Composts from Various Municipal Solid Waste Feedstocks Affect Vegetable Crops. II. Growth, Yields, and Fruit Quality

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ABSTRACT. Compost (biosolids and yard trimmings at 134 t·ha⁻¹) was applied to a sandy field soil with fertilizer at 0%, 50%, or 100% of the grower's standard rate (71N–39P–44K kg·ha⁻¹ broadcast and 283N–278K kg·ha⁻¹ banded in bed centers). Raised beds were constructed and covered with polyethylene mulch, and 'Elisa' bell peppers (*Capsicum annuum* L.) were transplanted into the plots. Foliage samples taken at early harvest indicated that leaf N concentrations increased and Cu concentrations decreased with increasing fertilizer rates. Leaf concentrations of P, K, Ca, and Mg increased and Cu decreased in plots amended with compost. Marketable pepper yields from plants grown in plots amended with compost were 30.3, 35.7, and 31.1 t·ha⁻¹ in plots with 0%, 50%, and 100% fertilizer rate, respectively. Without compost, yields were 19.8, 31.1, and 32.0 t·ha⁻¹ with 0%, 50%, and 100% fertilizer rate. 'Valent' cucumbers (*Cucumis sativus* L.) were seeded through the same polyethylene mulch into the previous pepper plots. Marketable cucumber yields were not affected by residual fertilizer, but were higher (26.8 t·ha⁻¹) in plots amended with compost than without compost (22.7 t·ha⁻¹). In a second experiment, a biosolids–yard trimming–mixed waste paper (MWP) compost and a biosolids–yard trimming–refuse-derived fuel (RDF) compost were applied at 0 or 134 t·ha⁻¹ with fertilizer at 0%, 50%, or 100% fertilizer rates, respectively. With no fertilizer, total yields from pepper plants were higher in plots amended with composts than without composts. In 50% fertilizer plots, yields were similar between compost treatments. At 100% fertilizer rate, yields with MWP compost were significantly higher than yields with RDF compost or with no compost. In plots without fertilizer or with 50% fertilizer rates, mean fruit size (g/fruit) was largest with MWP compost, intermediate with RDF compost, and smallest without compost. With 100% fertilizer, mean fruit size was larger with either compost than without compost. Composts combined with low rates of fertilizer generally produced higher pepper yields than other treatments. Residual compost increased yields of a subsequent cucumber crop. Yields from pepper plants without fertilizer were higher when soil was amended with composts with added MWP or RDF, but, with fertilizer, yields were similar or only slightly increased.

Researchers have reported beneficial effects of composts on vegetable crop growth and yields (Bryan and Lance, 1991; Maynard, 1994). Sweet corn (*Zea mays* L.) grain yields from plots amended with 40, 80, and 160 t·ha⁻¹ biosolids–wood chips compost for 2 years were similar to yields from plots fertilized with 179N–122P–112K kg·ha⁻¹ (Hornick et al., 1988). With N at rates of 240 kg·ha⁻¹ on a tomato (*Lycopersicon esculentum* Mill.) crop and 120 on the subsequent squash (*Cucurbita pepo* L.) crop, fruit yields from tomato and squash plants grown in soil amended with one municipal solid waste (MSW) compost at 48 t·ha⁻¹ or another at 24 t·ha⁻¹ were similar to those from plants grown in plots without composts (Ozores-Hampton et al., 1994). When MSW was used at 67 and 135 t·ha⁻¹ on drip-irrigated plots, with fertilizer at 215, 309, or 403 N; 44 P; and 248, 356, or 464 K (kg·ha⁻¹), yields were reduced in the initial crop of bell peppers in MSW plots while the

subsequent tomato crop had more extra-large and total marketable fruit compared with no-compost plots (Clark et al., 1994).

In areas where commercial growers already produce high yields using methods such as fumigation, polyethylene mulch, and high rates of fertilizers, they are reluctant to use composts due to bulkiness and variations in physical, biological, and chemical properties. Although most composts are relatively low in available nutrients, it is not clear if they can be substituted for all or part of the synthetic fertilizer applications. Increases in microorganism populations, additions of or increased availability of micronutrients, modifications of soil structure, and changes in water availability may result in early or total yield increases that cannot be predicted solely on nutritional composition of composts.

