Manganese Nutrition of Soybeans

Manganese Deficiency

Function of Manganese

- The splitting of the water molecule (Hill Reaction) and subsequent evolution of O_2
- Activates enzymes leading to the biosynthesis of lignin and flavonoids. Flavonoids in legumes stimulate nodulation gene expression.

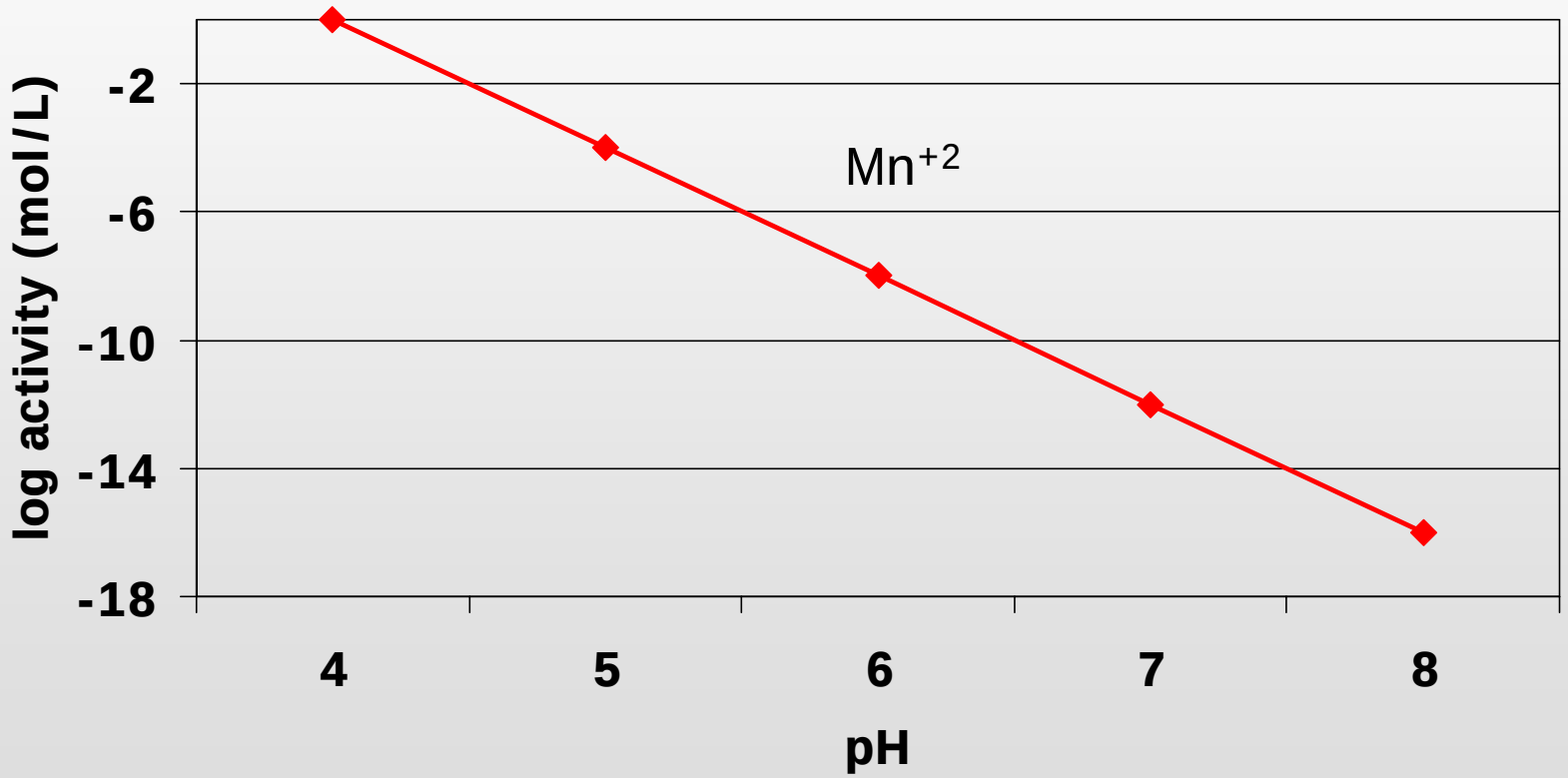
Mn Function in N Nutrition

- Responsible for degradation of fixed N transported from roots to shoots.
  - Ureides are products of N-fixation in nodulated legumes and transported from the nodule to the shoot, where they are broken down.
  - Manganese is a required cofactor of ureide breakdown

