VARIOUS LEVELS OF N, P, K FERTILIZATION IN SOIL-PEAT-HAYDITE MEDIA AND THEIR EFFECT ON 'SINCERITY' GERANIUMS, (Pelargonium hortorum)

by

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TABLE OF CONTENTS

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INTRODUCTION

Geraniums are presently one of the most important flower crops in the United States and the demand for them is still on the increase. Geraniums grow rapidly when supplied with adequate water, a steady fertilization program, an aerated media, temperatures of 60° F to 65° F, and proper spacing, timing, and pinching. However, when any one of these greenhouse growing conditions are not followed, geranium growers may begin to encounter problems.

In any fertilizer program for greenhouse crops the soluble salt content of the media should be kept under close observation. High soluble salt levels may be a serious problem in greenhouse geranium production.

High soluble salt levels may be recognized by slower growth rates, gradual hardening of plant growth, reduction in flower size, lighter green foliage and neucrosis of the lower leaves (1). This injury is often the result of inadequate watering, excessive fertilizer applications, poor physical structure of the media causing improper drainage, or high salt content in the irrigation water.

To help prevent the build-up of soluble salts many growers of geraniums are using either soil with inert amendments or an entirely soil-less media. Soil-less media may consist of peat moss and sand (U. C. System) or peat moss and either vermiculite or perlite (Cornell System).

Haydite is used as an amendment to soil to increase porosity and to facilitate movement of water and air. Haydite (a calcined clay) is a combination of clay and shale which is fused at high temperatures. It

is available in the midwest, California and parts of Canada. Haydite comes in a range of partical sizes and it costs approximately 0.17¢/-cubic foot as compared to 0.10¢/cubic foot for sand or gravel. Haydite may be used to replace perlite, fine gravel, or other coarse aggregate.

The objectives of this thesis were to study geranium growth as influenced by nutrient levels varying from 50 to 400 ppm NO_3 of soluble 20-8.8-16.6 fertilizer. Toxicity levels of these nutrients on geraniums were observed and recorded in soil and soil-less media. Peat moss and haydite were used as amendments and/or media. Nutrients retained or leached from the media were determined.

Results are presented in manuscript form to be published in the Journal of American Society for Horticulture Science.

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LITERATURE CITED

Laurie, et. al. (6) stated that when geraniums are irrigated and fertilized with regular and proper levels of nitrogen and potassium, in a media that has calcium and phosphorus pre-mixed into it prior to potting, growth and development of the plants are rapid and of good quality. It is impossible to make a generalized statement as to the exact amount of nutrients required to grow geraniums due to the wide variability of the types of media that may be used.

Jackson (4) found that best growth of geraniums occurred when nitrogen, phosphorus, and potassium were supplied to the plants in nutrient solution concentrations of 20 to 50, 10, and 30 to 50 ppm, respectively. Ball (1) recommends a constant feeding program of 200 ppm nitrogen and potassium in equal parts of soil, peat and haydite. Liquid feeding is done every two weeks using a soluble 20-20-20 or 25-10-10 fertilizer at the rate of one ounce to two gallons of water. Dunham (2) stated that four to eight ounces of a 20-20-20 fertilizer should be used per 100 gallons of water when plants are fertilized with each watering. This would be 60 to 120 ppm of N, 26 to 53 ppm of P, and 50 to 100 ppm K, respectively.

According to Lunt and Kofranek (8) nutrient disorders in geraniums are of concern, especially with producers of cuttings, because their profits are related to rapid vegetative growth and high quality plants. The most noticeable symptoms of nitrogen deficiency in geraniums are the reduction of plant growth, the older leaves become discolored, loose

their luster, and may also turn bright red. Plants with a phosphorus deficiency have dark green leaves with older leaves turning dull red. Potassium deficiency produces pale colored young leaves with the older leaves being a light yellow color between the veins.

Haun and Cornell (3) noted that high levels of phosphorus and potassium, and low levels of nitrogen favored root growth, while low phosphorus and potassium levels, and high nitrogen levels reduced root growth and mortality of rooted cuttings, but increased foliage growth and percentages of N, P, K, and Ca were found in the stems.

Kofranek, et. al. (5) found geraniums to be very sensitive to high salt levels. By increasing the sodium chloride and calcium chloride levels in the root zone from 15 to 75 me/liter, the growth of some geranium varieties was reduced by 43 percent.

White (9) noted that geraniums may be grown in nearly any type of media from peat moss to a heavy clay soil as long as the media is given the proper balance of fertilizer and water, and is free of toxins and pests. However, the growing media should have a low soluble salt level for greater fertility control when using a constant fertilization program.

Laurie, et. al. (6) suggest that if the base soil used is heavy, add $\frac{1}{4}$ - $\frac{1}{2}$ inch grade haydite, perlite or calcined clay, as well as organic matter in a 1:1:1 mixture. The inorganic material increases the soil porosity and facilitates movement of water and air through the media.