In hot, humid climates, organic matter decomposes rapidly, which may result in more temporary benefits compared to those reported in temperate climates (Dick and McCoy, 1993).

The objectives of this research were to investigate the effects of a yard trimming–biosolids compost with increasing fertilizer rates on bell pepper (*Capsicum annuum*) growth, nutrient uptake, and yields; measure the residual effects of the compost on a subsequent cucumber (*Cucumis sativus*) crop; and determine the effects of adding compost feedstocks of RDF or MWP to biosolids–yard trimming compost with increasing fertilizer rates on bell pepper crop yields.

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Materials and Methods

Experiment 1

The experiment was conducted on a commercial vegetable farm near Jupiter, Fla. Soil type was a Riviera fine sand (loamy, siliceous, hyperthermic Arenic Glossaqualf).

BELL PEPPER CROP. Treatments consisted of standard compost (SC) (Roe and Stoffella, 1997) at $134 \text{ t} \cdot \text{ha}^{-1}$ (49.7% moisture) or no compost in a factorial arrangement with fertilizer at 0%, 50%, and 100% of the grower's standard rate ($71\text{N}-39\text{P}-44\text{K kg} \cdot \text{ha}^{-1}$ broadcast and $283\text{N}-0\text{P}-278\text{K kg} \cdot \text{ha}^{-1}$ banded in bed centers). Composts and broadcast fertilizer were applied manually over the treatment area, beds were constructed, and banded fertilizer was applied on 1 Dec. 1993. Beds, 20 cm high, 92 cm wide, and spaced 1.7 m center to center, were fumigated with a 98% methyl bromide : 2% chloropicrin mixture at $202 \text{ kg} \cdot \text{ha}^{-1}$ and were covered with black polyethylene mulch (0.0318 mm thick). Each plot consisted of a 9.1-m length of one bed. A completely randomized block experimental design was used, with each treatment replicated five times.

Bell pepper transplants ('Elisa'), about 5 weeks old, were transplanted into the beds on 20 Jan. 1994. Plants were spaced 30 cm apart in two offset rows per bed spaced 45 cm apart. Plant population was equivalent to 39,120 plants/ha. Subsurface irrigation was used throughout the growing season. Standard pest control methods were used to control weeds, insects, and disease. (Hochmuth, 1988)

Plant height was measured 25 Feb., and stem diameter (about 2 cm above ground) was measured 25 Feb. and 15 Mar. Relative green color of one most recently matured leaf per plant was measured with a SPAD meter (Minolta Corp., Ramsey, N.J.) on 25 Mar. and 1 Apr. Twelve randomly selected plants per plot were used to measure each of these variables.

The most recently matured leaf from 15 plants in each plot was collected for tissue analysis on 3 Mar. Leaves were dried for 72 h at 68°C , ground to 20 mesh in a Wiley mill, extracted, and analyzed for total Kjeldahl N and for P, K, Ca, Mg, Mn, Cu, Fe, and Zn using inductively coupled plasma spectrophotometry (ICP) (Hanlon and DeVore, 1989).

Fruit were harvested on 8 Apr., 19 Apr., and 2 May from the center 6.1-m section of each plot. Marketable fruit were graded into large (U.S. Fancy, diameter at least 7.5 cm and length at least 8.75 cm) and medium (U.S. no. 1, diameter and length at least 6.75 cm).

Soil samples were taken on 2 May using a 1.8-cm-diameter soil tube. The upper 10 cm of soil was removed in three random sites per plot and combined. The next 10 cm of soil from the same three holes were combined. Electrical conductivity (EC), NH_4N , NO_3N , and pH of soil samples were extracted in a 2 water : 1 soil solution. The Walkley-Black dichromate method was used to determine percent organic matter (Nelson and Sommers, 1982). Phosphorus, K, Ca, Mg, Mn, Zn, and Cu were extracted by the Mehlich I method and analyzed by ICP (Hanlon et al., 1990).

CUCUMBER CROP. Pepper plants were removed by mowing on 7 May 1994. Without removing the polyethylene mulch, cucumbers ('Valient') were machine sown into the same plots on 26 Sept. 1994. Seeds were spaced 30 cm apart, between holes in the polyethylene mulch created by removing the previous pepper crop, in two offset rows spaced 45 cm apart. The same completely randomized block experimental design as in the previous crop was used, with each treatment replicated five times.

