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Effects of Composts and Soil Amendments on Physicochemical Properties of Soils in Relation to Phytophthora Root and Crown Rot of Bell Pepper

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Two field tests were conducted in 1995 to examine the effects of composts and soil amendments on physicochemical properties of soil in relation to Phytophthora root and crown rot of bell pepper. Chitosan, crab shell waste, humate, sewage sludge-yard trimmings, and wood chips were applied to test plots, some of which affected the levels of P, K, Mg, pH, and H. Physicochemical properties were not related with disease incidence, but percent organic matter, estimated nitrogen release, K, and Mg were correlated with total microbial activity. The elements K and Mg were especially responsible for the increased soil microbial activity that could affect development of root and crown rot of pepper.

Keywords : compost, pepper, physicochemical property, *Phytophthora capsici*, soil amendments

Root and crown rot of pepper (*Capsicum annuum* L.) caused by *Phytophthora capsici* Leonian is a destructive soilborne disease occurring in tropical, subtropical, and warm areas of the world. This disease has been one of the major factors limiting pepper production in southeast Florida, USA since 1932 (Weber, 1932). Resistance of pepper to *P. capsici* is not commercially available, thus the standard control has depended on preplant applications of methyl bromide with chloropicrin, mefenoxam (the active isomer of metalaxyl) or fosetyl-Al in Florida, USA. However, methyl bromide has an extremely high ozone depletion potential and will begin to be phased out of use by about 2005 in accordance with the 1990 Clean Air Act and the 1992 Montreal Protocol (Hayes, 1994). Alternative methods of control of Phytophthora root and crown rot including soil amendments and composts (Hoitink and Kuter, 1985; Hoitink et al., 1991; Nemec and Lee, 1992; Kim et al., 1997a, b) have the potential to significantly reduce the pepper disease.

Previously, we reported that chitosan and perennial peanuts reduced disease incidence and severity, and observed sewage sludge-yard trimmings and wood chips increased total microbial activity and soil populations of certain microbial functional groups (Kim et al., 1997a). Therefore, in this study, we examined the effects of composts and soil amendments on physicochemical properties of the soil, and investigated the correlation between physicochemical properties and both disease incidence and total microbial activity.

Two field tests were established in a commercial pepper field with a history of Phytophthora root and crown rot at Boynton Beach, Florida, USA in 1995 (Kim et al., 1997a). Raised beds (20 cm high × 92 cm wide) were mechanically constructed with drip-irrigation lines, amended with composts and soil amendments, and covered with white plastic mulch without fumigation. Beds were spaced 1.68 m apart (center to center). Test A was arranged on three beds with 12.2 m long plots and five replications per treatment. Plots were treated with one of the following: chitosan (0.2%, v/v) (United States Biochemical Corp., Cleveland, OH, USA), crab shell waste (1.335 t ha^{-1}) (Keys Fisheries, Marathon, FL, USA), commercial humate from Leonardite shales (8.181 t ha^{-1}) (Agrachem Sales, Avon Park, FL, USA), sewage sludge-yard trimming (SY) (220 t ha^{-1}) (West Palm Beach Authority, West Palm Beach, FL, USA), and wood chips (220 t ha^{-1}) (The Scotts Company, Palm City, FL, USA). Non-treated plots served as controls. These composts and soil amendments were applied over the beds and incorporated 20 cm deep using a rotor-tiller on August 21, 1995. For the chitosan treatment, pepper seedlings were root-dipped in a 0.2% (w/v) chitosan suspension amended with 0.01% (v/v) Tween-20 just prior to transplanting. Test B was similar to test A except one of the three beds contained 6.1 m long plots and humate was not included in this test. In both tests, composts and soil amendments were used at rates recommended by the supplier or reported in the literature. Five-week-old bell pepper seedlings, cv. Boynton Belle, grown in commercial potting mixture (Metro-Mix 220, Scotts-Sierra Horticultural Products Co., Marysville, OH, USA) were planted into beds of the tests in two rows

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on September 11, 1995.