Manganese Uptake

- Mn is taken up and transported as Mn^{+2}
- Mn is relatively immobile in the plant and is scarcely translocated in the phloem.

Availability of Mn^{+2} in Soil Solution



Mn nutrition problems with herbicide resistant soybeans

- Insertion of gene giving herbicide resistance may have changed soybean root exudates. Plants solublize less Mn than conventional soybeans.

- Glyphosate application may interfere with Mn metabolism within the plant.

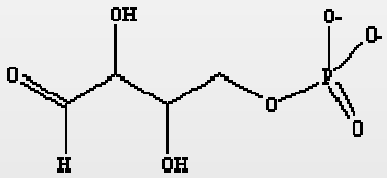
Glyphosate

- Glyphosate inhibits the shikimate pathway, responsible for the biosynthesis of phenolics, flavonoids and lignin.
- Mn reducing soil microorganisms also posses the shikimate pathway.

- What is 'shikimate pathway' you ask??

Overall Reaction for the Shikimate Pathway

D-Erythrose-4-Phosphate 2 Phosphoenoylpyruvate NAD^+ NADPH ATP ⟶ Chorismate + NADH + $NADP^+$ + ADP + 4 P_i



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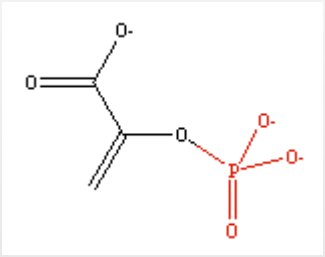

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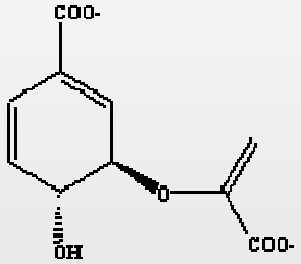


D-Erythrose-4-Phosphate + Phosphoenoylpyruvate ⟶ Chorismate

Glyphosate

- Glyphosate inhibits the shikimate pathway, responsible for the biosynthesis of phenolics, flavonoids and lignin.
- Mn reducing soil microorganisms also posses the shikimate pathway.
- **Glyphosate is an organic compound and can persist in the rhizosphere and can interfere with Mn-reducing microorganisms.**

