Does Phosphite Enhance Phloem Transport of Zn and Mn in *Phaseolus vulgaris* L. and *Zea mays* L.?

Levent Ozturk, Ismail Cakmak, Sabanci University, Istanbul, Turkey;
Alvin Alexander, Aglukon, Düsseldorf, Germany;
Volker Römheld, Institute of Plant Science, Plant Nutrition,
University Hohenheim, Stuttgart, Germany
e-mail: v.roemheld@uni-hohenheim.de

Overview

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Introduction:

- Phosphites are wide-spread used as foliar sprays.
- It is well documented that phosphites can function as fungicides (Lobato et al., 2008; Araujo et al., 2008).
- Phosphites cannot be used by normal plants as a source for phosphate (Weinmann et al., 2008; Gerendas et al.,).
- Only in molecular engineered plants with a specific gene phosphites can be used as a source for phosphate (Lopez-Arredondo and Herrera-Estrella, 2012).

- There are observations and also the belief that phosphite can mediate phloem transport of micronutrients and thus the storage of micronutrients in seeds.

- In principle, such an enhanced phloem transport has been shown by sugar alcohols for boron.

- Thus, the aim of the following research was to study whether phosphite can function as a phloem carrier for micronutrients (^{65}Zn, ^{54}Mn) in common bean (*Phaseolus vulgaris* L.) and maize (*Zea mays* L.).

Material and methods:

- ^{65}Zn and ^{54}Mn were applied as sulfate or phosphite as point application with PlantaCare as surfactant to the plants precultured two weeks without or with Zn or Mn.

- 76 h after the first and 48 h after the second point application the plants (6 replicates per treatment) were harvested as 7 (common beans) or 6 fractions (maize) and analyzed for radioactivity.

- The application zone (fraction No. 2) was washed with NaEDTA and water before measuring the radioactivity.

Setup of common bean and maize plants in a climate chamber at the Sabanci Univ.

Control (preculture + Mn)

Preculture – Mn
(severe Mn deficiency)