Liquid fertilizer (total of $149\text{N}-52\text{K kg} \cdot \text{ha}^{-1}$) was applied in three applications with an injection wheel to all plots. Fruit were harvested on 10, 18, and 21 Nov. from a 4.5-m length of each plot. Marketable fruit were weighed and counted.

Experiment 2

The experiment was conducted on a commercial vegetable farm in Boynton Beach, Fla. Soil type was a Myakka sand (sandy, siliceous, hyperthermic Aeric Haplaquad).

Broadcast applications of fertilizer were applied manually on appropriate plots on 22 Aug. Fertilizer rates were the same as for Expt. 1. Refuse derived fuel and MWP composts (Roe and Stoffella, 1997) were applied manually on 22 and 23 Aug. 1994, respectively. Compost treatments consisted of a control (no compost), or MWP or RDF compost at $134 \text{ t} \cdot \text{ha}^{-1}$ (44% and 31% moisture, respectively). Each compost treatment was amended with 0%, 50%, or 100% fertilizer rate. A 7.5-cm rain occurred on 23 Aug. 1994. Plots were lightly tilled, beds (20 cm high, 92 cm wide and spaced 1.7 m, center to center) were constructed and fumigated as in Expt. 1, banded fertilizer was manually applied, and beds were covered with white on black polyethylene mulch (0.0318 mm thick) on 24 Aug. 1994. Each plot consisted of a 9.1-m length of one bed. A completely randomized block design was used, with each treatment replicated four times. Irrigation and pest control were the same as Expt. 1.

Bell pepper seedlings ('Summersweet 860'), about 5 weeks old, were transplanted into the beds on 26 Sept. Plants were spaced 30 cm apart in two offset rows per bed spaced 45 cm apart. Plant population was equivalent to 39,120 plants/ha.

Data were subjected to an analysis of variance by the SAS software program (SAS Institute, Cary, N.C.). Treatment means were subjected to LSD mean separation procedure or partitioned into linear or quadratic contrasts for fertilizer rates.

Results and Discussion

Experiment 1

PEPPER CROP. Fertilizer $\times$ compost interactions for plant height and stem diameter were significant (Table 1). Plants grown in plots without compost were shorter without fertilizer than with fertilizer. In plots with compost, plant heights were similar. On both measurement dates, the stem diameter of plants without compost increased when fertilizer was added; but with compost, fertilizer decreased stem diameter.

Fertilizer $\times$ compost interactions in green leaf color, as measured by the SPAD meter, were not significant at the first and third reading dates, but on 1 Apr., readings from plants grown without compost increased with increasing fertilizer rates and with compost increased with either fertilizer rate (Table 1). At the first and third dates, readings increased quadratically with increasing fertilizer rates, regardless of compost use. Lower readings were observed in compost treatments on the first but not on the third date.

The SPAD meter measures chlorophyll status of the leaf by quantifying the relative green color (Turner and Jund, 1991). Correlations between SPAD readings and crop N concentrations vary with species, crop stage, and N nutrition (Minotti et al., 1994; Piekielek and Fox, 1992). Our readings were similar to those of Roberts and Anderson (1994) who reported SPAD readings of pepper plants grown with different mulches for two growing seasons ranged from 48.9 to 63.8.

Fertilizer $\times$ compost interactions were significant for leaf Fe and Zn concentrations (Table 2). Iron leaf concentration increased in plots with compost and no fertilizer or 50% fertilizer plots and decreased from plots with compost and 100% fertilizer. Leaf Zn concentration decreased with compost in unfertilized plots and increased or was similar with compost from fertilized plots.

Leaf total N concentration increased linearly, Mn decreased quadratically, and Cu decreased linearly with increasing fertilizer

Table 1. Pepper plant height, stem diameter, and SPAD color readings from plants grown with increasing fertilizer rates and with or without biosolids-yard trimming compost (Expt. 1).

