Everybody Talks About Soil Management - What the Nurseryman can do About it,

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For the past twenty years I have attended nurserymen's conferences; talked with many nurserymen and read a sizeable portion of the current literature. The subject of soils management, which is basic to all our efforts, rarely comes to light. Think about it! How often is this subject left out, or relegated to a very minor time slot in our meetings, discussions, and literature? Agreed, it is a complex subject, but this hasn't stopped us from considering other subjects. Could it be the economics of our operations that sideline this topic so often? Certainly it is easier to show results faster and to cut operating costs more quickly in almost every other facet of our work. Perhaps this has been one of our hang ups It seems to me, that for many reasons, we can no longer put soil management on the sidelines.

Up to now we usually have turned to operational improvements when we had to drive down costs because of a budget "squeeze". This was logical because new products and new machines were being developed rapidly to facilitate reduction of costs. However, now we are highly mechanized and we are using many products, unheard of a few years ago, to operate more efficiently. It is possible that we are now reaching the point where the greatest return from an investment of our time and finances will be realized from innovations in soil management and not operational improvements

Better soil management practices are becoming a more important issue because of the tree improvement programs which are relatively new arrivals on the nursery production scene. Through these tree improvement programs we are working towards genetically and physiologically improved seed sources. Because of the costs involved in these programs, this improved seed will be more costly and probably available in smaller quantities. Therefore, with smaller amounts of seed we probably will be required to produce quantities of seedlings similar to those now produced, but of increased value. We cannot risk failures from micro soil differences which result in extremes in seedling density, nutrient deficiencies or toxicities.

Although current trends indicate a possible declining demand for regular forest planting stock in some areas of the country, there also appears to be indications that new types of stock, such as whip size hardwoods, will be needed. This new type of material will, probably be used to fill demands

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tied to the environmental programs now entering the picture (greenbelts, screens, park plantings, highway plantings, etc.). If we are to satisfy such new needs, we should be aware of our present fertility level, and be prepared to improve or change it, if necessary, to produce the new types and species of stock.

Another reason for better soil management practices at this time also hinges on the greater public awareness of total environment. The public is no longer going to sit idly by. We will have to use soil amendments, pesticides and herbicides with great care to avoid pollution of the water and air, Even the use of excessive quantities of fertilizer must be curtailed, The results of a pot culture study we carried out at Mont Alto Nursery , which I shall discuss shortly, will show you how easy it is to add fertilizer that is not doing the job intended.

Perhaps I have spent more time than I should have on the reasons why we must now really exert more effort in the direction of better soil management. However, I feel that we, as nurserymen, are on the threshold of a whole new concept of our business because of the pressures from without that certainly were not apparent a few short years ago.

For most of us there will be difficulties in dislodging funds to improve our soil management program (this has always been the case with the governmental and private nurseries I have been associated with). It is our job to sell the idea of soil management improvements to our supervisors .

You have also heard the comment many times that our universities and colleges can do soil investigations for us. In some states there is a good source of help from these institutions . But in many states the colleges and universities only have finances for basic research. To get this basic research data down to the point where it becomes practical for us to incorporate it in our program takes many additional man hours and money. And this is where a problem arises!

Additional difficulties arise in soil management work when nurserymen get together and try to compare notes on soils tests or tissue tests. In many cases comparisons on any basis are most difficult because there are so many different testing methods, chemicals and reporting units used in soils and tissue analyses procedures. Also, since computers have come into use, changes in reporting have occurred which can throw out results of previous tests, and then continuity (which is extremely important) has been lost, Another stumbling block to a good soils management program is the fragmented nature of the literature. Many times it is concerned with agricultural problems or young plantations and only gives a clue to our needs. Other times it is a report of basic research or is in highly technical terms not adaptable to our use. Some of the literature is not readily available to us because it is published in technical journals, foreign language publications or other printed matter which does not come across our desk.

So far, I've said that there are many reasons why we need a better soils management program than we now have. I have also mentioned some of the difficulties lying in our path toward achieving this goal. Now , I would like to outline two procedures that will allow every nurseryman to improve his soil management practices somewhat. I imagine that most of you in this room have gone through Procedure I, which I shall explain shortly, and might consider going on to the second procedure. Neither procedure will be a panacea, but either one will make improvements in our soil management possible.

PROCEDURE I

If time and money are severely limiting factors, which they often are, the following method might have to suffice:

A. Locate what in your opinion are good and poor seedling growth areas for 'each species.

B. Take soil samples in both the apparently good and poor areas.

C. From the soils analyses ascertain, if possible, relative nutrient deficiences or excesses , If you can get assistance on this from a trained soils analyst, I would suggest it; as interactions between elements, and proper nutrient levels for a particular species are not easily discernable. This type of assistance might be obtained from the laboratory that does the soil analyses, a county agent's office, a forestry extension service, or a college soils department.

D. If a nutrient deficiency or excess is indicated where seedlings are growing poorly, identify the nutrient or nutrients causing the trouble. Make a correction (addition or subtraction) in your additives (again with expert help if possible), but do this only on a small scale first. Use three plots in different locations for each correction you make, and leave an untreated plot adjacent. If the change increases seedling quality, then enlarge the scope of the revision in the following year.

Finally, if on a relatively small scale, during a three year period, the quality improves; then, the change can probably be instituted safely as a routine soil additive practice.

PROCEDURE II

A. If possible, locate a public or private soil and tissue testing facility that will maintain relatively stable testing methods over a long period. I'll admit that this is a difficult task as most laboratories change procedures to reduce costs or to up date quality of analyses. However, every effort should be made to reduce variability in testing results. Any changes in testing procedures eliminates the possibility of good comparison of results over a period of years, and this reduces the chances of finding the direction in which changes are moving;

B. The steps in this procedure are:

1. Take individual soil samples in all areas used for production; sample problem areas individually. Be sure sampling is done with a sample tube, with about 15 cores/sample. The sample must be representative of the area. (I use the area between two pipelines as a sample unit as often the same treatments and the same species are found in this unit).

2. Have tissue tests made for each species grown, if this service is available. Samples should come from areas whereby ocular estimate you find both the best quality and your poorest quality trees, roots, and tops , Consult the person analyzing the tissue for the correct time of the year to collect and the proper location on the seedling to gather tissue.

3. When results of soil and tissue tests are returned, have a soils expert analyze the results, (or do it yourself if you have to). Where are your problems (with which species, in what areas, what elements are involved)?

4. Set up a pot culture study. Start with a species which has been difficult to propagate satisfactorily, and with soil from the areas on the outer fringes of your soil fertility levels From your own experience and with the help of soils experts, and the literature; plan possible treatments to correct suspected difficulties. After seedlings germinate and harden off, cut off excess seedlings to

obtain the desired density. Use four pots (replicates) per treatment as a minimum, and more to suit your needs. Apply planned additives on a predetermined time schedule. Use distilled water for watering and keep moisture content about 3/4 of the way from wilting point to field capacity. The measurements to be taken after each growth period area shoot diameter and height, shoot and root dry weights, soils and tissue analyses . The number of measurements desired will govern the number of replicates required. A greenhouse would help so that this study could be carried out in the winter. However, this work can be done outside in one or two growing seasons. It is possible that this pot culture work might be done under an agreement with a university forestry department.

