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The Affect Of Different Percentages Of Sand, Clay And Peat In Soil Mixtures On The Emergence Of Seedlings

William C. Postle

June 1, 1937

William C. Postle
Ann Arbor, Michigan
June 1, 1937

Professor L. J. Young
Professor of Silviculture
University of Michigan.

Dear Sir:

This problem was worked out and is presented as thesis work required for a Masters Degree in Forestry.

Some difficulty was encountered due to limited time and space due to the fact that the major portion of the data had to be gathered in the winter months necessitating the use of a green house. However, the limited data indicates generally the results which would be obtained by an intensive study of the subject and would therefore be of much use in limiting any such intense study.

I here wish to express my appreciation to Dr. F. G. Gustafson who kindly permited me to use the Plant Physiology Greenhouse which is located in the Court of the Natural Science Building.

Professor M. W. Senstius, Professor of Soils, Department of Geology, was very generous and helpful in assisting me in making many of the soil measurements, especialy those of specific gravity and mechanical analysis. For this assistance, I am very grateful.

Professor L. J. Young was also most helpful in offering suggestions as to proceedure and methods to be used. He also furnished much valuable assistance in obtaining the necessary supplies and equiptment.

Very respectfully,

William C. Postle

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I

Introduction

In the school nursery it was noticed that when the seeds germinatedthe soil covering them caked, thus preventing the emergence of a large number of the seedlings. It was also known that the seedlings came up freely in the sandy soils. Thus, the problem of finding the affect of various mixtures of sand and clay on the ability of seedlings to emerge and come up out of the soil was given to me. To this problem was added the affect of humus in the form of peat.

Other Measurements of the soil were to be taken to try to find some property which was correlated directly with the ability to emerge from the soil which might be used as an indicator of the affect on emergence.

II

II

Procedure

In order to determine the affect of the various soil mixtures on the ability of seedlings to emerge from them, the various mixtures were made up for the entire range and seeds grown in all of the possibilities.

The range of possibilities used was a triangle chart as presented by Dr. G. W. Conrey in a course in Forest Soils at Ohio State University which gives 66 possibilities by 10% classes. (See Chart No. 1) This kind of chart is used as the basis for presenting all data in the following report.

Red pine (Pinus resinosa) was used for the tests chiefly because it was the smallest available seed that was in a viable condition at the time of the first planting.

It was impossible to run the entire set of possibilities at the same time due to limited space and material so that they were run in four groupes. The first groupe of mixtures was planted November 16, 1936 and the last groupe ceased emerging April 22, 1937.

The seeds were kept in cold storage during the period before planting so as to maintain their ability to germinate.

A. Material Used.

1. Flats. To facilitate handling and counting, the seeds were planted in wooden flats 10" x 10" x 4" which were

Obtained from the Seeding and Planting Laboratory. Approximately 80 flats were used for each set up.

2. Base Soil. If each flat were to be filled with the proper soil mixture it would require approximately 2 truck loads of material. The prepatation and treatment of such a large quantity of material would require too much time and equipment so it was thought better to fill the flats with a base soil and just change the soil around the seeds and above them.

A sandy soil from the Stinchfield Property was used for this purpose.

3. Sand. The sand was obtained from the Seeding and Planting Laboratory and showed the following composition by a Mechanical Analysis.(1)

Sand	--	94.13 %
Clay	--	3.10 %
Silt	--	2.27 %
		100.00 %

All the sand was run through a 2 mm soil sieve and any larger particles discarded. The remaining part used in the soil mixtures consisted of the following sizes:

1 to 2 mm in Diameter -----	3%
.5 to .9 mm in Diameter -----	45%
Below .5 mm in Diameter --	52%

(1) Bouycoucos - G. J.; J. Am. Loe. Agron. Vol. 23, April 1930.

4. Clay. The clay was obtained from a clay lense in the sand and gravel bank of the University of Michigan which is located behind the University Hospital. The lense lay in a layer of very fine, clean sand but seemed to be entirely free of sand. A mechanical analysis showed the following composition.

Sand -----	3.26%
Silt -----	54.40%
Clay -----	42.34%
	100.00%

This shows that it is more of a silt than a clay but since it was used as a clay all along and the analysis is none to accurate I will continue to refer to it as clay.

5. Peat. The peat used was obtained from a local seed store and was of the ordinary variety used in gardening and for mulching.

6. Black Nursery Soil. In connection with the pure sand, clay and peat mixtures, some others were run with the soil of the nursery. This soil was obtained from the Botanical Garden of the University of Michigan and consisted of the following;

Sand -----	37.9%
Clay -----	27.2%
Silt -----	34.9%
	100.0%

B. <u>Preparation of the Soil Mixtures</u>.

1. Treatment For Damping Off. All the materials, sand, clay, peat and base soil, were brought into the greenhouse and allowed to become partially dry. The sand, clay and peat were in buckets while the base soil was already in the flats.

Formaldehyde of a concentration of 1 part in 80 was used to kill the damping off fungi. This solution was applied to the flats using about 1 gallon of solution to 15 flats. The material in the buckets was saturated with the solution.

After all the materials had been treated with formaldehyde solution, the greenhouse was shut up tight for one week.

It was found advisable to repeat the formaldehyde treatment of the base soils after the second set of seeds had been grown as there were a few indications of attack by the damping off fungi.

2. Preparation of the Materials for Mixing. After the treatment for damping off the materials were allowed to dry thoroughly.

The peat was found to be lumpy but was reduced to fineness bu rubbing it between the palms of the hands. The whole supply of peat was worked over in this manner and when a fine,even texture was obtained it was placed in large paper sacks for use as needed.

The sand was passed through a 2 mm soil sieve and all particles over 2 mm in diameter were discarded. The remainder was placed back in the buckets till needed.

Preparing the clay presented a more difficult problem. If the clay were to be mixed intimatly with the other materials it would have to be finely divided and the clay when dry, consisted of hard lumps.

The lumpy clay was placed in a large porcelin mortar and carefully ground to a powder with a pestle, care being taken not to grind up the rock fragments or sand which might be present. Having pulverized the clay in the mortar, it was passed through the 2 mm soil sieve and all material larger than 2 mm in diameter was discarded. The material passing through the sieve was largely flowerlike with very little grainy material of any kind. It was then placed in paper sacks and kept in a dry place till needed.

3. Mixing the Soils of Various Compositions. All the different mixtures vary by 10% so a measure was made which was just 1/10 of the total material necessary for each soil mixture.

To save time the soils for one planting were all prepared and placed in paper sacks and then planted at the same time.

C. Planting and Care of the Seeds.

1. Number of Seeds. There were three flats of each soil mixture with 100 seeds in each flat. Thus the number of seeds which came up gave the % of seeds germinating and emerging from the soildirectly. In the case of the black nursery soil

only two flats were used.

2. Method and Depth of Planting. The base soil in the flat was leveled to a depth of 5/8 of an inch lower than the top of the flat. This was done by means of a board which had a section nearly the width of the flat 5/8 of an inch lower than the rest. When such a board was run back and forth over the surface of the soil with the ends on the edges of the flat the desired depth of base soil was obtained.

Soil of the desired composition was then placed on the surface and leveled at a depth of ¼ of an inch from the top by means of a similiar board as described above which had a ¼ inch blade.

100 seeds were scattered evenly over the surface and gently pressed into the soil by means of a broad flat board. This pressing into the soil did not change the depth of the soil surface but merely pressed the seeds down even to the surface so that they would all have as near a uniform covering as possible.

More soil of the same composition was then added and leveled even with the top of the flat by means of a flat board so that the seeds had an even covering.

The newly placed soil was extremely loose and great care was taken with the first watering so as to keep from disturbing the even covering of the seeds. It was found best to lightly moisten the surface and then wait several minutes before wetting

The soil thoroughly.

The base soil was moist before planting and the planted flats were watered lightly two times the day they were planted thus insuring a binding together of the various materials used in making up the soil.

3. Can Sample. Since the soil mixture was only about 5/8 of an inch thick in the flat some difficulty would have been encountered in making tests as to water content etc. In order to avoid such difficulty and to facilitate such measurements, cans were partially filled with the same mixture of soil as the accompanying flat and the two treated alike.

These cans were ordinary food containers which had been cleaned and had had the bottoms perforated. They were carefully weighed and measured before the soil sample was placed in them.

To make the soil in the cans have the same physical properties as that in the flat, they were watered every day and treated exactly as the adjacent flats.

4. Watering. The flats were watered every day at as near the same time as possible. The cans recieved a comparable amoun t of water at the same time.

D. Measurements Taken.

1. Emergence. A daily record of the emergence was kept by clipping and recording the number of seedlings which appeared free above the soil each day.

Emergence was considered over when the flat went five consecutive days with no additional seedlings emerging.

The data on the chart (Chart No. 3) are the arithmetic averages of the number of seeds emerging in the flats. However, in a few cases the numbers are not true averages having been altered due to the fact that the flats were known to have been exposed to conditions which might have interfered with the germination.

In one case two of the three flats emerged 98 and 94 seedlings respectively while the third flat produced only 50. In this case the latter flat was omitted and an average taken of the first two for obviously something interfered with the germination in the third flat.

2. pH at the Time of Planting. At first it was thought that a chart of the pH readings taken at the time of planting would be of importance. However, when the pH was was determined by the use of the Soiltex Soil Reaction Tests, it was found that a variation was obtained only in the last column to the left or where there was no clay and along the bottom lines of 90 and 100% peat. The rest of the mixtures showed a pH of 7.0 and up.

Evidently the pH did not vary enough in these mixtures to have any affect on the emergence.

3. Resistance. An attempt was made to measure the actual physical resistance the soil offered the plant. This was done by placing small square plates, 1 cm. square, in the soil at

the same depth that the seeds were planted. A wire was attached to the center of each of these plated and extended above the surface of the soil with the projecting end curved into a hook.

The plates were placed in the soil at the time of planting the seeds and remained there till near the completion of the emergence. Thus the soil over then received the same treatment and should be the same as that over the seeds.

The force required to pull these plates from the soil was determined by fastening the hook to one side of a beam balance and pouring sand into a container on the otherend. Theweight of the quantity of sand required to pull the plate from the soil was considered to be the resistance of the soil per square centimeter.

The figure recorded on the chart (Chart No. 15) is the average of the measurement of three flats.

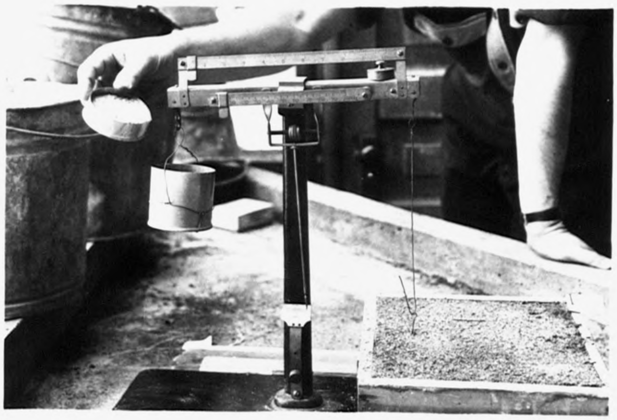


Illustration No. 1

Method of Measuring Resistance

4. % of Pore Space. The actual % of pore space was determined from the following formula;

$$\% \text{ of Pore Space} = \frac{\text{Sp. Gr. - Apparent Sp. Gr.}}{\text{Sp. Gr.}} \times 100$$

The apparent specific gravity was obtained from measurements of the soils in the cans by dividing the dry weight by the volume and the results are shown as Chart No. 8.

The specific gravity of each of the four base constituents was determined in the Soils Laboratory by using Tetalin as a wetting agent and found to be as follows;

Sand - used 10 grams.

1. Weight of bottle plus Tetalin -------- 69.64 g.
2. " " " " " plus sand 76.06 g.
3. Bottle, Tetalin and sand should weigh 79.64 g.
4. Weight of Tetalin displaced --------- 3.58 g.

Sp. gr. of Tetalin is .985

3.58/.985 = 3.63 cc of Tetalin displaced or the volume of 10 grams of sand.

10/3.63 = 2.75 sp. gr. of sand.

Clay - used 10 grams.

1. Weight of bottle plus Tetalin ------------ 69.64 g.
2. " " " " " plus clay -- 76.14 g.
3. Bottle, Tetalin and clay should weigh --- 79.64 g.
4. Weight of Tetalin displaced ------------- 3.50 g.

3.50/.985 = 3.55 cc of Tetalin displaced or the volume of 10 grams of clay.

10/3.55 = 2.82 sp. gr. of clay.

Black Nursery Soil - used 10 grams.

1. Weight of bottle plus Tetalin -------------- 69.64 g.
2. Bottle, Tetalin and black soil should weigh 79.64 g.
3. " " " " " did weigh --- 75.82 g.
4. Weight of Tetalin displaced ---------------- 3.82 g.

3.82/.985 = 3.88 cc of Tetalin displaced or volume of 10 grams of black soil.

10/3.88 = 2.58 sp. gr. of the black nursery soil.

Peat - .99 grams used with acetone as the wetting agent.

Weight of Acetone plus bottle(10cc) --- 23.74 g.
" " the bottle(10cc) ---------- 15.74 g.
" of Acetone. -------------------- 8.00 g.

Therefore the sp. gr. of acetone is .8 .

Weight of bottle plus acetone --------------- 63.60 g.
Bottle, acetone and peat should weigh ------- 64.59 g.
" " " " did weigh ---------- 64.23 g.
Weight of the acetone displaced ------------- .36 g.

.36/.8 = .45 cc of acetone or volume of .99 grams of peat.

.99/.45 = 2.20 sp. gr. of peat.

In order to remove all the air, the bottle with the peat in it was placed in a dessicator and evacuated for 15 minutes.

Since the soils were made up by volume % it was necessary to change them to % by weight. This was done by using the corner values from the apparent specific gravity chart (Chart No. 8) which gives the weight per unit volume of the pure materials. Then by multiplying each constituent by its % of volume, the weight of the mixture was obtained and the % of the total calculated.

By multiplying the % by weight times the specific gravity and adding up the results the specific gravity of the soil mixtures were obtained and are shown on Chart No. 9.

An example of the proceedure is as follows;

	Sand	Clay	Peat
1. % by volume	20	30	50
2. Apparent Sp. Gr.	1.63	1.35	.223
3. Weight in soil mixture	3.26	4.05	1.115
4. % by weight	38.7	48.2	13.1
5. Specific gravity	2.65	2.82	2.20
6. Weight in the sample	1.06	1.36	.288

7. The sum of 6 is 2.708 or the specific gravity of this soil mixture.

By applying the specific gravity and apparent specific gravity values to the formula already stated, the values for the % of pore space were obtained and tabulated on Chart No. 10.

5. Grams of Water Per CC of Fresh Soil. Fresh soil was considered to be soil approximately 6 hours after watering or in other words the seeds and cans were watered around 9 o'clock

in the morning and the cans were weighed around 3 o'clock in the afternoon.

It was believed that the amount of water per cc in the soil at this time would be a fair indication of the amount of water held by the soil for the plant or at least give a range, which,when correlated with emergence on the same soils, give some indication of the optimum range.

The values were taken from the can samples and obtained by subtracting the dry weight from the fresh weight and then dividing by the volume of the soil.

6. Water Lost the First Hour After Saturation Expressed as a % of the Water in Saturate Soil. As a measure of the soils ability to retain the water falling upon them, they were immersed in water and then weighed while still in a saturate condition. They were then allowed to drip for one hour and weighed again.

In immersing the cans in water, care was taken so that no bubbles of air were under the cans and that the water came up from the bottom. In this manner nearly all the air was driven off by the progressive rise of the water.

As soon as the surface of the soil in the can showed free water the can was transfered to the balance and weighed, care being taken that no water was lost.

E. Graphical Treatment of the Data.

When the actual data for one of the sets of measurements were placed on the triangle chart it was found to fluctuate in varying degrees and, since there were only a small number of measurements taken and in fact in many cases only one, this fluctuation was to be expected.

However, since the chart is purely a mechanical affair with all lines on it increasing or decreasing by 10% of some factor, it is reasonable to assume that the data collected from soils made up according to its direction should lie along definate curves of some sort.

On this assumption the data were taken and curved first by one set of parallel lines such as clay % and a new set of values read called the first balance. Then using the first balance data a different set of parallel lines such as peat % were curved and a second set of values read called the second balance. The remaining set of parallels were treated in the same way and the third balance obtained.

Thus the chart has been balanced in all directions and all points adjusted in relation to all the surrounding points so that as near as set of accurate data as possible is available.

III

Results.

A. Emergence. Chart No. 3 gives the original data as they were collected with Charts No. 4, 5, and 6 showing the first, second and third balances respectively. These charts are preceeded by graphs showing the curves from which they were derived.

It is first necessary to limit the data to that portion of the chart where cracks do not affect the results, for obviously beyond that range the data is very erratic and useless. Such a limitation cuts out all data of mixtures of more than 30% and the mixtures of 30% clay with no sand, with the exception of the data for mixtures of 40% clay which contain 40% or more of sand.

All ones eliminated were seriously cracked due to shrinkage of the soil and are shown on Chart No. 2.

Since all the seeds have a germinating capacity it was thought advisable to express the results of the balanced emergence chart as % of the maximum obtained so that it might be applied to other cases or species. This is shown on Chart No. 7.

This chart shows that the optimum emergence is obtained with the use of pure sand and the ability to emerge dedreases very slightly as the % of peat increases.

With the addition of 10% clay the emergence is affected very little in the higher sand % but is decreased in the high peat % where with pure peat it goes down to 87% of maximum.

With the addition of 10% more clay or a total of 20% clay the emergence is still little affected in the higher sand % but falls rather rapidly to where the mixture is 40% sand, 40% peat and 20% clay, where the emergence is only 85% of maximum. This falls to 75% with a mixture of pure clay and peat.

With 30% clay even the sandy mixtures are affected as is seen by the mixture of 30% clay and 70% sand which gives only 87% emergence.followed by a 55% emergence with an increase of 10% peat.

The rest of the 30% clay column shows negligible emergence down to pure peat where cracking allowed the seeds to come through.

The same condition exists in the first three mixtures at the top of the 40% clay column after which cracking makes the data erratic.

B. % of Pore Space. Taking the data from Charts No. 8 and 9, the data for % of pore space as presented on Chart No. 10 were calculated. Charts No. 11, 12 and 13 are the first second and third balances respectivly. The third balance was expressed as % of maximum and is shown on Chart No. 14.

Comparing the % of maximum chart for the % of pore space with that of emergence, it is obvious that they are nearly opposite for the largest % of pore space is in the pure peat and graduated toward the pure sand which is generally more than 50% less than the pure peat.

The % of pore space increases slightly with an increase in clay %.

C. Resistance. Since the resistance was measured in the flats, the same allowance was made for cracking as has already been described and shown on Chart No. 2.

The original data are shown on Chart No. 15 with the first, second and third balances on Charts No. 16, 17 and 18 respectively.

From the third balance it can be seen that the addition of 10% clay more than doubles the mechanical resistance to the seeds while the relative % of sand and peat have little affect.

Comparing the balanced resistance chart with the emergence chart it is found that emergence is nearly absent where the resistance is over 225 grams per square centimeter.

No statement can be made as to the graduation of resistance downward or increased emergence in relation to % of clay for the two charts show clearly that the mixture of the two other constituents have important affects on the results.

This fact is shown up in the 20% clay column with a mixture of 80% sand and no peat, with a resistance of 120 grams per square centimeter and with a maximum emergence while at the other end of the same column with 80% peat and no sand and a resistance of 110 grams per square centimeter the emergence is only 75% of maximum.

As a comparison with the other measurements the chart of % of Maximum was calculated and is shown as Chart No. 19.

This chart further illustrates the increase in resistance with the addition of clay.

D. Water Lost the First Hour After Saturation Expressed as a % of the Water in Saturate Soil. These data are shown on Charts No. 20 through 23 in the usual order.

These charts follow closely the charts of % of pore space which is as was to be expected. It did not indicate, as had been hoped, the water holding capacity of peat and the advantageous affect of increased amounts of clay for such purposes.

The values are expressed as % of Maximum on Chart No. 24.

E. Grams of Water Per CC of Fresh Soil. The data gathered for this appears on Charts No. 25, 26,27 and 28.

The balanced chart shows that the mixture with the highest % of peat retains more water after a long period of time. This fact used in connection with the results of the Water lost the first hour data show that while the highest % of peat loose excess water rapidly, they retain more in the long run.

This is very important for when this chart is compared with the emergence chart it is seen that while the emergence varies little in the first clay % column, the grams of water per cc of fresh soil varies nearly the entire range.

It is very evident that this has little to do with the ability of the seeds to come through as long as the seeds are watered daily as was the case in this problem.

However, if it were the case of an actual nursery it would be of prime importance to balance the necessity of watering against the maximum possible emergence. This water holding capacity is more closely tied up with germination.

F. Black Nursery Soil. The degree of cracking in the mixtures where black nursery soil was used in place of clay is shown on Chart No. 29. This chart shows that cracking due to shrinkage of the soil eliminated all the mixtures over 30% clay and all the 30% clay mixtures which contain less than 40% sand.

Emergence data obtained from the above mixtures (Chart No. 30) shows that the ability to emerge extends to the right on the chart or into the higher black soil %. This is as might be expected for the black nursery soil contained nearly 40% sand while the clay had only 2.3% sand.

There is approximately no affect on the emergence till the black nursery soil is 30% of the mixture and here in the lowest figure obtained from the unbalanced data was 81 seedlings emerging. It is also in this clay % class that cracking becomes serious and disrupts the data as is shown on Chart No. 29.

Resistance data were also collected for these mixtures and are shown on Chart No. 31. These indicate, according to findings with clay, namely that emergende is negligable when the resistance is over 225 grams per square centimeter, that in no mixture is the resistance of the soil strong enough to prevent emergence. However, all values to the right of the line shown on the chart are subject to serious error due to cracking and are omitted from further discussion.

An attempt was made to predict the emergence from the resistance obtained from the mixtures using the black nursery soil by comparing them with the balanced rèsistances and results obtained by the use of clay. The results obtained by such a prediction are shown on Chart No. 32.

These predicted emergence results are generally higher than the results actually obtained as shown on Chart No. 30 but all are with in 5% of the actual data.

Such results lead me to believe that with a base chart based on more measurements and with smaller graduations, it would be possible to predict the emergence of seedlings from any specific soil by measuring the resistance of that soil by meass described in this report or similiar ones.

IV

Summary

With no clay in the mixture the relative amounts of sand and peat have very little affect on the emergence of the seedlings. However, with the addition of clay,the mixture with the higher % of peat shows a decreased emergence. This decrease is not serious till the % of clay reaches 30% where with 70% sand the emergence is only 85% of maximum, with 60% sand only 55% of maximum and below that emergence is negligible.

% of pore space is just opposite to emergence with respect to sand and peat and decreases slightly with the addition of clay with respect to peat and increases slightly with respect to sand.

The resistance approximately doubles with the addition of 10% clay while the relative portion of sand and peat in the mixture have little affect. There is no emergence where the resistance is over 225 grams per square centimeter.

Water lost the first hour after saturation follows closely the % of pore space and shows no relation to emergence.

The grams of water per cc of fresh soil, while showing no relation to emergence, indicate the possible optimum mixture to be used to obtain minimum watering with optimum germination and emergence.

The application of the balanced resistance chart as a means of predicting the emergence to be obtained and the relatively accurate results obtained in its use in the case of the mixtures with the black nursery soil, indicate a possible means of predicting the emergence of any soil.