Soil samples for analysis of physicochemical properties were taken from three plots per treatment. Random samples (8-10 cores) from each plot were collected using a sampling tube (22 cm deep, 2.2 cm in diameter) on October 25, 1995. Pooled soil samples from each plot were put into polyethylene bags and stored in ice chests. All samples were manually mixed prior to analysis. Physicochemical properties of soil including organic matter (%), estimated nitrogen release (ENR), P_1, P_2, K, Mg, Ca, pH, H, and cation exchange capacity (CEC) were analyzed by A&L Southern Agricultural Laboratories, Inc. (Pompano Beach, FL, USA) using the procedures by Page et al. (1982) and Chapman and Pratt (1961). Percent organic matter content was determined chemically on the dried and screened soil sample. P_1 was the amount of readily available phosphorus and P_2 was the amount of water soluble phosphates, weak acid soluble phosphates, and a small amount of active reserve phosphates. The soil pH was measured on a 1 : 1 soil to water solution. The CEC, a measure of the capacity of a soil to hold exchangeable cations, included H^+, Ca^{++}, Mg^{++}, K^+ and Na^+. Total microbial activity (μg hydrolyzed FDA min^{-1} g^{-1} dry weight of soil) by measuring hydrolysis of fluorescein diacetate (FDA) was previously determined as follows: chitosan = 0.373 and 0.274, crab shell waste = 0.481 and 0.311, humate = 0.512, SY = 0.999 and 0.405, wood chips = 0.585 and 0.323, and untreated control = 0.461 and 0.246 for tests A and B, respectively (Kim et al., 1997a). Disease incidence (%) was previously determined on October 30, 1995 as follows: chitosan = 76.8 and 60.3, crab shell waste = 61.4 and 70.9, humate = 90.8, SY = 77.8 and 57.4, wood chips = 87.6 and 73.1, and untreated control = 87.7 and 54.1 for tests A and B, respectively (Kim et al., 1997a). Both disease incidence and total microbial activity were analyzed for correlation with physicochemical properties of soils treated with composts and soil amendments.

All field tests were established in a randomized complete block design. Statistical analyses were conducted using the Statistical Analysis System (SAS Institute, Cary, NC, USA). Analysis of variance was conducted using the general linear models procedure and means were separated using the least significant difference. Relationships among variables were examined using the correlation procedure.

A wide range of response of physicochemical properties of soil treated with composts and soil amendments was found in both tests A and B (Table 1). Composts and soil amendments significantly affected the levels of P, K, and Mg in test A, and K, Mg, pH, and H in test B (Table 1). These results indicate that composts and soil amendments can increase soil elements that may affect plant health and disease development as observed in a study of citrus foot rot caused by *P. parasitica* (Nemec and Lee, 1992). They observed that humate increased Ca, Mg, K, S, Cu, B, Fe and Zn in the treated plots while gypsum increased leaf Ca and S, and bark Ca. The increased Ca in the gypsum treatment reduced the citrus foot rot (Nemec and Lee, 1992).

Table 1. Physicochemical properties[a] of soils treated with composts and soil amendments at Boynton Beach, Florida, USA in 1995

Test and treatment[b]	Organic matter (%)	Organic matter ENR (kg/ha)	P_1 (ppm)	P_2 (ppm)	K (ppm)	Mg (ppm)	Ca (ppm)	pH	H (meq/100g)	CEC (meq/100g)
Test A										
Chitosan	3.13[c] a	119.5 a	47.3 ab	73.3 abc	3.0 c	64.3 b	916.7 a	6.60 a	0.33 a	5.43 a
Crab shell waste	3.13 a	119.5 a	71.0 a	100.7 a	7.7 c	72.0 b	993.3 a	6.60 a	0.37 a	5.93 a
Humate	2.97 a	115.7 a	34.0 b	60.0 bc	8.0 c	75.0 b	940.0 a	6.30 b	0.60 a	5.93 a
SY	3.57 a	129.1 a	58.3 ab	75.3 abc	130.7 a	96.7 a	920.0 a	6.57 ab	0.40 a	6.13 a
Wood chips	3.33 a	124.0 a	39.7 b	49.0 c	63.3 b	91.7 a	943.3 a	6.47 ab	0.47 a	6.10 a
Control	3.07 a	117.9 a	66.0 a	87.7 ab	4.0 c	67.0 b	893.3 a	6.53 ab	0.40 a	5.43 a
Test B										
Chitosan	2.87 a	113.5 a	58.7 a	69.7 a	16.7 c	67.3 b	946.7 a	6.97 a	0.07 b	5.40 a
Crab shell waste	3.30 a	123.2 a	58.7 a	72.0 a	36.7 bc	74.0 ab	973.3 a	6.80 a	0.17 ab	5.73 a
SY	2.90 a	114.2 a	62.3 a	78.3 a	94.0 a	86.0 a	903.3 a	6.83 ab	0.17 ab	5.63 a
Wood chips	3.33 a	124.0 a	86.3 a	95.0 a	67.0 ab	87.7 a	970.0 a	6.93 a	0.07 b	5.80 a
Control	3.10 a	118.7 a	58.0 a	70.3 a	20.3 c	65.7 b	940.0 a	6.73 b	0.23 a	5.53 a

