EVALUATION OF MEDIA AND WATER SOURCES FOR PLANT STARTING

By

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ABSTRACT

Experiments were conducted to determine the effect of media and level of soluble salts in water upon the greenhouse growth and field performance of tomatoes, zinnias and marigolds. The media used were peat-lite, University of California mix, composted virgin sod and 1:1:1 mixtures of sand-soil-peat moss and sand-soil-manure. The conductivities of the water used, varied from 0.4 to 4.0.

The peat-lite and the University of California mixes produced transplants and resultant field yields which were higher than those produced on the sand-soil-manure in one year and less satisfactory the next. In general, they were higher than those produced on the sand-soil-peat moss mix in both years. Virgin sod was superior to peat-lite in its ability to provide an environment which could withstand the influence of soluble salts.

Partially decomposed peat whose principal component was sphagnum moss produced greater dry weight in transplants than pure sphagnum peat moss when used as a component of peat-lite. The addition of an iron chelate to peat-lite as a solution during watering was more effective in increasing growth than the incorporation of iron chelate during media preparation.

In testing the fertilizer requirements for peat-lite, maximum dry weights and the highest root/stem ratios were produced when 6-9-6 at 8 lbs. per cubic yard of mix plus one feeding of 10-52-17 was used.

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[1] Dr. J.D. Campbell was present at Khon Kaen University, Khon Kaen, Thailand, during the preparation of the manuscript.

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INTRODUCTION

In 1960 there were approximately twenty-five bedding plant growers in Manitoba, mainly concentrated in the Greater Winnipeg area (42). The Manitoba Department of Agriculture estimated that there were approximately twenty-five percent more growers in the province in 1967 than there were in 1960. Some commercial greenhouses are located in smaller centers such as Portage La Prairie, Brandon, Dauphin and Morris. The capacity of the greenhouses in Manitoba varies from 500 to 20,000 flats, with the majority of growers having over 1,000 flats. The estimated retail value of bedding plants sold in Manitoba in 1960 was $400,000 (42). The estimate for 1967 would probably be thirty to forty percent higher due to increase in volume and retail price.

One of the major problems in the bedding plant industry is plant loss between pricking off[1] and marketing. One type of plant loss is the result of soluble salt accumulation in the soil. The second cause of plant loss is the result of uneven plant growth and development caused by non-uniform soil mixes. Since the poorly developed plants are undesirable for sale, they are discarded and thus constitute an economic loss to the grower.

[1] This is a term applied to the process of removing the seedling from the seedling flat.

The greatest concentration of growers in the Greater Winnipeg area is along the Red River. In spite of the proximity of the river, most growers use ground water rather than river water for watering because ground water requires less labor and equipment to obtain. Since the construction of the Red River floodway, the soluble salt content of the ground water on the east side of the river has increased considerably. This has resulted in severe plant losses to some growers in this location.

The basic components of the mixes used by growers are sand, manure, peat moss, composted virgin sod and locally available top soil. The soil mixes in general use are a 1:1:1 mixture of sand, soil and peat moss, a 1:1:1 mixture of sand, soil and manure, and pure virgin sod. The soil and manure used could vary in texture, structure, nutrient content and reaction. This great variability could result in inconsistent mixes.

The use of a standardized media of known composition should eliminate the problems caused by variable soil factors. Boodley and Sheldrake (8) at Cornell University introduced the "Peat-lite" mix for this purpose. The major components of peat-lite are sphagnum peat moss and horticultural vermiculite. Both materials are relatively inert.

The nutritive additives are ground superphosphate, dolomitic limestone, and either a complete fertilizer such as 5-10-5 or a nitrogen fertilizer such as 33.5-0-0. Chandler and Matkin (4) at the University of California worked with a media composed of sand and peat moss. To date they have perfected five formulations of the two ingredients with six different fertilizer additions. These mixes are generally called the U.C.[1] mixes and have been successfully used throughout California in flats, pots and greenhouse benches.

The objective of this study was to determine the effects of several media and soluble salt levels in water on bedding plant growth and resultant field performance.

[1] University of California.

LITERATURE REVIEW

The growing medium is one of the fundamental factors influencing bedding plant production. According to Hartmann and Kester (22) media for propagation must be sufficiently firm and dense to anchor and hold the plant; it must retain moisture but yet permit drainage and aeration; it should have no excessive shrinkage upon drying; it should be free from weed seeds and plant pests such as nematodes and disease organisms; and the pH level should be suitable for the plant being grown.

The use of growing containers changes the normal physical relationship between the plant root and the substrate. Bunt (10) noted that to sustain high growth rates in containers, large frequent watering was required. However, if watering is excessive, the substrate is exposed to excessive leaching. The same worker observed that the high root concentration in relation to the volume of soil in the container created a demand for a high rate of oxygen supply and carbon dioxide removal.

In an attempt to simulate the normal relationships between plant root and substrate, growers have resorted to the use of natural and artificial soil amendments.

One of the natural soil amendments commonly used is sand (10, 11, 13, 24, 26, 35). Kuenen (25) has defined sand as particles of rock between 0.05 and 2 mm in diameter, whose origin can be calcium carbonate, aluminum silicate or silicon dioxide. Silicon dioxide sand is desirable as a component of a soil mix for it is most abundant and relatively inert (4). Bunt (11) observed that sand is desirable in a soil mix because of its ability to establish a wide range of pore sizes and air capacities. Lawrence and Newell (26) stated that sand should be added to seed and potting mixes to obtain correct porosity, to improve aeration and to provide adequate drainage.

Another natural soil amendment used is peat. Peat, as defined by Lucus et.al.(28) is the organic remains of plants which have accumulated in places where decomposition has been retarded by excessively wet conditions. The same authors broadly classify peat as moss peat, reed-sedge peat, and peat humus. Peat of the moss type has been used extensively in soil mixes (4, 12, 13, 20, 24, 26, 27, 28, 35). Recommendations for the use of peat in mixes varied. Lucus et.al.(28) suggested a potted plant mix consisting of 2 parts loam, 1 part sand and one part peat; Huth and Nicklow (24) suggested a mix composed of 2 parts loam and 1 part peat; Campbell (9) suggested a mix consisting of 2 parts soil, 2 parts peat and 1 part sand.

Lucus and co-workers (28) stated that sphagnum peat moss is the most desirable type for soil mixes as a result of its chemical and physical uniformity. In its pure form it can absorb 18 to 26 times its own weight in water (5).

According to Huth and Nicklow (24) peat moss in soil mixes provides better physical conditions for root growth. Long (27) stated that cuttings rooted more favourably in peat moss mixes as a result of more favourable moisture and aeration. Bunt (10) reported that peat moss gave improved growth and earlier flowering with tomato and improved growth with antirrhinum.

Still another component of soil mixes is barnyard manure (3, 4, 22, 26, 40). Manure is defined as the solid and liquid excreta from farm animals mixed with the litter used to bed the stock. Several authors (3, 4) have noted that the composition of manure depended upon the proportion of solid and liquid excreta and litter; the kind, age and food of the animal producing it; the type the litter used; and the care taken to preserve the manure. Value of the manure as a source of nutrients in the soil mix will vary with its composition but Lawrence and Newell (26) stated that manure generally contains 0.5% N, 0.25% P, 0.25% K and some trace elements.

The same report also stated that manure may contain weed seeds, disease organisms and a high concentration of soluble salts. Hepler (23) compared the effect of manure and peat as components of a growing medium on the production of greenhouse tomatoes. He discovered that after the first six weeks the plants on the manure plot appeared larger but that there was no difference in the time of fruit ripening or fruit size.