White (9) stated that organic matter when used as soil amendments should have these desirable characteristics: (a) a low rate of decomposition, (b) freedom from toxins and pests, (c) uniformity between lots,

and (d) ready availability.

Dunham (2) found that soils amended with peat moss were more acid and required more frequent applications of nutrients than vermiculite amended soils. He also noted that the addition of vermiculite increased the water holding capacity of the soil mixes. Thus, vermiculite-peat moss-soil mixes contained more nutrients due to decreased leaching losses. He concluded that the peat moss-soil mix responded best to frequent light applications of fertilizer while the vermiculite soil mix required less frequent applications of fertilizer.

Lowell (7) comments that he likes growing pot plants in a peat-vermiculite mix. The mix is lighter than soil, it is easier to ship and it grows good quality plants. Cornell mix uses a combination of perlite and peat moss or vermiculite and peat moss for growing plants (9). This mix has the disadvantage of being too light weight, thus, the pot has a tendency to fall over when taller plants are grown in it.

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Various levels of N, P, K fertilization in soil-peat-haydite media and their effect on 'Sincerity' geraniums[1]

Abstract: Dry weight, height, numbers of branches and flowers of 'Sincerity' geraniums (Pelargonium hortorum) were significantly increased when plants were supplied 50, 100 and 200 ppm NO_3 from soluble 20-8.8-16.6 fertilizer, as compared to 400 ppm NO_3. Significantly more growth and flowering occurred on geraniums grown in equal parts of silty clay loam and peat moss. Addition of haydite to a soil or peat media resulted in reduction of geranium growth and flowering. Haydite amended media was found to retain more soluble salts, while the leachate contained less soluble salts, thus causing possible injury to geraniums. Soluble salts increased in all media as fertility level increased and as time progressed through the growing period. All media were watered with constant amounts and at similar intervals.

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INTRODUCTION

Geraniums (Pelargonium hortorum) are an important greenhouse flower crop that are successfully grown using a number of cultural systems. Although complete analysis fertilizers such as 20-8.8-16.6 are generally applied for constant feeding, their rate of application may vary from 20 to 50 ppm NO_3 (3) and 60 to 120 ppm NO_3 (2) in soil mixes and upwards to 200 ppm in soil-peat haydite mixes (1). For biweekly feeding, NO_3 may be applied as high as 750 ppm (1). Geraniums are sensitive to high salt build-up which usually is associated with excessive fertilization rates or poorly structured media. Excessive fertilization is expensive and a serious environmental pollutant.

White (6) reports that geraniums may be grown in any type of media from peat moss to a heavy clay soil. Heavy base soils should be amended with a calcined clay, haydite, or perlite as well as organic matter in a 1:1:1 mix (5). We grew 'Sincerity' geraniums at four fertility rates in five media containing peat moss, haydite, and/or soil to determine optimal fertilization rates. Leachate and soil analysis with growth response were used to determine effects of constant fertilization rates.

MATERIALS AND METHODS

Two hundred terminal cuttings of geraniums (Pelargonium hortorum) 'Sincerity' were taken on May 22, 1972 and rooted under mist in sterile haydite. The basal ends of the 10 cm cuttings were dusted with Hormodin. Misting intervals during the rooting period were set at three seconds every five minutes during daylight hours. Benlate drench was used periodically throughout the rooting and growing processes.

Rooted cuttings were randomly planted in 10 cm geranium pots containing peat moss, haydite and/or soil media (Table 1). Particle size of the haydite was 1.5 x 3.0 mm.

Table 1. Volume percentages of ingredients used for growing 'Sincerity' geraniums.

	MEDIA INGREDIENT (%)		
TREATMENT	Soil*	Peat moss	Haydite
1	100.0	----	----
2	50.0	50.0	----
3	50.0	----	50.0
4	----	50.0	50.0
5	33.3	33.3	33.3

*The soil type was silty clay loam.

Five randomly selected plants from each of the media were grouped together in spacings of 25 cm by 25 cm. Each block of 25 plants was treated daily with one of four levels of soluble 20-8.8-16.6 fertilizer: (1) 50 ppm NO_3, (2) 100 ppm NO_3, (3) 200 ppm NO_3, (4) 400 ppm NO_3. Each treatment was replicated twice. Approximately 250 ml of fertilizer solution was applied to each 10 cm pot with each watering regardless of media. With all media this rate supplied some leaching.

Samples of leachate were collected from each experimental treatment each week for seven weeks until the plants were marketable. Conductivity of the leachate was measured in mhos/cm using a Solu-Bridge instrument. This instrument was also used to measure soluble-salt content in the soil by using a two distilled water to one dry soil dilution. A pH reading for each leachate was also recorded.

Spurway soil analyses were made twice during the plant growing period. These tests measured available NO_3, P, K, Ca, NH_4, and pH of the growing media. Samples were analyzed at the University of Minnesota Soil Testing Laboratory.