Chart No. 1

Possibilities For Soil Mixtures

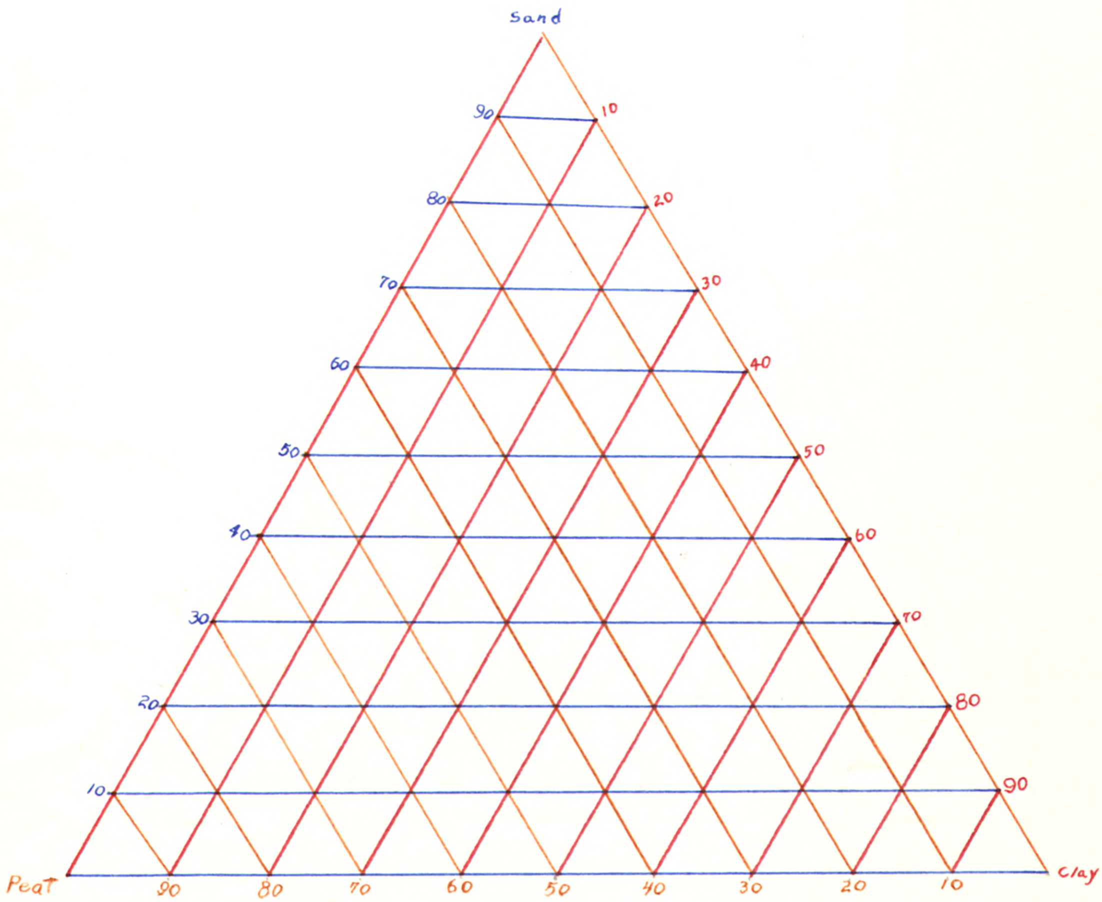
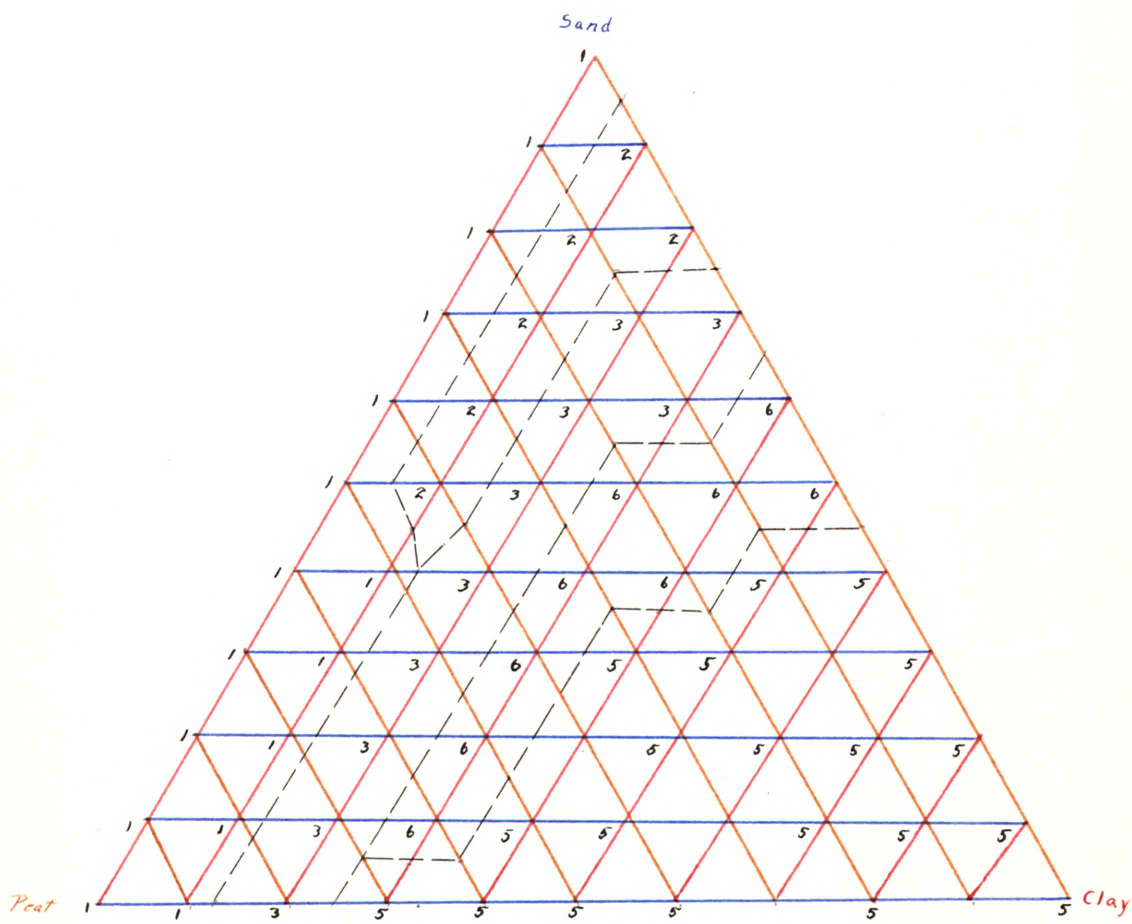


Chart No. 2

Zones of Cracking



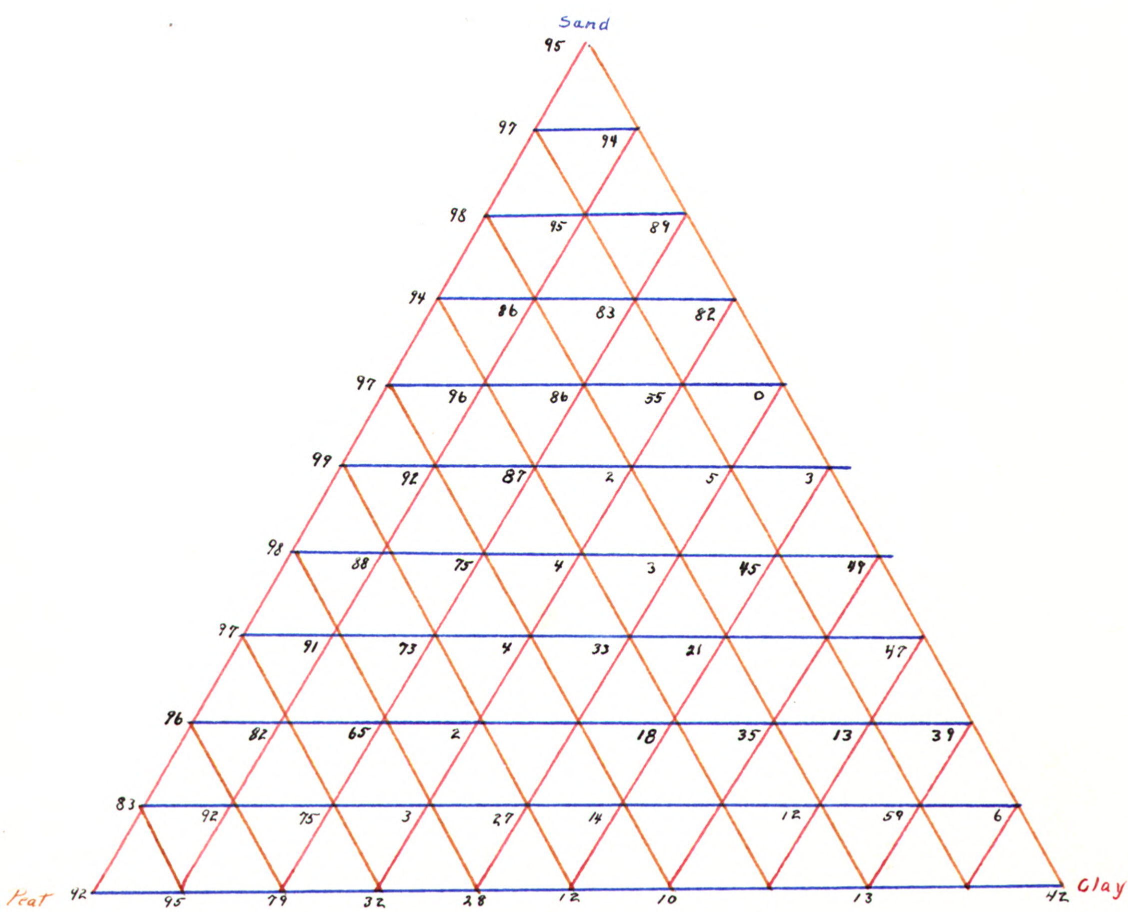
1. Seeds emerge freely.
2. Cracking due to heaving of seedlings; many cracks; little affect on emergence.
3. " " " " " " ; few cracks; caking hinders emergence slightly.
4. Light Cracking due to shrinkage of soil.
5. Heavy " " " " " ".
6. Soil resistant or nearly so to both heaving & shrinkage - little or no cracking, some heaving - few seedlings emerge.

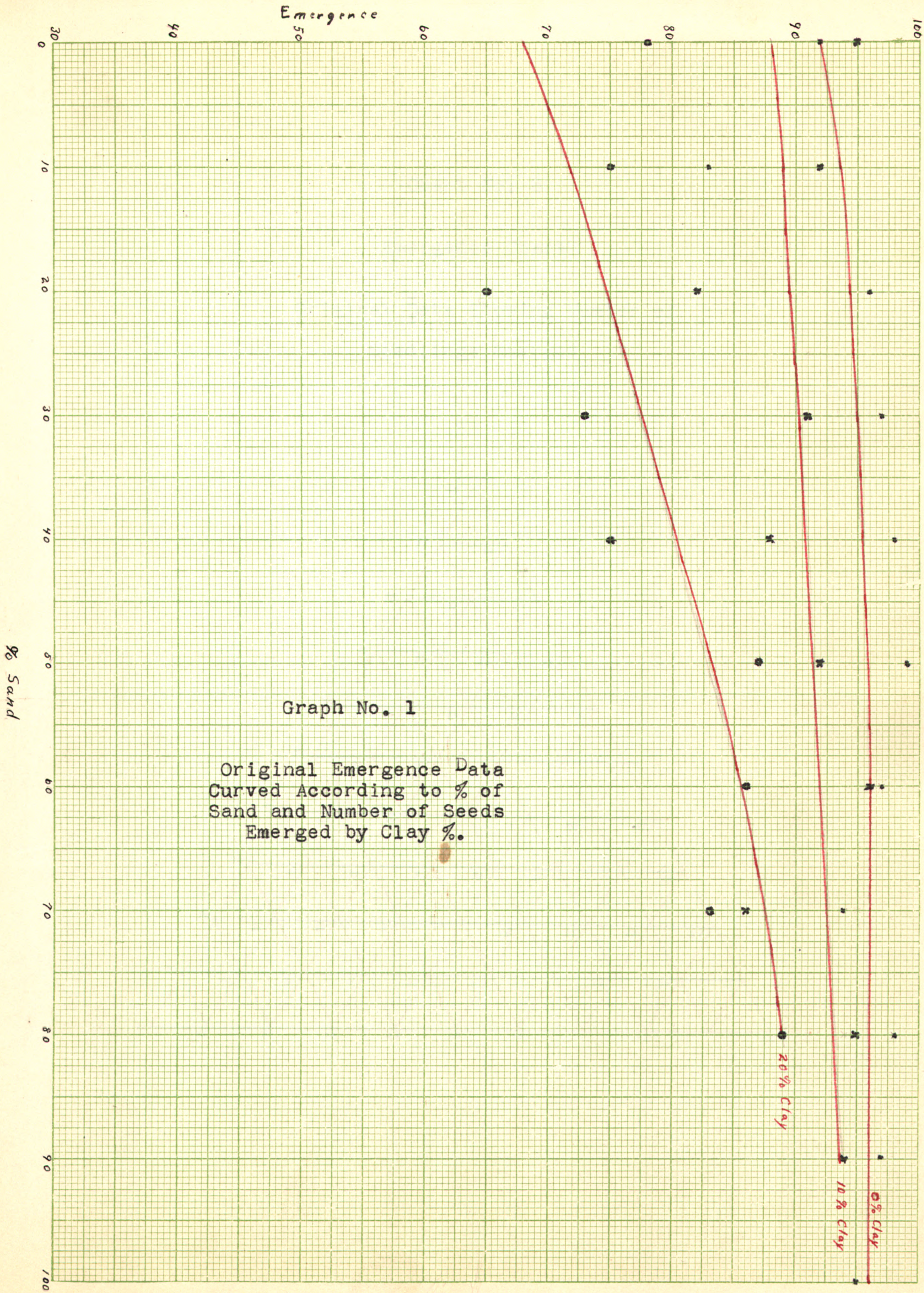
Chart No. 3

Emergence Chart

Original Data Showing Number of

Seedlings Emerged





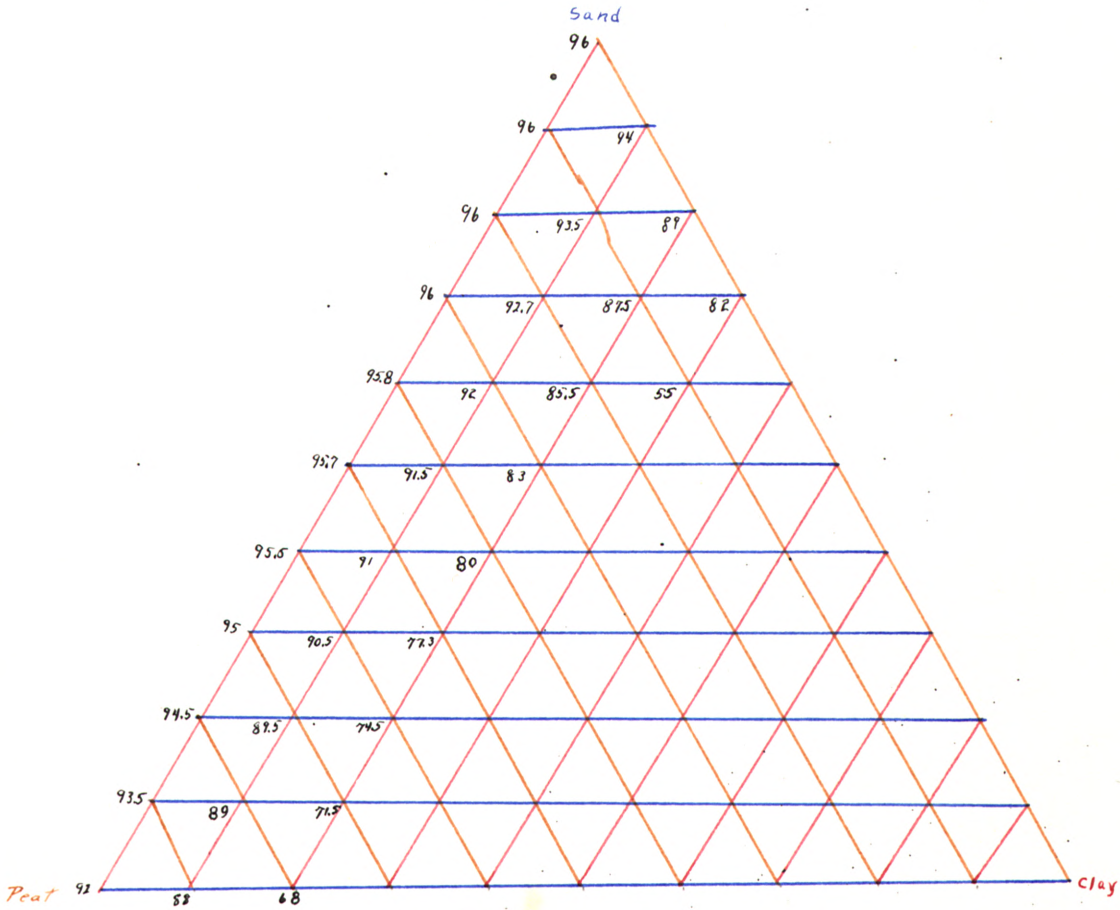
Graph No. 1

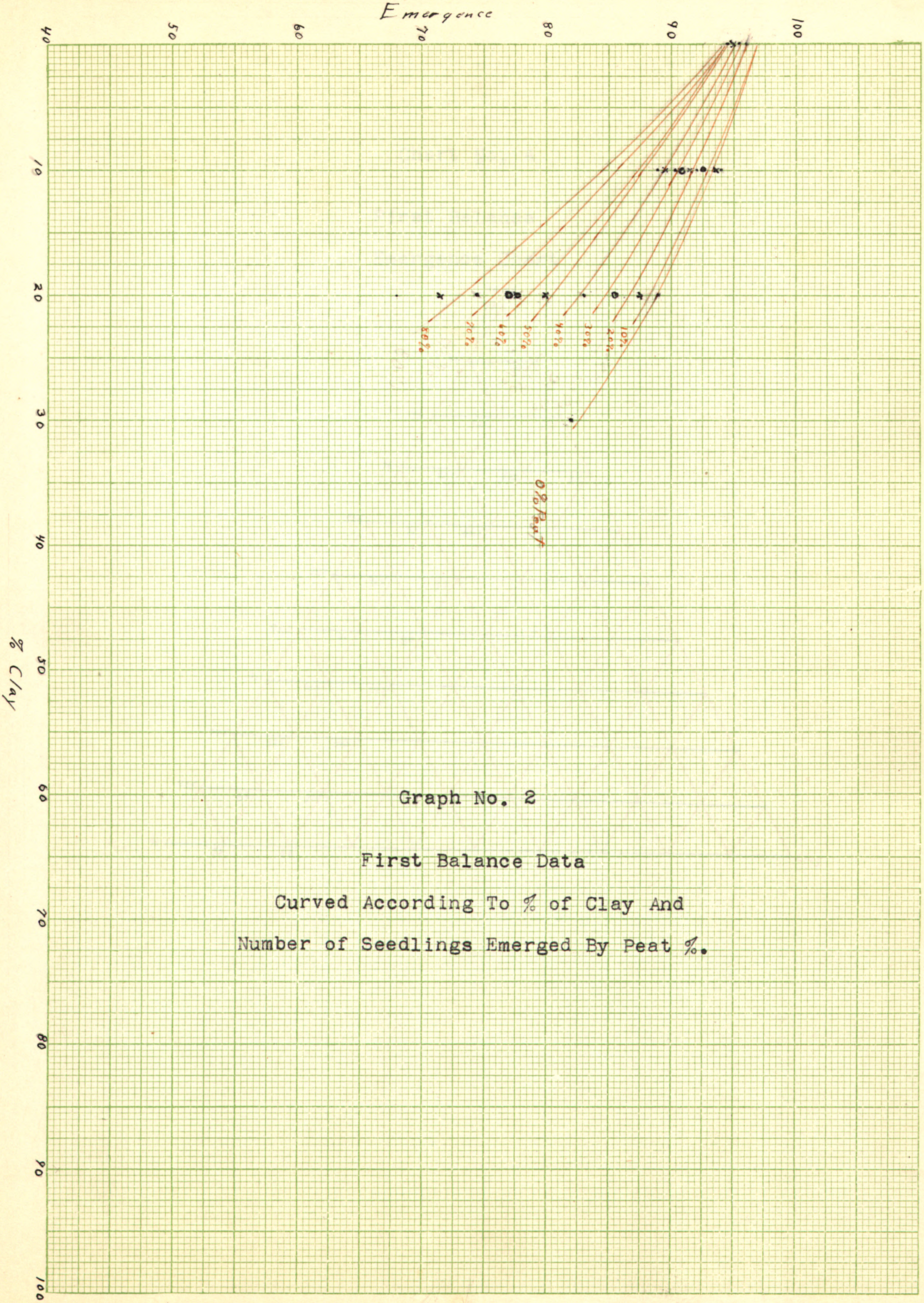
Original Emergence Data
Curved According to % of
Sand and Number of Seeds
Emerged by Clay %.

Chart No. 4

First Balance

Emergence Chart





Graph No. 2

First Balance Data

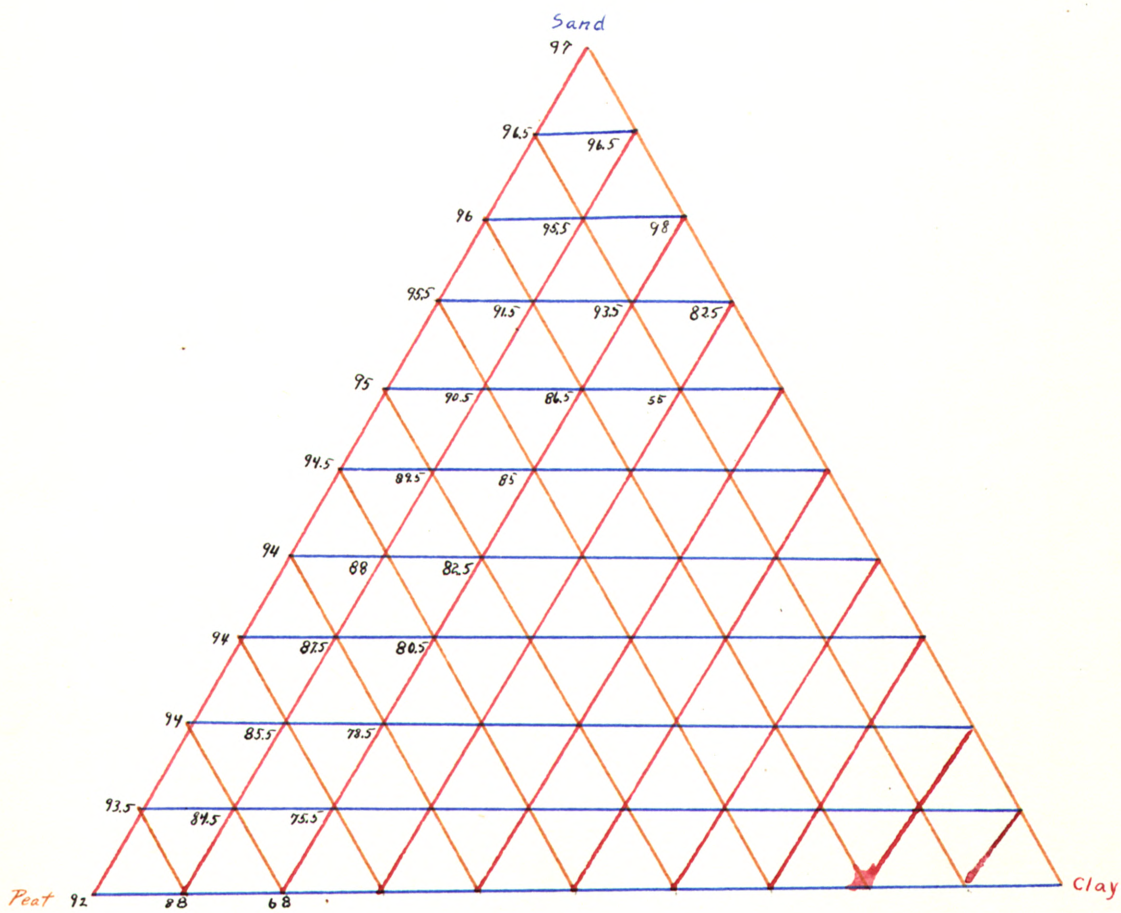
Curved According To % of Clay And

Number of Seedlings Emerged By Peat %.

Chart No. 5

Emergence Chart

Second Balance



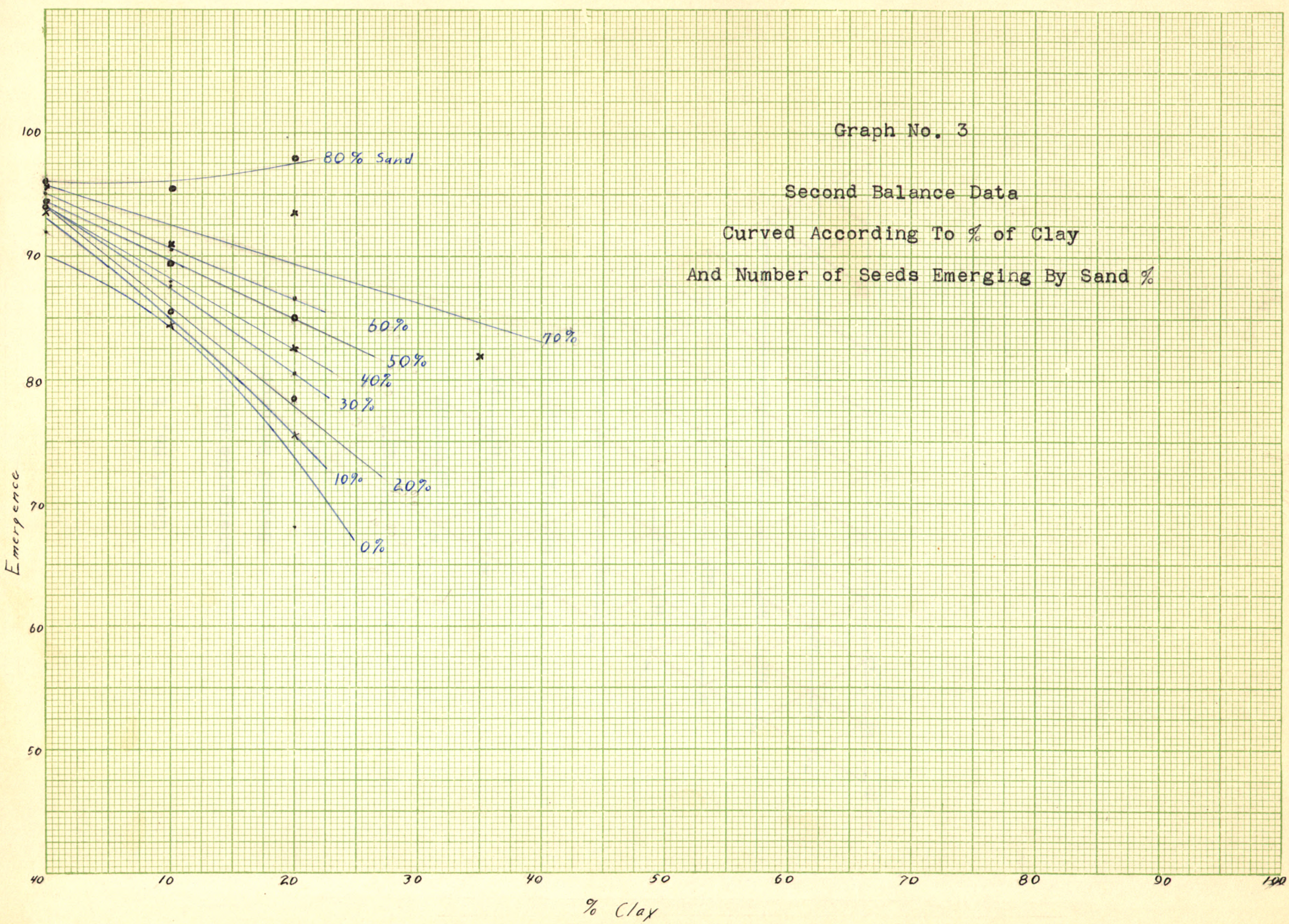
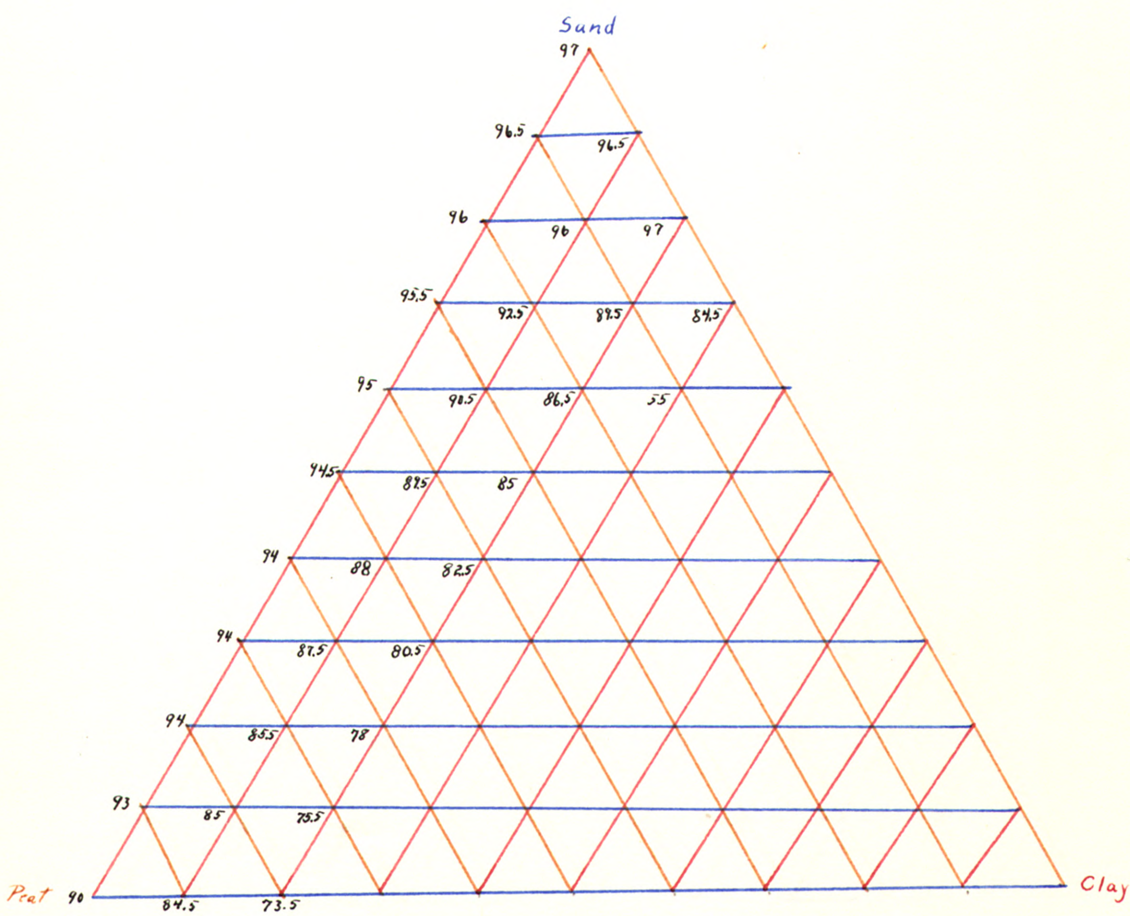

