THE EFFECT OF MECHANICAL COMPOSITION AND CLAY MINERAL TYPES ON THE MOISTURE PROPERTIES OF SOILS

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Lewis H. Stolzy

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The Effect of Mechanical Composition and Clay Mineral Types on the Moisture Properties of Soils

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Lewis Hal Stolzy

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R L Cook

Major professor

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AND CLAY MINERAL TYPES ON THE

MOISTURE PROPERTIES OF SOILS

By

Lewis H. Stolzy

AN ABSTRACT

Submitted to the School of Graduate Studies of Michigan
State College of Agriculture and Applied Science
in partial fulfillment of the requirements
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DOCTOR OF PHILOSOPHY

Department of Soil Science

1954

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Lewis H. Stolzy

ABSTRACT

The Effect of Mechanical Composition and Clay Mineral Types on the Moisture Properties of Soils

A study was made on the moisture characteristics of thirty-eight Michigan soils. Moisture properties were determined on cores and bag samples taken from each horizon. Field capacity measurements were made on the different horizons after they were artificially saturated and allowed to free drain for 36 to 48 hours.

The soil cores were taken into the laboratory and various tensions from 0 to 1 atmosphere were determined on the tension table and by the porous plate method. Tensions from 3 to 27.19 atmospheres were determined on less than two millimeters air dry samples taken from the different horizons. The pressure-membrane apparatus was used for these determinations. Moisture equivalents, mechanical analyses and wilting point determinations were also made on the soil samples.

The Norelco X-ray Spectrometer was used to determine the types and amounts of clay minerals present in the soil clays. Montmorillonite, illite and kaolinite were present in Michigan soils. Illite predominated in most horizons. Kaolinite was generally present in the different horizons in varying amounts. Montmorillonite was the least common in the different horizons with twenty percent being the largest amount present in any one horizon.

The data for the various horizons for each soil were tabled and the moisture release curves for these horizons were drawn. The field

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capacity, moisture equivalent and the wilting point were indicated on the release curves. The drop in moisture tension values from 1 to 5 atmospheres especially on the A_p horizon indicated that soil structure is still a factor to be considered in moisture studies above 1 atmosphere.

The relationship of field capacity to moisture equivalent, to 0.06 atmosphere tension and to 0.33 atmosphere tension were studied. Similar relationships for field capacity and moisture equivalent were found for Michigan soils as were found by other investigators for soils in different parts of the country. Samples with field capacity values below 12 percent have a much lower moisture equivalent. Those from 12 percent to 22 percent moisture equivalent approach field capacity but are still lower. Samples with above 22 percent moisture equivalent have lower field capacities. The 0.06 atmosphere tension is the best measure of field capacity on samples below 12 percent moisture while a tension between 0.06 atmosphere and 0.33 atmosphere would be the best measure of field capacity above 12 percent.

The permanent wilting percentages were determined on the stems of tomato plants. These percentages were then compared with the 5, 8 and 15 atmosphere tensions. The permanent wilting percentage approached most nearly the 5 atmosphere tensions with the line of best fit falling between the 5 and 8 atmospheres tension.

The percent of available water in the different soil horizons varied from 4 to 16 percent moisture on surface soils when the clay content of the soil sample was less than 28 percent. This decreased with higher percentages of clay. Subsurface samples had from 4 to

10 percent available moisture when the clay content of the soil sample was less than 18 percent. While subsurface samples with clay contents higher than 18 percent decreased in available water with increasing percentages of clay.

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ACKNOWLEDGEMENT

The author expresses his appreciation to Dr. A. E. Erickson for his interest and guidance throughout the course of this study. The author also wishes to thank him at this time for his willingness to secure equipment which was such a necessary part of this investigation.

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He is also indebted to Doctors E. P. Whiteside and R. L. Cook for their assistance in the preparation of the final manuscript.

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INTRODUCTION

Much of the experimental data generally gathered on different Michigan soils are mainly concerned with the chemical and nutrient relationships between soils and plants. Until recently there has been little organized effort to determine the moisture characteristics of the different soil types in Michigan. The need for such a study in this state has prompted a project in which the moisture characteristics of the soil profile of the more important agricultural soils are studied in detail. The one phase of this project that is included in this investigation shows how the types and sizes of soil materials can affect the different moisture determinations of the soils.

Field capacity and wilting percentage are the physical properties most often referred to in any soil moisture study. Field capacity is generally considered as the amount of water a soil retains against the force of gravity one to three days after water has been applied either as rain or irrigation. The moisture content of a soil after a plant has permanently wilted is considered the wilting percentage of that soil. Most of the investigations concerning field capacity and wilting percentages have been concerned with the development of rapid methods of measuring these two points on soils taken from the field. The results obtained differ from one region to another, with different types of soils and with the investigators.

Briggs and McLane (5) developed one of the first methods for determining a measure of field capacity which they termed "moisture equivalent". This is numerically equal to the percentage of moisture that a soil can hold against a centrifical force 1000 times that of gravity. This single determination has been studied and used more intensively than any other soil moisture characteristic. Briggs and Shantz (6) later correlated moisture equivalent with wilting percentage. After making 1300 determinations on 20 different soils, they concluded that the wilting coefficient could be determined by dividing the moisture equivalent by the factor of 1.84.

Veihmeyer and Hendrickson (32) (33) conducted intensive studies on the relationship of moisture equivalent to field capacity, wilting percentage and mechanical analysis. They found moisture equivalent to be a good indication of field capacity for soils with a moisture equivalent from 30 percent down to about 12 to 14 percent. Below this range, moisture equivalent is less than field capacity. They also found that a linear relationship does not exist between wilting point and moisture equivalent. The ratio varies from 1.4 to 3.8 with both high and low ratios with sands as well as clays. They also showed that moisture equivalent is a fairly reliable measure of the texture of the soil.

Browning (7) and Harding (12) found that moisture equivalent was equal to field capacity at a value of about 21 percent; while soils with moisture equivalent lower than this had a greater field capacity value and soil with moisture equivalent higher than 21 percent had a lower field capacity value. Stoltenberg and Lauritzen (30) found that the ratio of moisture equivalent to field capacity varied from 0.74 to 1.24.

Middleton (17) and Smith (28) seemed to think that there was a direct relationship between moisture equivalent and the percentages of sand, silt and clay as determined by mechanical analysis. The presence of considerable amounts of organic matter in the soil seemed to increase the moisture equivalent and disturbed the relationship between the moisture equivalent and mechanical analysis. Bouyoucos (3) found no relationship between coarse silt and sand and the moisture equivalent. However, he found a remarkably close relationship between the moisture equivalent and the colloidal content of the soil.

Wilcox and Spilsburg (36) found that the field capacities of certain Canadian soils were closely related to the percentages of sand they contained. Wilcox (35) in a separate investigation of 93 soils collected at two different depths found that organic matter content did not affect field capacity. Moisture equivalent proved to be the best laboratory determination of field capacity and permanent wilting percentage, while the determination of percentage of sand and colloidal material proved reasonably satisfactory. It was evident in his investigation that as the soil particles became finer the range between field capacity and wilting percentage became greater up to a clay content of about 35 percent.

Coile (8) studied the effect of incorporated organic matter on the moisture equivalent and wilting percentage values of soils. He found that incorporated organic matter greatly increased the moisture equivalent on light-textured soils while the wilting percentage was increased at a lesser rate. On fine-textured soils moisture equivalent was increased but not at the same rate as in those of coarser texture.

wilting percentage values of fine-textured soils appeared to be but little affected by incorporated organic matter. Coile also concluded that the commonly used ratio, 1.84, of moisture equivalent to wilting percentage was of very little value. Robertson and Kohnke (27) using twenty samples from different depths of seven Indiana soils found no correlation between wilting percentage and the texture or the organic matter content of soils.

Furr and Reeve (10) used 80 southern California soils in their study of permanent wilting in relation to soil moisture. The sunflower was used as the test plant. They classified wilting into two stages: first, permanent wilting point as marked by permanent wilting of the basal leaves and the ultimate wilting point as marked by complete permanent wilting of the apical leaves. It was found that the ratio of the moisture equivalent to the first permanent wilting point or the ultimate wilting point is not constant. It was also found that the colloidal content of the soil is not a reliable basis for calculation of the wilting points of soils.

Richards and Weaver (26) used 71 of the soils that Furr and Reeve (10) had used for their study. They used the pressure plate apparatus (24) or the suction-plate apparatus (26) for tensions between 0 and 1 atmosphere. The pressure membrane apparatus (21) was used for tensions above 1 atmosphere. They found, on an average, a fairly close relationship between the moisture retained at 0.33 atmosphere and moisture equivalents. They also found in connection with this study of 71 soils that 64 of the soils were between the first permanent wilting point and the ultimate wilting point at the 15 atmospheres tension. Veihmeyer and Hendrickson

(34) in a comparison of methods of measuring field capacity and permanent wilting percentage felt that Richards' 15 atmospheres for permanent wilting percentage had promise but there was not always good agreement at what tension permanent wilting occured in the plant.

Colman (9) determined the field capacity of soils on irrigated plots as well as on plots during periods of rainfall. These moisture results were then compared to those obtained on the same soils screened and drained at 0.33 atmospheres. The apparatus used was similar to that used by Richards and Weaver (26). A constant relationship was found to exist between field capacity and 0.33 atmospheres tensions. Field capacity was found to equal the 0.33 atmospheres tension at 25 percent moisture but at lower moisture values the field capacity was greater than 0.33 atmospheres of tension while at moisture values above 25 percent it was less. A similar relationship was found between field capacity and moisture equivalent by Browning (7), except that 21 percent moisture marked the point where field capacity and moisture equivalent were equal.

Peale and Beale (18) after determining field capacities, moisture equivalents, permanent wilting percentages and 15 atmospheres tensions for several South Carolina soils set up linear equations in which field capacities could be determined from moisture equivalents and the wilting percentages from the 15 atmospheres tensions.

Woodruff (37) investigated the dehydration curves of finely divided clays as a means of studying the possible mechanisms by which the soil retains water. Three types of clays were used: kaolinite, beidellite and montmorillonite. From the results obtained, Woodruff classified the three different mechanisms which may operate to retain water in a clay under moisture tensions: (a) adsorption associated with swelling and shrinking, (b) structural formation which is operative at low moisture tension with montmorillonite and is associated with swelling and shrinkage (c) surface tension which is operative at higher tension where shrinkage ceases and also at lower tensions of most kaolinite systems or coarser fractions.

In view of the conflicting results obtained by investigators on moisture properties of soils it was felt that the types of clay minerals found in the soil might have a partial bearing on the inability of investigators to reproduce results obtained by others on soils containing the same percentage of sand, silt and clay.

EXPERIMENTAL PROCEDURE

The locations of the various soils used in this experiment were selected by E. P. Whiteside* during the summers of 1952 and 1953. Locations of these various soils by counties are given in Figure 1 and the legal descriptions the sites are given in Table I. Under the direction of A. E. Erickson** various types of field data were obtained on these soils during the summers of 1952 and 1953.

Only a portion of the data collected on these sites are included in this study but in order to better understand how certain data such as field capacity were obtained a brief description of the work is discussed here.

Fifteen concentric infiltrometers were forced into the soil with a special type of driver. Ten of these measured infiltration of the surface and five of them were used to measure infiltration of a subsurface layer. A large burette was mounted above each ring to maintain a constant water head on the center ring, and to measure the amount of water flowing into the soil. An equal constant head was also maintained on the outer ring in order to avoid lateral flow of water from the central ring. An initial run of seven hours was followed twelve hours later by a second run (wet run) for seven hours. Four of the infiltrometer locations were then covered with heavy

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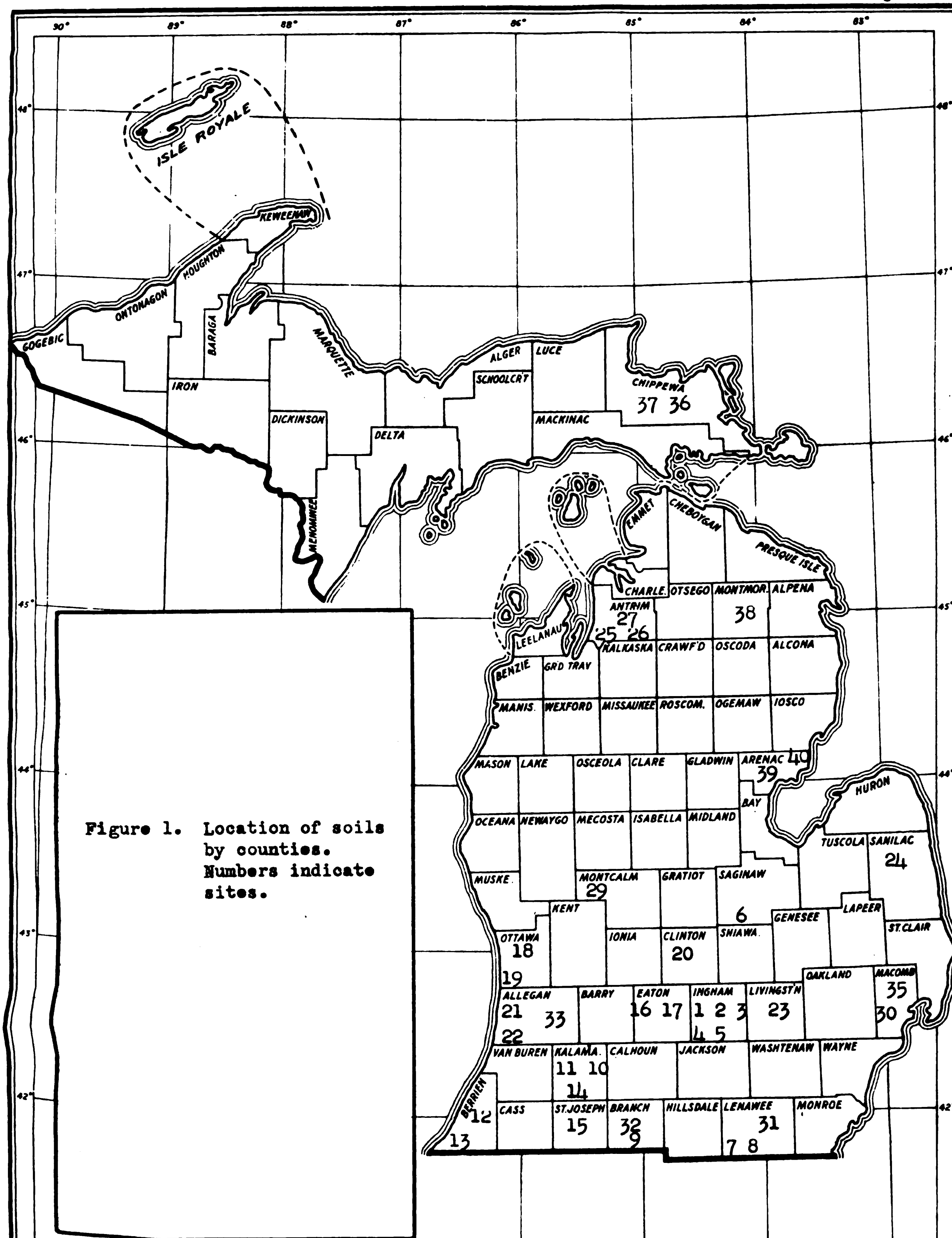

Figure 1. Location of soils by counties. Numbers indicate sites.

TABLE I

IDENTIFICATION OF SOILS

Site No.	Soil Series	County	Legal Description
1	Berrien	Ingham	SW Corner NW $\frac{1}{4}$ Sec. 19 T4N R1W
2	Granby	Ingham	NE 40 SE $\frac{1}{4}$ Sec. 24 T4N R2W
3	Hillsdale	Ingham	NE 40 SW $\frac{1}{4}$ Sec. 30 T4N R1W
4	Miami	Ingham	NW 40 NE $\frac{1}{4}$ Sec. 31 T4N R1W
5	Brookston	Ingham	NW 40 NE $\frac{1}{4}$ Sec. 30 T4N R1W
6	Sims	Saginaw	NE 40 NW $\frac{1}{4}$ Sec. 33 T9N R5E
7	Nappanee	Lenawee	NW Corner SW $\frac{1}{4}$ Sec. 15 T8S R3E
8	Hoytsville	Lenawee	NW Corner SW $\frac{1}{4}$ Sec. 15 T8S R3E
9	Fox	Branch	W Side NW 40 NW $\frac{1}{4}$ Sec. 23 T6S R7W
10	Fox	Kalamazoo	SW Corner NW $\frac{1}{4}$ Sec. 4 T2S R10W
11	Warsaw	Kalamazoo	SW Corner SE 40 NW $\frac{1}{4}$ Sec. 7 T2S R11W
12	Spinks	Berrien	SE Corner NE 40 NE $\frac{1}{4}$ Sec. 33 T4S R17W
13	Berrien	Berrien	N Side NE 40 NW $\frac{1}{4}$ Sec. 26 T5S R19W
14	Warsaw	Kalamazoo	N Side SW 40 SE $\frac{1}{4}$ Sec. 19 T4S R11W
15	Fox	St. Joseph	NW Corner NE $\frac{1}{4}$ Sec. 26 T5S R12W
16	Conover	Eaton	NE Corner SE $\frac{1}{4}$ Sec. 9 T4N R5W
17	Miami	Eaton	SW 10 NW 40 SW $\frac{1}{4}$ Sec. 14 T4N R5W
18	Granby	Ottawa	SW Corner SE 40 SW $\frac{1}{4}$ Sec. 35 T7N R15W
19	Saugatuck	Ottawa	NE Corner NW $\frac{1}{4}$ Sec. 4 T6N R15W
20	Conover	Clinton	SE Corner Sec. 35 T8N R1W
21	Granby	Allegan	NE 40 NW $\frac{1}{4}$ Sec. 21 T2N R15W
22	Berrien	Allegan	NW 40 SW $\frac{1}{4}$ Sec. 23 T1N R14W
23	Hillsdale	Livingston	NE 10 SW 40 NW $\frac{1}{4}$ Sec. 28 T3N R6E
24	Guelph	Sanilac	NW 40 SW $\frac{1}{4}$ Sec. 13 T13N R15E
25	Kalkaska	Antrim	SE 40 SW $\frac{1}{4}$ Sec. 34 T30N R6W
26	Kalkaska	Antrim	SE 40 SW $\frac{1}{4}$ Sec. 34 T30N R6W
27	Mancelona	Antrim	NE 10 SW $\frac{1}{4}$ Sec. 19 T30N R5W
29	Coral	Montcalm	NE 10 NW $\frac{1}{4}$ SW $\frac{1}{4}$ Sec. 8 T11N R9W
30	Paulding	Macomb	NW 10 NE 40 Sec. 25 T4N R13E
31	Hoytsville	Lenawee	SW 40 NW $\frac{1}{4}$ Sec. 12 T8S R5E
32	Coldwater	Branch	NE 40 NE $\frac{1}{4}$ Sec. 20 T5N R7W
33	Nappanee	Allegan	NE 10 NW $\frac{1}{4}$ Sec. 33 T2N R12W
35	Nappanee	Macomb	NW 40 NW $\frac{1}{4}$ Sec. 26 T4N R14E
36	Pickford	Chippewa	NE 40 NW $\frac{1}{4}$ Sec. 25 T46N R1W
37	Ontonagan	Chippewa	NW 40 NW $\frac{1}{4}$ Sec. 19 T46N R3W
38	Selkirk	Montmorency	SW 40 SW $\frac{1}{4}$ Sec. 25 T31N R4E
39	Pickford	Arenac	SE 10 NE 40 NE $\frac{1}{4}$ Sec. 17 T20N R6E
40	Selkirk	Arenac	SW 40 SW $\frac{1}{4}$ Sec. 9 T20N R6E

pieces of canvas to minimize evaporation. After a period of 36 to 48 hours four moisture samples were taken with a $1\frac{1}{4}$ inch soil auger from the different horizons of the four infiltrometer locations. During the initial infiltration run a soil pit was dug on the site and on the second run 10 to 15 three-inch soil cores were taken from each horizon. The method and apparatus used is that described by Uhland and O'Neal (31). These cores were brought to the laboratory for measurement of tensions from 0 to 1 atmosphere*. At the same time the cores were collected, bag samples were taken from each horizon. The bag samples were passed through a two millimeter screen and used for all determinations except the measurements of 0 to 1 atmosphere tensions and field capacity.

The tensions on the soil cores from 0 to 0.06 atmospheres were measured on blotter paper tension tables similar to those described by Leamer and Shaw (16). A series of five tables, one above the other, were set up in a metal cabinet to decrease evaporation losses from the cores and the table. The tensions on the tables were 0.01, 0.02, 0.03, 0.04 and 0.06 atmospheres. The soil cores were covered on the lower side with number one filter paper and cheese cloth to prevent soil losses. They were then placed in three inches of water for a period of two days or until they reached saturation. The weights were recorded and they were placed on the 0.01 tension table

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* 1 atmosphere = 1.013×10^6 dyne cm.$^{-2}$ = 14.71 pounds in.$^{-2}$ = 76.39 cm. of mercury = 1036 cm. of water = 34.01 feet of water at 21° C.

for a period of two days. They were then reweighed and moved to a higher tension.

After the above tensions from 0.01 to 0.30 atmospheres were determined the cores were placed on porous ceramic plates as described by Richards and Fireman (24). These were then placed in pressure cookers as described by Richards (22). The 0.33 and 1.0 atmosphere tensions were measured by this method using pressure control units as described by Blake and Corey (2). The cores were left in the pressure cookers at each tension for a period of two days and then reweighed. They were then oven dried at a temperature of 105° to 110° centigrade and again reweighed. Percent moisture on an oven dry basis was calculated for each tension. From the oven dry weight the volume weight for each core was also determined.

Soil moisture tensions for the 3, 5, 8, 15 and 27.2 atmospheres were determined on Richards' pressure membrane apparatus (20) (21). This is similar to the ultrafiltration apparatus which has been used for many years in chemical and biological work. It consists of a chamber into which a soil sample or a number of samples can be placed on a Visking cellulose sausage casing supported on the underside by a screen base. Thus when the pressure is applied in the chamber the samples come to equilibrium with the membrane at that pressure. The general procedure was to measure out twenty soil samples of approximately 25 grams each. These were poured into rubber rings placed on the membrane. The chamber was then partially filled with distilled water. The water was added very slowly in order not to wash the samples out of the rubber rings. After a period of two days of soaking, excess water was drawn from the membrane and the chamber sealed. The unit was placed in a constant temperature oven at 35° centigrade and pressure then was applied gradually to the chamber until the desired atmosphere was reached. The chamber was kept at this pressure for a period of two days or more depending on the length of time required for the particular sample to reach equilibrium with the membrane. This was determined both by measuring with a burette the flow from the chamber and also by running the same soil sample for different lengths of time. After the sample had reached equilibrium it was removed from the chamber and the percent of moisture determined.

On fine-textured soils dehydration of the sample was accompanied by shrinkage. This pulled the soil away from the membrane and prevented the sample from reaching equilibrium. In order to avoid this Richards (21) placed a diaphragm on the top wall of the chamber. After the greater portion of the water had been forced from the chamber and the soil had reached sufficient rigidity to hold its shape, a differential mercury manometer was attached. This manometer adds a four pound per square inch pressure directly on top of the soil samples which holds them in contact with the membrane. The first source of pressure was compressed air purchased in a cylinder which was later supplanted by a compressor that could deliver 400 pounds per square inch. A bubbler system was arranged in the air line so that the air would pass through water before entering the pressure chamber. This was to avoid a possible drying out of the soil sample by the compressed air as it diffused through the membrane.

The pipette method was used for the mechanical analyses (15).

Samples of 10 grams for fine-textured soils and 25 grams for coarse-textured soils were treated with 6 percent hydrogen peroxide to destroy the organic matter and hydrochloric acid to destroy the carbonates. After it was washed free of chlorides the sample was then dispersed by titration with sodium hydroxide to a phenolphthalein end point using an external indicator. It was then washed through a 300 mesh sieve. The sands were oven dried and weighed. The material passing through the 300 mesh sieve was poured into a sedimentation cylinder and diluted to one liter.

Making the assumption that all soil particles have a density of 2.65 gm/cm^3, Stoke's Law was used to determine the depth and time of sampling for the 2μ clay at a temperature of 30° centigrade. A 25 milliliter aliquot of the material was taken and the percentage of material per sample was determined on an oven dry basis. Two samples containing the clay fraction were taken for each soil. The first was for the purpose of figuring the amount of clay and the second, consisting of 100 millilters, was used in the making of slides for X-ray analyses. A composite sample was taken to be used later in determining the quantity of fine clay ($<.2\mu$).

The hygroscopic coefficients are approximate. They were moisture determinations on air dry soils during the summer months.

Moisture equivalent was determined on approximately 30 grams of air dry soil saturated for a period of 24 hours and then drained for 30 minutes. The sample was then centrifuged for 30 minutes at 2440 revolutions per minute, a force equal to 1000 times that of gravity.

The percent of total carbon was determined on the upper two horizons of each soil type using the combustion train method described by Hopper (14).

Permanent wilting percentages were determined in the greenhouse on tomato plants as described by Breazeale and McGeorge (4) in which a tube was placed on the stem of the tomato plant. This was sealed at one end and the soil for which the wilting point was desired was placed in the tube surrounding the stem. This soil was kept moist until root development on the stem was evident. The top of the tube was then sealed and left on the plant for a period of two weeks or until the back pull of the soil for moisture equaled the suction pressure of the plant. The percentage of moisture left in the soil was then determined on an oven dry basis.

The percentages of montmorillonite, illite and kaolinite were determined by the X-ray method. The slides to be X-rayed were prepared according to the instructions of Gieseking and Erickson (11). The method consisted of placing a quantity of sodium dispersed ($<2\mu$) clay, equal to 0.05 grams, in a 15 milliliter centrifuge tube. The clay suspension was then diluted to 15 milliliters and two drops of glycerol were added to the suspension. The suspension was shaken and allowed to stand for a period of at least ten hours. It was then flocculated with one drop of concentrated hydrochloric acid and centrifuged. The supernatent liquid was poured off and the sediment was made into a viscous paste and transferred to a microscope slide. The clay on the slide was allowed to air dry in the room, after which it was placed in an anhydrone charged desiccator for at least 24 hours

before it was X-rayed.

Standard clay suspensions were made in order to determine the types as well as the amounts of clays present. The standard solutions were made with clays obtained from the following regions: montmorillonite from Clay Spur, Wyoming; illite from Morris, Illinois and kaolinite from Bath, South Carolina.

The procedure for obtaining the clays from the samples has been discussed with the mechanical analyses of the soil samples. After aliquots of each clay were obtained they were diluted to the same density. The slides in Table II were then made as discussed above using different proportions of clay suspensions amounting to 0.03 grams per slide.

The X-ray unit was the Norelco X-ray Spectrometer with a high and low angle Geiger counter Goniometer and Brown Electronic recorder. The X-ray tube contained a tungsten filament and a copper target. A nickel filter was used to filter out radiations of shorter wave lengths than that of copper $K\alpha$. The X-ray unit was adjusted to 15 milliamperes at 35 kilovolts.