5. From an analyses of the pot culture results, pilot test plots can be set up in the field. If the results of the pilot test studies in the field concur with pot culture results, then changes can be made in the field on a limited basis first, and then incorporated into routine soil management plans.

6. It would also be desirable, if time and money are available, to outplant representative seedlings from pot culture and pilot test studies. Do the seedlings you consider best actually perform better in the field?

7. Soil tests, and tissue tests should be made after the second rotation to determine what effects, if any, switches in soil management have had. Are changes accomplishing what was expected? If not, adjustments to the program should be instituted.

Perhaps, at this point, you are thinking that whether you would use Procedure I or Procedure you are going to spend a good deal of time. Your question is, "What am I really going to get for all the time I would have to spend?" Let me give you a few examples of what can result from the use of these procedures.

I have just completed some preliminary work involving soil management problems at one of the northern state nurseries in Pennsylvania. In this case, because of limited time, only a modified Procedure I (soil tests of all propagation areas, and recommendations for field pilot tests) was considered. Last August a systematic soil sampling was made by the nursery superintendent. He sent the soil samples to our laboratory at Mont Alto and the soil analyses work was performed last fall and early winter. After the tests were completed I analyzed the results and made recommendations for soil management changes to the superintendent. I asked him for an on site conference early this summer before he instituted any pilot tests of changes in soil management.

In July we had this conference at his nursery. The interesting point I'd like to make here is that I had made recommendations in the soils laboratory based on the soil analyses results during the winter. When I arrived at his nursery we sat down in his office and went over the soil analyses results and the recommendations for changes . While we were in the office I predicted what problems and nutrient deficiency symptoms we might find in the field. When we went into the field there were the problems and nutrient deficiency symptoms as predicted, Perhaps this will indicate how valuable even soil test results alone can be, Now , this nursery superintendent will start putting in field test plots incorporating adjustments to his soil management program that should correct some of the problems and nutrient deficiencies .

Although the use of a modified Procedure I as shown above is a valuable tool in soil management, it is not as reliable nor does it yield as much information as Procedure II (soil analyses, tissue analyses, pot cultures, field test plots, and outplanting studies). I am now in the process of using Procedure II (less tissue analyses) at Mont Alto Nursery, and I would like to describe this work briefly.

After a systematic soil sampling of all the propagation areas at the Mont Alto Nursery, I found that there was a great variation in soil condition and nutrient level. On the basis of this observation, I decided to take the two soils at the extremes of the levels for the pot culture studies , Therefore, I used the two soils described below:

	Block A Section 8	Block E Section 2
pH	5.6	4,6
Organic matter%	2.5	1.3
K (Available lbs/A)	250	125
P " " "	31	15.5
Mg	94	20
Mn	23	45
Fe	2.5	8
Ca	1000	200
Al	34	130
NH3	0	0,5
NO_3	6	23
Texture	Sandy loam	Sandy loam

I decided to use some fertilization materials now in use, and also to use a complete soluble fertilizer,, limestone and sulfuric acid; all at various levels

The species to work with in the pot cultures, field test plots and outplantings were selected to cover a wide range. The species are American elm, Virginia pine, white pine and larch (either Japanese or European). Pot culture studies on the first two are complete, the third is in progress, and the latter will be accomplished next year.

In setting up the treatments I tried to set high and low limits as follows:

Additive	Range
Urea 45%	58,5# to 468# Actual N/A
Complete soluble (14-28-14)	122# Act N, 244# P_2O5, 122# K_2O to 366# Act N, 732# P205, 366# K20/A
Limestone (Dolomitic)	1 to 2 ton
Sulfuric Acid	20.1 to 60.3 gal/A.
Superphosphate	234#

Also, combinations of all these treatments were used and four replicates per treatment were considered a minimum, Total pots in each study (including control pots not treated) ranged from 152 to 176 varying with treatments.

Additions of sulfuric acid, limestone and superphosphate were made at the time soils were potted. Treatments of Urea 45% and the complete soluble fertilizer were made in several applications during the first two months of the study. No treatments were made during the latter 9 months.

During each complete study period, the soil moisture content was kept fairly constant (about 3/4 of the way from wilting point to field capacity).

When the studies were initiated seed was sown in each pot. After it germinated and hardened off, excess seedlings were cut off to bring the pots to the desired density.

Now , let me describe the completed pot culture studies in more detail. At the conclusion of the first growth period (comparable to age 1-0) at the end of five months, two pots of each four pot replicate were dismantled. Measurements of the stem diameter and seedling height for each seedling in each pot were taken. The average root weight and shoot weight for each pot was obtained. And a soil analyses of the soil for each treatment was made.

After a dormant period, the trees in the remaining two pots per replicate were allowed to grow . At the end of the second growth period (comparable to age 2-0) these pots were diamantled and the same measurements and soil anaylses were made as at the end of 5 months

At this point it was quite evident that more replicates of each treatment would have been most desirable to answer questions in regard to the length of time the limestone, sulfuric acid, and fertilizers continued to have an effect on soil nutrient, pH levels, and seedling growth. Also, more replicates were needed for stock to be outplanted. Unfortunately, time and money were not available to fill these needs.

A rough estimate of mine and my assistants' time that was required to carry out one eleven month pot culture study (including setting up, care of the pots, measurements, soil analyses, and reports) was about 1000 man hours. Cost of materials would have to be added to cost of man hours for a total cost figure.

Now, you might ask, what benefits you could expect to get out of such a study. Let me present the following observations that the completed pot culture studies made possible:

1. There is a great variation in soil pH and nutrient level on Mont Alto Nursery. It is so great that seedling growth and response to fertilization, types of fertilizers, and rates of other additives cannot be applied uniformly throughout the Nursery.

2. The two completed studies seemed to indicate quite conclusively that additions of nitrogen fertilizers (of the types used and probably other forms also) do have a direct correlation with reduction in soil pH. For either of the sandy loam soils used in the studies the following results are applicable:

Application rate Actual lbs N/A.	Av. drop in pH caused by the N applications
100	0.20
200	0035
350-450	0.65

Although this drop in pH might not be serious in a soil at higher pH and nutrient levels , it could be for a soil such as found in Block E at Mont Alto (pH 4.6 and low nutrient level). For example, dropping the pH might make phosphorus more unavailable, and create toxic conditions of manganese, aluminum, and iron.

3. Dolomitic limestone additions at the 1 ton rate raised the soil pH 1,0 unit, while the 2 ton rate raised it 1.5 units. However, the effect of the limestone on seedling growth seemed to indicate that the one ton rate was almost as effective as the two ton rate and perhaps the higher rate raised the pH level too much, There also were indications that it probably would have been better to use straight limestone so that a large buildup of available magnesium in the soil could be avoided The studies also confirmed reports in the literature that for limestone of the texture used, 70% of the limestone was effective within 3 months and all of it within one year , Unfortunately as stated before, the study wasn't long enough to observe when the limestone effect sta ed to dissipate,

4, The effect of adding sulfuric acid to a soil such as that in Block A at Mont Alto Nursery (pH 5,6) seemed to be of little advantage. The 20.1 gal/A. rate did lower pH 001 unit while the 60.3 gal/A. rate lowered the pH 0.2 unit. However, when these results are compared to the effect of nitrogen fertilizers on soil pH, the use of acid is really not very practical, An addition of one hundred pounds of actual nitrogen/Acre equaled the effect of 60 gal/Acre of concentrated sulfuric acid on lowering soil pH.