Graph No. 3
Second Balance Data
Curved According To % of Clay
And Number of Seeds Emerging By Sand %
80 % Sand
70%
60%
50%
40%
30%
20%
10%
0%
Emergence
% Clay
40
50
60
70
80
90
100
10
20
30

Chart No. 6

Emergence Chart

Third Balance



Chatt No. 7

Emergence Chart

Expressed as % of Maximum Emergence

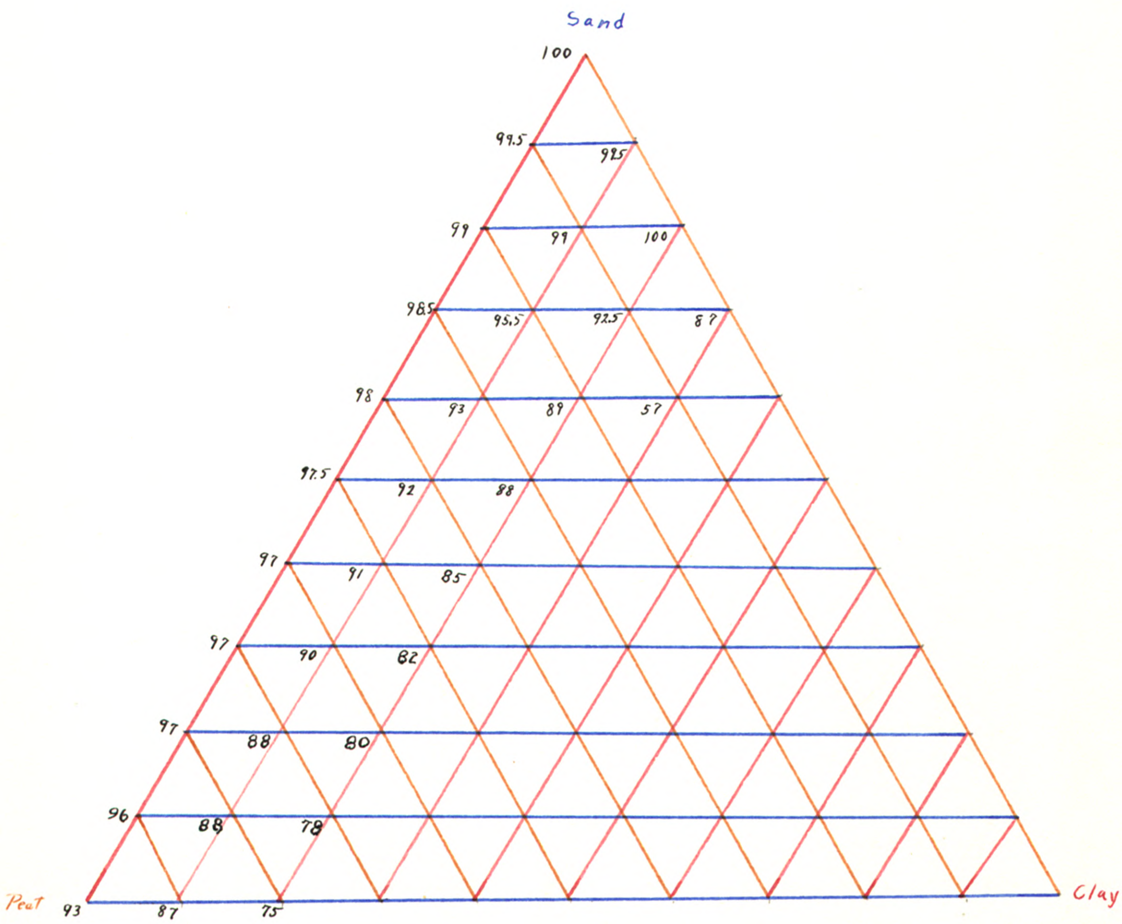


Chart No. 8

Apparent Specific Gravity

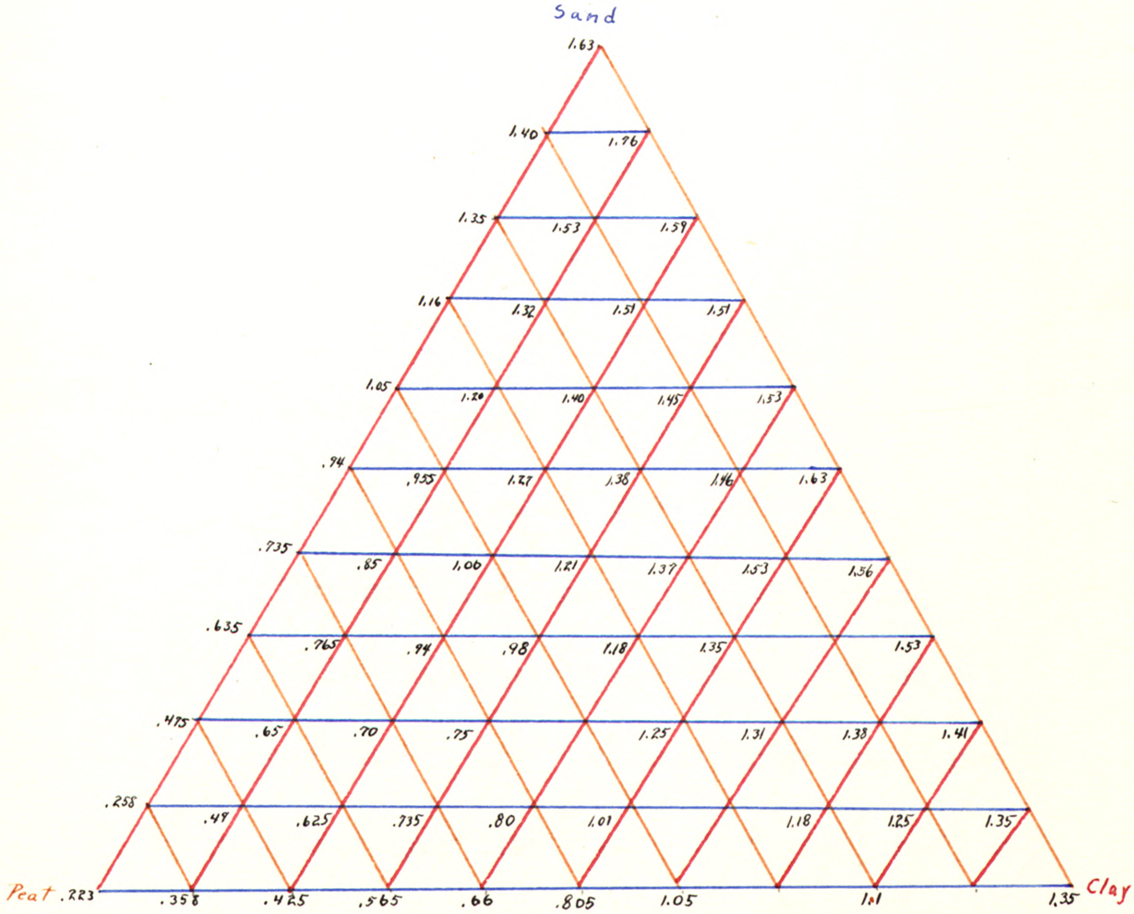


Chart No. 9

True Specific Gravity

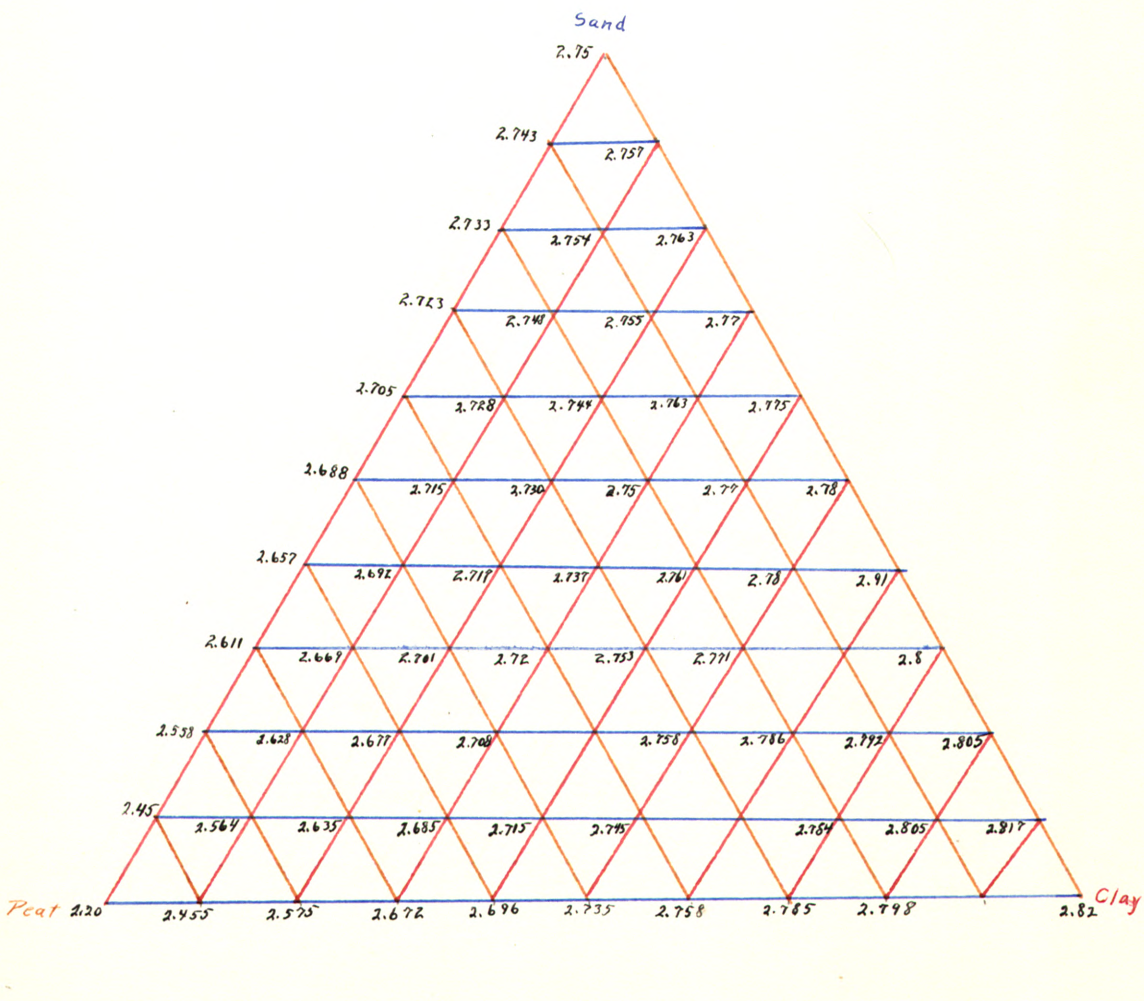
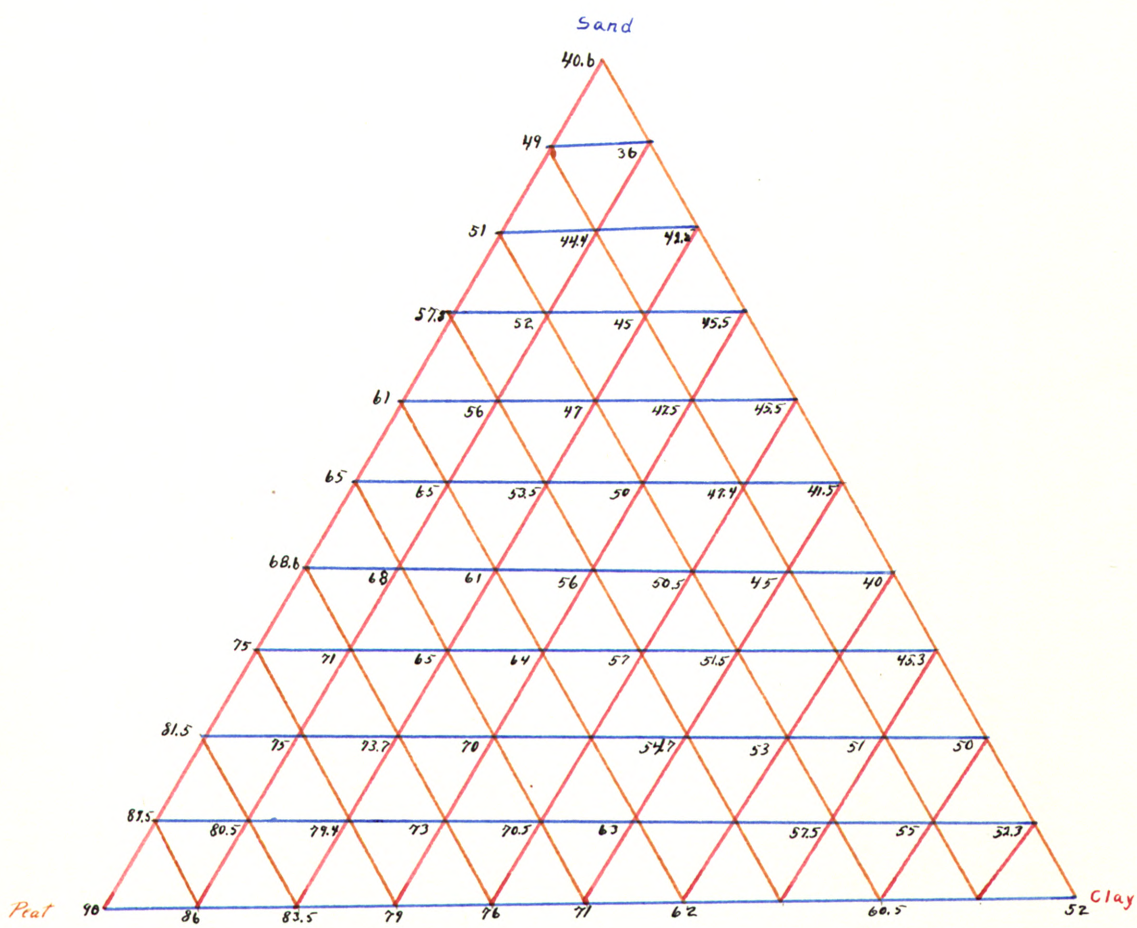


Chart No. 10

% of Pore Space

Original Data



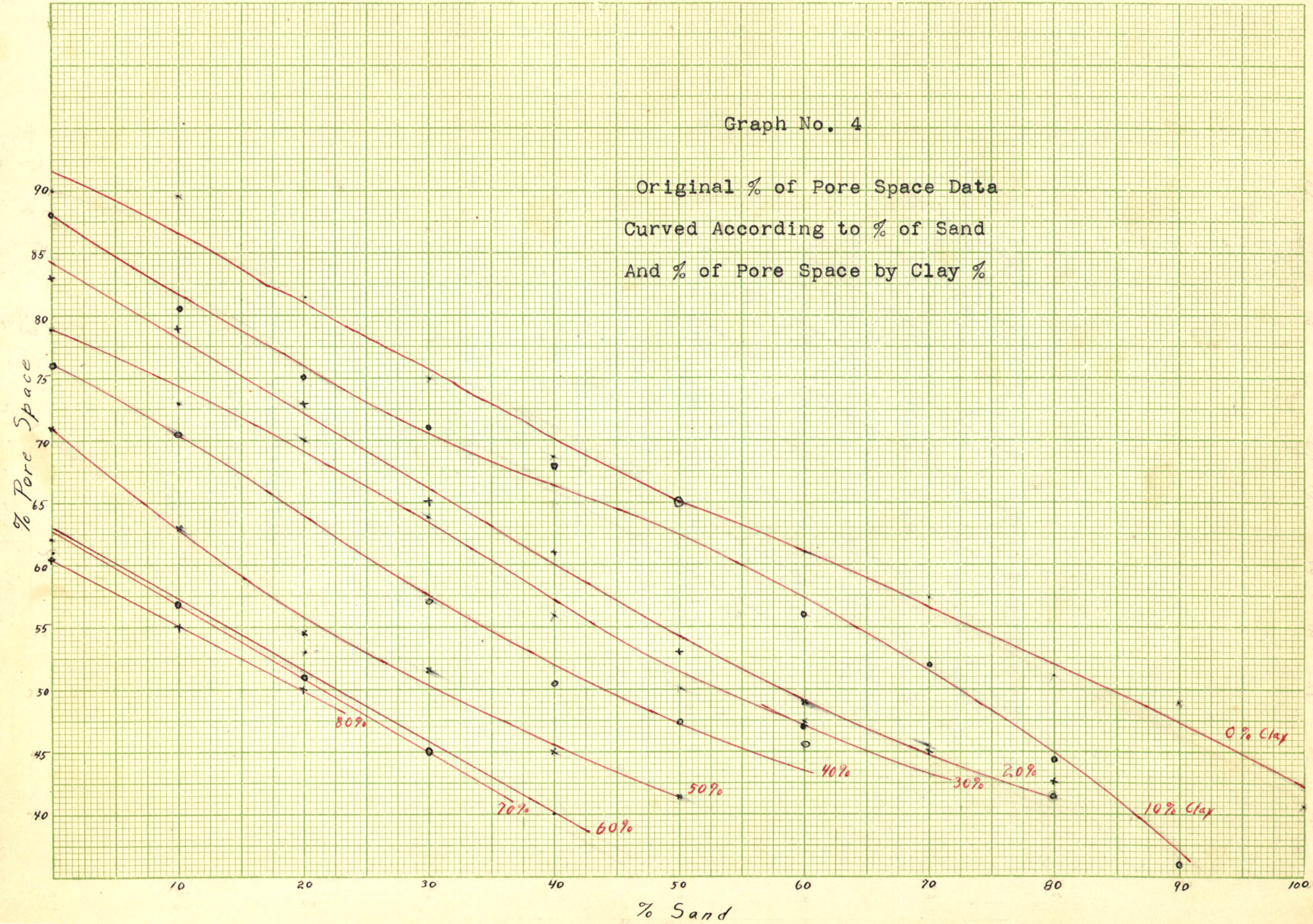
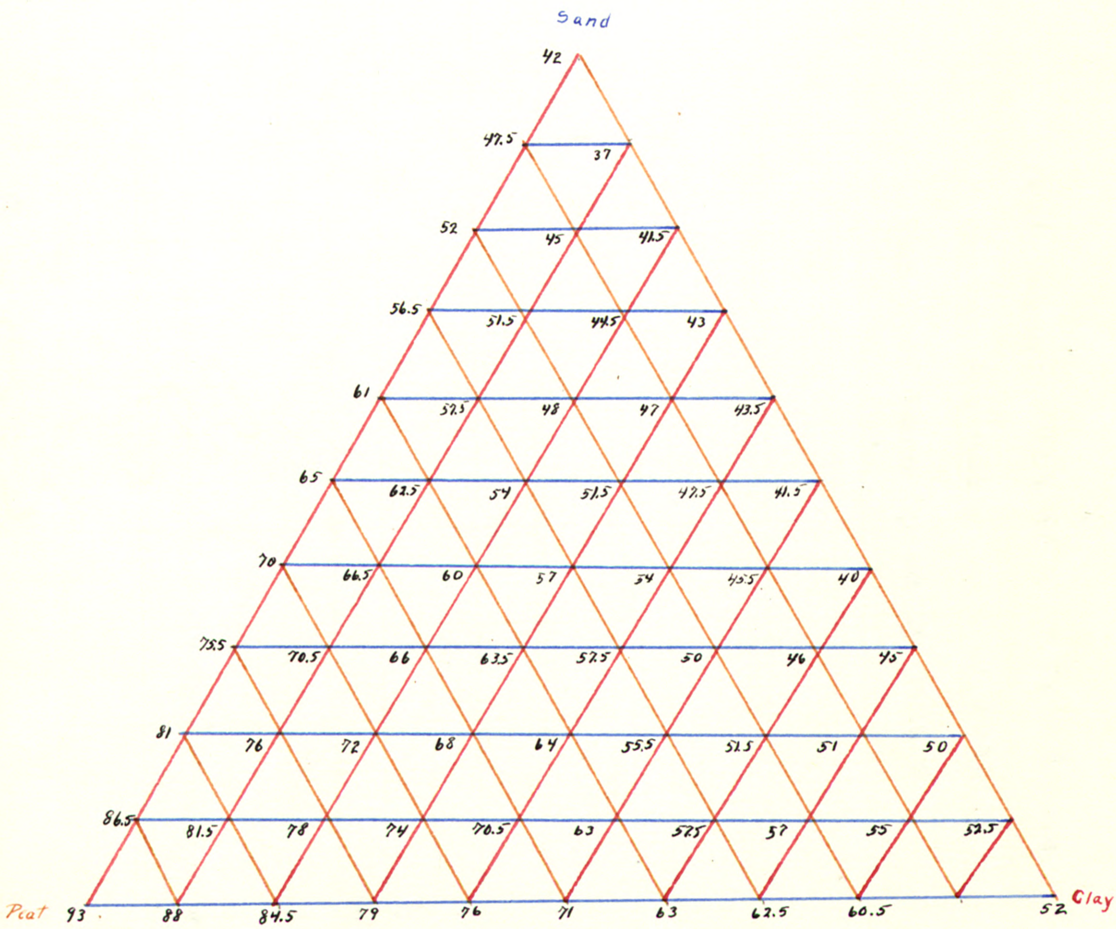

Graph No. 4
Original % of Pore Space Data
Curved According to % of Sand
And % of Pore Space by Clay %
% Pore Space
% Sand
0% Clay
10% Clay
20%
30%
40%
50%
60%
70%
80%