The X-ray diffraction intensity patterns of the standard clays and the soil clays were all measured within a space of eight days. The X-ray diffraction intensities for each slide were recorded as the goniometer rotated from 2° to 13°. This took into account the spacing of 21.4 A° to 13.8 A° which contains all of the expanding lattice minerals of the montmorillonite group including vermiculite, the spacing of 13.8 A° to 9.2 A° which contains the illite group and micaeous minerals and the kaolinite peak with a spacing of 7.1 A°.

TABLE II

THE AMOUNTS OF MONTMORILLONITE, ILLITE AND KAOLINITE USED TO MAKE UP THE STANDARD SLIDES

Slide	Percent by Weight of the Different Clays		
Numbers	Montmorillonite	Illite	Kaolinite
1	0	100	0
2	5	95	0
3	10	90	0
4	20	80	0
5	30	70	0
6	40	60	0
7	50	50	0
8	75	25	0
9	100	0	0
10	0	95	5
11	0	90	10
12	0	80	20
13	0	70	30
14	0	60	40
15	0	50	50
16	0	25	75
17	0	0	100
18	5	90	5
19	25	50	25
20	25	25	50
21	50	25	25
22	75	0	25
23	25	0	75
24	50	0	50
25	45	10	45

In using these standard clay samples as a basis for determining the percentage of clay minerals present in the soil the assumption was made that all of the clay mineral groups found in the soil have the same intensity of diffraction as the standard clay samples. After the goniometer had reached 13° another slide was placed in the spectrometer and the X-ray diffraction intensity pattern was recorded from 13° to 2° for this slide. This was done in order to save time by not having to return the goniometer to 2° after each sample. The time required to measure the pattern for each slide was approximately 11 minutes.

After recording the X-ray diffraction intensity patterns it was necessary to determine the boundary between the X-ray diffraction intensity due to the clay mineral groups and that due to general scattering (labeled background in Figure 2). This boundary remained the same for both the standard clay samples and the soil clay samples as is indicated in Figures 2 and 3. The portions of the curve related to a particular clay mineral was determined from the X-ray diffraction intensity pattern of the 25 standard clay samples. These are indicated in Figure 2 by the vertical lines and are reproduced in Figure 3 for the soil clays. After the diffraction peaks for the soil clays were marked out their areas were measured with a planimeter.

The X-ray diffraction patterns of the twenty-five standards listed in Table II were determined before and after the soil clays had been measured to evaluate the fluctuation in the intensity of the X-ray beam. Also in order to correct for fluctuations in the X-ray intensity during the period that the soil clays were being measured

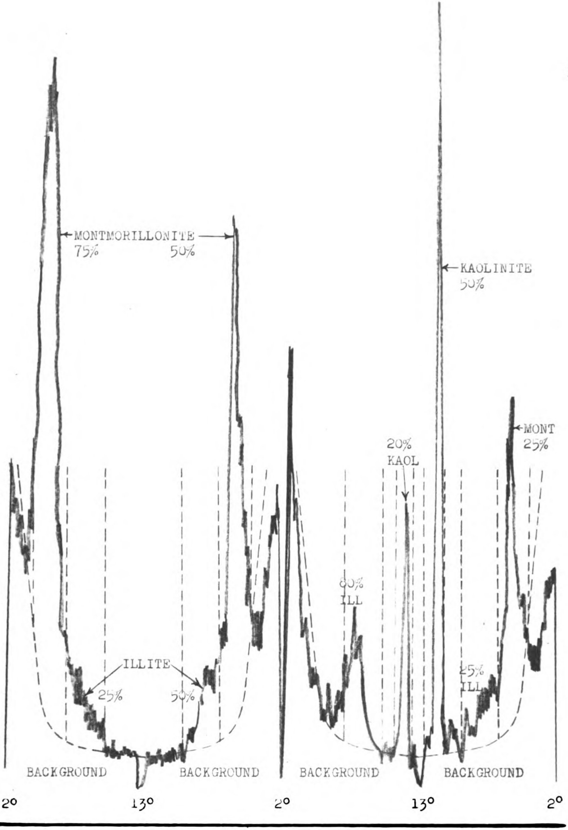

Figure 2. Diffraction intensity patterns as recorded by the Norelco X-ray Spectrometer of standard montmorillonite, illite and kaolinite clays showing how the peaks related to the clay minerals were marked out for measuring.

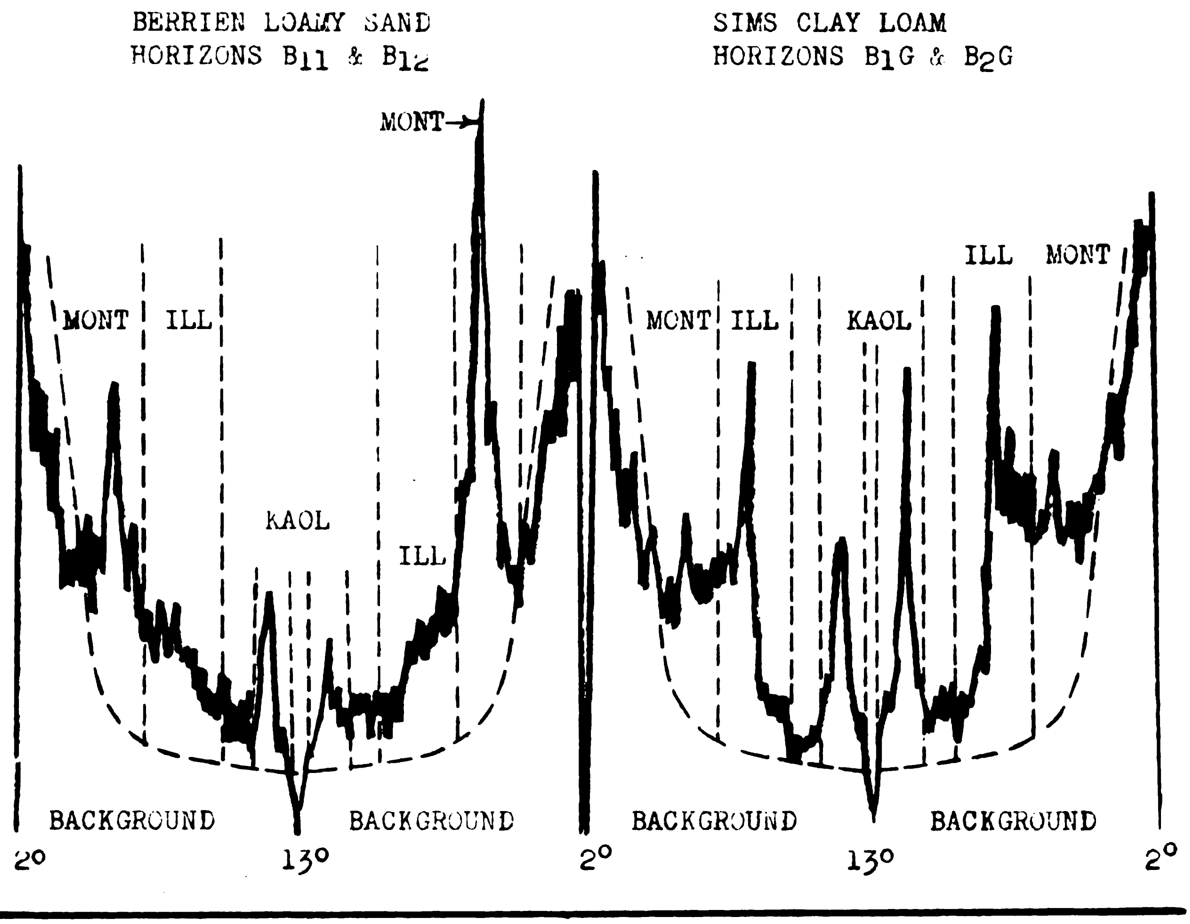

Figure 3. Diffraction intensity patterns as recorded by the Norelco X-ray Spectrometer of Berrien loamy sand and Sims clay loam soils.

a 100% kaolinite standard slide was remeasured at regular intervals.

The 100% kaolinite sample was used because the peak height was a definite point which could be reproduced on successive runs with the same sample. These peak heights were then measured and using the highest value of 114 as 1, a curve was made (Figure 4) to determine the correction factor to be used for each area measured with the planimeter.

The curve of the X-ray diffraction intensities versus the percent of each clay are shown in Figures 5, 6 and 7. These curves were determined by the area of the first and second run of the standards with the areas for the second run being adjusted for the decrease in the X-ray diffraction intensity. The curves were then used to determine the percent of montmorillonite, illite and kaolinite clay in each of the soil samples.

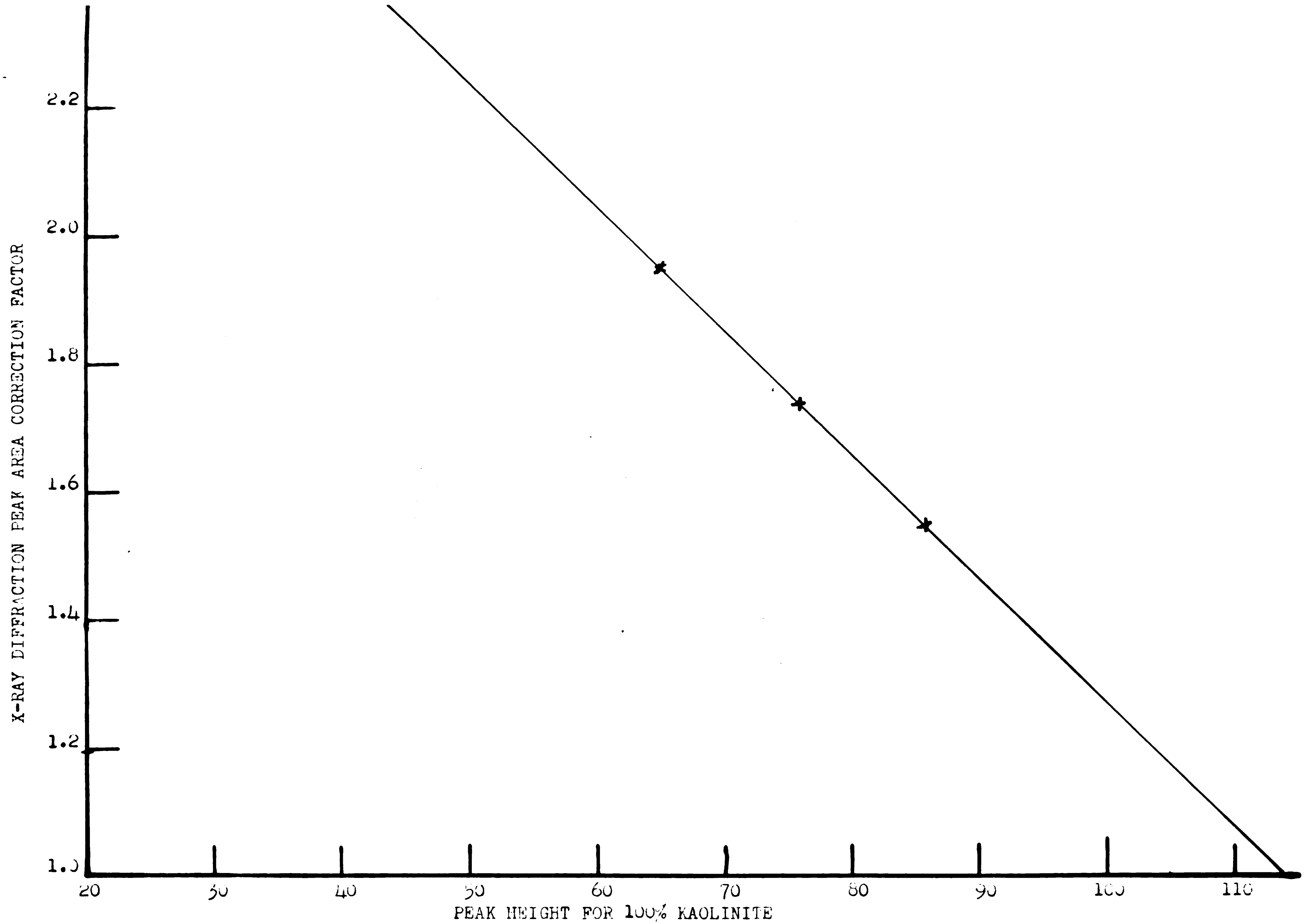

Figure 4. Peak heights versus X-ray diffraction peak area correction factors for montmorillonite, illite and kaolinite areas using 100% kaolinite as a standard.

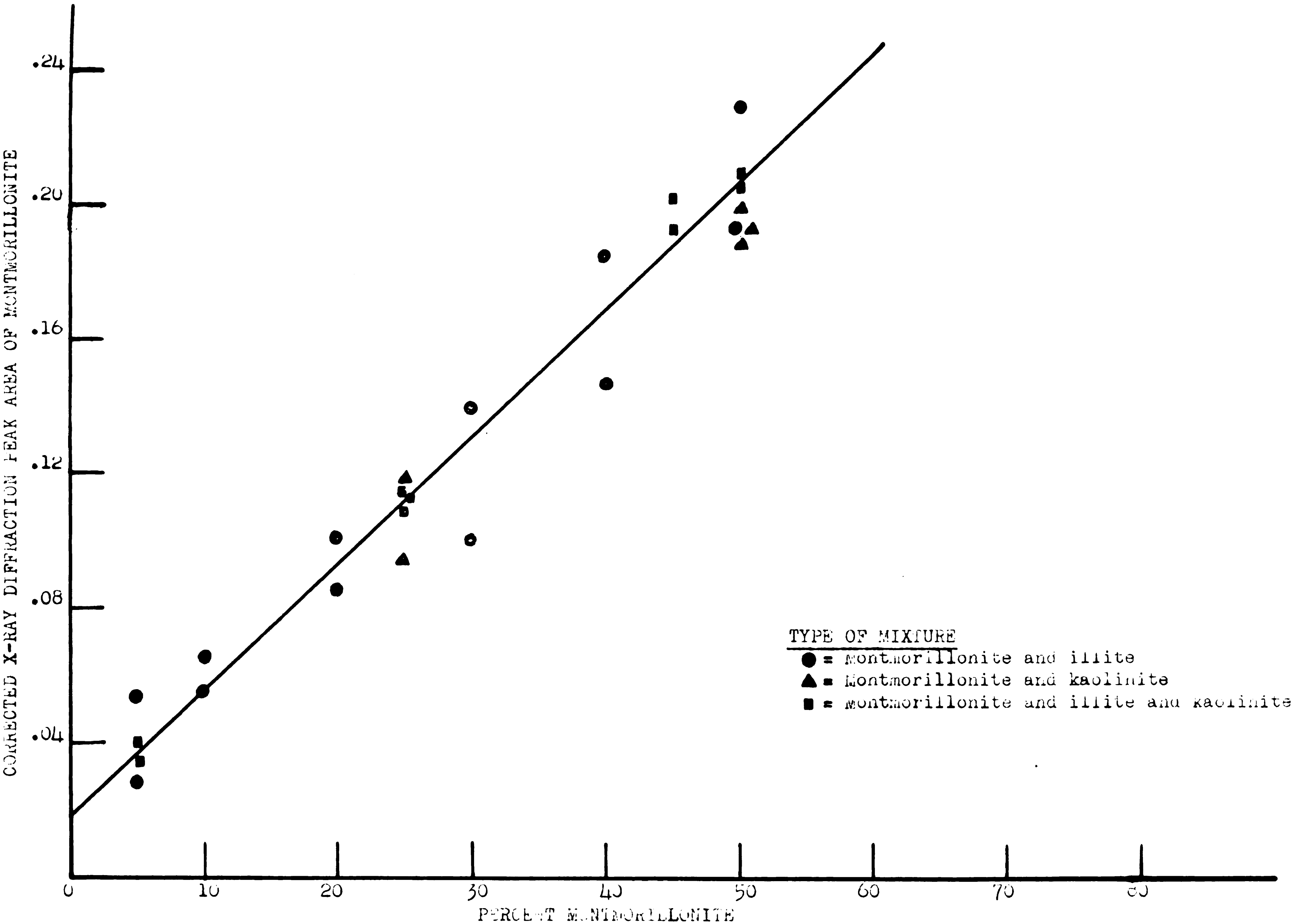

Figure 5. Percent montmorillonite versus X-ray diffraction peak area as recorded by the Norelco X-ray Spectrometer.

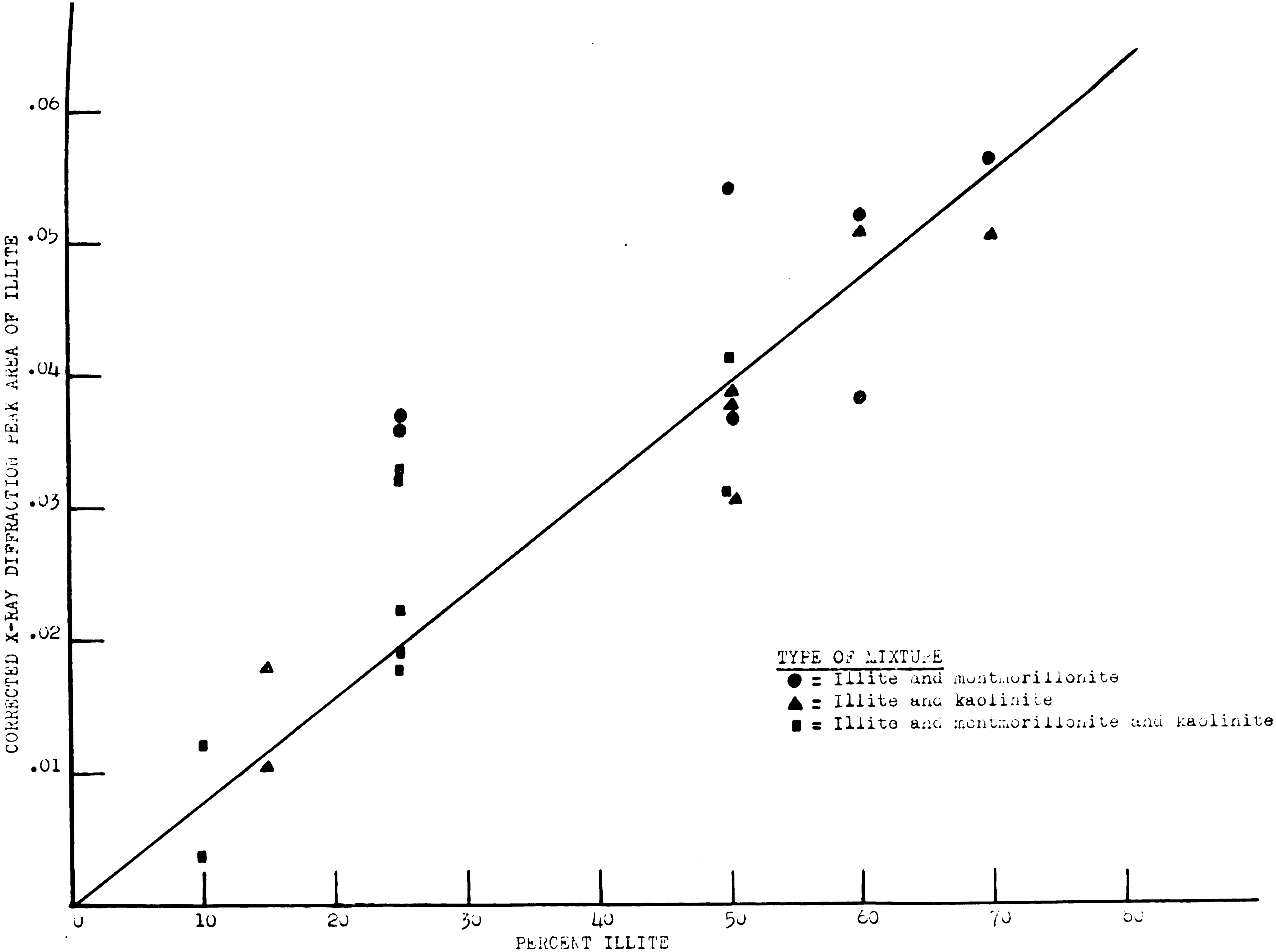

Figure 6. Percent illite versus X-ray diffraction intensity area as recorded by the Norelco X-ray Spectrometer.

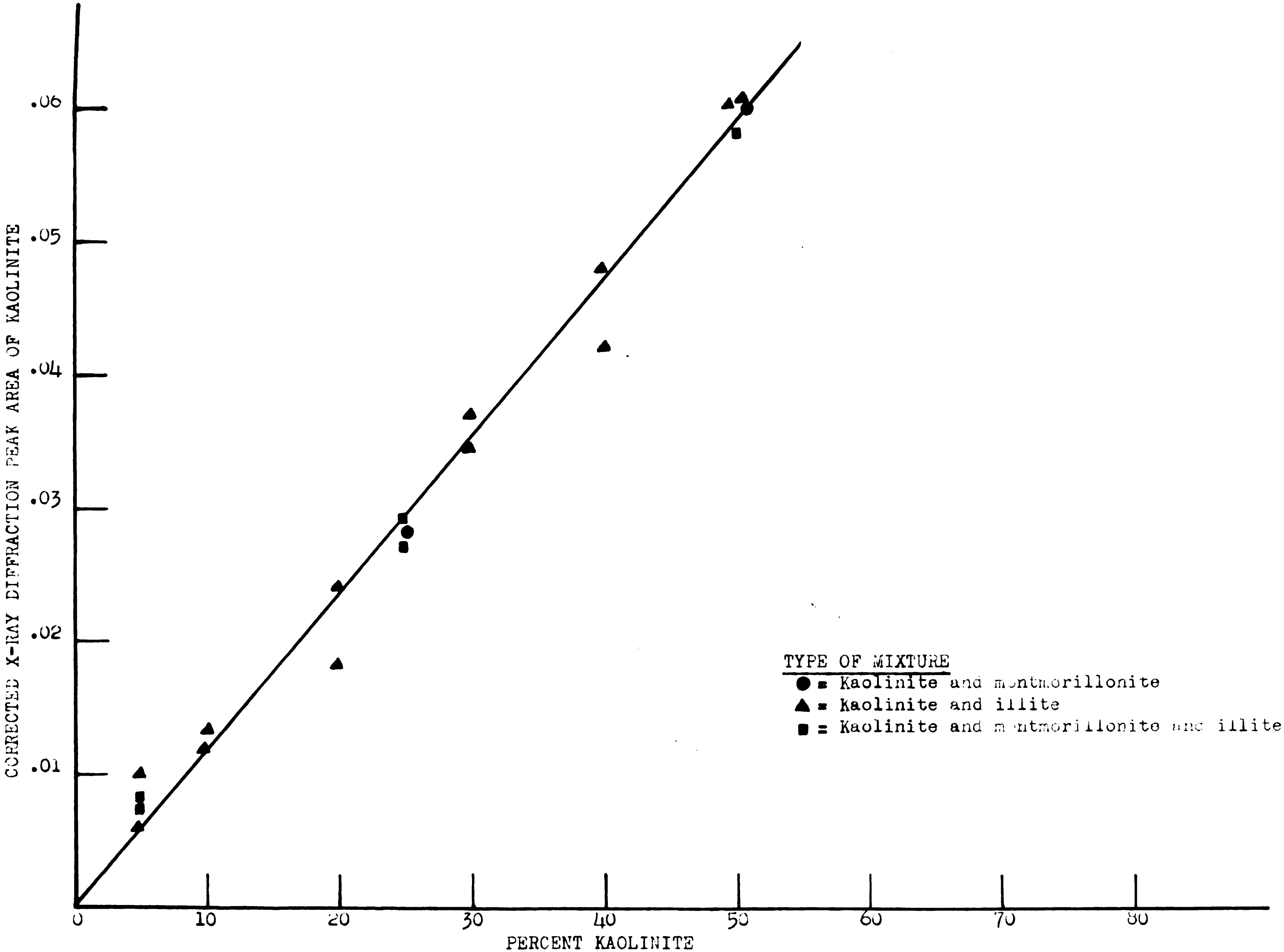

Figure 7. Percent kaolinite versus X-ray diffraction peak area as recorded by the Norelco X-ray Spectrometer.

RESULTS AND DISCUSSION

The data which were necessary to characterize the different soils for this investigation were arranged in tables according to site numbers and included in the Appendix. Except where noted all moisture and mechanical analysis values are averages of two or more determinations. Volume weight data are averages of the number of cores taken in a given horizon, usually 10 but varying from 5 to 15 in number. The percentages for each type of clay mineral are single determinations. Missing data such as field capacity and type of clay minerals were not measured for various reasons.

The Moisture Release Curves

The moisture release curves for the different horizons of each site were drawn on semi-logarithmic paper. Field capacity, moisture equivalent and permanent wilting percentage are indicated on the curves. The moisture release curves for each site accompany the table for that site in the Appendix. The dotted line on the moisture release curve is the change from the undisturbed core samples to the disturbed, less than 2 millimeter air dried soil samples. It can be noted that in most cases except for very coarse-textured soils there is a break from the 1.0 atmosphere tension to the 3.0 atmosphere tension. This is most generally true of the A_p horizon. The drop in moisture values between the cores and the air dry soil would indicate that soil structure is still a factor to be considered at between 1.0 and 3.0

atmospheres and is a much greater factor on surface soils.

In some finer-textured subsurface soil samples, moisture tension values for the 3.0 atmospheres were higher than for 1.0 atmosphere. This is especially noticeable on site 22 for the B horizon and on several of the horizons for sites 31, 33, 35 and 37. The cause of such a discrepancy is the removal of coarser materials (< 2 mm). As in the case of the C_1 horizon for site 35 approximately 10 percent of the material was greater than two millimeters, while in the C_2 horizon for the same site the corresponding percentage was 5.

In some cases on fine-textured soils field capacity and even moisture equivalent were above the zero tension determined on the cores. This condition was especially true on the Ontonagon silty clay, site 37, and the Selkirk silty clay loam, site 36. This discrepancy could be due to two things: (a) insufficient drainage of the profile before field capacity samples were taken or (b) the possibility that the soil cores did not reach saturation in the laboratory.

In a comparison of field capacity measurements with soil moisture tensions, Figure 8 shows a wide range of tensions at which field capacity occurs. Other investigators have found that field capacity values occurred most often at tensions between 0.06 and 0.33 atmospheres. As shown by the data presented in Figure 8 field capacity measurements exceeded this range of tensions.