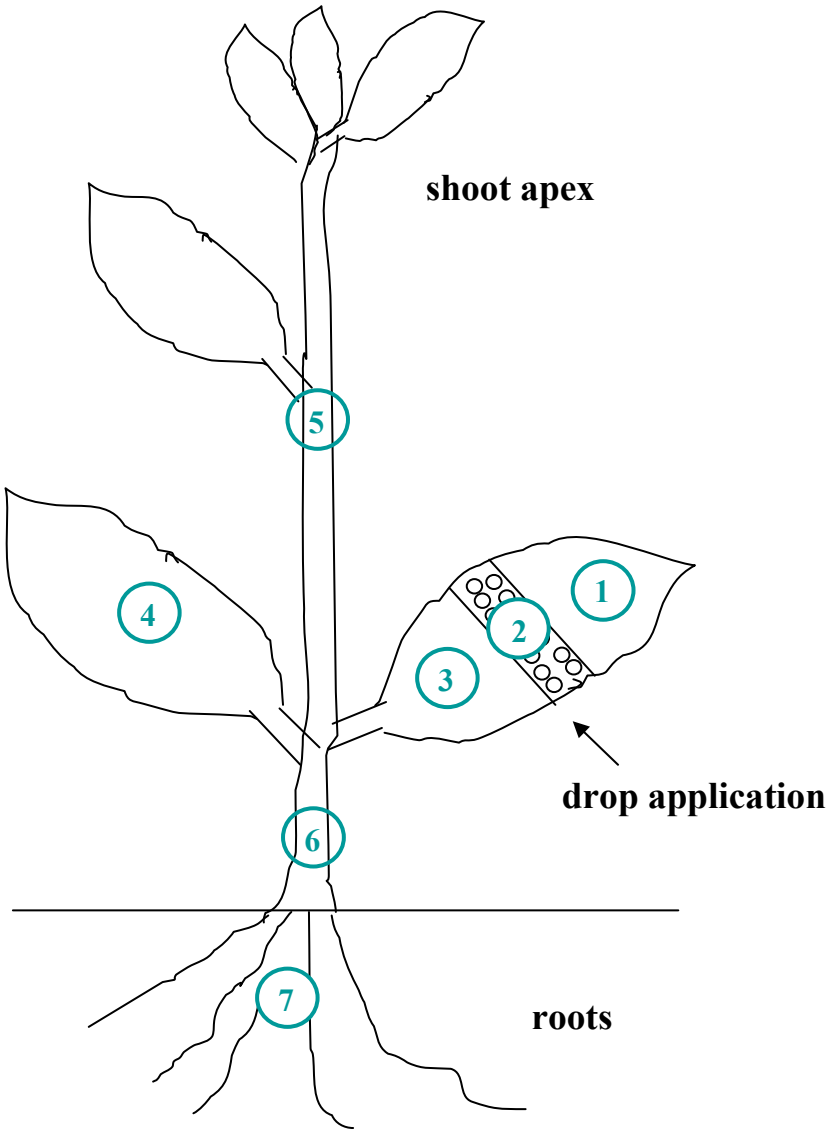
Common bean ICP results

Pre Culture	Plant part	Ca	K	Mg	P	S	Fe	Cu	Mn	Zn
				(%)					(mg kg^{-1})	
Control		2.11 ± 0.03	2.66 ± 0.16	0.42 ± 0.04	0.38 ± 0.02	0.44 ± 0.07	53 ± 4	5 ± 1	24 ± 0	25 ± 3
-Mn	Shoot	2.97 ± 0.23	4.31 ± 0.48	0.58 ± 0.01	0.64 ± 0.09	0.56 ± 0.09	80 ± 9	8 ± 0	5 ± 1	46 ± 2
-Zn		1.68 ± 0.12	2.84 ± 0.11	0.34 ± 0.03	0.50 ± 0.02	0.20 ± 0.01	65 ± 9	5 ± 1	26 ± 3	10 ± 2
Control		1.29 ± 0.05	3.74 ± 0.23	0.45 ± 0.03	0.60 ± 0.03	0.51 ± 0.01	215 ± 6	29 ± 12	21 ± 2	77 ± 2
-Mn	Root	1.28 ± 0.12	4.54 ± 0.41	0.52 ± 0.01	0.70 ± 0.14	0.60 ± 0.05	225 ± 17	30 ± 8	3 ± 0	84 ± 12
-Zn		0.92 ± 0.02	4.99 ± 0.07	0.51 ± 0.04	0.54 ± 0.02	0.72 ± 0.07	178 ± 25	21 ± 4	23 ± 2	40 ± 14

