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Impact of Vermicompost on Vegetable Transplant Quality

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Abstract. **Vermicomposting is a promising method of transforming unwanted and virtually unlimited supplies of organic wastes into usable substrates. In this process, the digestive tracts of certain earthworm species (e.g., *Eisenia fetida*) are used to stabilize organic wastes. The final product is an odorless peat-like substance, which has good structure, moisture-holding capacity, relatively large amounts of available nutrients, and microbial metabolites that may act as plant growth regulators. For these reasons, vermicompost has the potential to make a valuable contribution to soilless potting media. The objective of this study was to evaluate the transplant quality and field performance of vegetable transplants grown in vermicompost. Tomato (*Lycopersicon esculentum* Mill.), eggplant (*Solanum melongena* L.), and pepper (*Capsicum annuum* L.) transplants were grown in a commercial soilless mix including 0%, 10%, or 20% (v/v) worm-worked cattle manure. Growth of vegetable transplants was positively affected by addition of vermicompost, perhaps by altering the nutritional balance of the medium. Transplant quality was improved in peppers and eggplants while tomato transplant quality was slightly reduced. There were no significant differences in field performance.**

Alternative substrate amendments for soilless media are needed due to finite supplies of peat moss (Barkham, 1993; Robertson, 1993). As a result there has been increased interest in using composted materials as extenders. At the same time, organic wastes from municipalities, food processing, and other industries are being produced in quantities that, if processed in the appropriate manner, could serve as a cheap and readily available source for organic supplements in peat-based media. One promising method of processing organic wastes into a value-added product is vermicomposting. In this process, organic material is stabilized into an odorless peat-like substance in the digestive tracts of various species (e.g., *Eisenia fetida* and *E. andrei*) of earthworms. The final product has attributes desirable as a component in soilless media, including good structure, drainage, aeration, and moisture-holding capacity (Edwards and Burrows, 1988). Suitable substrates for vermicomposting include animal manure (Frederickson and Knight, 1988; Hand et al., 1988), sewage sludge (Neuhauser et al., 1998), paper mill sludge (Elvira et al., 1996), and coffee pulp (Orozco et al., 1996).

The nutrient content of vermicompost (VC) depends on the parent material, but is usually higher in most nutrients when compared to a commercial potting media with a starter fertilizer (Edwards, 1998b). Regardless, vermicomposting converts the nutrients in the original waste to readily available forms for plant uptake such as nitrate, ammonium, exchangeable calcium and magnesium, and soluble phosphorus (Edwards and Burrows, 1988; Orozco et al., 1996). For these reasons, VC could contribute to soilless potting media by providing an organic nutrient source and additional structure.

Research has shown that addition of VC improves plant growth, with the most positive effects in media containing 10% to 20% by volume (Atiyeh et al., 2000a; Subler et al., 1998; Wilson and Carlile, 1989). Many kinds of plants have exhibited positive growth responses when grown in media amended with VC including marigold (*Tagetes patula* L.), tomato (*Lycopersicon esculentum* L.) (Atiyeh et al., 2000a, 2000c; Bachman, 1998; Subler et al., 1998;), Ficus, and *Dracaena* (Grappelli et al., 1985).

Vegetable transplant production is one possible market where VC could improve transplant quality and reduce production time. Media for transplant production should have small particle size, good drainage and moisture retention (Sterrett, 2001), which are reported characteristics of media containing VC (Atiyeh et al., 2001; Bachman, 1988). A comparison of cabbage (*Brassica oleracea* L. var. *capitata*) transplants grown in 100% VC and commercial seedling medium showed that larger, more mature transplants were obtained with the 100% VC treatment (Edwards and Burrows, 1988). However, larger size and greater maturity are not always beneficial traits when transplanting into the field especially by mechanical means. Transplant quality is usually assessed using the following criteria: uniformity, stockiness, adaptability, early maturity in the field, and overall health. If transplants grow faster in VC and result in the same quality, vegetable transplant production time could be reduced, although higher growth rates could result in poorer quality transplants.

The objective of this research was to evaluate the effect on the quality and field performance of transplants when grown in media amended with VC. We chose three vegetable crop species that vary in difficulty in transplanting: tomato, which is considered easy to transplant, and two species considered moderately difficult to transplant, pepper and eggplant (*Solanum melongena* L.) (Maynard and Hochmuth, 1997).