Chart No. 11

% of Pore Space

First Balance



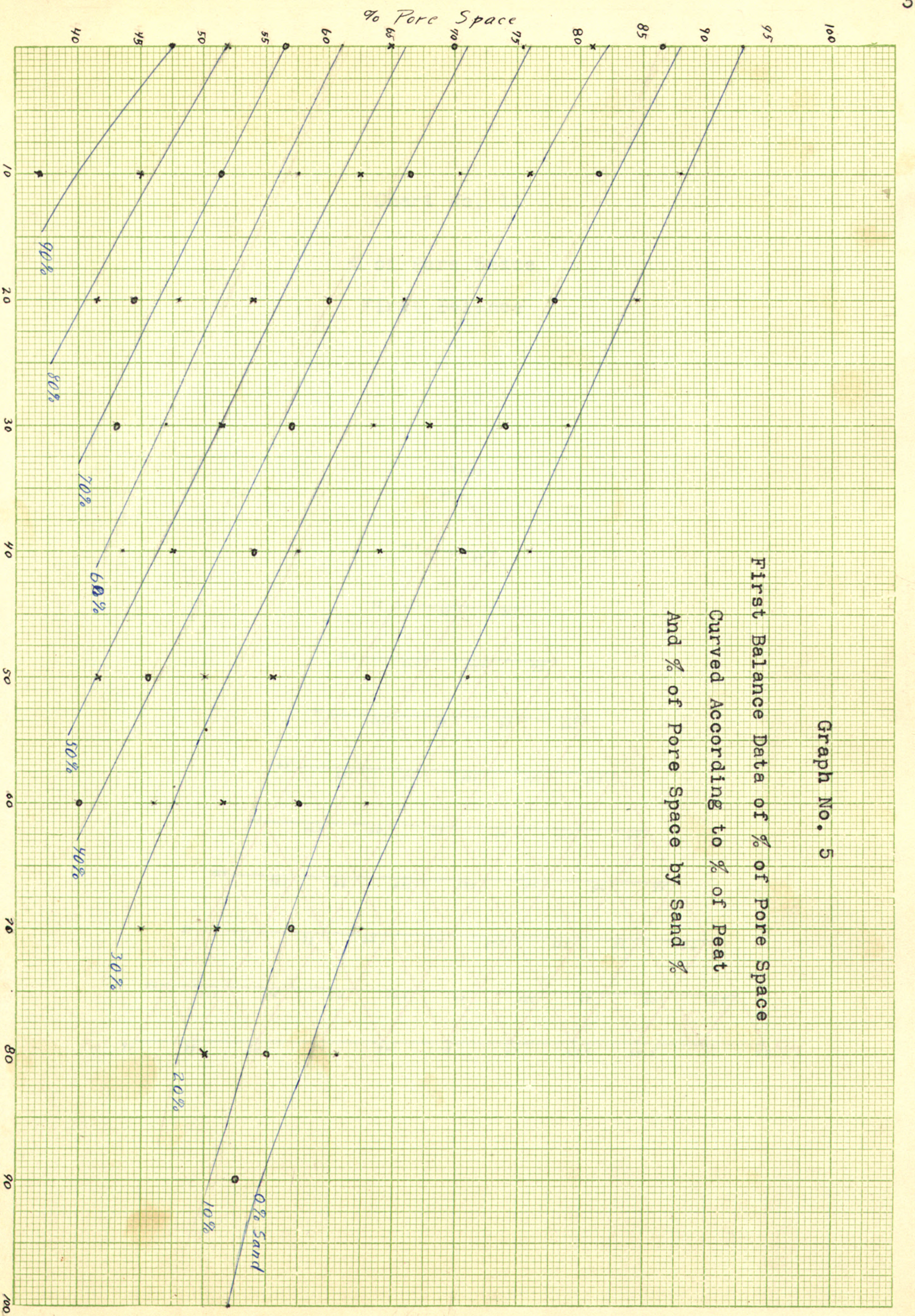
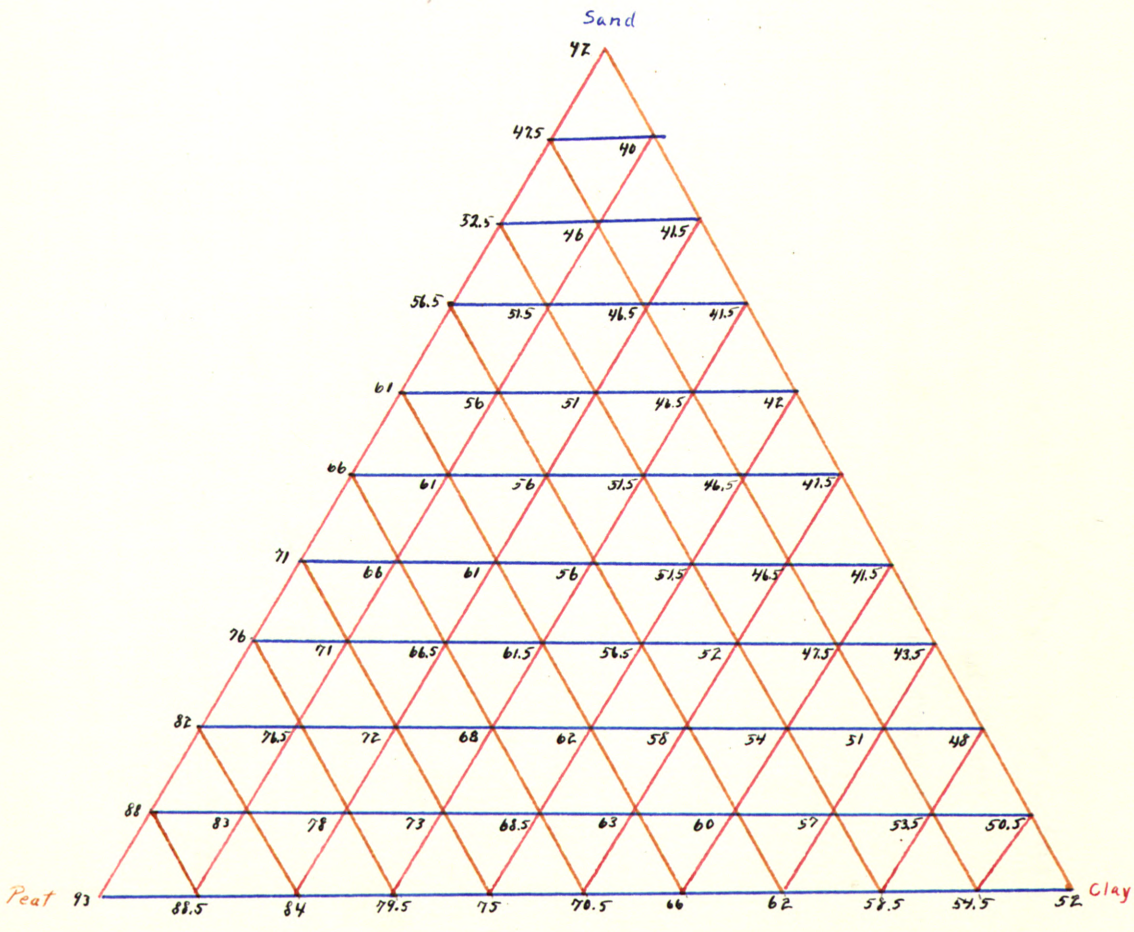

Graph No. 5
First Balance Data of % of Pore Space
Curved According to % of Peat
And % of Pore Space by Sand %
% Pore Space
40
45
50
55
60
65
70
75
80
85
90
95
100
% Peat
10
20
30
40
50
60
70
80
90
100
90%
80%
70%
60%
50%
40%
30%
20%
10%
0% Sand

Chart No. 12

% Of Pore Space

Second Balance



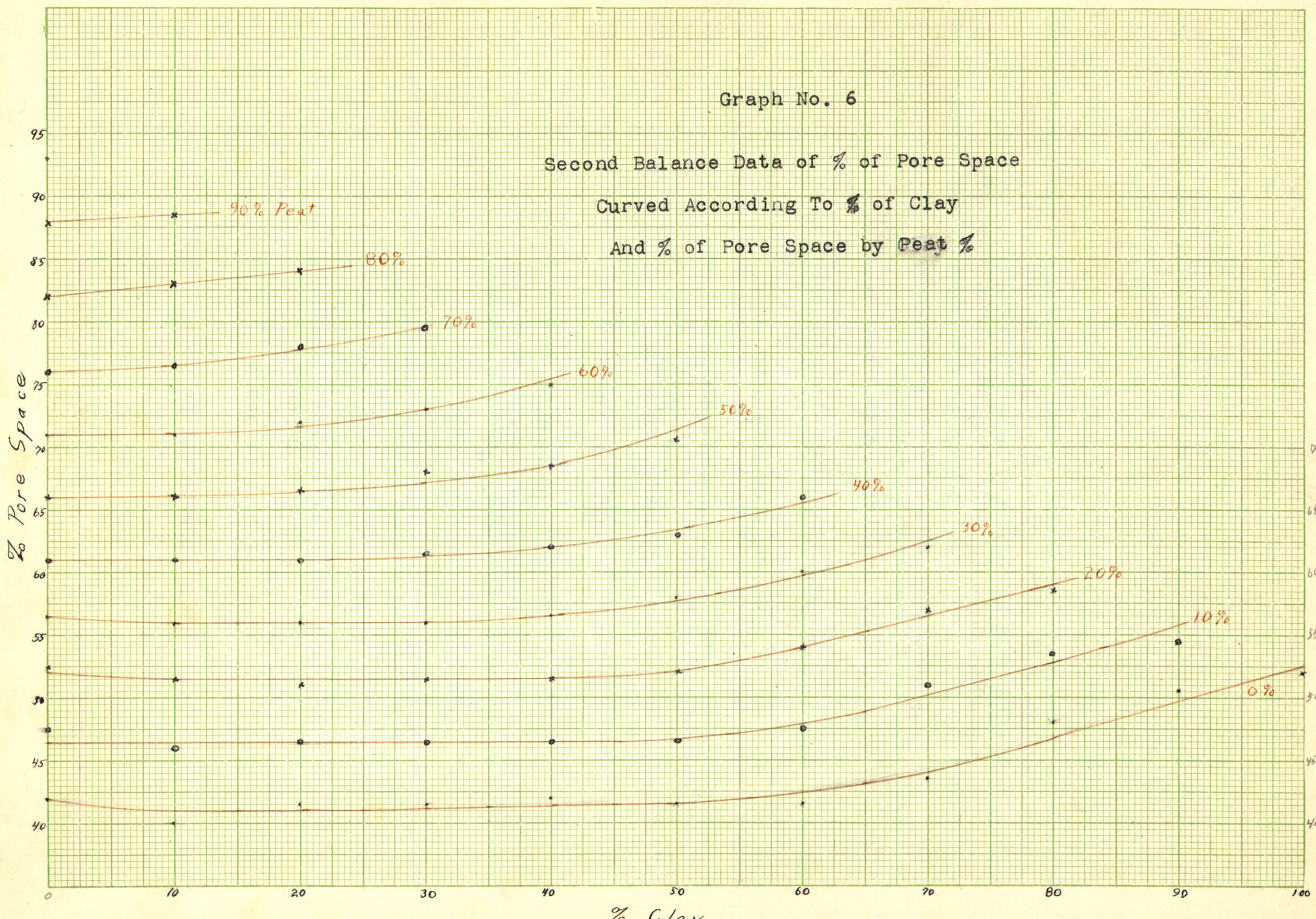

Graph No. 6
Second Balance Data of % of Pore Space
Curved According To % of Clay
And % of Pore Space by Peat %
% Pore Space
% Clay
90% Peat
80%
70%
60%
50%
40%
30%
20%
10%
0%

Chart No. 13

% of Pore Space

Third Balance

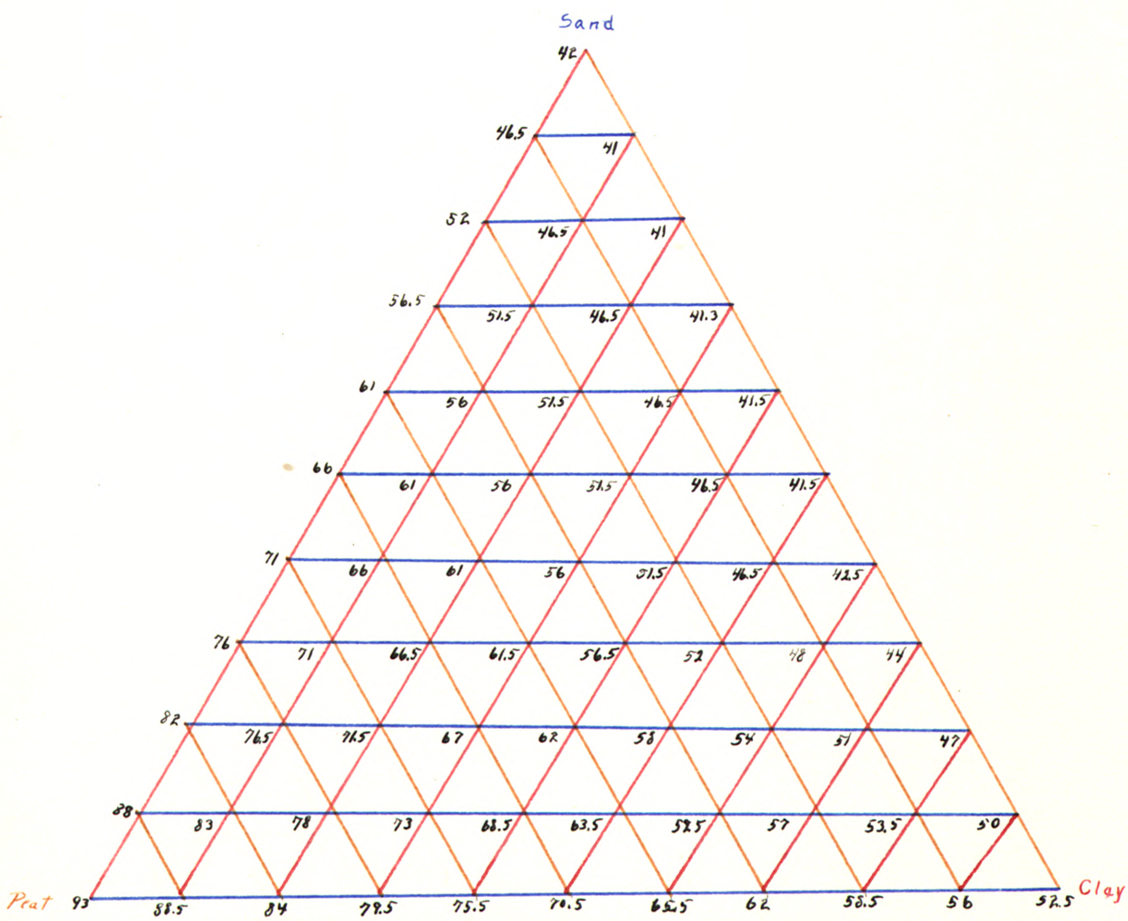


Chart No. 14

% of Pore Space

Expressed as a % of Maximum

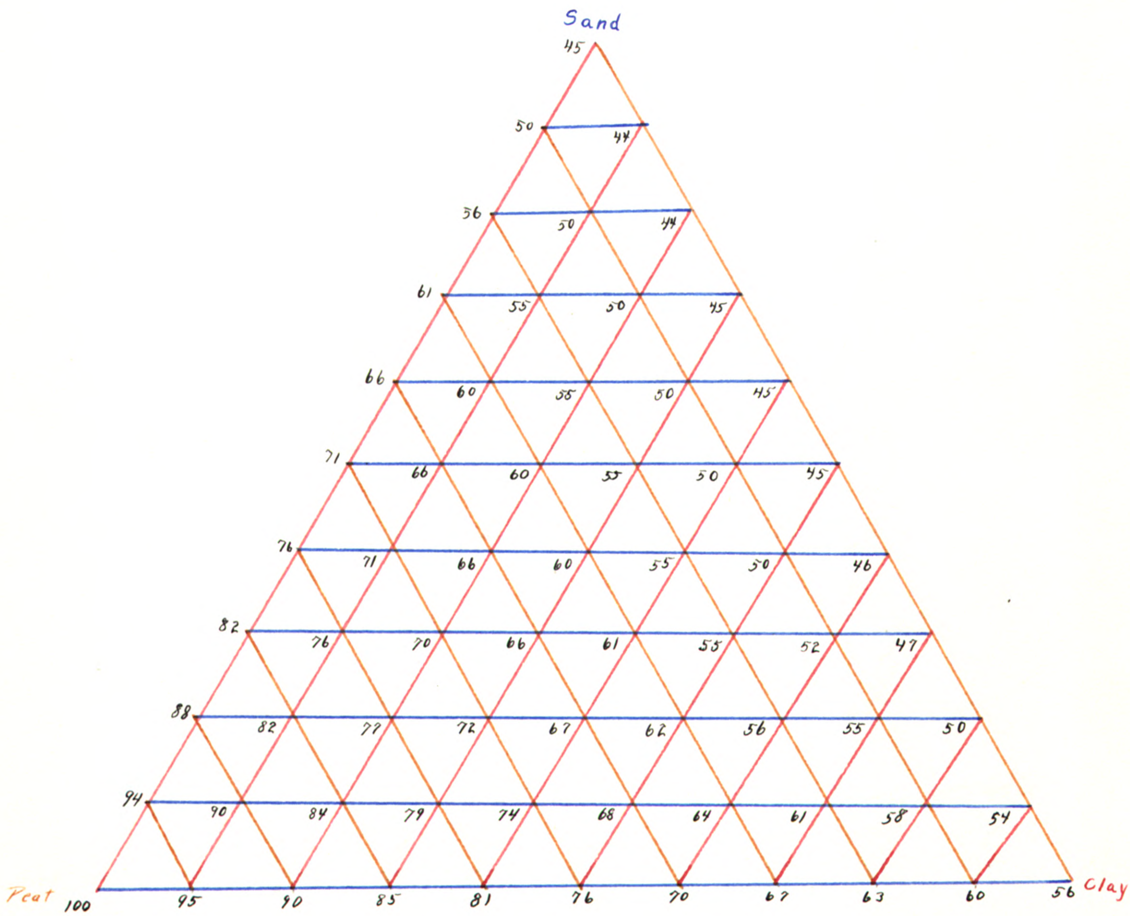
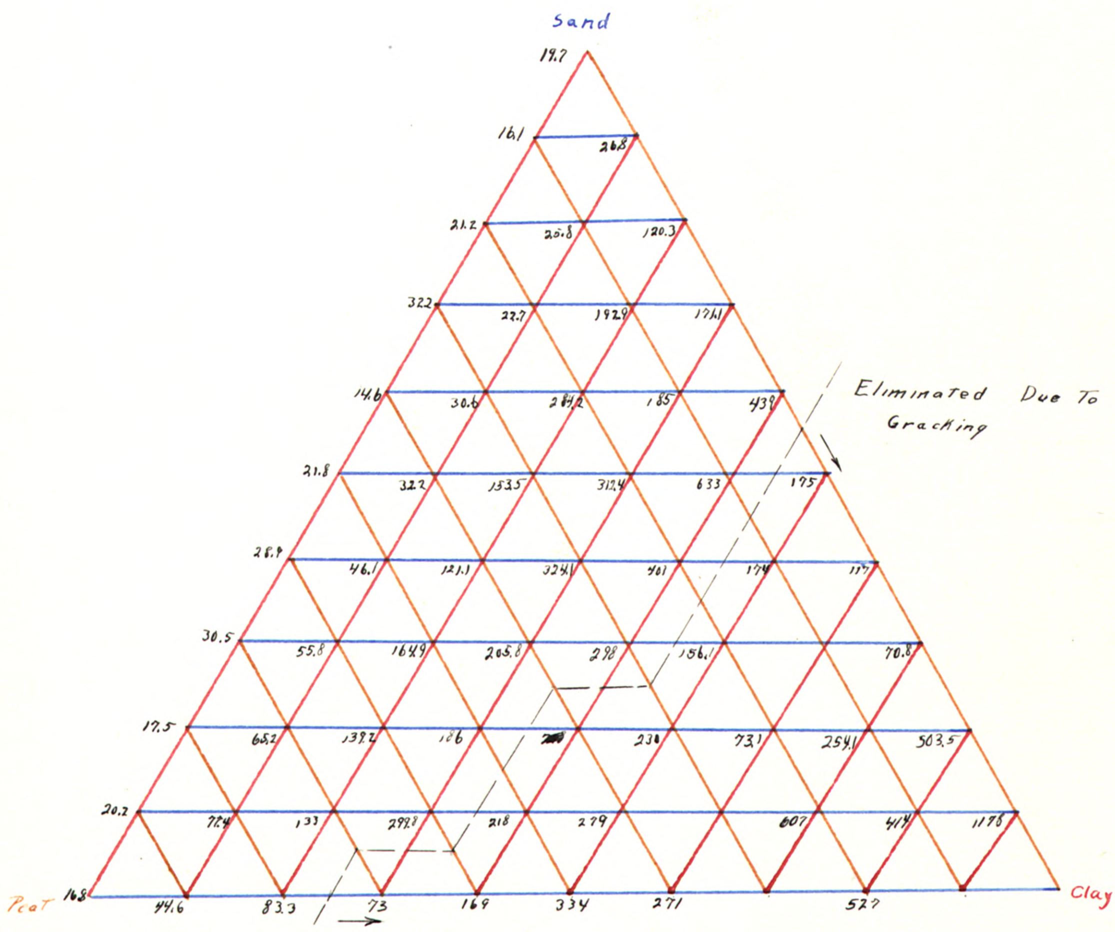


Chart No. 15

Resistance

Original Data Expressed as Grams Per Square Centimeter.



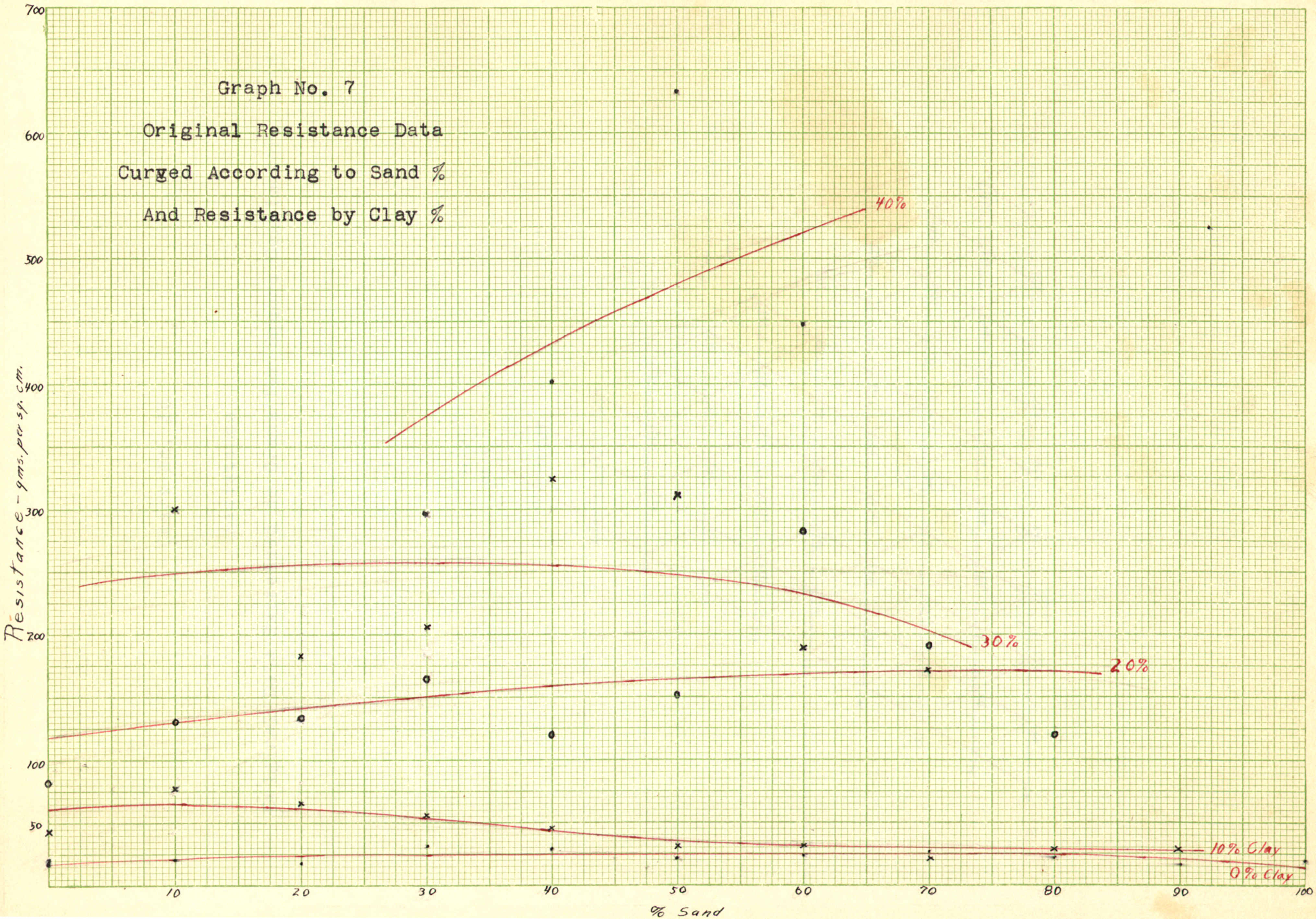
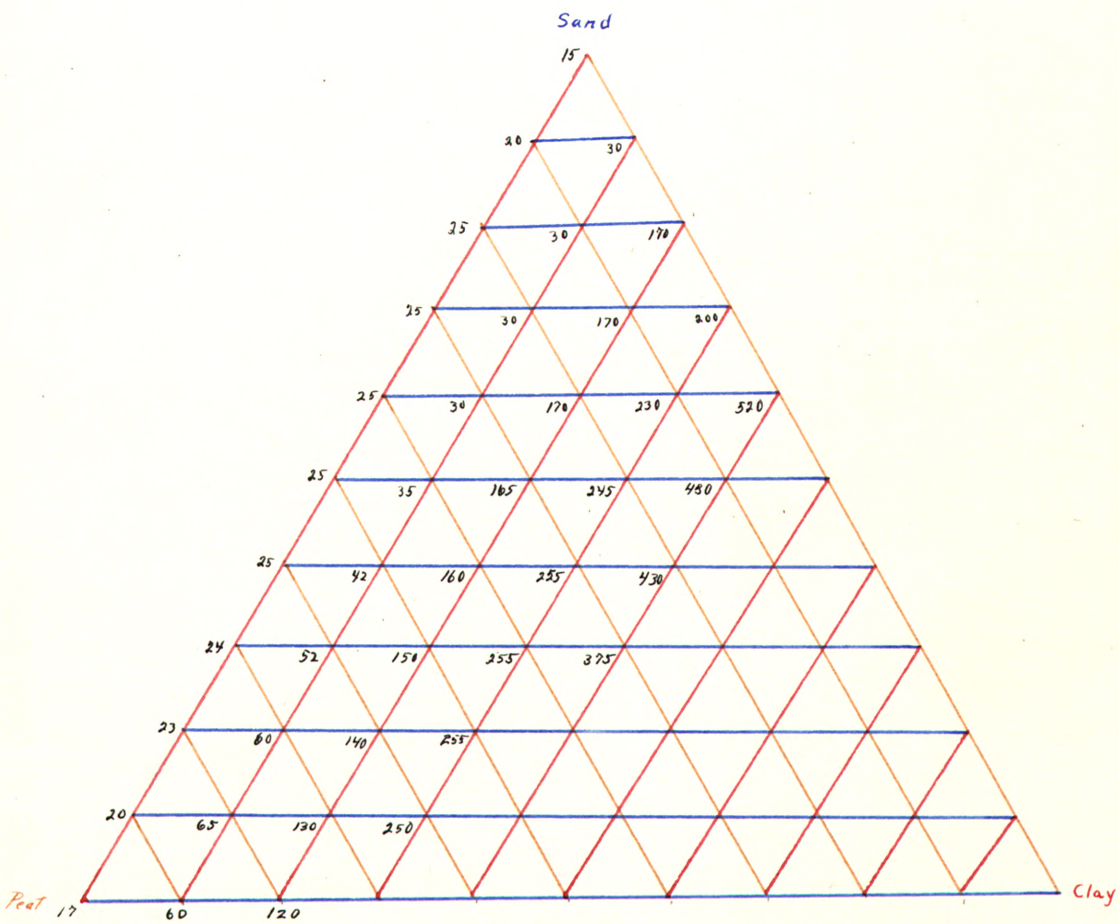