It is very probable that the group of soils that had a field capacity value above 0.33 atmospheres were not brought up to field capacity during the infiltration runs. The reasoning here is partly based on Smith and Browning's work (29) in which they showed that a

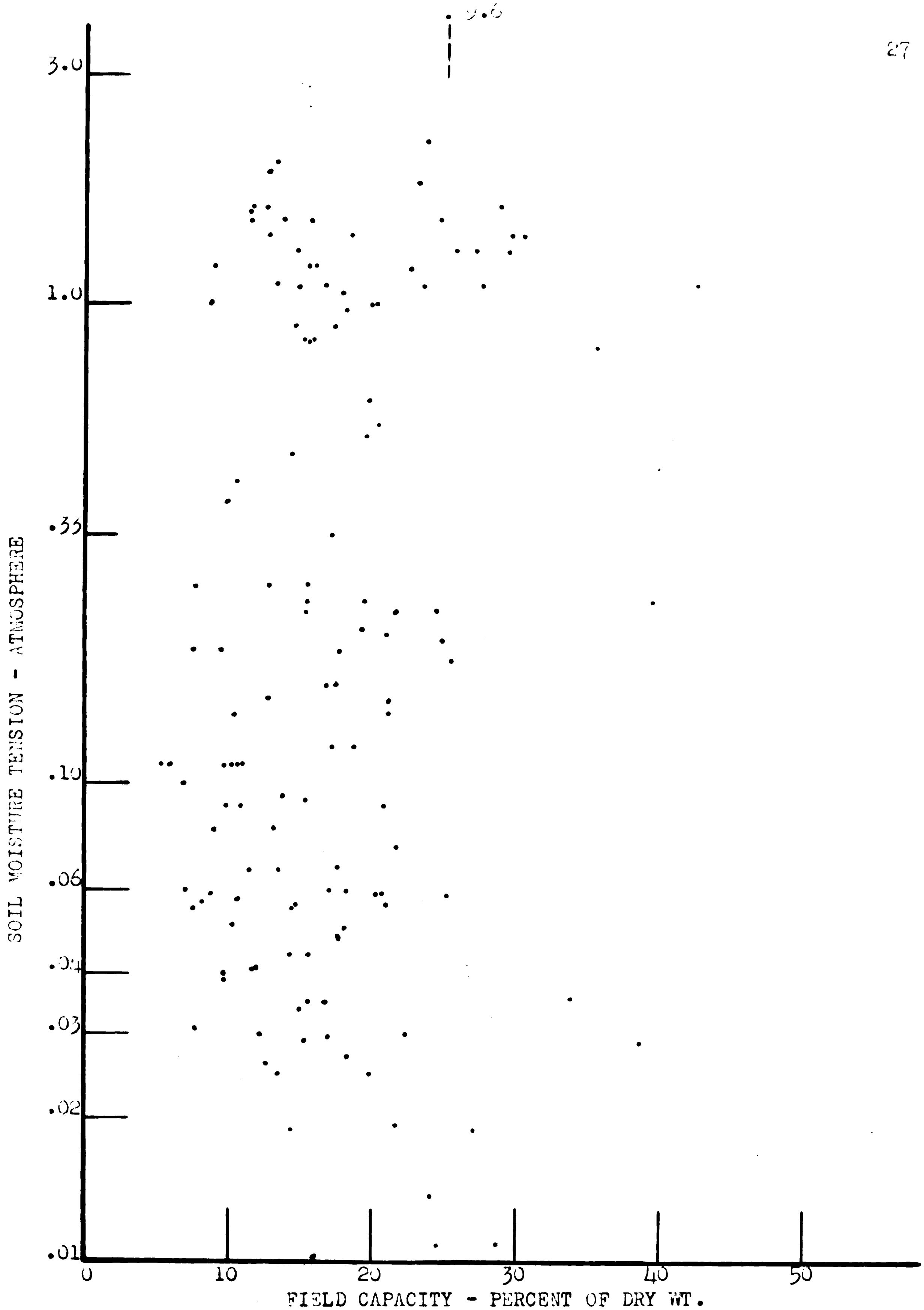

Figure 6. Field capacity versus tension as it occurs on the moisture release curve.

lack of complete artificial wetting resulted in a field capacity value equal to or lower than the moisture equivalent after two days of free drainage. This is the case for many of these samples. Also the reasoning here is based on the fact that many of these soils were very fine-textured soils and so would be slow in becoming completely wet during a dry season. The Miami soil, site 4, was one of these soils that was measured during a very dry season. However, why the A horizon of the Berrien and Granby soil, sites 1 and 2, have such a high tension for field capacity cannot be explained except for the fact that they probably dried below field capacity during the two days that these were left to drain before field capacity values were taken. During that two days the temperature was very high and the surrounding soil was dry.

The soil samples with tension values below 0.06 atmospheres were in many cases subsoil samples in which due to low permeability drainage had not been sufficient for moisture to reach field capacity. In some cases they were due to insufficient wetting of the soil cores from that particular horizon. The period of time necessary for proper drainage of soils of such high clay content is hard to determine. If the subsoil is drained properly the surface will lose part of its moisture through evaporation. Many of these soil cores had such a low percentage of continuous non-capillary pore space when brought into the laboratory that several days of soaking did not saturate them with water.

Clay Minerals

In the X-ray determination of the amount of clay minerals present

In the soil clays there were a few cases in which the total amount of clay minerals exceed 100 percent. This was very evident on the A_p horizon of the Warsaw silt loam, site 11, in which the total amount of clay minerals are 134 percent. The reason for this discrepancy was that the clay minerals in these particular samples have a much higher diffraction characteristic than the standard clays that were used. Some of the fine-textured soils such as the Pickford, site 36, and the Ontonagon, site 37, the diffraction characteristics for the clay minerals were very low. A further investigation of the types of minerals present in these fine-textured soils was not made.

In comparing these results on clay mineral analysis with the results obtained by other investigators it was found that Pennington and Jackson (19) studied a Miami soil from Wisconsin and found that the B_2 horizon contained 30 percent montmorillonite, 15 percent illite and 10 percent kaolinite. In comparison the Miami sample studied here (site 4) from the B_{21} horizon contained 5 percent montmorillonite, 60 percent illite and 12 percent kaolinite. Bidwell and Page (1) studied the clay fraction from some Ohio soils in the Miami catena. The B_2 and the C_2 horizons in a Miami silt loam contained only illite while a Michigan Miami loam (site 17) had both illite and kaolinite present. However, in Brookston silty clay loam they reported a medium amount of both montmorillonite and illite in the B_2 horizon while in this investigation it was found that in the BG_3 horizon of a Brookston sandy loam (site 5) only illite and kaolinite were present while the BG_1 and the BG_2 horizons contained fairly large amounts of all three types of clay minerals.

Moisture Relationships of Field Capacity

Field Capacity versus Moisture Equivalent. The relationship of field capacity to moisture equivalent has generally been used for field capacity values when those data are not available. This relationship is shown in Figure 9. The 45° line is used to show the variation in the two values. The relationship of field capacity to moisture equivalent for Michigan soils is very close to that found by other investigators (7) (9) (12) (33) in different parts of the country. All values below 12 percent have a much lower moisture equivalent than was obtained for field capacity. From 21 percent to 25 percent field capacity values approach moisture equivalent and are in some cases lower but predominately are higher.

Field Capacity versus 0.06 Atmosphere. The 0.06 atmosphere tension or 60 cm. of water has been used as the boundary between capillary and non-capillary pore space.

A comparison between the moisture contents at this tension and field capacity is shown in Figure 10. For soils with a field capacity value of less than 17 percent the 0.06 atmosphere tension measurement would lead to more accurate field capacity determinations than would the measurement of moisture equivalent. However, for field capacity values higher than 17 percent the 0.06 atmosphere tension measurements would lead to results generally a little low. The measurement of moisture equivalent would constitute a better laboratory determination of field capacities where the results were running over 17 percent. The closer agreement on moisture equivalent above 17 percent can be related to the use of air dry soil in which structure was not a

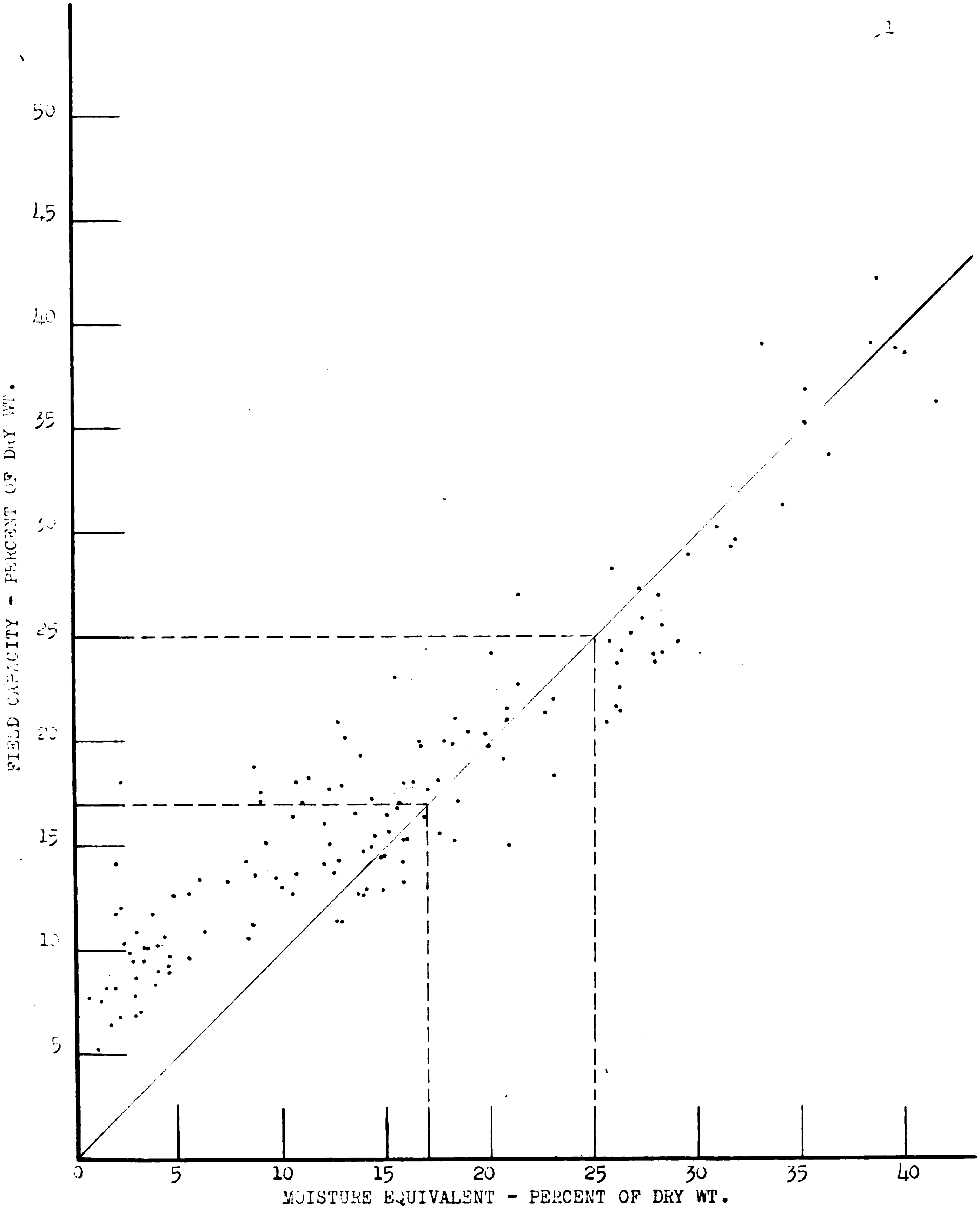

Figure 9. Relation of field capacity to moisture equivalent. The 45° line is drawn in for reference.

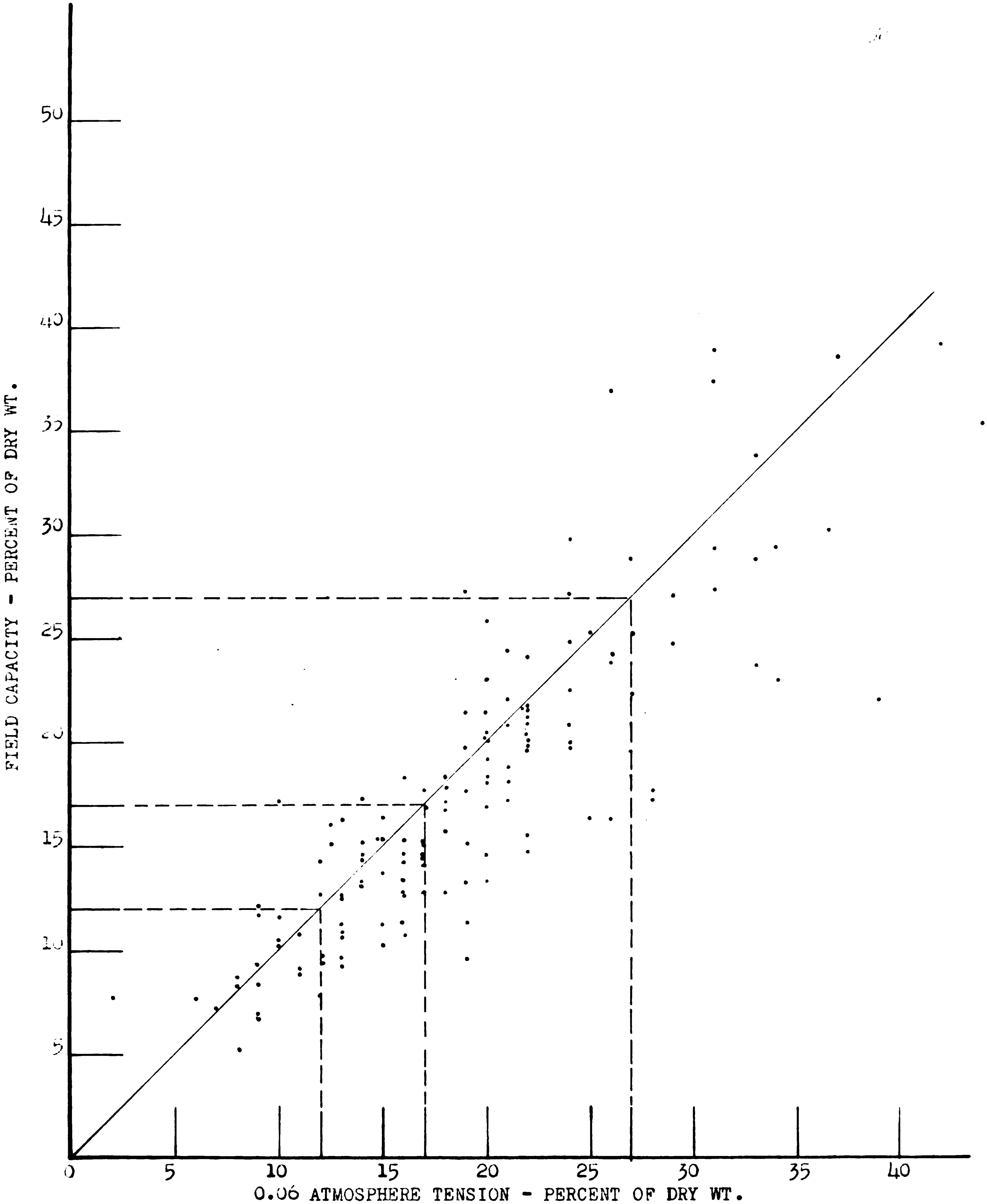

Figure 10. Relation of field capacity to 0.06 atmosphere tension. The 45° line is drawn in for reference.

problem. Tension measurements on undisturbed soil samples still have the influence of structure.

<u>Field Capacity versus 0.33 Atmospheres.</u> Field capacity values below 12 percent are higher than those indicated by the tensions at 0.33 atmospheres (Figure 11). Between 12 percent and 27 percent the measurements obtained by the tensions at 0.33 atmospheres have good agreement with field capacity and are a better measure of field capacity than those obtained at 0.06 atmospheres above 17 percent moisture. The accuracy of measurements at both 0.06 and 0.33 atmosphere tension values becomes less above 27 percent moisture. In comparing the field capacity values between 12 percent and 27 percent as determined at the two tensions the line of best fit would appear to fall between the 0.06 atmosphere and 0.33 atmosphere tensions. This is shown by the fact that over two-thirds of the values at 0.06 atmospheres fall below the 45° line while three-fifths of the 0.33 atmospheres values fall above the line. The wider scattering of values above 28 percent is due mainly to the discrepancy mentioned earlier, that of taking of field capacity measurements and the inadequate wetting of soil cores.

<u>Relationship of Field Capacity to Structure and Types of Clay Minerals.</u> It is a generally established fact that field capacity is determined to some extent by structure which is in turn affected by organic matter and percent of sand, silt and clay. In most cases the A_p horizon had the highest moisture content for tensions of 0 to 1 atmosphere. This is due mainly to the influence of soil structure or organic matter constituent and is brought out by the lower volume weights for this horizon. This higher moisture content of the A_p

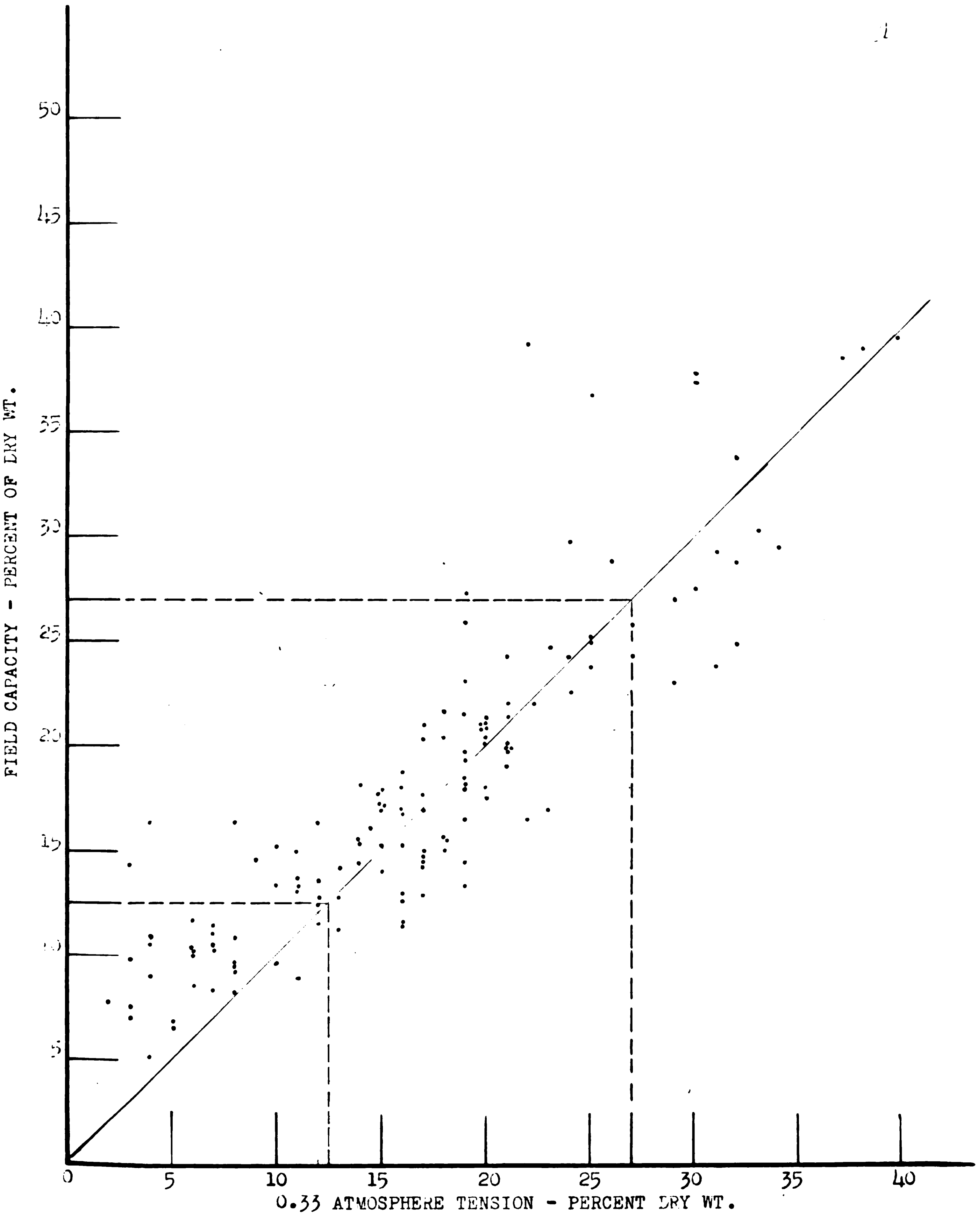

Figure 11. Relation of field capacity to 0.33 atmospheres tension. The 45° line is drawn in for reference.

horizon for the release curves between 0 and 1 atmosphere does not necessarily continue from 3 to 27 atmospheres unless the clay content of the Ap horizon approaches that of the other horizons.

Any comparison of field capacity to the type of clay mineral seems to be obscured by soil structure. Soil structure could be influenced some by the type of clay minerals present in the soil. For the most part the predominating clay minerals are the illite and kaolinite types. Both have a non-expanding crystal lattice. Montmorillonite with an expanding crystal lattice would have the greatest influence on moisture properties of soils. In only two samples did the montmorillonite clays make up more than 20 percent of the clay minerals present and in these two samples the total amount of clay ($< 2\mu$) amounted to 5 and 18 percent. This would then amount to less than 4 percent of montmorillonite present in any of the soil samples studied which would have little influence on even the higher moisture tensions measured on the soil. If there had been a wider range of clay mineral composition this relationship could have been studied more fully.

Moisture Relationships at the Wilting Point

The method of Breazeale and McGeorge (4) that was used for determining wilting point is based on the theory that when the soil moisture reaches equilibrium with the plant the back pull of the soil for the remainder of the moisture equals the pull of the plant for more moisture. Therefore, if the soil remains long enough around the plant which has sufficient root development in that soil even the finest-textured soil should come to equilibrium. The one difficulty encountered with the very fine-textured soils was shrinkage which caused cracks to form. When the soils were kept very moist to prevent the shrinkage, root development did not take place due to the lack of oxygen. When they were allowed to dry down to an optimum moisture condition the soil was too hard to be penetrated properly by the roots. This made it difficult to get reproducable determinations and the results from duplicate samples of fine-textured soils varied widely. Thus, results reported here are averages of two figures within 10 percent of each other.

Relationship of Wilting Point to Different Tensions. Richards and Weaver (25) were among the first to suggest the 15 atmospheres as a possible measure of the permanent wilting percentage. They came to this conclusion after comparing the different tensions with the permanent wilting percentages determined by Furr and Reeve (10). The 15 atmosphere moisture values fell between the first permanent wilting percentages and the ultimate wilting percentages.

The permanent wilting percentages reported here have a higher value than the ultimate wilting percentages reported by Furr and Reeve (10) on California soils because the entire sunflower plant permanently wilted with their method. The wilting percentages as determined in this investigation are closely related to Furr and Reeve's first permanent wilting percentages where only the basal leaves wilted. This is born out by Figure 12 which shows that the permanent wilting percentages are greater than the 15 atmosphere percentages.

The comparisons between permanent wilting percentage and different tensions were made in Figures 12, 13 and 14. The 45° lines were drawn

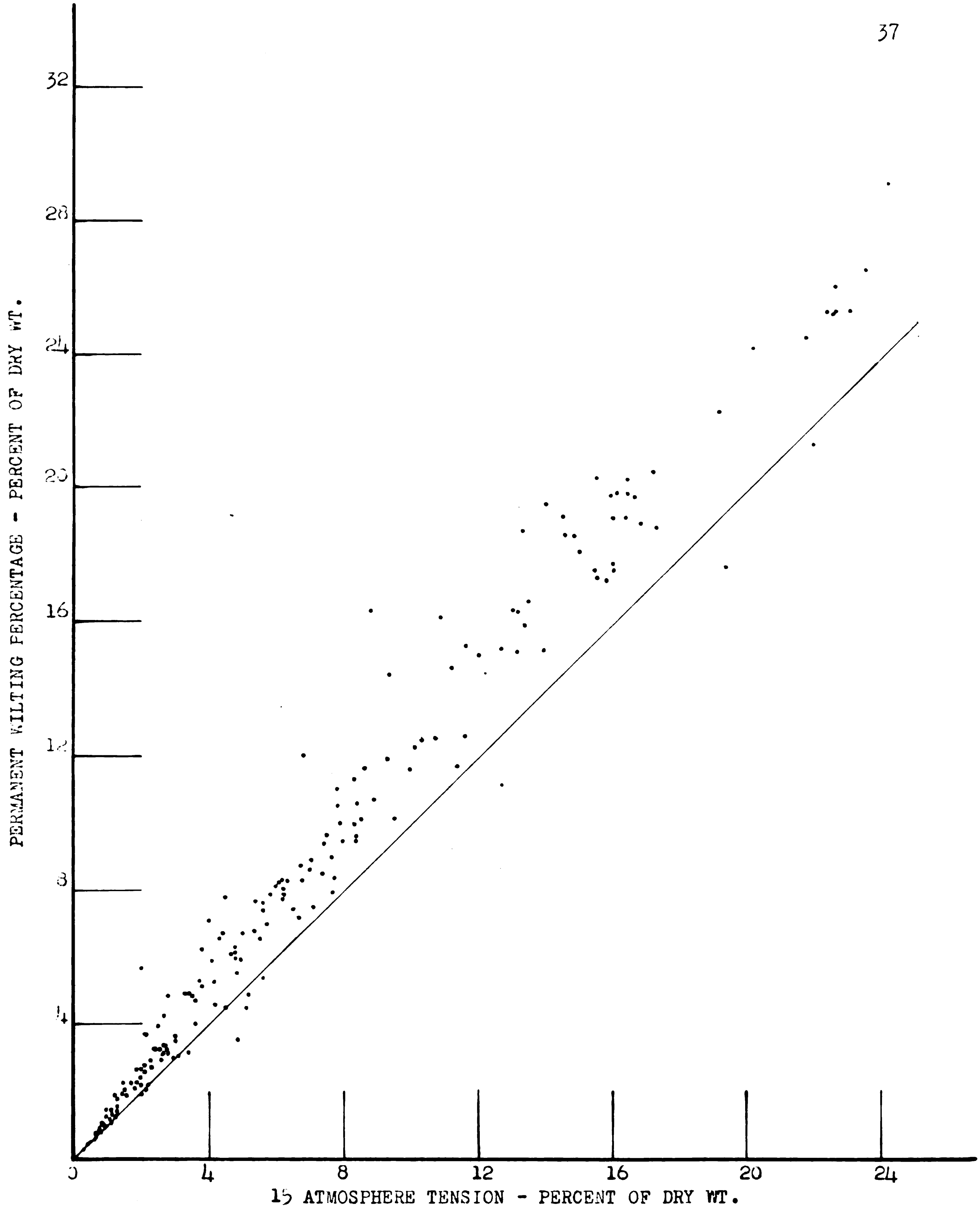

Figure 12. Relation of permanent wilting percentage to 15 atmosphere tension. The 45° line is drawn in for reference.