Materials and Methods

Experiment 1. Eggplant (‘Epic’), bell pepper (‘Paladin’), and fresh-market tomato (‘Mountain Fresh’) seeds (Rupp Seeds, Wauseon, Ohio) were sown into 50-cell plug trays (5 × 5 × 6 cm) (Hummert International, Earth City, Mo.) on 4, 6, and 18 Apr. 2001, respectively. Each selection is a commercially grown fresh market variety with some inherent disease resistance. A commercial soilless potting medium [Metro Mix 360 (MM360); The Scotts Co., Marysville, Ohio] was blended with VC at 0%, 10%, and 20% by volume in a small cement mixer. The VC was derived from dairy cattle manure processed by *E. fetida* at the Ohio Agricultural Research and Development Center (OARDC, Wooster, Ohio). Nutritional analyses of the VC and the mixes were completed at the Star Lab at the OARDC (Table 1). Two plug trays were sown per treatment with three replications.

Vegetable seedlings were grown in a double polycarbonate-glazed greenhouse, irrigated daily by hand, and fertigated with 200 $mg \cdot L^{-1}$ N using 20N–4.4P–16.6K Peter’s Professional Peat-lite Special (The Scotts Co.) three times per week. On 14, 19, and 22 June 2001, 10 random transplants from each set of plug trays were evaluated for stem height (soil level to apical meristem), stem width at the cotyledonary node, number and area of fully expanded leaves (including cotyledons), and shoot and root dry weights. Leaf area values were obtained with a leaf area meter (model 3100; LI-COR, Inc., Lincoln, Neb.), and area per leaf was calculated from the observed values. Dry weights were recorded after tissue was dried at 55 °C for 5 d, and the shoot to root ratio was determined from the dry weight data.

Chlorophyll was extracted with N, N-dimethylformamide (DMF) from three pieces about 1-cm^2 cut with a paper punch from the newest, fully expanded leaves per seedling (Moran and Porath, 1980). Each tissue sample was stored in 5 mL of DMF in complete darkness at 4 °C for 5 d. Absorbance of the resulting extract was measured at 647 and 664 nm with a spectrophotometer (U-2000; Hitachi, Tokyo, Japan). Actual chlorophyll concentration was determined using the formula from Moran (1982).

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On 11 June 2001, 15 plants from each experimental unit were transplanted into a Miamian silty loam at the Waterman Agricultural and Natural Resources Laboratory (Columbus, Ohio). In May 2001, 45.4 kg·ha^{-1} of N (46–0–0) had been incorporated into the soil before bed shaping. Black plastic mulch and drip irrigation was installed on raised beds of 22.9 m in length and 91 cm in width and with centers spaced 1.5 m apart. Plants were placed in single rows with 45.7 cm in-row spacing in each 7.6 m plot with three replications. A randomized complete block design was used with the three treatments randomized in each row. Immediately after transplanting, 236 mL of liquid starter fertilizer (10–52–10) was applied to each seedling. Treflan (trifluralin; α,α,α-trifluo-2,6-dinitro-*N*,*N*-dipropyl-*p*-toluidine, Dow AgroSciences LLC, Indianapolis, Ind.) was applied before planting to discourage pre-emergent weed growth, and Roundup (glyphosate; N-phosphonomethylglycine, Monsanto Co., St. Louis, Mo.) was used between rows to control post-emergent weed growth. No additional pesticides were utilized due to low pest pressure. Plants were irrigated to supplement rainfall to 2.5 cm per week. Tomatoes were trellised according to Neary (1992).

The number of days to first flower was determined as the number of days until over 50% of the plants per plot had opened their first flower as in Garner and Björkman (1999). Yield was measured every 7 to 10 d for a period of one month. Peppers and eggplants were hand-harvested when they reached a marketable size (7.5 to 15 cm diameter) while tomatoes were hand-harvested when they reached the breaker stage of fruit maturity. Peppers were harvested on 27 July and 2, 8, and 20 Aug.; eggplants were collected 27 July and 6, 15, 20, and 30 Aug.; and tomatoes were harvested on 15, 21, and 30 Aug. Total yield, number of fruit, and individual fruit weight was determined on each harvest date. Marketable and nonmarketable fruit were weighed separately. The aboveground biomasses of the pepper plants were harvested on 27 Aug. and dried at 55 °C for 10 d. Data within each species were analyzed with Fisher's protected LSD on SAS V8 (SAS Institute, 1990). There were no significant differences, and hence not reported.

