Evaluation of a Compost Derived from Sugarcane Processing By-Products

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ABSTRACT

Few studies have been conducted to determine the efficacy of composted sugarcane (interspecific hybrids of *Saccharum* spp.) processing by-products (SPB) as soil amendments and horticultural growing media. A mature SPB compost derived from chopped sugarcane tops, bagasse, and cane wash (soil washed from cane harvested by the push rake-crane grab method) was obtained from a recently closed commercial sugar mill. Three experiments were conducted under greenhouse conditions to evaluate the nutrient supplying capacity of SPB compost using 'Tex-Cuban' silage corn (*Zea mays* L.) as the test crop. The SPB compost had an intermediate N supplying capacity between a good quality yard compost and a Hilo silt loam (medial over hydrous, ferrihydritic, isohyperthermic Acrudoxic Hydrudands) field soil. However, SPB compost had a lower natural P supplying capacity than Hilo soil at a similar concentration of modified Truog (0.01 M H_2SO_4 + 0.02 M $[NH_4]_2SO_4$) soil test P. While a lack of available P was found to be the primary limitation to SPB compost use as a growing media it supported vigorous plant growth once the P deficiency was eliminated via P fertilization. The SPB compost is adequate in exchangeable K and tends to be sufficient to nearly sufficient in most other mineral nutrients. Arsenic contamination of SPB compost from its cane wash soil component was not considered to be a major concern because the As was primarily in forms of limited bioavailability.

INTRODUCTION

Increasing regulation of the burning of crop residues and processing by-products has stimulated interest in the utilization of composted sugarcane processing by-products (SPB) as soil amendments and horticultural growing media (Neel et al., 1978; Stoffella and Graetz, 2000; Boopathy et al., 2001; Meunchang et al., 2005; Mathews and Thurkins, 2006). The SPB composts are derived from various mixtures of cane tops (immature stalk and green leaves), cane wash, filtercake residue, and excess bagasse not used for energy at the mill or for industrial fiber products. Physical improvements in soils amended with SPB composts through added organic matter appears to be the greatest potential benefit of these materials in addition to serving as a partial fertilizer substitute for N and K (Stofella and Graetz, 2000; Boopathy et al., 2001; Meunchang et al., 2005; Mathews and Thurkins, 2006). The composting process should also eliminate potential autotoxic effects to ratoon sugarcane crops or allelopathic effects on other crops that can occur when postharvest sugarcane residues are left on the field surface (Viator et al., 2006).

Some potential users of SPB compost in Hawaii have raised concerns about possible arsenic (As) contamination of food crops. This is because surface soils from long-term sugarcane growing lands in Hawaii have often been found to contain relatively high total As concentrations in excess of 80 to 100 mg kg^{-1} (Ortiz Escobar et al., 2006; Univ. of Hawaii Agricultural

Diagnostic Service Center Laboratory, unpublished data). The United States Environmental Protection Agency's soil risk assessment screening level for As is 20 mg kg^{-1}. While geogenic background concentrations of As in Hawaii's soils typically range from < 0.01 to about 13 mg kg^{-1}, significantly elevated concentrations are believed to have resulted from sodium arsenite use as a herbicide in sugarcane fields between about 1915 and 1950 (Clements and Munson, 1947; Halbig et al., 1985; Ortiz Escobar et al., 2006). However, As bioaccessibility in most of these soils of volcanic origin is generally considered to be of low risk (Ortiz Escobar et al., 2006). This has been attributed to strong retention of As by oxides and hydroxides of Fe and to a lesser extent, Al (Raven et al., 1998; McLaren et al., 2006). Organic matter can also adsorb As and thereby decrease As availability especially in acidic soils (Cao et al., 2003; Cao and Ma, 2004).

An additional concern with use of As-contaminated SPB compost may be potential release of sorbed As via competitive displacement from soil binding sites by phosphate fertilizers, thereby increasing soil As bioaccessibility (Cao et al., 2003; Cao and Ma, 2004). However, such concerns are unlikely for compost derived in part from amorphous, Fe- and Al-rich (Andic) soil materials of volcanic origin (Peryea, 1991). Furthermore, phosphate as a chemical analogue of arsenate may compete with As for uptake from soil solution (Tu and Ma, 2003).