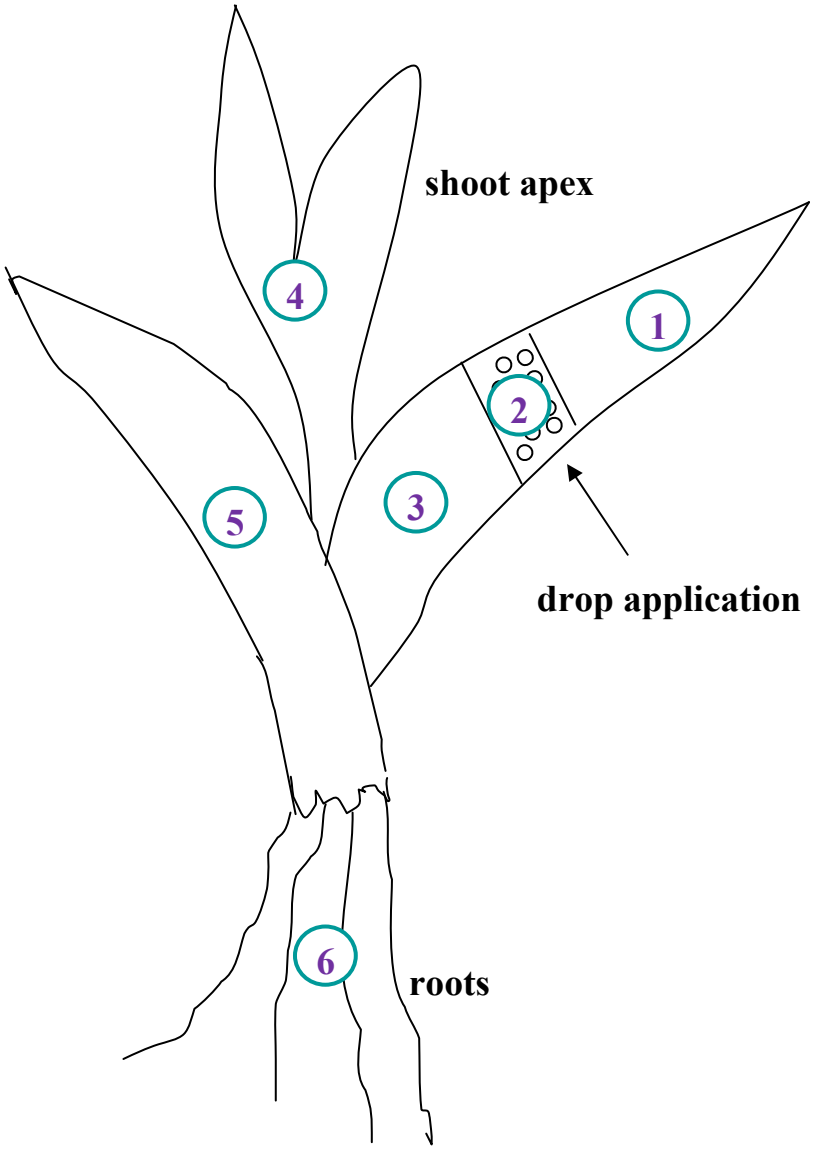
Point application of radioactive labelled solution by Levent Ozturk at the Sabanci Univ., Istanbul, Turkey

Point application
(15 x 2.5 uL)

Harvested fractions of common bean *(Phaseolus vulgaris* L.*)*



Harvested fractions of maize *(Zea mays* L.*)*



Main results:

Common Bean: Dry Matter

Leaf Appl.	Pre Culture	±Phosphite	Dry matter production		
			Shoot	Root	Shoot:Root
			(g plant^{-1})		
Zn-65	Control	-	1.87 ± 0.36	0.62 ± 0.11	3.04 ± 0.47
		+	1.56 ± 0.09	0.54 ± 0.02	2.88 ± 0.14
	-Zn	-	1.72 ± 0.33	0.64 ± 0.12	2.69 ± 0.19
		+	1.68 ± 0.31	0.64 ± 0.14	2.64 ± 0.10
Mn-54	Control	-	1.76 ± 0.25	0.64 ± 0.07	2.77 ± 0.13
		+	1.98 ± 0.26	0.67 ± 0.09	2.96 ± 0.21
	-Mn	-	0.98 ± 0.12	0.40 ± 0.06	2.46 ± 0.13
		+	0.86 ± 0.18	0.34 ± 0.07	2.51 ± 0.12

Preculture – Mn and – Zn resulted in a higher R/S ratio in common beans!

Maize Dry Matter

Leaf Appl.	Pre Culture	±Phosphite	Dry matter production		
			Shoot	Root	Shoot:Root
			(g plant^{-1})		
Zn-65	Control	-	0.50 ± 0.11	0.22 ± 0.06	2.27 ± 0.25
		+	0.42 ± 0.06	0.20 ± 0.03	2.08 ± 0.23
	-Zn	-	0.49 ± 0.06	0.26 ± 0.04	1.89 ± 0.14
		+	0.48 ± 0.08	0.25 ± 0.04	1.96 ± 0.18
Mn-54	Control	-	0.57 ± 0.10	0.28 ± 0.04	2.04 ± 0.17
		+	0.46 ± 0.06	0.24 ± 0.03	1.95 ± 0.19
	-Mn	-	0.39 ± 0.06	0.19 ± 0.03	2.02 ± 0.17
		+	0.33 ± 0.05	0.16 ± 0.02	2.12 ± 0.21

Preculture – Zn resulted in a higher R/S ratio in maize plants!

