Phosphorus and Potassium Induced Micronutrient Deficiency in Vegetables Grown in Manure-Amended Soils: How Much is Too Much?

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Introduction

- Compost can result in excess levels of P and K in soils (1)
- P (Olsen) > 40 ppm result in environmental restrictions
- K > 800 ppm may result in micronutrient antagonism (2)

Hypothesis

- P or K from excessive compost will result in reduced crop yield or micronutrient concentration (Figure 1).

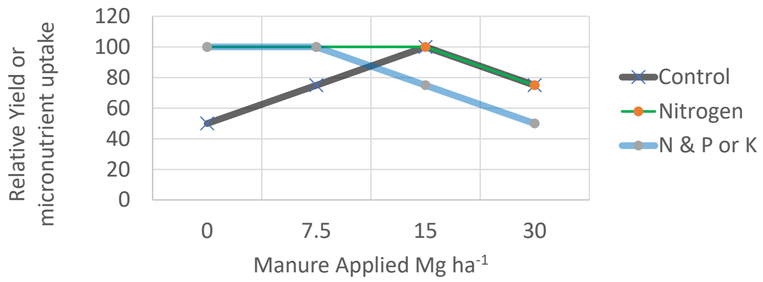

Figure 1.) Hypothesized crop yield or micronutrient response interaction to fertilizer and compost additions of P or K

Methodology

- 2 years on same sites to test cumulative effects 2016-2017
- Bozeman location already had elevated P & K levels of 103 and 787 mg kg^{-1} respectively.
- Corvallis location started with low P & K levels
- Both sites had soil pH>7.0
- 4 levels of annual compost addition (Table 1)
- 4 Fertilizer split plots (none, +N, +N&P, +N&K, Table 2)
- Standard soil tests at beginning and end of experiment
- Swiss chard yield and micronutrient concentration were measured

Dry Weight Mg ha^{-1}	Wet Weight tons $acre^{-1}$	P kg ha^{-1}	K kg ha^{-1}
0	0	0	0
6	7.5	55	92
12	15	110	184
24	30	220	364

Table 1.) Annual rates of compost and associated P & K inputs.

Fertilizer	Fertilizer kg ha^{-1}	N kg ha^{-1}	P kg ha^{-1}	K kg ha^{-1}
NH_4NO_3	488	165	0	0
KNO_3	1273	165	0	560
$NH_4H_2PO_4$ & NH_4NO_3	161 435	17 +148 =165	84	0
Control	0	0	0	0

Table 2.) Annual rates mineral fertilizer and associated N, P, and K inputs. Fertilizer was applied in split plots to test interaction with compost.

Nutrient	Concentration
Total N	0.4 %
Inorganic N	0.017 %
P (P_2O_5)	0.9 %
K (K_2O)	3.4 %
Na	0.23 %
Ca	3.2 %
Mg	0.8 %
S	0.22 %
Zn	90 mg kg^{-1}
Fe	6060 mg kg^{-1}
Mn	292 mg kg^{-1}
Cu	23 mg kg^{-1}

Table 3.) Nutrient Concentration (Dry Weight Basis) of Composted Sheep Manure. Product shown is actual product applied.

Soil Results
Bozeman Fall 2017 only

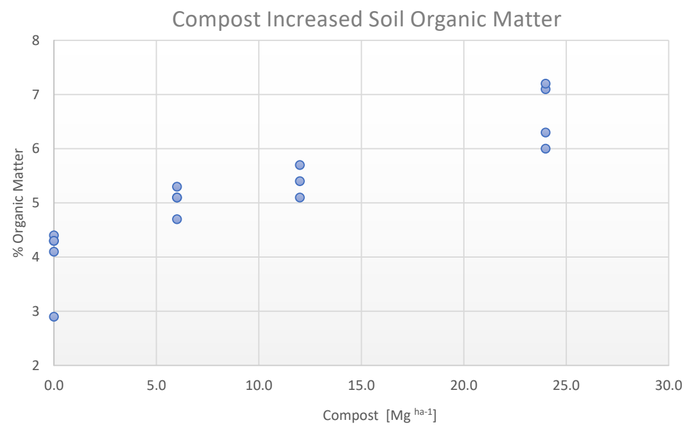

Figure 2.) Fall 2017 soil organic matter content increased steadily with increasing compost application rates

