Switchgrass Responses to Manganese Availability

Ying Guo[1] and Felix B. Fritschi[1]

[1]Division of Plant Sciences, University of Missouri, Columbia, MO,65211

Introduction

Manganese (Mn) is an essential micronutrient and has a broad range of functions. Manganese plays a key role in photosynthetic processes, including as an activator for the NAD malic enzyme (NAD-ME; Figure 1). NAD-ME releases CO_2 from malate that was transported from mesophyll cells into the bundle sheath cell of the NAD-ME subtype of C4 plants (Figure 2).

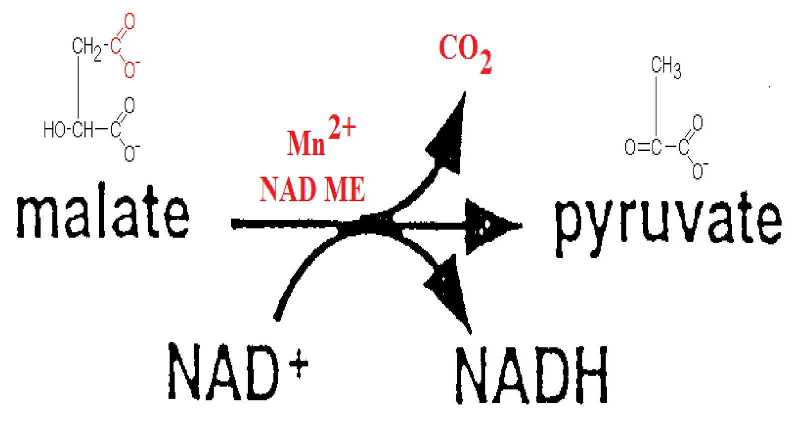

Figure1. NAD-malic enzyme (NAD-ME) catalyzes the oxidative decarboxylation of malate. Re-drawn from Leaver C. J. (1998)

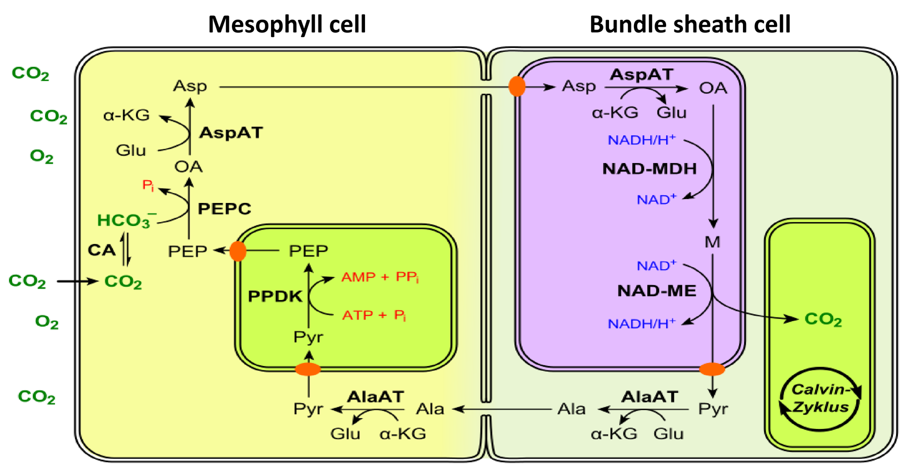

Figure2. NAD-ME type C_4 pathway. PEP =Phosphoenolpyruvate; OA = Oxaloacetate; Pyr =Pyruvate; AlaAT = Alanin-Aminotransferase; AspAT = Aspartat-Aminotransferase; PEPC = PEP-Carboxylase; PPDK = Pyruvate-Phosphat-Dikinase; NAD-MDH = NAD-Malatdehydrogenase; NAD-ME = NAD-Malic enzyme (Modified from https://es.wikipedia.org)

As a perennial bioenergy feedstock, switchgrass (*Panicum variegatum* L.), a NAD-ME type C4 plant, is considered a promising species for sustainable production of large amounts of bioenergy feedstock. To date, only limited information is available on the Mn requirement of switchgrass.

Considering the crucial role of Mn in the photosynthetic process, the objective of this study was to characterize the response of switchgrass photosynthesis and biomass production to Mn availability.

Materials and Methods

Two switchgrass genotypes, Alamo and Cave-in-Rock, were grown hydroponically with Mn concentrations ranging from 0 to 100 μM under controlled conditions (Figure 3) and in pots with vermiculite under field conditions (Figure 4) in Columbia, MO. Under controlled conditions, plants were harvested at 60 days after the start of Mn treatments and total biomass was determined. Shoot dry weight was quantified at 110 days after starting Mn treatment in the field experiment. Net photosynthetic rate and stomatal conductance were measured with the LI-COR 6400 portable photosynthesis system and relative chlorophyll content was estimated using the SPAD-502 at 75-80 days after the start of Mn treatments in the field. Leaf tissue was collected and stored at -80°C for future enzyme activity analyses.