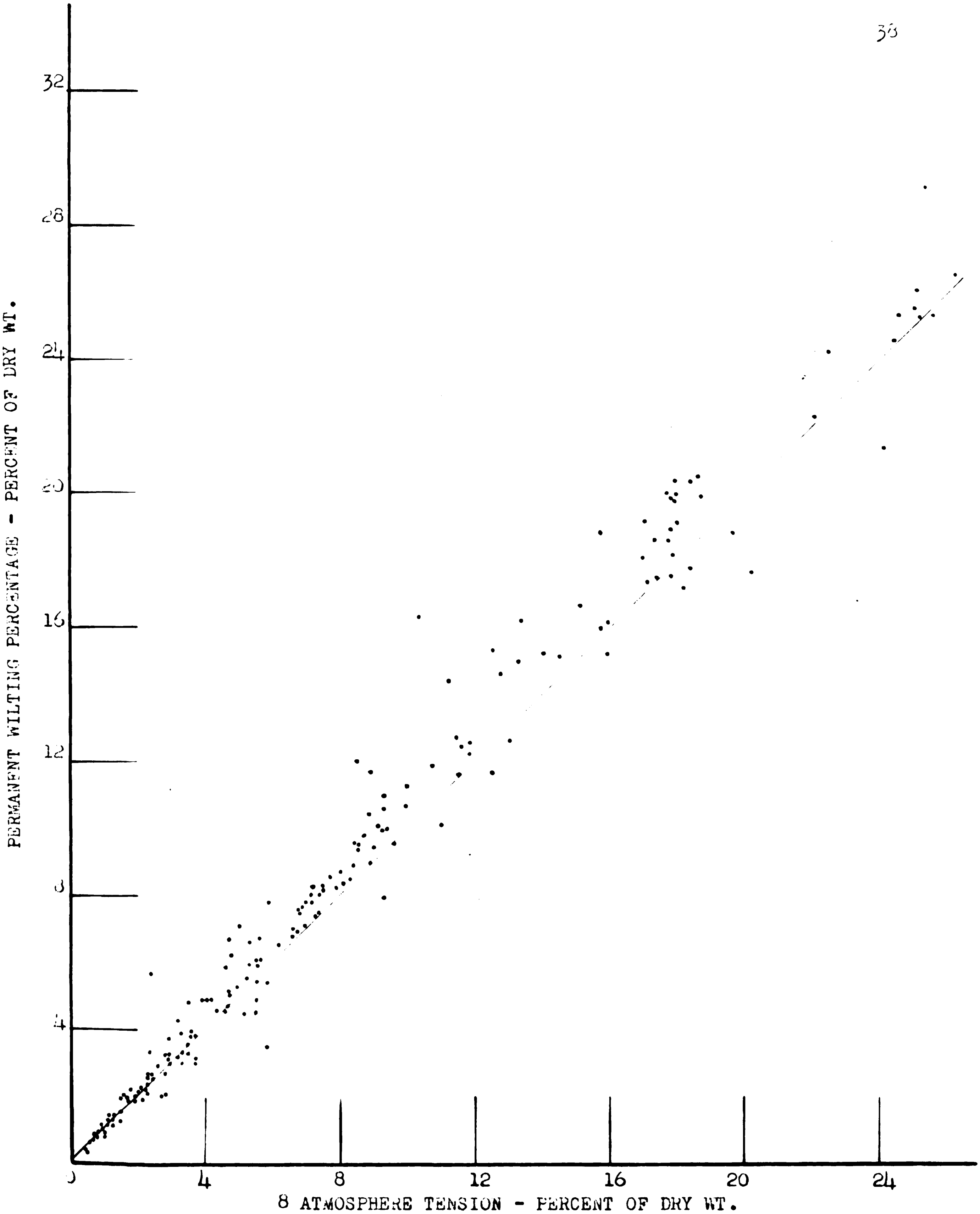

Figure 13. Relation of permanent wilting percentage to 8 atmosphere tension. The 45° line is drawn in for reference.

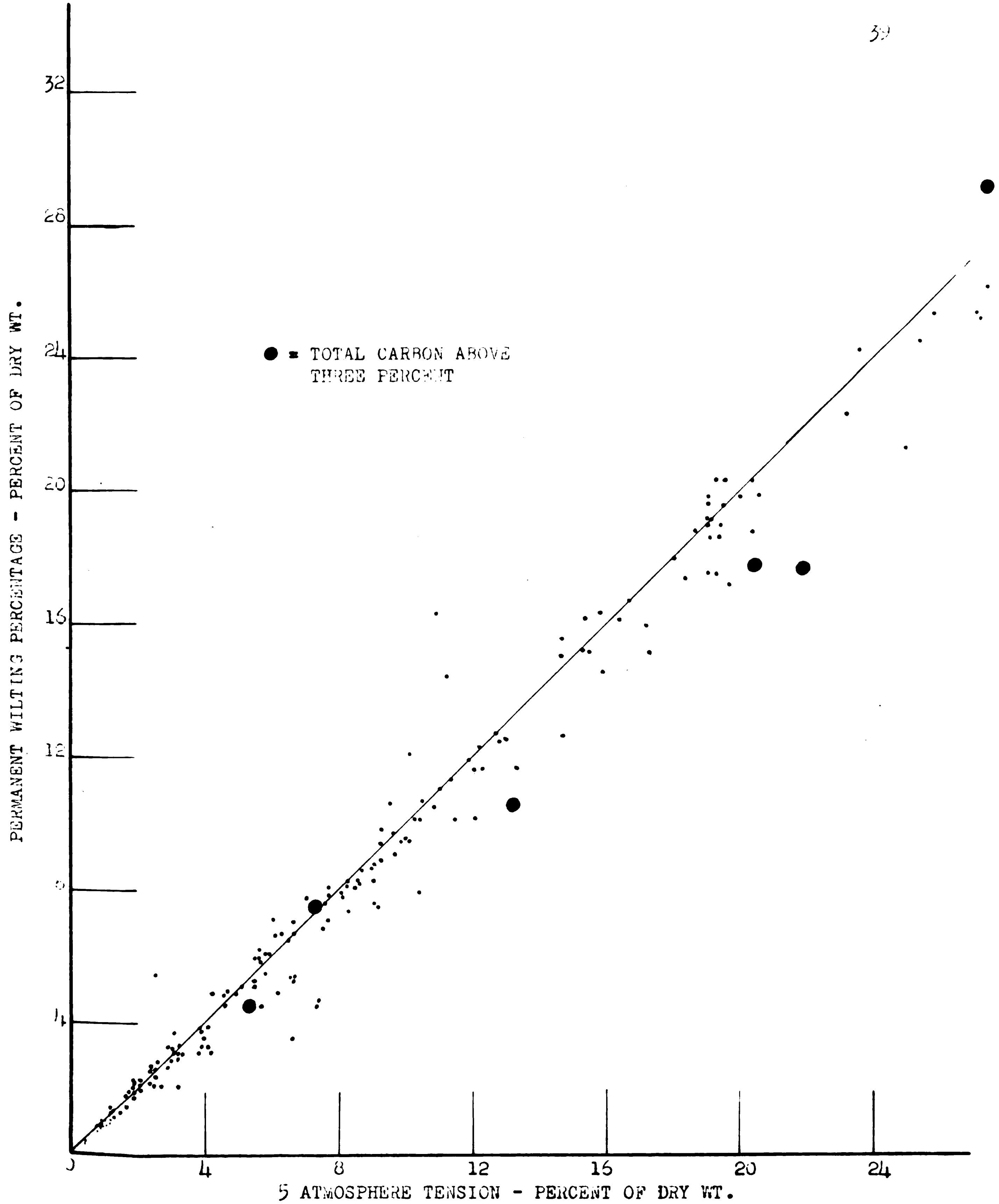

Figure 14. Relation of permanent wilting percentage to 5 atmosphere tension. The 45° line is drawn in for reference.

in for comparison purposes. As shown in Figure 12 the permanent wilting percentages were considerably above those indicated by the 15 atmosphere tensions. This is shown by the fact that nearly all points are above the 45° line. The points come closer to the line for the 8 atmosphere determinations (Figure 15) but the closest relationship was found by comparing permanent wilting percentages with 5 atmosphere tensions (Figure 14). A closer inspection of Figures 13 and 14 shows that permanent wilting values fall on the upper side of the 45° line at the 8 atmosphere tension. This is more apparent as the permanent wilting percentages increase in moisture content. In Figure 14 the larger portion of the values fall beneath the 45° line and becomes more apparent as the permanent wilting percentages increase in moisture content. From these two relationships it can be seen that the line of best fit for the permanent wilting percentages would fall somewhere between the 5 and 8 atmospheres tensions and probably at about 6 atmospheres tension.

From observation of the wilting percentages of the top soil it was felt that organic matter could be a factor influencing this value. The wilting points of the first two horizons from each profile were listed according to the amount of total carbon they contained. These were then compared with the 5 atmosphere tension values. Those soils containing less than 0.5 percent carbon were on the average equal to the 5 atmosphere tension values. Those containing 0.5 to 3 percent total carbon had on the average wilting point values from 0.3 to 0.4 percent less than the values at 5 atmospheres tension. The wilting percentage values of soils which contained more than 3 percent total

carbon were 1.5 percent below those at 5 atmospheres tension. However, due to the fact that there were only six soils with total carbon above 3 percent, with two having wilting percentage values greater than the 5 atmospheres tension, it is felt that the number of determinations for soils high in organic matter were not sufficient to say definitely that organic matter influenced wilting percentage. If, however, this observation is correct then it would appear that the plants capacity for removing water from soils increases with an increase in organic matter. That is, plants are able to withdraw water at a higher tension as the organic matter of the soil increases.

Relationship of Permanent Wilting Percentages to Percent Clay and Type of Clay Minerals

Permanent wilting percentages were based on air dry soil samples and therefore were not influenced in this study by soil structure. Therefore, there should be a direct relationship between permanent wilting percentage and clay content. This relationship was born out in Figure 15 which does not appear to be a straight linear relationship. In plotting this graph it was evident that total carbon influenced the wilting point determinations. The A_p horizons were classified into different total carbon ranges and the values marked on the graph. There were five values that were above 3 percent total carbon. All of the permanent wilting percentages for these values fell the farthest below the curves. The next highest range from 2 to 3 percent total carbon fell below the main curve but not as far as the group containing more than 3 percent carbon. The rest of the values were close to or on the main curve.

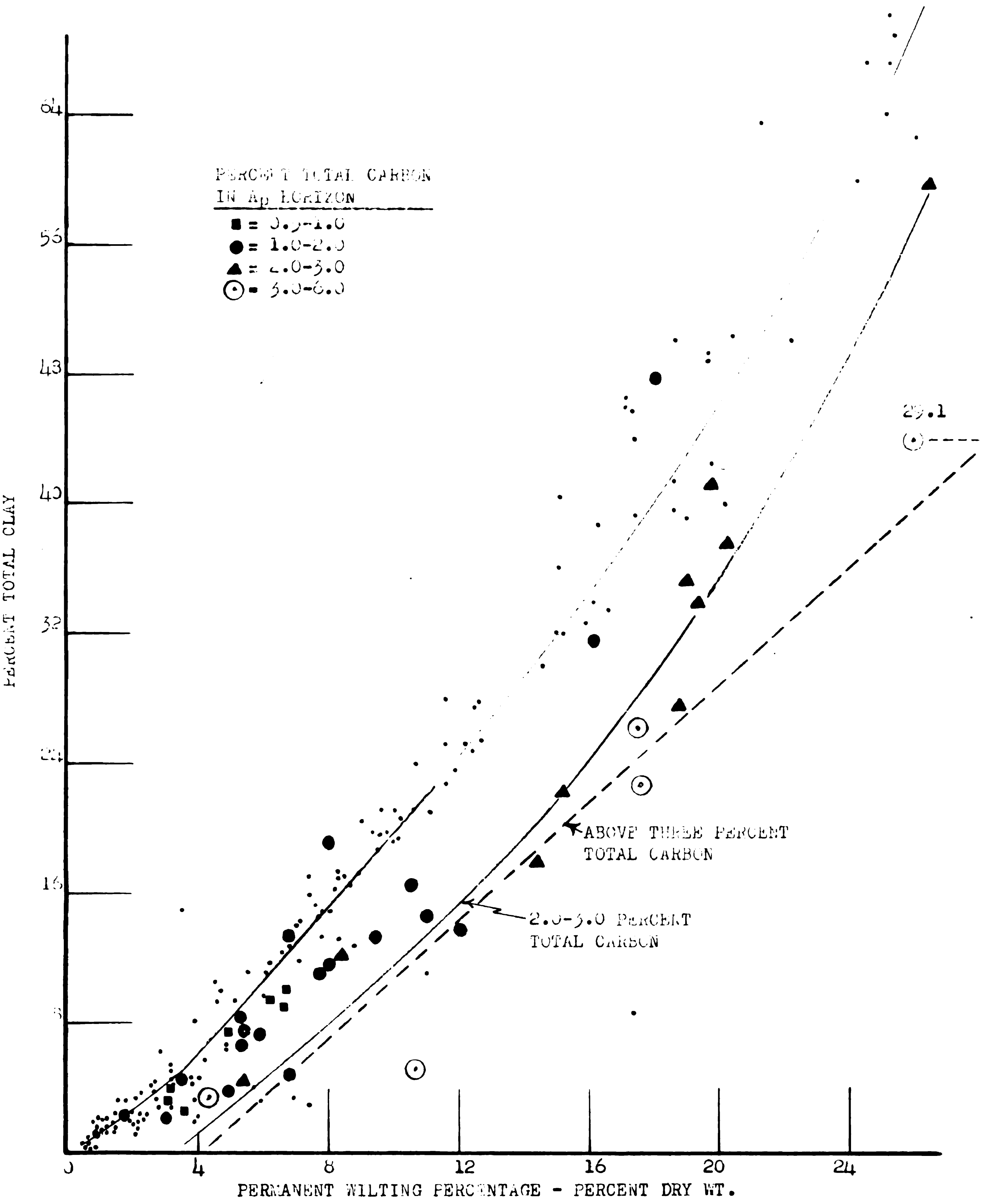

Figure 15. Relation of total clay to permanent wilting percentage. Curves represent distribution of permanent wilting percentages at different levels of total carbon.

It was felt that an imperical formula could be worked out that would take into account such factors as organic matter and types of clay minerals. The moisture release curves as determined by Woodruff (37) for the different types of clay minerals were used to assign the values of 5 for montmorillonite, 2 for illite and 1 for kaolinite and other minerals. Total carbon was given a value of 10 which would take into account the conversion factor of 1.7 for changing total carbon to organic matter. The imperical formula used was

Index Number = Total Carbon x 10 + Montmorillonite x 5 x percent Clay per sample + Illite x 2 x percent Clay + rest of Clay Mineral x 1 x percent Clay.

After plotting the index number versus permanent wilting percentage the same type of curve as in Figure 15 was obtained with more scattering. The figure and the graph were not included because Figure 15 was a much better relationship.

Percent Available Water

Percent Available Water Based on Field Capacity. The amount of water available for plant growth is the moisture present in the soil between field capacity and permanent wilting percentage. This difference has been determined for each sample and listed in Table III. Missing values are subsoil samples on which field capacity data were not taken. Sample 38 had a negative value due to insufficient wetting of the subsurface soil during the infiltration runs.

Several factors usually affect the amount of available water present in the soil. Structure is one of these factors which is in

TABLE III

THE PERCENT AVAILABLE WATER IN THE DIFFERENT SAMPLES.
THE DIFFERENCE BETWEEN FIELD CAPACITY AND
PERMANENT WILTING PERCENTAGES

Sample Number	Percent Water	Sample Number	Percent Water	Sample Number	Percent Water
1	10.0	41	6.4	81	
2	7.8	42	5.3	82	14.6
3	5.7	43	8.2	83	15.3
4		44	6.0	84	8.5
5		45	7.9	85	7.8
6	12.5	46	4.4	86	4.4
7	9.4	47	7.5	87	12.1
8	15.5	48	9.8	88	7.8
9		49	6.0	89	5.2
10		50	2.3	90	1.7
11	15.6	51	5.9	91	8.4
12	13.7	52	5.0	92	
13	6.7	53		93	
14	8.5	54	10.5	94	12.8
15	11.2	55	12.4	95	9.5
16		56	12.1	96	9.1
17		57	7.6	97	7.5
18	8.0	58		98	10.5
19	4.4	59		99	6.7
20	3.4	60	5.9	100	11.3
21	4.8	61	6.8	101	9.7
22	4.3	62	4.3	102	
23		63	7.3	103	4.5
24	12.0	64	6.1	104	8.7
25	7.5	65	6.5	105	11.0
26	7.1	66		106	8.0
27	7.7	67	6.8	107	
28		68	10.5	108	8.3
29		69	9.2	109	12.7
30	21.6	70	4.3	110	5.9
31	14.5	71	5.5	111	4.8
32	6.4	72		112	6.6
33	4.2	73	10.6	113	
34	1.8	74	7.6	114	10.0
35	14.3	75	5.7	115	7.4
36	5.8	76	5.5	116	8.9
37	0.2	77	8.8	117	7.7
38	-1.1	78		118	13.1
39		79		119	
40	13.2	80		120	5.1

TABLE III (continued)

Sample Number	Percent Water	Sample Number	Percent Water	Sample Number	Percent Water
121	12.5	145		172	4.8
122	8.6	149	13.5	173	4.0
123	3.7	150	11.2	174	7.4
124	4.2	151	12.5	175	
125	5.3	152	6.9	176	17.7
126	9.7	153	9.0	177	4.4
127		154	12.1	178	4.7
128		155	13.6	179	12.4
129		156	11.4	180	9.8
130	7.2	157	11.0	181	12.4
131	11.0	158		182	13.0
132	7.9	159	4.6	183	7.5
133		160	5.8	184	10.1
134	7.4	161		185	6.9
135		163		186	8.6
136		164	12.2	187	4.5
137		165	6.5	188	
138		166	5.7	189	7.3
139		167		190	11.9
140		168	11.5	191	6.4
141	7.7	169	7.2	192	5.0
142	5.7	170	4.4		
143		171	4.4		

turn affected by the amount of organic matter, percent clay, tillage practices, drainage, etc. Many soils with a high clay content which were investigated had such a high water table throughout most of the year that good root development and other factors necessary for the building of structure throughout the horizons were at a minimum.

A comparison was made in Figure 16 showing the percent of available water present in relationship to the percent of clay present in the soil sample. Also the A_p horizons and the horizons immediately under these were plotted separately from the subsurface soils. It can be noted that the greatest majority of the values for available water fall between 4 and 16 percent moisture on an oven dry basis. The two samples containing available moisture above 16 percent were surface samples highest in organic matter content (samples 30 and 176). These samples also contained a relatively high percentage of clay. Both of these soils from which the samples were taken had been left for several years with a grass sod cover. In general subsurface samples containing less than 18 percent clay vary between 6 and 16 percent available moisture and samples above 18 percent clay have 5 to 15 percent available moisture.

<u>Percent of Available Water Based on Moisture Tensions.</u> In order to better see the relationship between available water and clay on undisturbed samples the 0.06 and 0.33 moisture tensions were used in the place of field capacity to determine the available water in each horizon. Permanent wilting percentages were subtracted from the 0.06 atmosphere tensions on all moisture values on or below 12 percent at that tension. The reason for using the 0.06 atmosphere tension for

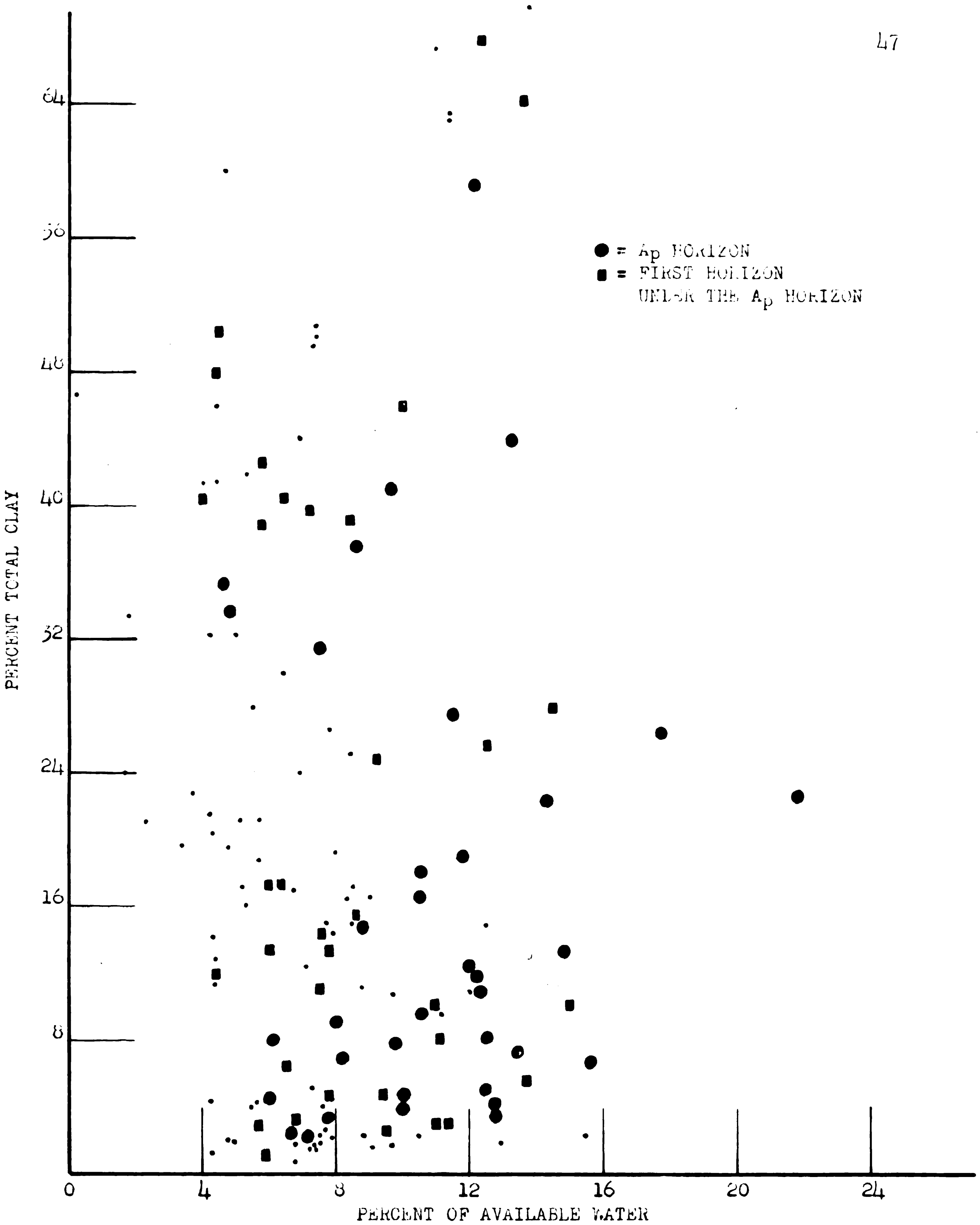

Figure 16. Relation of total clay to available water. Differences between field capacity values and permanent wilting percentage values.

soil samples less than 12 percent is that for this range the 0.06 atmosphere tension is the best measure of field capacity. The remainder of the permanent wilting percentages were subtracted from 0.33 atmosphere tensions. These differences were listed in Table IV. The available water in the different horizons based on the two tensions were plotted against the percent clay in Figure 17. The same general relationships are shown here as in Figure 16 with the surface soils having more available water. Most of the values for the subsurface samples fall between 4 and 10 percent. Both Figures 16 and 17 show that available water is greater in the surface horizons than in subsurface horizons due to greater organic matter content and better structure.

TABLE IV

PERCENT AVAILABLE WATER IN THE DIFFERENT SAMPLES. THE DIFFERENCE BETWEEN 0.06 ATMOSPHERE TENSION AND PERMANENT WILTING PERCENTAGES BELOW TWELVE PERCENT MOISTURE AND THE DIFFERENCE BETWEEN 0.33 ATMOSPHERE TENSION AND PERMANENT WILTING PERCENTAGES ABOVE TWELVE PERCENT MOISTURE

Sample Number	Percent Water	Sample Number	Percent Water	Sample Number	Percent Water
1	13.8	40	15.9	79	
2	4.2	41	10.9	80	
3	7.7	42	5.2	81	
4	8.3	43	6.1	82	14.5
5	7.4	44	5.3	83	15.3
6	18.4	45	4.9	84	8.5
7	6.0	46	0.8	85	4.4
8	6.5	47		86	3.9
9	9.9	48	12.1	87	13.0
10	9.1	49		88	10.2
11	14.7	50	6.4	89	8.6
12	14.7	51	7.9	90	2.7
13	9.7	52		91	9.4
14	14.0	53		92	
15	17.0	54		93	4.7
16	19.1	55	12.3	94	10.5
17	22.3	56	7.9	95	7.8
18	12.4	57	7.4	96	8.8
19	8.9	58		97	0.9
20	8.6	59		98	7.4
21	7.2	60	4.2	99	7.0
22	10.0	61	6.2	100	8.5
23	5.8	62	4.3	101	7.0
24	9.6	63	0.7	102	6.6
25	6.0	64	10.6	103	7.0
26	4.4	65	7.1	104	10.0
27	6.2	66		105	8.3
28	5.9	67	6.6	106	5.9
29	26.6	68	9.5	107	5.1
30	20.4	69	6.6	108	0.3
31	11.4	70	6.0	109	15.1
32	2.6	71		110	8.3
33		72		111	7.0
34	2.4	73	9.8	112	3.3
35	16.4	74	7.3	113	5.4
36	4.7	75	6.4	114	7.8
37	0.9	76	4.5	115	3.2
38	0.9	77	8.5	116	2.0
39	1.1	78		117	9.6

TABLE IV (continued)

Sample Number	Percent Water	Sample Number	Percent Water	Sample Number	Percent Water
118	10.8	142	6.2	171	0.4
119	6.1	143		172	7.5
120	Neg.	145		173	0.7
121	9.7	149	13.1	174	1.7
122	4.4	150	7.1	175	Neg.
123	2.3	151		176	25.3
124	5.0	152	6.3	177	5.9
125	4.6	153	6.7	178	7.8
126	8.5	154	10.5	179	10.7
127	11.0	155	4.7	180	0.5
128	6.3	156	4.0	181	0.5
129	6.0	157		182	Neg.
130	5.9	158		183	8.8
131	5.4	159	11.9	184	1.7
132	9.8	160	7.2	185	
133	9.5	161	3.5	186	5.7
134	1.6	162	3.9	187	2.6
135	8.9	164	13.2	188	7.1
136	6.7	165	9.1	189	9.3
137	8.6	166	5.5	190	11.0
138	7.2	167	5.2	191	4.9
139	5.7	168	14.2	192	4.8
140		169	0.4		
141	7.9	170	0.8		

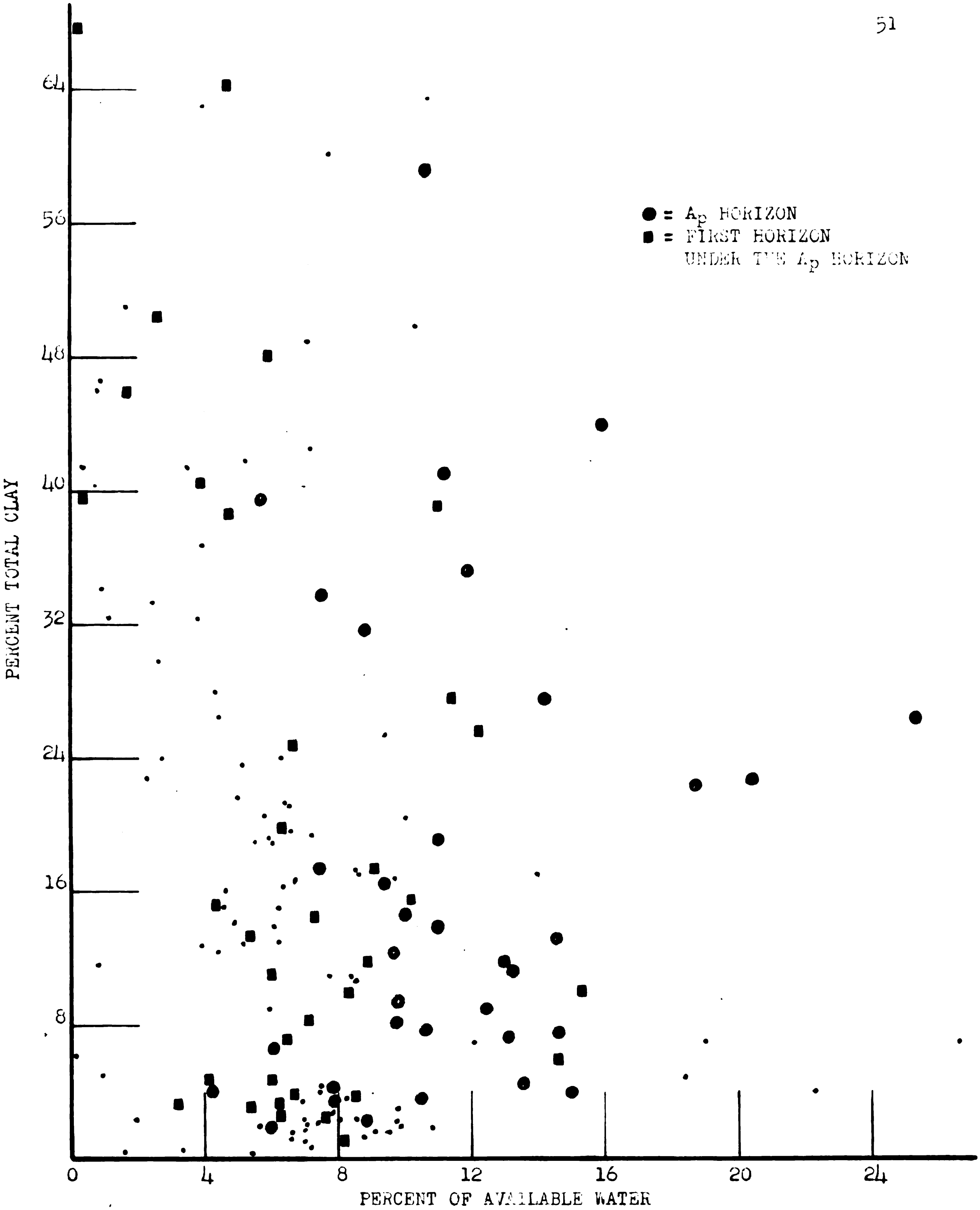

Figure 17. Relation of total clay to available water. Differences between the 0.06 or 0.33 atmosphere tension values and permanent wilting percentage values.