One of the artificial soil amendments is vermiculite. Barshad (6) defined vermiculite as a hydrated magnesium - aluminum - iron silicate with a layer lattice structure. Carleton described the production of commercial vermiculite. He stated that the vermiculite ore passes through a furnace at temperatures near 2000°F. The moisture present between the layers is converted to steam which in turn forces the layers apart. The end result is small sterile sponge-like kernels which are known as commercial vermiculite. The interface of a kernel totals approximately three square feet (8). This allows for a large moisture holding capacity and a cation exchange capacity of 1.2 - 1.6 me/gram (6). This high cation exchange capacity enables a grower to use higher fertility levels than he could with soil (8).

O'Rouke and Maxon (32) stated that No. 2 grade vermiculite was best as a rooting media for cuttings. Boodley and Sheldrake (8, 35) stated that in peat-lite, No. 2 vermiculite (diameter 2 - 3 mm) should be used for bedding plant production and No. 4 vermiculite (diameter 1 mm) should be used for seed germination.

Artificial soil mixes for plant starting and container growing are presently available (4, 8). These mixes have been developed to eliminate production failure created by the use of natural soil mix components of questionable composition (4). Basically, the artificial mixes consist of macro-components such as sand, peat moss, perlite and vermiculite as well as micro-components such as fertilizers and limestone. Peat-lite, developed by Boodley and Sheldrake (8), consists of a 1:1 mixture of sphagnum peat moss and vermiculite. Micro-component additions include ground superphosphate, dolomitic limestone and either 5-10-5 or 33.5-0-0 (8, 28, 35, 36). Sheldrake (36) reported the satisfactory starting of cucumbers, summer and winter squash, watermelon and muskmelon in peat-lite. Fries (20) reported the satisfactory production of annual bedding plants such as petunia, salvia, marigold, zinnia, ageratum, coleus, alyssum and basil as well as perennials such as geranium, pansy and chrysanthemum on peat-lite.

Sheldrake (34) reported chlorosis on petunia, pepper and tomato grown in peat-lite. Read and Sheldrake (33) found that chlorosis on peat-lite was the result of the lack of available iron in the mixes accentuated by the high Mn:Fe ratio present in the vermiculite. Elimination of chlorosis was more successful by spraying with Fe-DTPA, Fe-EDTA, Fe-EDDHA and ferrous sulfate than by direct addition to the soil. No minor elements other than iron are required in peat-lite. Boodley and Sheldrake (8) reported that the superphosphate and the 5-10-5 supply satisfactory amounts of minor elements for a twelve-week growing period.

Perlite is another artificial soil amendment. Chemically, it is a combination of silicon, aluminum, potassium and sodium oxide (1). DeWerth (17) in his description of commercial perlite production stated that the ore is heated to 1800°F, at which time it expands thirteen times to produce granules of sterile horticultural perlite. The Perlite Institute (1) reported a growing medium consisting of a 1:1 mixture of perlite and peat moss. Huth and Nicklow (24) reported that in a comparison between the 1:1 peat moss-vermiculite mix and a 1:1 peat moss-perlite mix, the peat moss-perlite mix consistently gave a poorer growth rating with flower seedlings and a lower production of dry weight with vegetable crop seedlings. Huth and Nicklow (24) postulated this to be the result of the lower nutrient holding capacity of the perlite.

Matkin and Chandler (4) working in California developed the U.C. mix to provide a growing medium which would fulfill the requirements of the commercial nurserymen. Five basic U.C. mixes have been developed. These are:

(1) 100% sand

(2) 75% sand 25% peat moss

(3) 50% sand 50% peat moss

(4) 25% sand 75% peat moss

(5) 100% peat moss

The chemical additions consist of dolomitic limestone and a source of nitrogen, phosphorous and potassium. The same authors reported the successful use of the U.C. mixes in pots, flats, benches and planter boxes.

The accumulation of soluble salts in greenhouse soils has been reported by several workers (29, 37). Baker et al (4) believe that this salt accumulation in greenhouse soils is the result of the excessive use of chemical and organic fertilizers, improper irrigation practices, poor drainage, and the use of soils initially high in salts.

Bernstein and Haywood (7) stated that the presence of excessive concentrations of soluble salts in the root zones affects plant growth by increasing the osmotic pressure of the soil solutions which in turn results in a decrease in the physiological availability of water. The same workers noted that the accumulation of toxic quantities of sodium, calcium, chloride and sulfate ions can depress plant growth. Smith and Warren (37) observed that injury did not occur in lettuce until the concentration of sulfate in a 1:2 soil-water extract exceeded 1200 ppm, while the crop was injured at concentrations above 120 ppm of chloride. McCall et al (29) stated that floricultural plants may be reduced in yield and quality because of soluble salts without any visual evidence that soluble salts are present in excess in the soil supporting the growth. Dunkle and Merkle (19) reported that plant growth was not increased and in cases decreased when the conductivity of a 1:2 soil-water extract was greater than 227×10^{-5} mhos.

Several workers (4, 9, 26) stated that the growing media has a direct bearing on salt accumulation. Boyko (9) reported the successful production of melons and tomatoes on the sands of the Negev desert while irrigating with highly saline water. He partially attributed this success to the removal of the sodium and magnesium chlorides from the root zone into deeper layers during irrigation.

Baker (4) stated that organic matter retarded salt removal from media even though it improved permeability. He also noted that peat moss retarded salt removal less than did organic materials such as fir bark and pine shavings.

MATERIALS & METHODS

EXPERIMENT I (1966 & 1967)

A comparative evaluation of the effect of different starting media upon the dry weight of tomato and zinnia transplants and their field performance was conducted in 1966 and 1967. Four treatment media were used. Their composition per cubic yard was:

1.		Peat-lite Mix	
		No. 2 vermiculite	11 bushels
		Shredded peat moss	11 bushels
		Powdered superphosphate	1 lb.
		Dolomitic limestone	5 lbs.
	(1966)	Ammonium nitrate	3 lbs.
	(1967)	6-9-6 [1]	8 lbs.
2.		Modified U.C. Mix	
		Fine sand	11 bushels
		Shredded peat moss	11 bushels
		Superphosphate	2 lbs.
		Dolomitic limestone	10 lbs.
	(1966)	Ammonium-phosphate-sulfate	1 lb.
	)	Potassium sulfate	1 lb.
	(1967)	6-9-6	8 lbs.
3.		Sand	7 bushels
		Manure	7 bushels
		Soil	7 bushels
4.		Sand	7 bushels
		Peat Moss	7 bushels
		Soil	7 bushels

Seeds of Starfire tomato and Will Rodgers zinnia were planted in the greenhouse on May 2, 1966 and May 1, 1967 in a sterilized 1:1:1 mixture of sand, soil and peat moss to which one pound per cubic foot of superphosphate was added.

[1] Diammonium phosphate and potassium sulfate.

The seedlings were transplanted on May 16, 1966 and May 12, 1967 into flats of treatment media. Each treatment consisted of 54 plants in one flat, plants being separated by 2" x 2" vita bands. The experimental design for each species in the greenhouse was a randomized complete block with four treatments and four replications.

Soil samples were taken weekly from each flat during greenhouse growth. Nitrate nitrogen, easily soluble plus absorbed phosphorous and exchangeable potassium were determined by the "La Matte quick test kit" which follows the procedures established by Morgan (30). In 1967 the Provincial Soil Testing Laboratory at the University of Manitoba performed the nitrogen, phosphorus and potassium tests. The modified Harper Method (21) was used to determine the quantity of nitrate nitrogen; Olsen's method (31) was used to determine available phosphorus and exchangeable potassium was determined with a flame photometer. In both years pH was determined on a 1:2 soil-water extract by a Fisher Accumet pH meter. Electrical conductivity in mhos x 10^{-3} was determined at room temperature on a 1:2 soil-water extract using a Beckman Solu Bridge Model R.D. - B15 soil tester.

