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DIFFERENCES IN VEGETABLE CROPS YIELD RESPONSE TO COMPOSTED WASTE AS THE SOIL AMENDMENT IN URBAN GARDENING

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ABSTRACT: To determine the feasibility of using composted wastes as soil amendments for growing vegetables vs. the conventional use of commercial fertilizer in urban gardens, both cool and warm season vegetable crops were grown in plots amended with composted yard waste, cow manure or commercial fertilizer (10-10-10). Both composted materials were applied at a rate of 44,800 kg/ha and the fertilizer (control plots) at 336 kg/ha. Crops grown were the cool season varieties broccoli, cabbage, lettuce, and onions while warm season varieties were bell peppers, collard greens, snap beans, and tomatoes. Seedlings were grown in a greenhouse and then transplanted in field plots when they were six weeks old. Cool season crops were planted on April 25 and warm season on May 10. Throughout the growing season, low-input sustainable techniques were used for crop maintenance so that no chemical pesticides were applied. Results showed that most of the varieties grown produced yields equal to or greater in the compost amended than in the fertilizer treated plots. Yield of vegetables crops showed significant varietal differences in yield responses to the composted wastes as soil amendments. For example, in Experiment II it can be seen that the yield of onions was about 24% higher in the Leagfro amended plots while in Experiment II the yield of tomatoes was 44% more in the composted amended plots. Generally, the vegetable crop varieties grown in soil amended with composted yard waste and cow manure produced yield that were equal to and sometimes exceeded that produced by plots amended with the commercial fertilizer (10-10-10).

INTRODUCTION

For the past decade, modern agriculture has been confronting a system in which "urban sprawl" is increasing and the gap between sparsely populated rural cropping systems and metropolitan areas has vastly decreased. More importantly, increase in agricultural activity within urban areas has been fueled by the demand for fresh vegetables by emigrees from rural areas (Garnett, 1996; Liebhardt et al., 1989; Weir and Allen, 1997). These emigrees from rural areas bring their crop producing desires with them and thus try to grow vegetable crops wherever they can (Liebhardt et al., 1989; Steele, 1996). A major deterrent to the production of vegetables in these garden areas is the lack of available land. In some metropolitan areas, this lack of garden space is partially alleviated by the use of abandoned and/or vacant lots (Garnett, 1996).

Since urban gardening is usually done in highly populated and small land areas, sustainable low-input techniques which rely on lower rates of fertilizer and pesticides application would be the more sensible cultural practice to use in growing vegetables in these gardens. Low input techniques are highly desirable in urban areas because of poor environmental quality brought on by high population density. These techniques improve the environment by improving land use and recycling waste (Smit and Nasr, 1992). Besides helping to clean up our environment, solid wastes (plant and animal) when composted have the potential to become viable sources of soil amendments in crop production (Dixon et al., 1995; Neuger, 1996). A study near the city of Cleveland showed that composted waste from nearby businesses was successfully used for commercial fertilizer in the growing of crops in the metropolitan area (Neuger, 1996). In another study, fertilizer use was reduced by the addition of animal waste as a nitrogen source in crop production (Smit and Nasr, 1992). At The University of the District of Columbia, Washington, DC, Weir and Allen, 1997 and Dixon et al., 1995 successfully grew several cool and warm season vegetables using composted yard waste and biosolids composts as soil amendments.

While it has been shown that composted waste can successfully grow vegetables, there is a need to determine the yield response of different vegetables when grown in plots where composted waste was the soil amendment. Therefore, the purpose of this study was to evaluate the effect of two sources of composted waste as soil amendments in the production of several vegetable crops grown in a metropolitan area such as the District of Columbia.

MATERIALS AND METHODS

The study was conducted over a period of two years (FY 2001-2002) at the University's Muikirk Experiment Station in Beltsville, MD. Soil type at the station is an acid silt loam, classified locally as Christiana silt loam. The experimental design used was a randomized complete block (RCBD) consisting of three treatments and three replications per treatment. Treatments were composted cow manure from the Beltsville Agricultural Research Center in Beltsville, Maryland and composted yard waste (Leafgro) produced by the Maryland Environmental Center in Upper Marlboro, MD. Both the composted cow manure and yard waste were applied at a rate of 44,800 kg/ha. Plots in which commercial fertilizer (10-10-10) was applied at a rate of 336 kg/ha were used as the control. Main plots were composted waste and fertilizer treatments and vegetable crop varieties were subplots. Each sub-plot was 3m x 3m consisting of three rows each 91 cm wide. Crops used in the study were the warm season varieties such as bell peppers (*Capsicum annuum* var California wonder), collard greens (*Brassica oleracea* var Georgia) and snap beans (*Phaseolus vulgaris* var Kentucky wonder). Cool season varieties were broccoli (*Brassica oleracea* var premium crop), cabbage (*Brassica oleracea*), lettuce (*Lactuca sativa* var Iceberg), and onions (*Allium cepa* var Sweet spanish) (Table 1).

