majalis* plants in the greenhouse drought period (August, 2011) (Fertilization in the tree nursery: K8: conventional = 0.8 g N L^{-1}; K24: conventional loading = 2.4 g N L^{-1}; E24: exponential loading = 2.4 g N L^{-1}). Mean ± standard deviation; n = 6 for E24 and control; n = 5 for K8 and K24 drought. Different letters show significant differences: capitals between fertilization treatments and lower case between drought and control. Tukey test, $p \leq 0.05$

Conclusion

Loading was successfully achieved: Having plants of similar size (E24 and K8) or even smaller in size (K24) but of higher nutrient (N and P) concentration and / or content to those of conventionally fertilized plants (Fig. 1, Table 1). **Exponentially nutrient loaded plants had an advantage** over the non loaded and conventionally loaded plants in closing stomata earlier (Fig. 2), tolerating lower relative water content (Fig. 3) and in synthesizing osmotically active compounds i.e. sucrose and proline (Fig. 4, 5); thus **postponing reaction to drought** depicting a huge benefit of exponential nutrient loading.

References

Cuesta, B., Villar-Salvador, P., Puértolas J., Jacobs, D. F., José Benayas, R. M. (2010). Why do large, nitrogen rich seedlings better resist stressful transplanting conditions? A physiological analysis in two functionally contrasting Mediterranean forest species. Fo. Eco. and Management 260: 71 - 78.

Harb, A., Krishnan, A., Ambavaram, M. M. R. and Pereira, A. (2010). Molecular and physiological analysis of drought stress in *Arabidopsi*s reveals early responses leading to acclimation in plant growth. Plant Physio. 154: 1254 - 1271.

Salifu, K. F., Jacobs, D. F. and Birge, Z. K. D. (2009). Nursery nitrogen loading improves field performance of bare root oak seedlings planted on abandoned mine lands. Res. Ecol. 17 (3): 339 – 349.

Timmer, V. R. (1996). Exponential nutrient loading: a new fertilization technique to improve seedling performance on competitive sites. New Forests 13: 275 - 295.