Extensive Soil Mix Studies for Greenhouse Production of Seedlings and Transplants

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In the Cornell greenhouse program we have been studying the characteristics that make up good quality potting mixes for production of vegetable seedlings and transplants. Both conventional and organic potting mixes have been studied, but in our most recent work which we will describe here our objective was to compare different commercially or locally available organic substrates for use in seedling germination (200 plug trays with a 20 mL volume per cell) or in 4-inch container transplants (500 mL volume per pot). We have noticed an increased interest in organic production methods and locally prepared potting mixes. However as compared to conventional mixes, organic mixes can be more challenging to manage fertility, pH, and salts. Many organic potting mixes have enough fertility to support sufficient plant growth for about the first 4 weeks; these mixes seem to be preferred by organic growers to avoid the expense and labor of supplementing with additional fertility. Therefore in our trial we did not add additional fertilizers to see how the mixes would perform on their own. If necessary, additional fertility can be added by top-dressing granular materials or using liquid products. We have had success with many organic fertilizers in our trials.

The mixes trialed in this study included: Sun Gro Sunshine Natural & Organic #1 (Sun 1) and #4 (Sun 4), Sun Gro Metro-Mix Natural and Organic PX-2, a Cornell vermicompost mix (Cor), an Ithaca locally formulated mix (Ith), Vermont Compost Fort Lite (VFL) and Fort Vee (VFV), and McEnroe Organic Premium Lite (MOPL). All these mixes were acceptable for certified organic production. The Cornell vermicompost mix was, by volume, 70% peat, 35% coarse perlite and 5% vermicompost (Worm Power LLC, Avon, NY). To this we added 2.5 lbs./yd^3 dolomitic limestone (more can be used if the irrigation water is low in alkalinity), 5 lbs./yd^3 each of green sand and rock phosphate and 3.5 5 lbs./yd^3. The Ith mix was formulated by a local grower in Ithaca New York and was made of compost, peat, coconut coir, perlite and other aggregates and a poultry litter fertilizer. All plants were grown in a glass greenhouse at Cornell University at 70 °F average daily temperature.

In the seedling germination trial seeds of tomato (‘Celebrity’ untreated) and pepper (‘Declaration’ untreated) were sown on the 200 cell trays with 3 replications per substrate treatment. After 4 weeks the experiment was terminated. Germination percentage was determined and the dry weight of 10 combined representative seedlings from a tray was measured.

For the transplant experiment plugs (well-rooted 4-5 week old seedlings) of (‘Celebrity’ untreated) and pepper (‘Declaration’ untreated) were transplanted into 4-inch containers. There were 10 replicate plants for each substrate treatment. Each week leachate samples were taken from 5 randomly selected containers from each substrate treatment and sampled for pH and EC (electrical conductivity, i.e. soluble salts - a measure of fertilizer and non-fertilizer salts). After 4 weeks the experiment was terminated. Plant height and dry weight were determined.

Seedling germination percentages and dry weights from the seedling experiment are reported in Table 2. Germination of pepper was significantly reduced and very poor from the Ith

substrate. This appears to be due to high salts and immature compost in that mix. Size of pepper plants was greatest for the VFL, VFV and MOPL mixes. For tomato trial the germination percentage was greatest for Sun 1 (not significantly different from Sun 4). Ith and Cor mixes had the lowest germination percentage and these were not significantly different from VFL or MOPL. For tomato, the greatest dry weight was found with Cor, MOPL, VFV and VFL. Germination and growth of peppers seems to be negatively affected by high pH of mixes (>6.5) and high EC. Tomato has heavier fertilizer requirements and appears to be less affected by substrate pH and high ammonium in fresh compost.

For the 4-inch container transplant experiment, plant height and dry weights are reported in table 3. Many of the substrates had pH levels above the desirable range during the 4 week production period (optimum during production is 5.5-6.5). Substrate pH increased over time due to our moderately alkaline irrigation water at Cornell University. By three weeks after experiment initiation EC levels of containers had all dropped indicating that nutrients were being consumed by the plant or leached out of the substrate. For pepper, plant size was similar for the VFL, VFV, MOPL, Ith and Cor mixes. However, the Ith mix gave variable growth of plants. Plants were significantly smaller with Sun 1, Sun 2, and PX-2 mixes. For tomato, plant size was greatest for the Ith mix, followed closely by VFV, VFL, MOPL, and Cor. Again plants were significantly smaller with Sun 1, Sun 2, and PX-2 – these mixes had much lighter starter nutrient charge than the other mixes. For optimal plant growth additional organic fertility will need to be added soon after transplanting when using these mixes; while the other mixes tested appear to be suitable for pepper and tomato transplant growth in 4-inch containers at least for 4 weeks.