SUMMARY

This investigation was undertaken to determine the moisture properties of several Michigan soils and their relationship to mechanical composition and types of clay minerals. The different horizons of 38 Michigan soils were characterized as to their moisture properties. Field capacity values were taken after infiltration studies in the field. Moisture percentages at tensions from 0 to 1 atmosphere were measured on cores from each horizon. Moisture percentages at tensions from 3 to 27.19 atmospheres were determined on disturbed samples. All other measurements were made on air dried samples.

Moisture tension curves for each horizon were drawn. It could be seen from these curves that the change from undisturbed samples to disturbed samples involved a breaking down of the soil structure which caused a considerable drop in moisture from the 1 to the 3 atmospheres tension. In general the A_p horizons were most affected by the change from undisturbed to disturbed samples. In many of the fine-textured samples the moisture release between 0.01 and 1.0 atmospheres tension on the undisturbed sample was almost negligible, however, the moisture release on the disturbed samples were much more pronounced.

The types and amounts of clay minerals in the soil were determined by X-ray diffraction using montmorillonite from Wyoming, illite from Illinois and kaolinite from South Carolina as standards. All three types of these minerals were found to be present in Michigan soils

with the highest percentage of montmorillonite in the A_p horizon of the Granby soils. The illite minerals were predominant in most of the soil horizons while varying amounts of kaolinite seemed to be present in the majority of the soil horizons. In this investigation there was no relationship shown between the type of clay minerals and various moisture determinations. This was mainly due to the fact that the montmorillonite which would contribute most to variations in soil properties made up a very small percentage of the clay contained in the soil.

The difficulity in determining field capacity by laboratory methods may partly be due to the breaking down of the soil structure when going from an undisturbed sample to a disturbed sample. When comparing moisture equivalent with field capacity it was found to be too low for field capacity values below 12 percent. Field capacity values above 12 percent more nearly approached moisture equivalent and were at an optimum at approximately 25 percent moisture. The 0.06 atmosphere tension was the best measure of field capacity values below 17 percent. The 0.33 atmosphere tension was a good measure of field capacity values from 12 to 28 percent moisture. Field capacities above 17 percent moisture were more closely related to the moisture equivalent than other measurements.

The wilting percentage determinations seemed to have a close correlation at the 5 atmosphere tension with about 6 atmosphere tension being possibly the best measure of wilting point. The permanent wilting percentages of soils decrease with increasing amounts of organic matter.

The percent of available water contained in the soil profile is in general higher in the A_p horizon than in the subsurface horizon. The lack of agreement between percent clay and available water is definitely due to variations in field capacity values. The variations in field capacity values are due to structural differences in the various soil horizons. A farther study is needed that would not only investigate field capacity in relationship to soil texture but also would relate field capacity to soil structure.

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APPENDIX

TABLE V

BASIC DATA ON BERRIEN LOAMY SAND SITE NUMBER ONE*

Sample Number	1	2	3	4	5
Horizon	Ap	B_{11}	B_{12}	B_g	D
Depth (inches)	0-10	10-21	21-29	29-42	42-55
Hygroscopic Coefficient	1.0	0.61	0.47	0.41	1.2
Permanent Wilting Point	5.4**	3.8**	3.3	2.7	8.6
Field Capacity	16.4	12.6	9.0		
Moisture Equivalent	10.6	5.5	4.6	3.5	13.3
Total Carbon	2.8	0.36			
Sand	80.9	84.4	87.6	92.9	67.3
Silt	10.3**	7.6**	5.8**	2.1	13.2
2 u Clay	4.4	4.6	4.4	3.7	17.4
.2 u Clay					
Montmorillonite	10	10	5	5	10
Illite	30	30	0	50	90
Kaolinite	4	8	8	12	12
Volume Weight (gms/cc)	1.3	1.4	1.5	1.6	1.7
Moisture Content at:					
0.00 Atms	40	35	31	23	22
0.01 Atms	38	31	31	21	19
0.02 Atms	36	31	23	20	19
0.03 Atms	32	25	20	19	18
0.04 Atms	31	20	15	15	18
0.06 Atms	25	13	11	11	18
0.33 Atms	19	8	4	4	16
1.00 Atms	17	7	4	4	15
3.00 Atms	7.6	4.3	3.3	2.7	9.0
5.00 Atms	6.7	3.9	3.0	2.5	8.7
8.00 Atms	5.9	3.7	2.8	2.3	7.7
15.00 Atms	5.6	3.0	2.4	2.0	7.0
27.19 Atms	5.3	2.8	2.1	1.9	6.0

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.

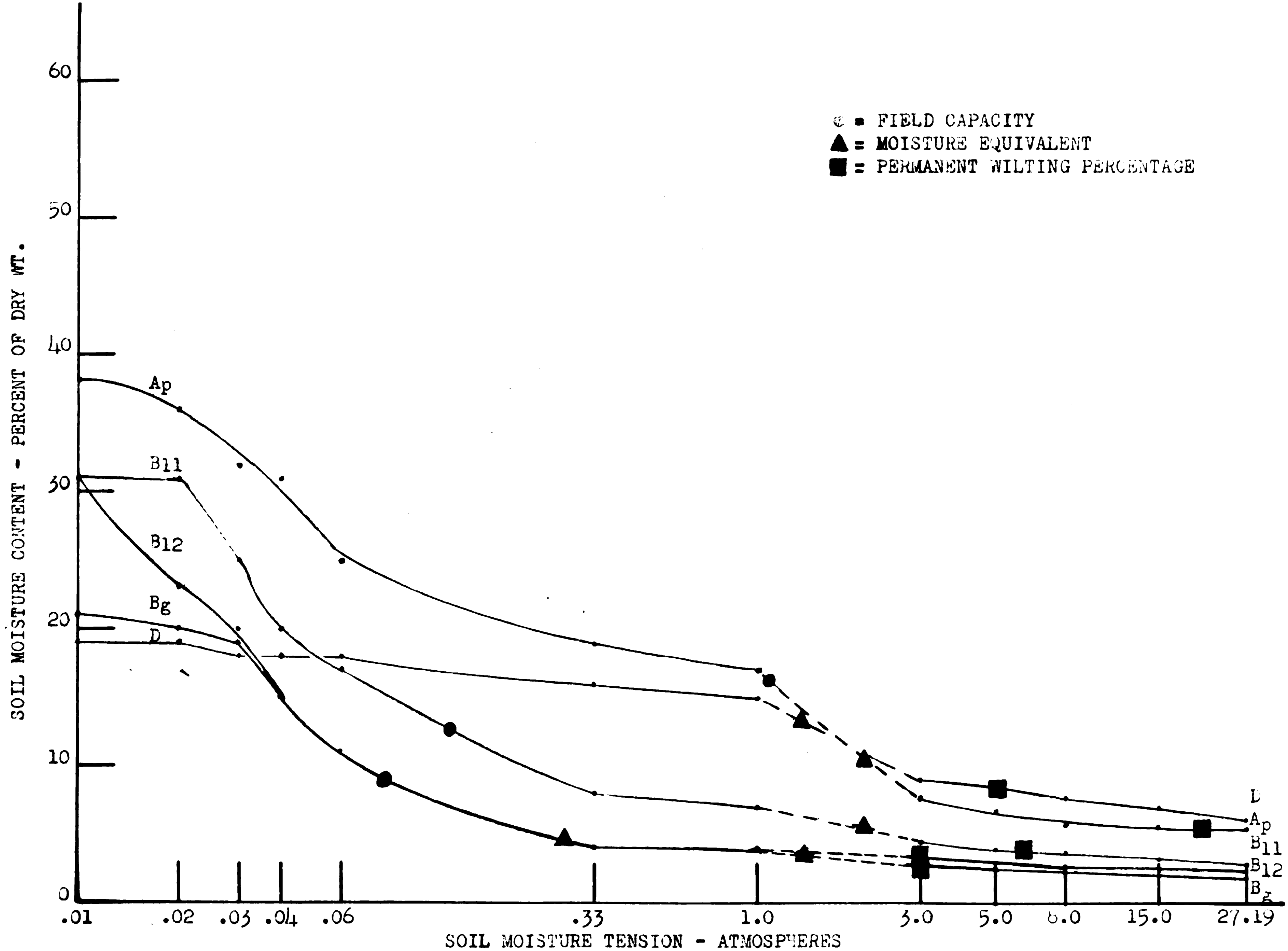


Figure 16. Moisture release curves for Berrien loamy sand site number one.

TABLE VI

BASIC DATA ON GRANBY LOAMY SAND SITE NUMBER TWO*

Sample Number	6	7	8	9	10
Horizon	Ap	Ag	B2g	B3g	C1
Depth (inches)	0-9	9-19	19-27	27-40	40-55
Hygroscopic Coefficient	1.9	0.60	0.18	0.15	0.12
Permanent Wilting Point	10.6	4.0	1.5	1.1**	0.90
Field Capacity	23.1	13.4	17.1		
Moisture Equivalent	15.4	6.1	2.4	2.3	1.9
Total Carbon	4.2	0.64			
Sand	79.0	85.4	95.8	96.2	95.6
Silt	7.6**	7.5	0.94	0.84	0.78
2µ Clay	4.9	4.6	2.4	2.0	1.6
.2µ Clay					
Montmorillonite	20	10	<5	<5	0
Illite	60	30	30	30	10
Kaolinite	16	12	8	10	2
Volume Weight (gms/cc)	1.1	1.5	1.6	1.6	1.6
Moisture Content at:					
0.00 Atms	47	28	22	21	22
0.01 Atms	46	26	21	19	21
0.02 Atms	44	24	20	19	21
0.03 Atms	41	21	17	18	19
0.04 Atms	38	18	15	15	16
0.06 Atms	34	14	10	11	10
0.33 Atms	29	10	4	5	4
1.00 Atms	27	10	3	4	3
3.00 Atms	13.6	4.4	1.5	1.2	1.1
5.00 Atms	13.3	3.9	1.4	1.1	0.92
8.00 Atms		3.6	1.3	1.2	0.82
15.00 Atms	12.7	3.6	1.1	0.94	0.88
27.19 Atms	10.6	3.6	1.1	0.86	0.68

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.

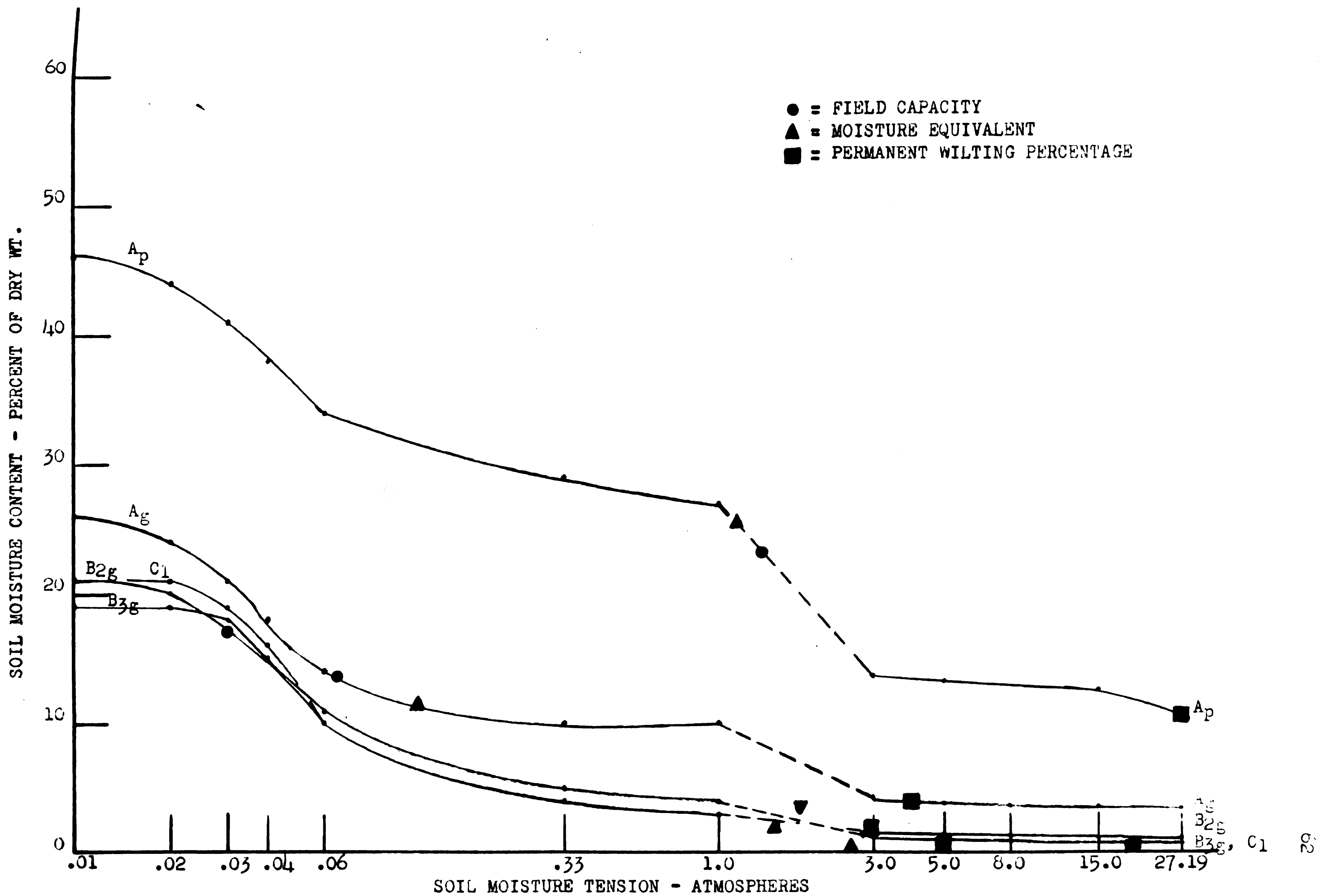


Figure 19. Moisture release curves for Granby loamy sand site number two.

TABLE VII

BASIC DATA ON HILLSDALE SANDY LOAM SITE NUMBER THREE*

Sample Number	11	12	13	14	15	16	17
Horizon	A_2	A2	B_{21}	B_{22}	B_3	C_1	C_2
Depth (inches)	0-7	8-13	13-20	20-26	26-32	34-38	38
Hygroscopic Coefficient	0.74	0.50	1.01	1.1	0.72	0.55	0.32
Permanent Wilting Point	5.3**	4.3	8.3	8.0	6.0	4.9	5.7
Field Capacity	20.9	16.0	15.0	16.5	17.2		
Moisture Equivalent	12.7	10.6	14.2	15.0	11.0	9.9	10.2
Total Carbon	1.1	0.32					
Sand	56.3	46.8	58.5**	60.3**	68.9	62.1	18.1
Silt	31.5	44.5	22.5	20.5**	24.3**	26.0	48.2
2µ Clay	7.5	5.8	16.9	15.0	9.7	7.0	4.0
.2µ Clay							
Montmorillonite	<5	0	0	5	<5	<5	0
Illite	20	10	30	50	50	50	50
Kaolinite	8	2	8	10	8	8	8
Volume Weight (gms/cc)	1.4	1.5	1.5	1.4	1.3	1.4	1.3
Moisture Content at:							
0.00 Atms	33	27	28	32	34	33	37
0.01 Atms	31	24	26	30	33	31	35
0.02 Atms	29	24	25	29	32	31	34
0.03 Atms	28	23	24	28	31	30	33
0.04 Atms	27	22	23	27	30	30	33
0.06 Atms	24	21	22	26	28	28	32
0.33 Atms	20	19	18	22	23	24	28
1.00 Atms	17	16	16	17	16	15	22
3.00 Atms	6.4	4.4	9.0	8.6	6.0	4.8	2.9
5.00 Atms	5.6	3.7	8.3	7.7	5.5	4.3	2.6
8.00 Atms	5.0	3.2	7.3	7.2	5.3	4.0	2.4
15.00 Atms	4.2	2.6	6.2	6.2	4.8	3.5	2.0
27.19 Atms	4.3	2.5	5.6	5.8	4.2	3.3	1.6

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.

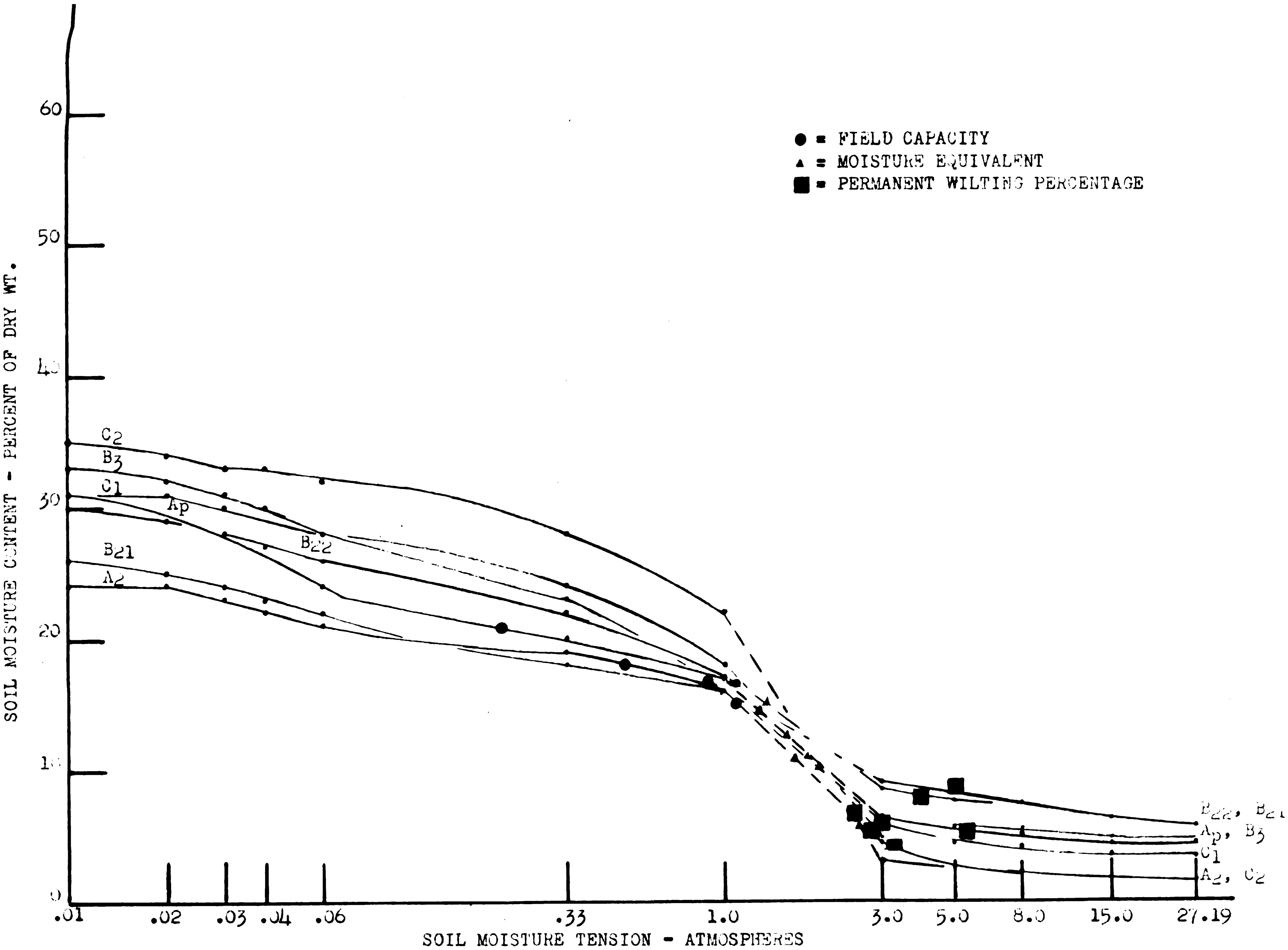


Figure 20. Moisture release curves for Hillsdale sandy loam site number three.

TABLE VIII

BASIC DATA ON MIAMI SANDY LOAM SITE NUMBER FOUR*

Sample Number	18	19	20	21	22	23
Horizon	A_p	A_2	B_1	B_{21}	B_{22}	C
Depth (inches)	0-6	7-11	12-16	16-21	25-28	40-45
Hygroscopic Coefficient	0.51	0.66	1.3	1.2	1.1	1.2
Permanent Wilting Point	6.6	7.1	9.4	9.8	9.0**	10.2**
Field Capacity	14.6	11.5	12.8	14.6	13.3	
Moisture Equivalent	14.9	12.8	14.8	14.3	15.8	17.6
Total Carbon	0.53	0.43				
Sand	57.1	56.5	50.9	52.0	55.5	41.8
Silt	29.8	19.9	26.2	24.8	27.3	28.7
2µ Clay	8.9	11.8	19.7	19.5	20.5	20.7
.2µ Clay			10.8			11.9
Montmorillonite	<5	0	<5	5	<5	5
Illite	20	20	50	60	50	50
Kaolinite	4	8	<2	12	8	10
Volume weight (gms/cc)	1.4	1.6	1.6	1.6	1.5	1.7
Moisture Content at:						
0.00 Atms	29	22	24	22	24	21
0.01 Atms	25	19	21	21	22	21
0.02 Atms	24	18	20	20	21	20
0.03 Atms	22	17	19	19	20	19
0.04 Atms	21	17	19	18	20	19
0.06 Atms	20	18	18	17	19	18
0.33 Atms	19	16	16	17	19	16
1.00 Atms	14	15	15	16	18	14
3.00 Atms	7.6	7.3	10.2	10.4	10.4	13.2
5.00 Atms	6.1	6.2	9.3	9.4	9.7	12.0
8.00 Atms	5.3	5.1	8.5	8.7	8.9	11.0
15.00 Atms	4.3	4.1	7.4	7.6	7.6	9.5
27.19 Atms	4.2	3.4	6.5	6.6	6.4	8.0

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.

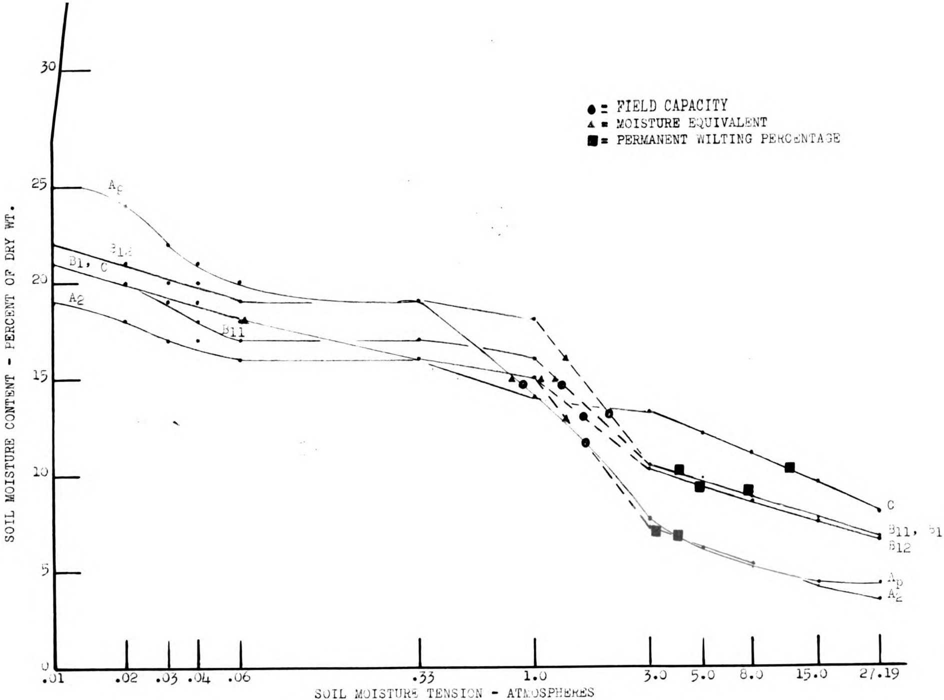


Figure 21. Moisture release curves for Miami sandy loam site number four.