Both composted waste and fertilizer were broadcasted on seed beds and disked into the soil at a depth of three inches. After soil amendments were applied to seed beds and thoroughly mixed into the soil, samples were taken from each block and analyzed at the University of Maryland Soil Laboratory for pH level, percent of organic matter (% OM), and nitrogen concentration (Table 2). No herbicides were applied; therefore, only mechanical weed control (small manually operated garden cultivator and hoeing) were used throughout the field study. Seeds were germinated in a greenhouse and immediately after germination transferred to 7.6 cm diameter plastic pots (medium used was Pro-Mix, a potting mixture produced by Premier Horticulture, Inc., Quakertown, PA 18951, USA).

Seedlings were transplanted into field plots when they were six weeks old. Planting times for both years were April 25 for cool season crops and May 10 for the warm season crops. Within row spacing for cool season crops was 38 cm between each plant but varied slightly for warm season crops. Bell peppers and collards were planted 46 cm apart while snap beans were spaced 30 cm and tomatoes spaced 76 cm apart. During the growing season, field plots were maintained with limited cultural inputs. Data collected for analysis were the fresh weights of heads from broccoli, cabbage and lettuce, mature bulbs of onions, leaves of collard greens, pods of snap beans and ripe tomatoes.

RESULTS AND DISCUSSION

For both cool and warm season crops, yield response to the composted amendments depended on crop variety and environmental conditions existing in the field. Highest yield produced by onions in Experiment I was in the fertilizer amended plots. In Experiment II, the onion crop yield was highest in plots amended by leafgro (Table 3). In this experiment yield of onions was approximately 24% higher in the leafgro amended plots (Table 3). Lettuce produced its highest yield in the leafgro amended plots and lowest in the fertilizer treated ones in Experiment I (Table 3). In Experiment II, there were no significant differences in vegetative yield between the composted cow manure and the fertilizer (10-10-10) amended plots (Table 3).

Unlike lettuce, broccoli showed a significantly greater vegetative growth in the fertilizer amended plots than either in the composted cow manure or the leafgro treated plots. No data was obtained for this crop in Experiment II because plants were completely defoliated by wildlife (possibly ground hogs and rabbits). In Experiment I vegetative growth for cabbage was best in the fertilizer amended plots. Heads were larger in these plots than those in either the cow manure or the leafgro treated plots. In Experiment II, yield of cabbage in terms of head weight showed no significant differences between cow manure, leafgro and fertilizer amended plots (Table 3).

As indicated before, yield response of warm season crops in the compost amended plots depended on the variety. In Experiment I, yield of bell pepper showed no significant difference between that produced in the leafgro and fertilizer (control) and the leafgro amended plots (Table 4). Yield response by this crop in Experiment II was strikingly different because the lowest was produced in the fertilizer amended plots and highest in the leafgro treated plots (Table 4).

Vegetative yield of collard greens was significantly higher in the fertilizer amended plots in Experiment I but there were no significant differences in yield in either the composted amended plots or the fertilizer treated plots (Table 4). The favorable yield response of collard greens to all three soil amendments in Experiment II is attributable to the fact that this crop was very tolerable to the high temperatures and rainfall during the period May through August of the year 2002. Yield of snap beans was considerably higher in Experiment I (FY 2001) with the highest being produced in the fertilizer amended plots (Table 4).

The low yield in Experiment II was attributable to a severe attack of fungus disease (data not shown). Tomato plants produced significantly higher yield in the composted amended plots than in the control plots (fertilizer amended). For example, in Experiment II tomato plants produced approximately 44% more in the composted cow manure plots than in the fertilizer amended ones (Table 4). In both experiments, the soil organic matter concentration in plots amended with composted cow manure was higher than plots treated with commercial fertilizer (Table 2). In Experiment II, it should also be noted that both soil OM and nitrogen concentrations were higher than in Experiment I for plots given all three amendments (Table 2).