Graph No. 7
Original Resistance Data
Curged According to Sand %
And Resistance by Clay %
Resistance - gms. per sq. cm.
% Sand
40%
30%
20%
10% Clay
0% Clay

Chart No. 16

Resistance

First Balance



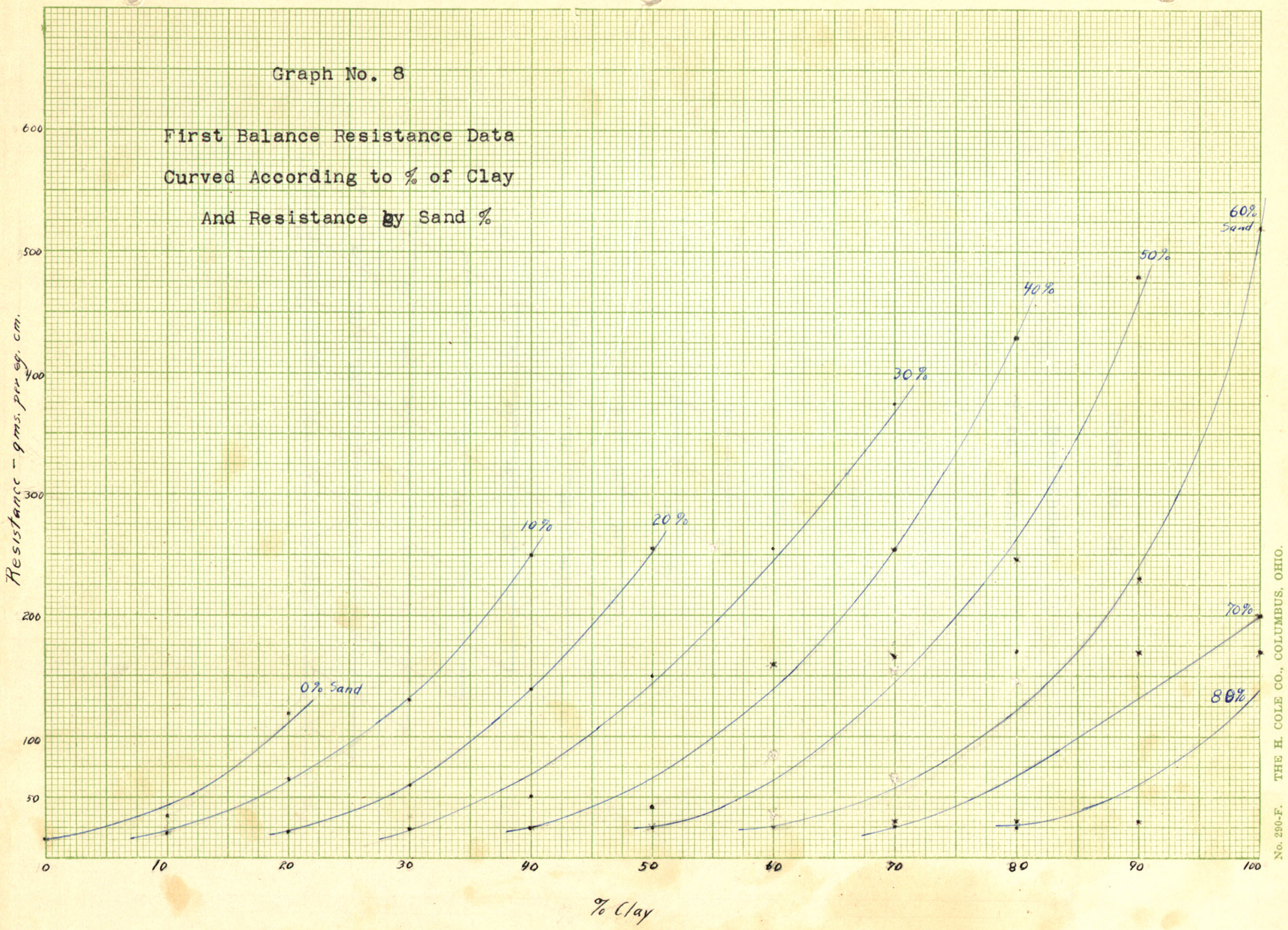

Graph No. 8
First Balance Resistance Data
Curved According to % of Clay
And Resistance by Sand %
Resistance - gms. per sq. cm.
% Clay
0% Sand
10%
20%
30%
40%
50%
60% Sand
70%
80%
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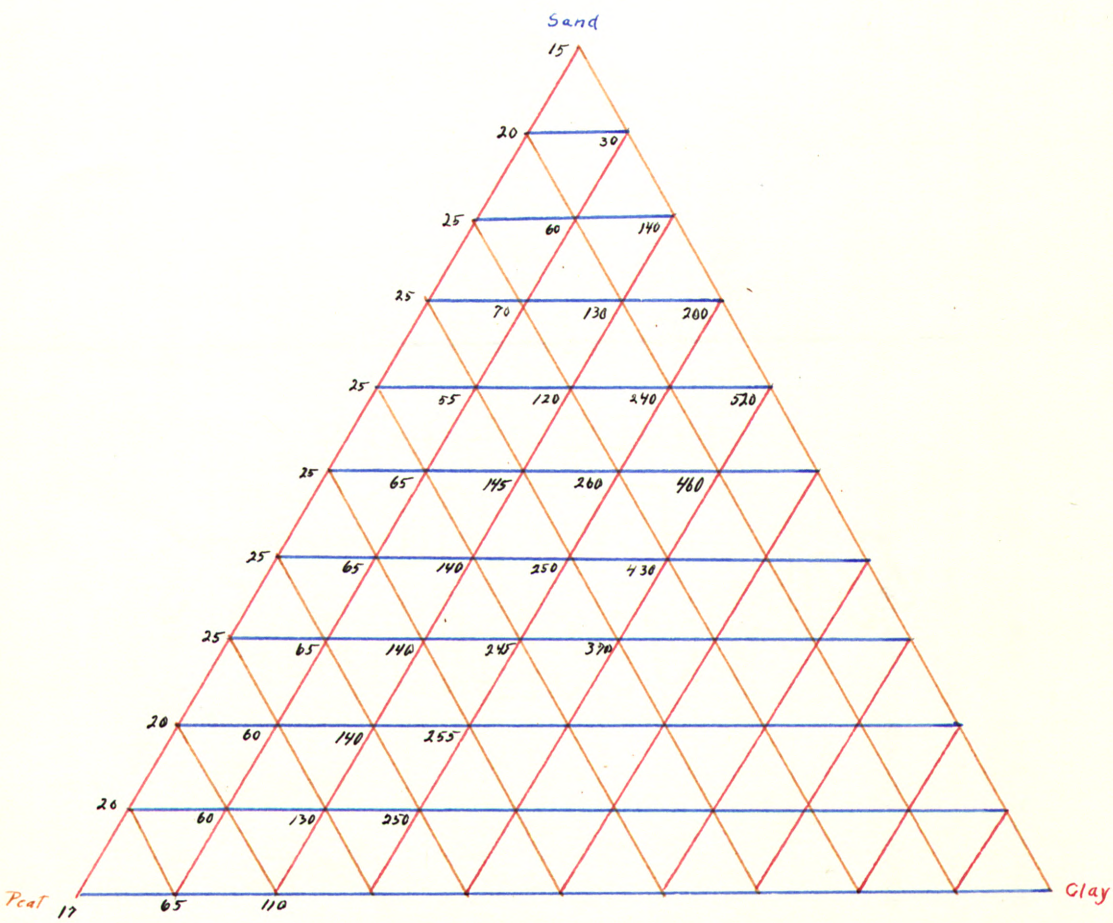
Chart No. 17

Resistance

Second Balance



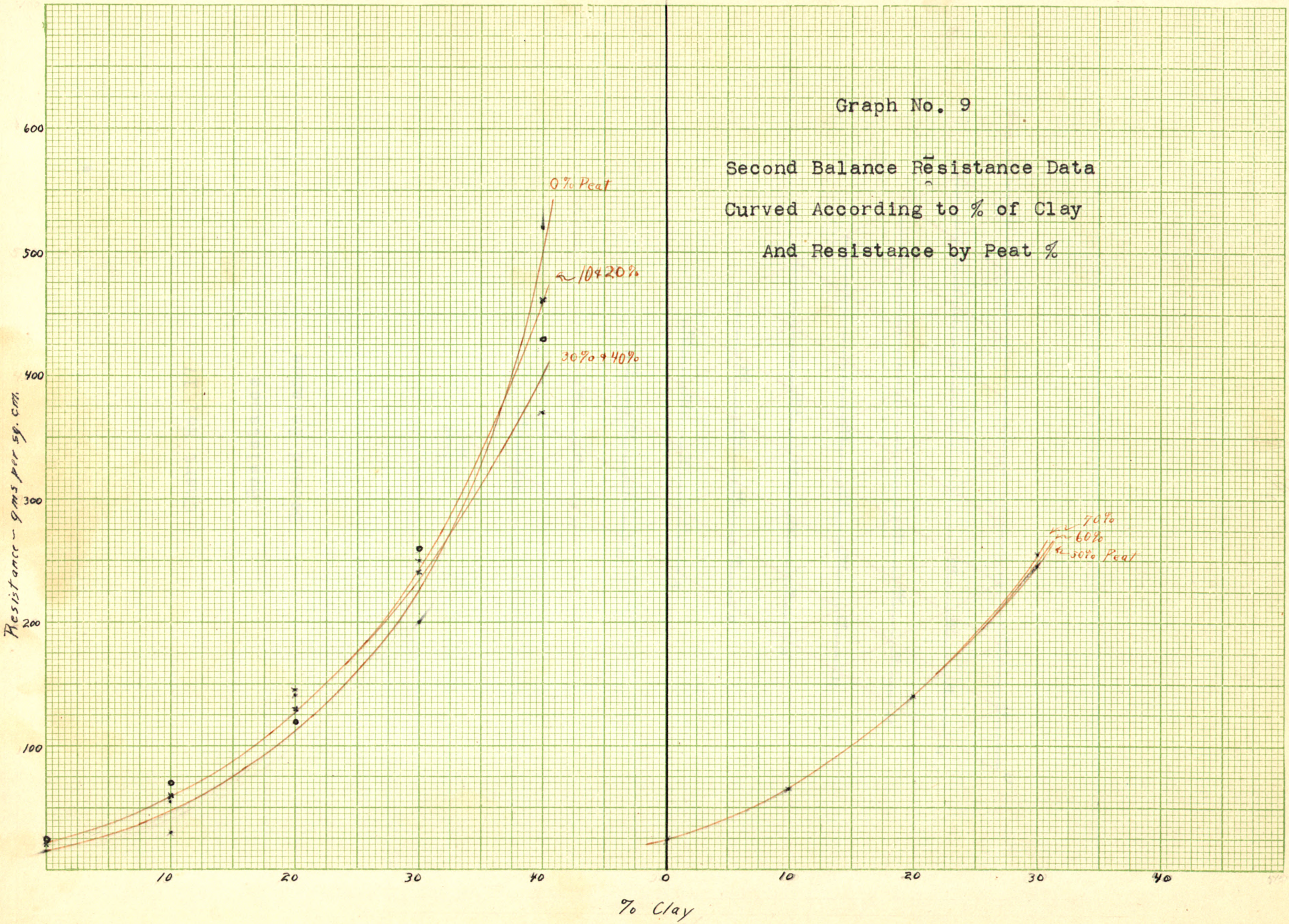

Graph No. 9
Second Balance Resistance Data
Curved According to % of Clay
And Resistance by Peat %
Resistance – gms per sq. cm.
100
200
300
400
500
600
% Clay
10
20
30
40
0
0% Peat
10 & 20%
30% & 40%
70%
60%
50% Peat

Chart No. 18

Resistance

Third Balance

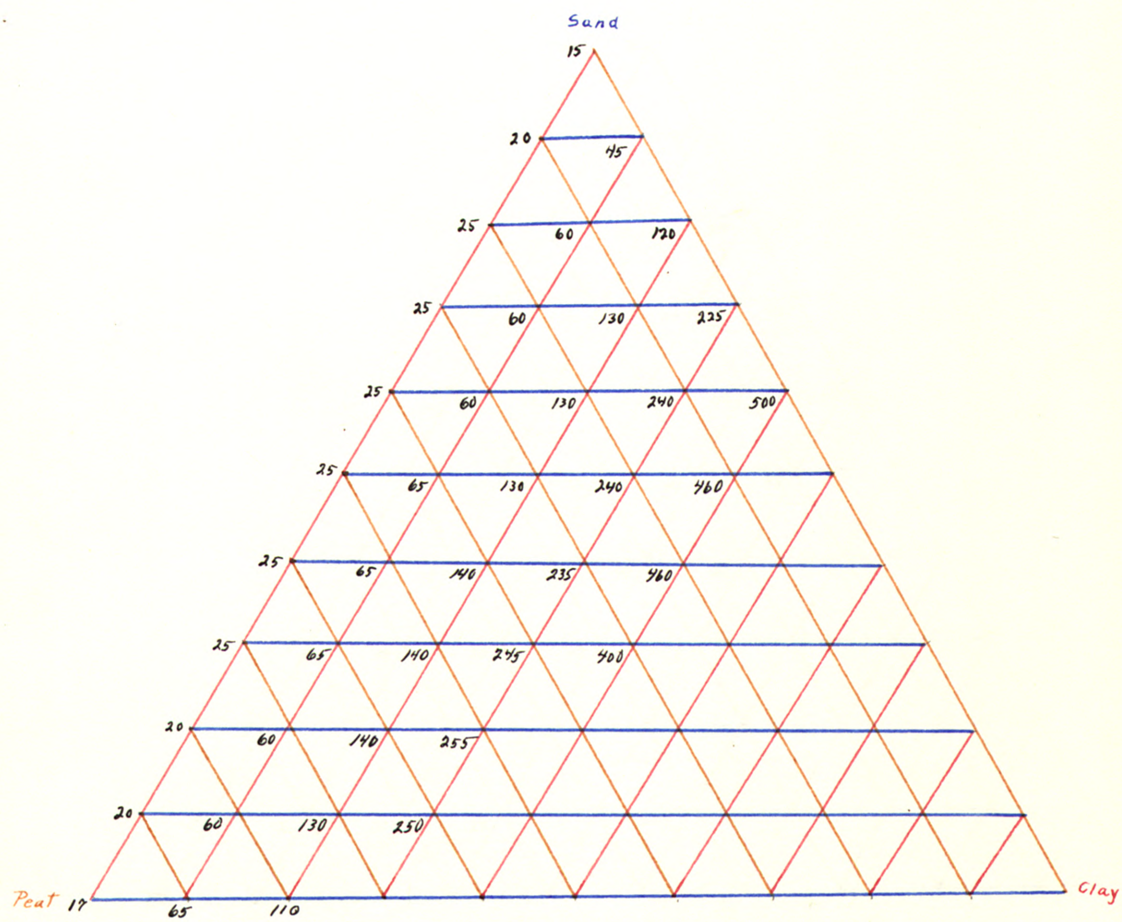


Chart No. 19

Resistance

Expressed as % of Maximum

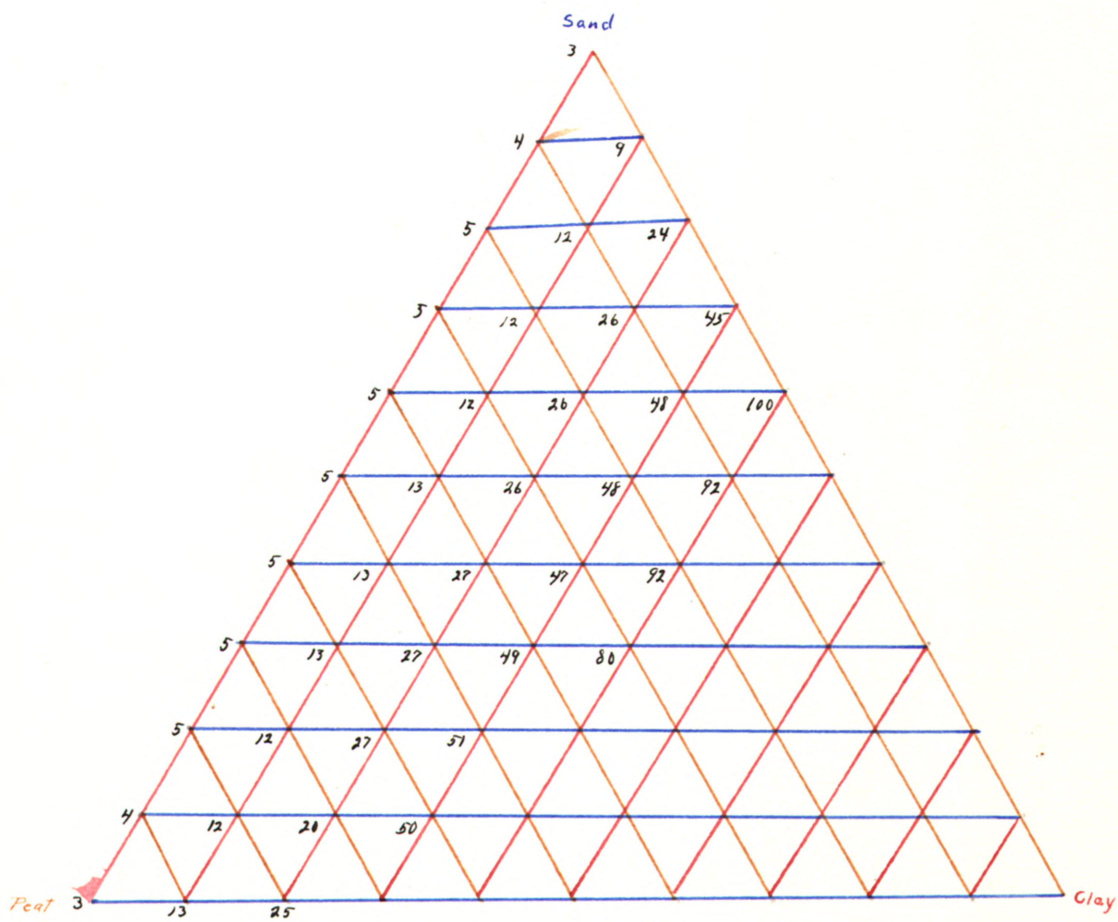
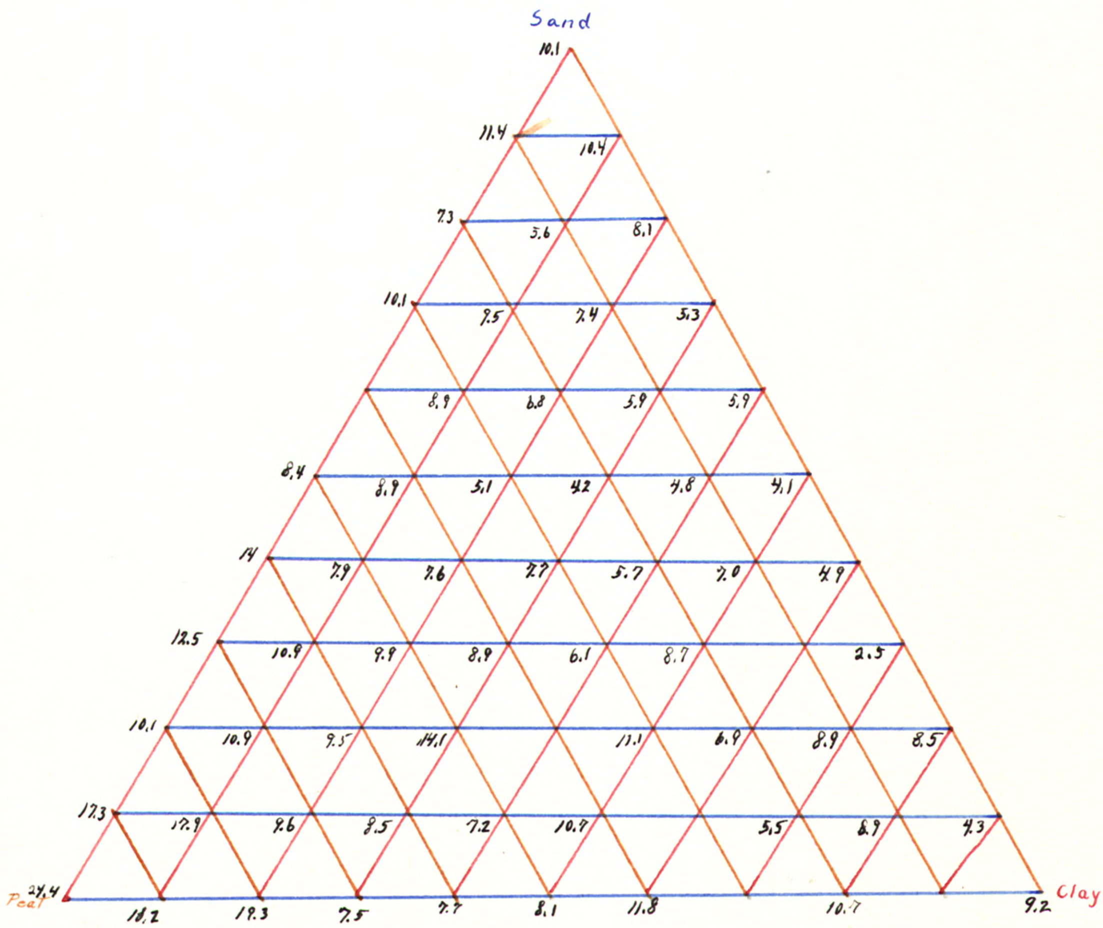
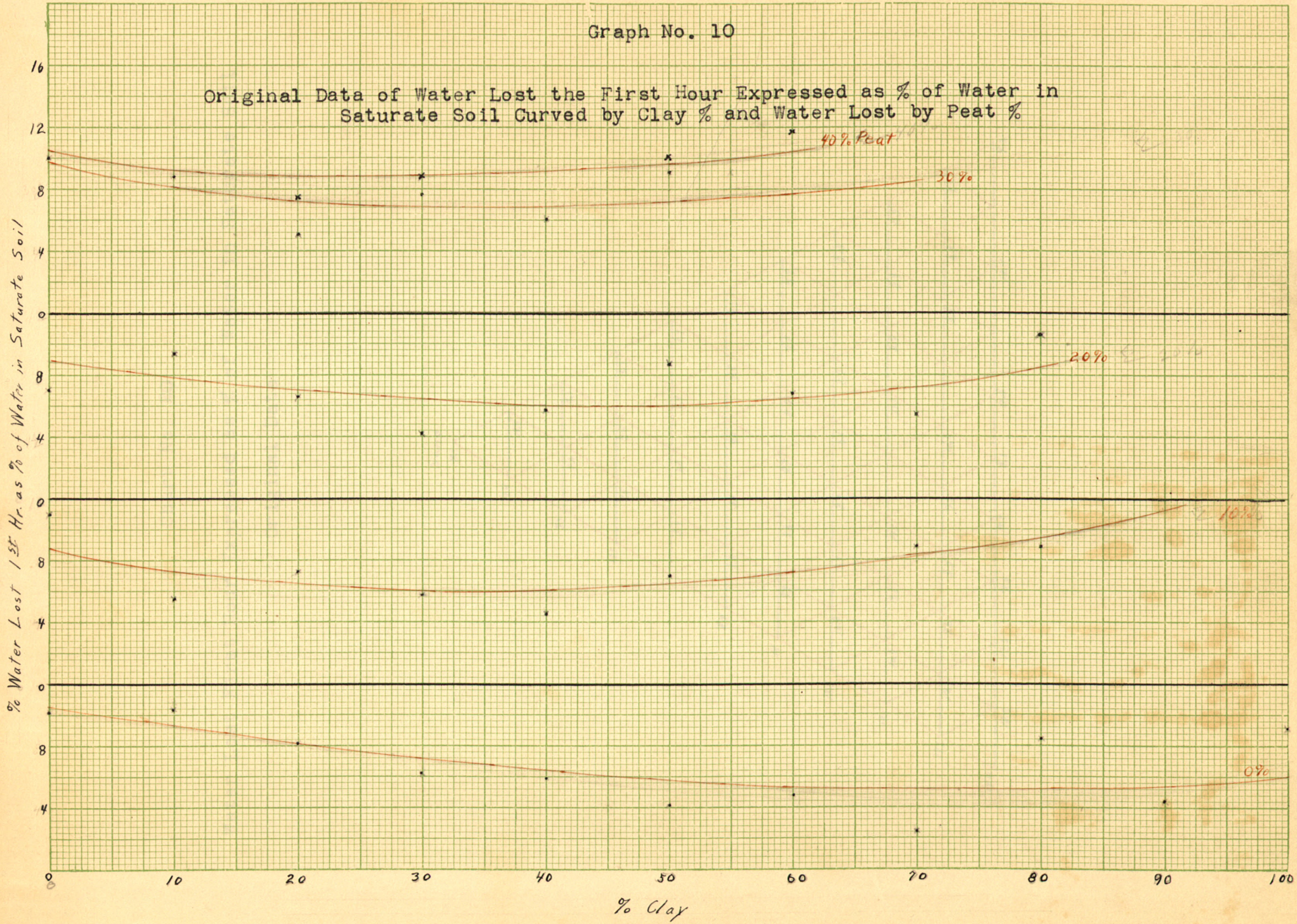


Chart No. 20

Water Lost First Hour Expressed as % of Water in Saturate Soil

Original Data




Graph No. 10
Original Data of Water Lost the First Hour Expressed as % of Water in Saturate Soil Curved by Clay % and Water Lost by Peat %
40% Peat
30%
20%
10%
0%
% Water Lost 1st Hr. as % of Water in Saturate Soil
% Clay
0
10
20
30
40
50
60
70
80
90
100
4
8
12
16

Graph No. 10 (Cont.)