5, The results of the studies appeared to show that the fertility level of Block E soils is probably too low (available P 15# and K 100#/A), without the use of complete nutrient additives, to raise a good crop of Virginia pine 2-0 seedlings. It may be too low for other species as well. The fertility level of Block A (available P 30# and K 200#/A) might also be too low , but it is high enough to get a crop response to just nitrogen alone; while nitrogen alone in Block E is not capable of inducing good Virginia pine 2-0 seedlings, Also, possibly a pH range of 5.6 to 5,8 is best for Virginia pine seedling growth.

6, Some yellowing of Virginia pine needles and elm leaves occurred when the two ton rate of limestone was used, This might be associated with high available calcium (and its interrelationships with other nutrients) in the soil. We find a similar type of coloring in seedbed areas where available calcium levels in the soil are high,

There were indications in both of the completed studies that seedlings take up during the first growth period a major portion of many nutrients needed for the second growth period. These observations were developed from an analyses of the drain figures at the 5 month and 11 month periods in the study. If in further studies, this proves to be so perhaps we should be paying more attention to supplying adequate nutrients in the first growth period and reducing efforts to top dress during later growth periods.

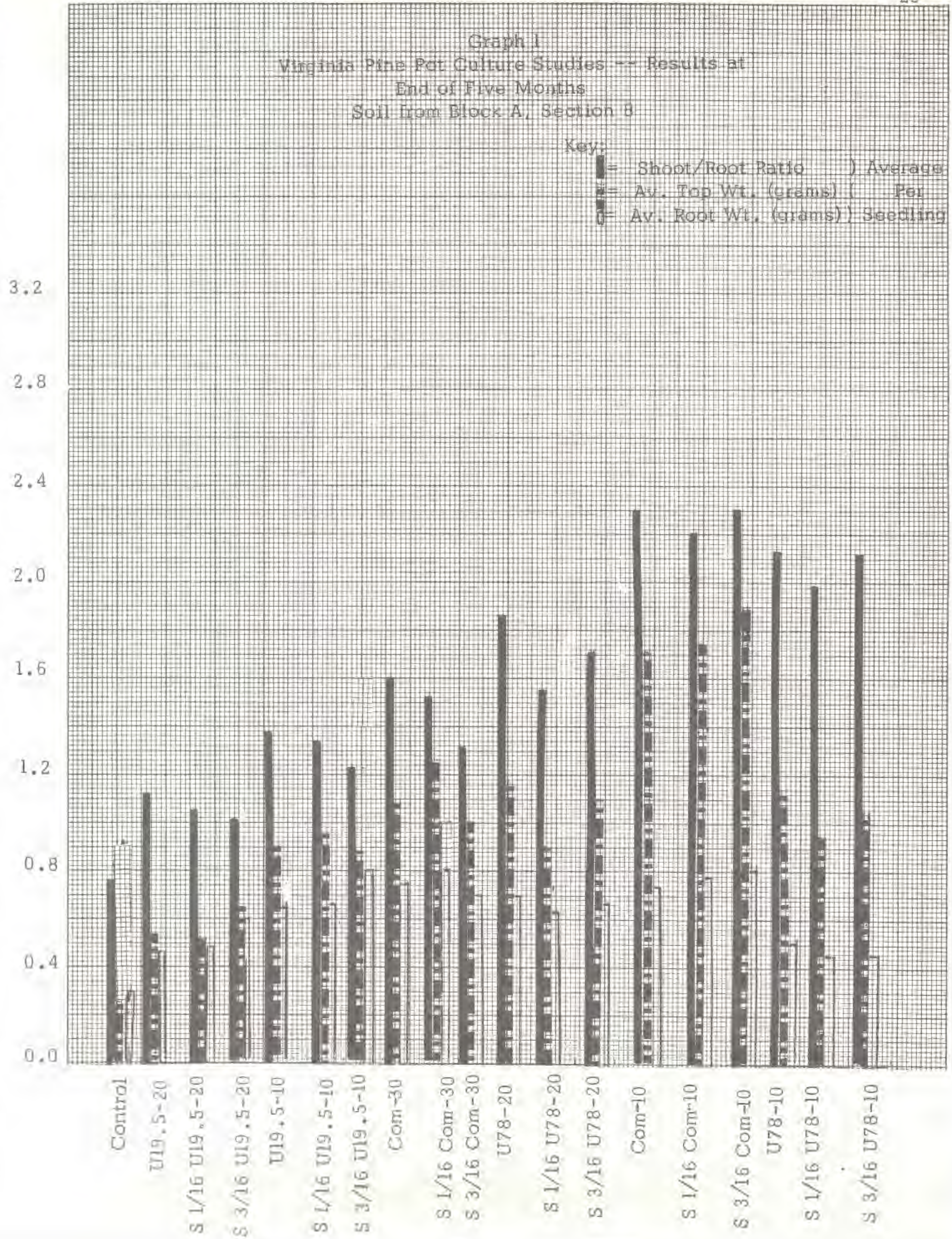
Timing of fertilizer applications seemed to be a key to good seedling growth. On the basis of these studies, field tests at Mont Alto are going to be instituted whereby soluble fertilizers will be used during the first growth period to put nutrients at the disposal of seedlings when they probably need them most. For instance, for trees that seem to have only one growth flush (i.e, white pine, Norway spruce, etc.) soluble fertilizers will be applied from just after the seedlings harden off until about July 15 (when buds are formed). For trees, with growth flushes continuing thru the growing season (i.e. Virginia pine, larch, etc.) soluble fertilizers will be applied from just after seedlings harden off until October 1 (end of growing season). At the same time, where existing soil nutrient levels are low , greater amounts of fertilizers will be added to cover crops to attempt to raise these levels.

In the Virginia pine pot culture study it appeared that nitrogen alone applied in the first two months at a rate of 117# actual N/A in Block A soils (higher nutrient and pH levels) induced as good Virginia pine seedling growth (weight of tops and roots) as it took a complete soluble fertilizer (122# N, 244# P05, 122# K 0/A) to achieve in Block E soils (lower nutrient and pH levels). And nitrogen alone at 234# actual N/A for Block A soils achieved the same effect on growth as a complete fertilizer (366# N, 732# $P_2 05$, 366# $K_2 0$/A) in Block E soils This certainly indicates that to use a complete soluble fertilizer in Block E is necessary to eliminate the limiting effect of the P and K levels, while in Block A nitrogen alone can do the same job. It would be a waste of fertilizer to use nitrogen alone in Block E soils as no positive results could be expected, and it would be a waste of money to use a complete soluble fertilizer in Block A where P and K are at higher levels. (See charts with code index at end of paper).

10. It was noted in the Virginia pine study that it required a rate of 234# actual N/A for Block A soils or a complete fertilizer at 366# actual N, 732# $P_2 0_5$, 366# $K_2 0$/A for Block E soils to produce 2-0 seedlings with an average stem diameter of 3/32" or better. The disadvantage of using these rates is that they might produce excessive shoot/root ratios . Two possible solutions to this problem are: 1) use the higher rates of fertilizer and prune seedling tops in the second growth period, or 2) reduce densities from 50/sq. ft. to 30/sq. ft. and use lower rates of fertilization to possibly achieve the desired diameter. The latter solution might be best as higher rates of nitrogen application (366# and 468# actual N/A) tended to cause mortality of 1-0 seedlings; although it did not seem to be nearly so injurious to the seedlings during the second growth period. (See charts with code index at end of paper).