The higher levels of OM and nitrogen observed in Experiment II are attributable to the fact that these plots had more vegetative cover, which was turned under in the fall of FY 2001 and early spring of 2002. Yield response of the cool season vegetable crop varieties studied also followed this same OM and soil nitrogen concentration relationship except that cabbage total yield in Experiment II was higher than that obtained in Experiment I (Table 3, Figures 1 and 2). It should also be pointed out that the lower yield produced by the cool season crops lettuce, broccoli and cabbage in the leafgro amended plots in Experiment I could be attributable to the relatively low OM and nitrate concentration (Table 2, Figure 1) in the soil.

This study has demonstrated that composted waste materials such as yard waste and cow manure can be successfully used in growing vegetable crops. Preliminary studies of others such as Weir and Allen 1997, Neuger 1996, and Smit and Nasr 1992 have supported these findings. However, it should be pointed out that the degree to which this composted waste can produce yields comparable to commercial fertilizer as the soil amendment depend on the crop variety and existing climatic conditions. For example, during experimental period (FY 2001-2002) the growing seasons were dominated by short spring seasons where temperatures were constantly in the range of 85-90^{o} F followed by the usual hot summer months. Under this type of weather conditions, cool season crops such as broccoli and lettuce do not thrive very well. In this study, broccoli and lettuce grew well in early April. However, by the end of April to the first week in May when plants were just forming heads, most of them "bolted" and thus produced no marketable yield.

Unlike the cool season crops, warm season varieties such as bell peppers, collards and tomatoes were not adversely affected by the warm summer temperature and continued to grow well into the warmer climate of August to September. The yields of bell peppers and snap beans in the cow manure and fertilizer amended plots were much lower than that generally produced in the leafgro treated plots. This was particularly shown in Experiment II where the low yields of 12.9 and 9.8 kg/m^2 in the fertilizer amended plots were found for bell peppers and snap beans, respectively (Table 4, Figure 2). The low yields of these two warm season crops may be due to disease infestation during a rainy period in late June. Bell peppers were severely infected by anthracnose and the snap beans by what appeared to be the tobacco mosaic virus and fusarium wilt (data not shown).

CONCLUSION

Based on this study, it can be seen that composted waste materials can be used as viable soil amendments in growing garden vegetables. Varieties grown in soil amended by composted yard waste and cow manure produced yields that were either equal to or sometimes significantly more than when commercial fertilizer was used as the soil amendment. However, to maximize productivity by using these composted materials as soil amendments, care should be taken to ascertain that adaptable varieties are chosen since they differ in their growth response to the composted soil amendments. Additionally, composted animal waste such as cow manure is often a host for various diseases, therefore, care should be taken to select varieties that are resistant to various bacterial, fungal and viral diseases. This is a critical issue since with urban gardening crops are grown under intensive conditions. Under these conditions, cultural practices such as rotation are not feasible and thus disease organisms tend to build up in seed beds. Although these problems can arise, with careful management, vegetable crops can be successfully grown with composted waste as the soil amendment. However, even if yields are not as good as when commercial fertilizer is used, it should be noted that benefits can be gained by the gardener since a cleaner environment can be derived when recycled materials are disposed of as soil amendments.

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Table 1. Composted waste and crops studied.

Composted Waste	Crops	
	Cool Season	Warm Season
Composted Yard Waste	Onion	Bell pepper
	Lettuce	Collard greens
	Broccoli	Snap beans
	Cabbage	Tomato
Composted Cow Manure	Onion	Bell pepper
	Lettuce	Collard greens
	Broccoli	Snap beans
	Cabbage	Tomato
Fertilizer (10-10-10)	Onion	Bell pepper
	Lettuce	Collard greens
	Broccoli	Snap beans
	Cabbage	Tomato

Table 2. Soil pH, organic matter and nitrate nitrogen levels after the addition of lime and compost as soil amendments.

Experiment No.	Soil Amendment	Soil Nutritional Components		
		pH	% OM	NO_3 (PPM)
I, FY 2001	Composted Cow Manure	7.5	3.7	16.6
	Leafgro	7.5	2.8	6.8
	Fertilizer	7.5	2.8	13.4
II, FY 2002	Composted Cow Manure	7.0	4.8	42.0
	Leafgro	6.6	5.4	35.1
	Fertilizer (10-10-10)	6.4	3.6	35.6

Table 3. Differences in the yield of cool season crops when composted waste is used as soil amendment.

Crop	Soil Amendment	Total Yield (kg/10m^2)	
		Exp #1	Exp #2
Onion	Cow Manure	7.5	13.9
	Leafgro	14.3	16.4
	Fertilizer	20.2	12.5
Lettuce	Cow Manure	14.0	36.6
	Leafgro	17.2	31.8
	Fertilizer	11.4	37.0
Broccoli	Cow Manure	19.1	-*
	Leafgro	14.7	-
	Fertilizer	35.6	-
Cabbage	Cow Manure	37.9	60.5
	Leafgro	31.5	57.5
	Fertilizer	81.5	53.0
LSD .05		5.4	2.1

* Plants defoliated by wild life.