Original Data of Water Lost the First Hour Expressed as % of Water In Saturate Soil Curved By Clay % and Water Lost By Peat %.

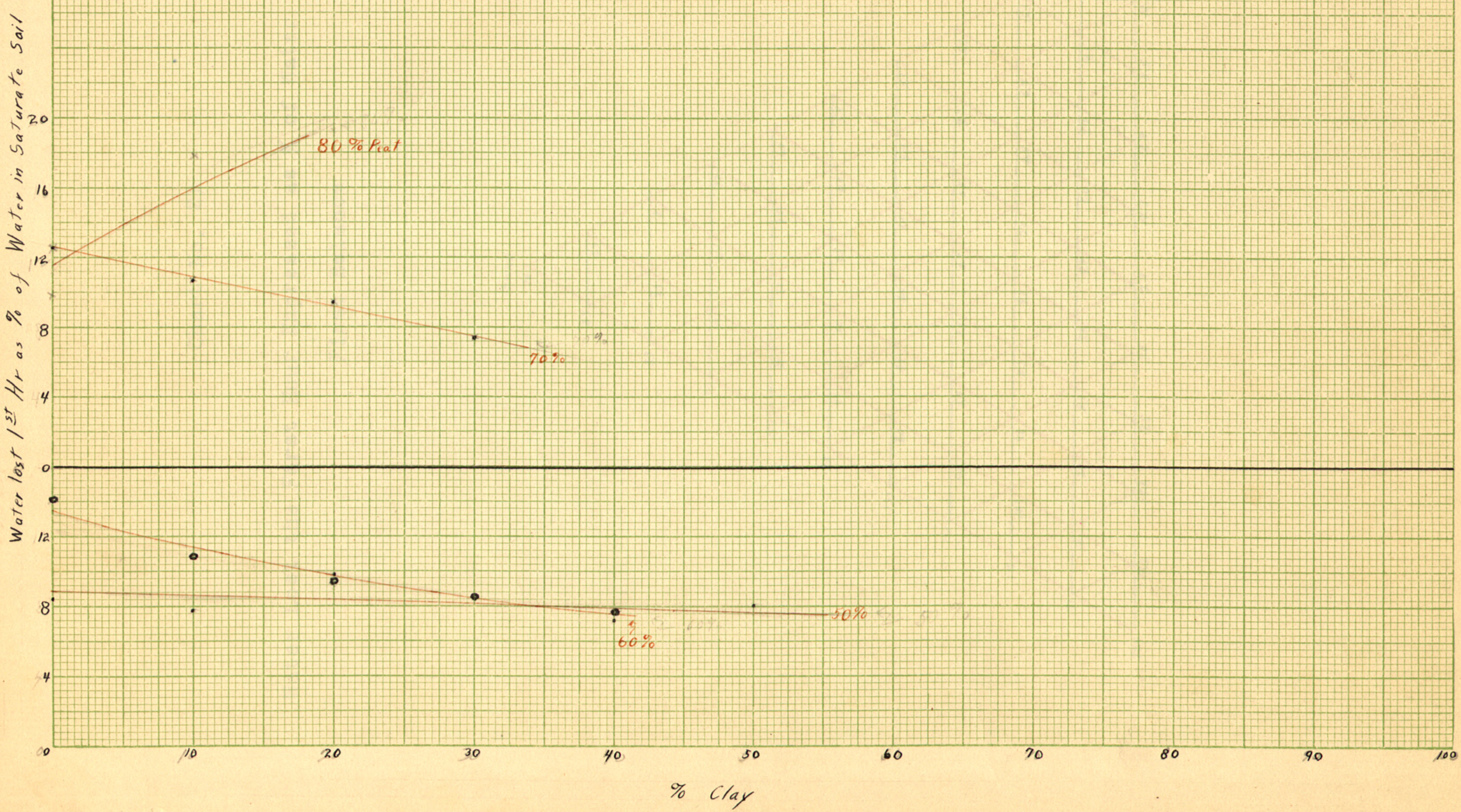
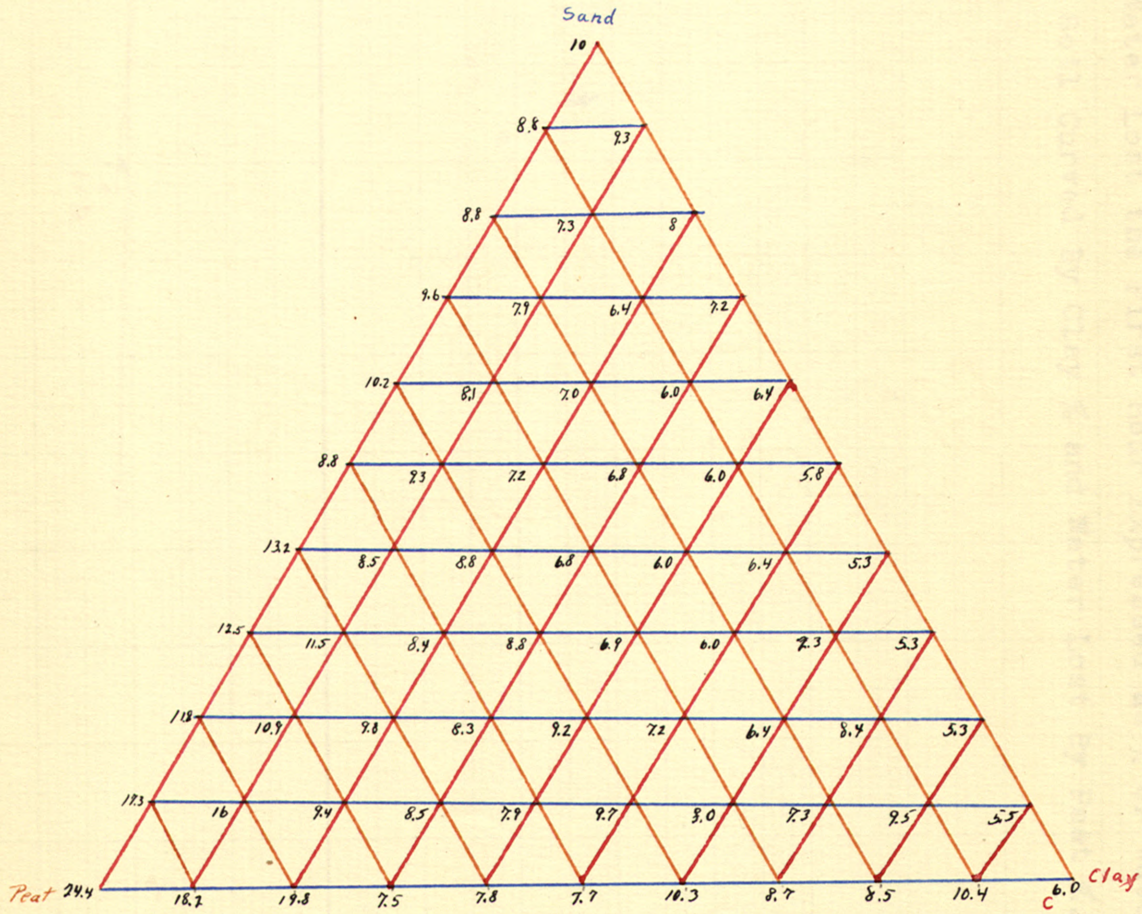
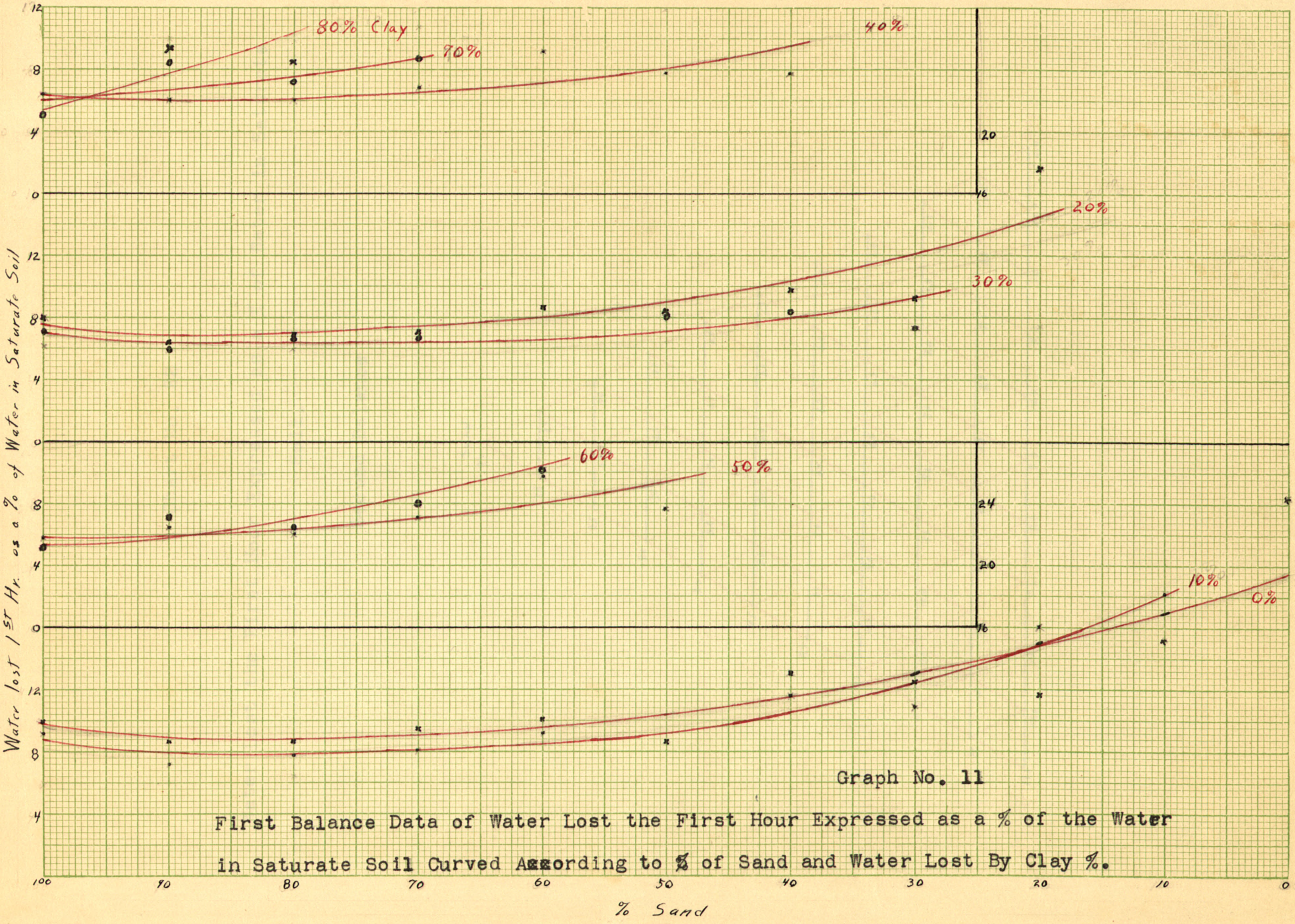


Chart No. 21

Water Lost the Fárst Hour Expressed as % of Water in Saturate Soil

First Balance





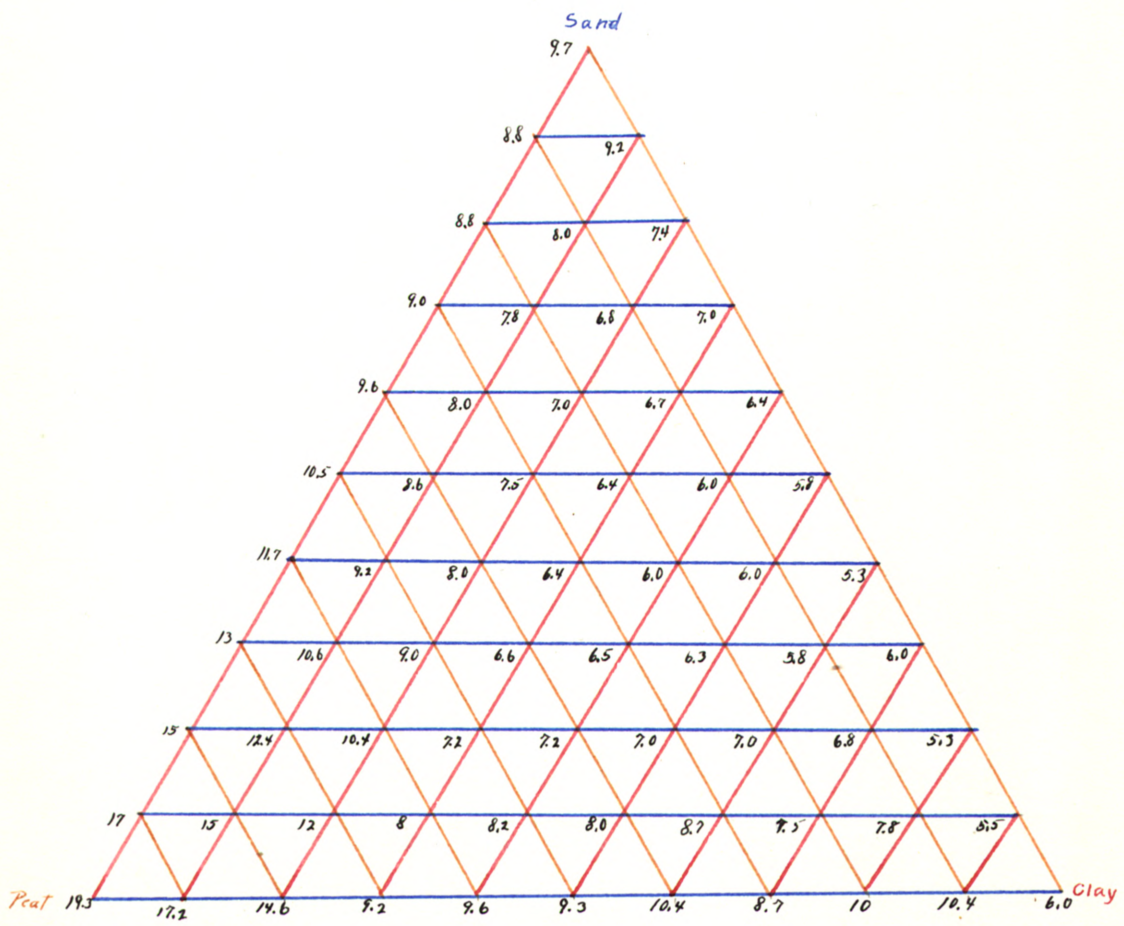
Graph No. 11

First Balance Data of Water Lost the First Hour Expressed as a % of the Water in Saturate Soil Curved According to % of Sand and Water Lost By Clay %.

Chart No. 22

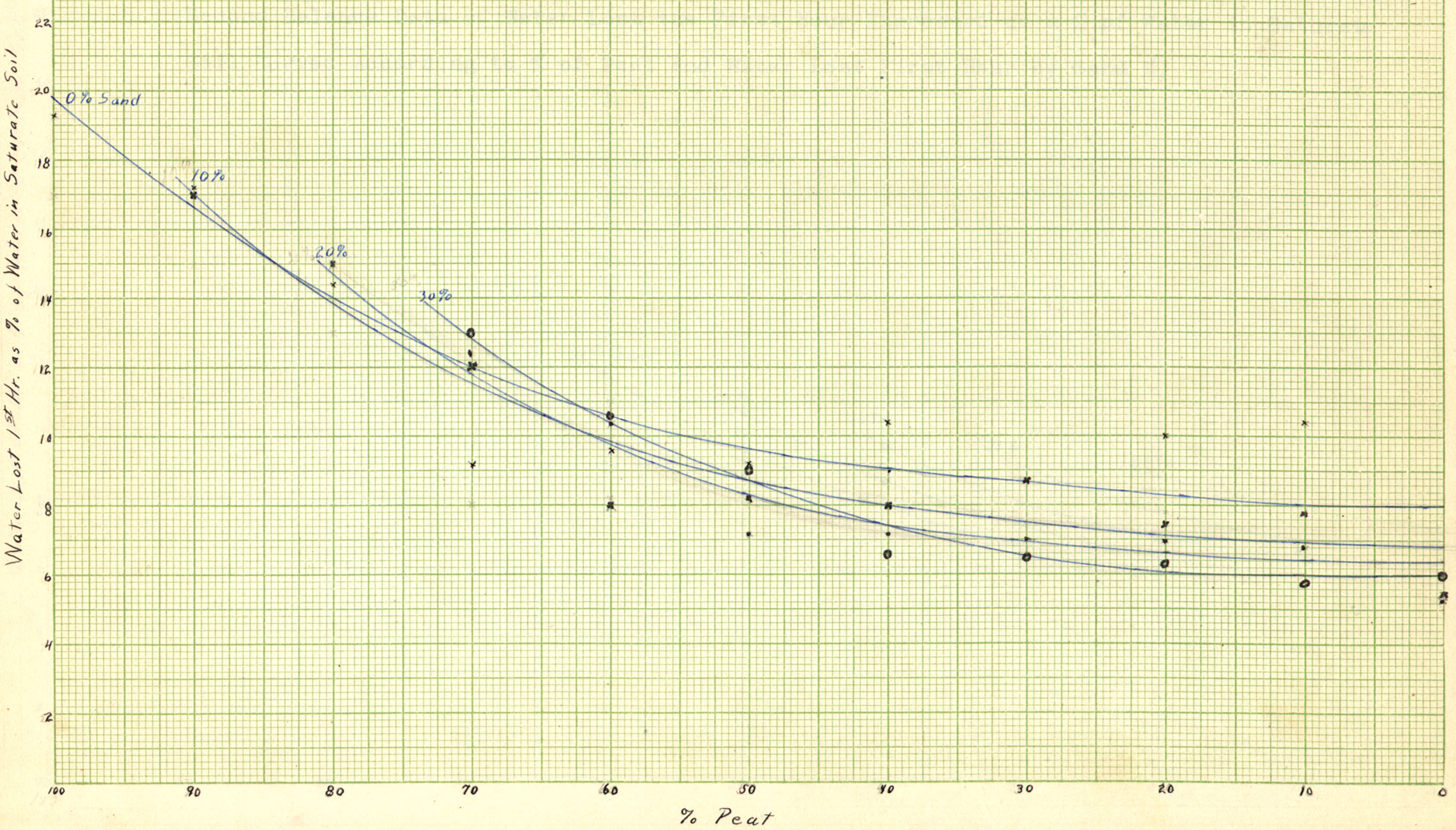
Water Lost the First Hour Expressed as a % of Water in Saturate Soil.

Second Balance



Graph No. 12

Second Balance Data of Water Lost the First Hour Expressed as a % of Water in Saturate Soil Curved According to% of Peat and Water Lost First Hour by Sand %.



Graph No. 12
(Cont.)

Second Balance Data of Water Lost the First Hour Expressed as a % of Water in Saturate Soil Curved According to % of Peat and Water Lost First Hour by Sand %.

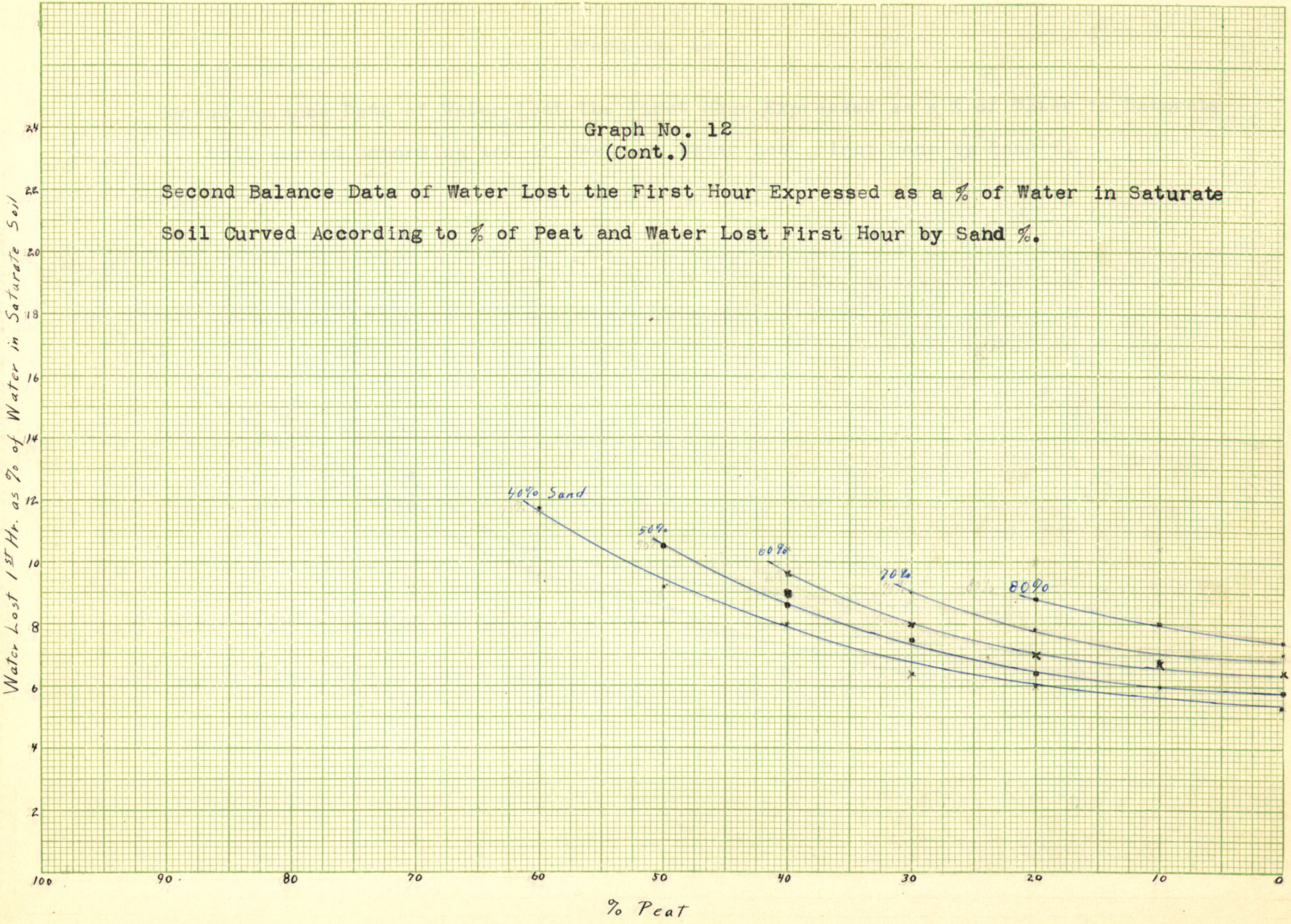


Chart No. 23

Water Lost the First Hour Expressed as a % of Water in Saturate Soil

Third Balance

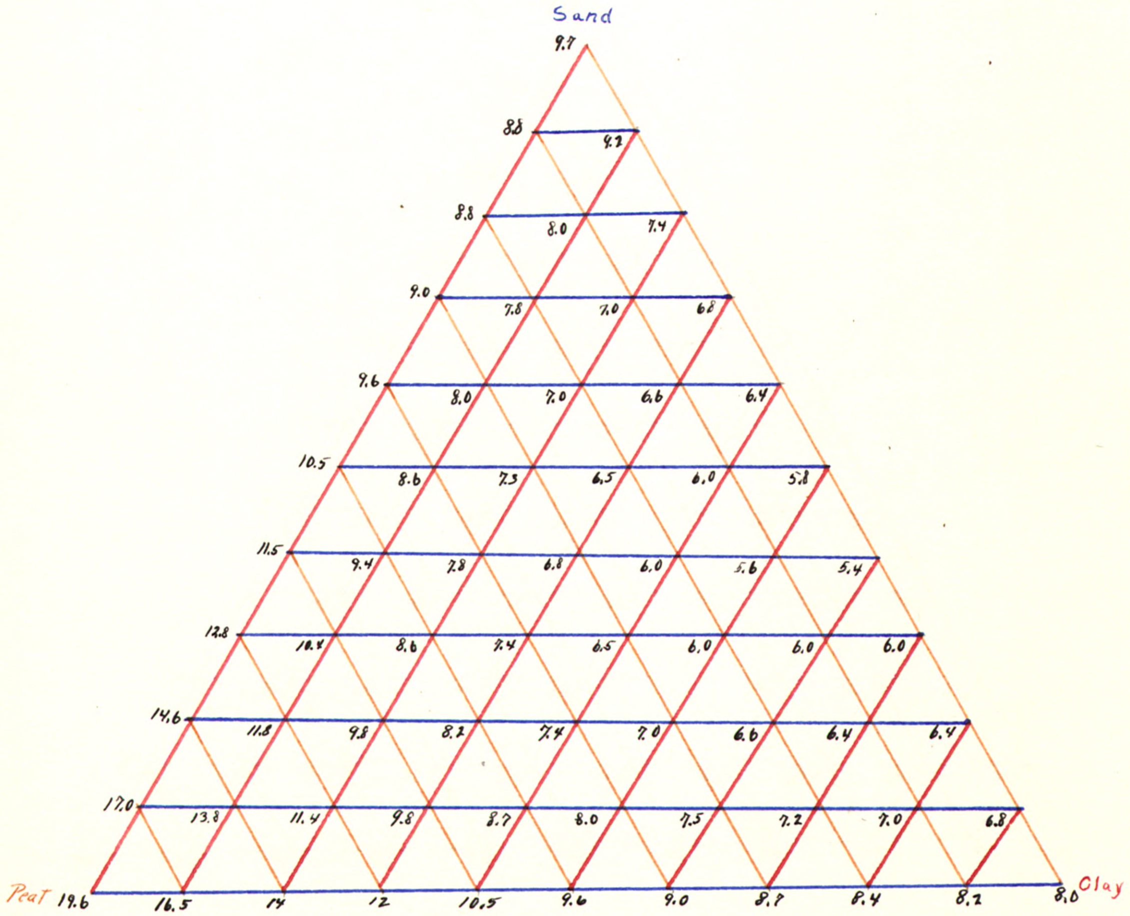


Chart No. 24

Water Lost the First Hour Expressed as a % of Water in Saturate Soil.

