

To the Graduate Council:

I am submitting herewith a thesis written by John Edward Willingham, Jr., entitled "Influence of Hydrophilic Polymer Amended Soil on Growth of Tomato and Pepper Transplants." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Plant and Soil Science.

David L. Coffey
David L. Coffey, Major Professor

We have read this thesis
and recommend its acceptance:

Gary M. Lessman
Alvin D. Rutledge

Accepted for the Council:

Carmichael
Vice Provost
and Dean of The Graduate School

INFLUENCE OF HYDROPHILIC POLYMER AMENDED SOIL
ON GROWTH OF TOMATO AND
PEPPER TRANSPLANTS

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

John Edward Willingham, Jr.

March 1985

AG-VET-MED.

Thesis
85
.W546

ACKNOWLEDGMENTS

The author would like to express his gratitude to all those who gave assistance during the course of this project.

Jesus Christ.

The University of Tennessee Agricultural Experiment Station and Dr. Lloyd Seatz for supplying the facilities and equipment for this project.

Dr. David Coffey for his friendship, support and guidance throughout this study.

Dr. Alvin Rutledge for his friendship and assistance during this study.

Dr. Gary Lessman for his assistance and guidance throughout this study.

Bobby McKee and the entire farm crew at the Plant and Soil Science Field Laboratory, Knoxville for their help in field work during my field research.

Carolyn Drake for her excellent help in the typing of this thesis.

Alice, John, Hollie and Griffin Willingham for their love, encouragement and support during this study.

Mr. and Mrs. John Willingham, Sr. for their love, support and encouragement.

Dr. and Mrs. R. H. Duncan for their love, support and encouragement.

ABSTRACT

Tomato (Lycopersicon esculentum) and bell pepper (Capsicum annuum) transplants were grown in soils amended with hydrogel (Viterria) and a starchpolyacrylonitrile graft copolymer (Super Slurper). Two levels of each material were evaluated in the greenhouse. The recommended rate for Viterria was .25% or 113 g./1.0 bu. of soil and for Super Slurper was .125% or 57 g./1.0 bu. of soil. These recommended rates were used throughout the test and they were also doubled the first year of the test. Since there was no significant difference found between the recommended and two times the recommended levels, the higher levels were not included in subsequent studies. More water was required for initial saturation and for wetting during the growth period for the amended soils than for the unamended soils. Plant height, stem diameter, fresh weight and dry weight were increased from plants grown in amended soils than from plants grown in unamended soils for tomato transplants. Tomato transplants grown in soil treated with Viterria and Super Slurper were of sufficient size for field transplanting within five weeks while the control plants required six weeks. Leaf nutrient concentration of P and Ca from plants grown in amended soil was higher but no different in concentrations of N, K and Mg. The amendments substantially increased the pH in the growth media. The amendments had no influence on subsequent yields of tomato in the field.

TABLE OF CONTENTS

CHAPTER	PAGE
I. INTRODUCTION	1
II. LITERATURE REVIEW.	3
Chemical and Physical Properties	3
III. MATERIALS AND METHODS.	8
Greenhouse Test, 1978.	8
Field Test, 1978	10
Greenhouse Test, 1979.	10
Field Test, 1979	11
Greenhouse Test, 1980.	11
Greenhouse Test, 1984.	12
IV. RESULTS AND DISCUSSION	13
Data Analyses.	13
V. SUMMARY AND CONCLUSION	31
LITERATURE CITED	33
VITA	37

LIST OF TABLES

TABLE	PAGE
1. Influence of Soil Amendments on Initial Water Absorption and on Water Required During Growth Period of Tomato Transplants, Greenhouse Trial, 1978.	14
2. Influence of Amended Soil Growth Media on Growth of Tomato Transplants, 1978	15
3. Influence of Amended Soil Growth Media on Nutrient Content of Tomato Transplants, Greenhouse Trial, 1978.	17
4. Influence of Amended Soil Growth Media on Growth of Pepper Transplants, Greenhouse 1978.	19
5. Influence of Two Soil Amendments in the Transplant Media on Subsequent Marketable Yield of Tomatoes and Bell Peppers, Knoxville, 1978	20
6. Influence of Amended Soil Growth Media on Growth of Tomato Transplants, 1979	22
7. Influence of Amended Soil Growth Media on Nutrient Content of Tomato Transplants, 1979	25
8. Influence of Two Soil Amendments in the Transplant Media on Subsequent Marketable Yields of Tomatoes, Knoxville, 1979, Field.	26
9. Influence of Amended Soil Growth Media on Growth of Tomato Transplants Grown for Six Weeks in Two Sizes of Peat Pots, 1980.	28
10. Influence of Soil Amendments on the pH of Growth Media	30

CHAPTER I

INTRODUCTION

The practices involved in greenhouse production of tomato and pepper transplants are very important to subsequent yields in the field. Proper nutrition, sunlight and water are critical in proper production of tomato transplants (4,5,16).