Treatment	Plant ht (cm)		Diam (cm)				SPAD reading			
	25 Feb.		25 Feb.		15 Mar.		25 Mar.	1 Apr.		2 May
	Compost (C) at 0 or 134 (t·ha ⁻¹)									
Fertilizer ² (F)	+	–	+	–	+	–		+	–	
0	20.4	17.6	0.72	0.53	1.08	0.87	53.3	52.1	52.8	44.1
50	20.3	20.3	0.65	0.62	1.03	1.01	60.7	58.9	62.8	58.6
100	20.4	20.3	0.65	0.63	1.03	0.97	60.6	56.9	66.0	61.6
F effects							Q*			Q*
C (t·ha ⁻¹)										
0							60.4			54.8
134							56.6			54.7
C effects							**			NS
F × C	**		**		**		NS	*		NS
LSD _(0.05) (F × C)	0.5		0.02		0.02			3.8		

²Fertilizer rates expressed as percent of grower's standard (71N-39P-44K kg·ha⁻¹ broadcast and 283N-0P-278K kg·ha⁻¹ banded).

NS,*,**Nonsignificant or significant at $P \leq 0.05$ or 0.01, respectively; Q = quadratic.

rates (Table 2). Compost increased leaf contents of P, K, Ca, and Mg and decreased Cu content.

Fertilizer × compost interactions were significant for large and total marketable yields and percentage of culls (Table 3). Yield of large peppers increased with fertilizer in no-compost plots and remained the same or decreased with fertilizer in compost plots. Total marketable fruit yield increased from plants in plots without compost and with fertilizer. However, with compost yields increased only at the 50% fertilizer rate. Percentage of culls in no-compost plots increased only at the 50% fertilizer rate, but with compost they decreased at both fertilizer rates. Extra-large fruit yield and mean fruit weight increased quadratically with increasing fertilizer.

SOIL ANALYSIS. Fertilizer × compost interaction was significant for NH₄ content at 0 to 10 cm depth. In the unfertilized plots, compost increased soil NH₄ content; whereas, the 50% and 100% fertilizer rate decreased soil NH₄ content (Table 4).

Nitrate content at both depths increased linearly with increasing fertilizer rates. Compost increased P content at 0 to 10 cm, pH at both soil depths, and K, Ca, and Mg contents at both soil depths.

The percentage of pepper fruit culls in Expt. 1 increased by 31% with addition of compost without fertilizer and decreased by 77%

and 41% with the 50% and 100% fertilizer rate, respectively (data not shown). These culls were almost exclusively due to blossom end rot. In the first harvest, percentage of culls at all fertilizer rates decreased with addition of compost (data not shown), so the interaction was a result of the later two harvests. There were no interactions between compost and Ca concentrations of the leaf tissue or soil, but tissue and soil analyses (Tables 2 and 4) resulted in lower Ca concentrations in plants and soil from plots without compost compared with those with compost. Increased Ca levels and water availability may lower incidence of blossom end rot (Mengel and Kirkby, 1987).

CUCUMBER CROP. Residual fertilizer rates did not significantly affect any of the measured yield variables, therefore only data for compost effects are presented (Table 5). Plots amended with compost had higher total marketable yield but similar fruit size and percentage of culls compared with plots without compost (Table 5).

Despite the 4 months that elapsed between pepper plant removal and subsequent cucumber planting, residual effects of compost increased total marketable cucumber yields. Fontes (1985) reported similar increased cucumber yields from residual compost following a tomato crop. Dick and McCoy (1993) report that high radiation loads and soil temperatures in tropical soils mineralize

Table 2. Nutrient concentration of pepper leaf and petiole tissue samples measured on 3 Mar. from plants grown with different fertilizer rates and with or without compost (Expt. 1).

	T-K-N	P	K	Ca	Mg	Mn	Cu	Fe	Zn		
Treatment	%						ppm				
	Compost (C) (t·ha ⁻¹)										
Fertilizer ^z (F)								-	+	-	+
0	4.9	0.4	3.9	1.1	0.4	196	338	94	96	167	155
50	5.5	0.4	3.8	1.0	0.4	185	284	87	103	135	145
100	5.8	0.4	4.1	1.1	0.4	206	287	147	94	137	139
F effects	L*	NS	NS	NS	NS	Q*	L*				
C (t·ha ⁻¹)											
0	5.3	0.39	3.5	0.9	0.35	196	321				
134	5.5	0.42	4.3	1.1	0.46	195	284				
C effects	NS	**	**	**	**	NS	*				
F × C	NS	NS	NS	NS	NS	NS	NS	*		*	

²Fertilizer rates expressed as percent of grower's standard fertilizer rate), which is 71N-39P-44K kg·ha⁻¹ broadcast and 283N-0P-278K kg·ha⁻¹ banded in bed centers.