Weekly counts of bloom numbers and heights were recorded for each treatment during the plant growing process. At the end of the experiment total dry weight of top growth and breaks were recorded.

Data were analyzed at the Kansas State University Statistical Laboratory using analysis of variance for a split-plot design.

RESULTS AND DISCUSSION

Fertility Levels: Although geranium growth in fertility rates of 50, 100, and 200 ppm NO_3 were not statistically different, plants appeared slightly larger and of better quality in the 100 ppm NO_3 level.

In all media, fertility rates of 400 ppm NO_3 caused excessive soluble salt build-up, thus causing injury or death of the plants (Plate 1). This high fertility rate resulted in significantly reduced plant height, breaks, total bloom number and total dry weight (Table 2).

Media: Geraniums grown in soil-peat medium produced significantly more dry weight, breaks, bloom number and height than soil, soil-haydite or peat-haydite media (Table 3). Geraniums grown in the soil-peat-haydite medium produced similar height, breaks, and bloom number as plants grown in soil-peat (Plate 2). The peat moss in these two media increased water holding capacity and available nutrient content.

Media which contained 50 percent haydite (peat-haydite or soil-haydite) did not retain water very well. Thus, they dried out rapidly reducing geranium dry weights by approximately one half. More frequent irrigation may be necessary with media containing haydite.

Silty clay loam medium became compacted, restricting root growth and retarding foliage growth, thus reducing plant dry weight by approximately one half. The possibility of overwatering may have occurred with the straight soil medium.

Plate 1. Upper Left: 'Sincerity' geraniums grown under 50 ppm NO_3, using a soluble 20-8.8-16.6 fertilizer in five types of media.*

Upper Right: Fertility rates of 100 ppm NO_3 visually produced the more vigorous 'Sincerity' geraniums in the five types of media.*

Lower Left: 'Sincerity' geraniums grown under 200 ppm NO_3, using a soluble 20-8.8-16.6 fertilizer in five types of media.* Note stunted growth as compared to 100 ppm NO_3.

Lower Right: Fertility rates of 400 ppm NO_3 resulted in reduced plant height, total bloom number, total dry weight, increased injury and death of 'Sincerity' geraniums in the five types of media.*

*The five types of media used were:

PH = Peat-Haydite
S = Soil
SH = Soil-Haydite
SP = Soil-Peat
SPH = Soil-Peat-Haydite