The present research was conducted under greenhouse conditions with the following objectives: 1) to compare the natural N supplying capacity of SPB compost with yard compost and a Hilo silt loam field soil, 2) evaluate corn growth and mineral composition responses to SPB compost thoroughly mixed with a Hilo field soil at volumetric ratios of 0, 6.25, 12.5, 25, 50, and 100% SPB, and 3) examine corn growth and mineral composition responses to adjustment of the modified Truog (MT, 0.01 M H_2SO_4 + 0.02 M $[NH_4]_2SO_4$) extractable P (Hue et al., 2000) concentration of the SPB compost to 35, 70, 140, and 280 mg kg^{-1} with monocalcium phosphate fertilizer.

MATERIALS AND METHODS

A mature SPB compost derived from chopped cane tops, bagasse, and cane wash was obtained from a recently closed commercial sugar mill near Honokaa, Hawaii (20^{o} N lat.). At the facility, SPB material was placed in excavated pits akin to landfill operations, covered with about 0.7m of soil, and allowed to compost for over10 years. A composite of the SPB compost was collected by removing the soil cover from four random pit sites with a back hoe and loading enough compost material to fill a clean, 120-L, heavy-duty, plastic trash can at each site. The SPB compost from the four sites was then thoroughly mixed and screened to pass a 8 mm sieve.

For comparison purposes the Ap horizon (0- to 15-cm depth) of a Hilo silt loam soil (medial over hydrous, ferrihydritic, isohyperthermic Acrudoxic Hydrudands) was obtained from an abandoned sugarcane field. The site had not been planted with sugarcane prior to the mid 1930s and therefore had likely received only a moderate amount of As input as sodium arsenite herbicide compared to older fields. A mature yard-waste compost was also obtained from a local supplier. This material was derived primarily from grass clippings, tree trimmings, and some wood chips, and was produced using the turned-pile method for about a year. Both the Hilo soil and the yard-waste compost were screened to pass a 8 mm sieve. Some physical and chemical analyses of the materials are presented in Tables 1 and 2.

Two separate experiments were conducted in a greenhouse to compare the SPB compost with Hilo soil and the yard compost. Experiment 1 compared the natural N supplying capacity of the two composts and the Hilo soil to corn. Experiment 2 evaluated corn growth and mineral composition responses to SPB compost thoroughly mixed with Hilo soil at volumetric ratios of 0, 6.25, 12.5, 25, 50, and 100% compost. The SPB compost, Hilo soil, and volumetric SPB compost-Hilo soil mixtures for the experiments were packed to a 5-L volume in (22.5 cm diam.) plastic pots according to their respective bulk densities. The pots were then brought to near field capacity moisture content ($\approx$800 g H_2O kg^{-1} media), allowed to equilibrate for 3 wk prior to planting corn, and maintained at this level throughout the experiment by addition of deionized water every few days. To prevent soil and leaching losses all pots were lined with polyethylene plastic bags prior to adding the various media. Both experiments were completely randomized designs with four replications.

'Tex-Cuban' open pollinated silage corn (Florida Foundation Seed Producers, Greenwood, FL) was planted to all the pots at a rate of five seeds per pot. No fertilizers were applied to the pots in experiment 1. In contrast all pots in experiment 2 were fertilized at planting with the equivalent of 250 kg N ha^{-1} (0.98 g N pot^{-1}) as NH_4NO_3. Three days after emergence the plants in both experiments were thinned to two per pot. Plants were harvested by cutting 1 cm above the ground 15 d after emergence in experiment 1 and 45 d after emergence in experiment 2.

Experiment 3 examined corn growth and mineral composition responses to adjustment of the MT extractable P concentration of the SPB compost to 35, 70, 140, and 280 mg kg^{-1} with thoroughly mixed monocalcium phosphate fertilizer. The P buffer relationship between MT extractable P ($y = 20 + 0.15x$, $R^2 = 0.95$, $n = 12$) and the amount of fertilizer P added (mg kg^{-1}) to the SPB compost to achieve the desired concentration was determined prior to the experiment by the 32 d incubation procedure of Wang et al. (2000). All management procedures for experiment 3 were identical to experiment 2 in terms of potting SPB compost, planting, N fertilization, thinning, growing period, and harvesting. The only difference was the equilibration period prior to planting was 32 d. The experimental design was a completely randomized with three replications per P level.