NS,*,**Nonsignificant or significant at $P \leq 0.05$ or 0.01, respectively; L = linear, Q = quadratic.

Table 3. Large, medium, and total marketable pepper fruit; percentage of culls, and mean fruit mass from plants grown with several fertilizer rates and with or without compost (Expt. 1).

Treatment	Marketable fruit (t·ha ⁻¹)					Culls %	Fruit mass (g/fruit)	
	Large	Medium		Total				
		Compost (C)						
		–	+	–	+			
Fertilizer ² (F)								
0	13.2	11.3	12.5	19.8	30.3	2.0	2.6	171
50	22.1	12.5	12.5	31.1	35.7	4.2	1.0	199
100	21.1	12.0	9.2	32.0	31.5	2.6	1.5	202
F effects	Q*							Q*
C (t·ha ⁻¹)								
0	15.6							183
134	22.0							198
C effects	**							**
F × C	NS	*		**		*		NS
LSD _(0.05) F × C		1.8		3.5		1.43		

²Fertilizer rates expressed as percent of grower's standard, which is 71N–39P–44K kg·ha⁻¹ broadcast and 283N–0P–278K kg·ha⁻¹ banded in bed centers.

NS,*,** Nonsignificant or significant at $P \leq 0.05$ or 0.01, respectively.

compost rapidly. With subsurface irrigation, the beds are kept moist all the time, so some level of microorganism activity would be expected to continue. However, in our experiment, even when the compost was undisturbed under black polyethylene for 4 months, there were cucumber fruit yield increases in the plots with compost. Soil samples taken at the end of the pepper crop indicated increased P, K, Mg, Ca, and pH in plots with compost. Changes in soil chemical and physical characteristics such as reductions in bulk density and increases in hydraulic conductivity, water-holding capacity (Chang et al., 1983), increases in beneficial microorganisms (Chung et al., 1988), changes in forms of nutrients (Chauhan et al., 1979), and increases in NO₃ production, CO₂ evolution, EC, and cation exchange capacity (Fontes, 1985) resulting from additions of compost or other forms of organic matter have been reported. Yield of the cucumbers may have been influenced by these other edaphic variations in addition to the nutrient levels measured in our trial.

Experiment 2

Fertilizer × compost interactions were significant for early and total yield, and mean fruit weight (Table 6). The increases that

occurred when compost was added without fertilizer were not significant when the compost was added with the 50% fertilizer rate. At the 100% fertilizer rate, total yield increased only in plots amended with MWP compost, and fruit size increased with addition of either MWP or RDF compost.

In both experiments, the compost with the 50% fertilizer rate increased pepper yields as much or more than the 100% fertilizer rate, with or without compost. Maynard (1994) reported increased tomato yields for plants grown in soil amended with 112 t·ha⁻¹ MSW compost and 146 kg·ha⁻¹ N. Ozores-Hampton et al. (1994), however, reported fewer yield differences when tomatoes were grown with several MSW composts at 24 to 48 t·ha⁻¹ and 225 to 240 kg·ha⁻¹. Soil and climatic differences (Dick and McCoy, 1993) and additional fertilizer nutrients seem to affect the beneficial effects of compost on yields.

In both pepper experiments, fruit size also increased with use of compost. Increased fruit size for crops grown in compost amended plots has been previously reported (Maynard, 1995).

One potential problem with use of composts from municipal wastes is the possibility of presence of phytotoxic compounds. The MWP and RDF composts tended to contain higher amounts of

Table 4. Nutrient concentrations from soil samples taken on 2 May 1994, at the end of pepper harvest (Expt. 1).

