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Beyond Traditional Rootstocks: Comparative Analysis of M-series and Commercial Grapevine Rootstocks Under Salt Stress

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INTRODUCTION & AIMS

Mediterranean viticulture faces increasing challenges from soil salinization and water scarcity. While some rootstocks effectively reduce salt accumulation in grafted scions, mechanisms and performance of novel rootstocks remain largely unexplored. This study aimed to:

- Compare two novel M-series rootstocks (M2, M4) with established commercial standards (1103 Paulsen, R110) under salinity stress
- Evaluate their physiological responses and ion homeostasis mechanisms
- Identify genotype-specific salt tolerance thresholds and adaptation strategies

METHODS

Plant Material & Experimental Design

- Uniform 12-month-old rootstocks of four genotypes (1103 Paulsen, R110, M2, M4)
- Completely randomized block design with four salinity treatments (0, 25, 50, and 75 mM NaCl)
- Five-month experiment in controlled greenhouse conditions

Measurements

- Growth parameters: shoot length, trunk diameter, fresh and dry weight
- Physiological parameters: chlorophyll fluorescence, stomatal conductance, SPAD readings
- Ion content analysis: Na^+, K^+, Ca^{2+}, Cl^- in different plant tissues
- Visual damage assessment on a 0-5 scale

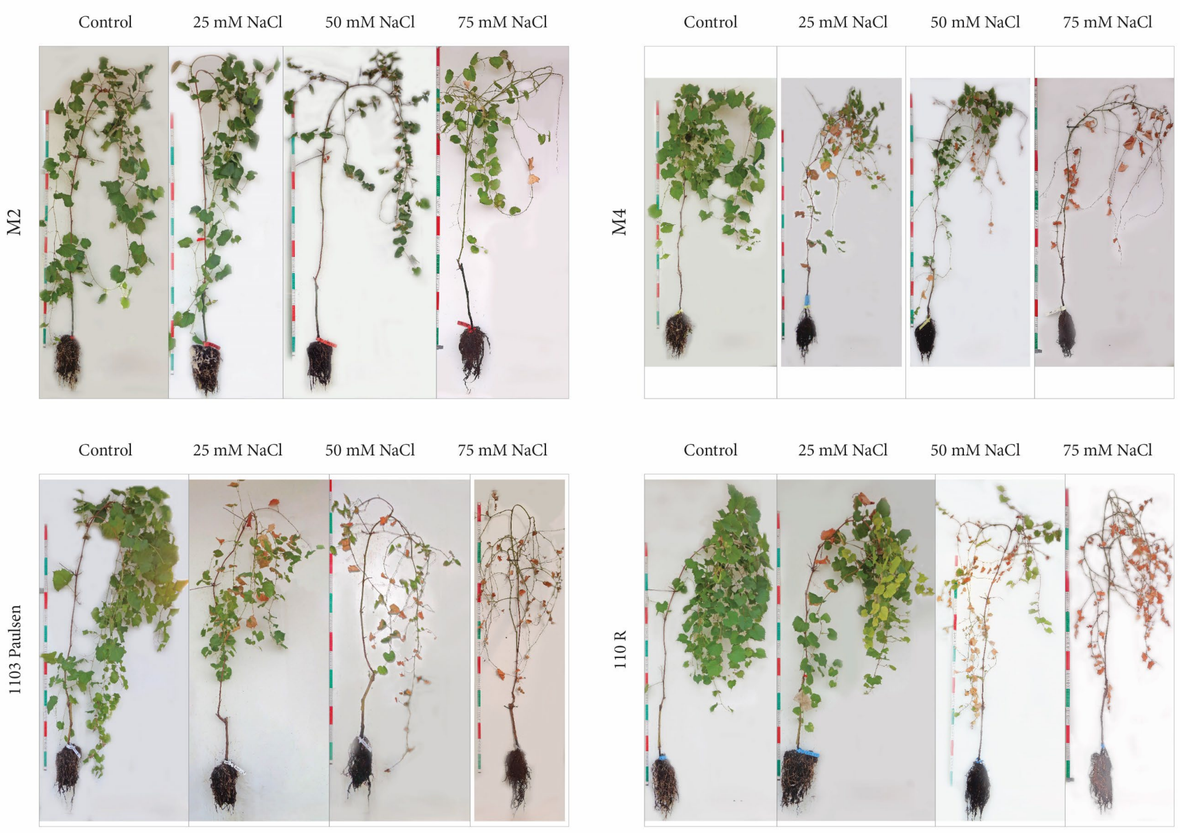

Figure 1. Visual aspect of the four rootstock genotypes subjected to the various salinity treatments at the end of the experiment