Table 4. Differences in the yield of warm season vegetable crops when composted waste used as the soil amended.

Crop	Soil Amendment	Yield (kg/10m^2)	
		Exp #1	Exp #2
Bell pepper	Cow Manure	13.3	16.9
	Leafgro	22.5	33.3
	Fertilizer	27.2	12.9
Collard greens	Cow Manure	60.5	53.9
	Leafgro	57.6	55.2
	Fertilizer	69.6	59.3
Snap beans	Cow Manure	36.7	15.8
	Leafgro	41.7	13.6
	Fertilizer	56.8	9.8
Tomato	Cow Manure	36.6	145.2
	Leafgro	59.3	69.0
	Fertilizer	26.4	82.0
LSD .05		11.4	8.0

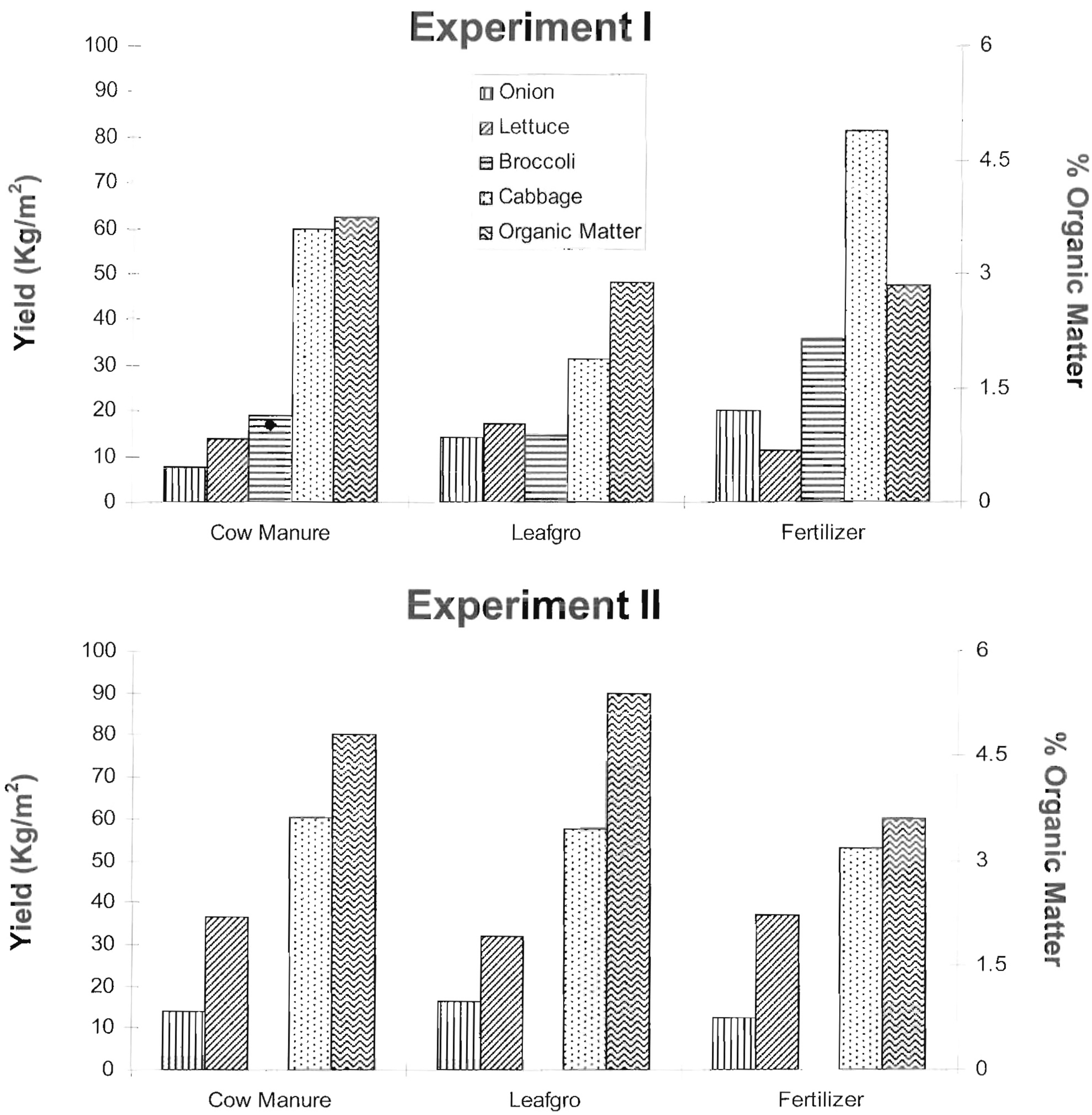

Figure 1. Relation of soil organic matter content to yield of warm season vegetable crops.

