Materials and Methods

Seeds of the gynoecious cucumber MSU-713-5 were germinated in soil at 28° C for 72 hr and the seedlings were transplanted to steamed soil in 6 inch clay pots and grown under ambient greenhouse conditions. The period of time was during the summer and the temperatures ranged from 70° to 90° F. At the time when the first true leaf of most plants was 5–7 cm in width, the plants were selected for testing. Plants were selected for uniformity of size and vigor and were randomly assigned to test groups, 10 plants per group. Plants were sprayed with the appropriate gibberellin formulation. The first treatment was made when the first true leaf reached 5–7 cm, the second was one week later and the third 2 weeks after the initial application. All plants were sprayed individually, until uniformly wet, with a stainless steel atomizer (Standard Safety Equipment Co.), at 15 psi.

The formulations were prepared as 1000 ppm stocks in 95% isopropyl alcohol and 5% X-77 (Colloidal Products Corp.) and diluted with tap water to the desired concentration. The group identification and spray concentrations are given in Table 1.

Table 1. Gibberellin formulations and concentrations applied to seedlings of gynoecious cucumber MSU 713-5.

Treatment number	Gibberellin	Concentration (ppm) and number of applications[a] 1	2	3
I.........	Check, no GA	0	0	0
II.........	A_3	1000	1000	1000
III.........	A_4	50	50	50
IV.........	A_7	50	50	50
V.........	A_{13}	50	50	50
VI.........	A_4 (45%)-A_7 (55%)	50	50	50
VII........	A_4 (45%)-A_7 (55%)	25	50	100

[a]First application when first true leaf reached 5–7 cm width; second, one week later and third, 2 weeks after initial treatment.

The sex of the flowers produced at each node was recorded at weekly intervals beginning 2 weeks after the final spray. At each weekly recording, all nodes were examined so that multiple flower production per node could be recorded. The experiment was terminated when at least 6 nodes had been produced above the last staminate flower.

Results and Discussion

The results obtained are tabulated in Table 2.

All treatments were effective in altering sex expression of the gynoecious cucumber used in this experiment. The relative activities of GA_7, GA_4 and GA_3 confirm the earlier work of Bukovac and Wittwer (2, 3) and Brian (4). The mixture of GA_7 and GA_4 is active and compares favorably with pure GA_7, especially when one considers the cost factor. It appears that GA_{13} is less active than GA_7 or the GA_4-GA_7 mixture. Further experiments are necessary to rank its activity along with GA_3 and GA_4.

Although no measurements were made, the elongation of the internodes was greatest with GA_3 followed by GA_4, GA_7 and the mixture and least by GA_{13}. The latter was hardly distinguishable from the controls.

Table 2. Effect of various gibberellins on production of staminate flowers on gynoecious cucumbers.

Treatment no. and GA formulation		Applications and concentration	Sex expression response[a]: Staminate flowers per plant (no.)	Last node producing staminate flower[b]
		No *ppm*		
I	Check	3 × 0	—	—
II	A_3	3 × 1000	22.4 d (6–40)[c]	11.4 cd (5–16)[c]
III	A_4	3 × 50	6.6 b (3–13)	10.1 c (4–14)
IV	A_7	3 × 50	25.2 d (7–45)	12.1 cd (6–16)
V	A_{13}	3 × 50	1.3 b (0– 3)	4.1 b (3– 6)
VI	A_4 A_7	3 × 50	14.6 c (5–23)	12.7 cd (5–16)
VII	A_4 A_7	1st at 25		
		2nd at 50		
		3rd at 100	21.7 d (10–34)	14.9 d (10–18)

[a]Means followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test.
[b]Average node, counting out from crown.
[c]Range of response.

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Fertility Levels in Soil-Substitute Media: Their Influence on Transplant Development, Macro-Nutrient Content, and Yield in Tomato[1]

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Abstract. Tomato transplants were grown in soil-substitutes of peat moss-Turface and peat moss-perlite. Nutrients were added to the mixtures in factorial combinations by varying the levels of N, P, K, and dolomite. Plants grown in peat-Turface were taller and heavier than those grown in peat-perlite. In either medium, plants grown with the high level (10 lb./yd^3) of dolomite were taller than the plants grown with the low level (5 lb./yd^3) of dolomite. Plants grown in peat-Turface contained more N, K, and Ca than did the plants grown in peat-perlite. Plants grown in peat-perlite contained more P than plants grown in peat-Turface. The growing medium had no influence on Mg content of plant tops. The highest and earliest yielding plants were those grown in peat-Turface. The 10-lb. rate of dolomite was essential for high early yields in peat-Turface, but the additional increment of dolomite had no effect on early yields for plants grown in peat-perlite. Interactions existed between media and nutrient levels for growth, nutrient uptake, and early yields.