Whole shoots of corn harvested in each experiment were dried at 60^{o}C for 72 h, weighed, and ground to pass a 1 mm screen using a Wiley Mill (Arthur H. Thomas Company, Philadelphia, PA). All samples were analyzed for total N using a ECS 4010 CNS combustion analyzer (Costech Analytical Technologies, Valencia, CA). In experiments 2 and 3 tissue concentrations of P, K, Ca, Mg, S, Fe, Cu, Mn, Zn, and B were determined by inductively coupled plasma emission spectroscopy (ICPES) following digestion in nitric acid and hydrogen peroxide as outlined by Jones and Case (1990). Tissue As concentrations were also determined for experiments 2 and 3 using an inductively coupled plasma mass spectrometer (ICP-MS, had typical detection limits of 0.1 μg L^{-1} and analytical uncertainties of $\pm$ 2% or better). In addition, 2 d after harvest the media for each pot in experiments 2 and 3 were thoroughly mixed and a subsample analyzed moist on a oven-dry (100^{o}C) equivalent basis for MT extractable P and As. Phosphorus in the extract was determined by the molybdenum-blue colorimetric method while As was determined by ICP-MS (Hue et al., 2000).

Data were analyzed by using Proc GLM of the Statistical Analysis System (SAS Inst., 1999). Fisher's *F*-test protected least significant difference (LSD) test was used for treatment mean separation in experiment 1. Trends in response to SPB compost rate and MT extractable P level in experiments 2 and 3 were determined using orthogonal polynomial contrasts (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Experiment 1

The corn seedling dry matter (DM) yield and N concentration data from experiment 1 (Table 3) indicates that SPB compost has an N supplying capacity that is intermediate between a very good yard compost and Hilo soil. The results of this short (15 d) bioassay were expected based upon the total extractable inorganic-N and readily mineralizable-N concentrations for the respective growing media (Table 2). Corn likely requires at least 50 mg kg^{-1} of extractable inorganic-N during rapid growth in media of low bulk density like compost or the Hilo soil (Fox, 1976). It is clear that Hilo soil is very deficient in N given that the adequate range for tissue N in corn seedlings < 30 cm tall is about 30 to 50 g N kg^{-1} (Reuter, 1986).

Experiment 2

Due in part to their low P content, sugarcane crop residues and processing by-products are not expected to contribute greatly to readily available P in composts and soils (Meunchang et al., 2005; Mathews and Thurkins, 2006). Whole shoots of 6 wk-old corn should contain > 1.4 g P kg^{-1} for optimal growth (Terman et al., 1972). In experiment 2 shoot DM yield of 45 d old corn plants was limited by insufficient tissue P supply when grown in pure (100%) SPB compost relative to pure Hilo soil (0% SPB compost) or Hilo soil - SPB compost mixtures sufficiently supplied with fertilizer N (Table 4). While the Hilo soil and SPB compost had similar concentrations of MT extractable P, the Hilo soil supported a greater equilibrium concentration of solution inorganic P (Pi) (Table 2). Soil solution Pi should be about 0.01 mg L^{-1} for 75% of maximum corn yield and 0.05 mg L^{-1} for near maximum yield (Fox, 1981). At the end of the study there was also no treatment effect ($p > 0.22$) for MT extractable P (mean = 38; SE = 1).

Despite fertilization of all treatments in experiment 2 with the equivalent of 250 kg N ha^{-1} as NH_4NO_3, the 100% SPB compost treatment had a greater tissue N concentration than the Hilo soil-SPB compost mixtures (Table 4). This result probably reflects reduced N dilution in the lower DM yield of the P-deficient 100% SPB compost treatment and to some extent the greater natural N supplying capacity of SPB compost relative to Hilo soil. The greatest shoot DM yield in experiment 2 was obtained for the 25% SPB compost mixture (Table 4). This is likely because this treatment supplied adequate K but was not limited by deficient (100% SPB treatment) or possibly marginal (50% SPB compost treatment) tissue P concentrations. Whole shoots of corn should contain ≥20 g K kg^{-1} for optimal growth (Reuter, 1986) and the Hilo soil - SPB compost mixtures containing less than 25% SPB were clearly K deficient (Table 4). This result coincides with the much greater total and exchangeable K concentrations for SPB compost than the Hilo soil (Tables 1 and 2). Depending on the media, exchangeable K should be at least 140 to 200 mg kg^{-1} or more for optimal growth of corn and most other crops (Pérez and Melgar, 2000; Yost and Uchida, 2000).