Experiment 2. The same varieties of peppers and tomatoes were seeded into 200-cell (2.3 × 2.1 × 3.7cm) plug trays (Hummert International, Earth City, Mo.) on 29 Oct. 2001. 'Epic' eggplant seeds were also sown that day but in the same 50-cell trays used in Expt. 1. Each plug tray was divided into three pieces so that each treatment medium (0%, 10%, and 20% VC) could be represented in each flat. The 50-cell plug tray contained 3 segments of 15 cells each while the 200-cell plug tray held 3 sections of 60 cells. A randomized complete block design was used with five replications. Data were only collected on three replications for peppers because of mice damage. Growing conditions were similar except all were fertigated three times a week with 50 mg·L^{-1} N using the same fertilizer as Expt. 1 until 28 Nov. 2001 when the concentration was increased to 100 mg·L^{-1} N. Photosynthetic active radiation (PAR) was supplemented with 100 μmol·m^{-2}·s^{-1} at bench height using high intensity discharge metal halide lamps when outside light intensity dropped below 300 W·m^{-2}.

Five random seedlings from each experimental unit (section of flat) were destructively harvested 2, 4, and 6 weeks after germination. At the 2-week harvest, stem height, number and area of fully expanded leaves, root length (soil line to longest root tip), and total dry weight (shoot + root) were measured. At 4 and 6 weeks after germination, stem height, stem width at the cotyledonary node, leaf number and area, and total dry weight were recorded. Root length at 4 weeks was not an accurate measure because roots had begun to grow into the capillary mat underneath the plug trays. Peppers were only harvested at 2 and 4 weeks because they were replanted and delayed due to the mice damage. No plants were transplanted into the field. Data were analyzed as in Expt. 1.

Experiment 3. Eggplant, pepper, and tomato seeds were sown in the same manner as Expt. 2 on 16 and 17 Apr. 2002. The same experimental design was used except two flats of eggplant transplants equaled one replication. Cultural practices were similar to Expt. 1 except transplants were fertigated three times a week with 50 mg·L^{-1} N during their entire growing period in the greenhouse. Five random seedlings were harvested at 2, 4, and 6 weeks after germination, and the same parameters measured as in Expt. 2 except that shoot and root dry weights were recorded separately. Relative chlorophyll contents were compared 6 weeks after germination with a SPAD chlorophyll meter (SPAD-502; Minolta, Osaka, Japan). One reading on each of the three newest, fully expanded leaves per seedling was averaged to obtain the relative chlorophyll value.

Six-week-old eggplant (4 June), tomato (7 June), and pepper (10 June) seedlings were transplanted into raised beds at Waterman Farm as in Summer 2001 but in another area of the farm with the same soil type. Twelve seedlings were planted in single rows with 45.7 cm in-row spacing in each 6.1-m plot in a randomized complete block design with five replications. Before raised bed preparation, 31.8 kg·ha^{-1} of N (46–0–0) was incorporated into the soil. An additional 13.6 kg·ha^{-1} of N as $CaNO_3$ (15-0-0) was applied in two liquid side-dressings on 11 and 30 July. All other cultural practices followed the Summer 2001 methods.

Days to first flower were recorded as before. Yield was measured four times every 7 to 10 d for each species. Fruits were hand-harvested at the same stage of maturity as in 2001, but only marketable fruit yield was measured. Peppers were harvested on 8, 19, and 27 Aug. and 6 Sept.; eggplants were harvested 23 July and 1, 9, and 20 Aug.; and tomatoes were collected on 23 and 29 Aug. and 6 and 13 Sept. Eggplants and tomatoes were only harvested from the middle six plants per plot. In 2002, pepper transplant survival rate was poor, and as a result, there were uneven numbers of plants per plot. Yield was collected from all plants, but yield data were compared as fruit weight per plant and number of fruit per plant. Aboveground biomass from all the pepper plants and the six eggplants per plot that were harvested were collected and dried at 55 °C for 10 d to generate the dry weight values. All data were analyzed as in Expts. 1 and 2. However, no significant differences were found, and so these results are not reported.