While we tested the same mixes for both seedling and transplant production, many growers prefer to use separate mixes for these two activities. A more finely textured mix is usually chosen for seedling germination to ensure constant water supply to the germinating seed. However decent aeration of the substrate is still necessary for both seedling and germination mixes (i.e. they should not be too water logged as roots need oxygen). When comparing the seedling to the container trials, the seedlings were more sensitive to mixes high in EC whereas the 4-inch transplants were able to take advantage of the added fertility in these high EC mixes.

To follow up the 4-inch transplant experiment we wanted to see if we could use a granular organic fertilizer, Sustane 8-4-4, to improve the fertility and plant performance of a low fertility mix (Sun 4). Sustane 8-4-4 was incorporated into the potting mix prior to transplanting pepper and tomato seedlings at a rate of 0, 5, 10, 15, and 20 lbs/yd^3. Sustane 8-4-4 successfully grew nice size transplants with optimal fertilizer rates of 5 lbs/yd^3 for pepper and 10 lbs/yd^3 for tomato.

Organic supplied nutrients are primarily slow release and depend on biological processes to convert organically bound nutrients into a plant available form. Conditions that promote microbial activity include warm temperatures, a well-aerated root-zone and a balanced pH. Therefore nutrient release rates of a given fertilizer will vary from operation to operation based on their growing conditions. We expect that our experiences in a well-heated greenhouse (70 °F) may differ from growers if cooler temperatures are used.

Work is in progress at Cornell to compare the performance of several different granular organic fertilizers on 4-inch tomato transplants at average daily temperatures of 50, 60, and 70 °F. Our initial results indicate that these fertilizers perform well (with some minor differences) at 60 and 70 F, but plant growth and nutrient availability was really reduced at 50 °F.

Table 1. Analysis of substrates using the saturated media extract method. Preferred range is as reported by the J.R. Peters laboratory.

	pH	Soluble Salts (mmhos/cm)	NO3-N	NH4-N	P	K	Ca	Mg	Na	Cl
			ppm							
Sun 1	6.6	0.43	15	13	5	15	27	17	17	44
Sun 4	6.7	0.52	16	19	10	27	25	15	28	52
PX-2	5.5	1.97	32	18	35	239	112	77	28	58
Cor	5.2	0.48	9	27	13	38	9	5	28	52
Ith	7.1	1.37	2	41	68	215	18	6	77	172
VFL	5.3	3.7	270	3	30	315	347	91	210	180
VFF	5.9	3.37	263	2	21	293	282	71	180	179
MOPL	5.7	3.8	277	1	35	331	390	168	87	120
Preferred Range	5.2-6.3	0.75-3.5	35-180	0-20	5-50	35-300	40-200	20-100	N/A	N/A

Table 2. Germination percentage and plant size of pepper and tomato seedlings in response to different organic substrates. Within each column, values followed by the same letter are not significantly different from each other.

	Germination percentage		**Dry weight of 10 seedlings (g)**	
	Pepper	Tomato	Pepper	Tomato
Sun 1	91% A	90% A	0.10 A	0.33 AB
Sun 4	73 A	85 A	0.17 A	0.19 B
Cor	77 A	60 D	0.40 A	0.69 A
Ith	21 B	46 D	0.15 A	0.60 AB
VFL	87 A	72 CD	0.35 A	0.70 A
VFV	92 A	63 BC	0.33 A	0.77 A
MOPL	71 A	72 CD	0.27 A	0.75 A

Table 3. Plant height and dry weight of pepper and tomato transplants grown in 4-inch containers in response to different organic substrates. Within each column, values followed by the same letter are not significantly different from each other.

	Plant height (cm)		**Plant dry weight (g)**	
	Pepper	Tomato	Pepper	Tomato
Sun 1	14.6 C	22.3 B	0.60 B	1.63 D
Sun 4	14.6 C	22.5 B	0.59 B	1.95 D
PX-2	16.0 C	24.5 B	0.72 B	2.57 D
Cor	20.3 B	31.6 A	2.22 AB	6.76 C
Ith	22.1 AB	31.8 A	5.28 A	9.76 A
VFL	24.8 A	32.1 A	2.51 AB	8.21 B
VFV	19.4 B	33.2 A	2.12 AB	7.88 BC
MOPL	21.6 B	32.5 A	2.48 AB	8.48 AB