Since watering in the greenhouse can be a very labor consuming task and the timing of the watering can be very critical, the study was done to determine if additional water to the transplant media could reduce the time and worry of these two areas in greenhouse management. With additional water available to the plants, the number of times required to water transplants could be reduced, saving some labor and water costs. Also, if water were available for a longer period of time, the risk of plants drying out when routine watering was late could be reduced and the shelf life of plants could then be increased. If, with additional water, the nutrient uptake of the plants could be influenced in a positive manner, one might expect an increase in the growth of the vegetable transplants. If water requirements were met and if this additional water caused nutrient uptake to be increased, it may be possible to grow a vegetable transplant in less time, thus increasing in grower returns by reducing labor and water usage as well as providing a more vigorous transplant for the field.

Super Slurper and Viterria, two soil amendments, were tested to determine their influence on the growth of tomato transplants. These two amendments are supposed to increase the water holding capacity of the soil. Two main objectives of this study were:

1. to determine how much additional water is absorbed in a commercial soil mix by incorporating two levels of these two amendments as well as ascertaining if the additional absorbed water is available to the plants; and

2. to determine if this additional water influenced the nutrient uptake of the transplants.

CHAPTER II

LITERATURE REVIEW

1. CHEMICAL AND PHYSICAL PROPERTIES

Super Slurper

Super Slurper is chemically identified as hydrolyzed starch-polyacrylonitrile graft copolymers (2,3,4). This material is capable of absorbing up to 2,000 times its weight in distilled water. One half of this water is absorbed in the first 30 seconds and most is absorbed within the first 10 minutes. The swollen material retains 65 to 75 percent of the absorbed fluid under centrifugation (4).

The properties of Super Slurper are dependent on whether the grafted branches of the synthetic polymer are in free acid or alkali carboxylate form. The free acid form has only limited solubility in water and is not therefore very useful as an absorbant. The addition of alkali increases the swelling and solubility of the graft copolymer. The graft copolymer in the alkali carboxylate form will dry to form a continuous film which is capable of imbibing several hundred times its weight in water (2,3,5).

Manufacturers and researchers are interested in the graft copolymer for items such as disposable diapers, kitty litter, soil conditioners and as a seed coating (1).

Viterria

Viterria is described chemically as a hydrogel concentrate. This hydrogel is capable of absorbing 150 times its weight in water.

Manufacturers and researchers are interested in this material strictly from an agricultural standpoint.

It has been reported that this hydrogel added to the soil medium increases the available water by up to 50 percent. It can also be used as a seed coating that will attract enough water to germinate soybean seed in a dry seedbed (6).

The use of Viterria and Super Slurper as a seed coating for soybeans has at times had undesirable responses by attracting water and swelling the seeds, causing them to germinate when the soil was too dry for the roots to penetrate, resulting in the death of the seedling.

Plant Effects

Viterria (5) and Super Slurper (1,3) greatly affect plant growth. They markedly improve the available water holding capacity of the soil mix. In tests conducted on Easter lilies, chrysanthemums, tomatoes and oats, Viterria (5,9,10) and Super Slurper (4) caused significant increases in top growth of plants. This was shown by the increase in both fresh and dry weights produced by the treated plants.

The increased amount of available water in the soil of plants treated with Viterria (5,7,8) and Super Slurper (1,4) also increased

the shelf life (time between watering) of the plants tested. This would decrease the frequency of watering needed and consequently the cost of labor required to maintain plants. It has also been reported that Viterria (7) increased medium volume by 15 percent to 25 percent, therefore reducing the total amount of medium required for potted plants. These factors could save on production costs and therefore increase grower returns.

Increased root growth was also shown with Viterria (5,8,10) and Super Slurper (3,4). This increase in root growth from Viterria (5,8,10) was attributed to improved aeration because of increased pore space in the 3:1 commercial potting soil medium which is considered low in capillary pore space.

Super Slurper (3,4) has been tested on sandy soils to evaluate its effectiveness in reducing wind and water erosion. A 1 percent concentration of Super Slurper in sand has been shown to reduce wind erosion (4). However, when Super Slurper was tested in rain erosion control, the results were not as promising. At rates of 500 to 1,000 pounds per acre, it tended to slough and ooze from the ground and did not cause the sandy soils to fuse and become more stable.

Super Slurper (6) and Viterria (7) are being investigated as seed coating materials to increase the water imbibition potential of soybean seed for increasing germination. Super Slurper has been tested in this area for three years but the results are inconclusive. One year the soybeans were seeded by airplane in a growing wheat field. The soybeans germinated and grew so quickly that when the

wheat was ready for harvest, the tops of the soybeans were cut off as well (6). In field tests with corn, during a dry season, there was reported a 30 percent increase in plant population stand from the coated seed when compared to the noncoated seed. This resulted in a 14 bushel yield increase. This research suggested that seed coating could be successful if adequate moisture were present at planting time (6).

It was shown that both Super Slurper (3,6) and Viterria (8,9, 10) were excellent for reducing wilt, increasing shelf life, reducing the amount of water needed and increasing top and root growth of plants in greenhouse operations.

Nutrient Uptake

There are several ways that Viterria and Super Slurper amended soils may influence nutrient uptake by plants. Their effect on soil temperature and soil pH, and amount of available water present in the soil are a few.

It has been shown that the uptake of P, K, Mg and Ca are greatly affected by soil temperatures (13,16,22,33). This is mainly due to the limited amount of root growth. The limited root system of seedling tomatoes planted in cold soils can contribute to nutrient deficiencies, particularly P. Plant growth and nutrient uptake of plants grown at a soil temperature of 55°F were greatly reduced below that from plants grown at 21°C or 30°C (13).