TABLE IX

BASIC DATA ON BROOKSTON SANDY LOAM SITE NUMBER FIVE*

Sample Number	24	25	26	27	28	29
Horizon	A_p	BG_1	BG_2	BG_3	C	D
Depth (inches)	0-10	13-17	18-23	27-32	42-46	47-53
Hygroscopic Coefficient	1.2	0.84	0.85	1.0	0.56	0.54
Permanent Wilting Point	8.4	6.0	6.6	7.8	5.1**	3.4
Field Capacity	20.4	13.5	13.7	15.5		
Moisture Equivalent	16.9	8.6	10.7	14.4	12.1	11.1
Total Carbon	2.0	0.44				
Sand	56.4	75.3	67.3	54.1	46.6	39.5
Silt	28.6	14.1	18.2	28.3	25.9	26.1
2 μ Clay	12.2	11.0	12.4	15.0	9.4	6.9
.2 μ Clay						
Montmorillonite	<5	15	10	0	<5	5
Illite	20	70	70	40	40	50
Kaolinite	8	16	14	10	12	16
Volume Weight (gms/cc)	1.4	1.6	1.6	1.7	2.0	2.0
Moisture Content at:						
0.00 Atms	30	22	22	20	13	31
0.01 Atms	29	21	20	18	12	30
0.02 Atms	27	19	18	17	12	30
0.03 Atms	25	18	17	16	12	30
0.04 Atms	24	17	16	16	11	30
0.06 Atms	22	16	15	15	11	30
0.33 Atms	18	12	11	14		30
1.00 Atms	17	11	10	13	11	29
3.00 Atms	9.9	6.0	7.1	8.6	6.5	4.9
5.00 Atms	9.0	5.7	6.5	7.8	5.5	4.1
8.00 Atms	8.1	5.6	6.2	7.2	4.7	3.4
15.00 Atms	7.7	4.9	5.5	6.2	3.8	2.7
27.19 Atms	7.1	4.7	4.8	5.4	3.3	2.2

* Except when noted figures indicate percent on an oven dry basis.

** Figures include only one determination.

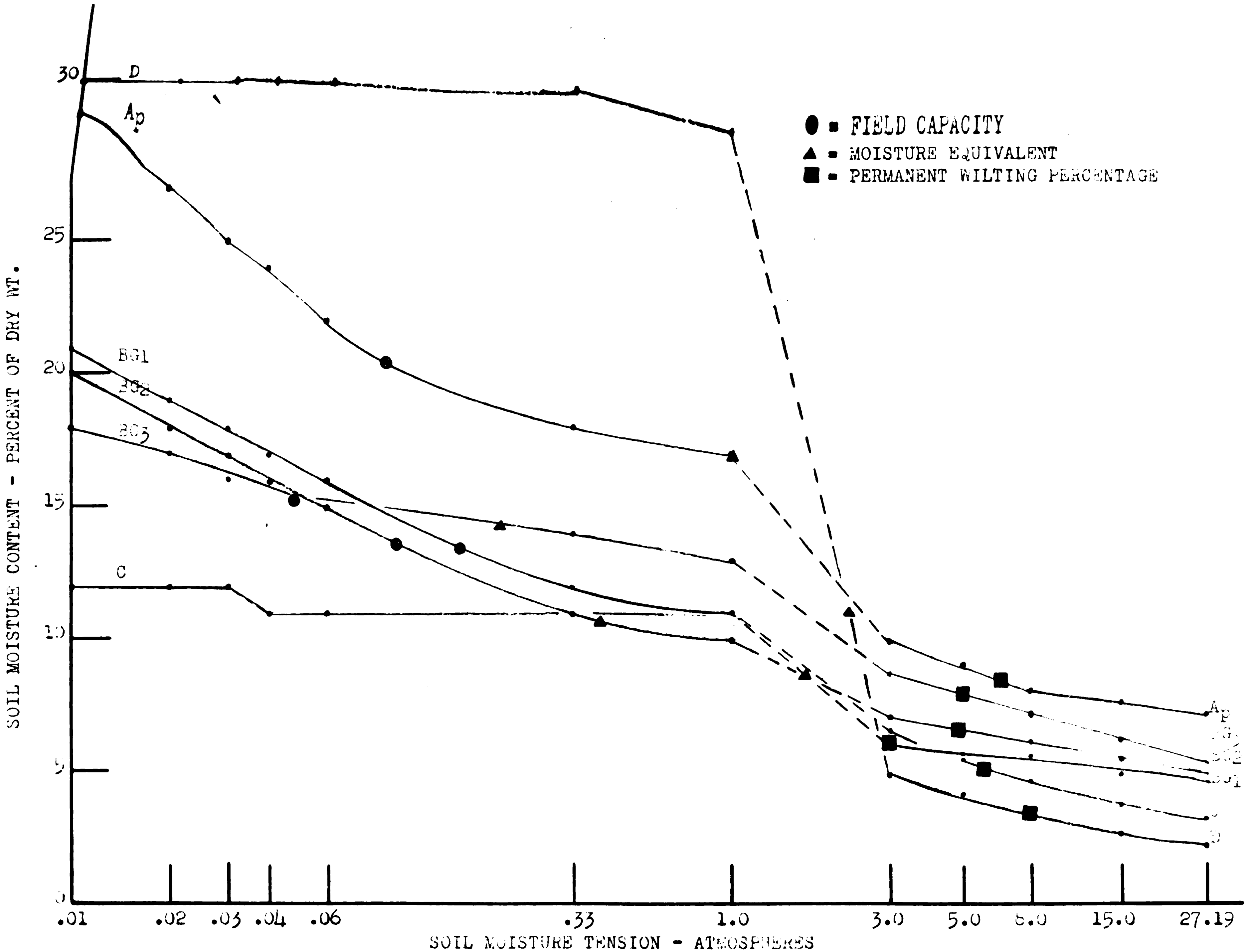


Figure 22. Moisture release curves for Brookston sandy loam site number five.

TABLE X

BASIC DATA ON SIMS CLAY LOAM SITE NUMBER SIX*

Sample Number	30	31	32	33	34
Horizon	A_p	B_1G	B2G	B3G	C
Depth (inches)	0-7	7-22	22-25	26-29	37-40
Hygroscopic Coefficient	3.1	2.0	1.6	1.8	1.8
Permanent Wilting Point	17.6**	12.6**	14.6	15.0	16.6
Field Capacity	39.2	27.1	21.0	19.2	18.4
Moisture Equivalent	33.1	21.4	20.9	20.6	25.0
Total Carbon	5.4	1.3			
Sand	36.9	37.2	30.3	33.2	35.8
Silt	28.3	30.4	29.3	30.9	31.0
2μ Clay	22.6	27.8	29.9	32.2	33.4
$.2\mu$ Clay	10.8	13.0	15.1	15.4	15.5
Montmorillonite	0	5	<5	10	0
Illite	20	60	50	60	20
Kaolinite	8	18	10	18	8
Volume weight (gms/cc)	1.0	1.4	1.5	1.5	1.6
Moisture Content at:					
0.00 Atms	60	33	26	27	23
0.01 Atms	52	29	24	23	21
0.02 Atms	47	27	23	22	21
0.03 Atms	46	26	22	21	21
0.04 Atms	44	25	21	21	20
0.06 Atms	42	24	21	20	20
0.33 Atms	38	24	17		19
1.00 Atms	37	23	17	20	18
3.00 Atms	23.6	15.6	15.1	15.9	17.7
5.00 Atms	21.9	14.7	13.9	14.7	16.6
8.00 Atms	20.2	13.0	12.8	13.3	15.1
15.00 Atms	19.4	11.6	11.2	12.0	13.4
27.19 Atms	16.0**	10.2	9.7	10.0	11.3

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.

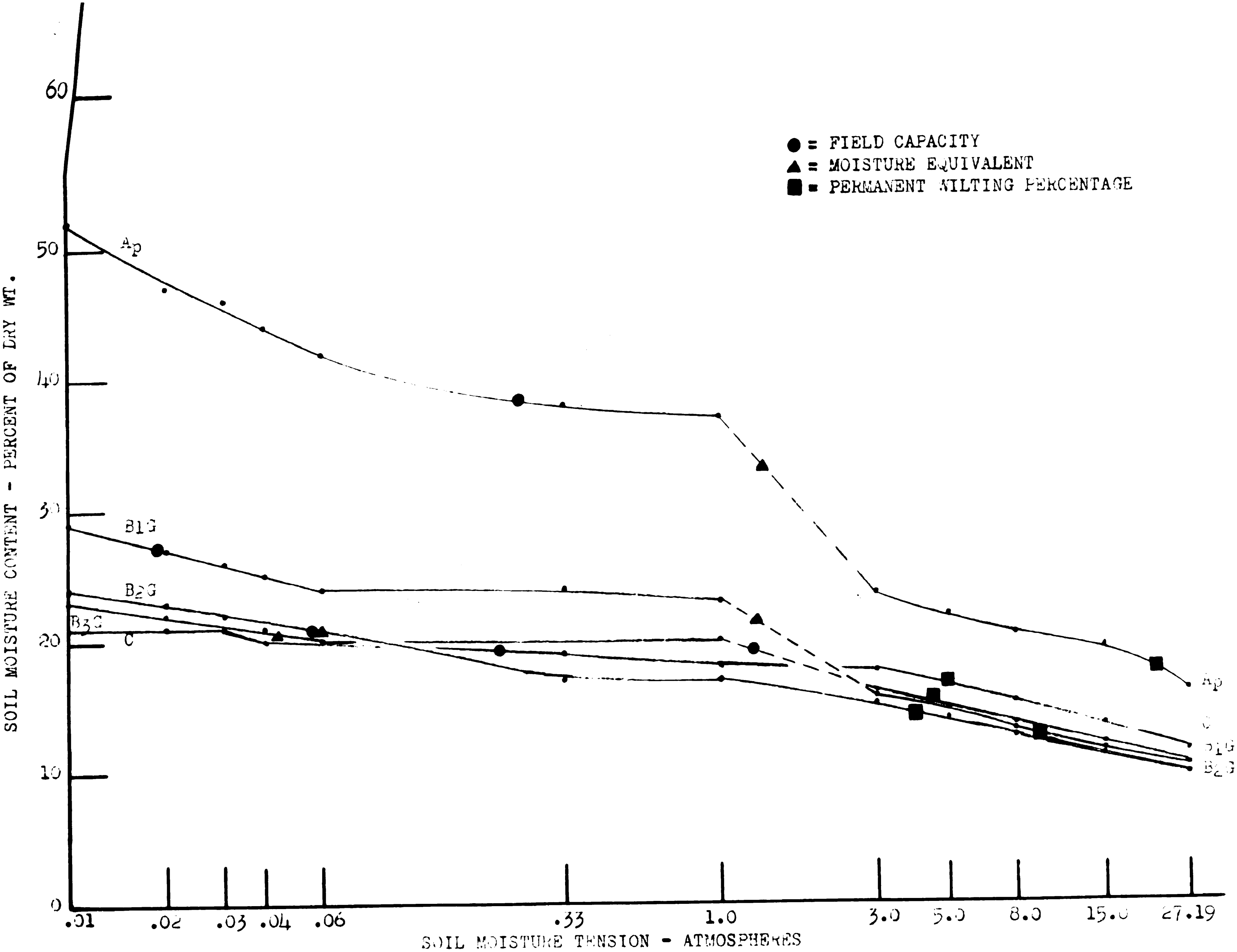


Figure 25. Moisture release curves for Sims clay loam site number six.

TABLE XI

BASIC DATA ON NAPPANEE SILT LOAM SITE NUMBER SEVEN*

Sample Number	35	36	37	38	39
Horizon	A_p	$B1_g$	B_{2g}	C	D
Depth (inches)	0-5	6-13	13-20	20-41	41
Hygroscopic Coefficient	1.6	2.2	2.3	1.5	1.3
Permanent Wilting Point	15.3	16.3	19.1	16.1	15.9
Field Capacity	29.6	22.1	21.0	15.0	
Moisture Equivalent	24.9	23.0	25.5	20.8	22.4
Total Carbon	2.3	0.59			
Sand	28.9	23.5	13.3	10.6	12.3
Silt	42.6	32.3	35.6**	27.3	27.0**
2μ Clay	22.3	38.7	46.6	34.1	32.7
.2μ Clay	8.0	17.1	20.9	14.3	14.3
Montmorillonite	<5	5	0	<5	<5
Illite	30	50	50	50	40
Kaolinite	4	10	4	<2	10
Volume Weight (gms/cc)	1.1	1.5	1.5	1.6	1.7
Moisture Content at:					
0.00 Atms	49	28	26	23	20
0.01 Atms	40	24	24	21	19
0.02 Atms	37	23	23	20	18
0.03 Atms	36	22	22	20	18
0.04 Atms	35	22	22	20	18
0.06 Atms	34	21	22	19	17
0.33 Atms	34	21	20	17	17
1.00 Atms	33	21	19	17	16
3.00 Atms	22.8	17.2	20.2	17.5	18.5
5.00 Atms	14.7	15.8	19.0	16.5	17.2
8.00 Atms	12.5	14.6	18.0	15.9	15.7
15.00 Atms	11.6	13.0	16.4	13.1	13.4
27.19 Atms	9.0	11.6	14.1	11.1	10.9

* Except when noted figures indicate percent on an oven dry basis.

** Figures include only one determination.

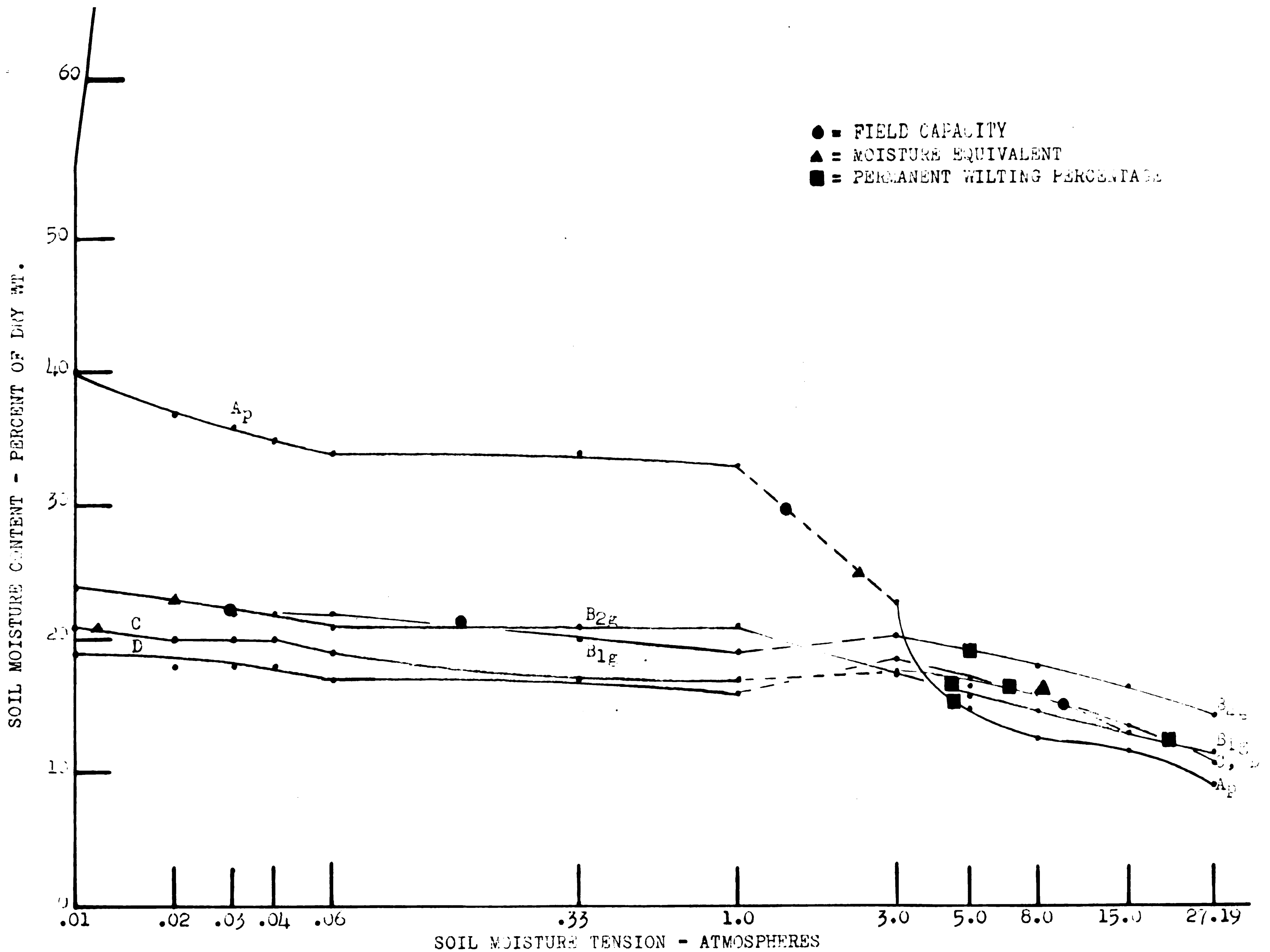


Figure 24. Moisture release curves for Nappanee silt loam site number seven.

TABLE XII

BASIC DATA ON HOYTSVILLE CLAY LOAM SITE NUMBER EIGHT*

Sample Number	40	41	42
Horizon	Ap	G1B	G2B
Depth (inches)	0-7	7-12	12-43
Hygroscopic Coefficient	3.5	2.6	2.4
Permanent Wilting Point	29.1	19.1	19.8
Field Capacity	42.3	27.5	25.1
Moisture Equivalent	38.6	27.4	26.8
Total Carbon	4.7	1.7	
Sand	11.5	17.4	15.2
Silt	32.0	36.6	38.1
2 µ Clay	43.9	39.1	41.9
.2 µ Clay	18.5	18.7	20.4
Montmorillonite	5	5	<5
Illite	50	70	50
Kaolinite	8	<2	8
Volume Weight (gms/cc)	0.92	1.3	1.4
Moisture Content at:			
0.00 Atms	62	36	31
0.01 Atms	55	33	29
0.02 Atms	50	32	28
0.03 Atms	49	32	28
0.04 Atms	48	32	28
0.06 Atms	46	31	27
0.33 Atms	45	30	25
1.00 Atms	43	28	25
3.00 Atms	28.7	20.3	20.7
5.00 Atms	27.4	19.2	19.1
8.00 Atms	25.3	17.8	17.8
15.00 Atms	24.1	16.0	15.9
27.19 Atms	19.3**	14.2	13.8**

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.

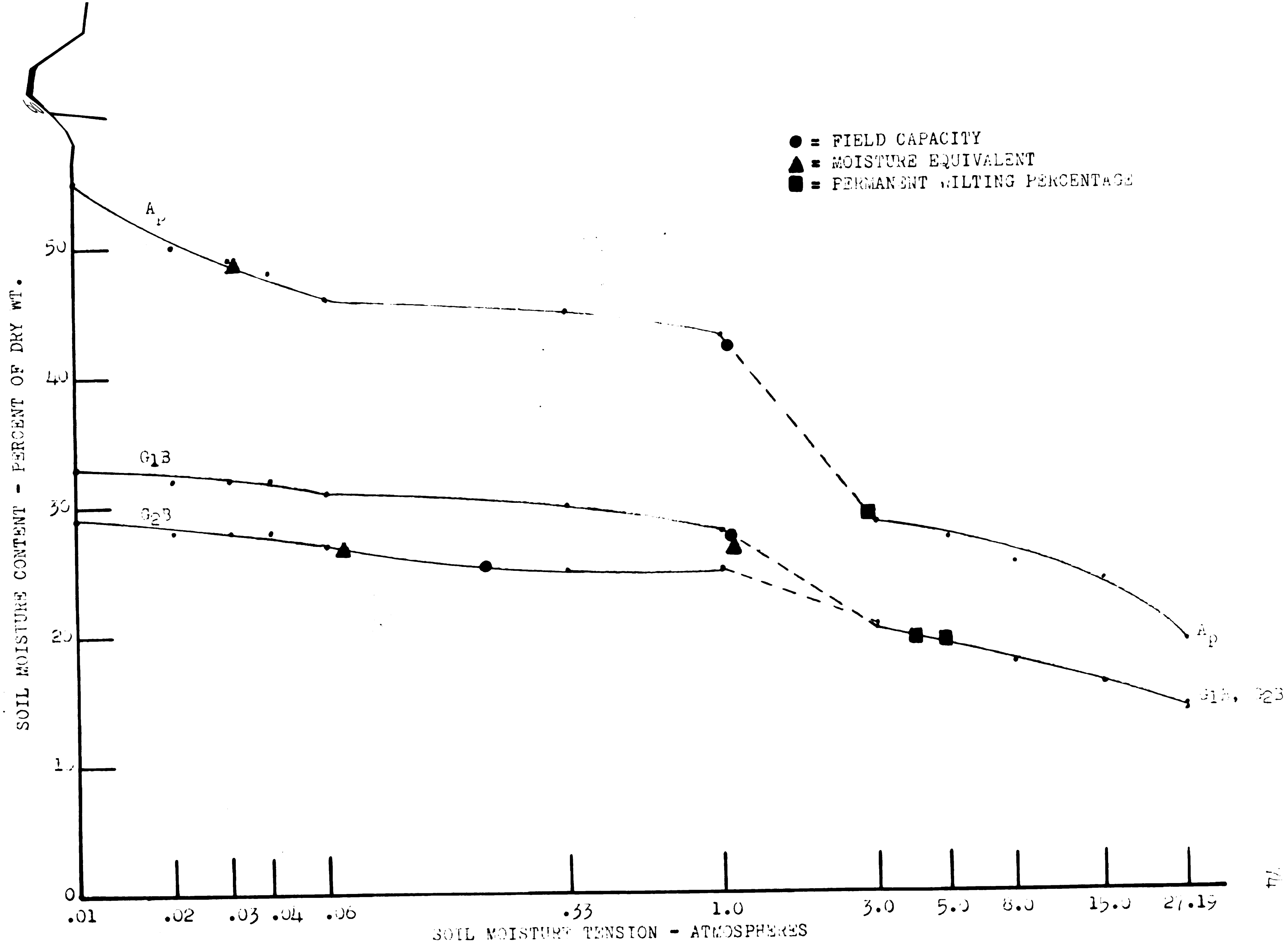


Figure 25. Moisture release curves for Hoytsville clay site number eight.

TABLE XIII

BASIC DATA ON FOX SANDY LOAM SITE NUMBER NINE*

Sample Number	43	44	45	46	47
Horizon	A_p	B_1	B_2	B_3	C_1
Depth (inches)	0-8	8-14	14-20	20-37	37
Hygroscopic Coefficient	0.61	0.96	1.2	0.92	0.23
Permanent Wilting Point	4.9**	6.7	7.1**	6.2	2.0
Field Capacity	13.1	12.7	15.0	10.6	9.5
Moisture Equivalent	10.0	10.5	12.3	8.5	3.4
Total Carbon	0.8	0.5			
Sand	72.0	67.2	76.3	79.2	63.6
Silt	19.2	18.1	7.9	7.2**	21.6
2µ Clay	6.7	13.3	14.3	11.8	2.3
.2µ Clay					
Montmorillonite	0	<5	5	5	0
Illite	20	20	50	50	30
Kaolinite	8	6	8	<2	8
Volume weight (gm/cc)	1.6	1.6	1.6	1.5	
Moisture Content at:					
0.00 Atms	20	20	21	22	
0.01 Atms	20	17	19	20	
0.02 Atms	19	15	17	17	
0.03 Atms	18	14	18	15	
0.04 Atms	16	13	14	14	
0.06 Atms	14	12	14	13	
0.33 Atms	11		12	7	
1.00 Atms	10	12	11	6	
3.00 Atms	5.4	6.9	8.1	6.2	2.2
5.00 Atms	5.1	6.4	7.7	5.9	1.9
8.00 Atms	4.0	5.6	6.9	5.6	1.7
15.00 Atms	3.3	5.0	6.7	4.8	1.5
27.19 Atms	3.1	4.6	6.0	4.1	1.4

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.

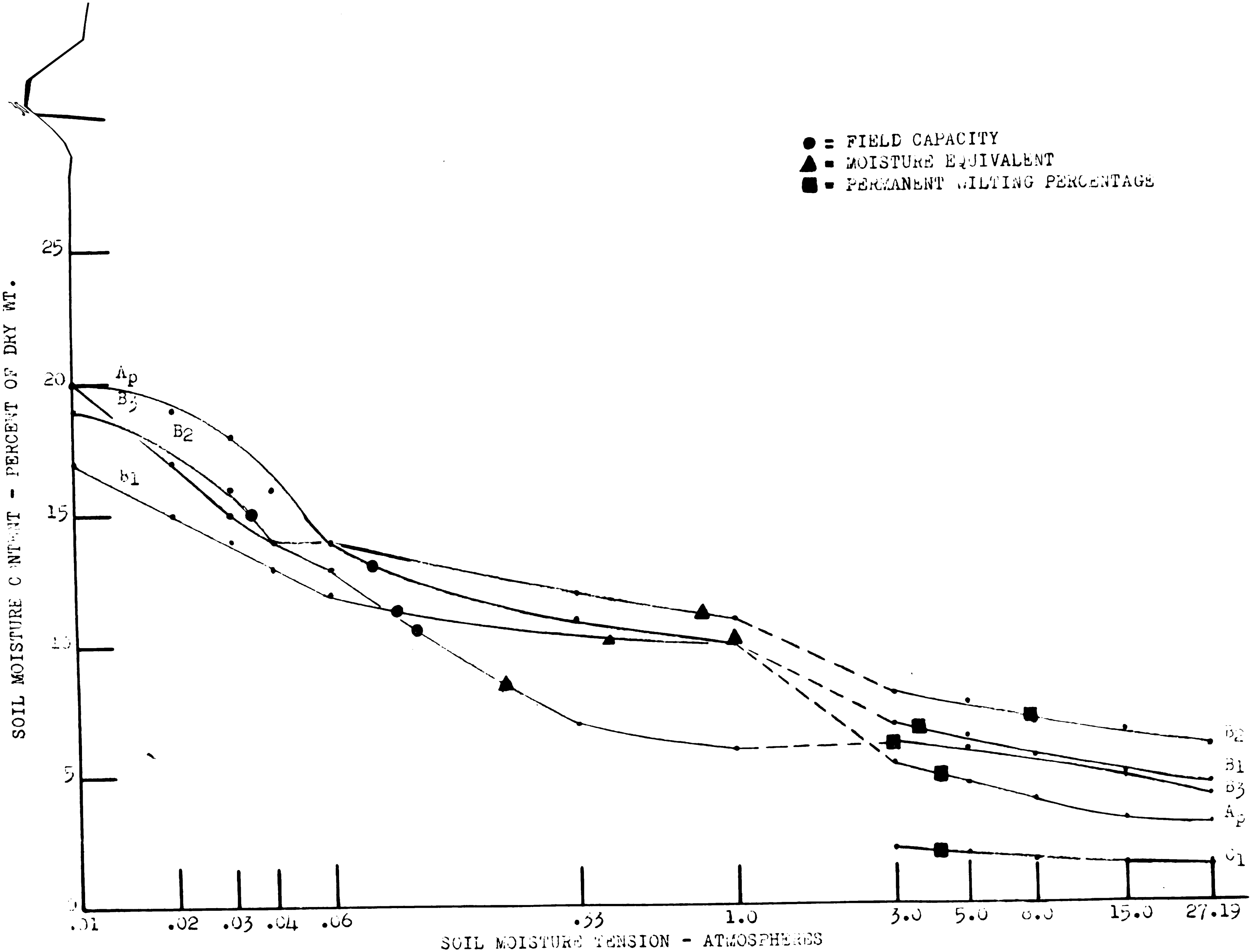


Figure 20. Moisture release curves for Fox sandy loam site number nine.