Whole shoot Mg concentrations were in the adequate range (3 to 6 g kg^{-1}; Reuter, 1986) for all treatments (Table 4). If plants have adequate P, one model suggests that Mg uptake is enhanced by phosphorylation of Mg transport proteins on the root plasmalemma (Reinbott and Blevins, 1994). Marginal to deficient P status likely contributed to the trends for lower Mg concentration that were observed for the 50, and particularly, the100% SPB compost treatment. This occurred despite the fact that the SPB compost contained a 3-fold greater Mg concentration than Hilo soil. Tissue Mg concentration increased in the 12.5 and 25% SPB compost treatments relative to pure Hilo soil (0% SPB compost). This finding supports the idea that the exchangeable Mg in the SPB compost was available for uptake but that Mg uptake was limited by P deficiency in the 50 and 100% SPB compost treatments.

Whole shoot Mn concentrations were in the adequate range (50 to 160 mg kg^{-1}; Reuter, 1986) for all treatments except pure Hilo soil (0% SPB compost) (Table 4). This treatment had a concentration of 38 mg kg^{-1} which is slightly less desired. Tissue Mn increased with increasing percentage of SPB compost in the growing media (Table 4). This can be attributed to the greater exchangeable Mn concentration in SPB compost than Hilo soil (Table 2). While SPB compost and Hilo soil had similar total Mn concentrations (Table 1) the greater Mn solubility for SPB can likely be attributed to dissolution and chelation of Mn by the greater organic C (Table 1) in SPB compost (Porter et al., 2004).

Tissue Zn concentrations were in the adequate range (20 to 50 mg kg^{-1}; Reuter, 1986) for all treatments (Table 4). The slightly greater Zn concentration (40 mg kg^{-1}) observed for the 100% SPB compost treatment than the other treatments (means between 28 and 32 mg kg^{-1}) can be attributed to reduced dilution in DM yield.

There were no treatment effects ($p > 0.40$) for tissue concentrations of Ca (mean = 3.9 g kg^{-1}; SE = 0.3), S (mean = 1.4 g kg^{-1}; SE = 0.1), Fe (mean = 95 mg kg^{-1}; SE = 7), Cu (mean = 8 mg kg^{-1}; SE = 1, or B (mean = 12 mg kg^{-1}; SE = 1). Based on the norms of Reuter (1986), the concentrations of Ca and S are possibly marginal or slightly deficient while Fe, Cu, and B are clearly sufficient. It is well established that media rich in amorphous (oxalate extractable) Fe and Al like the SPB compost and Hilo soil tend to supply less S than might be expected given their relatively high concentrations of extractable SO_4-S (Table 2) (Wolt et al., 1992).

There was no treatment effect for As ($p = 0.20$, mean = 0.15 mg kg^{-1}, SE = 0.01). The tissue As concentration is not of concern and is well below the health-based food and fodder standards of 1 and 2 mg kg^{-1}, respectively (Brandstetter et al., 2000; Horswell and Speir, 2006). Even lower As concentrations than were observed in the present study would be expected if the corn plants were allowed to grow to vegetative maturity (Horswell and Speir, 2006). It also should be noted that the smallest quantities of As accumulate in grains and fruits (Horswell and Speir, 2006). The lack of a treatment effect for tissue As concentration can be attributed in part to the similar oxalate extractable As concentrations (Table 2) for the SPB compost (13 mg kg^{-1}) and Hilo soil (15 mg kg^{-1}) despite the 1.7 fold greater total As concentration (Table 1) for SPB compost (65 vs 39 mg kg^{-1}). Oxalate extractable As is thought to represent the pool of potentially labile P associated with amorphous (noncrystalline) hydrous metal oxides (McLaren et al., 2006). Most of the As in the SPB compost can therefore be considered to be in relatively inert or recalcitrant forms.

Experiment 3

In experiment 3 shoot DM yield and P concentration of 45 d old corn plants increased dramatically as the soil MT extractable P concentration was increased above 35 mg kg^{-1} through P fertilization (Table 5). This further confirms the poor P supplying capacity of SPB compost that was observed in experiment 2.