Two weeks prior to field transplanting, in both years, the plants grown on the peat-lite and U.C. mix showed signs of chlorosis. To combat this condition, the affected treatments were sprayed with

Sequestrene 330 at a concentration of 1.7 gms per liter.

On June 9, 1966 and June 7, 1967 fifteen plants were removed from each flat. The roots and tops were dried at 45°C and dry weights were taken. Twenty of the remaining plants from each flat were transplanted in the field. The field experimental design for each species was a randomized complete block with four treatments and four replications. Individual plots consisted of two 30-foot rows with a 3-foot spacing between rows and plants. Transplants were watered with starter solution at the rate of one pint per plant in 1966. The starter solution was 10-52-17 [1] at a concentration of 1 tablespoon per gallon of water (13). No starter solution was used in 1967.

Field performance of tomatoes was determined in the following manner:

1. Early yield was obtained when two or more ripe fruit were present on 50% of the plants. A fruit was considered ripe when 50% of the surface area of the fruit was pink in color.

2. Final yield of ripe fruit was obtained on August 31.

3. Market yield was obtained by grading early and final

[1] Diammonium phosphate, dipotassium phosphate, mono potassium phosphate.

yields according to the regulations established by the Fruit and Vegetable Sales Act for the Province of Manitoba (41).

Field performance of zinnias was determined in the following manner:

1. Earliness of bloom was measured by counting the number of flowers in bloom by July 15.

2. Size of the first bloom was established by weighing the first flower after drying at 45°C.

3. The total number of flowers produced was measured by counting flowers present per plant on August 31.

EXPERIMENT II (1966)

The objective of this experiment was to determine the effect of soluble salt levels in water on seedling growth in two different media. Ten levels of soluble salts were used. The levels, as measured by the conductivity in mhos x 10^{-3} were 0.4, 0.8, 1.2, 1.6, 2.0, 2.4, 2.8, 3.2, 3.6 and 4.0. These levels were obtained by diluting saline water obtained from a local bedding plant grower with tap water. The media used were peat-lite, as outlined in Experiment I, and virgin sod produced on Red River clay. The test plant was the French marigold, variety Naughtly Marietta.

The marigolds were seeded on May 6 in a sterilized 1:1:1 sand-soil-peat moss mix and were transplanted on May 19 into the test media. Each plot consisted of 32 plants in one flat with 2.25 inches between rows and 3 inches between plants. The experimental design in the greenhouse was a split-plot with ten treatments (soluble salt levels in water), two subtreatments (media) and four replications. Tap water (conductivity 0.15 x 10^{-3}) was used until May 27 because the saline water was unavailable. Water at the conductivities shown above was used from May 27 until plants were transplanted into the field.

Soil samples and a count of dead plants was taken weekly from each greenhouse plot. The pH of a 1:5 soil-water extract was determined on a Fisher Accumet pH meter. The soluble salt content of the media was determined by measuring the conductivity of a 1:5 soil-water extract at 25°C on a Beckman Solu Bridge soil tester.

On June 20 five plants from each greenhouse plot were transplanted in one row, field plots with plants and rows spaced 18 inches apart. The experimental design in the field was the same as that in the greenhouse. Roots and tops of the remaining plants were dried at 45°C and weights were taken.

Earliness of field bloom was estimated by the percentage of plants in bloom on June 27.

EXPERIMENT III (1966)

The recommended rates of limestone addition to peat-lite vary from 5 to 10 lbs. per cubic yard. Normally, undecomposed sphagnum peat moss is the peat component of peat-lite. In Manitoba native peat moss in various stages of decomposition is available. The prime objective of this experiment was to determine a suitable rate of limestone addition and to evaluate the suitability of native peat moss as a component of peat-lite mixes. Experiment I revealed that in peat-lite the addition of iron was necessary to produce non-chlorotic plants. The second objective of this experiment was to evaluate the effect of two methods of iron chelate application on plant growth and development.

The composition of a cubic yard of treatment media was as follows:

1. No. 2 Vermiculite	11 bushels
Sphagnum peat moss	11 bushels
Powdered superphosphate	1 lb.
Dolomitic limestone	5 lbs.
Ammonium nitrate	3 lbs.
2. No. 2 Vermiculite	11 bushels
Sphagnum peat moss	11 bushels
Powdered superphosphate	1 lb.
Dolomitic limestone	10 lbs.
Ammonium nitrate	3 lbs.

3. No. 2 Vermiculite	11 bushels
Medika [1] muck	11 bushels
Powdered superphosphate	1 lb.
Ammonium nitrate	3 lbs.
4. No. 2 Vermiculite	11 bushels
Medika muck	11 bushels
Powdered superphosphate	1 lb.
Dolomitic limestone	5 lbs.
Ammonium nitrate	3 lbs.

The subtreatments were:

1. Sequestrene 138 at 4 gms per peck of mix incorporated at the time of mixing.

2. Sequestrene 138 applied in solution at the rate of 4 gms per peck of mix. Applications were made one and three weeks after transplanting.

The test plant was the tomato, variety Starfire. The tomatoes were seeded in a sterilized 1:1:1 sand-soil-peat moss mixture on November 18. The seedlings were transplanted on December 5 into the test peat-lite. The plants were separated by 3" x 3" vita bands. Each plot consisted of twelve plants and a sub-plot of six plants. The experimental design was a split-plot with four treatments and two sub-treatments replicated four times.

[1] Medika - a one thousand acre peat bog situated in sections 19, 20, 29 and 30 of Township 9 and Range 12 EPM.

Soil samples were taken weekly from each plot. The pH was established by the use of a 1:5 soil-water extract on a Fisher Accumet pH meter. Conductivity of a 1:5 soil-water extract was measured at room temperature on the Beckman Solu Bridge soil tester.

The tomato plants were observed weekly and a visual estimate of condition was established. The condition of the plants was rated as follows:

Condition	Rating
(a) Excellent	5
(b) Good	4
(c) Slightly chlorotic	3
(d) Chlorotic	2
(e) Highly chlorotic	1

The plants were removed from the flats four weeks after transplanting. The roots were washed and the roots and tops were dried at 45°C. Root and top weights were established.

EXPERIMENT IV (1967)

The objective in this experiment was to determine the sources and level of nitrogen in peat-lite mixes required to produce satisfactory dry weight in the transplants. The sources and levels of nitrogen per cubic yard of peat-lite were:

I	33.5-0-0	-	$1\frac{1}{2}$ lbs.
II	33.5-0-0	-	3 lbs.
III	6-9-6	-	8 lbs.
IV	6-9-6	-	8 lbs. plus one feeding of 10-52-17 at 2 tablespoons per gallon of water, applied two weeks after transplanting.
V	6-9-6	-	8 lbs. plus two feedings of 10-52-17 at 2 tablespoons per gallon water, applied one and three weeks after transplanting.

The test plant was the tomato, variety Starfire.

The tomatoes were seeded on May 1 in a sterilized 1:1:1 sand-soil-peat moss mix which contained one pound of superphosphate per cubic foot. The seedlings were transplanted on May 12 into the peat-lite. Each plot consisted of one flat or 24 plants, separated by 3" x 3" vita bands. The experimental design was completely randomized with five treatments and four replications.

Soil samples were taken weekly from each plot. Soil tests for nitrate nitrogen were performed by the Provincial Soil Testing Laboratory at the University of Manitoba, using the Modified Harper Method (21).