Common Bean: Distribution ratio of applied Zn and Mn

Leaf Appl.	Pre Culture	±Phosphite	Fraction 1	Fraction 2	Fraction 3	Fraction 4	Fraction 5	Fraction 6	Fraction 7
						(% Zn distribution)			
Zn-65	Control	-	0.50 ± 0.06	94.68 ± 0.34	0.59 ± 0.10	0.51 ± 0.09	1.38 ± 0.10	0.89 ± 0.07	1.45 ± 0.14
		+	0.63 ± 0.26	93.88 ± 1.55	0.59 ± 0.16	0.59 ± 0.18	1.73 ± 0.49	0.99 ± 0.26	1.59 ± 0.28
	-Zn	-	0.63 ± 0.10	91.32 ± 1.61	0.79 ± 0.14	0.64 ± 0.09	1.54 ± 0.32	1.20 ± 0.22	3.88 ± 1.04
		+	0.64 ± 0.16	91.85 ± 2.14	0.76 ± 0.28	0.64 ± 0.22	1.47 ± 0.38	1.13 ± 0.42	3.50 ± 0.91
Mn-54	Control	-	1.10 ± 0.32	95.25 ± 0.79	0.33 ± 0.07	0.23 ± 0.06	1.74 ± 0.30	0.80 ± 0.17	0.55 ± 0.10
		+	0.60 ± 0.18	96.05 ± 0.61	0.26 ± 0.05	0.17 ± 0.04	1.71 ± 0.31	0.69 ± 0.11	0.52 ± 0.10
	-Mn	-	0.57 ± 0.10	92.36 ± 0.50	0.45 ± 0.07	0.31 ± 0.06	2.27 ± 0.18	0.93 ± 0.15	3.11 ± 0.42
		+	0.53 ± 0.10	92.68 ± 1.36	0.37 ± 0.07	0.21 ± 0.07	2.58 ± 0.84	0.86 ± 0.19	2.77 ± 0.42

Under preculture – Zn and – Mn more translocation of radioactivity per phloem into the roots (fraction No. 7)! No phosphite effect!

Maize: Distribution ratio of applied Zn and Mn

Leaf Appl.	Pre Culture	±Phosphite	Fraction 1	Fraction 2	Fraction 3	Fraction 4	Fraction 5	Fraction 6
					(% Zn distribution)			
Zn-65	Control	-	2.24 ± 0.27	85.61 ± 1.39	0.79 ± 0.19	3.94 ± 0.59	3.98 ± 0.58	3.43 ± 0.51
		+	2.23 ± 0.27	85.44 ± 1.00	0.84 ± 0.15	3.90 ± 0.30	3.88 ± 0.58	3.70 ± 0.30
	-Zn	-	2.37 ± 0.38	80.97 ± 2.60	0.80 ± 0.27	3.74 ± 0.50	4.29 ± 0.59	7.84 ± 1.88
		+	2.05 ± 0.23	78.79 ± 2.13	1.09 ± 0.40	3.73 ± 0.48	5.80 ± 1.52	8.54 ± 1.17
Mn-54	Control	-	10.18 ± 2.29	85.81 ± 2.43	0.81 ± 0.26	1.58 ± 0.57	1.07 ± 0.26	0.54 ± 0.15
		+	12.14 ± 2.40	85.00 ± 2.17	0.60 ± 0.08	1.07 ± 0.29	0.85 ± 0.19	0.35 ± 0.07
	-Mn	-	7.00 ± 1.93	85.87 ± 1.29	1.02 ± 0.17	2.68 ± 0.61	2.42 ± 0.39	1.03 ± 0.22
		+	7.91 ± 4.16	85.43 ± 2.78	1.05 ± 0.29	2.47 ± 0.72	2.25 ± 0.61	0.89 ± 0.27

Under preculture – Zn and – Mn more translocation of radioactivity per phloem into the roots (fraction No. 6)! No phosphite effect!!