Reductions in shoot N, K, Mn, B, and As concentration with increased MT extractable P (Table 5) can be attributed primarily to dilution in greater DM yield. The N, K, Mn, and B concentrations were all sufficient based on the norms of Reuter (1986) and the As concentrations are not of concern based on the health-based food and fodder standards of 1 and 2 mg kg^{-1}, respectively (Brandstetter et al., 2000; Horswell and Speir, 2006). The MT extractable P concentration level had no effect on MT extractable As (mean = 1.0 mg kg^{-1}; SE = 0.01).

There were no treatment effects ($p > 0.10$) for tissue concentrations of Ca (mean = 3.4 g kg^{-1}; SE = 0.3), Mg (mean = 3.9 g kg^{-1}; SE = 0.3), S (mean = 1.3 g kg^{-1}; SE = 0.1), Fe (mean = 139 mg kg^{-1}; SE = 39), Cu (mean = 4 mg kg^{-1}; SE = 1), or Zn (mean = 37 mg kg^{-1}; SE = 5). Based on the norms of Reuter (1986) the concentrations of Ca, S, and Cu are possibly marginal or slightly deficient while Mg, Fe, and Zn are clearly sufficient.

CONCLUSIONS

Experiment 1 demonstrated that SPB compost has an intermediate N supplying capacity between a good quality yard compost and Hilo soil. Based on solution Pi and the yield and shoot P concentration data from experiment 2 it can be concluded that SPB compost has a lower natural P supplying capacity than Hilo soil at a similar concentration of MT extractable P. While a lack of available P is the primary limitation to SPB compost use as a growing media it supported vigorous plant growth once the P deficiency was eliminated via P fertilization in Experiment 3. The SPB compost is adequate in exchangeable K and tends to be sufficient to nearly sufficient in most other nutrients. Arsenic contamination of the SPB compost from cane wash soil was not considered to be a major concern because the As was primarily in forms of limited bioavailability.

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Table 1. The bulk density, pH, and selected total elemental concentrations of the yard compost, sugarcane processing by-product (SPB) compost, and the Hilo soil used in the experiments (Waters Agricultural Laboratories, Camilla, GA).

	Material		
	Yard compost	SPB compost	Hilo soil
Bulk density (g cm^3)	0.23	0.65	0.75
pH	6.4	6.0	5.8
Total organic C (g kg^{-1})	384.7	148.7	68.3
Total N (g kg^{-1})	21.5	7.2	4.6
Total P (g kg^{-1})	3.1	4.0	4.3
Total K (g kg^{-1})	1.0	1.8	0.5
Total Ca (g kg^{-1})	32.8	13.2	16.4
Total Mg (g kg^{-1})	8.0	4.8	2.5
Total S (g kg^{-1})	2.8	11.3	2.4
Total Fe (g kg^{-1})	22.6	147.3	181.5
Total Al (g kg^{-1})	13.2	89.1	102.4
Total Mn (g kg^{-1})	0.4	1.3	1.1
Total Na (g kg^{-1})	1.3	0.6	0.6
Total Cu (mg kg^{-1})	45	67	73
Total Zn (mg kg^{-1})	205	107	77
Total Ni (mg kg^{-1})	36	58	41
Total B (mg kg^{-1})	35	24	38
Total Mo (mg kg^{-1})	12	35	51
Total Pb (mg kg^{-1})	36	136	155
Total Cr (mg kg^{-1})	45	262	371
Total Co (mg kg^{-1})	8	42	37
Total Cd (mg kg^{-1})	1	3	4
Total As (mg kg^{-1})	10	65	39

Table 2. Concentrations of 1 *M* KCl extractable NH_4-N, NO_3-N, and total inorganic-N; readily mineralizable N; modified-Truog (MT, 0.01 *M* H_2SO_4 + 0.02 *M* $[NH_4]_2SO_4$) extractable P; soil solution inorganic P (Pi); 1 *M* NH_4OAc exchangeable Ca. Mg, K, and Na; 0.2 *M* NH_4Cl exchangeable Mn; 0.04 *M* $Ca(H_2PO_4)_2$ extractable SO_4-S; and acid (pH 3) Na oxalate (0.2 *M*) extractable Fe, Al, and As for the yard compost, sugarcane processing by-product (SPB) compost, and the Hilo soil used in the experiments[a].