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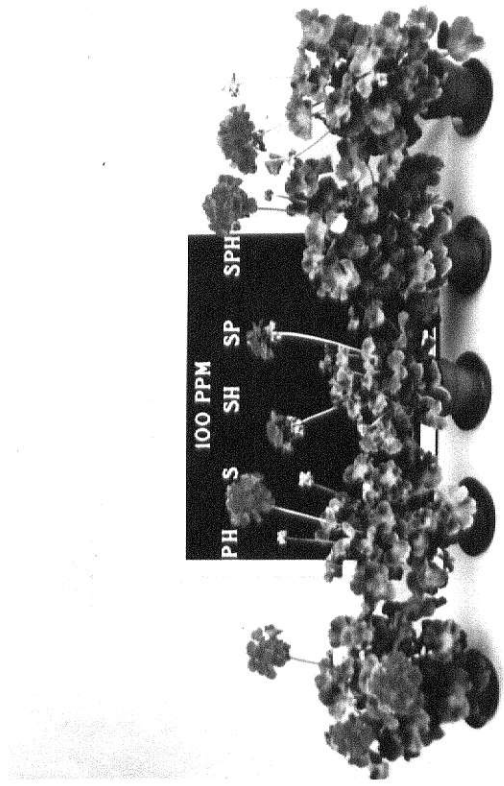
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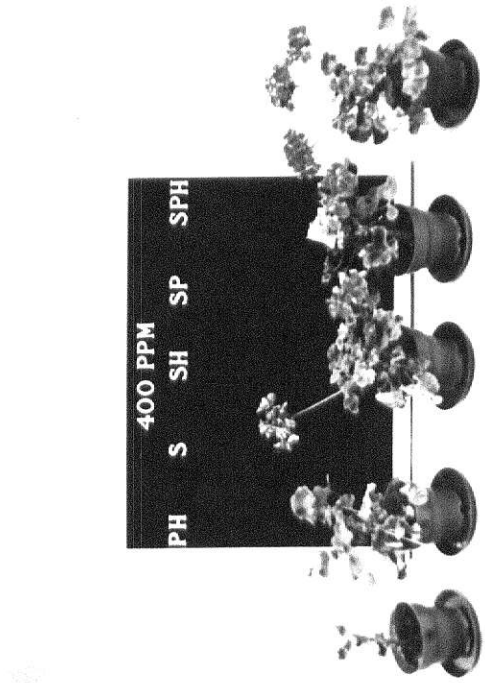
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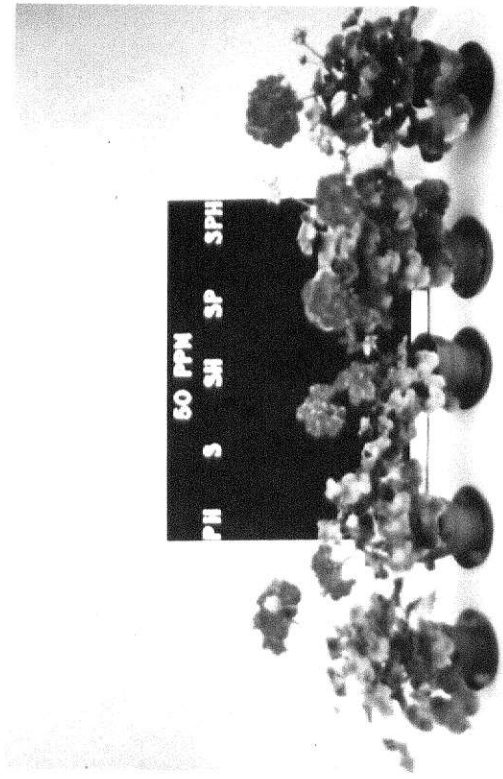
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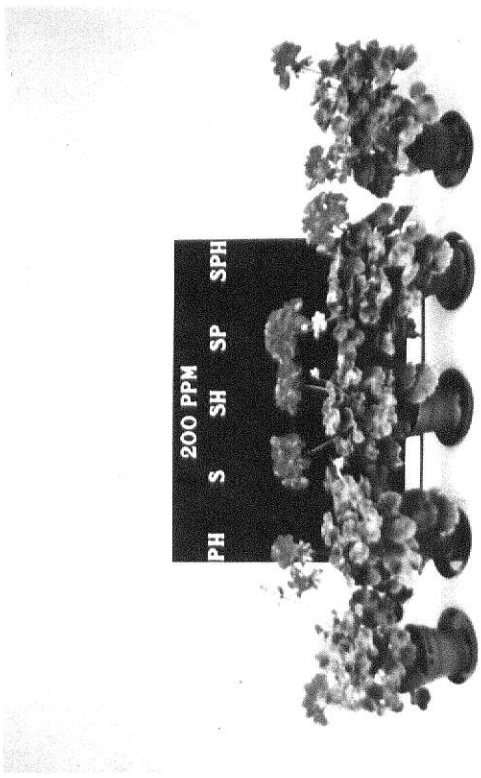
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Table 2. Effects of fertilizer levels on growth and flowering of 'Sincerity' geraniums after seven weeks.

20-8.8-16.6 Concentration (NO_3, ppm)	Total Height (cm)	Breaks (No.)	Total Blooms (No.)	Total Dry Weight (g)
50	14.8 a*	5.6 a*	12.5 a*	18.6 a*
100	15.8 a	6.0 a	11.5 a	19.1 a
200	13.7 a	5.3 ab	11.4 a	17.6 a
400	11.4 b	4.5 b	8.1 b	11.0 b

*Means in any one column not having a letter in common are significantly different at the 5% level. (Duncans Multiple Range Test)

Table 3. Effects of media on growth and flowering of 'Sincerity' geraniums after seven weeks.

Media	Total Height (cm)	Breaks (No.)	Total Blooms (No.)	Total Dry Weight (g)
Soil	12.9 b*	4.8 b*	10.7 bc*	13.5 c*
Soil-Haydite	12.6 b	4.9 b	9.2 c	12.6 c
Soil-Peat	16.2 a	6.4 a	12.6 a	25.1 a
Peat-Haydite	13.3 b	4.9 b	9.0 c	12.2 c
Soil-Peat-Haydite	14.6 ab	5.7 ab	11.6 ab	19.7 b

*Means in any one column not having a letter in common are significantly different at the 5% level. (Duncans Multiple Range Test)

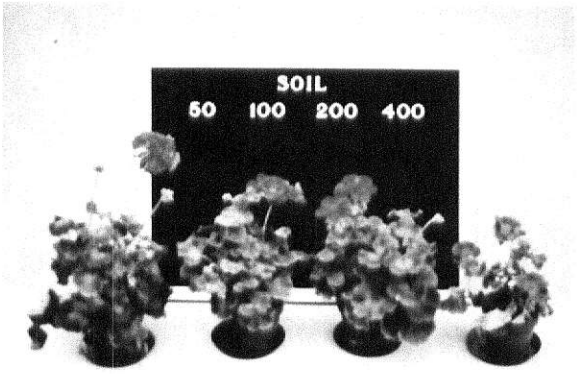
Plate 2. Upper Left: Growing 'Sincerity' geraniums in a straight soil medium under fertility levels of 50, 100, 200 and 400 ppm NO_3.

Upper Right: Using a 1:1 soil-haydite medium to grow 'Sincerity' geraniums at fertility levels of 50, 100, 200 and 400 ppm NO_3.