Common Bean: (nmoles/fraction)

Leaf Appl.	Pre Culture	±Phosphite	Fraction 1	Fraction 2	Fraction 3	Fraction 4	Fraction 5	Fraction 6	Fraction 7	Total
						(nmol Zn)				
Zn-65	Control	-	0.98 ± 0.05	189 ± 31	1.16 ± 0.03	0.99 ± 0.05	2.76 ± 0.53	1.78 ± 0.25	2.90 ± 0.50	200
		+	1.19 ± 0.19	192 ± 53	1.13 ± 0.06	1.12 ± 0.05	3.34 ± 0.44	1.91 ± 0.13	3.15 ± 0.55	204
	-Zn	-	0.95 ± 0.08	141 ± 20	1.20 ± 0.09	0.97 ± 0.04	2.35 ± 0.43	1.83 ± 0.22	5.85 ± 0.85	154
		+	1.05 ± 0.07	158 ± 35	1.23 ± 0.10	1.04 ± 0.07	2.48 ± 0.74	1.81 ± 0.19	5.76 ± 0.70	171
						(nmol Mn)				
Mn-54	Control	-	2.43 ± 0.97	210 ± 44	0.71 ± 0.05	0.49 ± 0.03	3.73 ± 0.31	1.72 ± 0.34	1.19 ± 0.14	220
		+	1.22 ± 0.39	197 ± 42	0.51 ± 0.05	0.33 ± 0.01	3.44 ± 0.70	1.40 ± 0.31	1.05 ± 0.21	205
	-Mn	-	1.00 ± 0.33	162 ± 34	0.76 ± 0.06	0.53 ± 0.04	3.99 ± 0.87	1.62 ± 0.28	5.49 ± 1.48	176
		+	0.94 ± 0.36	165 ± 60	0.63 ± 0.11	0.34 ± 0.03	4.32 ± 1.44	1.44 ± 0.28	4.76 ± 1.33	178

Maize:

Leaf Appl.	Pre Culture	±Phosphite	Fraction 1	Fraction 2	Fraction 3	Fraction 4	Fraction 5	Fraction 6	Total
						(nmol Zn)			
Zn-65	Control	-	4.07 ± 1.17	157 ± 48	1.38 ± 0.17	7.10 ± 1.81	7.11 ± 1.52	6.20 ± 1.69	183
		+	4.10 ± 0.82	158 ± 32	1.50 ± 0.05	7.26 ± 1.75	7.08 ± 1.11	6.83 ± 1.29	185
	-Zn	-	5.88 ± 2.18	198 ± 55	1.80 ± 0.21	8.95 ± 2.19	10.15 ± 1.85	18.16 ± 2.38	243
		+	4.61 ± 1.05	177 ± 37	2.35 ± 0.73	8.42 ± 2.05	12.96 ± 3.97	19.04 ± 3.65	225
						(nmol Mn)			
Mn-54	Control	-	16.61 ± 8.22	141 ± 62	1.22 ± 0.20	2.41 ± 0.79	1.62 ± 0.26	0.80 ± 0.07	164
		+	28.17 ± 11.44	192 ± 49	1.34 ± 0.38	2.29 ± 0.26	1.84 ± 0.20	0.76 ± 0.08	227
	-Mn	-	13.86 ± 8.45	160 ± 48	1.81 ± 0.19	4.75 ± 0.74	4.34 ± 0.73	1.85 ± 0.45	186
		+	17.37 ± 17.82	160 ± 54	1.84 ± 0.32	4.31 ± 0.51	3.91 ± 0.32	1.54 ± 0.16	189

As before, preculture – Zn and – Mn enhanced phloem transport into roots in both plant species; but again no phosphite effect!

Summary - Outlook

- Phosphite does not promote phloem transport of ^{54}Mn or ^{65}Zn in common bean and maize.

- This finding is in accordance of an earlier study with *Capsicum annum* L. where phosphite didn't significantly enhance Ca, Mn and Zn content in the fruits.

- Low Zn and particularly low Mn nutritional status enhanced Zn and Mn translocation via phloem into roots.

- It will be of interest whether phosphite can promote phloem transport of Ni as observed by industry in USA and Brazil.

Thank you for your attention!
Dankeschön!