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Introduction

DEVELOPMENT of plants in soil and other media containing soil is variable and unpredictable. Besides temperature, humidity, solar energy, and watering practices, variability can be attributed to different kinds and amounts of nutrients present, degree of weathering, and physical properties of different soils. These factors can result in variable drainage, aeration, soil-water-nutrient interrelationships, and growth.

Use of standardized mixtures of soil-substitute materials, with the addition of known amounts of specific nutrients, offers promise as a means of overcoming the variability in soils and composts. Such mixtures can be uniformly formulated at each mixing and the addition of specific quantities of certain nutrients to the mixture for a particular crop would assist the researcher and grower in producing uniform transplants.

The use of soil-substitutes for growing horticultural crops is not new. Baker (1) proposed combinations of sand and peat moss. Boodley and Sheldrake (3) and DeWerth and Odom (5) recommended mixtures of peat moss and perlite for growing transplants. Boodley and Sheldrake also recommended a mixture of peat moss and vermiculite. However, the reports show differences in the amounts of fertilizers recommended for growing tomato transplants in a 1:1 mixture of peat moss and perlite. These variations in rates of the same fertilizers and medium seem to indicate that tomato plants will grow satisfactorily at a wide range of nutrient levels in the peat-perlite mixture.

These studies were initiated to evaluate rates of various nutrients and 2 soil-substitute growing media on transplant growth, nutrient content, and subsequent yields for tomato plants.

Materials and Methods

Studies were conducted over a 3-year period with different nutrient levels. The growing medium materials used in these studies were horticultural grades of peat moss, perlite and Turface[2]. The peat moss was passed through a ½-inch square mesh screen before it was moistened and mixed with either Turface or perlite on a 1:1 basis.

The 1965 experiment consisted of 2 levels (0.3 and 0.9 lb./yd^3) of N and K (NK), 2 levels (2 and 4 lb./yd^3) of P, and 3 levels (2.5, 5 and 10 lb./yd^3) of dolomite (D). The 1966 experiment consisted of 2 levels (0.3 and 0.9 lb./^{3}) of N and K, 1 level (2 lb./yd^3) of P, and 2 levels (5 and 10 lb./yd^3) of dolomite. The 1967 experiment consisted of 2 levels (0.5 and 1.0 lb./yd^3) of N, 2 levels (0.5 and 1.0 lb./yd^3) of K, 1 level (2 lb./yd^3) of P, and 2 levels (5 and 10 lb./yd^3) of dolomite. The nutrients were combined in a factorial arrangement. The N and K were combined as one factor in the 1965 and 1966 experiments. Sources of nutrient elements were ammonium nitrate, potassium sulfate, superphosphate, and dolomitic limestone. The nutrients were thoroughly mixed with each dry soil-substitute medium and then placed into 3-inch clay pots. No other nutrients were added to either the plants or the medium during the period the plants were grown in pots.

[2]Product of Wyandotte Chemicals Corporation, Wyandotte, Mich.

'Manapal' tomato seedlings were started from seed sown in an unfertilized mixture of peat-moss and Turface and transplanted into the pots of fertilized medium at the first true leaf stage.

The plants were grown in the greenhouse for 6 weeks each year before field setting. Each treatment, fertilizer within medium, consisted of 8 plants in each of 3 replications in a randomized block design. Four plants of each replicated treatment were used for collecting growth data while the remaining 4 plants were transplanted to the field in the 1966 and 1967 experiments. The same 4 plants used for collecting transplant growth data in 1967 were also used for composition analyses.

Total N of oven-dried tissues, stems and leaves, was determined by the Kjeldahl procedure as modified by Jackson (7). Ca, K and P was determined with the Technicon Autoanalyzer (13). Mg was determined with an atomic absorption spectrophotometer (12).

Results

Transplant growth. Plants grown in peat-Turface were generally taller, darker green, and thicker-stemmed than those grown in the peat-perlite (Fig. 1, Table 1). However, the influence on plant height by peat-Turface was not significantly greater than the influence by peat-perlite for all levels of fertility.