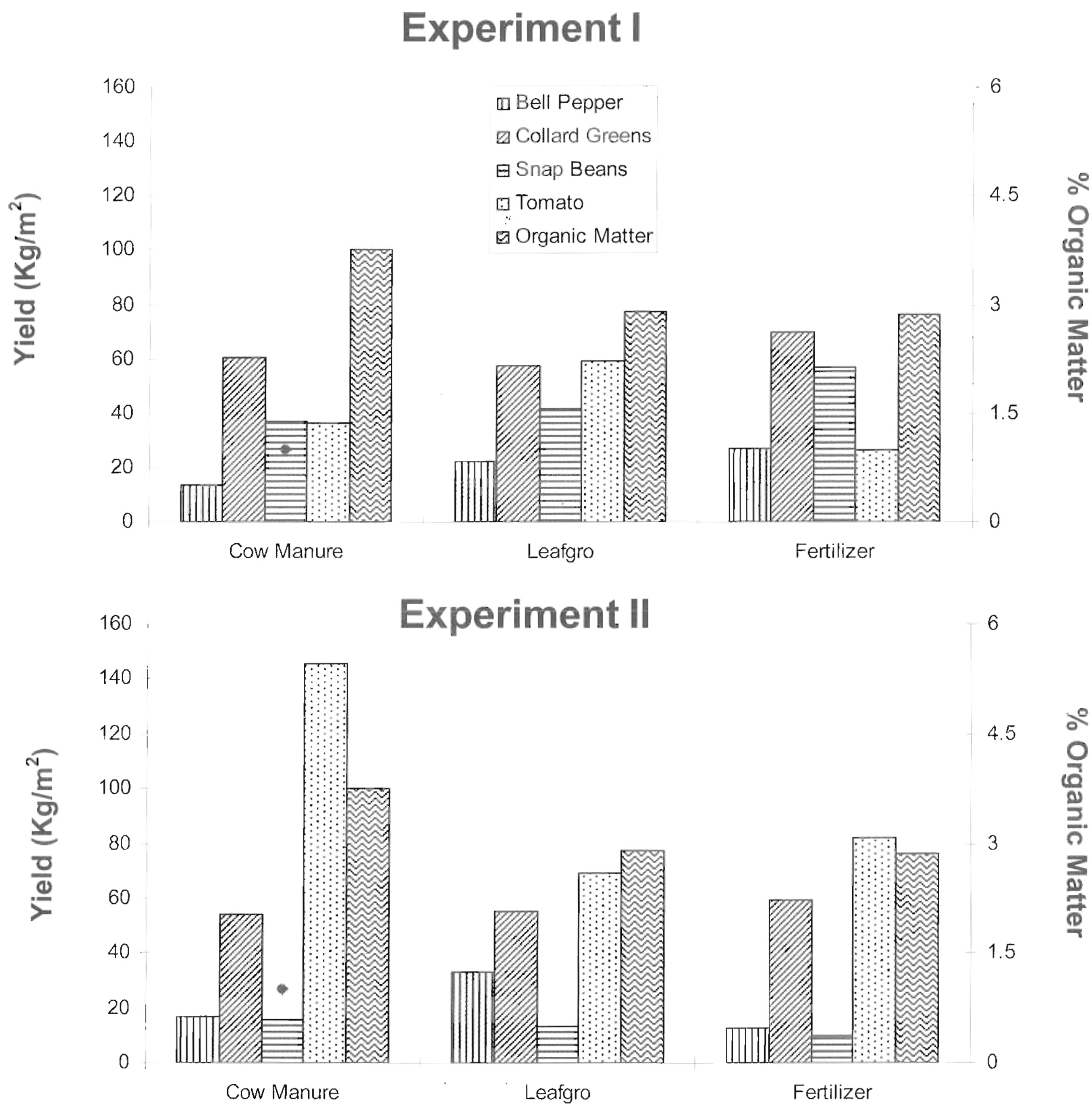

Figure 2. Relation of soil organic matter content to yield of cool season vegetable crops.