TABLE XIV

BASIC DATA ON FOX SANDY LOAM SITE NUMBER TEN*

Sample Number	48	49	50	51	52	53
Horizon	A_p	B1	B_2	B_3	C_1	C_2
Depth (inches)	0-8	8-12	12-21	21-34	34-41	41
Hygroscopic Coefficient	0.66	1.2	1.6	0.47	0.19	0.45
Permanent Wilting Point	4.9**	8.3	10.6**	3.1	1.4	3.2
Field Capacity	14.7	14.3	12.9	9.0	6.4	
Moisture Equivalent	13.9	12.6	14.1	4.3	1.7	4.6
Total Carbon	0.85	0.30				
Sand	52.4	45.4	66.0	90.6	96.1	90.6
Silt	36.9	35.1	10.3	5.9	1.5	1.9
2 µ Clay	7.7	17.3	21.2	2.7	1.9	5.4
.2 µ Clay			30.4			
Montmorillonite	5	<5	5	0	0	0
Illite	30	30	30	10	0	30
Kaolinite	10	8	8	0	0	10
Volume weight (gms/cc)	1.5	1.6	1.6	1.5		
Moisture Content at:						
0.00 Atms	23	22	23	23		
0.01 Atms	22	20	21	22		
0.02 Atms	21	19	19	18		
0.03 Atms	20	18	19	14		
0.04 Atms	19	17	18	12		
0.06 Atms	17	16	17	11		
0.33 Atms	17		17	11		
1.00 Atms	15	16	16	10		
3.00 Atms	6.0	9.5	10.2	3.3	1.4	3.3
5.00 Atms	4.9	8.3	9.6	3.1	1.3	3.3
8.00 Atms	4.1	7.5	9.3	2.9	1.3	3.2
15.00 Atms	3.4	6.3	8.4	2.7	1.1	2.8
27.19 Atms	3.1	5.8	8.0	2.6	1.0	2.6

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.

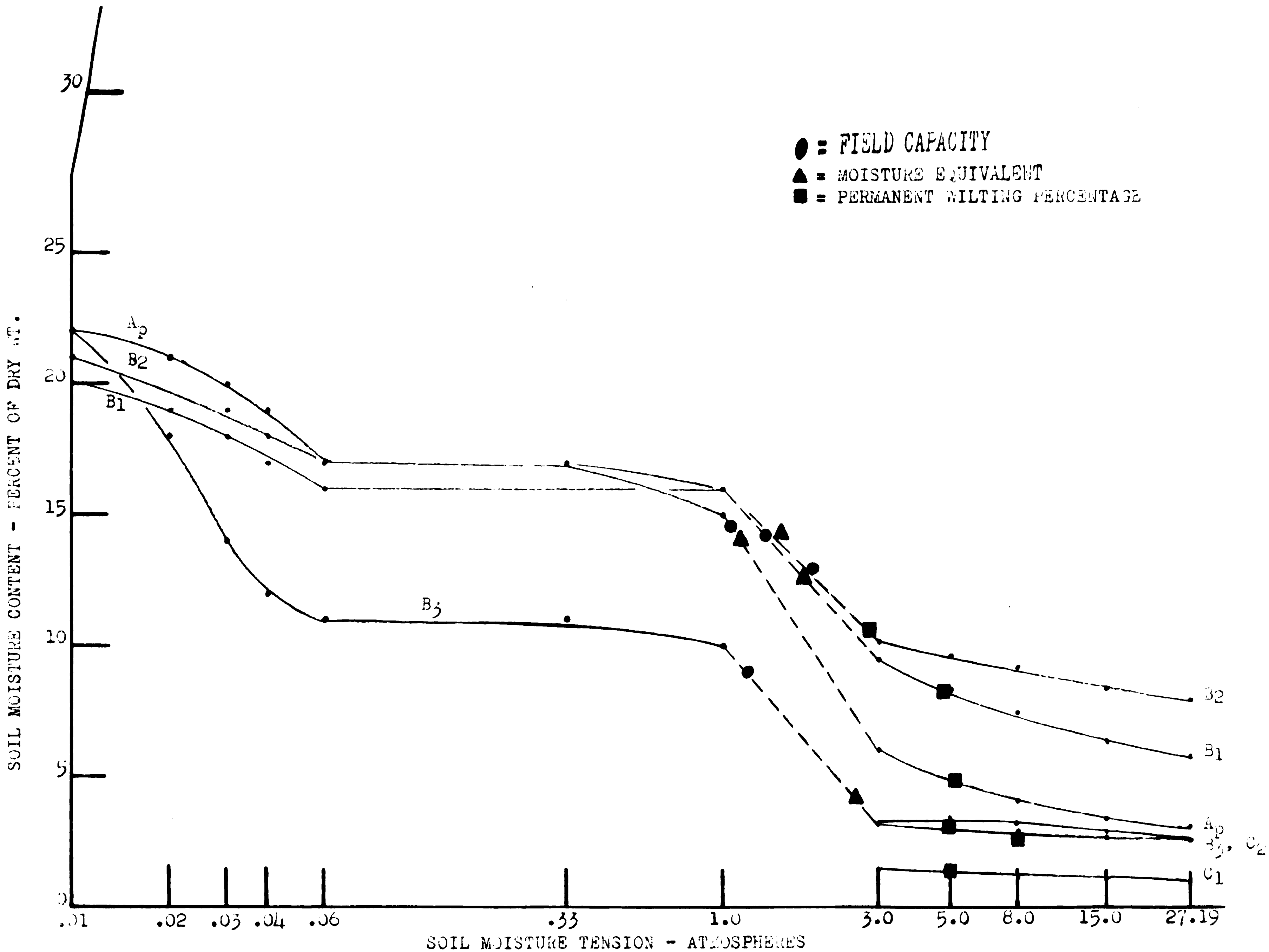


Figure 27. Moisture release curves for Fox sandy loam site number ten.

TABLE XV

BASIC DATA ON WARSAW SILT LOAM SITE NUMBER ELEVEN*

Sample Number	54	55	56	57	58	59
Horizon	Ap	A3B1	B2	B3	C1	C2
Depth (inches)	0-3	8-15	15-30	33-38	38-44	44
Hygroscopic Coefficient	2.1	2.5	2.0	0.34	0.13	0.28
Permanent Wilting Point	14.4	12.7	6.1	2.8	0.98	2.3
Field Capacity	24.9	25.1	18.2	10.2		
Moisture Equivalent	25.6	19.5	11.3	3.1	1.5	2.8
Total Carbon	2.6	0.44				
Sand	10.0	32.6	65.6	90.0	96.0	87.7
Silt	54.1	37.6	25.9	4.7	1.0	3.6
2 μ Clay	18.1	25.6	11.2	4.1	1.0	3.9
.2 μ Clay		14.7				
Montmorillonite	20	0	<5	<5	0	<5
Illite	90	0	30	40	20	40
Kaolinite	24	0	4	8	6	8
Volume Weight (gm/cc)	1.2	1.4	1.6	1.6		
Moisture Content at:						
0.00 Atms	39	29	21	19		
0.01 Atms	36	29	20	17		
0.02 Atms	34	28	19	15		
0.03 Atms	32	27	18	13		
0.04 Atms	30	26	17	11		
0.06 Atms	29	25	16	10		
0.33 Atms		25	14	6		
1.00 Atms		24	13	5		
3.00 Atms	15.4	13.8	8.3	2.7	1.0	2.3
5.00 Atms	13.2	12.8	5.9	2.4	0.99	2.0
8.00 Atms	11.2	11.4	5.5	2.3	0.93	1.8
15.00 Atms	9.3	10.3	4.7	2.1	0.81	1.4
27.19 Atms	8.5	10.0	4.4	2.0	0.81	1.5

* Except when noted figures indicate percent on an oven dry basis.

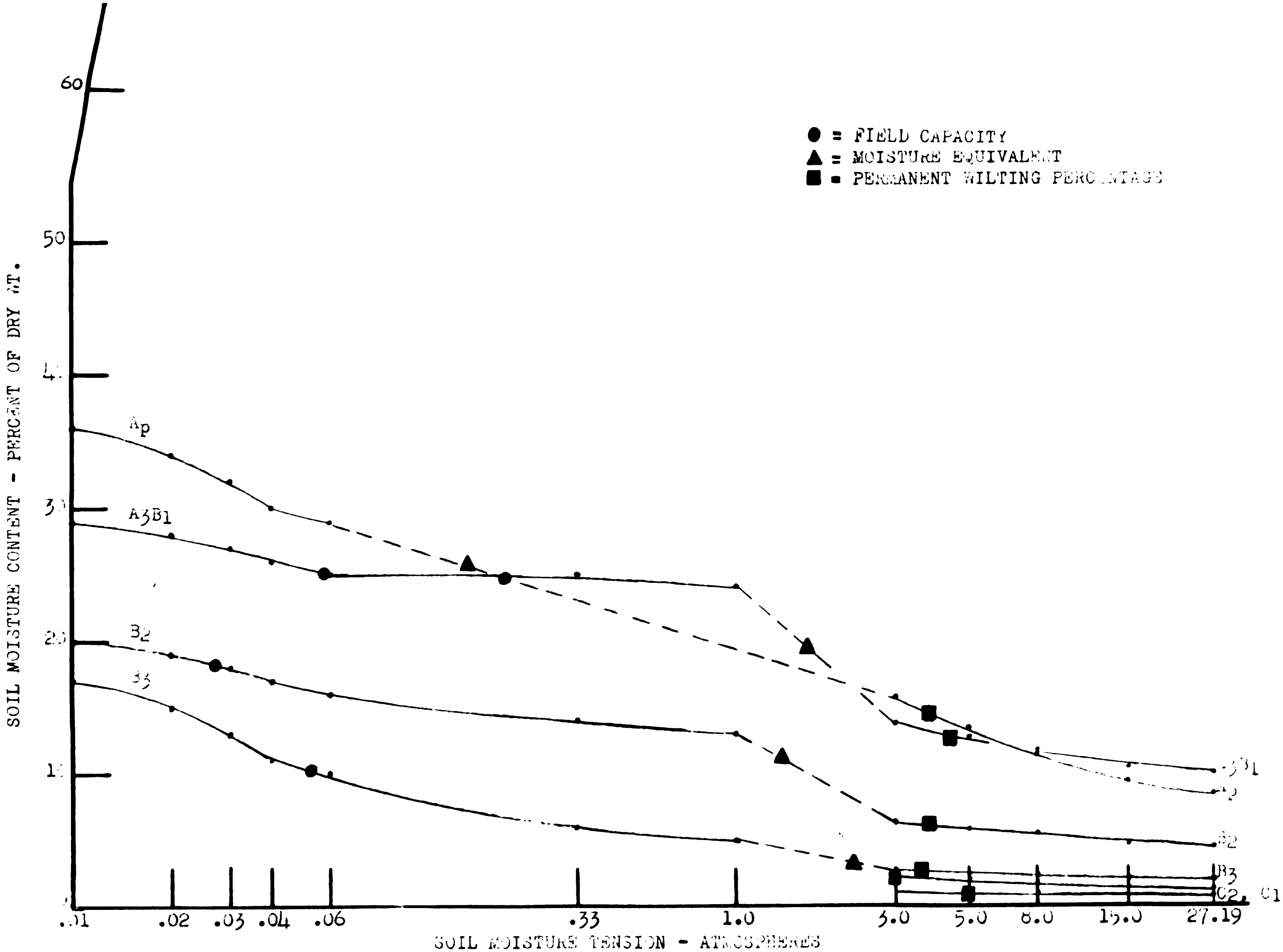


Figure 2[illegible]. Moisture release curves for Warsaw silt loam site number eleven.

TABLE VI

BASIC DATA [illegible]*

Sample Number	60	61	62	63
Horizon	Ap	A_2	C_1	D_3
Depth (inches)	0-10	10-30	30-40	40
Hygroscopic Coefficient	0.59	0.21	0.29	0.38
Permanent Wilting Point	3.0**	1.8	2.[illegible]	3.3
Field Capacity	9.7	8.6	7.0	10.6
Moisture Equivalent	4.7	2.9	3.2	4.4
Total Carbon	0.39	0.06		
Sand	84.5	90.1	92.9	69.1
Silt	[illegible]	6.3	1.2**	4.1
2 μ Clay	4.4	3.2	4.6	9.2
.2 μ Clay				
Montmorillonite	<5	0	0	5
Illite	10	0	0	50
Kaolinite	6	0	0	12
Volume Weight (gms/cc)	1.5	1.5	1.5	1.5
Moisture Content at:				
0.00 Atms	25	23	22	25
0.01 Atms	24	22	22	24
0.02 Atms	23	21	21	24
0.03 Atms	22	16	15	23
0.04 Atms	19	11	10	20
0.06 Atms	13	8	7	16
0.33 Atms	8	6	3	4
1.00 Atms	7	5	2	4
3.00 Atms	3.5	2.2	2.7	3.8
5.00 Atms	3.1	1.9	2.5	3.3
8.00 Atms	2.9	1.7	2.3	2.9
15.00 Atms	2.1	1.5	2.0	2.5
27.19 Atms	2.1	1.2	1.9	2.2

* Except when noted figures indicate percent on an oven dry basis.

** Figures include only one determination.

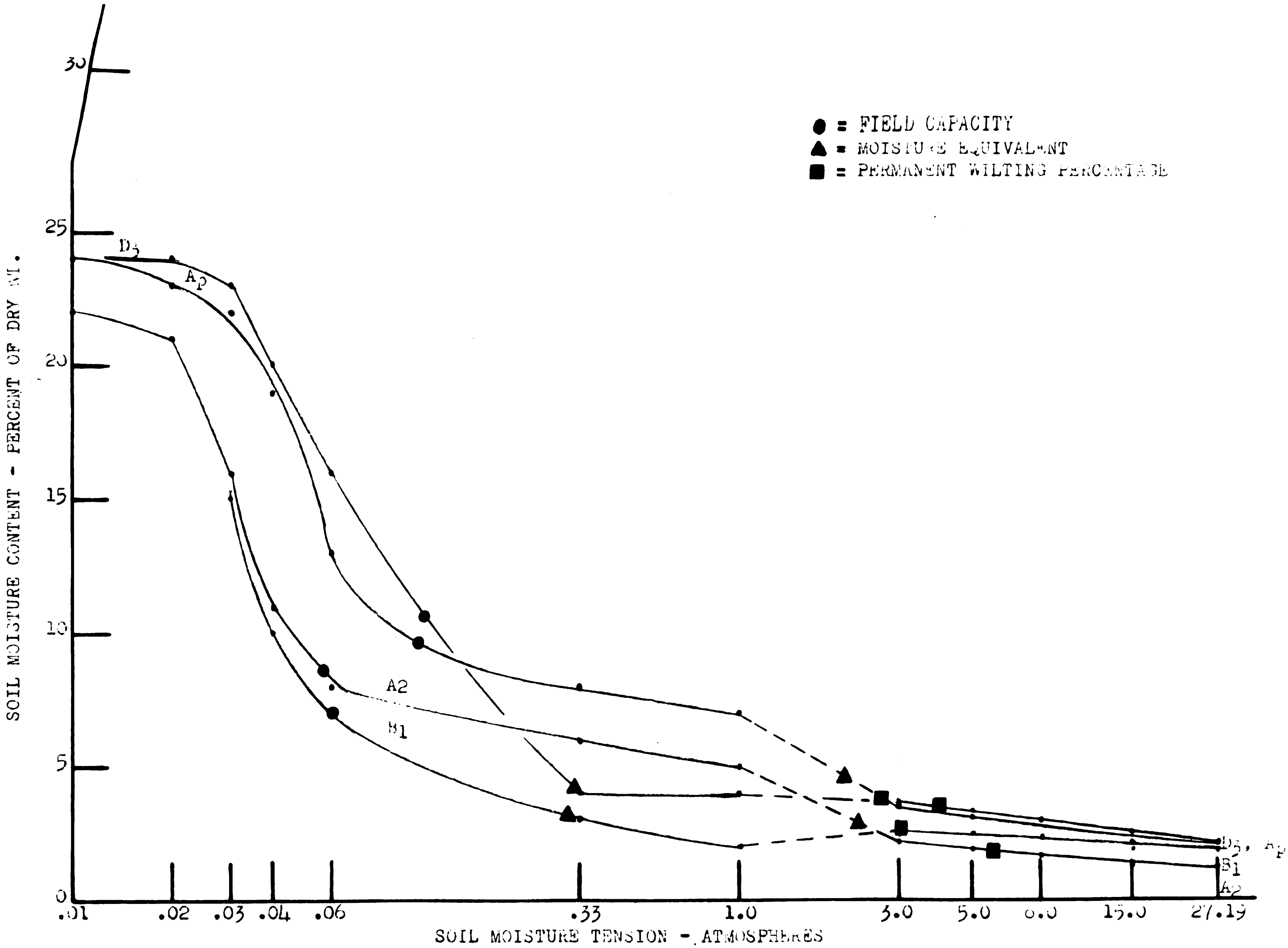


Figure 29. Moisture release curves for Spinks loamy sand site number twelve.

TABLE XVII

BASIC DATA ON [illegible] SANDY LOAM SITE NUMBER THIRTEEN*

Sample Number	64	65	66	67
Horizon	A_p	A_{21}	A_{22}	C_1
Depth (inches)	0-8	8-11	11-17	17-39
Hygroscopic Coefficient	0.70	0.52	0.27	0.14
Permanent Wilting Point	5.4**	4.9	3.3	1.4
Field Capacity	11.5	11.4		
Moisture Equivalent	12.6	8.2	5.6	2.0
Total Carbon	1.3	0.67		
Sand	69.3	75.0	81.2	95.9
Silt	17.7	14.1	13.3	1.7
2μ Clay	7.9	6.4	4.6	1.6
.2μ Clay				
Montmorillonite	0	5	<5	5
Illite	10	20	30	50
Kaolinite	6	8	10	12
Volume Weight (gms/cc)	1.4	1.5		1.6
Moisture Content at:				
0.00 Atms	26	22		19
0.01 Atms	25	21		18
0.02 Atms	24	19		16
0.03 Atms	22	17		12
0.04 Atms	21	15		9
0.06 Atms	19	13		8
0.33 Atms	16	12		8
1.00 Atms	15	11		7
3.00 Atms	7.6	4.9	3.4	1.5
5.00 Atms	6.6	4.2	2.9	1.3
8.00 Atms	5.5	3.5	2.4	1.2
15.00 Atms		2.8	1.9	1.0
27.19 Atms	4.3	2.6	1.7	0.87

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.

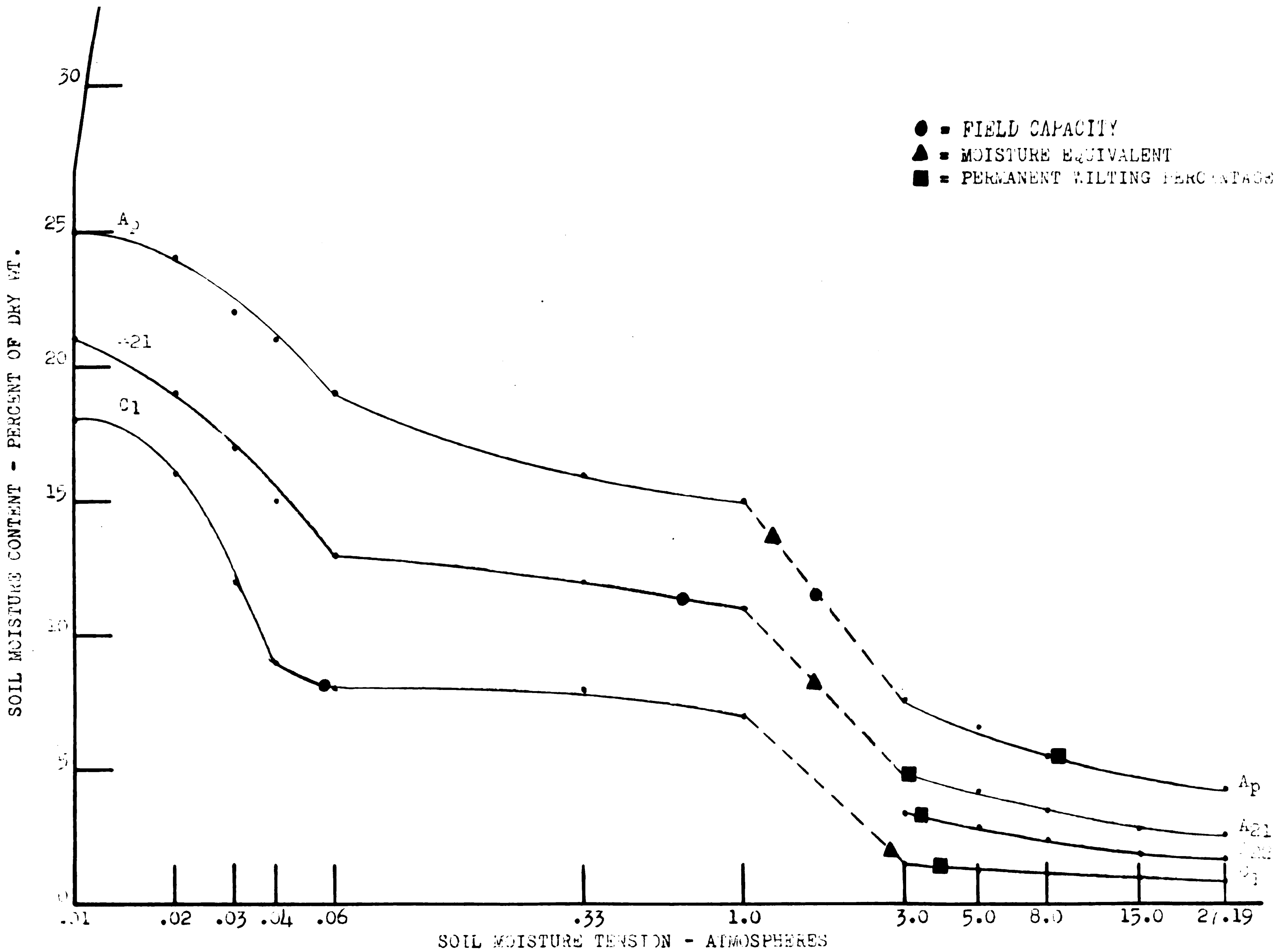


Figure 50. Moisture release curves for Berrien sandy loam site number thirteen.

TABLE XVIII

BASIC DATA ON WABASH SILT LOAM SITE NUMBER FOURTEEN*

Sample Number	68	69	70	71	72
Horizon	A_pA_1	B_{21}	B_{22}	C_1	D
Depth (inches)	0-11	11-21	21-28	28-41	41-65
Hygroscopic Coefficient	1.6	2.5	1.2	0.35	0.12
Permanent Wilting Point	10.5**	12.4	7.0**	2.5**	0.86
Field Capacity	21.0	21.6	11.3	7.8	
Moisture Equivalent	18.4	20.8	8.6	2.9	1.2
Total Carbon	1.8	0.81			
Sand	36.9	50.1	73.8	93.2	97.0
Silt	40.1	39.9	10.2	2.4	1.0
$<2\mu$ Clay	16.5	24.8	14.1	4.0	1.4
$.2\mu$ Clay		15.4			
Montmorillonite	0	<5	5	5	0
Illite	20	30	40	60	30
Kaolinite	6	4	6	10	6
Volume Weight (gms/cc)	1.5	1.4	1.6		
Moisture Content at:					
0.00 Atms	26	28	20		
0.01 Atms	24	25	20		
0.02 Atms	24	24	19		
0.03 Atms	23	23	19		
0.04 Atms	23	23	16		
0.06 Atms	22	22	15		
0.33 Atms	20	19	13		
1.00 Atms	19	18	13		
3.00 Atms	12.0	14.2	7.3	2.2	1.0
5.00 Atms	10.9	12.8	6.7	2.1	1.0
8.00 Atms	8.8	11.6	6.6	2.1	1.0
15.00 Atms	7.8	10.3	5.7	1.7	0.85
27.19 Atms	7.2	9.3	5.5	1.6	0.78

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.

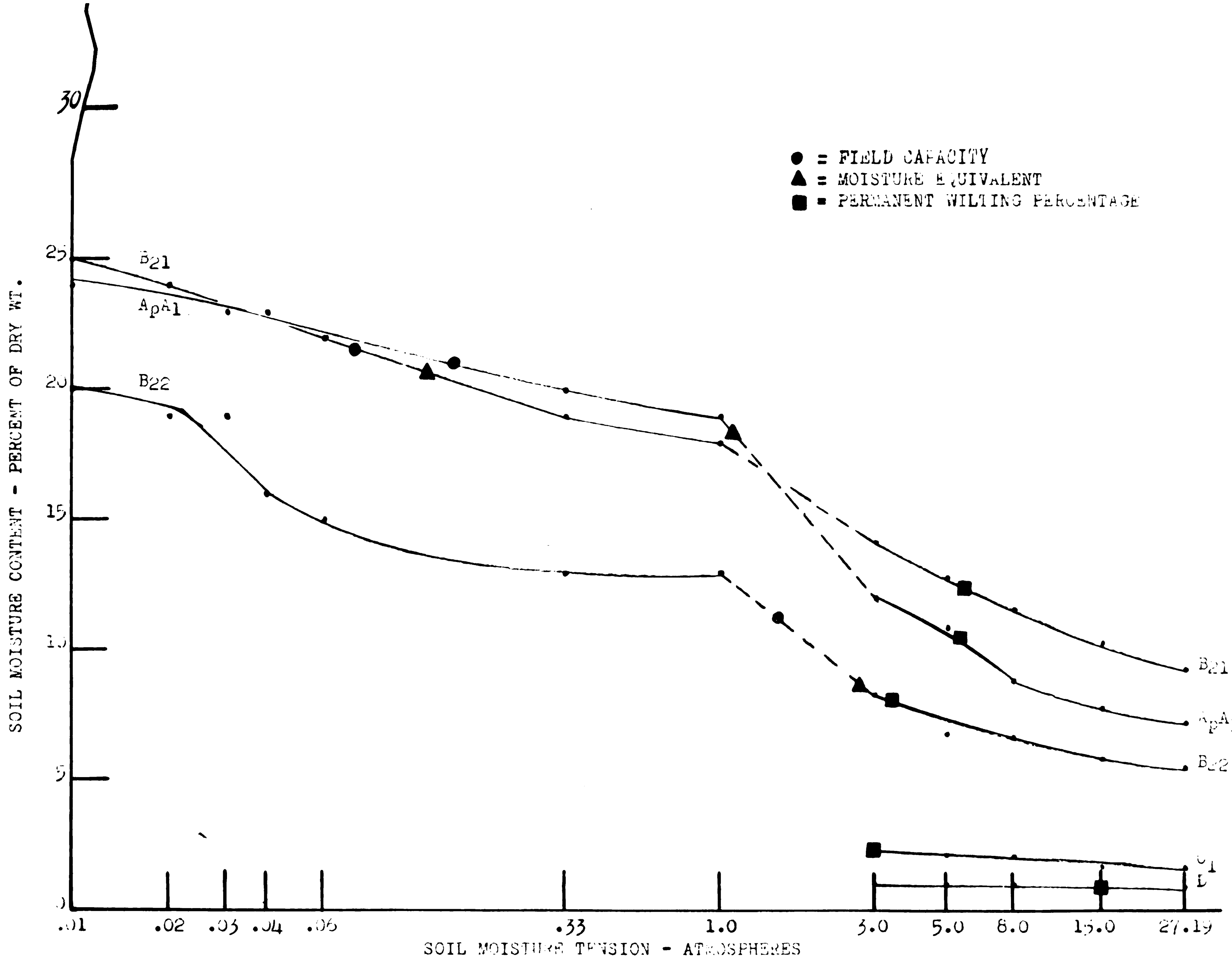


Figure 51. Moisture release curves for Warsaw silt loam site number fourteen.