Results

Transplant growth. Tomato height was significantly higher in the 20% VC media in the Expt. 1 (Table 2). In Expts. 2 and 3, tomato transplants grown in VC were taller than the control at all three harvests (Table 3). During weeks 2 and 4, both VC rates produced taller plants than the control while only 10% VC produced taller 6-week-old transplants (Table 3). Leaf number, and total and individual leaf area was increased in the 20% VC grown plants compared to the control during Expt. 1 (Table 2). In Expts. 2 and 3, 2-week-old transplants also had increased total and individual leaf areas when grown in VC (Table 3). Root dry weights were significantly greater in the 20% VC and 10% VC during the first growing season (Table 2). Dry root weights of 10% VC plants were lower than the control (Table 2). No difference in shoot dry weight or shoot to root ratio was detected. Tomatoes grown in 10% VC had lower relative chlorophyll content (30.8 SPAD units) than the control or 20% VC (32.8 and 32.5 SPAD units, respectively) in Expts. 2 and 3. No significant differences were detected in stem diameter among the tomato transplants during the entire study (data not shown).

No difference in eggplant seedling heights was detected during this study. In Expts. 2 and 3, 2-week-old eggplants had less total and individual leaf area when grown in 20% VC than the other two treatments (Table 4). In the same experiments, 6-week-old transplants had a slightly greater average stem diameter (4.5

Table 1. Nutritional content and chemical properties of the three soilless media mixes containing different proportions of vermicompost (VC) used as treatments in this study.

Mix	pH[z]	Soluble salts (mS·cm^{-1})	NO_3-N	NH_3-N	P	K	Ca	Mg
			(μg·mL^{-1})					
0% VC[y]	5.63	2.1	4	6.56	3	158	130	87
10% VC	6.04	2.8	82	1.06	19	316	167	119
20% VC	6.16	3.6	202	0.89	28	440	201	149

[z] Analyses conducted by the Star Lab at the Ohio Agriculture Research and Development Center (OARDC) in Wooster.

[y] Percent by volume VC content of soilless potting medium (Metro Mix 360; The Scotts Co., Marysville, Ohio).

Table 2. The effect of incorporating vermicompost VC) in the growing medium at three different rates on various growth parameters of transplants of three different vegetable species. Data from Spring 2001 growing season, Columbus, Ohio.

Treatment	Ht (cm)	Leaf no.	Leaf area (cm^2)	Area/leaf cm^2)	Dry shoot wt (g)	Dry root wt (g)	Shoot to root ratio
Tomato							
0% VC	40.7 b[x]	6.3 b	211.57 b	33.47 b	1.51 a	0.27 b	5.84 a
10% VC	39.8 b	6.0 b	196.96 b	32.77 b	1.66 a	0.20 c	11.70 a
20% VC	44.4 a	6.9 a	281.79 a	40.77 a	1.89 a	0.35 a	5.35 a
LSD	1.62	0.33	26.85	3.34	NS	0.05	NS
Eggplant							
0% VC	36.4 a	4.9 a	278.98 a	55.82 a	1.78 ab	1.52 a	1.84 c
10% VC	37.5 a	5.3 a	307.82 a	56.75 a	2.19 a	0.66 b	3.96 a
20% VC	37.2 a	5.0 a	272.04 a	53.28 a	1.58 b	0.69 b	2.76 b
LSD	NS	NS	NS	NS	0.42	0.35	0.81
Pepper							
0% VC	28.7 a	8.7 a	199.31 a	22.97 a	0.64 a	0.41 a	2.10 b
10% VC	28.2 a	8.3 a	171.70 b	20.77 b	0.48 b	0.24 c	2.55 ab
20% VC	27.7 a	8.5 a	184.70 b	21.67 b	0.60 a	0.33 b	3.07 a
LSD	NS	NS	13.99	1.26	0.09	0.08	0.85

[z] Each column was analyzed with Fisher's protected LSD per species at $\alpha = 0.05$. Values with different letters are significantly different at the 0.05 level.

[NS] Nonsignificant values.

mm) when grown in 20% VC compared with the control (4.3 mm). The same trend was seen in leaf number (Table 4). Differences in dry weights were only seen in 6-week-old seedlings during this study. In Expt. 1, eggplants grown in 10% VC had greater shoot dry weights and shoot to root ratios (Table 2). The control plants had higher dry root weights than the VC treatments (Table 2). Six-week-old eggplant transplants grown in 10% VC also exhibited greater total dry weight than the control in Expts. 2 and 3 (Table 4). Leaf chlorophyll content was also greater in 10% VC grown transplants (85.8 µg·cm^{-2}) than those grown in 20% VC (76.0 µg·cm^{-2}) in Expt. 1 only. No significant differences were found among root length during the study (data not shown).

