Transplant Growth and Stand Establishment of Bell Pepper (*Capsicum annuum* L.) Plants as Affected by Compost-Amended Substrate

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Keywords: organic agriculture, sustainable, compost, propagation, *Capsicum annuum*, potting mixtures

Abstract

The objective of this study was to determine the effects of using compost on bell pepper transplant growth and subsequent fruit yield after transplanting in the field. Bell pepper, '*X3R Wizard*', was seeded on the spring of 2000. Transplants were grown using (1) commercial transplant growing substrate (Pro-Mix PGX, 70% peat moss) routinely used to grow bell pepper transplants and (2) the same substrate amended with on-farm produced compost (Gromor Organics Inc., Tifton, Georgia). Compost-amended (20% by volume) substrate significantly increased transplant height by 10%. In addition, leaf area, shoot dry weight, root dry weight, and plant height were significantly higher for transplants grown in compost-amended substrate 51 days after seeding. Transplants grown in compost-amended substrate also yielded 20% more fruit than transplants grown in non-amended substrate. In a follow-up study in 2002, the effects of amending the substrate with various rates of compost (from 0% to 50% by volume) on transplant growth were determined. Forty-two days after seeding, plants grown in substrate amended with 0% and 10% compost were shorter and had lower root dry weights compared to plants amended with ≥20% compost rate. In conclusion, our results show that the utilization of compost as a substrate amendment resulted in high quality transplants with increased vigor. This growth enhancement was partly due to the mineral nutrients contained in the compost, although compost was unable to supply all the nutrients needed by the plants. The results of this study did not show any beneficial effects on fruit yield attributed to using compost for transplant production.

INTRODUCTION

Composting is the practice of using biological reduction of organic wastes to humus or humus-like substances (Stratton et al., 1995). Through the process of composting, biodegradable organic wastes are transformed into a product that can be utilized as a soil amendment or fertilizer. Recently, there has been a trend towards agricultural sustainability that has motivated a new interest in manure and compost utilization. Compost application improves the physical, chemical and biological properties of soils, and represents an environmentally-friendly means of disposal of organic wastes (Dick and McRoy, 1993; Hill and James, 1995; Mays et al., 1973). The application of compost has resulted in variable crop responses, from increases, to decreases and no changes in crop yields (Ozores-Hampton et al., 1998; Roe, 1998). In preliminary studies, we found that at first harvest, 70 days after transplanting, the marketable yield of pepper was twice as large when using transplants produced in compost-amended substrate compared to that using transplants grown without compost (8.70 t/ha and 3.69 t/ha, respectively) (Granberry et al., 2001). After weights of all marketable peppers (for all harvests) were combined, transplants grown in compost-amended substrate yielded 20% more than transplants grown in non-amended substrate.

The difficulty to predict the effects of compost on plant growth and yield derives from the differences in age (maturity) and composition (nutrient content, C:N ratio, etc.) among composts. Composts, used alone or in mixtures with other materials, can serve as horticultural potting media in organic or sustainable production systems. There is an increasing interest among transplant growers to find alternative materials for producing

Proc. IVth IS on Seed, Transplant and Stand Establishment of Hort. Crops
Ed.: D.I. Leskovar
Acta Hort. 782, ISHS 2008

substrates for transplant production (Clark and Cavigelli, 2005; Eklind et al., 2001; Raviv et al., 1998a, b; Russo, 2005).

One objective of this study was to determine the effect of using compost as a substrate amendment on the growth of bell pepper transplants and subsequent fruit yield after transplanting in the field. Another objective was to determine the ability of the compost to provide mineral nutrients to the plant in the absence of supplemental chemical fertilization applied through the irrigation water.

MATERIALS AND METHODS

Spring 2000-Trial

1. Transplant Stage. Transplants were grown (in black plastic trays) in a commercial greenhouse (Lewis Taylor Farms, TyTy, Georgia, U.S.A.) using either (1) commercial transplant growing substrate (Pro-Mix PGX, 70% peat moss) routinely used to grow bell pepper transplants or (2) the same substrate amended (20% by volume) with on-farm produced compost (Gromor Organics Inc., Tifton, Ga.). The design was completely randomized and consisted of 4 replications (200-cell tray) per treatment. Plants were fertilized through the irrigation water, according to the grower's standard practices. Plant height and plant growth variables [leaf area, dry weight of leaves, stems, shoots (leaves plus stems), and roots] were determined at 15 and 51 days after seeding (DAS). For dry weight determinations, plant samples were dried at 70°C for 48h.

Spring 2002-Trial

1. Transplant Stage. In the spring of 2002, follow-up studies were conducted to determine the effects of amending the transplant growing substrate with various rates of compost including the 20% rate used in 2000 on pepper transplants growth. The trials were conducted simultaneously at the Horticulture Farm, Coastal Plain Experiment Station, University of Georgia, Tifton, Georgia, and at Lewis Taylor Farms, TyTy, Georgia. The same substrate as the one used in 2000 was amended with compost at 0% (by volume), 10%, 20%, 30%, 40%, or 50%. Plants were fertilized (with N and K) through the irrigation water, according to the grower's standard practices. The design was a split plot arranged as a completely randomized design with six replications (tray), where the main plot was fertilization (with or without N and K fertilizer) and the subplot was the compost rate. The trials were repeated once (seeding dates were 1 February and 1 March 2002) in each of the farms.