[a] ENR = estimated nitrogen release. P_1 was determined the amount of readily available phosphorus and P_2 was determined water soluble phosphates, weak acid soluble phosphates, and a small amount of active reserve phosphates. CEC = cation exchange capacity which was measured in terms of milliequivalents (meq.) per 100 grams of soil. Soil samples were collected on October 25, 1995.

[b] Treatments were applied at the level of 0.2% (w/v) of chitosan, 1.335 t ha^{-1} of crab shell waste, 8.181 t ha^{-1} of humate, 220 t ha^{-1} of SY (sewage sludge-yard trimmings), and 220 t ha^{-1} of wood chips on August 21, 1995.

[c] Values are means of three replications. Means within columns followed by same letter did not differ significantly according to LSD ($P = 0.05$).

Table 2. Correlation coefficients between disease incidence (DI)[a] and total microbial activity (TMA)[b], and physicochemical properties[c] of soils treated with composts and soil amendments at Boynton Beach, Florida, USA in 1995

Test and variable	Organic matter (%)	Organic matter ENR	P_1	P_2	K	Mg	Ca	pH	H	CEC
Test A										
DI	0.156	0.156	-0.040	-0.167	0.284	0.391	-0.399	0.036	-0.066	-0.202
TMA	0.605**[d]	0.605**	0.184	-0.004	0.865***	0.745***	0.022	0.037	0.078	0.379
Test B										
DI	-0.441	-0.441	0.020	0.169	0.139	0.303	0.284	-0.085	0.147	0.332
TMA	0.150	0.150	0.258	0.368	0.647**	0.649**	0.015	0.329	-0.436	0.153

[a] Disease incidence of bell pepper treated with composts and soil amendments (Table 1) was evaluated on October 30, 1995.
[b] Total microbial activity was measured by hydrolysis of fluorescein diacetate in field soil sampled on October 25, 1995 (Kim et al., 1997).
[c] ENR = estimated nitrogen release. P_1 was the amount of readily available phosphorus and P_2 was the amount of water soluble phosphates, weak acid soluble phosphates, and a small amount of active reserve phosphates. CEC = cation exchange capacity. Soil samples were collected on October 25, 1995.
[d] Asterisks (** and ***) indicate significant difference at $P = 0.01$ and $P = 0.001$, respectively.

When physicochemical properties were analyzed for correlation with disease incidence, there was no relationship in either test A or B (Table 2). However, there was correlation between total microbial activity and the physicochemical properties of percent organic matter, ENR, K, and Mg for test A while K and Mg for test B (Table 2). These relationships indicate that the elements, especially K and Mg, influenced microbial activity in the soil. Press et al. (1996) had observations that organic by-products increased organic matter and other elements in soils. These products resulted in increased substrates for C mineralization that may cause increased shifts in Gram-negative bacteria beneficial to plant growth (Press et al., 1996). Similarly, in our previous work (Kim et al., 1997a), we observed that composts and soil amendments used in this study enhanced total microbial activity and soil microflora such as fungi, actinomycetes, Gram-negative bacteria, and fluorescent pseudomonads. These increased microbial activity and soil microflora had negatively correlated with root and crown rot of pepper (Kim et al., 1997a). Increases in K and Mg as observed with the treatments in this study had no direct effect on the disease, but affected soil microbial activity that could affect development of Phytophthora root and crown rot of pepper.

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