Middle Left: 'Sincerity' geraniums growing in a 1:1 soil-peat moss medium under fertility levels of 50, 100, 200 and 400 ppm NO_3 significantly produced more dry weight, breaks, bloom number and height than soil, soil-haydite or peat-haydite media.

Middle Right: A soil-peat-haydite medium in a 1:1:1 mix produced 'Sincerity' geraniums with similar height, breaks, and bloom number as those grown in a soil-peat medium under 50, 100, 200 and 400 ppm NO_3.

Lower: Growing 'Sincerity' geraniums in a totally artificial medium of peat-haydite in a 1:1 mix under 50, 100, 200 and 400 ppm NO_3.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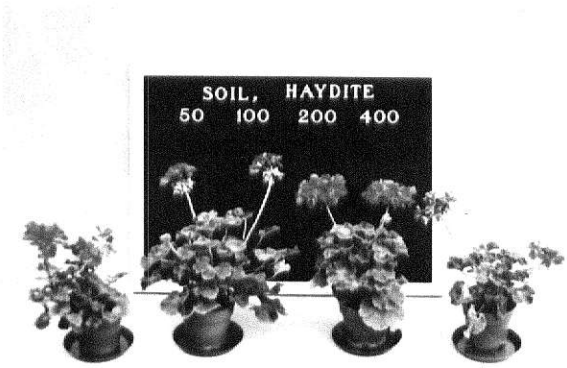
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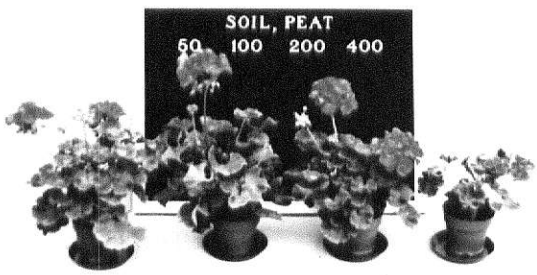
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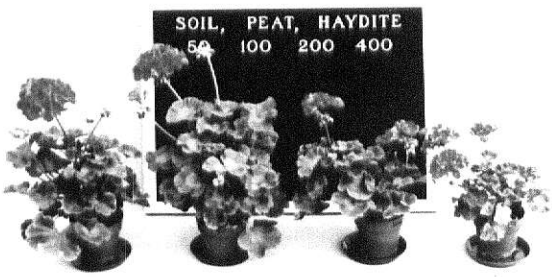
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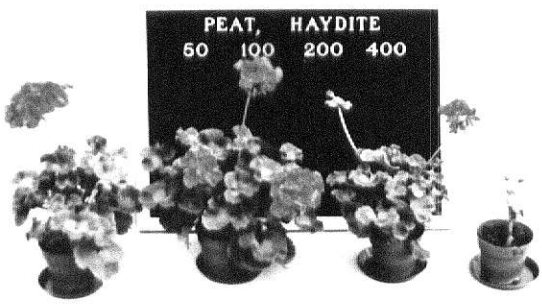
PEAT, HAYDITE
50 100 200 400

Fertility x Media Interaction: Dry weight measurements are indicative of geranium response in the various fertility and media treatments (Table 4). In general, geraniums in soil-peat and soil-peat-haydite media produced more total dry weight at 100 and 200 ppm NO_3 levels of fertility, respectively.

Although the fertility x media interaction was non-significant, geranium dry weight was greater in soil and soil-peat-haydite media at 200 ppm NO_3 and in soil-haydite, soil-peat and peat-haydite at 100 ppm NO_3. Recommended constant fertility rates should not exceed 200 ppm NO_3 as toxic effects on the plants may be observed and reduction in plant size noted.

Spurway Soil Analysis: Soluble salt accumulation was from two to five times greater in peat-haydite medium than in the other media (Table 5). The type of soluble salts in the peat-haydite medium were not determined. Analysis of nitrates and several other nutrient salts were similar when comparing the five growing media. Calcium levels were low in all media. This was probably due to increased hydrogen ion concentration (low pH).

Leachate Salts: After seven weeks silty clay loam soil had accumulated significantly more soluble salts than did combinations of media (Table 6). This was due to the low porosity in the soil medium. Fertilizer water moved less freely through media containing soil and peat, possibly accounting for soluble salt build-up in the leachate. Significantly less salt readings were found in the leachate from media containing haydite. Peat-haydite leachate contained the lowest level of soluble salts of all the

Table 4. The effect of fertility level and media on total dry weight (g/plant) of 'Sincerity' geraniums.

MEDIA	TOTAL DRY WEIGHT (g/plant)			
	50 ppm NO_3	100 ppm NO_3	200 ppm NO_3	400 ppm NO_3
Soil	15.4	11.0	17.4	10.2
Soil-Haydite	11.9	14.1	11.0	13.4
Soil-Peat	28.7	29.5	23.0	19.1
Peat-Haydite	16.7	19.3	10.6	2.3
Soil-Peat-Haydite	21.0	21.5	26.0	10.0

Table 5. Spurway soil analyses of five media fertilized at 100 ppm of NO_3.