Pepper seedling growth was inconsistent among experiments. No difference in pepper seedling height was observed in Expt. 1. However, 2-week-old pepper seedlings grown in 10% VC were taller than those grown in 20% VC, and 6-week-old transplants grown in 20% VC were taller than the control plants (Table 5). In Expts. 2 and 3, stem diameters were smaller in 6-week-old control plants (0% VC = 2.7 mm; 10% and 20% VC = 2.9 mm; $P < 0.05$) while root length was greater in the control (8.4 cm) than the other two treatments (10% VC = 7.7 cm; 20% VC = 7.8 cm; $P < 0.05$). Both rates of VC had an adverse effect on leaf area in Expt. 1 while only 20% VC reduced leaf area in 2-week-old seedlings in Expts. 2 and 3 (Table 2 and 5). However, 6-week-old transplants in Expts. 2 and 3 exhibited greater total leaf area when grown in 20% VC (Table 5). Pepper transplants grown in 10% VC in Expt. 1 had a lower shoot and root dry weight than the control and 20% VC groups, but the shoot to root ratio of the 20% VC group was greater than the control (Table 2). In Expts. 2 and 3, total dry weights were also increased in 2- and 6-week-old peppers with 10% and 20% VC, respectively compared to the control (Table 5). Peppers grown in 20% VC also had greater relative chlorophyll values (30.0 SPAD units) than the control (27.7 SPAD units) in Expts. 2 and 3, but this difference was not visible (data not shown).

Field data. No significant differences were observed in the data collected from the field. All groups were developmentally similar according to data collected on days to first flower. All fruit values (total yield, number of fruit, and average fruit size) were identical across treatments as well. Weekly yield and final biomass measurements were also not different (data not shown).

Discussion

Overall, the inclusion of VC to soilless growth medium resulted in a positive effect on various growth parameters of tomato, eggplant, and pepper plants. VC-grown tomato transplants were taller and had more leaf area, but dry weight did not increase accordingly resulting in slightly poorer quality (Tables 2 and 3). Eggplant and pepper transplant quality was slightly improved. Pepper transplants grown in VC resulted with greater height, stem diameter, leaf area, chlorophyll content, and total dry weight (Tables 2 and 4). Eggplant height remained the same but stem diameter, leaf number, and dry weight increased (Tables 2 and 5). However, in all three cases, the positive impact of VC on growth was not great enough to affect the time necessary to produce plants of sufficient size for transplanting.

Increased N levels are known to enhance vegetative growth and chlorophyll content in a manner similar to VC supplementation (Marschner, 1986). This indicates that the positive growth effects we observed might be due to the additional nutrients, especially NO_3^--N provided by the VC (Table I). Alternatively, the VC could have increased the cation exchange capacity (CEC) of the media, which would have allowed it to retain more positively charged nutrients, especially NH_4^+ (Edwards and Burrows, 1988). Finally, humic acids found in VC have also been shown to increase nutrient uptake and/or cause hormone-like effects (Atiyeh et al., 2000b; Valdrighi et al., 1996). Thus, regardless of the mechanism, the use of VC could possibly reduce the need for inorganic fertilizers, especially during the early stages of production.

Atiyeh et al. (2000a) observed higher marketable yield per plant and individual fruit weight when greenhouse tomatoes were grown in 20-L pots containing soilless media amended with 20% (v/v) pig-manure-based VC. Higher yields of tomatoes and peppers were also obtained when cow-manure-based VC was directly amended to the field soil at 5 t·ha^{-1} (Arancon et al., 2003). In contrast we did not observe any significant differences in the field performance of transplants when grown in media supplemented with VC. Possibly there were not enough degrees of freedom in the field data to observe any significant differences. Even when the number of replications was increased from three to five in the second summer, the increase may not have been sufficient to detect a difference between plots. However this seems unlikely in view of the fact that yield differences would probably have been minimal since the amount of VC contained in the 18-mL plug cell was small relative to that of the 20-L pots or mixed with the field soil.

Our results have shown that VC is a potential component in soilless potting media for vegetable transplant production at 10% and 20% rates. Transplant quality was not drastically changed and no adverse effects on yield were seen in the field. However, preplant analysis of the VC is strongly recommended to ascertain nutritional content and detect possible contaminants and adverse effects on media characteristics.

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Table 3. The effect of incorporating vermicompost (VC) in the growing medium at three different rates on various growth parameters of tomato transplants at three different times after germination. Data from Fall 2001 and Spring 2002 growing seasons, Columbus, Ohio.