2. Field. Transplants (fertilized) were removed from the greenhouse 49 days after seeding and were planted in a commercial field in Chula, Georgia. Pepper plants were grown on fumigated soil on plastic film mulch and were drip-irrigated, according to the recommendations of the University of Georgia, Extension Service (University of Georgia, 2006). The design was a randomized complete block with six treatments (compost rate) and four replications. The plot consisted of a 10-m long bed. Fruit were harvested four times during the season. After each harvest, fruit were graded according to the USDA Grade Standards and their weights were determined.

Statistical Analysis

Data were analyzed using the General Linear Model of SAS (SAS OnlineDoc Version 8, SAS Institute Inc., Cary, NC).

RESULTS

Spring 2000-Trial

1. Transplant Stage. Leaf area, shoot, and root dry wt., and transplant height were increased in transplants grown in compost-amended substrate (Table 1).

Spring 2002-Trial

1. Transplant Stage. Leaf area increased with increasing compost rates up to 20% compost and then remained about constant with increasing compost rates (Table 2). Shoot dry weight increased with increasing compost rates, while root dry weight was unaffected by compost rate. The root/shoot ratio decreased quadratically with increasing compost rates. Forty-two days after seeding, plants grown in substrate amended with 0% and 10% compost were shorter and had lower root dry weights compared to plants amended with ≥20% compost rate.

The application of N and K fertilizer through the irrigation water resulted in increased leaf area and increased shoot and root dry weight and a decreased root/shoot ratio compared to plants receiving no supplemental fertilization. This indicates that compost applied as an amendment to the substrate is unable to supply all the mineral nutrients needed by the plants.

2. Field. Eight weeks after field transplanting, transplants grown without any compost had reduced shoot and root dry weight (data not shown). Marketable (26.01 t/ha) and total (31.22 t/ha) fruit yield were not significantly affected by the incorporation of compost to the substrate where transplants were grown, although total fruit yield tended to increase with increasing compost rates.

DISCUSSION

Compost has a low mineral nutrient content and thus it may not provide all the crop nutritional requirements (Roe, 1998; Stratton et al., 1995). Our results showed that the leaf area, shoot dry weight, and root dry weight of transplants grown in compost-amended substrate alone, with no additional fertilizer, were only 35%, 40%, and 48% relative to those of transplants that did receive fertilizers. In unfertilized plants compost was the sole source of nutrients. Although compost alone was unable to provide sufficient nutrients to allow for optimal plant growth, compost provided some mineral nutrients that may explain, at least partially, the improved growth found in plants receiving fertilization through the irrigation water. Additionally, it is also possible that the growth stimulation with the use of compost may have been due to other factors, such as, the organic matter and microorganisms contained in the compost that may improve physical and biological properties of the soil. The reduction in the root/shoot ratio with increasing compost rates suggests the existence of changes in the patterns of allocation of assimilates between the root and shoot, with a preference of allocation of assimilates towards the roots at low compost rates.

In conclusion, our results show that the utilization of compost as a substrate amendment resulted in high quality transplants with increased vigor. This growth enhancement was partly due to the mineral nutrients contained in the compost, although compost was unable to supply all the nutrients needed by the plants. In contrast to our preliminary report (Granberry et al., 2001), and despite the improved vigor of the transplants grown in compost-amended substrate, the results of this study did not show any beneficial effects on fruit yield attributed to using compost for transplant production.

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Tables

Table 1. Effect of compost addition (20% by volume) to the substrate on the growth of bell pepper (cv. X3R Wizard) transplants. Lewis Taylor Farms (spring 2000).

Compost	Leaf area (cm^2)	Leaf DW (g)	Stem DW (g)	Shoot DW (g)	Root DW (g)	Height (cm)
NO	29.7	0.146	0.100	0.246	0.106	12.8
YES	39.2 **	0.169 **	0.161 **	0.330 **	0.135 **	14.1 **

** Significant at $P \leq 0.001$.

Table 2. Growth of bell pepper transplants as affected by the rate of compost applied as a substrate amendment and fertilization. Plants were either fertilized (with N and K) through the irrigation water or non-fertilized.

Treatment	Leaf area (cm^2)	Shoot DW (mg)	Root DW (mg)	Root/Shoot ratio
Compost rate (%)				
0	15.2 c	130 b	66 a	0.64 a
10	17.5 b	140 ab	73 a	0.60 ab
20	19.5 ab	155 a	76 a	0.56 bc
30	20.9 a	160 a	75 a	0.52 c
40	20.7 a	151 ab	72 a	0.54 c
50	21.2 a	156 a	73 a	0.53 c
Fertilization				
Yes	26.5 a	201 a	92 a	0.48 b
No	9.3 b	80 b	47 b	0.67 a
Significance				
Linear	0.002	0.035	0.050	0.013
Quadratic	0.010	0.076	0.067	0.042
Test	0.090	<0.001	0.047	0.087
Farm	<0.001	<0.001	<0.001	0.171
Compost (C)	<0.001	0.049	0.352	<0.001
Fertilization (F)	<0.001	0.016	0.065	<0.001
C x F	0.941	0.859	0.297	0.157
Rep	0.270	0.518	0.126	0.002

[z] Means separated within columns and compost and fertilizer treatments by Fisher's protected LSD test ($P \leq 0.05$).