MEDIA	NO_3 - FERTILITY LEVEL (100 ppm)						
	Soluble Salts (mhos/cm)	Nitrates (ppm)	Phosphorus (ppm)	Potassium (ppm)	Calcium (ppm)	Ammonium (ppm)	pH
Soil	15.0	49.0	5.0	28.0	35.0	4.5	4.8
Soil-Haydite	18.5	58.5	6.0	37.0	34.0	3.5	4.9
Soil-Peat	30.5	57.0	6.5	38.5	33.0	16.5	4.8
Peat-Haydite	84.0	41.0	5.0	31.0	42.0	8.0	5.0
Soil-Peat-Haydite	27.0	56.0	6.0	37.0	37.5	8.0	4.8

Averages based on analyses taken midway and at end of experiment.

Table 6. Leachate soluble salt readings from five media measured over a seven week period.

MEDIA	SOLUBLE SALTS (mhos/cm)			
	1st Week	3rd Week	5th Week	7th Week
Soil	131.5 b*	159.8 a*	181.4 b*	212.0 a*
Soil-Haydite	145.8 a	166.5 a	152.0 c	173.6 bc
Soil-Peat	139.1 a	162.9 a	200.6 a	188.1 b
Peat-Haydite	141.8 a	149.8 b	159.5 c	165.9 c
Soil-Peat-Haydite	139.8 a	160.4 a	168.5 bc	175.0 bc

*Means in any one column not having a letter in common are significantly different at the 5% level. (Duncans Multiple Range Test)

Average initial fertilizer water salt level = 113.3 mhos/cm

Initial soluble salt readings for all fertility levels = 55.5 ppm

media, due to higher salt retension in the artificial mix.

Soluble salt build-up increased in the leachate of all media as the fertility level increased and with time (Fig. 1). Uniform daily fertilizer solution applications to all media probably were not adequate for proper leaching of media containing peat and soil. Thus, leachate soluble salts in all cases were higher than the initial fertilizer soluble salt concentrations. Leachate soluble salt readings from a constant daily feeding of 50 ppm NO_3, increased from 25 to 48 percent in seven weeks. Even though this happened, the fertility application rate was thought to have been too low for maximum plant growth. Leachate soluble salt readings are not good indicators of media fertility levels.

Daily applications of 100 ppm NO_3 had low soluble salt leachate readings only for the first half of the growing season, until the media became saturated with nutrients. Once the media was saturated, a rapid build-up of excess soluble salts occurred, thus causing salt toxicity and wastage of fertilizer. Leachate readings from a constant daily feeding of 100 ppm NO_3, increased from 19 to 60 percent in seven weeks.

At high fertility levels of 200 and 400 ppm NO_3 the media rapidly became saturated with nutrients. The continued daily application of these high rates not only caused wastage of fertilizers, it also caused plant injury and death in some cases. Final leachates from 200 and 400 ppm NO_3 were 72 to 95 percent higher than initial fertility solutions.

In summary, high soluble salt levels may be injurious to geraniums grown in greenhouses. By keeping the constant fertilizer application levels at approximately 100 ppm NO_3, most salt injury can be prevented