Site Description

Crete silt loam soil
pH = 7.0
Bray-1P = 25ppm
K = 236 ppm
OM = 2.9%

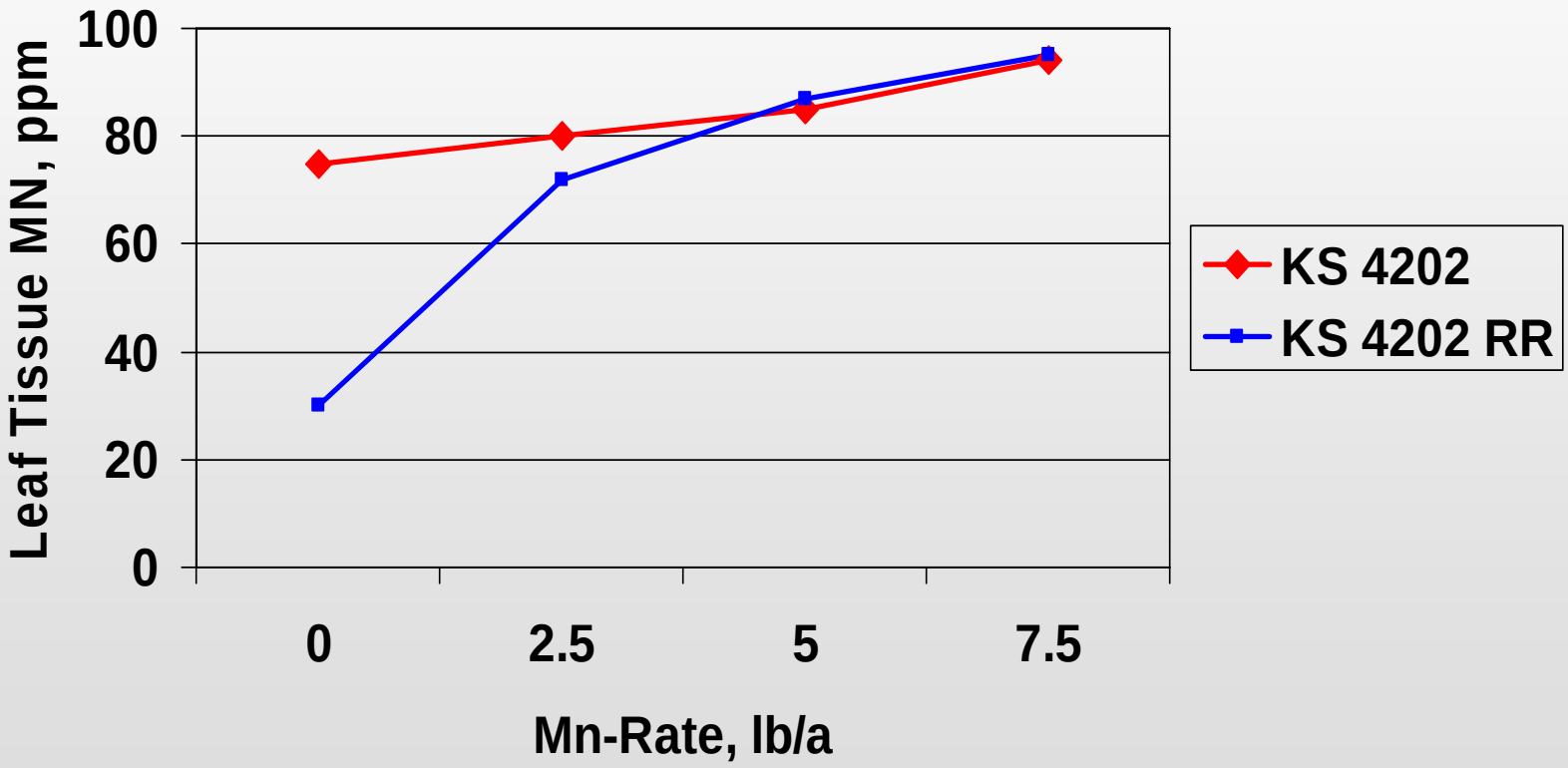
Treatments

- Varieties: KS 4202 and KS 4202 RR
- Mn rates: 0, 2.5, 5.0 and 7.5 lb/acre
- Application Method: Banded at planting
- Source $MnSO_4$ (24% Mn).