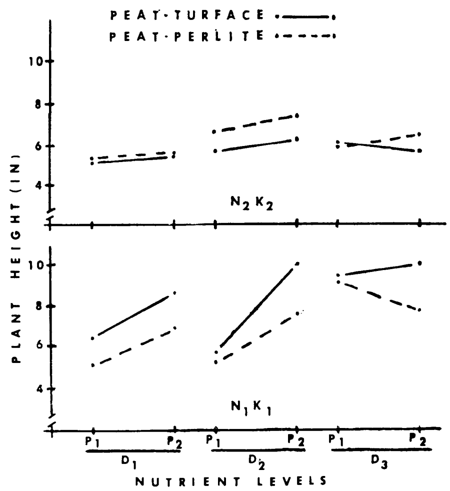

Fig. 1. Effect of N, P, K, and dolomite on heights of tomato transplants after 4 weeks of growth in different media in the 1965 preliminary study.

Results of the preliminary experiment in 1965 (Fig. 1) showed that combinations of N_1K_1 with either the low or the medium level of dolomite with P_2 caused plants to grow larger than those grown with the P_1 rate. However, the P_2 rate with high dolomite in peat-perlite caused a reduction in growth. For plants grown with N_2K_2, additional increments of either P or dolomite in either growing medium had no measurable effect on growth.

In 1966, the tallest plants were grown with the highest levels of NK and dolomite (Table 1). The interactions between medium and NK and between NK and dolomite were also significant. Tallest plants were grown in peat-Turface at the highest NK level.

Table 1. Effect of N, K, dolomite, and medium on height (inches) of tomato transplants.

NK level	1966 experiment Medium		Dolomite level		NK mean
	Peat-Turface	Peat-perlite	D_1	D_2	
N_1K_1	5.6	5.8	5.4	6.1	5.7
N_2K_2	9.1	6.8	6.6	9.3	8.0
Mean	7.4	6.3	6.0	7.7	
L.S.D. 5% NK					0.6
L.S.D. 5% Medium		0.6			
L.S.D. 5% D				0.6	
L.S.D. 5% Interaction (medium × NK)		0.9			
L.S.D. 5% Interaction (NK × D)				0.9	

N-level	1967 experiment Medium[a]		K_1		K_2		N mean
	P-T	P-P	D_1	D_2	D_1	D_2	
N_1	6.8	5.3	5.1	6.5	5.7	6.7	6.1
N_2	8.0	7.7	8.0	7.4	7.1	8.9	7.9
Mean	7.4	6.5	6.6	7.0	6.4	7.8	
Mean			D_1 = 6.5		D_2 = 7.4		
L.S.D. 5% N							0.4
L.S.D. 5% Medium							0.4
L.S.D. 5% D							0.4
L.S.D. 5% Interaction (K × D)							0.6
L.S.D. 5% Interaction (N × K × D)							0.8

[a]P-T indicates peat-Turface and P-P indicates peat-perlite medium.

In 1967, as in 1966, the tallest plants were those grown in peat-Turface (Table 1). Plants were tallest in both media when grown with the highest level of N. Interactions of K × dolomite and N × K × dolomite existed. Plants were tallest when grown with high K and high dolomite. With low N, added amounts of dolomite increased growth of plants at both levels of K. However, with high N and low K, additional amounts of dolomite had no effect on growth; whereas, with high N and high K, additional amounts of dolomite increased growth.

The influence of media and fertilizers on fresh and dry weight was similar to their effects on height. The correlation coefficients between height and fresh weight for plants in peat-Turface and peat-perlite were 0.728 and 0.752, respectively. The correlation coefficients between dry weight and fresh weight for plants in peat-Turface and peat-perlite were 0.871 and 0.992, respectively; and between dry weight and height for plants in peat-Turface and peat-perlite were 0.468 and 0.688, respectively. All correlations were highly significant.

Green tops of mature plants were weighed after all fruits were removed. Plants that were grown in peat-perlite were significantly larger and weighed 3.2 lb./plant as compared with 2.5 lb./plant for those grown in peat Turface.

Nutrient composition. The effect of growing medium on nutrient content of tomato stems and leaves for plants in the 1967 experiment is shown in Table 2. Plants grown in peat-Turface

Table 2. Effect of growing medium on N, P, K, Ca, and Mg content (% dry wt) in tops of tomato transplants.