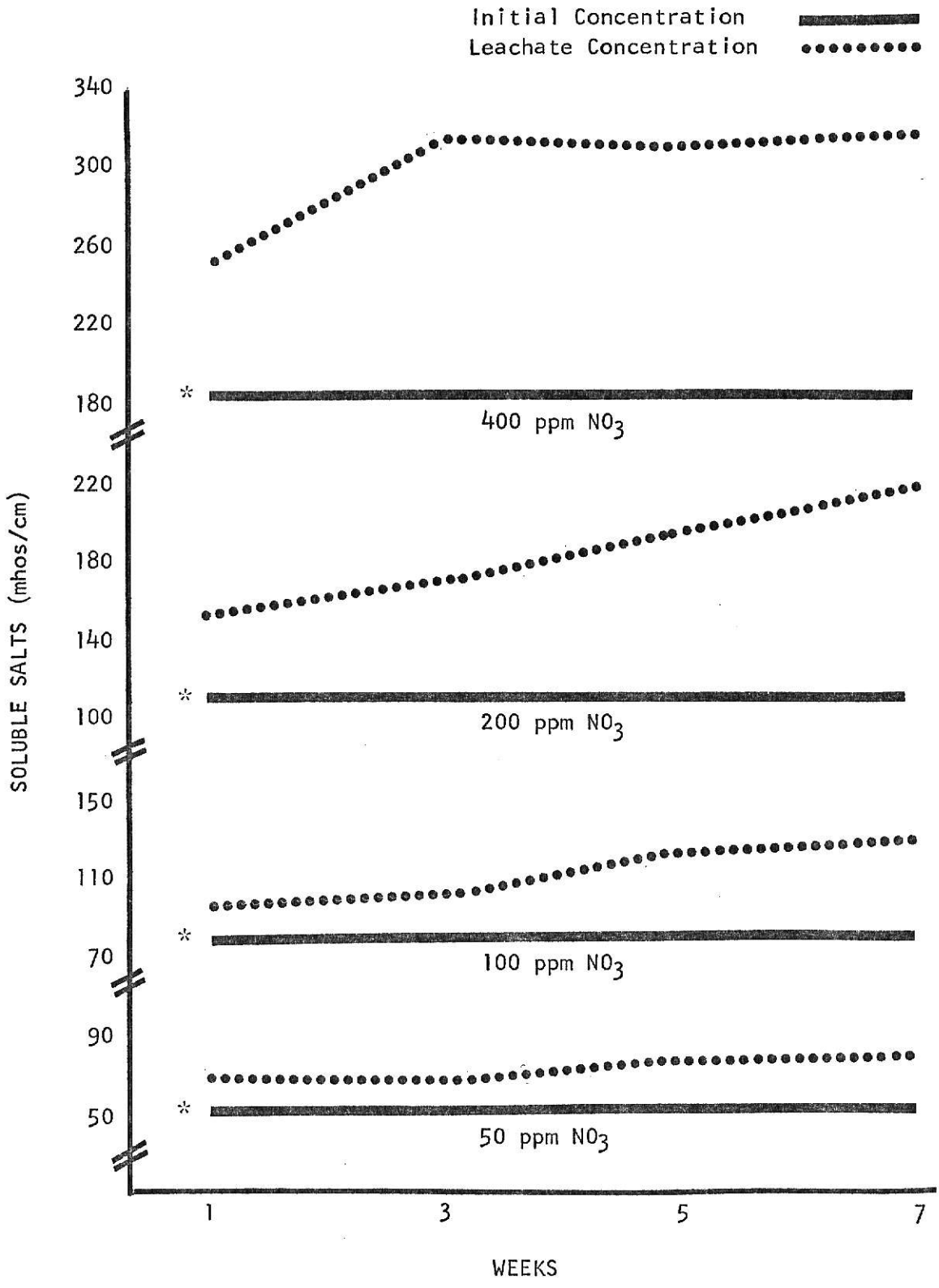

Fig. 1. Changes in leachate soluble salt (mhos/cm) content from geranium media fertilized at constant 50, 100, 200 and 400 ppm NO_3.

*These values include the salts of tap water and will vary according to location.

and at the same time plants will receive enough nutrients for proper growth. Reduced fertilizer application levels will also prevent excessive wastage of nutrients which is costly and may create pollution problems. Geranium growth and flowering in media containing some soil was found to be better than in a total artificial (peat moss-haydite) media.

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APPENDIX

EXPERIMENTAL PROCEDURES AND PROBLEMS

Experimental layout: A schematic diagram of the location of fertilizer and media treatments is shown in (Fig. 2). A split-plot design was used, with fertilizer treatments used as whole plots and media as sub-plots.

Soil analysis: As the fertility levels increased from 50 to 400 ppm NO_3 the levels of soluble salts, nitrates, phosphorus, potassium and ammonium significantly increased (Table 7).

Calcium levels decreased as the fertility levels were increased. Thus, a calcium deficiency occurred at all fertility levels and in all types of growing media (Table 8). The deficiency probably resulted due to increased hydrogen ion concentration (low pH).

The pH was acidic in all types of growing media and at all fertility levels. This was due to the acidic characteristics of the soluble fertilizers being added to the various media. The initial pH of the five media was as follows: soil 5.4, soil-haydite 6.6, soil-peat 5.4, peat-haydite 5.2, and soil-peat-haydite 5.2.

High ammonium content and low pH readings were found in the soil-peat and the soil-peat-haydite media. This was mainly due to the peat moss in the media.

Statistics: The Kansas State University computer center Aardvark program was used to compute analysis of variance for 32 variables. All of these variables are included in the manuscript. An example of the analysis of variance ran on the variates is presented in (Table 9).