I hope the above points give you some idea of how valuable pot culture studies can be. Of course, they should be accompanied by soil and tissue analyses, and followed by field pilot tests and outplantings. It might also be noted here again that these observations apply to Mont Alto Nursery; use of the results elsewhere would have to be confirmed by soil and tissue analyses, field pilot tests and outplanting.

It is up to each of us as nurserymen to determine whether we can afford not to be doing something to improve our soil management practices. Just how much we do will, of course, have to be tempered by economics (time and money available). We in Pennsylvania hope to accomplish a good deal toward updating our soil management programs during the seventies Hopefully, our nurseries soils will be at more desirable levels when high quality seed, from our seed orchards, enters the picture within the next 10 years



Graph 1
Virginia Pine Pot Culture Studies -- Results at
End of Five Months
Soil from Block A, Section 8
Key:
= Shoot/Root Ratio) Average
= Av. Top Wt. (grams) (Per
= Av. Root Wt. (grams)) Seedling
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0.0
Control
U19.5-20
S 1/16 U19.5-20
S 3/16 U19.5-20
U19.5-10
S 1/16 U19.5-10
S 3/16 U19.5-10
Com-30
S 1/16 Com-30
S 3/16 Com-30
U78-20
S 1/16 U78-20
S 3/16 U78-20
Com-10
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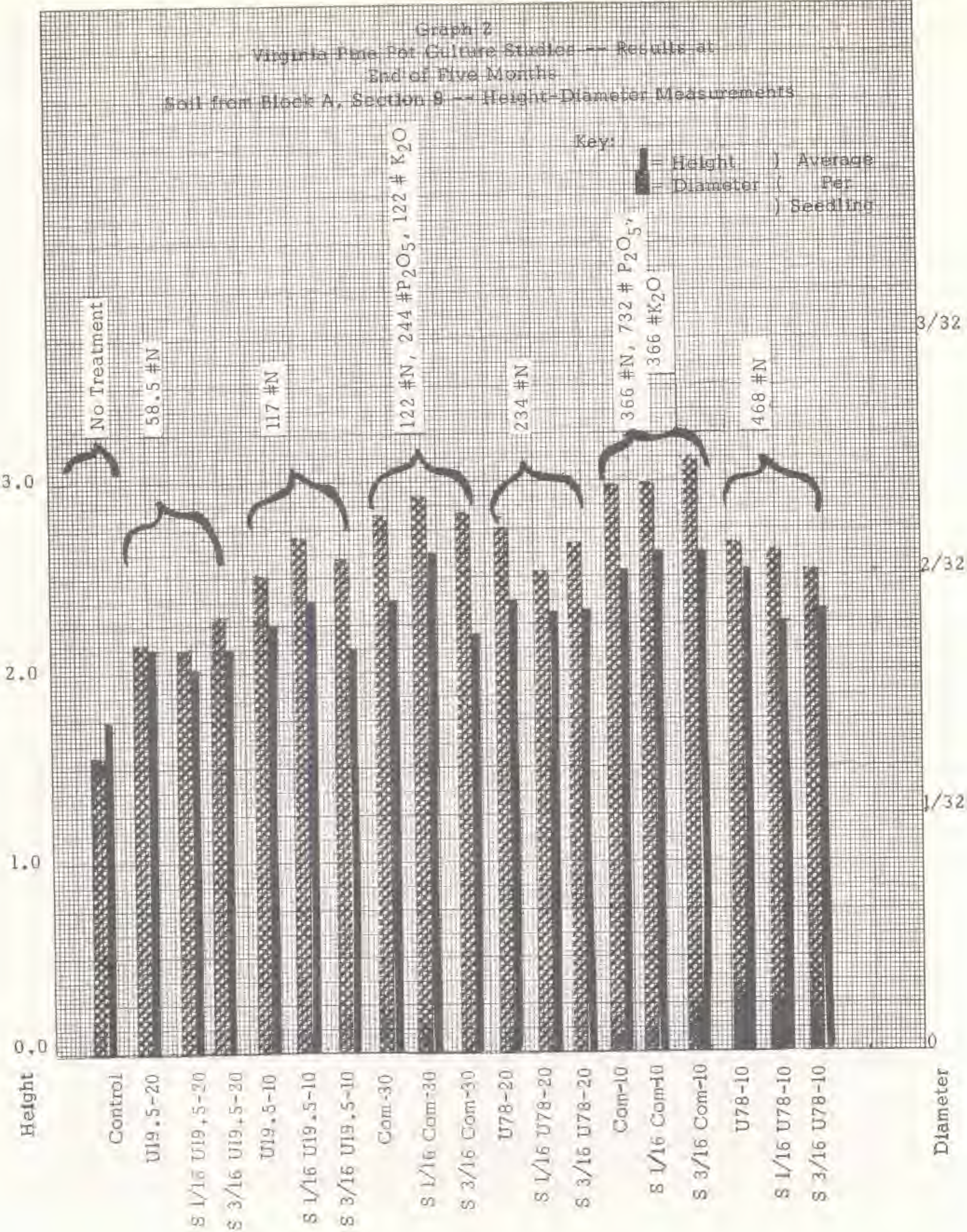
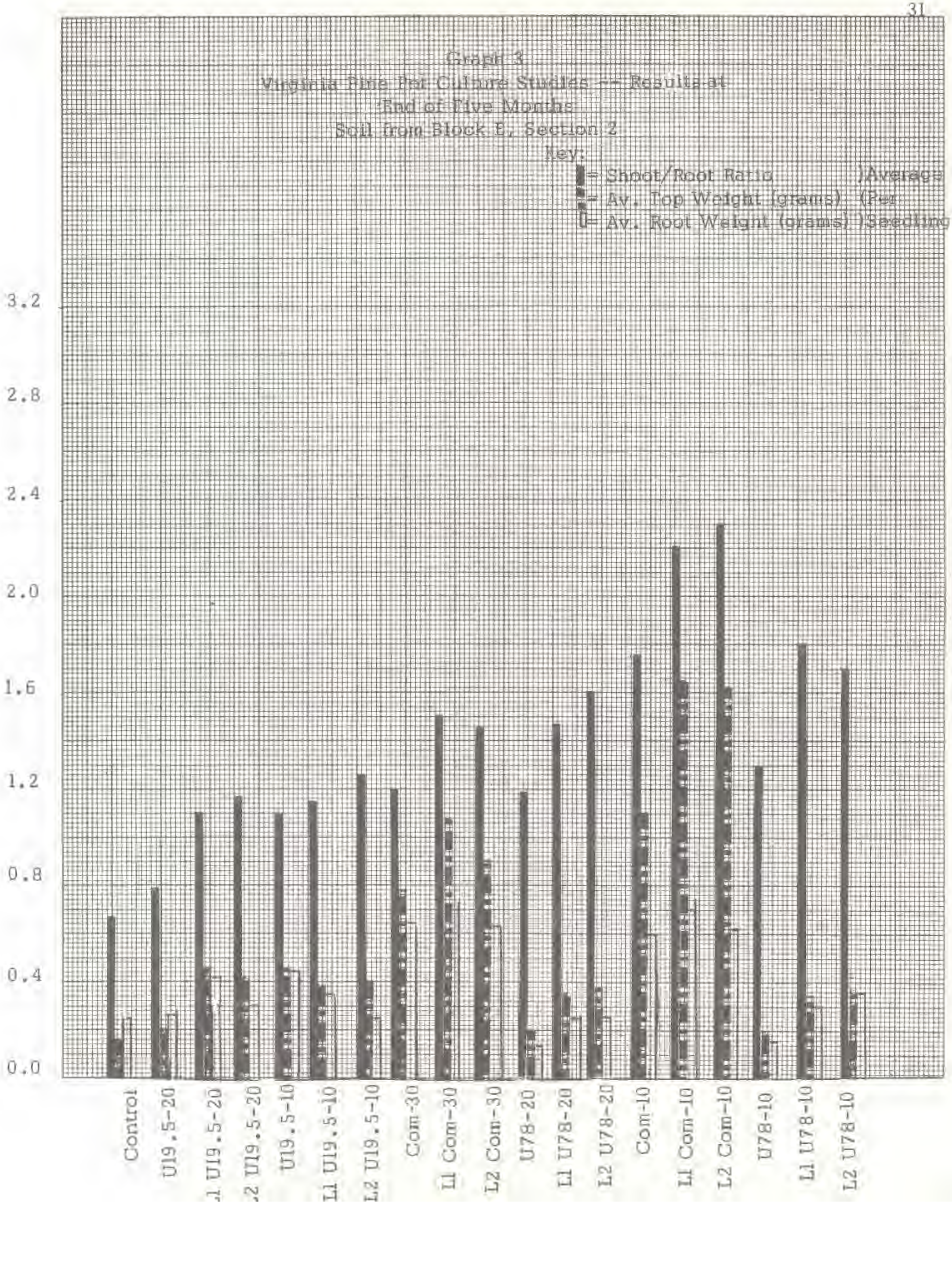
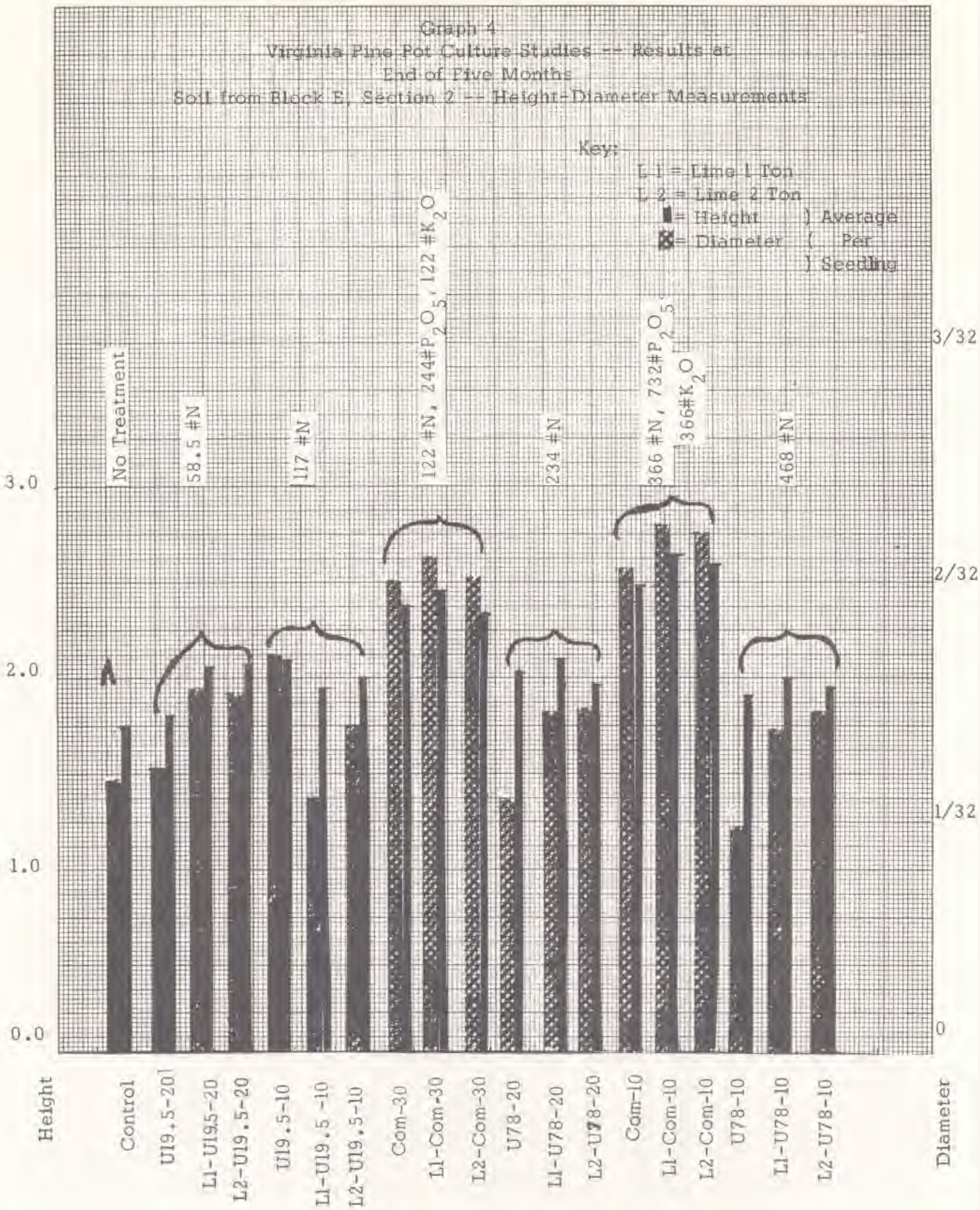
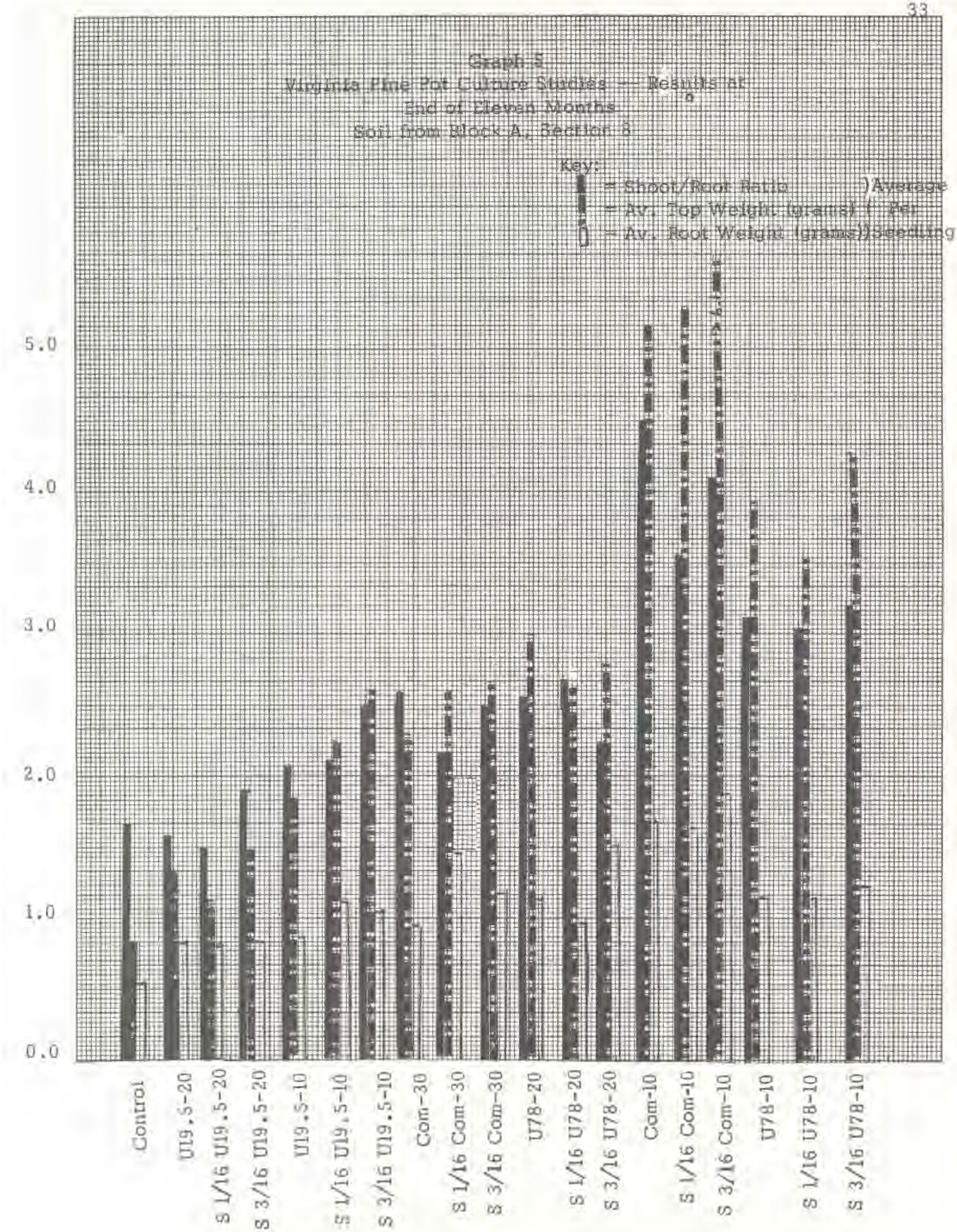
U78-10
S 1/16 U78-10
S 3/16 U78-10