	Material		
	Yard compost	SPB compost	Hilo soil
Extractable NH_4-N (mg kg^{-1})	57	78	9
Extractable NO_3-N (mg kg^{-1})	81	4	14
Total extractable inorganic-N (mg kg^{-1})	138	82	23
Readily mineralizable-N (mg kg^{-1})	426	270	31
MT Extractable P (mg kg^{-1})	380	35	37
Soil solution Pi (mg L^{-1})	1.88	0.005	0.008
Exchangeable Ca (mg kg^{-1})	8990	825	593
Exchangeable Mg (mg kg^{-1})	2354	355	120
Exchangeable K (mg kg^{-1})	995	468	91
Exchangeable Na (mg kg^{-1})	188	65	54
Exchangeable Mn (mg kg^{-1})	2	71	2
Extractable SO_4-S (mg kg^{-1})	120	318	778
Oxalate extractable Fe (g kg^{-1})	13.8	108.0	110.6
Oxalate extractable Al (g kg^{-1})	7.5	58.0	59.1
Oxalate extractable As (mg kg^{-1})	9	13	15

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[a] Extractable NH_4-N, NO_3-N, and readily mineralizable N determined by the methods outlined by Rowell (1994), extractable P and exchangeable cations by the methods described by Hue et al. (2000) and Alva (1993), soil solution Pi and extractable SO_4-S by the procedures of Fox (1981) and Fox et al. (1987), and oxalate extractable Fe, Al, and As as outlined by Mathews et al. (2005).

Table. 3. Effect of yard compost, sugarcane processing by-product (SPB) compost, and Hilo soil on shoot dry matter yield and N concentration of corn seedlings 15 d after germination in Experiment 1[a].

Treatment	Yield (g pot^{-1})	N (g kg^{-1})
Yard compost	3.2a	43.7a
SPB compost	2.2b	29.0b
Hilo soil	1.3c	8.6c
SE[b]	0.2	1.0

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[a] Means in the same column not followed by the same letter are different at $p < 0.05$ using Fisher's F-test protected LSD.

[b] Standard error of a treatment mean.

Table 4. Corn shoot dry matter yield and concentrations of N, P, K, Mg, Mn and Zn in response to sugarcane processing by-product (SPB) compost thoroughly mixed with Hilo soil at volumetric ratios of 0, 6.25, 12.5, 25, 50, and 100% compost in Experiment 2[a].

SPB compost (%)	Yield (g pot-1)	N ($g\ kg^{-1}$)	P ($g\ kg^{-1}$)	K ($g\ kg^{-1}$)	Mg ($g\ kg^{-1}$)	Mn ($mg\ kg^{-1}$)	Zn ($mg\ kg^{-1}$)
0	23.5	25.5	1.6	12.4	5.0	38	32
6.25	24.8	24.8	1.6	14.2	5.0	54	28
12.5	25.5	26.4	1.6	15.9	5.5	76	30
25	27.8	26.6	1.6	20.3	5.6	99	29
50	24.9	28.8	1.5	30.1	4.6	121	30
100	19.0	36.6	1.2	39.3	3.3	144	40
SE[b]	1.5	0.8	0.1	0.9	0.3	4	2
Linear effect	**	***	***	***	***	***	***
Quadratic effect	**	*	NS	**	*	***	*

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[a] *, **, *** Significant at the 0.05, 0.01, and 0.001 probability levels, respectively, or NS (nonsignificant $p >$ 0.10).

[b] Standard error of a treatment mean.

Table 5. Corn shoot dry matter yield and concentrations of N, P, K, Mn, B, and As in response to sugarcane processing by-product (SPB) compost adjusted to 35, 70, 140, and 280 mg kg^{-1} of modified Truog (MT) extractable P in Experiment 3[a].

MT extractable P (mg kg^{-1})	Yield (g pot-1)	N (g kg^{-1})	P (g kg^{-1})	K (g kg^{-1})	Mn (mg kg^{-1})	B (mg kg^{-1})	As (mg kg^{-1})
35	26.0	31.7	1.1	33.5	145	13	0.21
70	57.3	25.1	1.3	26.3	109	11	0.16
140	71.3	25.8	1.6	22.4	102	10	0.16
280	75.6	25.9	2.3	21.1	108	9	0.15
SE[b]	1.5	1.0	0.1	1.4	7	1	0.01
Linear effect	***	*	***	***	*	*	*
Quadratic effect	***	**	NS	**	**	NS	+

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[a] +, *, **, *** Significant at the 0.10, 0.05, 0.01, and 0.001 probability levels, respectively, or NS (nonsignificant $p > 0.10$).

[b] Standard error of a treatment mean.