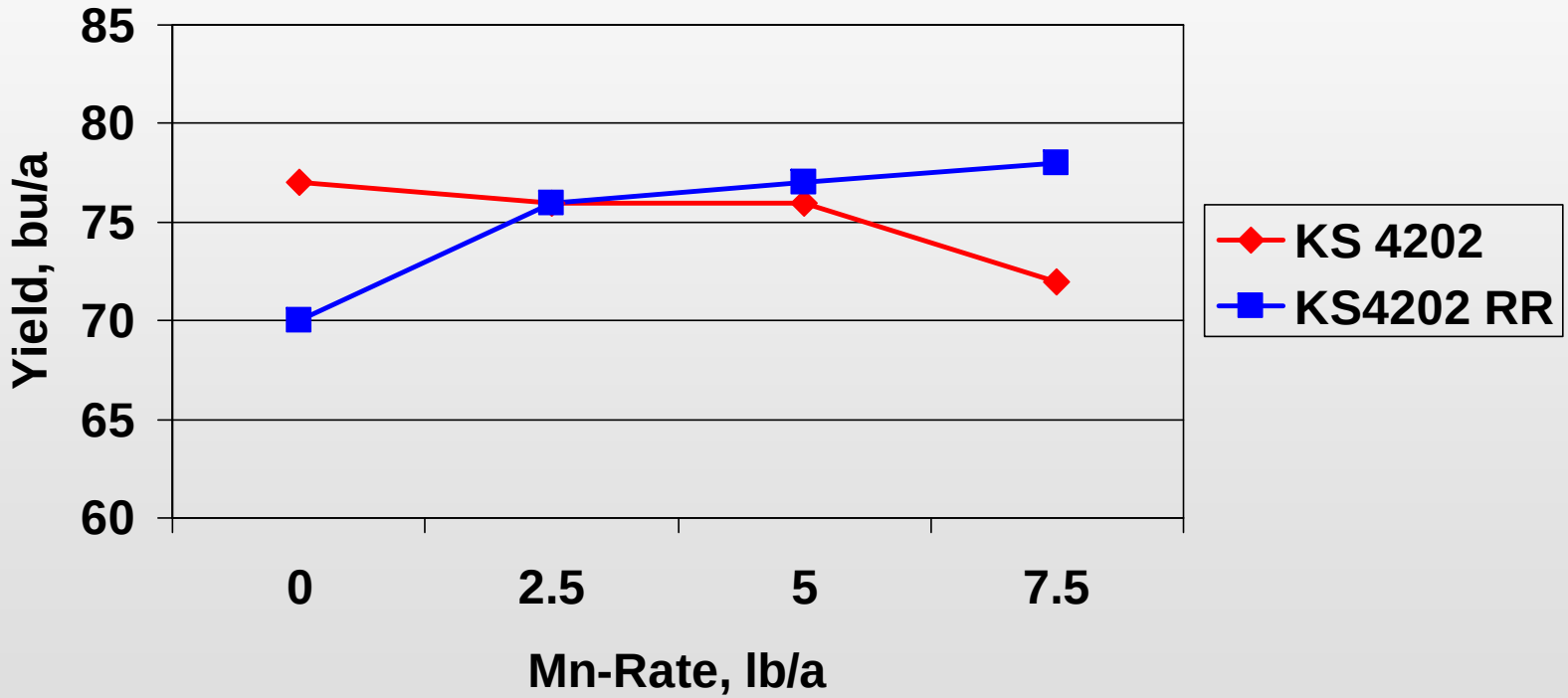

MANGANESE EFFECTS
GLYPHOSATE
RESISTANT
BEANS
0
LB MN
7.5


Glyphosate
Susceptible Variety
MN
7.5 LB/A
0

Mn Application Effects on Leaf Tissue Mn Concentration, 2005-2006



Mn Application Effects on Soybean Yield, 2005-2006.



Liquid Applied Manganese Effects on Soybean Yield, 2005-2007

Stage of Growth	Yield, bu/acre
Untreated check	**66**
Starter (.3 lb)	**66**
Starter (.6 lb)	**70**
Starter (.3 lb) + V4 (0.3 lb)	**74**
V4 (0.3 lb)	**66**
V4+V8 (0.3+0.3 lb)	**72**
V4+V8+R2 (0.3+0.3+0.3 lb)	**74**
LSD (0.05)	3

Liquid Mn Source Effects on Soybean Yield, 2006-2007

Material (.3lb Mn/a V4+V8+R2)	Yield, bu/acre
Mn Thiosulfate	**75**
Mn Glucoheptonate	**73**
Mn Mannitol	**74**
LSD (0.05)	**NS**

Conclusions

- Conventional and Glyphosate-Resistant soybeans did respond differently to Mn application.
- Addition of Mn significantly improved soybean yields in glyphosate-resistant varieties.
- Mn application fits in well with a soybean production program managed for high-yield.