Spent Mushroom Compost and Biological Amendments as an Alternative to Soilless Media

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Introduction

The vegetable transplant industry in Florida relies entirely on soilless media (predominantly peat moss) as a substrate for its plant production (Vavrina and Summerhill, 1992). Soilless media accounts for approximately 9.3% of the total production cost of a vegetable transplant (Zimet and Vavrina, 1995). Peat, a non-renewable resource, is harvested both in Florida and Canada to supply Florida's industry. Escalating peat costs cannot be easily passed on to the consumer, as the cost per 1,000 plants ($26.00) has remained essentially static over the last 5 years. Growers have been forced to use smaller cells for production thereby increasing the number of plants per greenhouse to reduce production costs. Smaller cell sizes increase space efficiency, but do not necessarily reduce peat use, or improve plant quality (Maynard et al., 1996). A locally produced, renewable, contaminant free, material such as spent mushroom compost (SMC), could provide a low cost alternative to soilless media for vegetable transplant production.

Quincy Farms (Quincy, FL) produces approximately 33,150 tons (dry weight) of composted horse manure/peat/straw per year from its mushroom production facility. The process requires fresh material for each production run as yields decline with each subsequent use of the same substrate. The spent mushroom compost (SMC) is presently transported to local area farms, dumped, and tilled in. This technique is considered more as waste disposal than as a value added soil amendment (0.5% N). A possible alternative use for SMC would be as a soilless mix (Gerrits, 1994). The vegetable transplant industry alone (a minor player in this market) uses about 3,400 tons of transplant mix per year.

Methods

A fresh SMC (60%) supplied by Quincy Farms (Quincy, FL) was air dried and screened through a 1/4 inch mesh. Of the 72.5 liters of SMC screened, 38 liters (52.4%) passed through unassisted, 12 liters (16.5%) passed through with a slight (hand) pressure applied, and 22.5 liters (31.1%) remained in clods. The clod material could have been utilized with additional milling procedures. Samples of the screened SMC were treated with various biologicals (micro-encapsulated bacteria and fungi) to prepare eight separate treatments which were compared to MetroMix 220 (Scott's Co., Marysville, Ohio) a standard soilless media for transplant production. The treatments were:

MetroMix 220 (MM)	
Compost Alone	
Compost + AG	nutrients & microbes
Compost + 1B2	polymer & microbes
Compost + GP1	enhances AG
Compost + AG & 1B2	
Compost + AG & GP1	
Compost + 1B2 & GP1	
Compost + AG, 1B2, GP1	

An identical trial was set up using the same biologicals as amendments to MM alone to assess activity in a peat based media. The amended soilless media treatments were placed in separate rows of a 242 cell Speedling flat. Each media row (11 cells) was separated from the next row containing media by a blank row to assure integrity and reduce splashing of the amendments between treatments. All flats were seeded with 'Agriset 761' (Peto Seed, Saticoy, CA) tomato. Four replications were set out in a randomized complete block design within the horticulture greenhouse at the Southwest FL Research and Education Center. Plants were watered as needed and fertilized with 200 ppm N weekly from a commercial 20-20-20 soluble source. Data was taken on germination and height, top fresh weight, root fresh weight, leaf area, top dry weight, root fresh weight, root to shoot ratio, and leaf number after 5 weeks of growth.

Results

Germination Tomato generally takes seven days to germinate at optimal temperatures. The data (number of seed out of 11) show that germination/emergence of all SMC treatments lagged behind that of MM alone for 5 days (8 days after planting in Table 1). SMC alone and GP1 emergence equalled that of MM on day 13, but 4 additional days were required for the other treatments to reach emergence levels comparable to MM.

The increased time to emergence resulting from the compost and compost amended substrates will be of great concern to the potential end user. We therefore ran a substrate toxicity test, utilizing a 20 g air dried sample of the SMC leached with 50 mls water. The leachate, used as the imbibitional water for germination, was applied to filter paper in Petri dishes. Twenty-five cress seed were placed on the leachate saturated filter paper. A control (distilled water) and a known cress germination inhibiting media (coconut coir) leachate were used for comparison. Three replications of each imbibitional agent were implemented.