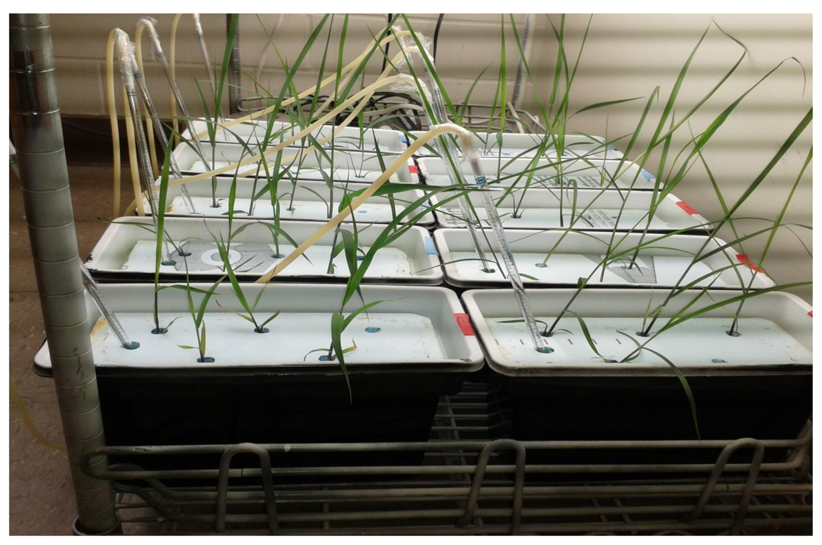

Figure 3. Chamber setup for switchgrass grown in complete nutrient solution consisting of 2.50mM NH_4NO_3; 2.0 mM KCl; 2.0 mM $CaCl_2.2H_2O$; 0.5 mM Mg $SO_4.7H_2O$; 0.08 mM K_2HPO_4; 0.32 mM KH_2PO_4; 0.025 mM FeSeq330; 0.6 μM $ZnSO_4.7H_2O$; 0.10μM $NaMoO_4.2H_2O$; 0.11 μM $NiCl_2.6H_2O$; 0.15 μM; $CuSO_4.5H_2O$; 2.3 μM H_3BO_3 containing different Mn concentrations ranging from 0-100μM.

Figure 4. Field setup for switchgrass grown in pots and drip-irrigated daily with complete nutrient solution consisting of 2.50mM NH_4NO_3; 2.0 mM KCl; 2.0 mM $CaCl_2.2H_2O$; 0.5 mM Mg $SO_4.7H_2O$; 0.08 mM K_2HPO_4; 0.32 mM KH_2PO_4; 0.025 mM FeSeq330; 0.6 μM $ZnSO_4.7H_2O$; 0.10μM $NaMoO_4.2H_2O$; 0.11 μM $NiCl_2.6H_2O$; 0.15 μM; $CuSO_4.5H_2O$; 2.3 μM H_3BO_3 containing different Mn concentrations ranging from 0-100μM.

Results

Chamber

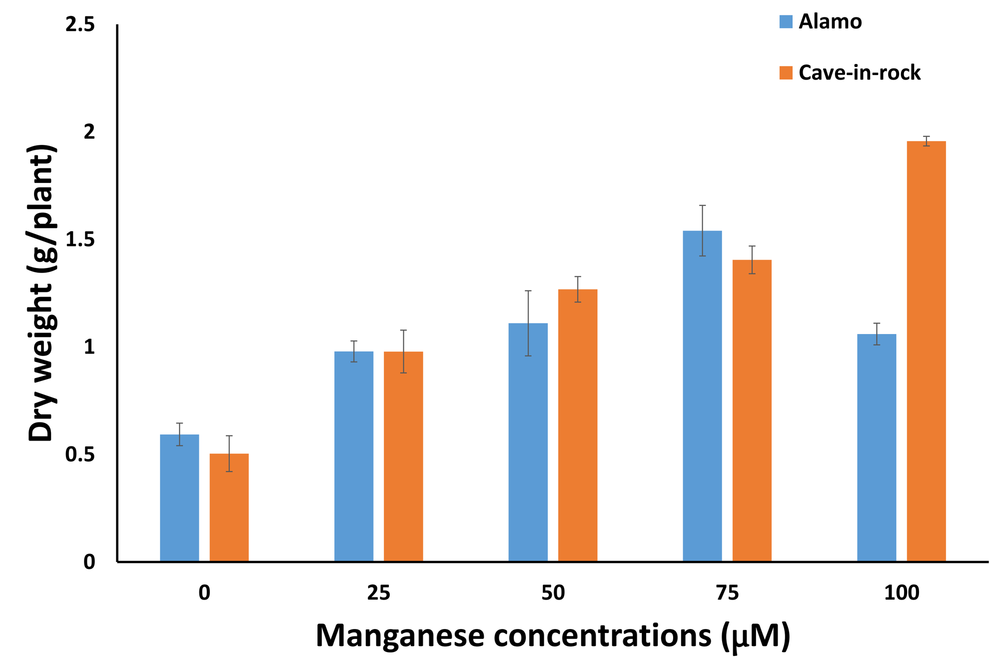

Figure 5. Total biomass of two switchgrass genotypes, Alamo and Cave-in-Rock, grown hydroponically in a complete nutrient solution with different Mn concentrations. Values are means ± SE, n=4.