On June 9 a sample of ten plants was removed from the flats. The roots were washed. The roots and tops were dried at 45°C and weights were taken.

Statistical analysis in all experiments was performed according to procedures outlined by Steel and Torrie (38).

RESULTS AND DISCUSSIONS

EXPERIMENT I (1966) (1967)

The objective of this experiment was to determine the effect of media on seedling growth in the greenhouse and on the resultant field performance of the transplants for a vegetable crop (tomato) and a flower crop (zinnia). The effect of four starting media upon the total dry weight produced by tomato and zinnia seedlings prior to field transplanting is shown in Table 1.

Table 1. The effect of starting media upon the total dry weight of tomato and zinnia seedlings prior to field transplanting in 1966 and 1967.

Treatment	Tomato		Zinnia	
	1966	1967	1966	1967
	Mean Weight Grams/Plant	Mean Weight Grams/Plant	Mean Weight Grams/Plant	Mean Weight Grams/Plant
I Peat-lite	0.247 b	0.835 a	0.175 b	0.718 a
II U.C. Mix	0.175 b	0.827 a	0.188 b	0.730 a
III Sand-Soil-Peat	0.200 b	0.691 a	0.235 b	0.444 b
IV Sand-Soil-Manure	0.537 a	0.548 a	0.460 a	0.536 b

(P = 0.05)

In this and in subsequent tables where Duncan's Multiple Range test was used, the treatments followed by a common letter are not significantly different.

In the ensuing text, the plants grown on peat-lite shall be referred to as treatment I, U.C. mix as treatment II; sand-soil-peat as treatment III and sand-soil-manure as treatment IV.

In 1966 zinnia and tomato seedlings in treatment IV produced a significantly (0.01) greater amount of dry weight. However, in 1967 the seedling dry weights produced by treatments I and II were significantly (0.01) higher than those produced in treatments III and IV for zinnias but not for tomatoes.

In 1966 the greenhouse temperature varied from 80 - 90°F during the day for several days immediately after seedlings were transplanted into the flats. The excessive evapotranspiration resulting from these high temperatures caused the plants in treatments I, II and III to wilt somewhat each day. No wilting was noticed in treatment IV. The significantly higher production of dry weight on treatment IV in 1966 could be due to the ability of this mix to provide adequate amounts of available water even when atmospheric conditions are conducive to high evaportranspiration. In contrast, the greenhouse temperatures after transplanting in 1967 ranged from 70 - 80° during the day. The lower temperature during transplant establishment probably resulted in the greater production of dry weight in 1967 in all treatments except treatment IV.

A possible reason for the relatively low dry weight production of treatment IV in 1967 could be the lower nitrate nitrogen content of the soil mix in comparison to that of 1966.

Field yields for tomatoes started on various media are given in Table 2.

Table 2. The effect of starting media upon the early and total yields of tomatoes in 1966 and 1967

Treatment	1966 Early Mean Yield Grams/Plant	1966 Total Mean Yield Grams/Plant	1967 Early Mean Yield Grams/Plant	1967 Total Mean Yield Grams/Plant
I Peat-lite	262.25 ab	742.75 b	285.75 a	1058.50 a
II U.C. Mix	164.25 b	651.5 bc	289.00 a	1028.00 a
III Sand-Soil-Peat	94.50 b	363.75 c	50.75 b	546.00 b
IV Sand-Soil-Manure	461.50 a	1074.50 a	40.25 b	497.00 b

(P = 0.05)

In 1966 treatment IV produced an early yield which was significantly (0.05) higher than treatments II and III but not significantly higher than treatment I. The total yield of treatment IV was significantly (0.05) higher than the other treatments. Treatments I and II produced significantly (0.05) higher yields than treatments III and IV in 1967.

In 1967 the performance of treatment IV in comparison to treatments I and II was the reverse of that in 1966. Possible reasons for the discrepancy could be the result of the two separate phenomenon. First of all, the high greenhouse temperature immediately after transplanting into flats in 1966 seriously set back treatments I and II and low seedling dry weights were produced. Secondly, the nitrate nitrogen content of treatment IV in 1967 was extremely low.

Field yields were closely correlated to total dry weights of the seedlings produced in the greenhouse. The correlation coefficient (r) between the total dry weight produced by the transplant and the field yield was .83 in 1966 and .93 in 1967.

This result reveals the necessity of transplanting seedlings with a maximum dry weight if a good field yield is to be realized. It also may provide a useful tool for the research worker, for he may be able to estimate field yield without actually growing the tomato in the field.

The early and total marketable tomato yields are shown in Table 3.

Table 3.

Starting media effects upon the early and total marketable yields of tomatoes in 1966 and 1967.

Treatment	1966 Early Marketable Grams/Plant	1966 Total Marketable Grams/Plant	1967 Early Marketable Grams/Plant	1967 Total Marketable Grams/Plant
I Peat-lite	23.50 b	186.5 b	205.25 a	882.00 a
II U.C. Mix	30.75 b	165.5 b	217.50 a	909.75 a
III Sand-Soil-Peat	11.50 b	125.25 b	36.75 b	438.75 b
IV Sand-Soil-Manure	167.50 a	447.00a	28.00 b	389.75 b

(P= 0.05)

Treatment IV produced signficantly (0.05) higher early and total marketable yields in 1966. In 1967 treatments I and II produced significantly (0.05), higher early and total marketable yields. Marketable yields, like total yields, appear to be directly related to plant growth in the greenhouse. Marketable yields, as percentages of total yields were higher in 1967 (83.72%) than in 1966 (32.63%). Excessive grading out in 1966 was the result of fruit deformities caused by growths at blossom end of the tomato. The cause of these deformities is at present unknown.

The effect of starting media upon the earliness of zinnia flowering and the size of the flower produced is shown in Table 4.

Table 4. The effect of starting media upon the number of flowers in bloom on July 15 and weight of first bloom.

Treatment	1966 Mean Yield Flowers/Plant [1]	1966 Mean Weight Grams/Flower [1]	1967 Mean Yield Flowers/Plant [1]
I Peat-lite	3.08 ab	1.80 a	3.31 a
II U.C. Mix	2.93 b	2.06 a	2.73 ab
III Sand-Soil-Peat	2.17 b	1.50 a	1.44 ab
IV Sand-Soil-Manure	3.52 a	1.74 a	1.06 b

(P= 0.05)

[1] Using $\sqrt{x + \frac{1}{2}}$ transformation

The $\sqrt{x + \frac{1}{2}}$ transformation was used to ensure the normal distribution of flower counts where some values were zero.

In 1966 there was no significance (0.05) difference in flower weights. No data were available in 1967 because during the drying process the labels were destroyed. This result indicates that the soil media in which the plants are started has no bearing on the size of flower produced (as measured by weight) or the procedure used was not sensitive enough to detect differences.

In 1966 a significant difference in earliness (number of flowers in bloom on July 15) between treatment IV and treatments II and III was detected. In 1967 treatment I produced a significantly greater number of flowers per plant than treatment IV. Once again, the results obtained in 1966 are not agreeable with those obtained in 1967. One possible reason for the discrepancy could have been the result of inferior initial growth on treatment IV in 1967 due to the lack of nitrate nitrogen during the latter weeks of the greenhouse growing period.

Starting media effects on the total number of flowers produced per plant is shown in Table 5.

Table 5. The effect of starting media upon the total number of zinnia flowers produced in 1966 and 1967.