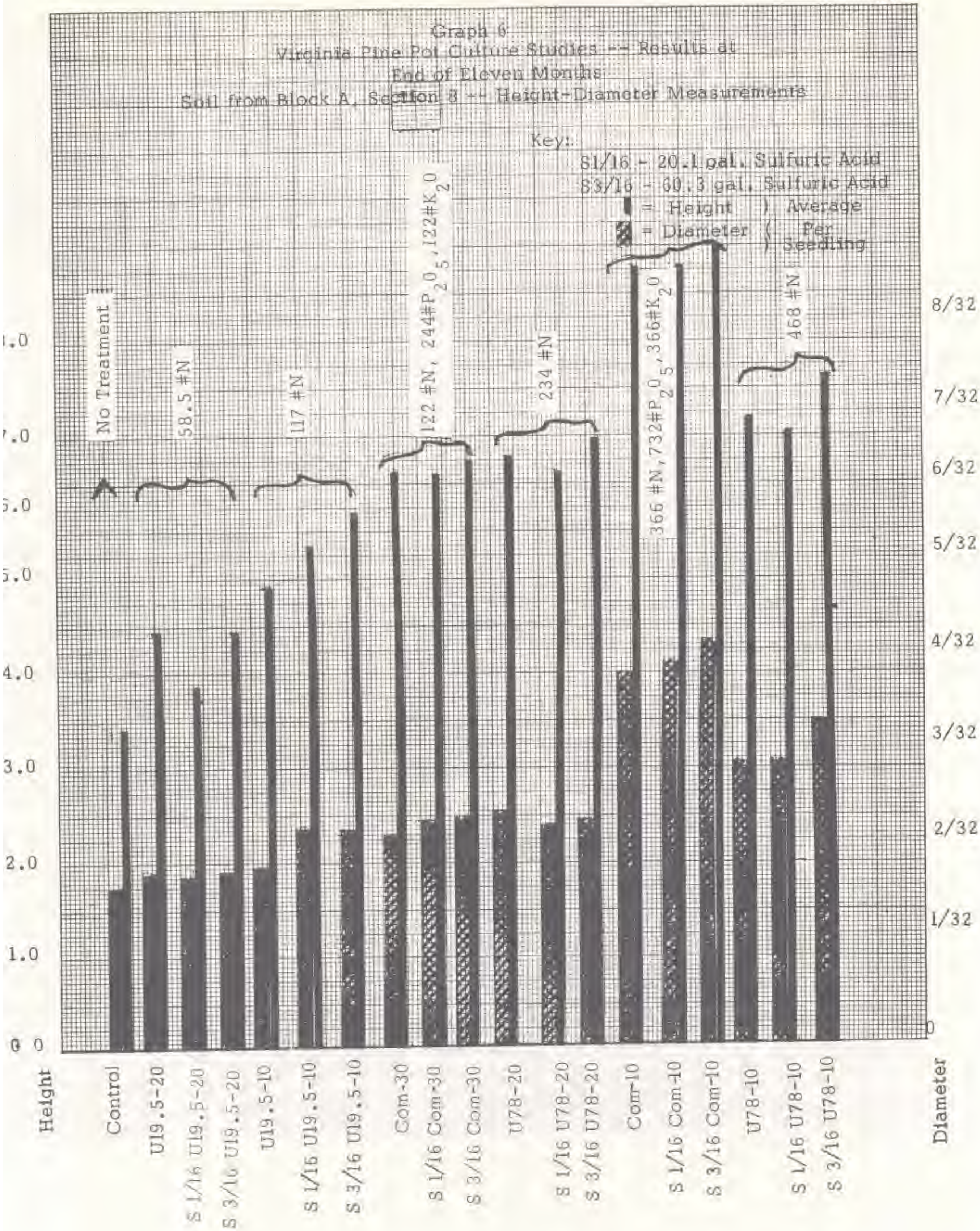

Graph 2
Virginia Pine Pot Culture Studies -- Results at
End of Five Months
Soil from Block A, Section 9 -- Height-Diameter Measurements
Key:
= Height) Average
= Diameter (Per
) Seedling
No Treatment
58.5 #N
117 #N
122 #N, 244 #P2O5, 122 # K2O
234 #N
366 #N, 732 # P2O5, 366 #K2O
468 #N
3.0
2.0
1.0
0.0
3/32
2/32
1/32
0
Height
Control
U19.5-20
S 1/16 U19.5-20
S 3/16 U19.5-20
U19.5-10
S 1/16 U19.5-10
S 3/16 U19.5-10
Com-30
S 1/16 Com-30
S 3/16 Com-30
U78-20
S 1/16 U78-20
S 3/16 U78-20
Com-10
S 1/16 Com-10
S 3/16 Com-10
U78-10
S 1/16 U78-10
S 3/16 U78-10
Diameter