It has also been shown that at soil pH levels higher than those required to inactivate Al, Mn and Fe, that the availability

of Ca, Mg, P, K, S, B, Cu and Zn is also greater (11,15,18,21,22,25, 26,27). Shoot concentrations of P, K and Ca increased when pH adjustments were made from pH 4.0 to pH 6.5 (17).

The stage of growth of the tomato seedling is very important for the uptake of some nutrients. It has been shown that the P nutrition is most critical during the early growth stage of a tomato plant (16,18,19,20,28). It has also been shown that a large supply of Ca must be readily available to young seedling tomatoes (14). Magnesium has also been shown to be present in significant quantities in seedling tomatoes (14,21). It has also been reported by several workers (29,30,31,32) that the tomato has a high P requirement early in the season, especially when temperatures are low and root systems are small. There is a significant interaction between root zone temperature and the uptake of P (12).

There seems to be little available information on the influence of K on the early growth of tomato seedlings (12).

Nutrients probably could be moved into the root zone with the extra water that is available in the Viterria and Super Slurper amended soils. Under normal conditions water moves from a solution of higher water potential to one of lower water potential across a differentially permeable membrane which separates the two solutions. When continuous and abundant water is available, osmosis may occur by means of mass flow in these membranes (23,24).

CHAPTER III

MATERIALS AND METHODS

In 1978, 1979 and 1980 two soil amendments were tested in the greenhouse on the growth of tomato and pepper transplants and treated plants were then evaluated for productivity in the field. These tests were conducted at the University of Tennessee Plant and Soil Science greenhouse and field laboratory in Knoxville, Tennessee.

The two soil amendments used were Viterria, a hydrogel concentrate, produced by Union Carbide and Super Slurper, a starch-polyacrylonitrile graft copolymer, produced by General Mills, Inc.

The soil mixture used throughout the tests consisted of two parts soil, one part vermiculite and one part peat moss mixed on a volume per volume basis. The amendments and levels were as follows:

Viterria .25%	113 g./1.0 bu. soil
Viterria .50%	226 g./1.0 bu. soil
Super Slurper .125%	57 g./1.0 bu. soil
Super Slurper .25%	114 g./1.0 bu soil

There was no fertilizer applied to the soil mixture. Greenhouse night temperature was maintained at 18°C. Daytime temperature varied from 21°C to 30°C.

1. GREENHOUSE TEST, 1978

In 1978, soils amended with the above materials and levels along with a control untreated soil mixture (3:1:1) were placed in 4 cm. plastic pots. Weights were recorded to the nearest gram. They

were then placed in standing water and allowed to imbibe water for two days. They were then removed from the water and allowed to drain for one hour. At this time they were weighed again to obtain how much water was absorbed by each treatment. One 5 cm. tomato seedling (cv. Manapal) was planted in each pot. The plants were allowed to grow for six weeks. Plants were watered as needed and at each watering the planted pots were weighed before watering. They were then watered, allowed to drain 15 minutes and then weighed again in the same manner. This allowed the amount of water used during the growth period to be determined. In this test each experimental unit consisted of six pots and was replicated four times.

Another test conducted to determine the effect on plant growth at the same time involved the filling of 5.7 cm. peat pots with the same four treatments plus the control. Seedling tomatoes (cv. Manapal) and peppers (cv. Big Bertha) were planted into each of the treated soils and allowed to grow for 31 days. Six pots were used for each treatment and treatments were replicated four times.

Growth data taken on these plants after 31 days included plant height and stem diameter in centimeters. The height was measured from the soil surface to the terminal growing point and stem diameter was taken at soil level with a caliper. Fresh and dry weights were taken on all plants. For nutrient analysis, the tissue was dried at 70°C and ground in a Wiley Mill using a 20 mesh screen. A Technicon Autoanalyzer was used to determine tissue content of N, K, P, Ca and Mg.

The tomato seedlings were allowed to grow until plants from one of the treatments obtained this height. At this point all plants were harvested and data taken as in 1978.

In the second test group the tomatoes were seeded in pro-mix and transplanted in 5.7 cm. peat pots. They were allowed to grow six weeks from the time of seeding. The seedlings grew in the amended medium for 32 days. Data were again taken in the same manner.

4. FIELD TEST, 1979

Tomato transplants were grown in the same manner as in 1978. Plant spacing remained the same and recommended cultural practices were followed. Grading and yields by grades of fruit were recorded as in 1978.

5. GREENHOUSE TEST, 1980

The three treatments used in 1979 were again tested using 5.7 and 7.6 cm. peat pots. The plants in both 5.7 and 7.6 cm. peat pots were compared. Seedling tomatoes (cv. Manapal) were planted, allowed to grow for 31 days from the time of seeding, then transplanted to the amended soil mix. The seedlings were then grown 31 days in the amended media. The growth data were then analyzed as in previous years. No plants were taken to the field in 1980.

All tests were arranged in a randomized complete block design with four replications. Analysis of variance and Duncan's multiple range test (5% level) were performed on all data.

6. GREENHOUSE TEST, 1984

Since pH is directly related to nutrient uptake, we wanted to determine if the Viterria or Super Slurper when added to soil would change to pH. Therefore, two additional tests were conducted in 1984 to determine the influence of these soil amendments of media pH. It was also felt that a pH determination of these two materials would be beneficial.