Treatment	1966 Mean Flowers/Plant [1]	1967 Mean Flowers/Plant [1]
I Peat-lite	3.12 a	2.62 a
II U.C. Mix	3.06 a	2.46 a
III Sand-Soil-Peat	3.01 a	2.59 a
IV Sand-Soil-Manure	3.14 a	2.63 a

($P = 0.05$)
[1] Using $\sqrt{x + \frac{1}{2}}$ transformation

There was no difference in the total number of flowers produced per plant. This result indicates that either the differentiation of floral primordia in the seedling is not affected by the media in which the seedling is grown or the influence of the starting media upon flower production has been removed by August 31.

In general, under ideal growing conditions the Peat-lite and U.C. mixes can produce bedding plants which are comparable to those produced on sand-soil-peat moss and sand-soil-manure mixes. However, conditions which caused severe moisture stress, in Peat-lite and the U.C. mix did not affect the plants grown in sand-soil-peat moss and sand-soil-manure as greatly. In general, excellent plants were produced on the sand-soil-peat moss and sand-soil-manure mixes if fertility levels were adequate. Thus, under Manitoba growing conditions, a mix composed of sand, soil and either manure or peat moss is recommended the starting of bedding plants.

EXPERIMENT II (1966)

Marigold seedlings were grown in two media; peat-lite and virgin sod. Water with ten levels of soluble salts ranging from conductivities of 0.4 to 4.0 were used for watering. The data in Table 6 show the effect of water soluble salts upon the level of soluble salts in the media and the survival of marigold seedlings.

The deaths of marigold seedlings were significantly (0.01) higher on peat-lite than on virgin sod. These deaths were probably the result of the combined effects of osmotic pressure and soil moisture tension. A high concentration of salts in the soil solutions would raise its osmotic pressure which would in turn decrease the amount of soil moisture available to the plant. Davis and Lucus (16) stated that the permanent wilting point on organic soil may range between 24 - 80% of field capacity. Since peat-lite contained one-half peat moss by volume, its permanent wilting point was probably higher than that of the virgin sod. As a result, the marigold seedlings grown on peat-lite probably suffered from lack of available moisture even though the peat-lite appeared to be as moist as the virgin sod. Although a significant (0.01) treatment effect upon plant death in peat-lite was recorded, the greater variation from level to level would indicate that some unmeasured factor was operating even though a covariance analysis between the

Table 6. The effect of media and soluble salts upon the survival of marigold seedlings in peat-lite and virgin sod.

	PEAT-LITE		VIRGIN SOD	
Water Conductivity mhos x 10^{-3}	Soil Extract Conductivity[1]	Percentage Plant Death[1]	Soil Extract Conductivity[1]	Percentage Plant Death[1]
0.40	1.43 abc	47.9 abcd	0.22 a	0 a
0.80	0.96 d	25.2 g	0.22 a	3 a
1.20	1.28 b	48.9 ab	0.25 a	0 a
1.60	1.26 c	46.7 abcde	0.28 a	0 a
2.00	1.52 abc	46.0 abcde	0.33 a	0 a
2.40	1.52 abc	48.0 abc	0.38 a	0 a
2.80	1.56 ab	27.1 g	0.34 a	0 a
3.20	1.43 abc	35.7 f	0.40 a	3 a
3.60	1.59 a	50.6 a	0.46 a	0 a
4.00	1.52 abc	35.6 f	0.47 a	3 a

(P = 0.05)

[1] Average of four replications

conductivity of the soil extract and plant death revealed a significant (0.05) positive correlation of 0.457. In virgin sod no such relationship was detected.

As outlined in Experiment I, the high temperatures in the greenhouse after transplanting caused excessive transpiration and wilting of plants on the peat-lite. The high atmospheric temperatures could have produced high soil temperatures which coupled with the lack of available water could have weakened the marigold root systems. Since the severity of the effect on the individual plant was the result of the plant position within the flat and the flat position on the bench, the plants were affected independently of treatment. This circumstance could have been the cause of the variable death between treatments when soluble salts were applied.

A correlation between water conductivity and soil extract conductivity yielded a significant (0.05) correlation coefficient of 0.748 for peat-lite and 0.963 for the virgin sod.

A significant (0.01) water conductivity - media interaction indicated that an increase in soluble salts probably caused more plant deaths on peat-lite than on virgin sod. There is an element of doubt here because of the possible influence of the unknown factor mentioned previously.

As shown in Table 7 the soluble salt content - mainly composed of sulfates - of the growing media increased significantly (0.01) over the growing period in both media. A salt accumulation was expected since the rate of watering was not high enough to cause excessive leaching. Soluble salts in water produced a significant (0.01) difference in the conductivities of both media extracts. This condition was expected since a salt accumulation would result in the media.

The conductivity of the peat-lite extract was significantly (0.01) higher than that of virgin sod. According to Baker (4) a comparison of soil extract conductivities measured on a soil-water proportion other than 1:1 has only limited value unless the relative water-holding capacities are considered. If water-holding capacities are different, the same concentration of salts in ppm could produce different conductivity values. The water-holding capacities of the test media are unavailable and no definite conclusion is drawn.

A significant (0.05) rise in pH was detected within media over the growing period, between media, and between soluble salt levels as shown in Table 7. The initial pH of peat-lite was approximately 5.2, while that of virgin sod was approximately 7.2. The low peat-lite pH could have been the result of the organic acids present in the peat moss.

Table 7. The effect of growing period upon soluble salt content and pH of peat-lite and virgin sod.

Water Conductivity mhos x 10^{-3}	Peat-lite Extract[1]								Virgin Sod Extract[1]							
	Week I		Week II		Week III		Week IV		Week I		Week II		Week III		Week IV	
	pH	Cond.	pH	Cond.	pH	Cond.	pH	Cond.	pH	Cond.	pH	Cond.	pH	Cond.	pH	Cond.
0.40	5.28	1.42	5.42	1.71	6.12	1.42	5.98	1.28	7.23	0.22	7.37	.21	7.66	0.23	7.76	.25
0.80	5.21	.89	5.95	.97	6.33	1.02	6.11	.97	7.27	0.19	7.62	.22	7.72	0.24	7.78	.24
1.20	5.58	1.41	5.77	1.44	6.48	1.13	6.13	1.28	7.25	0.17	7.45	.26	7.68	0.28	7.81	.29
1.60	5.38	1.38	5.65	1.23	6.16	1.17	6.00	1.25	7.45	0.18	7.71	.26	7.72	0.32	7.77	.36
2.00	5.62	1.24	5.78	1.64	6.16	1.42	6.82	1.76	7.47	0.19	7.50	.29	7.73	0.42	7.92	.42
2.40	5.60	1.41	5.82	1.38	6.27	1.49	5.98	1.79	7.25	0.20	7.27	.33	7.60	0.47	7.80	.51
2.80	5.33	1.54	5.76	1.55	5.92	1.49	5.92	1.67	7.42	0.15	7.60	.28	7.72	0.43	7.72	.51
3.20	5.63	1.37	5.86	1.37	6.48	1.55	6.21	1.45	7.42	0.18	7.47	.33	7.71	0.47	7.77	.62
3.60	5.57	1.20	6.02	1.50	6.48	1.76	6.12	1.85	7.43	0.19	7.42	.35	7.70	0.60	7.80	.69
4.00	5.33	1.08	5.82	1.54	6.17	1.69	6.01	1.76	7.43	0.17	7.75	.39	7.67	0.62	7.72	.73

[1] Average of four replications.

The pH of the virgin sod is typical of Red River clay. The addition of calcium, magnesium and sodium as soluble salts could have been the factor influencing the rise in pH. Significant (0.01) weeks x media and media x concentration interactions reveal a greater pH change in peat-lite than in virgin sod. This condition was probably the result of retardation of salt removal by the high organic matter content of peat-lite.