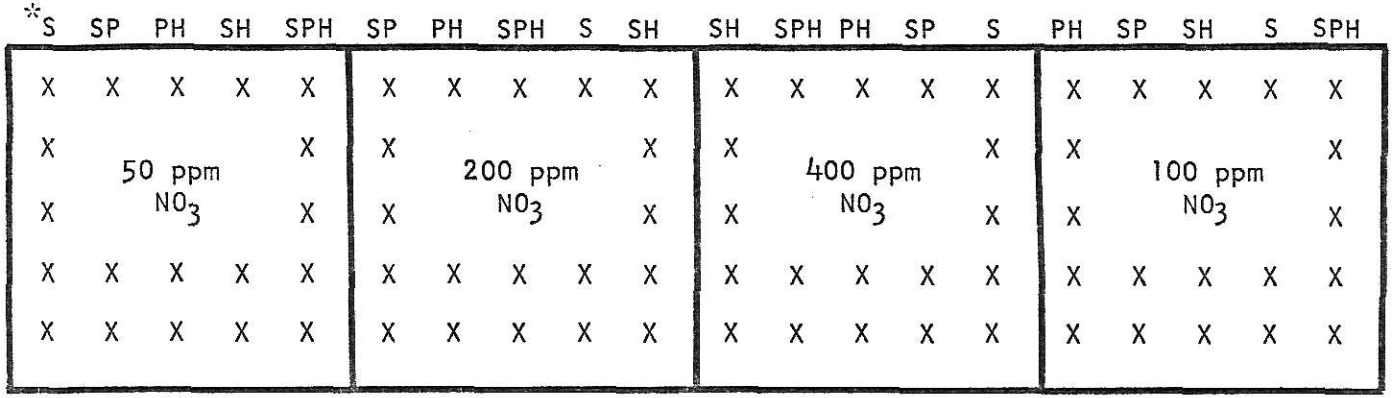

Fig. 2. Split-plot experimental layout of fertility and media treatments in replication number one.

*The five types of media used were:

S = Soil
SH = Soil-Haydite
SP = Soil-Peat
PH = Peat-Haydite
SPH = Soil-Peat-Haydite

Table 7. Spurway soil analysis in relation to fertility levels.

Fertilizer Levels (ppm)	Soluble Salts (mhos/cm)	Nitrates (ppm)	Phosphorus (ppm)	Potassium (ppm)	Calcium (ppm)	Ammonium (ppm)	pH
50	23.1 c*	14.5 d*	3.1 c*	17.6 d*	37.8 a*	3.7 d*	5.1 a*
100	35.0 bc	52.3 c	5.7 c	34.3 c	36.3 a	8.1 c	4.9 b
200	50.9 b	85.2 b	11.2 b	70.8 b	31.1 b	16.2 b	5.0 a
400	82.9 a	147.3 a	18.3 a	122.6 a	27.5 b	24.4 a	4.8 b

*Means in any one column not having a letter in common are significantly different at the 5% level. (Duncans Multiple Range Test)

Table 8. Spurway soil analysis in relation to media.

Media	Soluble Salts (mhos/cm)	Nitrates (ppm)	Phosphorus (ppm)	Potassium (ppm)	Calcium (ppm)	Ammonium (ppm)	pH
Soil	21.9 b*	57.1 a	9.5 a	50.6 b*	30.3 bc*	10.9 bc*	5.1 a*
Soil-Haydite	23.0 b	70.4 a	10.6 a	63.1 a	29.0 c	10.5 c	5.1 a
Soil-Peat	41.6 b	84.4 a	11.0 a	69.0 a	29.9 bc	19.3 a	4.9 bc
Peat-Haydite	110.8 a	81.0 a	8.0 a	61.5 a	42.8 a	10.9 bc	5.0 ab
Soil-Peat-Haydite	42.6 b	81.3 a	8.8 a	62.4 a	34.0 b	14.0 b	4.8 c

*Means in any one column not having a letter in common are significantly different at the 5% level. (Duncans Multiple Range Test)

Table 9. Analysis of variance of total bloom number for 'Sincerity' geraniums.

Source of Variance	Degrees of Freedom	Mean Square	F Value
Replications	1	23.72	9.64**
Fertility	3	56.60	23.01***
Replications x Fertility	3	1.87	0.76NS
Media	4	18.29	7.44**
Replications x Media	4	1.12	0.45NS
Fertility x Media	12	6.46	2.63NS
Error	12	2.46	
Total	39		

** Significant at the .01 level.

***Significant at the .001 level.

VARIOUS LEVELS OF N, P, K FERTILIZATION IN SOIL-PEAT-HAYDITE MEDIA AND THEIR EFFECT ON 'SINCERITY' GERANIUMS, (*Pelargonium hortorum*)

by

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'Sincerity' geraniums (Pelargonium hortorum) were grown in silty clay loam, peat moss and haydite media at 50, 100, 200 and 400 ppm NO_3. Nutrient levels were supplied from constant feeding of a complete 20-8.8-16.6 fertilizer. Although growth and flowering of geraniums in 50, 100, and 200 ppm NO_3 applications resulted in non-significant differences, the highest quality geraniums grew in 100 ppm NO_3 treatments. Fertilizer applications of 400 ppm NO_3 were found to be toxic and excessive.

Peat moss added to the media promoted geranium growth and flowering responses, while haydite amendment was less beneficial. Soil and leachate analyses showed that soluble salts accumulated in media containing haydite. Geraniums grown in a soil-peat medium at a 1:1 ratio were significantly the more vigorous plants.

Soluble salts built-up in the media and in the leachate as the fertility level increased and as time progressed causing toxic effects on 'Sincerity' geraniums.