Six 5.7 cm. peat pots were filled with the three amended soils as used in 1979. These were replicated four times. The initial soil pH of each pot was recorded. These pots were watered as if they had been planted but no seedlings were grown in them. At the end of five weeks the soil pH was again recorded. This process was repeated at the end of six weeks. This procedure allowed measurement of changes in pH from amendments.

The pH was determined by mixing one part soil by weight with one part distilled water by weight after allowing it to equilibrate for one hour and readings were taken on an Orion 701 pH meter.

The amendment materials, Viterria and Super Slurper, were also analyzed with a Perkin Elmer 500 Atomic Absorption Spectrophotometer for the presence of K, Ca, and Mg.

CHAPTER IV

RESULTS AND DISCUSSION

1. DATA ANALYSES

Water uptake data are shown in Table 1. The initial water uptake in mean grams per six pots for Viterria and Super Slurper treated soils was significantly greater than that for the untreated control soil. This indicated that the materials allowed more water to be absorbed and held or maintained, made available in the soil mixture. The water applied during the growth period was the same in all the Viterria and Super Slurper treated soils but in all areas was retained significantly more than that added to the untreated control. The initial water, that was needed to initially saturate the media, and the water used during growth were added together to obtain the total amount used during the test and was greater for the amended soils than for the untreated soil mixture. There were no significant differences among the treatments or between the concentrations of the individual materials.

The tomato transplant growth data for 1978 are shown in Table 2. The fresh and dry weights taken from the transplants were significantly different among all treatments. Viterria at 226 g per bushel of mixture resulted in the greatest growth in both fresh and dry weight and the control resulted in the least growth. This would suggest that the increased amount of water retained in the

TABLE 1. Influence of Soil Amendments on Initial Water Absorption and on Water Required During Growth Period of Tomato Transplants, Greenhouse Trial, 1978

Treatment	Level %	Water Uptake ^{YX}		
		Initial Uptake (g)	Growth Period Uptake (g)	Total Uptake (g)
Control		283.0 b	1990.0 b	2273.0 b
Viterria	0.25	452.8 a	2635.2 a	3088.0 a
Viterria	0.50	488.2 a	2691.9 a	3180.1 a
Super Slurper	0.25	523.6 a	2449.6 a	2973.2 a
Super Slurper	0.125	506.6 a	2361.3 a	2867.9 a

^XMeans in a column followed by the same letter are not significantly different at 5% level, Duncan's multiple range test.

^YMean of six pots.

TABLE 2. Influence of Amended Soil Growth Media on Growth of Tomato Transplants, 1978

Treatment	Level %	Tomato Transplant Growth ^{YX}			
		Fresh Weight (g)	Dry Weight (g)	Height (cm)	Diameter (cm)
Control		20.6 c	2.07 c	15.7 b	.49 b
Viterria	0.25	24.4 b	2.79 b	18.0 a	.57 a
Viterria	0.50	27.3 a	3.12 a	18.3 a	.59 a
Super Slurper	0.125	23.5 b	2.82 b	20.1 a	.63 a
Super Slurper	0.25	25.0 b	2.76 b	19.6 a	.61 a

^XMeans in a column followed by the same letter are not significantly different at 5% level, Duncan's multiple range test.

^YMean of six plants.

amended soils was to some extent available to the plant. This resulted in increased real growth as shown by the increased dry weight produced by the plants grown in the amended soils, since increased production of dry matter is a good indicator of real growth.

The height and stem diameter caliper measurements of the tomato transplants are also given in Table 2.

From these data it can be seen that the amended soils produced taller plants with larger stem diameters than those grown in the control soil mixture. These data indicate that tomato transplants of suitable size for field use can be grown in a shorter period of time by using Viterria or Super Slurper in the soil mix.

The nutrient data for the tomato transplants are shown in Table 3. The data show that N and K concentrations were not affected by any of the soil amendment treatments.

Plants grown in soils amended with Super Slurper had significantly higher concentrations of Ca than those grown in the control or Viterria treated amended soils. There was no difference between the two levels of Super Slurper in the soil on Ca concentration present in plants grown on these soils.

With Mg, only the plants grown in low levels of Super Slurper had greater concentration than those grown in the control soil.

Phosphorus concentrations were not affected by the higher levels of Viterria and Super Slurper. Tissue content concentration of P from the lower levels of both Viterria and Super Slurper were enhanced over the control.

TABLE 3. Influence of Amended Soil Growth Media on Nutrient Content of Tomato Transplants, Greenhouse Trials, 1978

Treatment	Level %	Nutrient Content ^x				
		N	P	K	Ca	Mg
		-----%				
Control ^x		3.9 a	.32 c	1.77 a	7.31 b	0.19 b
Viterria ^x	0.25	4.6 a	.39 a	2.34 a	7.4 b	0.25 ab
Viterria ^x	0.50	4.3 a	.32 c	2.11 a	7.1 b	0.25 ab
Super Slurper ^x	0.125	3.7 a	.36 b	1.92 a	10.1 a	0.26 a
Super Slurper ^x	0.25	4.5 a	.32 c	1.86 a	9.8 a	0.24 ab

^xMeans in a column followed by the same letter are not significantly different at 5% level, Duncan's multiple range test.