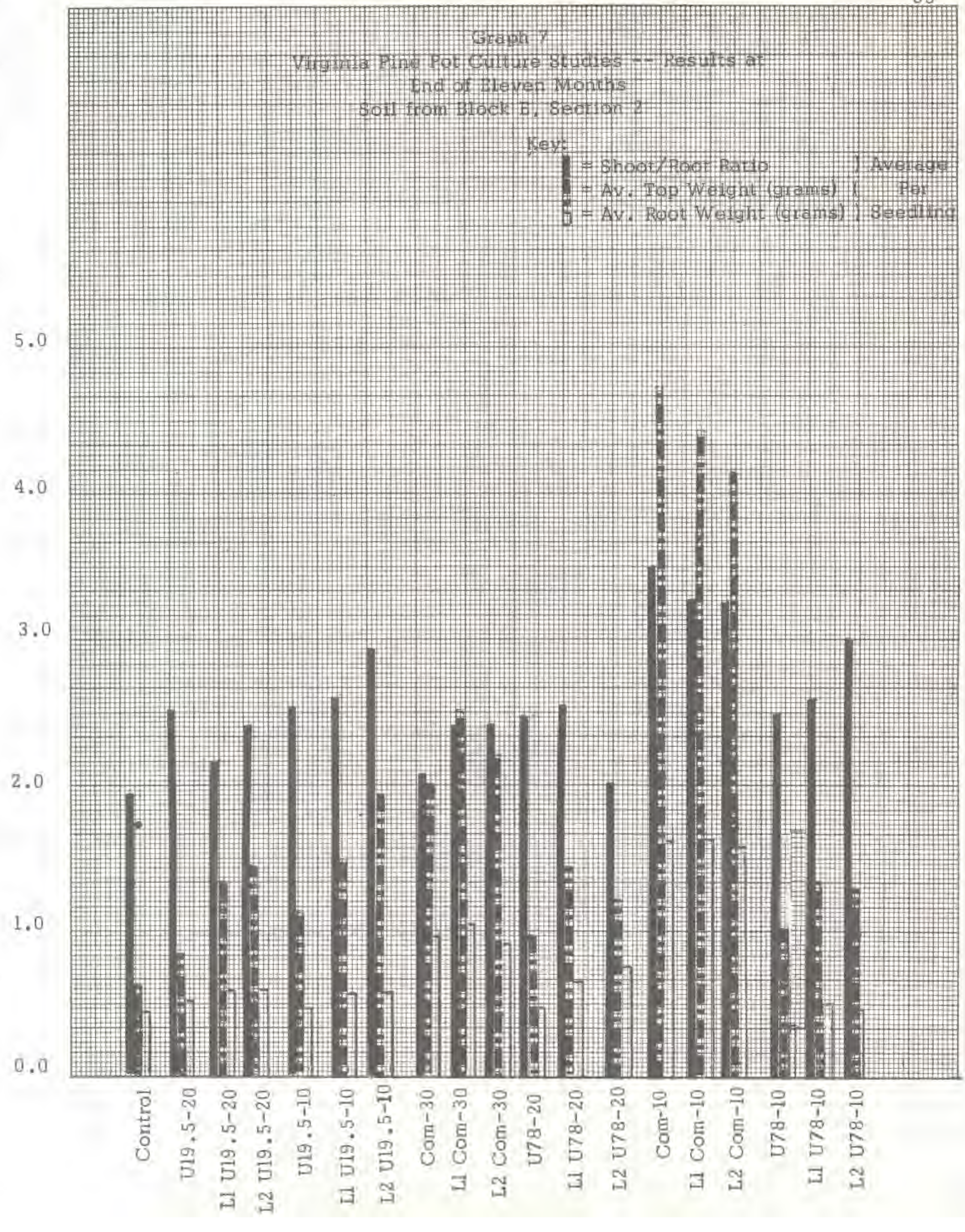

Graph 3
Virginia Pine Pot Culture Studies -- Results at
End of Five Months
Soil from Block E, Section 2
Key:
= Shoot/Root Ratio)Average
= Av. Top Weight (grams) (Per
= Av. Root Weight (grams))Seedling
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0.0
Control
U19.5-20
L1 U19.5-20
L2 U19.5-20
U19.5-10
L1 U19.5-10
L2 U19.5-10
Com-30
L1 Com-30
L2 Com-30
U78-20
L1 U78-20
L2 U78-20
Com-10
L1 Com-10
L2 Com-10
U78-10
L1 U78-10
L2 U78-10

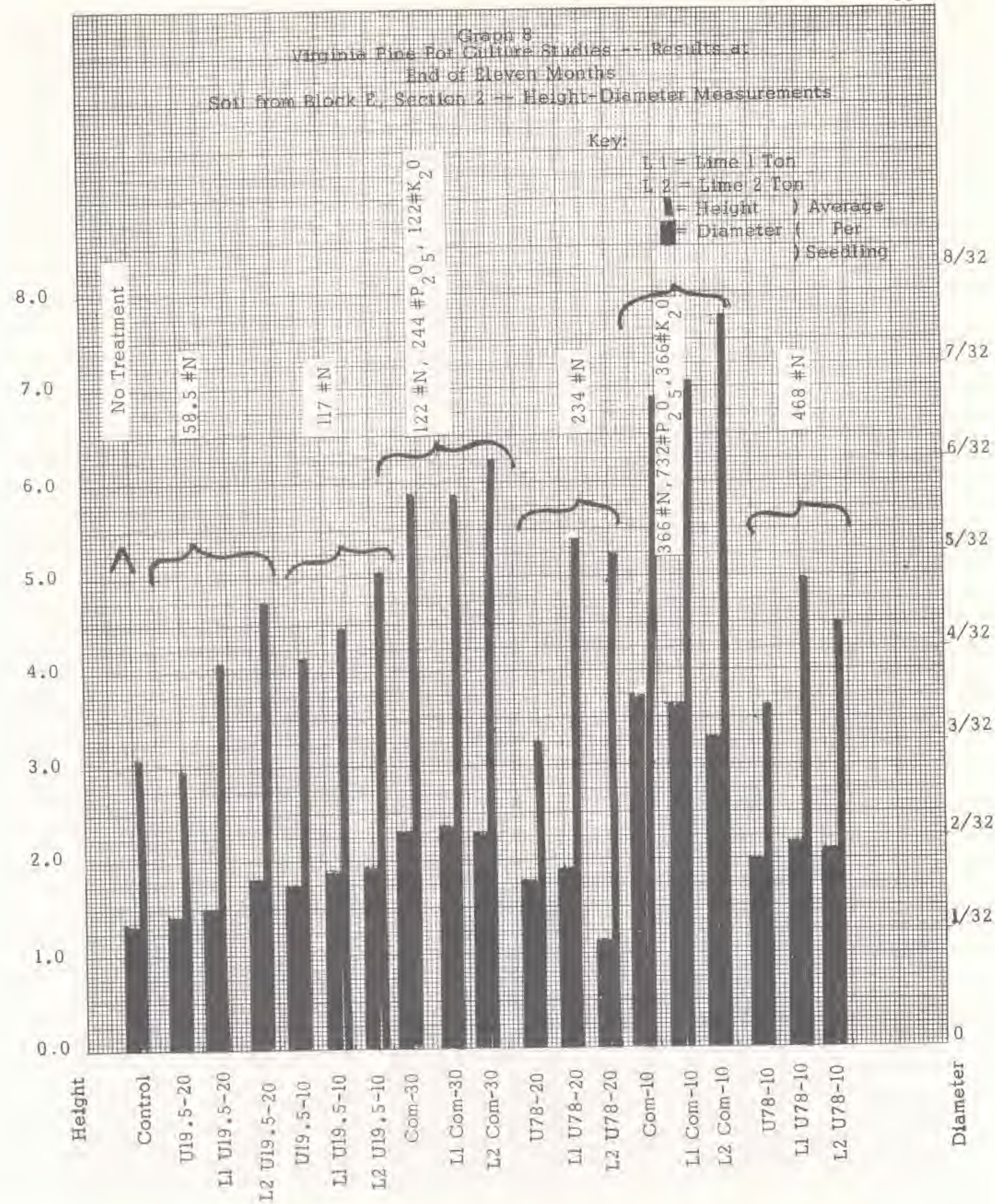


Graph 4
Virginia Pine Pot Culture Studies -- Results at
End of Five Months
Soil from Block E, Section 2 -- Height-Diameter Measurements