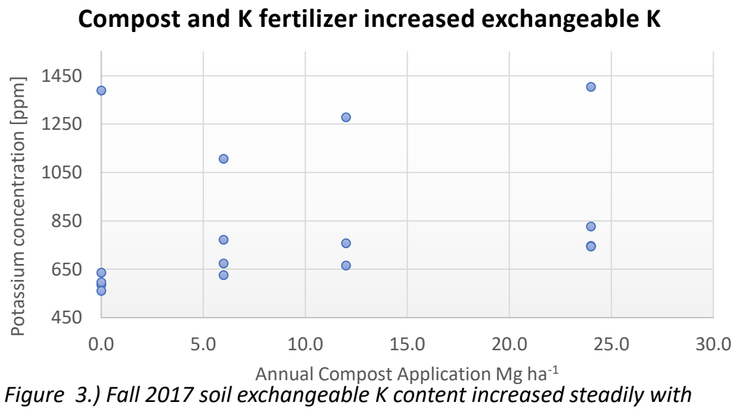

Figure 3.) Fall 2017 soil exchangeable K content increased steadily with increasing compost application rates. Elevated values are the plots receiving K fertilizer

- **Despite net P_2O_5 inputs of up to 568 kg ha^{-1}, soil Olsen P values at Bozeman did not change from the initial value of 103 mg kg^{-1} and did not differ among treatments. P must be remaining in organic form, fixed as calcium minerals, immobilized in the organic matter complex or otherwise not accounted for by the Olsen test.**

Crop Yield and Micronutrient Results

- Compost did not affect crop yield
- Compost did rarely decrease micronutrient uptake, and not below sufficiency levels
- Nitrogen fertilizer increased crop yield ¾ site years
- Our hypothesized compost:fertilizer interaction generally did not occur.

	Bozeman					
	------2016------			-----2017------		
	Compost	Fertilizer	C:F	Compost	Fertilizer	C:F
C	0.81	0.09	0.41	na	na	na
N	0.22	0.24	0.78	na	na	na
P	0.09	0.44	0.22	0.20	0.48	0.60
K	0.16	0.95	0.81	0.24	0.95	0.78
S	0.33	0.18	0.49	0.17	0.18	0.47
Ca	0.34	0.22	0.98	0.35	0.22	0.75
Mg	0.06	0.51	0.61	0.08	0.58	0.88
Na	0.68	0.69	0.50	0.82	0.81	0.09
Zn	**0.01+**	0.80	0.34	0.45	0.76	0.30
Fe	0.21	0.99	0.95	0.22	0.99	0.68
Mn	0.90	**0.00 -N**	0.71	0.94	0.12	0.29
Cu	0.26	**0.03 –N**	0.57	0.19	**0.01 -N**	0.50
B	0.48	**0.04 -K**	0.19	0.49	0.91	0.89
Yield	0.84	0.40	0.27	0.08	0.37	0.42
	Corvallis					
	-----2016------			------2017------		
	Compost	Fertilizer	C:F	Compost	Fertilizer	C:F
C	0.60	**0.00 +K**	0.40	na	na	na
N	0.15	**0.00 +N**	0.11	na	na	na
P	0.24	**0.00 –N, +P**	0.58	0.86	0.27	0.55
K	0.22	**0.00 -N**	0.35	0.63	**0.02 -P**	0.78
S	0.34	**0.01 –N**	0.58	0.80	0.14	0.71
Ca	0.55	0.11	0.43	0.10	0.36	0.68
Mg	0.42	**0.00 +N**	0.97	0.06	**0.00 +N**	0.51
Na	0.41	0.14	0.70	**0.00 +**	**0.00 +N**	**0.01**
Zn	0.42	0.07	0.21	**0.00 +**	0.57	0.63
Fe	**0.02 -**	**0.00 -K**	0.74	0.50	0.40	0.43
Mn	0.57	**0.00 +P**	0.98	0.40	0.40	0.81
Cu	**0.02 -**	0.18	0.89	0.18	0.13	0.20
B	0.12	**0.00 -K**	0.40	0.48	0.34	0.34
Yield	0.66	**0.00 +N**	0.86	0.42	0.16	0.56

*Table 4.) Anova P-Values for effects of Compost, Fertilizer, and Compost:Fertilizer Interaction on crop yield and tissue micronutrient concentration. Significant effects are shown in **Bold**. + indicates an increase, - a decrease, and the letters N, P, and K, indicate which specific fertilizer combinations caused the indicated effects.*

Conclusions

- We did not observe substantial antagonism of P or K on micronutrient uptake despite K levels as high as 1400 mg kg^{-1}.
- Additions of organic and mineral P did not increase soil Olsen P test values

References

1. Eghball, B., and J. F. Power. 1999. Phosphorus- and Nitrogen-Based Manure and Compost Applications Corn Production and Soil Phosphorus Joint contribution of USDA-ARS and Univ. of Nebr. Agric. Res. Div., Lincoln, NE, as paper no. 12133. . Soil Sci. Soc. Am. J. 63:895-901. doi:10.2136/sssaj1999.634895x
2. Dinkens, C., C. Jones, C. and K. Olsen-Rutz, 2017. Home Garden Soil Testing & Fertilizer Guidelines. MontGuide 200705AG. Montana State University Extension.