There was no significant influence of media or soluble salt on the total dry weight produced by the marigold seedlings or in the earliness of marigold flowering.

The death of marigold seedlings was greater in the peat-lite than in the virgin sod regardless of the concentration of the soluble salts in the water used. This indicates that under Manitoba conditions virgin sod can produce more satisfactory bedding plants than can peat-lite.

EXPERIMENT III (1966)

In sphagnum peat moss (pH 4.3), acidity results from the lack of exchangeable metallic cations. The quantity of these cations controls the base saturation and indirectly determines the hydrogen ion concentration of the soil solution. An increase in soil pH can be attained by adding compounds which carry these necessary cations. In this experiment the material used is dolomitic limestone. The primary object of this experiment was to determine the effect of two peat moss sources and two levels of dolomitic limestone on plant growth in peat-lite.

In Experiment I, the plants grown in the peat-lite mix appeared to be suffering from a deficiency of iron. When iron chelate was applied as a spray, the symptoms of iron deficiency were partially removed. Since spraying involved another operation the second aim of this experiment was to determine if iron chelate incorporated during media preparation produced comparable growth to iron chelate applied to the media surface as a solution during the growing period.

The effect of different levels of dolomitic limestone and method of iron chelate application upon plant growth is shown in Table 8.

Table 8. The effect of dolomitic limestone and iron chelate applied to four peat-lite mixes on soil reaction, soluble salt content over the growing period and the dry weight of tomato transplants.

	Peat-lite Mix	Mean Dry Weight [1] Grams/Plant		pH Value [1]					Conductivity (mhos x 10^{-3}) [1]				
		Chelate Incorporated in Mix	Chelate added as solution	Initial Mix	One Week	Two Weeks	Three Weeks	Four Weeks	Initial Mix	One Week	Two Weeks	Three Weeks	Four Weeks
I	Sphagnum peat with 5 lbs. limestone per cubic yard	3.10	3.35	5.1	5.6	5.6	5.3	5.6	2.30	3.20	2.35	2.15	2.12
II	Sphagnum peat with 10 lbs. limestone per cubic yard	2.42	4.15	5.5	5.9	5.5	5.8	5.9	2.58	2.72	2.97	2.20	2.17
III	Medika Muck	3.33	4.14	6.4	6.4	6.1	6.0	5.7	1.81	2.82	2.25	2.17	2.30
IV	Medika Muck with 5 lbs. limestone per cubic yard	3.78	4.84	6.5	6.4	6.1	6.0	5.8	2.00	2.80	2.25	2.15	2.45

1 Average of four replications

The Sequestrene 138 applied as a solution produced significantly (0.01) higher dry weight than that incorporated into the mix initially. As a result of its high solubility, the Sequestrene 138 initially incorporated into the mix was probably leached away before the root system was extensive enough to absorb the required amounts. This rapid removal of chelate could have resulted in slight iron deficiency, slower growth, and finally lower dry weight production.

The Sequestrene 138 in solution was added one and three weeks after transplanting. At this time, the root system was sufficiently large to absorb the required amounts of iron before it was leached away. This occurrance probably resulted in the greater dry weight production in the sub-treatment which had the Sequestrene 138 added as a solution.

There were no visual signs of chlorosis on any of the treatments. However, a greater amount of dry weight was produced when iron chelate was added as a solution. This indicates that this method produces the most desirable results.

The soluble salt content of the media did not vary greatly between treatments or over the growing period. Thus, it does not appear to be influenced by treatment.

Treatments III and IV produced significantly (0.01) greater growth, as measured by the amount of dry weight produced. The initial pH of treatments III and IV was 6.4 and 6.5 respectively. Treatments I and II produced less dry weight and had initial pH's of 5.1 and 5.5 respectively. This data supports the fact that tomatoes are somewhat tolerant of pH 5 but that growth and yield will increase if pH is raised (29). The peat moss component of treatments III and IV is Medika muck. Regardless of whether limestone is added to the Medika muck or not, it appears to be the more desirable form of peat moss for peat-lite mixes since it produces the highest seedling dry weight.

EXPERIMENT IV (1967)

Various types and levels of fertilizers are used to supply the nitrogen in peat-lite mixes. The purpose of this experiment was to determine the effect of several types and levels of nitrogen required to produce maximum growth of tomato seedlings prior to transplanting. The root and stem dry weights as well as the root/stem ratio of tomatoes produced on peat-lite mixes using several types and levels of fertilizer are shown in Table 9.

Treatment I produced significantly (0.05) higher root and stem weights and treatment III produced a significantly higher root weight than treatment II. However, treatment IV produced a significantly (0.05) higher root weight than the other treatments. Treatments I and IV produced significantly (0.05) higher total weights than treatments II and V. The nitrate nitrogen content of the treatment II media varied from 2223 to 1948 ppm. This high nitrate nitrogen content conceivably caused a decrease in the uptake of phosphorus. The resulting nitrogen - phosphorus imbalance in the plant probably caused slower growth and thus a lower dry weight production. This result is in accordance with the findings of Domaar and Ketcheson (18).

The recommended rates and types of fertilizers for use in

Table 9. The effect of nitrogen source and level upon root and stem dry weight and root/stem ratios in peat-lite mixes.

Treatment		Weight Grams/Plant Root	Stem	TOTAL	Root/Stem Ratio
I	33.5-0-0 $1\frac{1}{2}$ lbs. per cubic yard	0.0935 b	0.8918 a	0.9853 a	0.1038 b
II	33.5-0-0 3 lbs. per cubic yard	0.0715 c	0.6843 b	0.7558 c	0.1036 b
III	6-9-6 8 lbs. per cubic yard	0.0890 a c	0.8143 ab	0.9032 ab	0.1093 b
IV	6-9-6 8 lbs. per cubic yard plus one feeding of 10-52-17	0.1128 a	0.9028 a	1.0156 a	0.1248 a
V	6-9-6 8 lbs. per cubic yard plus two feedings of 10-52-17	0.0818 a c	0.7653 ab	0.8472 b	0.1066 b

(P = 0.05)

peat-lite mixes are 33.5-0-0 at a rate of 3 lbs. per cubic yard and 5-10-5 at rates between 2 and 12 lbs. per cubic yard. The results of this experiment indicated that the recommended rate of 3 lbs. of 33.5-0-0 per cubic yard was too high. Higher transplant dry weights resulted when 33.5-0-0 was used at 1½ lbs. per cubic yard than at 3 lbs./cubic yard. The fertilizer 6-9-6 (a substitute for 5-10-5) at a rate of 8 lbs. per cubic yard produced a dry weight which was comparable to that produced by 33.5-0-0 at 1½ lbs. per cubic yard and 6-9-6 with one and two feedlings of 10-52-17 during the greenhouse growing period.

Treatment IV produced a significantly (0.05) higher root/stem ratio. The high root/stem ratio in treatment IV was in all probability the result of a stimulated root development caused by the feeding of 10-52-17. The root/stem ratio in treatment V was lower than that of treatment IV. This result could be due to a lush production of top growth when the major elements, especially nitrogen, are present in luxury amounts.

Upon drying, the moisture is removed and the dry weight of the tops is low in comparison to that of the roots. The amount of moisture in the tops of treatment IV was probably less and thus a higher root/stem ratio resulted. In treatments I, II and III there was no additional stimulus and thus roots systems expanded at normal rates.

A high root/stem ratio is desirable for it ensures a maximum water absorbing surface in relation to a transpiring surface. Such a condition would reduce transplanting shock and hasten recovery from transplanting.