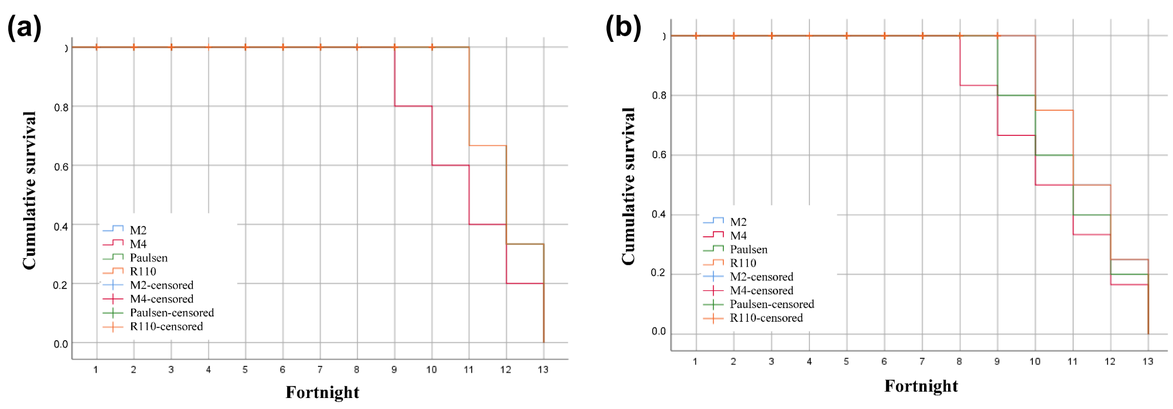

Figure 2. Cumulative survival under (a) 50 mM NaCl and (b) 75 mM NaCl

RESULTS & DISCUSSION

Growth Responses

- M2 maintained superior biomass and shoot length across salinity treatments
- R110 showed remarkable trunk diameter stability even under high salinity
- 1103 Paulsen exhibited intermediate growth performance with good stability
- M4 displayed the highest sensitivity with severe growth reductions

Physiological Adaptations

- 1103 Paulsen maintained stable photosynthetic efficiency and controlled energy dissipation
- M2 showed declining electron transport efficiency but sustained chlorophyll content
- R110 displayed erratic stomatal conductance patterns but stable SPAD values
- M4 exhibited poor photosynthetic performance and accelerated leaf damage

Ion Homeostasis

- Root tissue acted as primary ion reservoir, particularly for Na^+ and Ca^{2+}
- Stems functioned as Na^+ storage sites, protecting photosynthetic tissues
- Leaves maintained higher K^+/Na^+ ratios crucial for photosynthetic processes
- M2 and R110 demonstrated superior ion exclusion under moderate stress
- 1103 Paulsen exhibited effective ion compartmentalization mechanisms

Visual Symptoms (Figure 1) & Survival Analysis (Figure 2)

- Critical threshold identified between 50-75 mM NaCl where stress responses shift from adaptive to damaging
- M4 showed highest mortality rate under stress conditions
- M2 maintained the best overall condition with reduced but still considerable green foliage
- 1103 Paulsen and R110 showed extreme stunting and defoliation at 75 mM NaCl

CONCLUSIONS

- Genotype-specific salt tolerance strategies were identified:
  - M2: Superior biomass retention and growth with moderate ion compartmentalization
  - 1103 Paulsen: Robust photosynthetic efficiency and effective ion exclusion
  - R110: Effective ion management at moderate salinity but poor growth maintenance
  - M4: Most sensitive to salinity with severe reductions in growth and ion homeostasis
- Organ-specific responses highlighted specialized roles in salt stress management:
  - Roots: Primary ion reservoirs
  - Stems: Na^+ compartmentalization sites
  - Leaves: Maintained high K^+ for photosynthesis
- These findings provide valuable guidance for rootstock selection in salinity-affected vineyards and contribute to breeding programs targeting enhanced salt tolerance in Mediterranean viticulture.

REFERENCES

Rius-Garcia, X., Videgain-Marco, M., Casanova-Gascón, J., Acuña-Rello, L., & Martín-Ramos, P. Physiological Response to Salinity in Novel M-Series Grapevine Rootstocks: A Comparison with Commercial Standards. *Agronomy*, **2025**, *15*(2), 473.