The outcome of the leachate test (Fig. 1) showed that the reduced germination noted in the SMC was not the result of toxic compounds. Visual observation of the seedlings later in the study indicated that the air dried SMC did not hold water as well as the MM and was therefore removed more rapidly. This complication may be remedied by the addition of vermiculite, a known water holding agent. It is interesting to note that under the "assumed" water stress conditions imposed by the SMC, tomato seedling emergence in some biologically amended treatments was slower than in SMC alone (Table 1). This may also be a response to unavailable water, a necessity to all living organisms.

When the SMC biological amendments were applied to MM alone no differences in germination/emergence were noted at any time over the course of the trial (Table 2). This may substantiate the above reference to lower SMC water holding capacity, as all treatments in this study had available water at all times and hence performed like the MM.

Plant Parameters Table 3 displays the characteristics of a 5 week old tomato transplant grown in SMC, biologically amended SMC, and MM. The data indicate that the SMC and SMC amended substrates do not augment plant height, root fresh weight, top or root dry weight, number of leaves, or root to shoot ratio. However, the SMC alone and certain of the SMC plus biological amendments do provide a greater top fresh weight (AG, 1B2, GP1, AG + 1B2, AG/1B2/GP1) and a larger leaf area (all biologicals and their combinations).

Generally a greater top fresh weight without a supporting dry weight increase indicates more stored water or a more succulent plant. Transplant growers fear succulence as such plants do not transplant as well as "hardened" plants (those purposely stressed by withholding water and nutrients) especially under stressful conditions. The organic nature of the SMC would tend to deliver N in a slow release manner, affording growers less "control" over growth. However, greenhouse managers could impose more hardening control in this case if necessary.

The addition of the biological amendments to the SMC does not seem totally justified at this time. None of the categories assayed show the biologicals to perform better than the SMC alone which consistently posts the highest values measured. This is supported by the information illustrated in Table 4 which shows the addition of these biologicals alone or in combination does not benefit plant growth compared to MM alone.

Discussion

This study indicated that spent mushroom compost, at this early stage of development, may have promise as a soilless media for vegetable transplant production. Further studies must be carried out to determine modifications (such as vermiculite additions to improve moisture retention) necessary to make SMC more compatible with transplant grower needs. Studies must be carried out on product consistency as an inconsistent SMC will result in erratic plant growth for the end user (Vavrina, 1996) and possibly loss of market.

While this test did not show the benefits of amending the SMC with the suggested microbial package, of interest is the fact that when applied to the SMC, the biologicals out performed (in most cases) the MM. This implies two things: 1.) MM is predominantly cellulose, thereby offering very little carbon in a readily available source for utilization by the microbes (i.e. no food), and 2.) the SMC offers more microbial food sources, but relegates the microbes to the role of consumers which, while not hindering plant growth, does not impart any benefit either. Perhaps a better test would be to compare "raw" SMC to SMC "finished" with the suggested microbes.

It must be remembered that this is just a preliminary test, and though some conclusions can be drawn, further testing must be done before definitive statements can be made concerning the wholesale use of SMC as an alternative soilless media for vegetable transplant production.

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Table 1. Emergence of tomato seedlings from spent mushroom compost, with and without microbial amendments and MetroMix 220.*

Treatment	Number of seeds germinated out of eleven					
	8 DAP	9 DAP	10 DAP	13 DAP	15 DAP	17 DAP
SMC alone	0.25 b	1.25 b	1.7 b	6.2 ab	8.3 ab	9.3
MM alone	4.50 a	8.00 a	8.7 a	9.5 a	9.7 a	9.7
SMC + AG	0.00 b	0.00 b	0.5 bc	5.0 b	6.7 bc	9.0
SMC + 1B2	0.00 b	0.25 b	0.3 bc	3.3 b	5.3 c	9.0
SMC + GP1	0.00 b	1.00 b	1.5 bc	5.8 ab	8.3 ab	9.5
SMC + AG + 1B2	0.00 b	0.00 b	0.0 c	4.5 b	6.7 bc	9.5
SMC + AG + GP1	0.00 b	0.00 b	0.5 bc	5.3 b	7.0 bc	9.5
SMC + 1B2 + GP1	0.25 b	0.50 b	1.0 bc	3.3 b	5.5 c	8.0
SMC + AG/1B2/GP	0.00 b	0.50 b	1.3 bc	5.5 b	8.0 ab	9.5
LSD 0.05	1.33	1.45	1.6	3.9	2.4	NS

*Values followed by the same letter(s) are not significantly different from one another. The Fishers LSD ($p \geq 0.05$) value is the statistical measure of difference. NS stands for not significantly different.