The nitrogen levels were highest in treatment I and II (Appendix 11). In all treatments, levels decreased over the growing period probably as a result of utilization and leaching.

Although treatment IV produced the highest root/stem ratio, the added cost of supplementary feeding may prove to be uneconomical to the grower. Thus, of the five treatments studied, the ones recommended to growers would be 33.5-0-0 at $1\frac{1}{2}$ lbs. per cubic yard and 6-9-6 at 8 lbs. per cubic yard.

SUMMARY AND CONCLUSIONS

The media used for growing bedding plants in the greenhouse has a direct effect on the total dry weight produced by the plants and their field performance. In general, the tomatoes started on the sand-soil-manure mix produced higher transplant dry weights, higher early and final yields and higher early and final marketable yields than the plants started on peat-lite and U.C. mixes in 1966. However, the opposite resulted in 1967. In general, when compared using the above criterion, the peat-lite and the U.C. mixes proved to be superior to the sand-soil-peat moss mix in both years.

With Starfire tomato, the correlation between the dry weight of the tomato plant just prior to field transplanting and the total field yield was high. As a result of this correlation, field yield may possibly be predicted by transplant dry weight. More research should be done to determine if this situation also exists with other varieties of tomatoes as well as other vegetables.

The effect of media on the zinnia flower crop was not as pronounced as on the tomato crop. The size of flower produced as measured by the weight of the first flower, did not differ between starting media. In 1966 plants started in the sand-soil-manure produced greater number of blossoms by July 15 than the plants started on the U.C. and sand-soil-peat moss mixes. In 1967 the plants started in peat-lite produced a greater number of blossoms by July 15 than the plants started on sand-soil-manure mix. The total number of blossoms produced in both years did not differ. The result seem to indicate that the extent of growth and development of the transplant in the flat has an effect on earliness of blossoms but not on the total number of flowers produced. This conclusion is in contrast with that obtained for tomatoes where the growth and development prior to field transplanting had an effect not only on the early but also the final yield.

In the peat-lite and U.C. mixes severe plant wilting was evident under conditions of moisture stress. Under the same greenhouse conditions only slight plant wilting was noticed on the sand-soil-peat moss mix and no wilting was evident on the sand-soil-manure mix.

The death of marigold seedling was higher on peat-lite than on virgin sod regardless of the concentration of soluble salts in the water used for watering. The combination of the osmotic pressure of the soil solution and the soil mixture tension in the peat-lite could have been sufficient to render water unavailable to the plant. The virgin sod was able to buffer against the effect of soluble salts and supplied the required amounts of water to the growing plant. The inability of the peat-lite to buffer the roots against the effect of soluble salts could be a limiting factor in the use of peat-lite. Watering of peat-lite after transplanting should be carefully watched for even though the peat-lite may appear moist, moisture may be unavailable to the plants grown in it.

Native Medika muck proved to be superior to pure sphagnum peat moss as the peat moss component of peat-lite. This result is satisfactory in itself, but, when naturally occurring muck is utilized, an element of variability is introduced and thus the original purpose for the use of peat-lite (to attain a uniform mix) is defeated. However, further work could be done to determine the uniformity of the peat moss present in Eastern Manitoba and its value as a component of soil mixes.

Transplant dry weight was reduced when the recommended rate of 3 lbs. of 33.5-0-0 per cubic yard of peat-lite was used. However, satisfactory amounts were produced when either 33.5-0-0 at $1\frac{1}{2}$ lbs. per cubic yard of 6-9-6 at 8 lbs. per cubic yard were used. A maximum root/stem was obtained when 6-9-6 at 8 lbs. per cubic yard plus one feeding of 10-52-17 was used.

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Appendix 1 Soil test reading of nitrates, phosphorus, potassium, pH and conductivity prior to planting and at weekly intervals after transplanting tomato and zinnia seedlings in 1966 [1].

Soil Characteristics	Tomatoes				Zinnias			
	Peat-lite	U.C.	Sand-Soil-Peat	Sand-Soil-Manure	Peat-lite	U.C.	Sand-Soil-Peat	Sand-Soil Manure
Initial Mixture								
NO_3^- lbs/acre	263	36	38	54	320	24	48	54
P lbs/acre	200	185	175	200	200	200	175	200
K lbs/acre	273	196	119	190	240	172	112	151
pH	5.5	6.2	7.1	7.1	5.9	6.3	7.1	6.9
Conductivity (mhos x 10^{-3})	3.16	0.80	0.53	.81	2.48	0.72	0.37	0.55
One week after Transplanting								
NO_3^- lbs/acre	240	34	36	44	188	37	56	48
P lbs/acre	200	200	200	200	200	200	200	200
K lbs/acre	337	153	92	180	166	150	127	183
pH	6.3	6.7	6.9	6.9	6.5	6.7	6.9	7.0
Conductivity (mhos x 10^{-3})	2.93	0.50	0.56	0.56	3.16	0.62	.57	0.78
Two weeks after Transplanting								
NO_3^- lbs/acre	213	22	40	32	213	22	56	32
P lbs/acre	200	200	112	200	200	175	125	167
K lbs/acre	160	95	90	145	226	105	86	150
pH	5.8	6.2	6.5	7.1	6.1	6.2	6.6	6.6
Conductivity (mhos x 10^{-3})	2.7	0.62	0.46	0.50	3.83	0.42	0.51	0.51
Three weeks after Transplanting								
NO_3^- lbs/acre	176	16	36	42	160	14	38	26
P lbs/acre	200	200	175	200	200	156	175	175
K lbs/acre	282	105	100	120	235	92	92	205
pH	6.1	6.8	7.1	7.8	6.3	6.8	6.9	7.2
Conductivity (mhos x 10^{-3})	3.48	0.45	0.41	0.42	2.60	0.52	0.47	0.48

1 Average of four replicates.

Appendix 2 Soil test readings of nitrate, phosphorus, potassium, pH and conductivity prior to planting and at weekly intervals after transplanting tomato and zinnia seedlings in 1967 [1].

Soil Characteristics	Peat-lite	U.C.	Sand-Soil-Peat	Sand-Soil-Manure	Peat-lite	U.C.	Sand-Soil-Peat	Sand-Soil-Manure
Initial Mixture								
NO_3^- p p m	194	23	22	40	66	16	25	49
P p p m	48	197	16	215	59	253	15	197
K p p m	1497	138	29	184	1762	115	30	165
pH	5.7	7.1	7.3	7.6	5.7	7.1	7.7	7.7
Conductivity (mhos x 10^{-3})	1.54	0.98	0.42	0.66	1.80	1.09	0.72	0.72
One Week after Transplanting								
NO_3^- p p m	68	0	59	9	71	0	57	10
P p p m	26	219	13	221	37	221	15	214
K p p m	1140	106	34	176	1381	104	25	176
pH	5.7	6.8	7.1	7.4	6.0	7.0	6.8	7.5
Conductivity (mhos x 10^{-3})	1.18	0.81	0.44	0.36	1.60	0.60	0.57	0.36
Two weeks after Transplanting								
NO_3^- p p m	37	4	42	1	41	2	36	0.5
P p p m	40	301	54	172	37	289	56	181
K p p m	1105	109	35	216	1184	103	42	179
pH	6.0	7.0	7.1	7.4	6.1	7.1	7.6	7.9
Conductivity (mhos x 10^{-3})	1.7	0.64	0.64	0.37	1.81	0.58	0.39	0.35
Three weeks after Transplanting								
NO_3^- p p m	4	17	15	0.5	4	22	17	0.5
P p p m	24	235	66	121	25	201	52	173
K p p m	835	76	34	138	805	68	38	174
pH	5.9	6.8	7.6	8.1	6.4	7.0	7.5	7.9
Conductivity (mhos x 10^{-3})	1.60	0.71	0.24	0.26	1.01	0.55	0.33	0.29

[1] Average of four replicates.