Graph 5
Virginia Pine Pot Culture Studies -- Results at
End of Eleven Months
Soil from Block A, Section 8
Key:
= Shoot/Root Ratio)Average
= Av. Top Weight (grams) (Per
= Av. Root Weight (grams))Seedling
5.0
4.0
3.0
2.0
1.0
0.0
Control
U19.5-20
S 1/16 U19.5-20
S 3/16 U19.5-20
U19.5-10
S 1/16 U19.5-10
S 3/16 U19.5-10
Com-30
S 1/16 Com-30
S 3/16 Com-30
U78-20
S 1/16 U78-20
S 3/16 U78-20
Com-10
S 1/16 Com-10
S 3/16 Com-10
U78-10
S 1/16 U78-10
S 3/16 U78-10


Graph 6
Virginia Pine Pot Culture Studies -- Results at
End of Eleven Months
Soil from Block A, Section 8 -- Height-Diameter Measurements
Key:
S1/16 - 20.1 gal. Sulfuric Acid
S3/16 - 60.3 gal. Sulfuric Acid
= Height
= Diameter
Average Per Seedling
No Treatment
58.5 #N
117 #N
122 #N, 244#P2O5, 122#K2O
234 #N
366 #N, 732#P2O5, 366#K2O
468 #N
4.0
3.0
2.0
1.0
0
8/32
7/32
6/32
5/32
4/32
3/32
2/32
1/32
0
Height
Control
U19.5-20
S 1/16 U19.5-20
S 3/16 U19.5-20
U19.5-10
S 1/16 U19.5-10
S 3/16 U19.5-10
Com-30
S 1/16 Com-30
S 3/16 Com-30
U78-20
S 1/16 U78-20
S 3/16 U78-20
Com-10
S 1/16 Com-10
S 3/16 Com-10
U78-10
S 1/16 U78-10
S 3/16 U78-10
Diameter


Graph 7
Virginia Pine Pot Culture Studies -- Results at
End of Eleven Months
Soil from Block B, Section 2
Key:
= Shoot/Root Ratio
= Av. Top Weight (grams)
= Av. Root Weight (grams)
Average
Per
Seedling
5.0
4.0
3.0
2.0
1.0
0.0
Control
U19.5-20
L1 U19.5-20
L2 U19.5-20
U19.5-10
L1 U19.5-10
L2 U19.5-10
Com-30
L1 Com-30
L2 Com-30
U78-20
L1 U78-20
L2 U78-20
Com-10
L1 Com-10
L2 Com-10
U78-10
L1 U78-10
L2 U78-10


Graph 8
Virginia Pine Pot Culture Studies -- Results at
End of Eleven Months
Soil from Block E, Section 2 -- Height-Diameter Measurements
Key:
L 1 = Lime 1 Ton
L 2 = Lime 2 Ton
= Height) Average
= Diameter (Per
) Seedling
No Treatment
58.5 #N
117 #N
122 #N, 244 #P2O5, 122#K2O
234 #N
366 #N, 732#P2O5, 366#K2O
468 #N
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
8/32
7/32
6/32
5/32
4/32
3/32
2/32
1/32
0
Height
Control
U19.5-20
L1 U19.5-20
L2 U19.5-20
U19.5-10
L1 U19.5-10
L2 U19.5-10
Com-30
L1 Com-30
L2 Com-30
U78-20
L1 U78-20
L2 U78-20
Com-10
L1 Com-10
L2 Com-10
U78-10
L1 U78-10
L2 U78-10
Diameter

TREATMENT		CODING INDEX	Nutrient additives	
	Addition at time of potting	Addition per application (per Acre basis)	# of Applications	Total Amount Applied thru study period (per acre basis)
U19.5-10		19.5#Act N at 10 day intervals	6	117# Act. N
L1-U19.5-10	Ag. limestone @ 1 ton/A rate	" " " " " "	"	" " "
L2-U19.5-10	" " " 2 " " "	" " " " " " "	"	" " "
S 1/16-U19.5-10	Conc. Sulfuric acid @ 20.1 gal/A rate	" " " " " " "	"	" " "
S 3/16-U19.5-10	" " " " 60.3 " " "	" " " " " "	"	" " "
U19.5-20		19.5#Act N @ 20 day intervals	3	58.5# Act. N
L1-U19.5-20	Ag. Limestone @ 1 ton/A rate	" " " " " " "	"	" " "
L2-U19.5-20	" " " 2 " " "	" " " " " " "	"	" " "
S 1/16-U19.5-20	Conc. Sulfuric acid @ 20.1 gal/A rate	" " " " " " "	"	" " "
S 3/16-U19.5-20	" " " " 60.3 " " "	" " " " " " "	"	" " "
U78-10		78#Act N @ 10 day intervals	6	468# Act. N
L1-U78-10	Ag. limestone @ 1 ton/A rate	" " " " " "	"	" " "
L2-U78-10	" " " 2 " " "	" " " " " "	"	" " "
S 1/16-U78-10	Conc. Sulfuric acid @ 20.1 Gal/A rate	" " " " " "	"	" " "
S 3/16-U78-10	" " " " 60.3 " " "	" " " " " "	"	" " "
U78-20		78#Act N @ 20 day intervals	3	234#Act. N
L1-U 78-20	Ag. limestone @ 1 ton/A rate-	" " " " " "	"	" " "
L2-U78-20	Ag. " " 2 " " "	" " " " " "	"	" " "
S 1/16-U78-20	Conc. Sulfuric acid @ 20.1 gal/A rate	" " " " " "	"	" " "
S 3/16-U78-20	" " " " 60.3 " " "	" " " " " "	"	" " "
Com-10		61#act N, 122#P_2O_5, 61#K_2O at 10 day intervals	6	366#act N, 732#P_2O_5 366#K_2O
L1-Com-10	Ag. Limestone @ 1 ton/A rate		"	" " "
L2-Com-10	" " " 2 " " "	" " " "	"	" " "
S 1/16-Com-10	Conc. Sulfuric acid @ 20.1 gal/A rate	" " " "	"	" " "
S 3/16-Com-10	" " " " 60.3 " " "	" " " "	"	" " "
Com-30		61#Act N, 122#P_2O_5, 61#K_2O at 30 day intervals	2	122#act N 244#P_2O_5 122#K_2O
L1-Com-30	Ag. limestone @ 1 ton/A. rate		"	" " "
L2-Com-30	" " " 2 " " "	" " " "	"	" " "
S 1/16-Com-30	Conc. Sulfuric acid @ 20.1 gal/A rate	" " " "	"	" " "
S 3/16-Com-30	" " " " 60.3 " " "	" " " "	"	" " "