Medium	N	P	K	Ca	Mg
Peat-Turface	2.43	0.54	3.22	1.38	0.48
Peat-perlite	2.06	0.59	2.17	1.25	0.47
L.S.D. 5%	0.13	0.02	0.11	0.05	ns

contained more N, K, and Ca than did plants grown in peat-perlite; whereas, plants grown in peat-perlite contained more P than those grown in peat-Turface. The medium showed no effect on Mg content in plant tops.

The difference in N uptake for plants in the different media (Table 2) is shown by the interaction between N and K (Table 3). Plants grown in peat-Turface contained highest N when grown with a combination of high N and high K; whereas, plants grown in peat-perlite contained highest N when grown with a combination of high N and low K. High K in peat-perlite caused a reduction in N uptake at both N rates.

Table 5. Effect of K, dolomite, and medium on K content (% dry wt) in tops of tomato transplants.

Medium	K_1			K_2			Dolomite mean	
	D_1	D_2	mean	D_1	D_2	mean	D_1	D_2
Peat-Turface	3.18	2.75	2.97	3.62	3.49	3.56	3.40	3.12
Peat-perlite	1.67	1.64	1.66	2.42	2.95	2.69	2.05	2.30
Mean	2.43	2.20	2.32	3.02	3.22	3.12	2.73	2.71
L.S.D. 5% K								0.11
L.S.D. 5% D								ns
L.S.D. 5% Interaction (medium × K)								0.16
L.S.D. 5% Interaction (medium × D)								0.16
L.S.D. 5% Interaction (K × D)								0.16
L.S.D. 5% Interaction (medium × K × D)								0.29

Table 3. Effect of N, K, and medium on N content (% dry wt) in tops of tomato transplants.

Medium	N_1		N_2	
	K_1	K_2	K_1	K_2
Peat-Turface	2.24	2.13	2.44	2.88
Peat-perlite	2.09	1.62	2.85	1.66
L.S.D. 5% Interaction (medium × N × K)				0.27

The higher P content in plants grown in peat-perlite than in those grown in peat-Turface was found mostly for those grown with a combination of low N and high K in the peat-perlite medium (Table 4).

Table 4. Effect of N, K, and medium on P content (% dry wt) in tops of tomato transplants.

Medium	N_1		N_2	
	K_1	K_2	K_1	K_2
Peat-Turface	0.52	0.53	0.55	0.57
Peat-perlite	0.55	0.65	0.59	0.59
Mean	0.54	0.59	0.57	0.58
L.S.D. 5% Interaction (N × K)				0.03
L.S.D. 5% Interaction (medium × N × K)				0.04

The higher K content in plants grown in peat-Turface than in plants grown in peat-perlite was evident for those plants grown with either rate of K (Table 5). For both media, plants grown with high K had more K in their leaves and stems than had plants grown with low K. Plants grown in peat-perlite with low K had a low amount of K in their tops.

The main effects of dolomite on K content were not significant; however, the interaction of dolomite, with other treatments, was significant (Table 5). Plants grown in peat-Turface contained more K when grown with low dolomite than those grown with high dolomite. In contrast, plants grown in peat-perlite contained more K when grown with high dolomite than those grown with low dolomite. The interaction, medium × K × dolomite (Table 5), shows that the reduction in K uptake by high dolomite occurred in plants grown in peat-Turface with low K, and an increase in K uptake occurred in plants grown in peat-perlite with high K.

The higher Ca content in plants grown in peat-Turface than in those grown in peat-perlite was evident for those plants grown with high dolomite (Table 6). Both high K and high dolomite increased Ca uptake by plants, especially in those plants grown in peat-Turface.

An interaction between medium, K, and dolomite existed (Table 6). For

Table 6. Effect of K, dolomite, and medium on Ca content (% dry wt) in tops of tomato transplants.

Medium	K_1		K_2		Dolomite	
	D_1	D_2	D_1	D_2	D_1	D_2
Peat-Turface	1.20	1.47	1.34	1.50	1.27	1.49
Peat-perlite	1.24	1.06	1.13	1.25	1.19	1.16
Mean	K_1 = 1.23		K_2 = 1.33		1.23	1.33
L.S.D. 5% D						0.05
L.S.D. 5% Interaction (medium × D)						0.07
L.S.D. 5% Interaction (medium × K × D)						0.09

plants grown in peat-Turface, an increase in the dolomite level resulted in an increase in Ca content with either K level. In contrast, a combination of low K and high dolomite in peat-perlite caused a reduction in Ca uptake over a combination of low K and low dolomite, and plants grown in peat-perlite with high K and high dolomite contained more Ca than did the plants grown with high K and low dolomite.