APPENDIX 3 Analysis of variance for the effect of starting media upon the total dry weight of tomato and zinnia seedlings prior to field transplanting in 1966 and 1967.

		Tomato		Zinnia	
Source of Variance	D.F.	1966 Dry Weight Mean Square	1967 Dry Weight Mean Square	1966 Dry Weight Mean Square	1967 Dry Weight Mean Square
Media	3	0.1175**	0.0730	0.0707**	0.0739**
Replications	3	0.0377	0.0137	0.0147	0.0122
Error	9	0.0062	0.0285	0.0048	0.0065
Total	15				

* 5% level of significance

** 1% level of significance

APPENDIX 4 Analysis of variance for the effect of starting media upon the early and total yield of tomatoes in 1966 and 1967.

Source of Variance	D.F.	1966 Early Yield Grams/Plant Mean Square	1966 Total Yield Grams/Plant Mean Square	1967 Early Yield Grams/Plant Mean Square	1967 Total Yield Grams/Plant Mean Square
Media	3	101785.41*	342973.33**	78085.25**	365184.90**
Replications	3	20530.17	104587.40	25622.73	73840.10
Error	9	17374.33	35892.61	10139.78	46350.70
Total	15				

* 5% level of significance

** 1% level of significance

APPENDIX 5 Analysis of variance for the effect of starting media upon the early and total market yield of tomatoes in 1966 and 1967.

Source of Variance	D.F.	1966 Early Yield Grams/Plant Mean Square	1966 Total Yield Grams/Plant Mean Square	1967 Early Yield Grams/Plant Mean Square	1967 Total Yield Grams/Plant Mean Square
Media	3	21446.41**	85479.42*	42872.41*	311397.51**
Replications	3	1841.25	18672.67	19049.42	77763.23
Error	9	1553.11	15309.41	7994.91	31996.95
Total	15				

* 5% level of significance

** 1% level of significance

APPENDIX 6 Analysis of variance for the weights in grams of the first zinnia flowers in 1966.

Source of Variances	D.F.	S.S.	M.S.	F
Media	3	0.120	0.400	2.91 N.S.
Replications	3	0.640	0.213	1.55 N.S.
Error	9	1.233	0.137	
Total	15	1.993		

APPENDIX 7 Analysis of variance for the number of zinnia flowers produced per plant in 1966 and 1967.

Source of Variances	D.F.	1966 Flower Number M.S.	1967 Flower Number M.S.
Media	3	0.013 N.S.	0.024 N.S.
Replications	3	0.0171	0.064
Error	9	0.0202	0.024
Total	15		

APPENDIX 8 Analysis of variance for the effect of media on earliness of zinnia bloom in 1966 and 1967 as measured by the number of flowers in bloom on July 15.

Source of Variance	D.F.	1966 No. in Bloom M.S. [1]	1967 No. in Bloom M.S. [1]
Media	3	1.26	4.53 **
Replications	3	0.84	0.02
Error	9	0.398	0.158
Total	15		

* 5% level of significance

** 1% level of significance

[1] Using $\sqrt{x + \frac{1}{2}}$ transformation

APPENDIX 9 Analysis of variance for the effects of media and water soluble salt levels upon seedling death, total dry weight of seedling and earliness of marigold bloom.

Source of Variance	D.F.	Death Rate Mean Square	Dry Weight Mean Square	Earliness Mean Square
Replications	3	62.054	0.0103	685.15
Media	1	16262.390**	0.0331 N.S.	692.61 N.S.
Error (a)	3	66.698	0.0085	179.98
Concentrations	9	84.290**	0.0040 N.S.	592.45 N.S.
Media X Conc	9	536.013**	0.0052 N.S.	465.56 N.S.
Error (b)	54	28.319	0.0080	268.23
Total	79			

** 1% level of significance

APPENDIX 10 Analysis of variance for the effect type of media, water soluble salt level (concentrations), and duration of growing period (weeks) upon the pH and soluble salt content of the media.

Source of Variation	D.F.	pH Mean Square	Conductivity Mean Square
Replications	3	0.006	0.143
Weeks	3	5.196 **	0.863 **
Error (a)	9	0.023	0.070
Media	1	230.433 **	92.24 **
Concentrations	9	0.141 **	0.564 **
Weeks X Media	3	0.720 **	0.070
Weeks X Concs.	27	0.050	0.114
Media X Concs.	9	0.151 **	0.038
Error (b)	255	0.035	0.085
Total	319		

** 1% level of significance

APPENDIX 11 The analysis of covariance for the effect of soluble salt levels in media upon the death of marigold seedlings.

Source of Variance	D.F.								
Total	39	3.8187	62.3069	7273.1355					
Soluble Salt Levels	9	1.565	8.156	1996.729	.1459	8			
Replications	3	0.1990	8.3068	382.867	.9516				
Error	27	2.0545	45.8441	4893.5395	.4571 *	26	1022.9649	3870.5746	148.868
Soluble Salts Error	36	3.6197			.544 **	35	805.9954	6084.273	
Adjusted Soluble Salt Levels						9		2213.6984	245.966

* 5% level of significance

** 1% level of significance

APPENDIX 12 Analysis of variance for the effect of dolomitic limestone and iron chelate on the visual signs of chlorosis in tomatoes.

Source of Variance	D.F.	S.S.	M.S.	F	
Media	3	3.342	1.114	0.787	N.S.
Replications	3	3.094	1.031	0.851	N.S.
Error (a)	9	11.783	1.309		
Iron	1	2.594	2.594	2.156	N.S.
Iron x Media	3	11.469	3.823	3.177	N.S.
Error (b)	12	14.438	1.203		
Total	31				

APPENDIX 13 Analysis of variance for the effect of dolomitic limestone and iron chelate upon the total dry weight produced by tomato transplants.

Source of Variance	D.F.	S.S.	M.S.	F
Media	3	6.047	2.0156	10.81 **
Replications	3	2.538	0.8459	4.54 *
Error (a)	9	1.678	.1864	
Iron	1	7.344	7.3440	32.45 **
Iron x Media	3	2.271	0.7569	3.34
Error (b)	12	2.716	.2263	
Total	31	22.594		

* 5% level of significance

** 1% level of significance

APPENDIX 14 Levels of nitrate nitrogen in peat-lite over a three-week growing period.

Treatment	Initial Media	Media (NO_3) ppm One Week After Transplanting	Two Weeks After Transplanting	Three Weeks After Transplanting
33.5-0-0 - 1½ lbs/cubic yard	1078	985	991	963
33.5-0-0 - 3 lbs/cubic yard	2223	2055	1980	1948
6-9-6 - 8 lbs/cubic yard	227	164	58	7
6-9-6 - 8 lbs/cubic yard plus one feeding 10-52-17	247	185	71	7
6-9-6 - 8 lbs/cubic yard plus two feedings 10-52-17	200	202	48	21

APPENDIX 15 Analysis of variance for the effect of nitrogen source and level upon root and stem dry weights and root/stem ratio of tomato seedlings.

Source of Variance	D.F.	Root Weight M.S.	Stem Weight M.S.	Total Weight M.S.	Root/Stem Ratio M.S.
Media	4	0.00094 **	0.03311 **	0.044201 **	0.000309 **
Error	15	0.00012	0.00516	0.006529	0.000058
Total	19				

** 1% level of significance