Treatment	Ht (cm)	Leaf no.	Leaf area (cm^2)	Area/leaf (cm^2)	Total dry wt (g)
Week 2					
0% VC	4.8 b^z	4.0 a	10.80 b	2.70 b	0.046 a
10% VC	5.2 a	4.0 a	12.48 a	3.11 a	0.051 a
20% VC	5.1 a	4.0 a	12.67 a	3.17 a	0.050 a
LSD	0.26	NS	1.15	0.29	NS
Week 4					
0% VC	8.6 b	4.8 a	37.85 a	7.44 a	0.16 a
10% VC	9.1 a	4.7 a	36.48 a	7.29 a	0.17 a
20% VC	9.4 a	4.8 a	39.99 a	7.84 a	0.18 a
LSD	0.45	NS	NS	NS	NS
Week 6					
0% VC	13.9 b	6.2 a	88.43 a	12.88 a	0.35 a
10% VC	15.3 a	6.2 a	95.41 a	13.58 a	0.38 a
20% VC	14.2 b	6.4 a	102.30 a	14.23 a	0.41 a
LSD	0.86	NS	NS	NS	NS

^{z}Each column was analyzed with Fisher's protected LSD at $\alpha = 0.05$. Values with different letters are significantly different at the 0.05 level.

^{NS}Nonsignificant values.

Table 4. The effect of incorporating vermicompost (VC) in the growing medium at three different rates on various growth parameters of eggplant transplants at three different times after germination. Data from Fall 2001 and Spring 2002 growing seasons, Columbus, Ohio.

Treatment	Ht (cm)	Leaf no.	Leaf area (cm^2)	Area/leaf (cm^2)	Total dry wt (g)
Week 2					
0% VC	4.0 a^z	3.6 a	18.28 a	4.84 a	0.061 a
10% VC	3.9a	3.6 a	18.07 a	4.90 a	0.060 a
20% VC	3.8a	3.5 a	16.63 b	4.50 b	0.061 a
LSD	NS	NS	1.28	0.33	NS
Week 4					
0% VC	9.2 a	4.6 a	79.29 a	17.56 a	0.34 a
10% VC	9.1 a	4.5 a	80.58 a	18.09 a	0.35 a
20% VC	9.0 a	4.5 a	84.07 a	18.78 a	0.35 a
LSD	NS	NS	NS	NS	NS
Week 6					
0% VC	15.6 a	5.2 b	198.71 a	37.80 a	0.91 b
10% VC	14.7 a	5.6 a	212.64 a	37.38 a	1.00 a
20% VC	15.1 a	5.7 a	210.71 a	36.81 a	0.92 ab
LSD	NS	0.3	NS	NS	0.08

^{z}Each column was analyzed with Fisher's protected LSD at $\alpha = 0.05$. Values with different letters are significantly different at the 0.05 level.

^{NS}Nonsignificant values.

Table 5. The effect of incorporating vermicompost (VC) in the growing medium at three different rates on various growth parameters of pepper transplants at three different times after germination. Data from Fall 2001 and Spring 2002 growing seasons, Columbus, Ohio.

Treatment	Ht (cm)	Leaf no.	Leaf area (cm^2)	Area/leaf (cm^2)	Total dry wt (g)
Week 2					
0% VC	4.2 ab^z	4.0 a	8.30 a	2.09 a	0.032 b
10% VC	4.3 a	3.9 a	8.13 a	2.07 a	0.038 a
20% VC	4.0 b	3.8 a	6.89 b	1.80 b	0.034 ab
LSD	0.24	NS	1.14	0.23	0.004
Week 4					
0% VC	7.3 a	5.7 a	21.91 a	3.64 a	0.09 a
10% VC	7.2 a	5.6 a	20.57 a	3.53 a	0.09 a
20% VC	7.4 a	5.9 a	22.22 a	3.69 a	0.09 a
LSD	NS	NS	NS	NS	NS
Week 6					
0% VC	9.2 b	6.0 a	17.87 b	3.03 a	0.16 b
10% VC	9.5 ab	5.9 a	17.88 b	3.08 a	0.17 ab
20% VC	10.0 a	6.0 a	19.79 a	3.29 a	0.18 a
LSD	0.6	NS	1.34	NS	0.018

^{z}Each column was analyzed with Fisher's protected LSD at $\alpha = 0.05$. Values with different letters are significantly different at the 0.05 level.

^{NS}Nonsignificant values.

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