Yields. Early yields were influenced significantly by the medium and the dolomite levels only in the 1967 experiment (Table 7). Plants grown in peat-Turface produced higher early yields than had the plants grown in peat-perlite as indicated by the numbers and weight of fruits. Plants grown in peat-Turface had more fruits than those grown in peat-perlite, but only when grown with the highest level of dolomite.

Total yields, both weight and numbers of fruits for 4 harvestings, were not affected by the fertility levels and the growing medium used in these studies.

Discussion and Conclusions

Interrelationships between nutrients and their uptake by plants as reviewed by Broyer and Stout (4) have been observed in these experiments. However, the growing medium played an important roll in altering some of the reported patterns in nutrient uptake. The pattern of nutrient uptake by plants was not similar from both media for most of the nutrient combinations. The difference in texture, structure, and initial nutrient content of the different media was probably responsible for the differences in response by plants in the 2 media. The plate-like or lattice effect of Turface as compared with the spherical form of perlite forms a more packed medium than that of perlite with peat moss. Turfaced contained 130 ppm K, 130 ppm Ca, and 0.04 ppm Mg; whereas, perlite contained 7.9 ppm K, 5.5 ppm Ca, and no measurable amount of Mg. The base exchange capacity was very much the same for the 2 media, 48.1 me for peat-Turface and 50.2 me/100 g for peat perlite. However, since the base exchange capacity was only 16.5 and 4.7 me/100 g for Turface and perlite, respectively, then the base exchange capacity for each medium was probably influenced more by the peat moss than by either the Turface or perlite.

The physical differences between the media probably also accounted for what appears to have been the longer retention of N, K, and Ca in peat-Turface than in peat-perlite. Whereas, since P is less soluble than N, K, and Ca, plants grown in peat-perlite absorbed more P than those grown in peat-Turface, because this element was probably predominant in the peat-perlite medium at the end of the first 6 weeks of growth. Also, there could have been less PO_4- and NO_3- competition since the NO_3- and NH_4+ were more easily leached. This would account for the plants grown in peat-perlite to be lighter green than those grown in peat-Turface.

Table 7. Effect of dolomite on fruiting by tomato plants grown for 6 weeks in different media.

Medium	Weight of fruit (lb./plant)			Number of fruit/plant		
	D_1	D_2	mean	D_1	D_2	mean
Peat-Turface.	5.0	7.2	6.1	18.5	25.7	22.1
Peat-perlite..	4.3	4.7	4.5	17.1	16.5	16.8
Mean.......	4.6	6.0	—	17.9	21.1	—
L.S.D. 5% Medium.......			0.9			3.8
L.S.D. 5% D............			0.9			ns
L.S.D. 5% Interaction (medium × D).........			1.2			5.3

The pH of the media at each fertility level was satisfactory for plant growth. The pH's ranged from 5.5 to 6.2 with no significant differences due to treatments. The pH range was within the range claimed (10, 11) to be best for growth in a high organic medium.

The larger size of plants grown in peat-perlite than those grown in peat-Turface at the completion of the 1967 experiment was probably due to the reduced, early fruit set on the plants grown in peat-perlite. Plants grown in peat-Turface had increased set and fruit development at the expense of vine development after field setting.

This study and those by Hoagland (6) and others (2, 8, 9, 14) show that many fertilizer levels are equally effective for growing tomato transplants, which probably accounts for the difference in levels of fertilizers that were recommended by others (3, 5) in the use of peat-perlite. Greatest growth occurred in plants in both media when fertilized with the highest levels of N, K, and dolomite, and also for plants that were grown with high N, low K, and low dolomite in peat-Turface.

Since early yields were only slightly affected in 1 of 2 years, and total yields were not affected in either year, it appears that the combinations of the lowest rate of nutrients used in these experiments, except for dolomite in one experiment, where adequate for growing tomato transplants. Only in peat-Turface had the plants grown with the 10 lb. rate of dolomite produced more early fruits than those grown with the 5 lb. rate.

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