Table 2. Emergence of tomato seedlings from MetroMix 220 with and without microbial amendments.

Treatment	Number of seeds germinated out of eleven					
	8 DAP	9 DAP	10 DAP	13 DAP	15 DAP	17 DAP
MM alone	3.7	5.7	8.0	9.5	9.5	9.7
AG	4.0	7.3	9.0	9.5	9.5	9.5
1B2	4.5	7.7	9.5	9.7	9.7	10.0
GP1	3.5	7.7	9.3	9.7	9.7	9.7
AG + 1B2	5.5	8.2	9.0	9.0	9.0	9.5
AG + GP1	3.5	7.0	8.2	9.3	9.3	9.3
1B2 + GP1	6.0	8.0	9.5	9.7	9.7	9.7
AG/1B2/GP	4.3	7.7	9.0	9.5	9.5	9.7
LSD 0.05	NS	NS	NS	NS	NS	NS

Table 3. Tomato seedling growth parameters from culture in SMC or MetroMix 220 with and without microbial amendments.

Treatment	Height	Top FW	Root FW	Leaf Area	Top DW	Root DW	R:S	Leaves
	(cm)	(g)	(g)	(cm^2)	(g)	(g)		(#)
SMC alone	9.9	2.22 a	1.23	42.4 a	0.25	0.10	0.40	3.8
MM alone	8.4	1.29 c	0.92	21.2 d	0.17	0.07	0.40	3.6
SMC + AG	9.1	2.02 ab	1.07	41.3 ab	0.22	0.08	0.36	3.9
SMC + 1B2	9.7	1.89 ab	0.99	39.2 abc	0.20	0.09	0.38	3.7
SMC + GP1	9.5	1.99 ab	1.14	39.0 abc	0.22	0.09	0.39	3.7
SMC + AG + 1B2	8.9	1.80 ab	1.04	36.4 abc	0.20	0.08	0.40	3.7
SMC + AG + GP1	8.9	1.71 bc	1.01	34.5 bc	0.19	0.08	0.40	3.8
SMC + 1B2 + GP1	8.8	1.59 bc	0.93	32.6 c	0.17	0.07	0.41	3.6
SMC + AG/1B2/GP	9.8	1.85 ab	1.02	36.8 abc	0.21	0.08	0.40	3.9
LSD 0.05	NS	0.47	NS	NS	NS	NS	NS	NS

Table 4. Tomato seedling growth parameters from culture in MetroMix 220 with and without microbial amendments.

Treatment	Height	Top FW	Root FW	Leaf Area	Top DW	Root DW	R:S	Leaves
	(cm)	(g)	(g)	(cm^2)	(g)	(g)		(#)
MM alone	7.2	1.17	0.86	19.15	0.17	0.07	0.59	3.6
AG	6.9	1.15	0.79	18.96	0.17	0.06	0.38	3.5
1B2	7.2	1.20	0.87	19.64	0.18	0.07	0.40	3.9
GP1	6.9	1.16	0.85	19.32	0.18	0.07	0.41	3.7
AG + 1B2	7.0	1.16	0.87	19.13	0.18	0.08	0.43	3.5
AG + GP1	7.1	1.24	0.91	20.93	0.19	0.08	0.40	3.7
1B2 + GP1	7.1	1.15	0.83	18.88	0.17	0.07	0.42	3.7
AG/1B2/GP	7.0	1.07	0.83	18.17	0.16	0.07	0.43	3.7
LSD 0.05	NS	NS	NS	NS	NS	NS	NS	NS