These results show that concentrations of N, P, K, and Mg were not significantly different between the higher concentration of either Viterria and Super Slurper and that of the control. The only significant differences found between the higher levels of the two materials and the control were in Ca concentration. Only Super Slurper grown plants had significantly higher concentrations than Viterria grown plants here and there were no differences between the rates. Viterria was not different from the control at either level studied.

Fresh weights and dry weights of pepper transplants are shown in Table 4. As the data indicates, none of the treatments significantly influenced pepper plant growth. Since pepper is a smaller and slower growing plant than a tomato, continuing the test for a longer period of time might have resulted in detectable growth differences among treatments. However, for the six weeks growth period selected for this study, no significant differences were found. Because these treatments caused no effect on pepper growth, pepper was not included in subsequent studies.

Yields of tomatoes and peppers for 1978 are shown in Table 5. Weights of grade number one and two, and total marketable fruits of tomato and pepper are shown. The 1978 yields of tomatoes were not affected by any of the treatments. These yields are very low for Tennessee. Late field planting probably attributed to exceptionally low yields as the planting date was four to five weeks later than optimum for commercial tomatoes at this location. This brought

TABLE 4. Influence of Amended Soil Growth Media on Growth of Pepper Transplants, Greenhouse 1978

Treatment	Level %	Pepper Growth ^{XY}	
		Fresh Weight ^{XY} (g)	Dry Weight (g)
Control	-	21.5 a	2.18 a
Viterria	0.25	23.5 a	3.06 a
Viterria	0.50	28.5 a	3.54 a
Super Slurper	0.125	20.5 a	2.42 a
Super Slurper	0.25	31.0 a	3.70 a

^XMeans in a column followed by the same letter are not significantly different at 5% level, Duncan's multiple range test.

^YMean of six plants.

TABLE 5. Influence of Two Soil Amendments in the Transplant Media on Subsequent Marketable Yield of Tomatoes and Bell Peppers, Knoxville, 1978

Treatment	Level	Marketable Yield (metric tons/hectare) ^x			
		Tomato			Pepper Total
		Grade 1	Grade 2	Total	
Control		10.9 a	3.6 a	14.6 a	10.5 b
Viterria	0.25	8.3 a	4.0 a	12.3 a	15.2 ab
Viterria	0.50	12.3 a	2.9 a	15.2 a	13.7 ab
Super Slurper	0.125	14.1 a	5.4 a	19.5 a	19.5 a
Super Slurper	0.25	15.7 a	3.4 a	19.1 a	17.3 ab

^xMeans in a column followed by the same letter are not significantly different at 5% level, Duncan's multiple range test.

the peak production time during the extreme heat of the summer. Many of the blooms were aborted because of the heat. Also the incidence of early blight (Alternaria) was high in this study. This caused a rapid decline in the vigor and also reduced the photosynthetic capacity of the plants.

Even though there were no significant differences in the fresh and dry weights of the pepper transplants, there were some notable observations. Both levels of Viterria and Super Slurper did appear to exhibit more vigorous growth over the control. This increased growth in the greenhouse transplants may have produced a more vigorous plant in the field which in turn may have resulted in increased earliness and amount of fruit set which would account for an increase in overall yield of the peppers grown in amended media over the untreated plants during the test period.

The tomato transplant growth data for 1979 is shown in Table 6. The data is divided into transplants that were grown in five weeks and those grown in six weeks. In both growth periods, plants from all amended treatments were significantly different in fresh weight and dry weight. Plants grown in Super Slurper consistently had the greatest growth followed by those grown in Viterria which had intermediate growth and those grown in the control soil which had the least growth.

Those plants grown in the amended soils for six weeks were too tall and spindly to easily transplant in the field. They were also more susceptible to transplant shock because of the extremely

TABLE 6. Influence of Amended Soil Growth Media on Growth of Tomato Transplants, 1979

Treatment	Level %	Tomato Transplant Growth ^{yx}							
		Fresh wt. (g)		Dry wt. (g)		Diameter (cm)		Height (cm)	
		5 wk	6 wk	5 wk	6 wk	5 wk	6 wk	5 wk	6 wk
Control		16.64 c	22.81 c	1.63 c	2.18 c	.48 b	.54 c	12.4 c	17.0 c
Viterria	0.25	19.13 b	24.31 b	2.14 b	2.63 b	.52 ab	.61 b	14.8 b	18.7 b
Super Slurper	0.125	21.50 a	33.55 a	2.54 a	4.33 a	.56 a	.64 a	15.6 a	24.4 a

^xMeans in a column followed by the same letter are not significantly different at 5% level, Duncan's multiple range level.

^yMean of six plants.

succulent growth. The plants did not harden off well because of their very lush growth. Those plants grown for five weeks in the amended soils were much better adapted to transplanting. They were shorter and more stocky.

Plants grown for six weeks had a mortality rate in the field of 36.5% and experienced a great deal of stem breakage. Those plants grown for five weeks only had an 11 percent mortality rate but they also experienced some transplanting injury. The control plants at the five week planting were too small to make good transplants and experienced a 31 percent mortality rate. When the transplants were allowed to grow the additional week, the plants were then of proper transplanting size and the mortality rate dropped to only ten percent.