Expressed as a% of Maximum

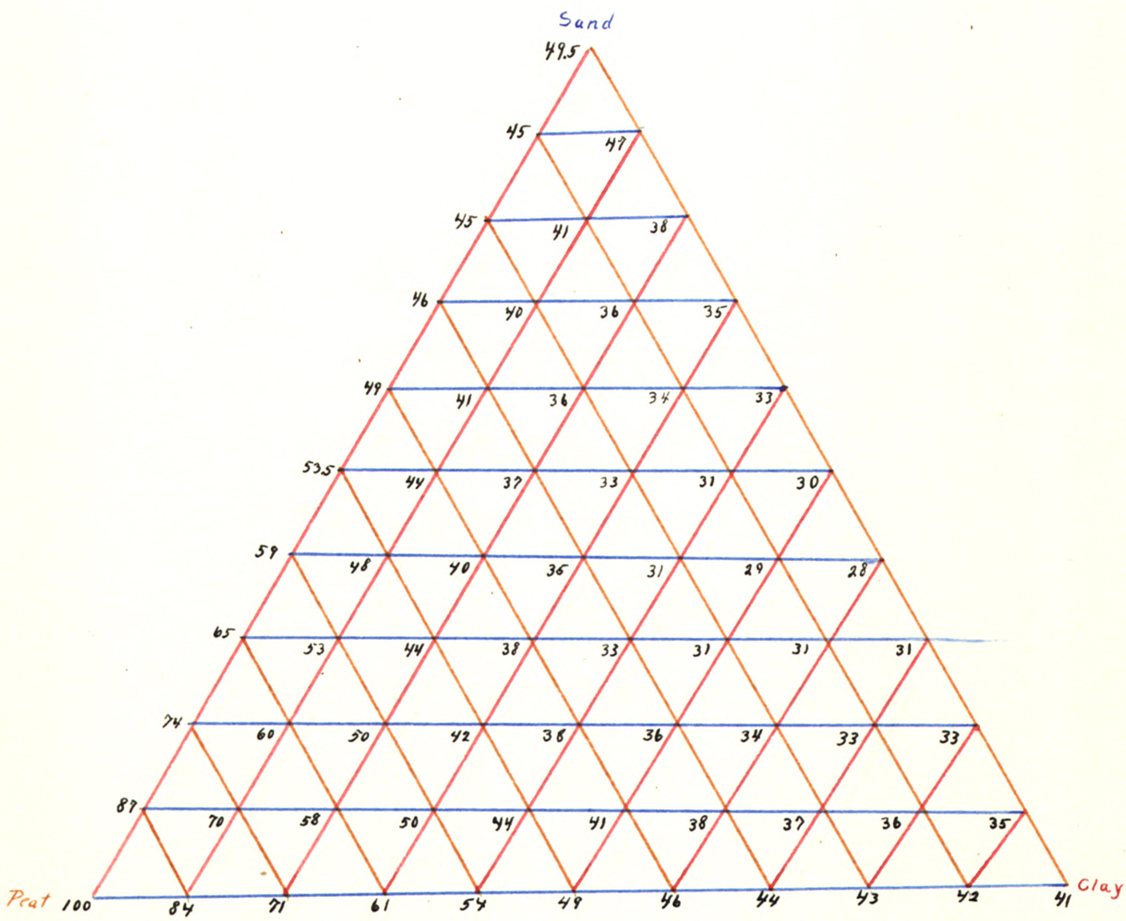
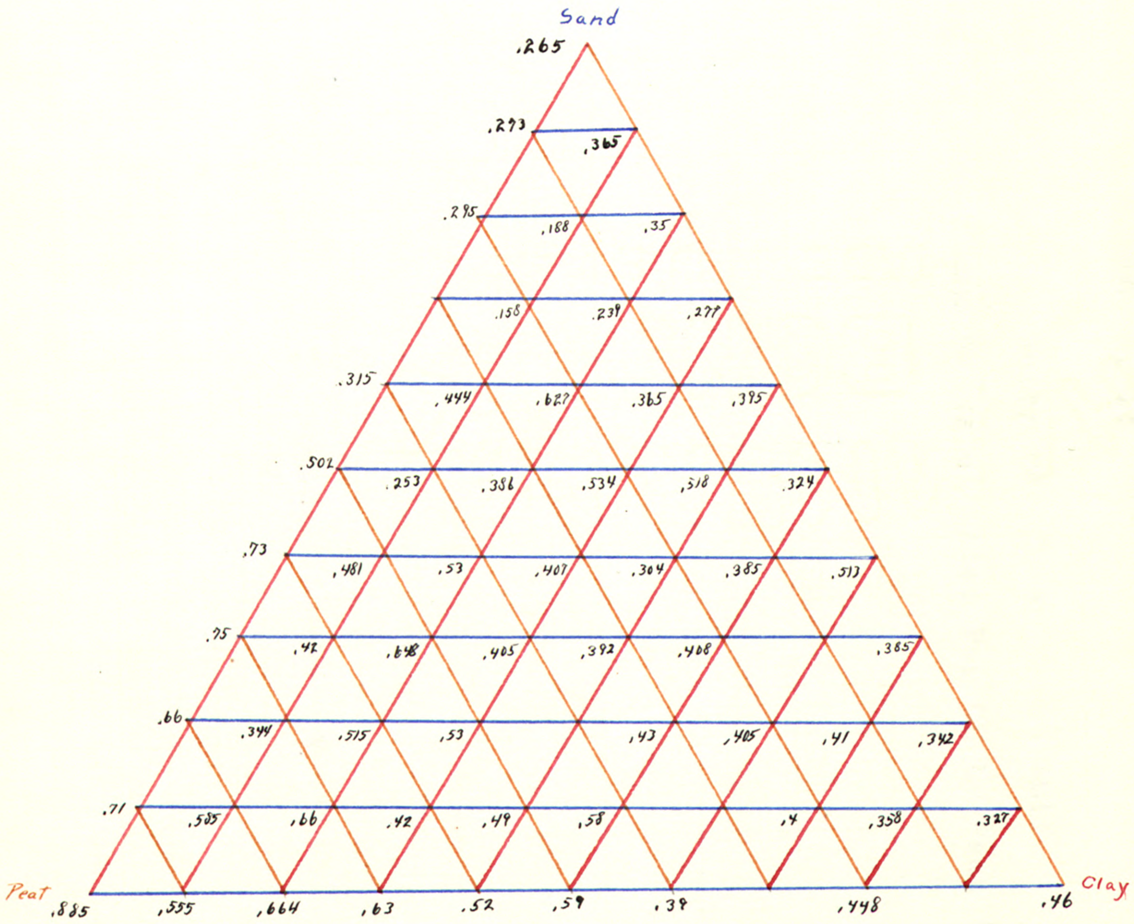


Chart No. 25

Grams of Water Per CC of Fresh Soil

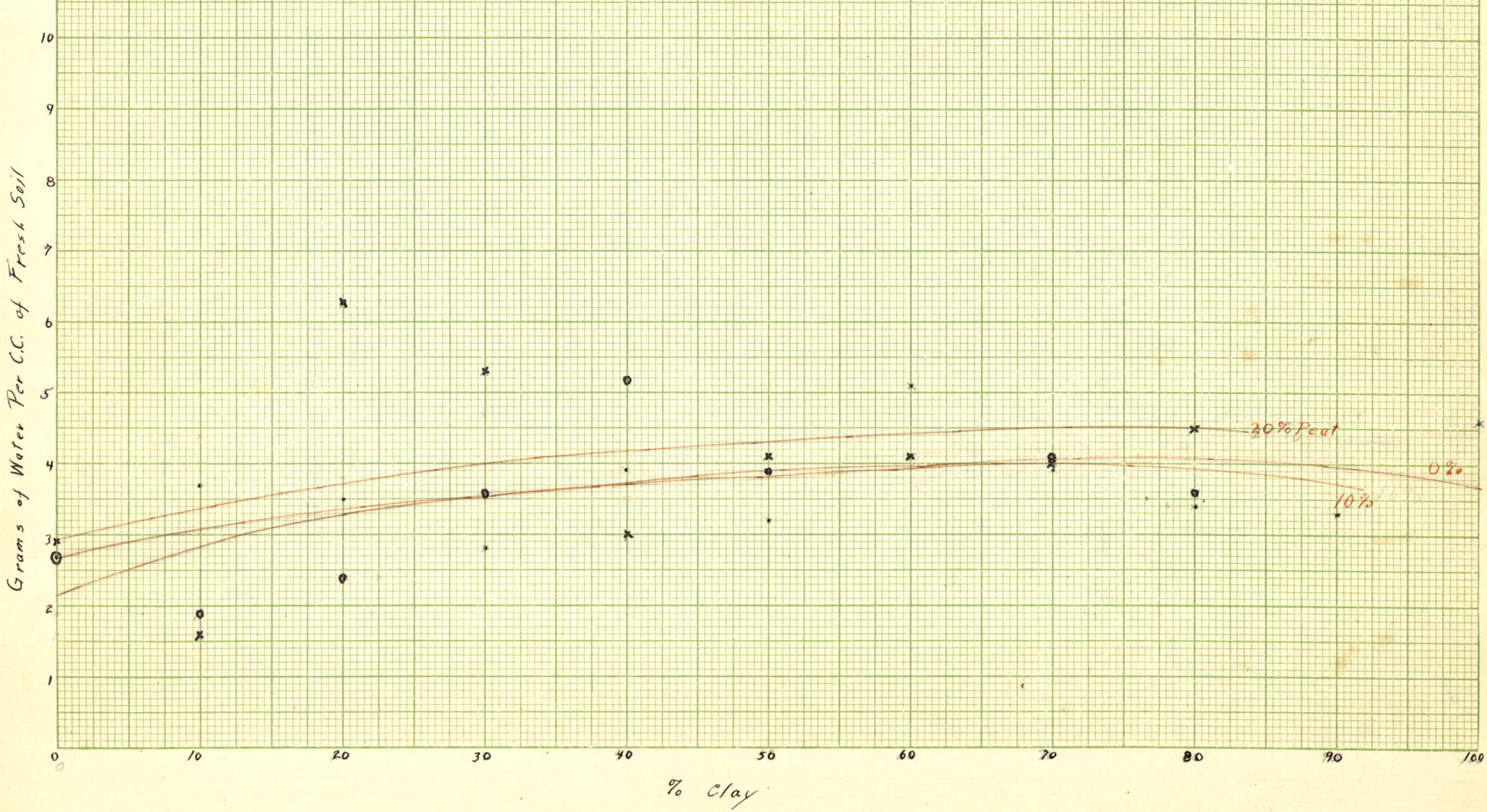
Original Data

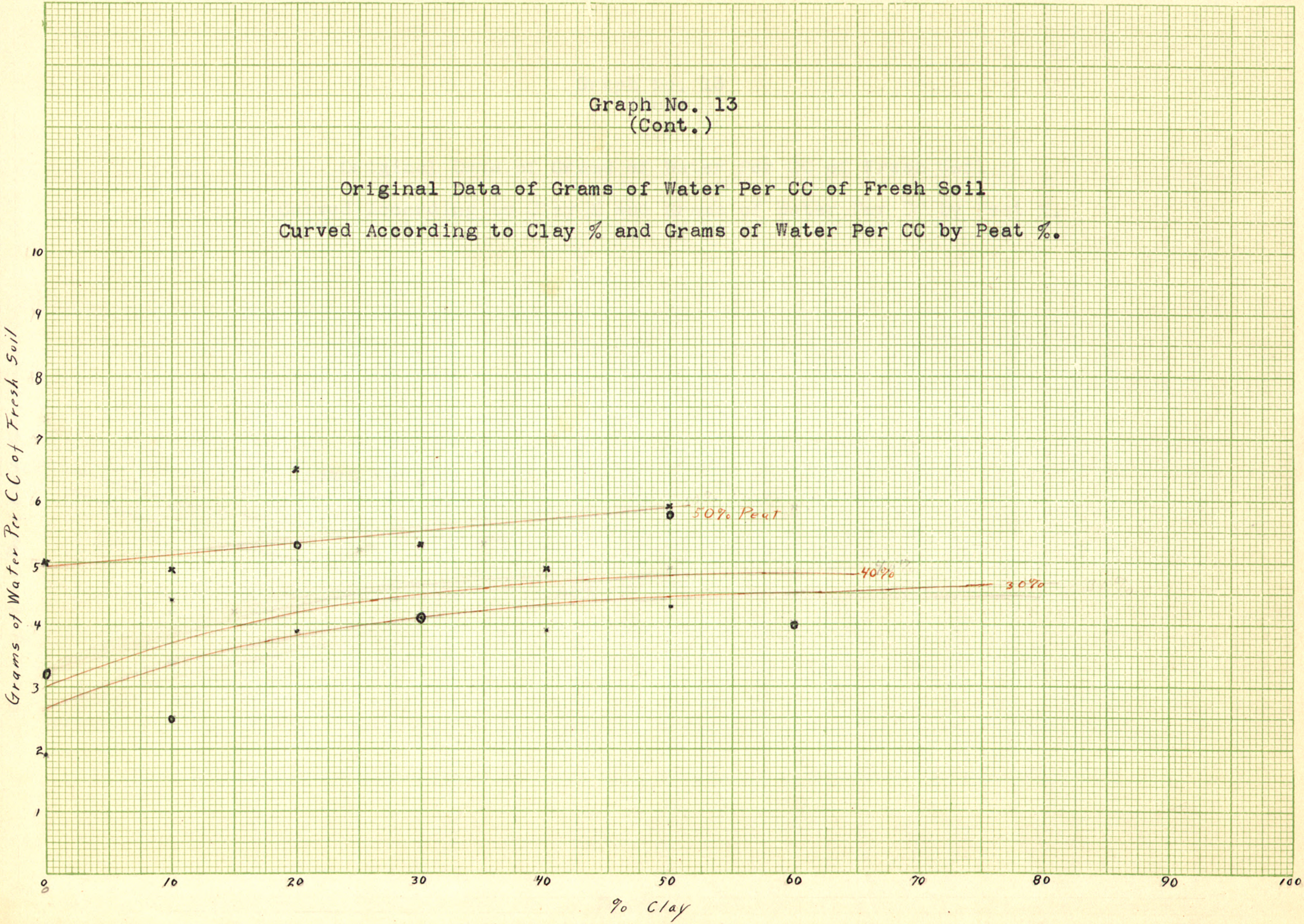


Graph No. 13

Original Data of Grams of Water Per CC of Fresh Sbil

Curved According to Clay % and Grams of Water Per CC by Peat %.




Graph No. 13
(Cont.)
Original Data of Grams of Water Per CC of Fresh Soil
Curved According to Clay % and Grams of Water Per CC by Peat %.
Grams of Water Per CC of Fresh Soil
% Clay
50% Peat
40%
30%
0
1
2
3
4
5
6
7
8
9
10
20
30
40
50
60
70
80
90
100

Graph No. 13
(Cont.)

Original Data of Gramd of Water Per CC of Fresh Soil

Curved According to Clay % and Grams of Water Per CC by Peat %.

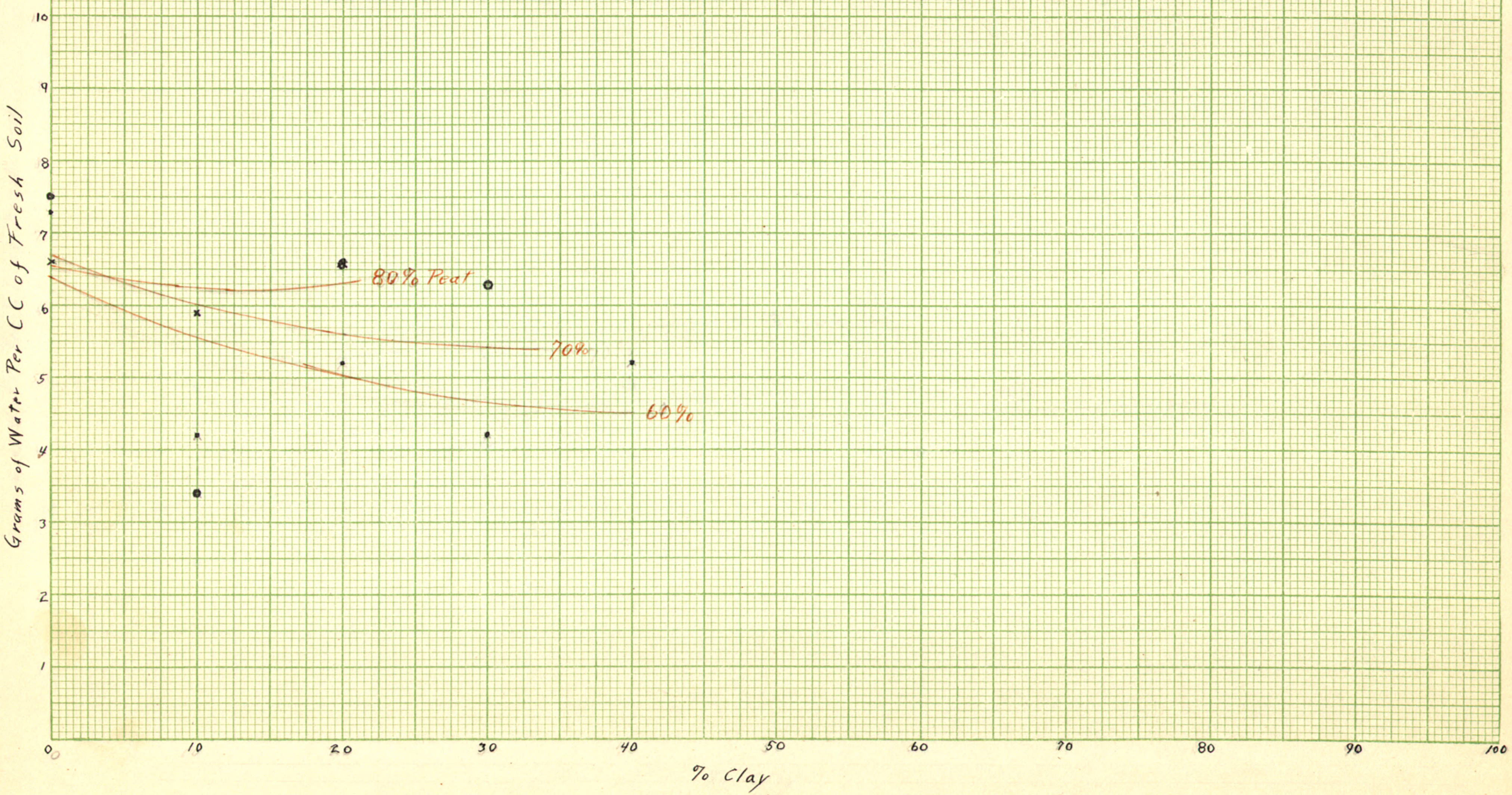


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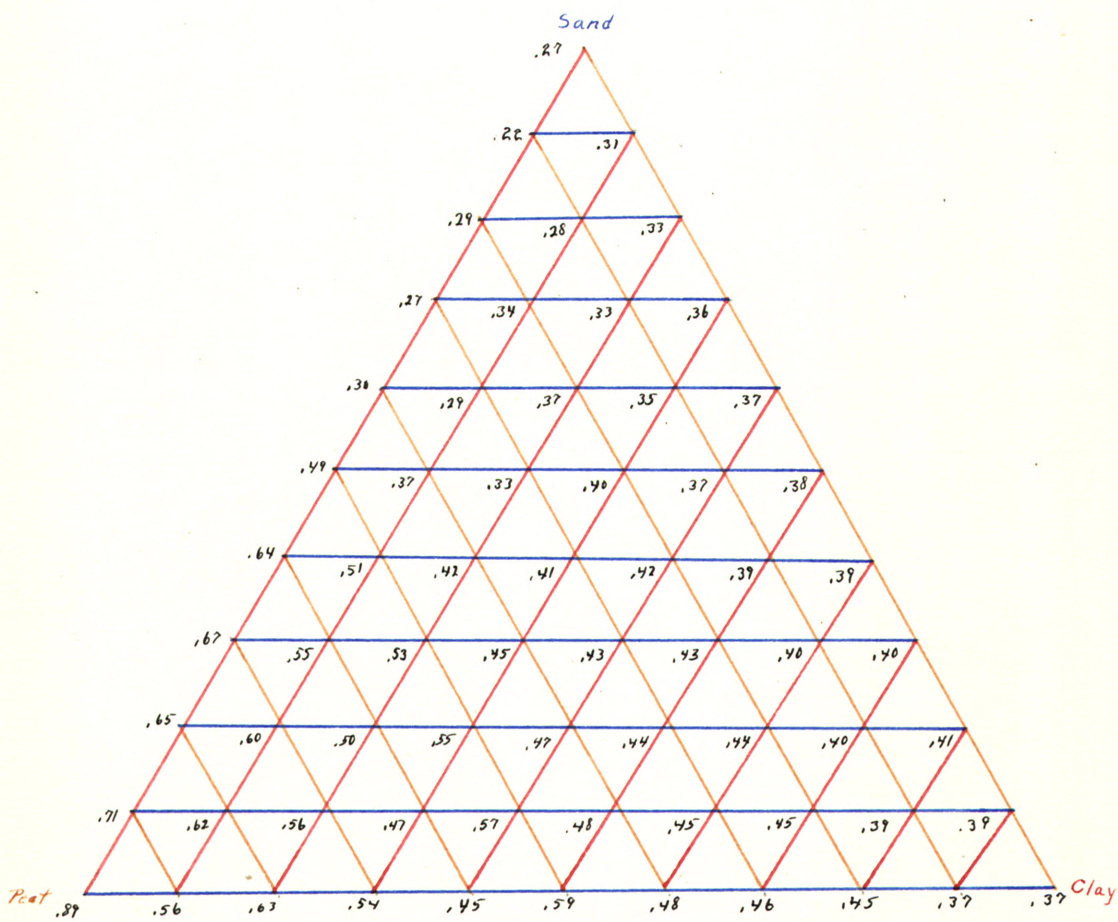
Chart No. 26

Grams of Water Per CC of Fresh Soil

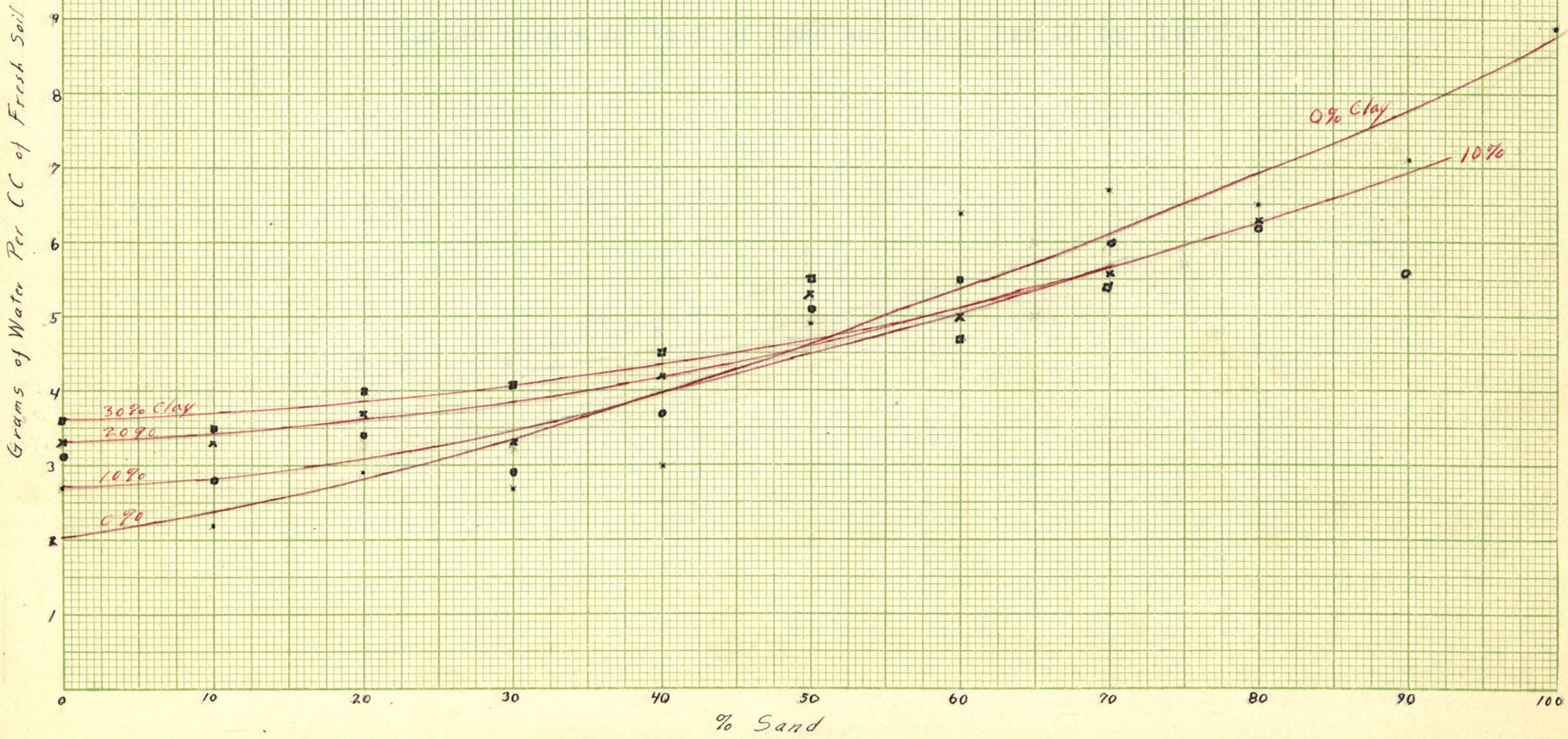
First Balance



Graph No. 14

First Balance Data of Grams of Water Per CC of Fresh Soil

Curved According to % of Sand and Water Per CC by Clay %.