Treatment	NH ₄		NO ₃		P		K		Mg		Ca		pH		
	ppm										%		pH		
	Soil depth (cm)														
	0–10	10–20	0–10	10–20	0–10	10–20	0–10	10–20	0–10	10–20	0–10	10–20	0–10	10–20	
Fertilizer ^a	Compost (C)														
0	1.8	2.2	1.1	10.0	4.2	133	100	101	48	71	44	1.3	0.8	5.9	5.6
50	24.9	19.5	8.2	201.6	85.1	147	109	268	102	88	52	1.3	0.9	5.8	5.7
100	57.4	25.9	14.7	427.0	189.3	175	118	475	185	102	63	1.3	0.9	5.8	5.7
Fertilizer (F) effects			NS	L*	L*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C (t·ha ⁻¹)															
0			9.0	228.0	90.5	103	90	225	71	63	39	1.0	0.8	5.5	5.5
134			7.0	197.8	95.2	201	128	338	152	112	67	1.5	1.0	6.2	5.8
C effects			NS	NS	NS	**	NS	**	**	**	**	**	**	**	**
F × C	**		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

²Fertilizer rates expressed as percent of grower's standard, which is 71N–39P–44K kg·ha⁻¹ broadcast and 283N–0P–278K kg·ha⁻¹ banded in bed centers.

NS,*,** Nonsignificant or significant at $P \leq 0.05$ or 0.01, respectively; L = linear.

Table 5. Cucumber yields, mean fruit size, and percentage of culls from plants grown in plots with or without residual basic compost (Expt. 1).

Compost (t·ha ⁻¹)	Total marketable yield (t·ha ⁻¹)	Fruit size (g/fruit)	Culls (%)
0	22.7	322	36.6
134	26.8	327	43.5
Significance	**	NS	NS

NS, ** Nonsignificant or significant at $P \leq 0.01$, respectively.

several heavy metals than basic compost (Roe and Stoffella, 1997) and may contain other compounds that were not identified in this experiment. When used without dilution, these composts resulted in some reduction in growth of seedlings (Roe and Stoffella, 1997). However, when incorporated into the soil at 134 t·ha⁻¹ there was no evidence of phytotoxicity, as yields were always equal to or higher than without composts.

When soil amendments contain heavy metals, there is a potential for the metals to accumulate in the soil. Bevacqua and Mellano (1993), using biosolids compost applications totaling half the rate that we used, reported increased soil concentrations of Zn, Ni, Cd, and Cu after 2 years. The metals tested in our experiment did not increase in pepper tissue with compost use (Table 2). However, uptake of metals into fruit and leaves depends not only on soil contents of metals, but also on factors such as soil pH and organic matter content (Stilwell, 1993). SC, which contained lower contents of most of the metals than MWP and RDF composts and no additional sources of possible toxic compounds, increased plant height in the field and in pots (Roe and Stoffella, 1997) compared with sandy field soil.

Soluble salts can also be a problem with high levels of composts (Chaney et al., 1980). Higher salt level in RDF compost (6.37 dS·m⁻¹) than that of MWP (3.55 dS·m⁻¹) or SC (4.44 dS·m⁻¹) may have contributed to the decreased seedling growth in RDF compost (Roe and Stoffella, 1997).

Our results indicate that biosolids-yard trimming composts, in

Table 6. Early (first) harvest, total yield, and mean fruit mass of peppers grown with different fertilizer rates and with mixed waste paper (MWP) or refuse-derived fuel (RDF) composts or without compost (Expt. 2).

Compost (134 t·ha ⁻¹)	Early harvest (t·ha ⁻¹)	Total yield (t·ha ⁻¹)	Mean fruit mass (g/fruit)
No fertilizer²			
0	6.5	13.9	123.7
MWP	14.7	26.1	180.1
RDF	12.9	25.0	168.3
50% Fertilizer			
0	14.0	25.5	159.7
MWP	14.2	24.2	181.4
RDF	12.5	22.9	167.2
100% Fertilizer			
0	11.6	20.9	158.9
MWP	13.3	24.7	171.5
RDF	11.4	21.0	169.0
Fertilizer (F) × Compost (C)	*	**	**
LSD _(0.05) F × C	2.3	2.7	9.0

²Fertilizer rates expressed as percent of grower's standard, which is 71N-39P-44K kg·ha⁻¹ broadcast and 283N-0P-278K kg·ha⁻¹ banded in bed centers.

*, ** Significant at $P \leq 0.05$ or 0.01, respectively.

conjunction with reduced fertilizer applications, may result in high pepper fruit yields. Even in a subtropical climate, the beneficial effects of high rates of compost may continue into a subsequent crop. It appears that MWP or RDF can be added to composts, at rates of 36% and 64%, respectively, without reducing yields of field grown peppers.

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