The transplant diameter and height in 1979 is given in Table 6. At five weeks the diameter of plants from the Super Slurper amended soils was greater than that of the control plants, while the diameter of the plants from the Viterria treated soil was similar to that of the control plants. In the plants grown in six weeks, all treatments were significantly different with Super Slurper treated plants having the greatest diameter and the control plants having the smallest diameter. The height of the transplants at both five and six week periods was significantly different among all treatments. Super Slurper treated soils produced the tallest transplants, Viterria treated soils produced intermediate plants, and control plants produced the shortest transplants.

The transplant nutrient data for 1979 is shown in Table 7. These data show the influence of Super Slurper and Viterria amended soils on the nutrient content of the transplants grown for both five and six week periods.

The plants which were grown for five weeks showed no significant differences in N or Mg content from any treatment. Plants from Super Slurper treated seed contained significantly more P and Ca than either the Viterria treated plants or the control plants. The plants from both the Viterria treated soils and the Super Slurper treated soils contained significantly more K than the control plants.

The plants grown for the six week period followed the same pattern with the exception of the Mg content. With the six week period, Super Slurper and Viterria soils produced plants which had higher concentration of Mg than the control plants.

It was also noted that the plants grown for the five week period, with the exception of magnesium, had the higher tissue percentage of all nutrients than those grown for the six week period. This might be due to the dilution effect resulting from the additional week's growth.

Yields for tomatoes in 1979 are shown in Table 8. Weights of number one, number two and total marketable fruits are shown.

The 1979 yields more closely resemble those expected under Tennessee conditions. These transplants were planted at the proper time and thus production was extended over a longer period of time. However, as in 1978, the yields were not affected by any treatment.

TABLE 7. Influence of Amended Soil Growth Media on Nutrient Content of Tomato Transplants, 1979

Treatment	Level %	Nutrient Content (%) x									
		N		P		K		Ca		Mg	
		5 wk	6 wk	5 wk	6 wk	5 wk	6 wk	5 wk	6 wk	5 wk	6 wk
Control		4.02 a	3.56 a	.40 b	.31 b	1.96 b	1.75 b	7.3 b	7.6 b	.23 a	.19 b
Viterria	0.25	4.17 a	3.08 a	.44 b	.31 b	2.60 a	2.10 a	7.1 a	7.4 b	.27 a	.29 a
Super Sturper	0.125	4.10 a	3.20 a	.57 a	.40 a	2.50 a	2.10 a	10.1 a	10.3 a	.25 a	.26 a

xMeans in a column followed by same letter are not significantly different at 5% level, Duncan's multiple range test.

TABLE 8. Influence of Two Soil Amendments in the Transplant Media on Subsequent Marketable Yields of Tomatoes, Knoxville, 1979, Field

Treatment	Level %	Marketable Yield (Metric tons/hectare) ^x		
		TW 1	TW 2	Total
Control		34.1 a	13.2 a	47.3 a
Viterria	0.25	35.9 a	13.5 a	49.4 a
Super Slurper	0.125	37.2 a	12.8 a	50.0 a

^xMeans in a column followed by the same letter are not significantly different at 5% level, Duncan's multiple range test.

Transplant growth data for 1980 is compared between plants grown in 5.7 cm peat pots and 7.6 cm peat pots. The data is shown in Table 9. These plants were grown for a six week period. In both the 7.6 cm and the 5.7 cm peat pots, the results were the same. Super Slurper produced the largest plant followed by Viterria and then the control. There were significant differences between each treatment.

It was thought that an increased size of container might reduce the time necessary to produce an acceptable transplant. But, when the two container sizes were compared by treatments, there were no significant differences found.

Two additional tests were conducted in 1984. The first test conducted was the analysis by atomic spectrophotometer of the materials Viterria and Super Slurper. They were analyzed to determine if nutrient content of transplant tissue was influenced by the presence of nutrients in the amendment materials themselves. If the presence of any of these nutrients was found in the amendments in either material, it could possibly affect the uptake of and subsequent concentration of that nutrient in the tomato transplants tissue (12,14,21,28,31,32). There were, however, no detectable levels of these nutrients found in either Viterria or Super Slurper.

The second test was conducted in 1984 to determine if the pH of the amended soil mixture was changed from the initial addition of the amendments to the soil until the samples were analyzed for nutrient content five to six weeks later.

Table 9. Influence of Amended Soil Growth Media on Growth of Tomato Transplants Grown for Six Weeks in Two Sizes of Peat Pots, 1980

Treatment	Level %	Tomato Transplant Growth ^Y			
		Fresh Weight (g)	Dry Weight (g)	Height (cm)	Diameter (cm)
<u>7.6 cm. peat pots</u>					
Control	-	22.8 c ^X	2.19 c	15.0 c	.54 c
Viterria	0.25	24.3 b	2.62 b	17.7 b	.61 b
Super Slurper	0.125	29.6 a	3.79 a	20.4 a	.66 a
<u>5.7 cm. peat pots</u>					
Control	-	19.4 c ^X	1.96 c	14.1 c	.52 c
Viterria	0.25	21.4	2.55 b	16.3 b	.58 b
Super Slurper	0.125	27.9 a	3.54 a	19.1 a	.66 a

^XMeans in a column from each pot size followed by the same letter are not significantly different at 5% level, Duncna's multiple range test.

^YMean of six plants.