Field

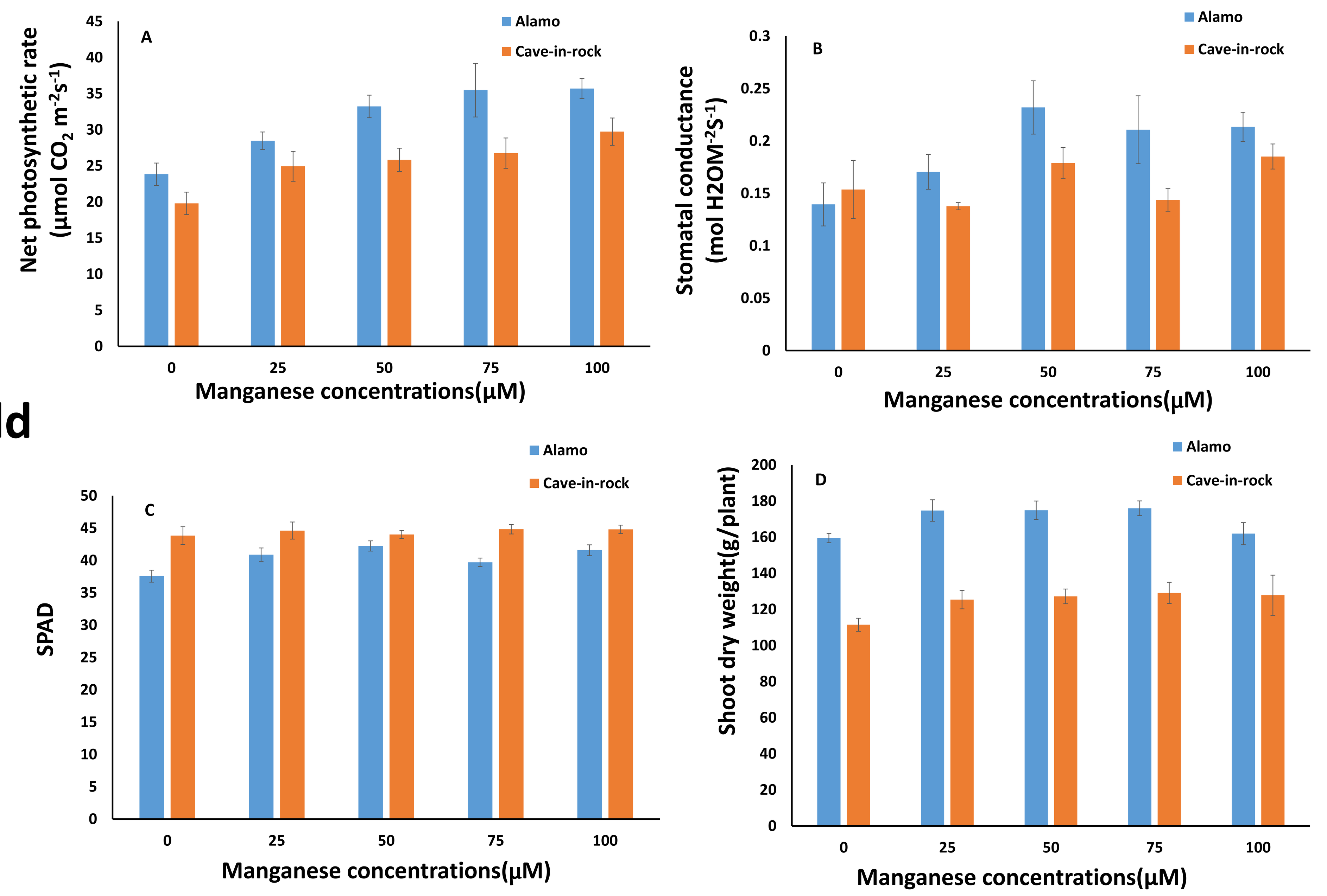

Figure 6. Leaf photosynthetic rate (A), stomatal conductance (B), relative chlorophyll content (C), and shoot dry weight (D) of two genotypes, Alamo and Cave-in-Rock, grown in pots under field conditions. Values are means ± SE, n=10

Conclusions

- **Total biomass of hydroponically grown plants increased with greater Mn concentration in both genotypes (Figure 5).**
- **Greater photosynthetic rates were achieved at elevated Mn concentrations in both genotypes under field conditions (Figure 6A).**
- **Shoot dry matter accumulation increased with the addition of low amounts of Mn, but this trend did not continue with increasing Mn concentrations (Figure 6D).**
- **In the Alamo genotype, Mn treatment had little effect on stomatal conductance and relative chlorophyll content, and there was no effect in the Cave-in-Rock genotype (Figure 6B,C).**

Future directions

- **Additional studies are needed to explore and characterize the role of Mn in switchgrass.**
- **Enzyme activities, including those of NAD-ME and Mn-SOD, will be examined in leave tissues from plants grown with different Mn availabilities.**
- **The influence of Mn fertilization on the biomass production of switchgrass will need to be determined in field plots.**