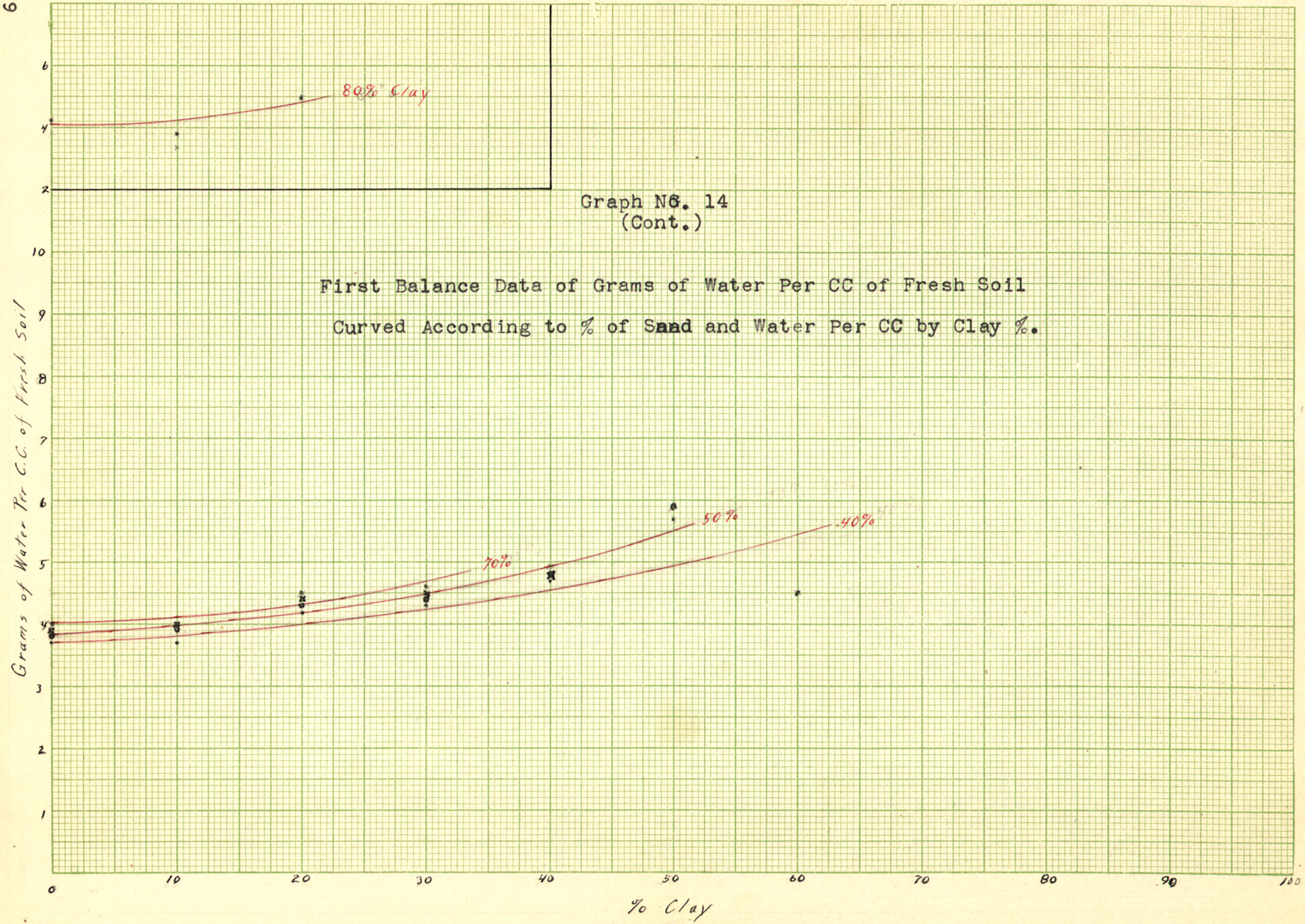

Graph No. 14
(Cont.)
First Balance Data of Grams of Water Per CC of Fresh Soil
Curved According to % of Sand and Water Per CC by Clay %.
80% Clay
70%
50%
40%
Grams of Water Per C.C. of Fresh Soil
% Clay
0
10
20
30
40
50
60
70
80
90
100
1
2
3
4
5
6
7
8
9
10

Chart No. 27

Grams of Water Per CC of Fresh Soil

Second Balance

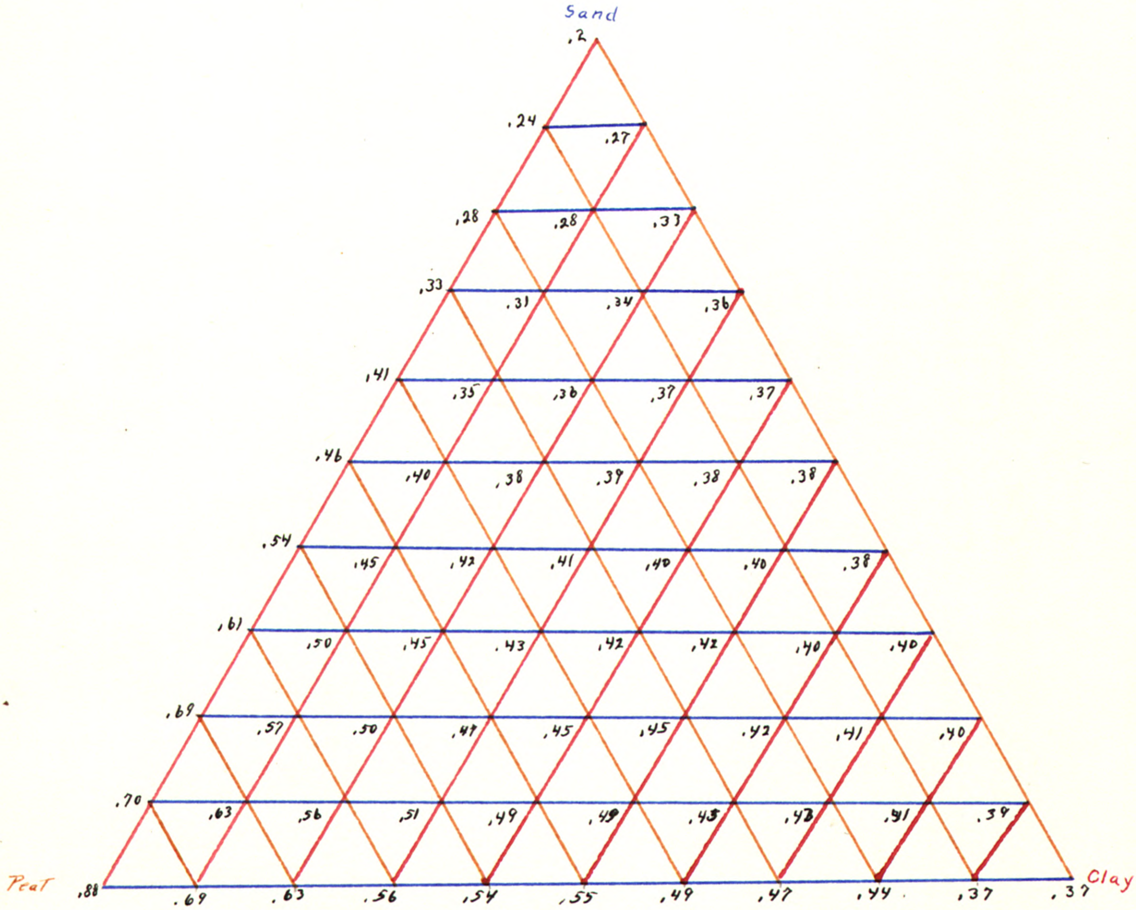


Chart No. 15

Second Balance Data of Grams of Water Per CC of Fresh Soil

Curved According to % of Clay and Grams of Water Per CC by Sand %.

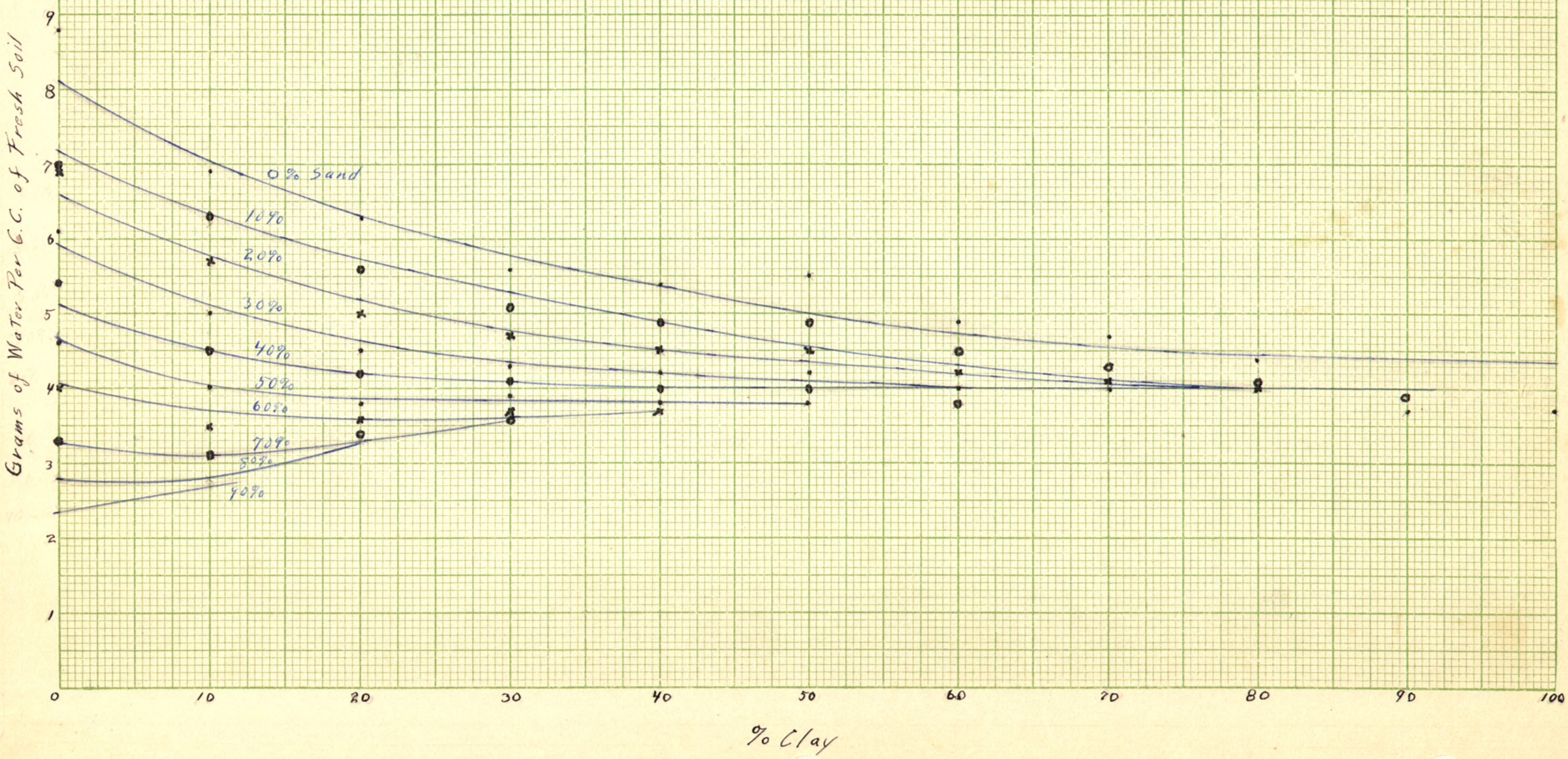


Chart No. 28

Grams of Water Per CC of Fresh Soil

Third Balance

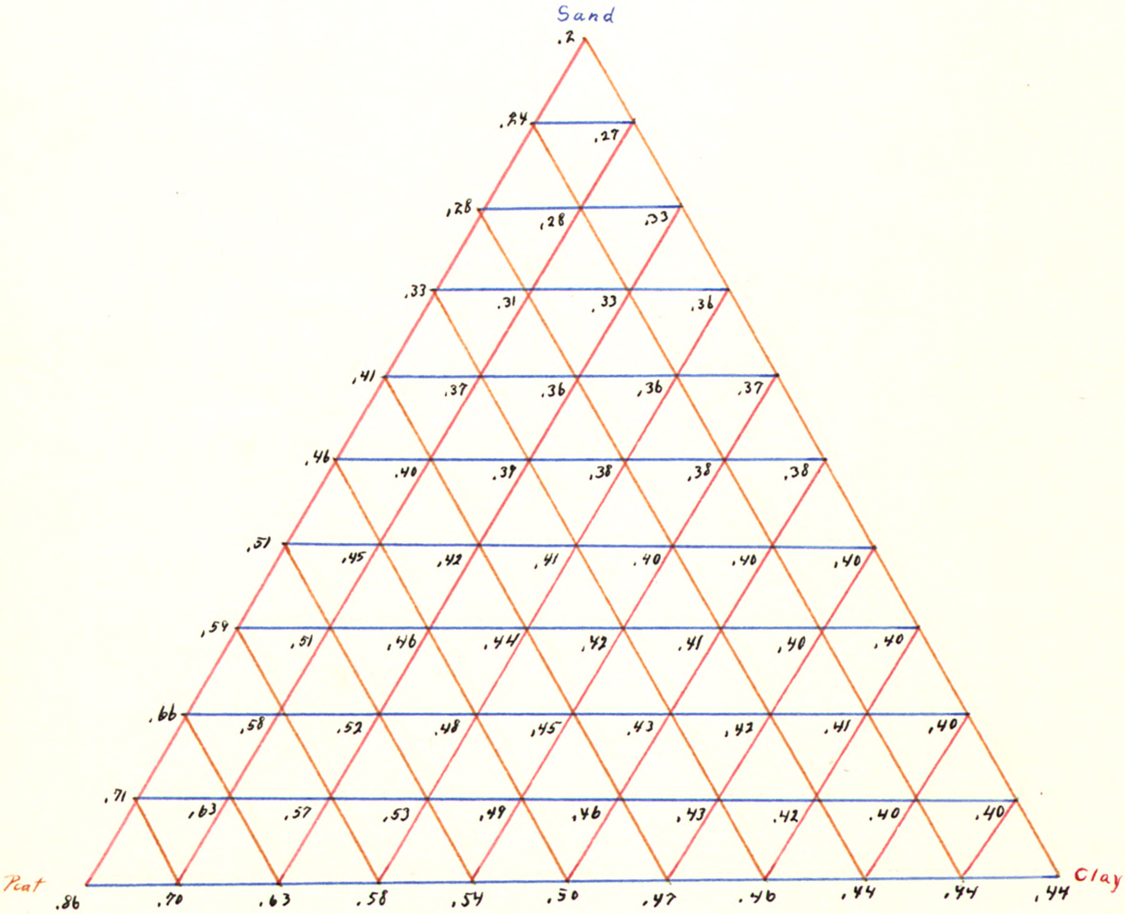
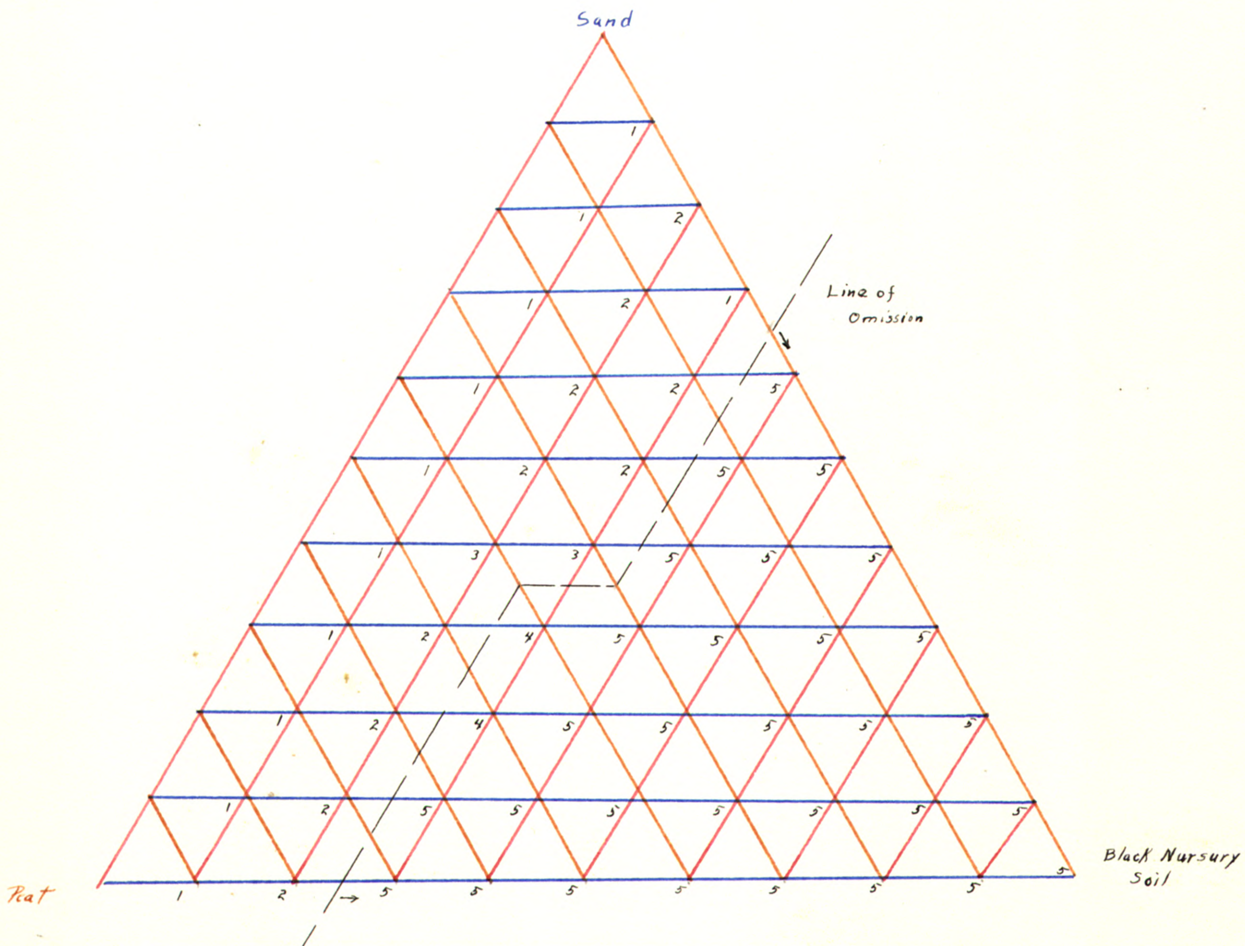


Chart No. 29

Cracking of Soil Mixtures Using Black Nursery Soil



1. Seedlings emerge freely.
2. Cracking due to heaving of seedlings: many cracks; little effect on emergence.
3. " " " " " " ; few " ; hindering emergence slightly.
4. Light Cracking due to shrinkage of soil.
5. Heavy " " " " " "
6. Soil resistant or nearly so to both heaving and shrinkage with little or no cracking and few seedlings emerge

Chart No. 30

Emergence Chart for Mixtures Using Black Nursery Soil

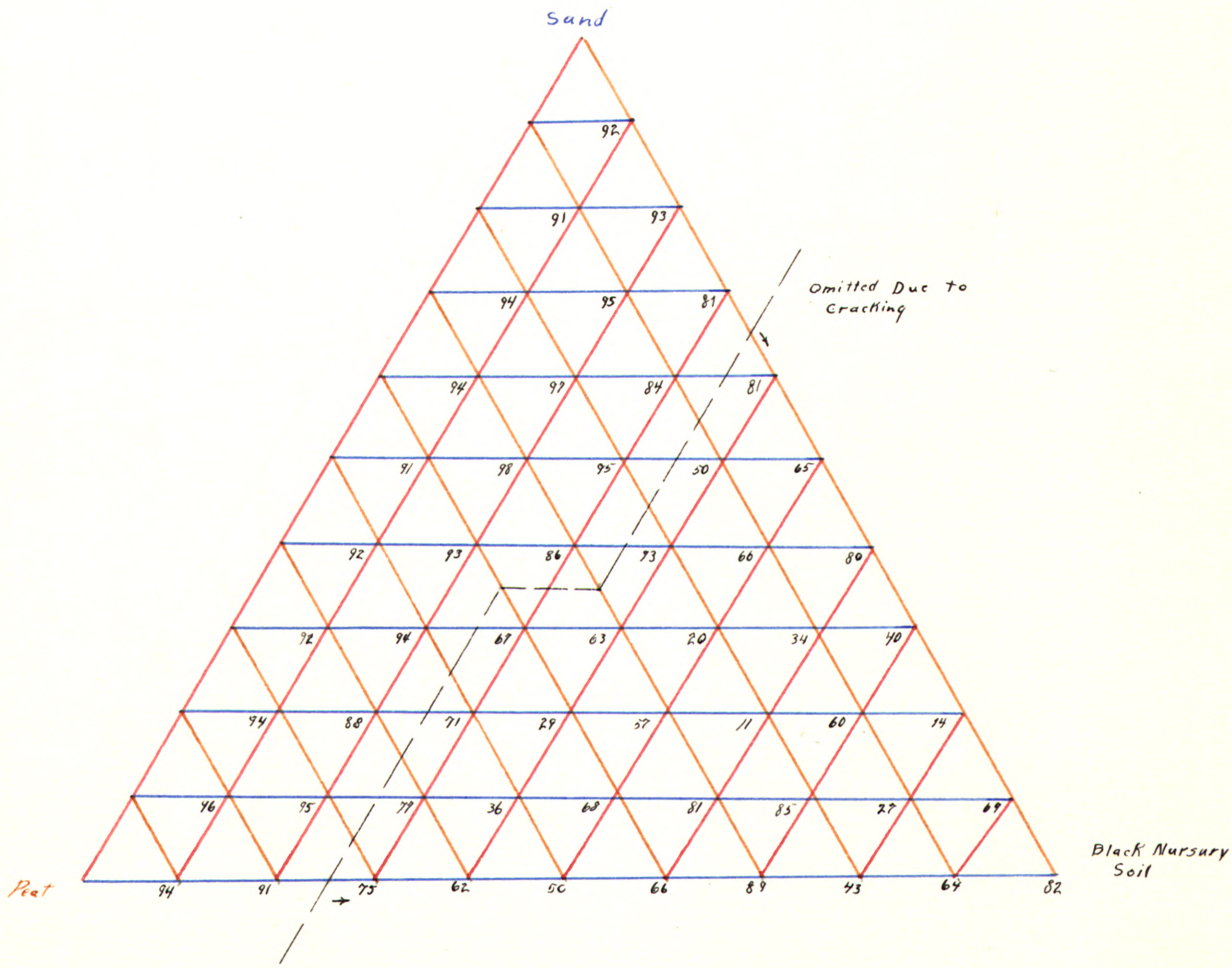


Chart No. 31

Resistance Chart For Mixtures Using Black Nursery Soil

Grams Per Square Centimeter

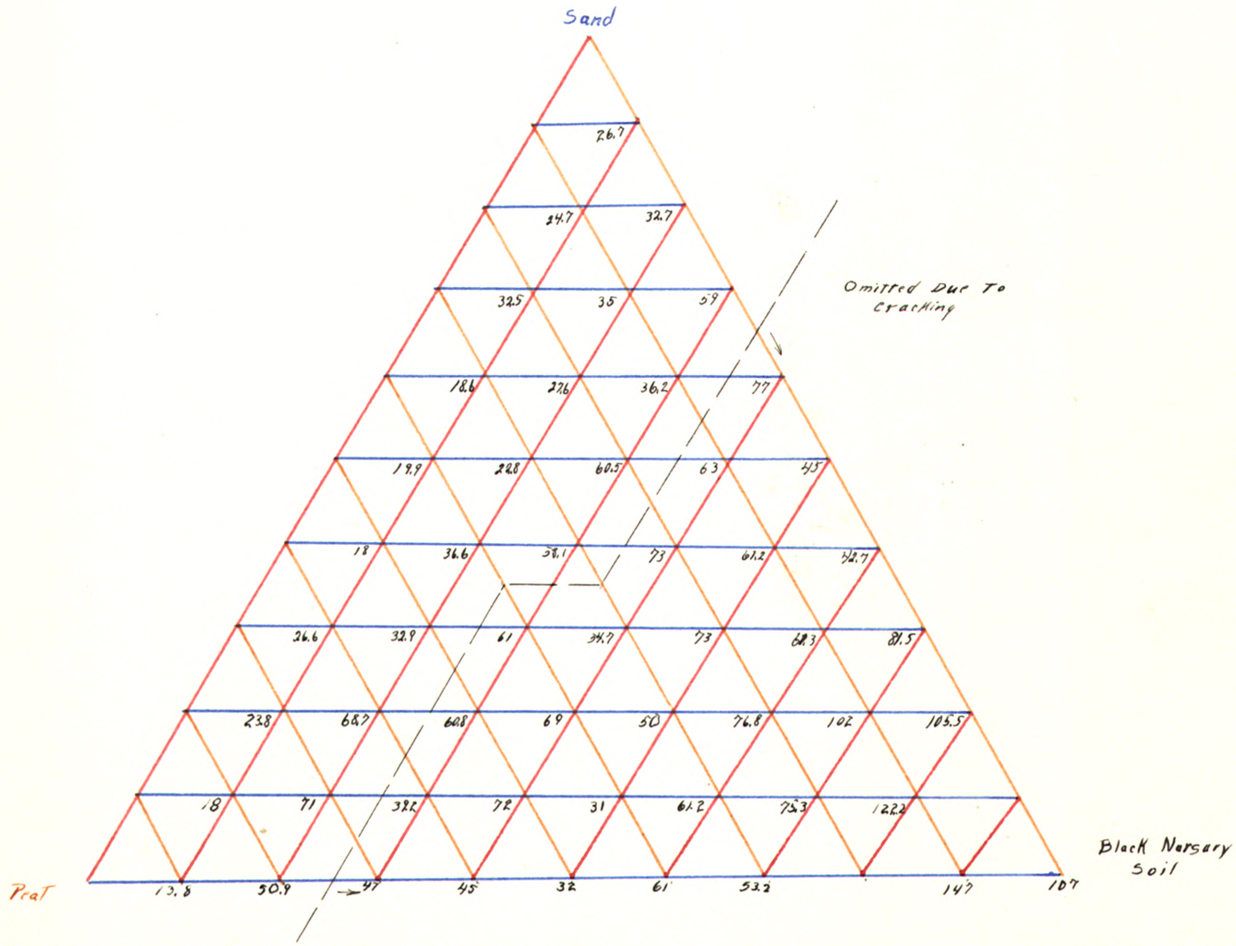


Chart No. 32

Predicted Emergence for Mixtures Using Black Nursery Soils as Indicated by Resistance.