The pH data is shown in Table 10. There was only a slight decrease in pH in the five or six weeks in the control mix but a substantial increase in pH from both Viterria and Super Slurper amended soils. The pH change over the five to six week periods with the amended soils should have an influence on the uptake of nutrients. It has been reported that nutrient intake was increased when pH adjustments were made from pH 4.0 to pH 6.5 (17). It has also been shown that Ca, Mg, K and P are more available at pH levels higher than those required to inactivate aluminum and iron (15,17,25,27). The pH changes found in the Viterria and Super Slurper amended soils should have been sufficient enough to have caused substantial increases in the uptake of K, P, Ca and Mg.

This increased nutrient uptake was not confirmed by plant studies but it was felt that, because of additional literature review, the pH factor should be investigated even though the studies were done at a later date. These studies were done without plants in the peat pots. We were interested only in seeding if the amendments caused an increase in the soil pH.

TABLE 10. Influence of Soil Amendments on the pH of Growth Media

Treatment	Level %	Greenhouse Trial 1984 ^{XY}		
		pH		
		Initial Mixing	After Six Weeks	After Six Weeks
Control		5.1 a	5.3 a	5.4 a
Viterria	0.25	5.1 a	5.8 b	5.9 b
Super Slurper	0.125	5.1 a	5.9 b	6.1 b

^XMeans of six pots.

^YMeans in a column from each pot size followed by the same letter are not significantly different at 5% level, Duncan's multiple range test.

CHAPTER V

SUMMARY AND CONCLUSION

In studying the effects of Viterria and Super Slurper amended soils on the growth of vegetable transplants, several useful aspects of the materials were found. Both materials increased the amount of water absorbed and held in the growing container. This additional water held was assumed to be available to the plant. This increase in available water in the amended soils increased the overall growth of the transplants. According to the results of this study, Super Slurper amends soils produced significantly larger tomato plants than did the Viterria amended soils. Greater fresh weight, dry weight, diameter and height of transplants were obtained when grown in Super Slurper amended soils.

An increased concentration of certain nutrients were found. Plants grown in Viterria and Super Slurper amended soils had higher concentrations of K and Mg than did the central plants. Plants grown in Super Slurper amended soils had higher concentrations of P and Ca than the Viterria amended soils or the control soils. There may be several factors that account for this increased concentration of nutrients. One factor might be increased uptake of nutrients that are brought to the rhizosphere of the transplants by the additional water that was found in these amended soils.

Another factor could be that of root growth. With increased water availability and increased top growth, one might expect increased

root growth. With a larger root system, a plant would be able to extract nutrients from a greater quantity of soil.

Possibly the largest factor involved in increased nutrient uptake would be that of the increased pH from the addition of the soil amendments. With the addition of Super Slurper and Viterria, the pH rose from 5.1 to 5.9 and 6.1, respectively. Increasing the soil pH to about 6.0 increases the availability of Mg, P, K and Ca in the soil (11,15,17,21,23,25,26,27).

Viterria and Super Slurper may have applications in commercial greenhouse operations to reduce the frequency of watering and to prevent slow growth due to moisture stress that is often experienced in conventional media and watering regimes. Another application could be the reduction of 7 to 10 days needed for producing tomato transplants. If the operation was not full time, heating costs could be replaced by taking these days off the cold end of the growing period. This would reduce the production cost and thus increase overall returns.

Finally, .25% Viterria, 113 g/1.0 bushel of soil and 125% Super Slurper, 57 g/1.0 bushel of soil, could be used effectively in greenhouse operations to reduce plant stress, watering time and time required to produce transplants. All of these factors could help in increasing profits for the greenhouse operator.

LITERATURE CITED

LITERATURE CITED

1. Anonymous. 1983. Viterria Agri-gel transplanting applications. Union Carbide Bul. No. 402.
2. Weaver, M. O., R. R. Montgomery, L. D. Miller, V. E. Sohns, G. F. Fanta and W. M. Doane. 1977. A practical process for the preparation of Super Slurper. Report of the Northern Regional Research Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Peoria, Illinois.
3. Weaver, M. O., G. F. Fanta and W. M. Doane. 1974. Highly absorbent starch-based polymer. Paper presented at the International Nonwovens and Disposables Association, Washington, D.C., March 5-6, 1974.
4. U.S. Department of Agriculture. 1975. Super Slurper compound with a super thirst. Agricultural Research Service Bul. No. B10-147.
5. Bearce, B. C. and R. W. McCollum. 1977. A comparison of peat-lite and noncomposted hardwood-bark mixes for use in pot and bedding-plant production and the effects of a new hydrogel soil amendment on their performance. Florists Review. Oct: 21-24.
6. Searle, L. 1977. A new chemical that absorbs 500 times its weight in water may increase aerial seeding odds. Soybean Digest. May: 36-41.
7. Anonymous. 1974. Viterria II, Hydrogel Soil Amendment. Union Carbide Bul. No. 5M-4038.
8. Conover, C. A. and R. T. Poole. 1979. Influence of pH on activity of Viterria II and effects on growth and shelf life of Maranta and Pilea. Fla. State Hort. Soc. 92:332-333.
9. Conover, C. A. and R. T. Poole. 1976. Influence of Viterria Hydrogel on growth and control of wilting of three foliage plants. Fla. Fol. Grower 13:9-11.
10. Eikhof, R. H., P. A. King and G. H. Koven. 1974. Control of wilting in potted plants. Ohio Florists Assn. Bul. No. 532.
11. Lucas, R. E. and J. K. Davis. 1961. Relationships between pH values of organic soils and availabilities of 12 plant nutrients. Soil Sci. 92:177-182.

12. Murphy, W. S. 1964. Phosphorus and Potassium nutrition of Southern Tomato transplants. Proc. Amer. Soc. Hort. Sci. 85:478-482.
13. Locascio, S. J. and G. F. Warren. 1959. Interaction of Soil Temperature and Phosphorus on Growth of Tomatoes. Amer. Soc. Hort. Sci. 75:601-609.
14. Hester, J. B. 1969. The Absorption of Nutrients by Tomato Plant at Different Stages of growth. Amer. Soc. Hort. Sci. 64:720-722.
15. Stevens, M. A. and K. N. Paulson. 1973. Phosphorus Concentration in Tomato Fruits: Inheritance and Maturity Effects. Amer. Soc. Hort. Sci. 98:607-610.
16. Wilcox, G. E. and R. Langston. 1959. Effect of Starter Fertilization on Early Growth and Nutrition of Direct-Seeded and Transplanted Tomatoes. Amer. Soc. Hort. Sci. 75:584-594.
17. Pill, W. G. and V. N. Lambeth. 1977. Effects of NH_4 and NO_3 Nutrition with and without pH Adjustment on Tomato growth, Ion Composition, and Water Relations. Amer. Soc. Hort. Sci. 102:78-87.
18. Noll, C. F. 1923. The effects of phosphate on early growth and maturity. Jour. Amer. Soc. Agron. 15:87-99.
19. McCool, M. M. et al. 1919. Some information concerning the use of phosphorus. Mich. Ag. Exp. Sta. Bul. No. 284.
20. Hester, J. B. 1939. The soil side of tomato growing. Campbell Soup Co. Bul. 1.
21. Lingle, J. C. 1960. The effect of source of phosphorus on the growth and phosphorus uptake of tomato seedling. Proc. Amer. Soc. Hort. Sci. 76:495-502.
22. Halbrooks, M. C. and G. E. Wilcox. 1980. Tomato plant development and elemental accumulation. J. Amer. Soc. Hort. Sci. 105:826-828.
23. Tisdale, S. L. and W. L. Nelson. 1975. Fertilizers and Efficient use of Water, In: S. L. Tisdale (ed.). Soil Fertility and Fertilizers. MacMillan Publishing Co., New York, pp. 622-647.
24. Noggle, G. R. and G. J. Fritz. 1976. The Plant in Relation to Water, In: G. J. Fritz (ed.). Introductory Plant Physiology, Prentice-Hall Co., Englewood Cliffs, N.J. pp. 414-457.

25. Paulson, K. N. and M. A. Stevens. The relationship of pH and titratable acidity of tomato fruits and their buffer composition. J. Food Sci.
26. Geraldson, C. M. 1957. Factors affecting Ca Nutrition of celery, tomato, and peppers. Soil Sci. Soc. Amer. Proc. 21:621-625.
27. Dirr, M. A. 1975. Effect of nitrogen form and pH on growth, $\text{NO}_3\text{-N}$, $\text{NH}_4\text{-N}$, and total N content of container grown Double file Viburnum. J. Amer. Soc. Hort. Sci. 100:216-218.
28. Watts, J. 1939. Anatomical symptoms of nitrogen, phosphorus, and potassium deficiencies in seedling hypocotyls of tomato. Ark. Ag. Exp. Sta. Bul. 366.
29. Brasher, E. P. 1941. Growth and yield of tomato plant when hardened with certain nutrient solutions. Proc. Amer. Soc. Hort. Sci. 38:629-632.
30. Locasio, S. J. and G. F. Warren. 1960. Interaction of soil temperature and phosphorus on growth of tomatoes. Proc. Amer. Soc. Hort. Sci. 75:601-610.
31. Wilcox, G. E. and R. Langston. 1960. Effect of starter fertilization on early growth and nutrition of direct seeded and transplanted tomatoes. Proc. Amer. Soc. Hort. Sci. 75:584-594.
33. Martin, G. C. and R. Langston. 1962. Root zone temperature and phosphorus treatment effects on tomato seedling growth in soil and nutrient solutions. Proc. Amer. Soc. Hort. Sci. 80:522-529.

VITA

John Edward Willingham, Jr. was born in Columbus, Georgia on October 13, 1947. He attended Bank High School, Birmingham, Alabama and Farragut High School of Knoxville, Tennessee and graduated in June 1965. He attended The University of Tennessee, Knoxville 1965-1968. He was self-employed in Valley Landscaping and Nursery in Pine Mountain, Georgia from 1968 to 1976. He re-entered The University of Tennessee, Knoxville in 1976 and received his B.S. in Agriculture in August 1978. Upon graduation he began graduate school at The University of Tennessee, Knoxville in January 1979 and also began employment as a Senior Research Technician in the Department of Plant and Soil Science.

He has been married to Alice Duncan Willingham since March 1968. He has three children, John Edward Willingham III born November 3, 1973, Hollie Elizabeth Willingham born October 25, 1975 and Griffin James Willingham born July 4, 1979.