TABLE XIX

BASIC DATA ON FOX SANDY LOAM SITE NUMBER FIFTEEN*

Sample Number	73	74	75	76	77	78
Horizon	Ap	A_2	B_1	B_2	B_{31}	B_{32}
Depth (inches)	0-11	11-14	14-17	17-24	24-28	28-36
Hygroscopic Coefficient	0.66	0.90	1.4	2.4	0.75	0.77
Permanent Wilting Point	6.2	7.7	9.6	11.7	5.5	4.6
Field Capacity	16.8	15.3	15.3	17.2	14.3	
Moisture Equivalent	15.4	16.2	15.8	15.5	8.3	6.1
Total Carbon	0.79	0.33				
Sand	46.5	40.0	44.1	40.6	83.3	86.8
Silt	41.4	43.5	32.6	26.0	4.5	2.8
2 µ Clay	9.3	14.5	21.2	28.0	11.3	9.3
.2 µ Clay			30.3	42.9		
Montmorillonite	0	5	0	10	0	<5
Illite	20	40	10	70	0	40
Kaolinite	4	12	0	12	0	8
Volume Weight (gms/cc)	1.4	1.6	1.6	1.7	1.7	
Moisture Content at:						
0.00 Atms	27	25	25	22	19	
0.01 Atms	23	20	21	20	18	
0.02 Atms	21	19	20	20	17	
0.03 Atms	20	18	19	19	16	
0.04 Atms	19	18	18	18	15	
0.06 Atms	18	17	17	18	14	
0.33 Atms	16	15	16	16	14	
1.00 Atms	15	14	15	15	13	
3.00 Atms	6.9	9.3	11.4	14.6	6.4	5.1
5.00 Atms	5.6	7.6	10.1	13.3	5.8	4.6
8.00 Atms	4.8	6.8	9.6	12.5	5.2	4.3
15.00 Atms	3.6	5.4	8.4	11.2	4.9	4.1
27.19 Atms	3.6	4.7	6.1**	10.4	4.4	3.7

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.

TABLE XIX (continued)

Sample Number	79	80	81
Horizon	C_1	C_2	D
Depth (inches)	36-46	46-54	54
Hygroscopic Coefficient	0.41	0.28	0.12
Permanent Wilting Point	3.1**	2.0**	1.2
Field Capacity			
Moisture Equivalent	3.8	3.1	1.7
Total Carbon			
Sand	91.2	92.3	97.2
Silt	1.8	2.7	1.2
2 μ Clay	5.9	3.9	1.6
.2 μ Clay			
Montmorillonite	5	0	
Illite	60	30	
Kaolinite	8	4	
Volume Weight (gms/cc)			
Moisture Content at:			
0.00 Atms			
0.01 Atms			
0.02 Atms			
0.03 Atms			
0.04 Atms			
0.06 Atms			
0.33 Atms			
1.00 Atms			
3.00 Atms	3.5	2.4	1.2
5.00 Atms	3.2	2.3	1.3
8.00 Atms	3.0	2.2	0.97
15.00 Atms	2.8	2.0	1.0
27.19 Atms	2.4	1.8	0.85

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.

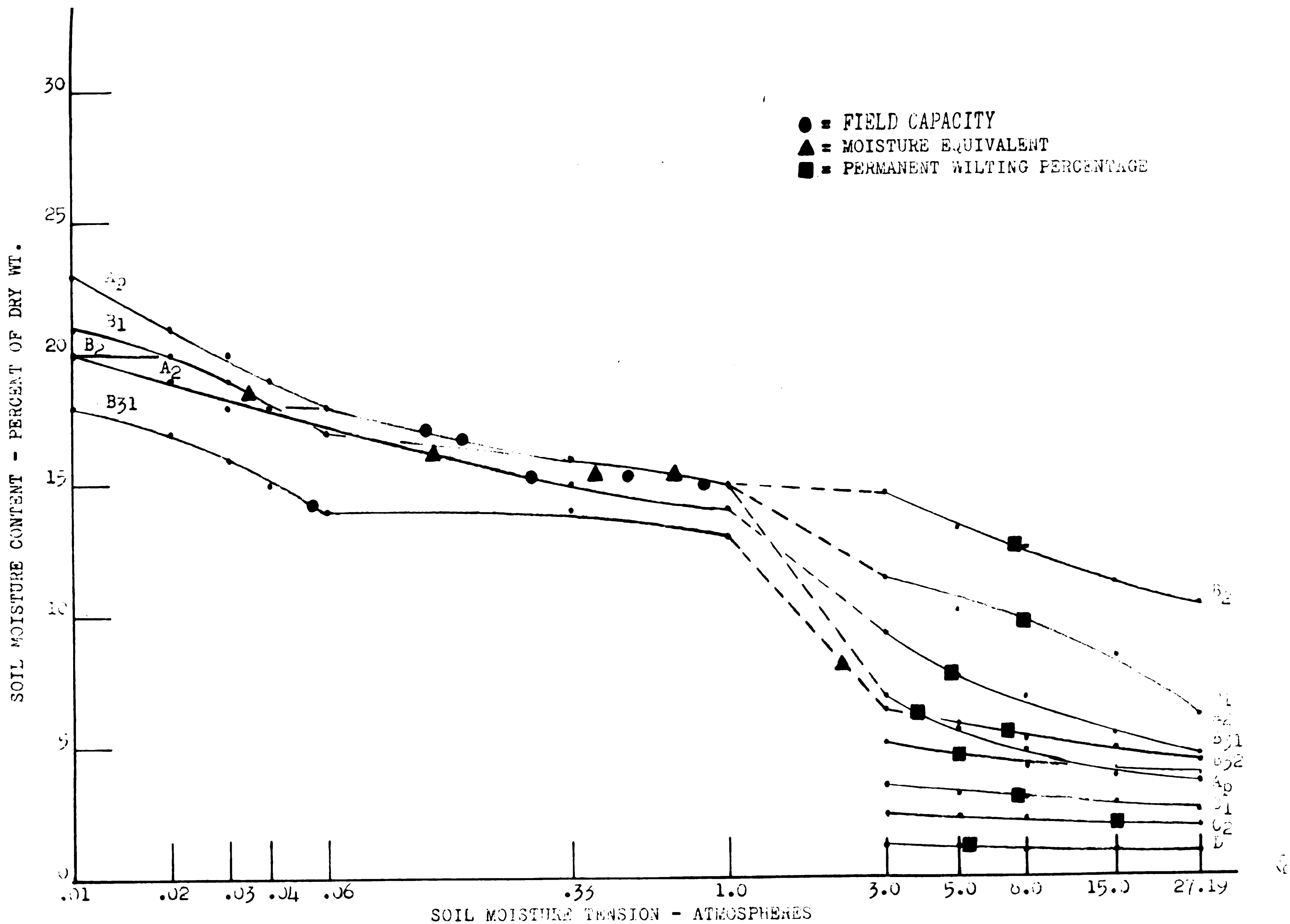


Figure 32. Moisture release curves for Fox sandy loam site number fifteen.

[illegible]

BASIC DATA [illegible]*

Sample Number	82	83	84	85	86
Horizon	Ap	A2	B_{1g}	B_{2g}	C
Depth (inches)	0-7	7-11	11-19	19-26	31
Hygroscopic Coefficient	1.4	0.57	1.54	1.6	0.66
Permanent Wilting Point	9.5	4.7	8.5	12.6	6.1
Field Capacity	24.3	20.1	17.0	20.4	12.5
Moisture Equivalent	20.5	15.1	15.7	19.7	13.7
Total Carbon	1.9	0.54			
Sand	40.6	55.2**	55.1	50.6	58.9
Silt	36.6	32.3	25.7	26.3	20.0
2 μ Clay	13.3	10.1	17.1	26.6	12.8
.2 μ Clay				15.7	
Montmorillonite	<5	0	<5	0	0
Illite	20	10	20	10	10
Kaolinite	6	2	4	4	2
Volume Weight (gms/cc)	1.3	1.5	1.6	1.5	1.9
Moisture Content at:					
0.00 Atms	34	24	25	25	15
0.01 Atms	30	22	23	24	14
0.02 Atms	29	22	22	23	14
0.03 Atms	28	21	21	22	14
0.04 Atms	27	21	21	21	13
0.06 Atms	26	20	20	20	13
0.33 Atms	24	20	17	17	12
1.00 Atms	22	19	15	16	11
3.00 Atms	12.0	6.5	10.2	14.2	9.7
5.00 Atms	10.1	5.4	[illegible]	13.0	6.5
8.00 Atms	8.6	4.0	6.5	11.0	7.4
15.00 Atms	6.2	5.0	7.2	10.7	6.0
[illegible].19 Atms	7.9	5.3	6.1	9.5	4.7

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.

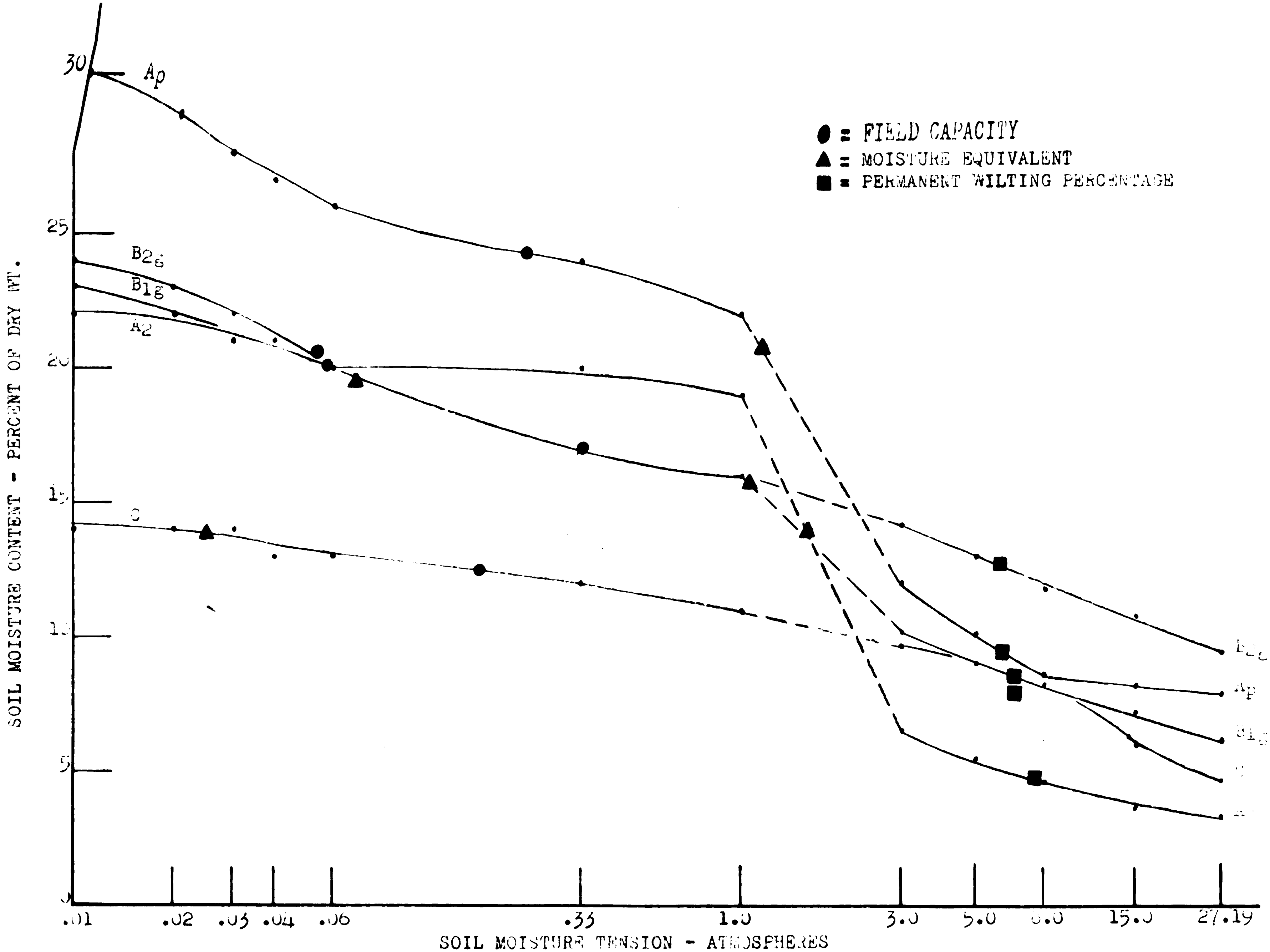


Figure 35. Moisture release curves for Conover loam site number sixteen.

TABLE XXI

BASIC DATA ON MIAMI LOAM SITE NUMBER SEVENTEEN*

Sample Number	87	88	89	90	91	92	93
Horizon	Ap	A2	A3	B21	B22	B3	C
Depth (inches)	0-8	8-12	12-18	18-24	24-32	32-45	45
Hygroscopic Coefficient	0.90	0.79	0.90	1.4	1.7	1.9	0.74
Permanent Wilting Point	8.0**	7.8	7.4**	10.3	11.6	12.2	8.3
Field Capacity	20.1	15.8	12.8	18.1	19.9		
Moisture Equivalent	17.7	15.1	13.8	18.3	18.2	18.8	14.3
Total Carbon	1.3	0.34					
Sand	48.0	46.8	49.5	44.9	44.7	45.8	57.3
Silt	36.0	37.8	33.8	27.6	28.2	28.7	22.7
2 μ Clay	11.6	13.4	17.2	24.0	25.3	25.2	15.2
.2 μ Clay				15.5		15.5	
Montmorillonite	0	0	0	0	0	0	0
Illite	0	0	10	30	30	0	10
Kaolinite	2	<2	2	6	6	0	6
Volume Weight (gms/cc)	1.5	1.6	1.7	1.6	1.6		1.9
Moisture Content at:							
0.00 Atms	26	25	19	23	24		15
0.01 Atms	24	20	18	22	24		15
0.02 Atms	24	20	18	22	23		15
0.03 Atms	24	19	17	21	23		14
0.04 Atms	23	18	17	21	22		14
0.06 Atms	22	18	16	20	22		13
0.33 Atms	21	18	16	19	21		13
1.00 Atms	19	17	14	18	20		12
3.00 Atms	9.7	8.4	9.8	12.1	13.0	13.6	9.8
5.00 Atms	8.1	7.0	8.3	11.0	12.0	12.4	8.7
8.00 Atms	6.8	5.9	7.3	10.3	11.5	11.8	7.3
15.00 Atms	5.8	4.5	5.4	8.8	10.0	10.1	6.1
27.13 Atms	5.8	5.8	5.0	7.6	8.8	8.7	4.9

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.

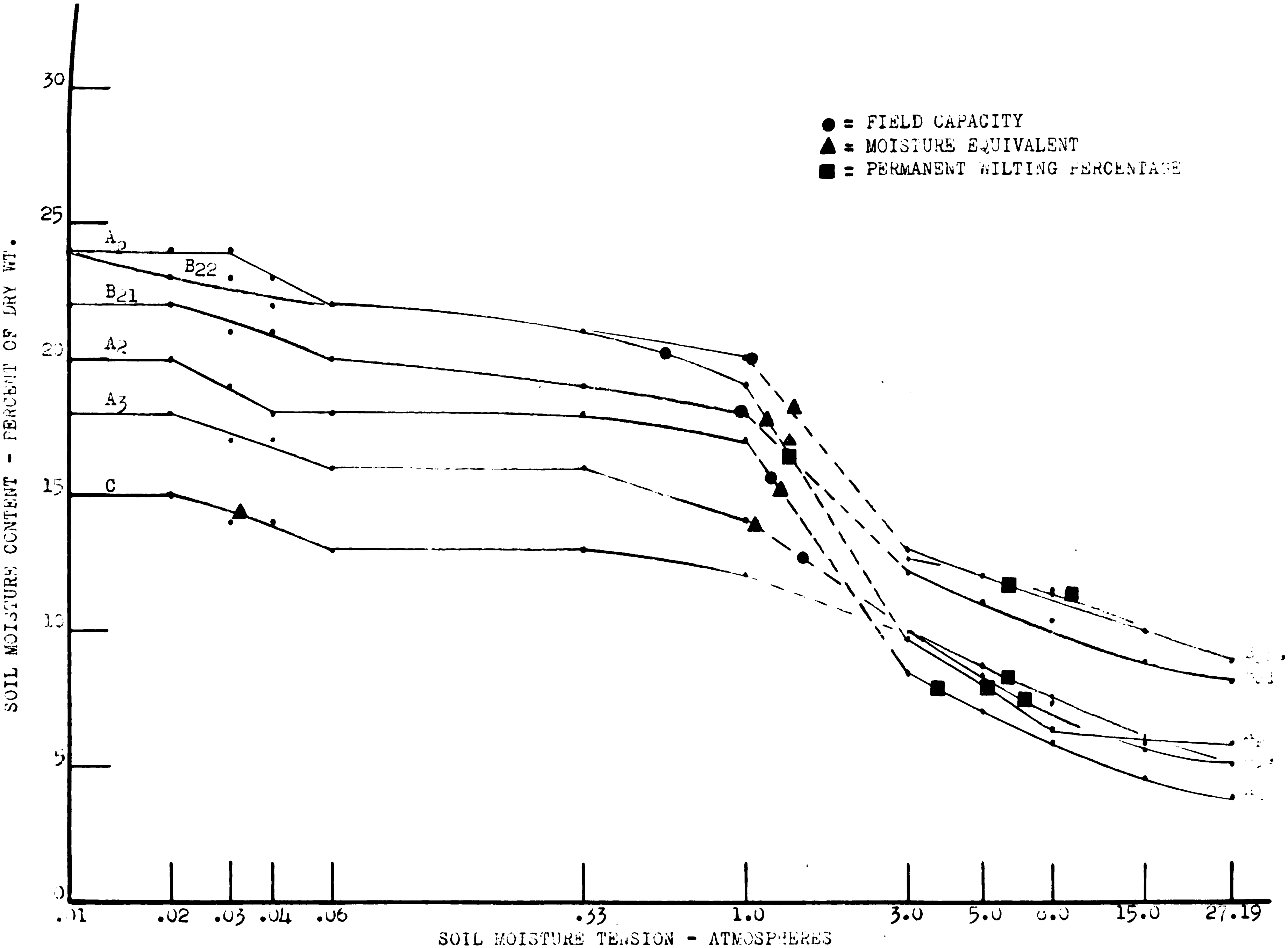


Figure 34. Moisture release curves for Miami loam site number seventeen.

TABLE XXII

BASIC DATA ON HANEY LOAMY SAND SITE NUMBER EIGHTEEN*

Sample Number	94	95	96	97	98
Horizon	Ap	A2G	GA3	CB	GC
Depth (inches)	0-8	8-14	14-18	21-25	25
Hygroscopic Coefficient	0.74	0.27	0.14	0.29	0.22
Permanent Wilting Point	4.5	2.2	1.2	2.1	1.6
Field Capacity	17.3	11.7	10.3	9.6	12.1
Moisture Equivalent	6.9	3.8	2.4	2.9	2.2
Total Carbon	4.2	0.47			
Sand	83.6	88.9	93.9	92.5	95.8
Silt	8.7	7.7	4.9	3.7	1.1
2 μ Clay	3.4	2.5	1.7	3.4	2.3
.2 μ Clay					
Montmorillonite	5	<5	0	10	10
Illite	10	20	20	30	50
Kaolinite	2	6	8	16	8
Volume Weight (gms/cc)	1.4	1.6	1.6	1.7	1.7
Moisture Content at:					
0.00 Atms	32	22	19	15	18
0.01 Atms	31	21	19	13	17
0.02 Atms	30	20	18	13	15
0.03 Atms	29	16	13	11	12
0.04 Atms	25	12	10	10	10
0.06 Atms	21	10	10	9	9
0.33 Atms	15	7	6	8	7
1.00 Atms	13	6	5	7	6
3.00 Atms	5.7	2.6	1.4	2.2	1.7
5.00 Atms	5.4	2.4	1.3	2.1	1.6
8.00 Atms	5.2	2.3	1.2	2.0	1.6
15.00 Atms	5.2	2.0	1.2	1.2	1.3
27.19 Atms		1.0	0.98	1.6	1.3

* Except when noted figures indicate percent on an oven dry basis.

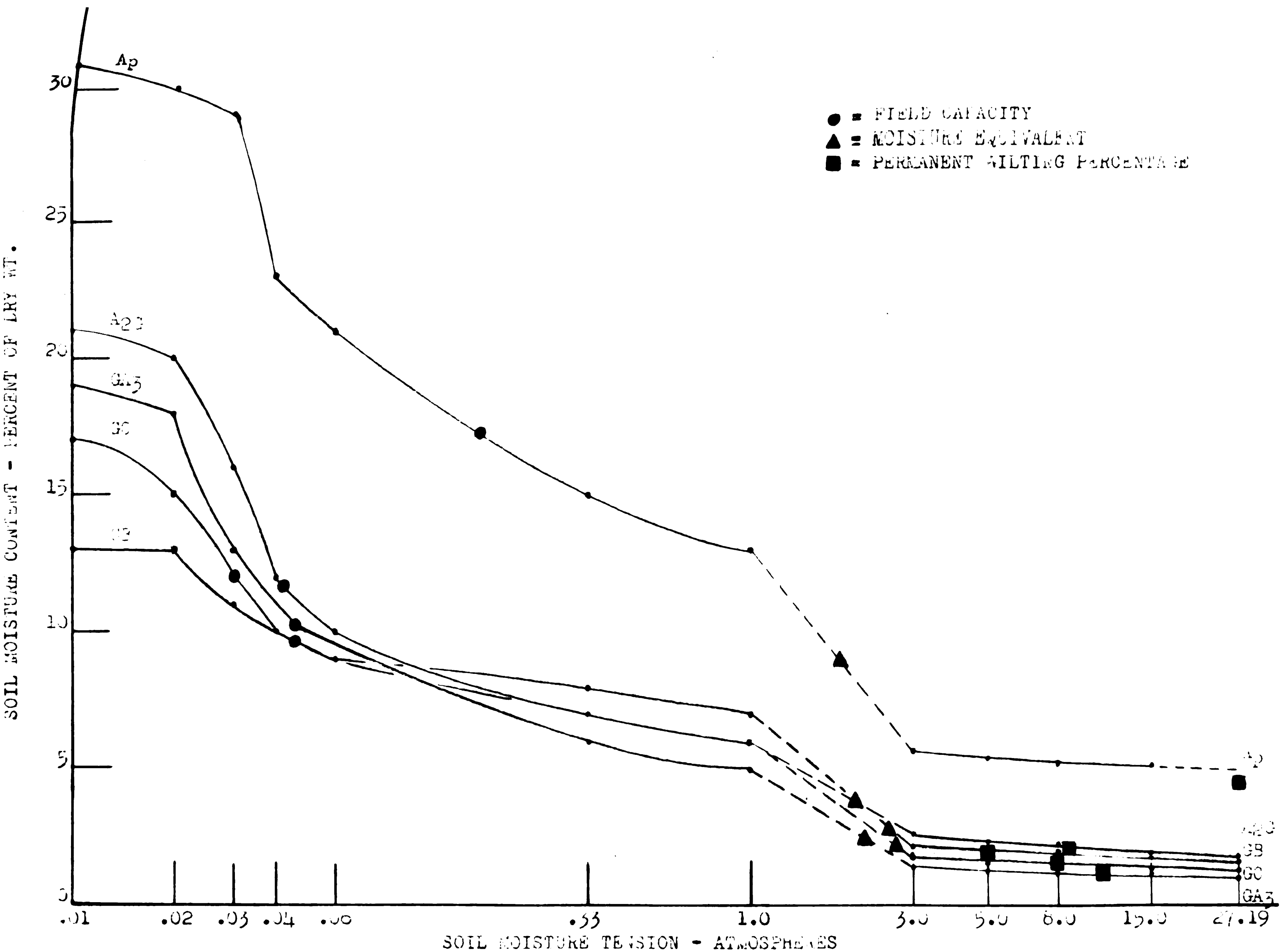


Figure 35. Moisture release curves for Granby loamy sand site number eighteen.

TABLE XXIII

BASIC DATA OF SAUGATUCK SAND SITE NUMBER NINETEEN*

Sample Number	99	100	101	102	103
Horizon	Ap	B22ir	B3p	B3p	C
Depth (inches)	0-15	12-18	18-23	23-29	29
Hygroscopic Coefficient	0.49	2.5	0.45	0.29	0.19
Permanent Wilting Point	5.0**	7.5	2.0	1.4	0.96
Field Capacity	9.7	10.8	11.7		9.3
Moisture Equivalent	5.6	8.8	2.1	1.5	1.2
Total Carbon	1.4	3.0			
Sand	88.3	84.3	95.2	96.9	96.8
Silt	8.8	4.7	1.5	0.47	0.74
2 μ Clay	2.4	3.1	1.8	1.3	1.1
.2 μ Clay					
Montmorillonite		5	0	0	
Illite		10	<10	10	
Kaolinite		6	0	4	
Volume Weight (gms/cc)	1.3	1.2	1.4	1.5	1.6
Moisture Content at:					
0.00 Atms	35	39	29	22	21
0.01 Atms	33	37	27	20	20
0.02 Atms	33	35	26	20	19
0.03 Atms	29	31	19	18	16
0.04 Atms	21	25	12	11	11
0.06 Atms	19	21	9	8	8
0.33 Atms	10	16	6	4	4
1.00 Atms	8	14	5	3	3
3.00 Atms	4.3	7.3	1.9	1.5	1.1
5.00 Atms	3.4	7.3	1.8	1.3	0.98
8.00 Atms	3.3	6.8	1.6	1.3	0.87
15.00 Atms	3.1		1.6	1.1	0.77
27.19 Atms	2.9	6.5	1.4	0.99	0.67

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.

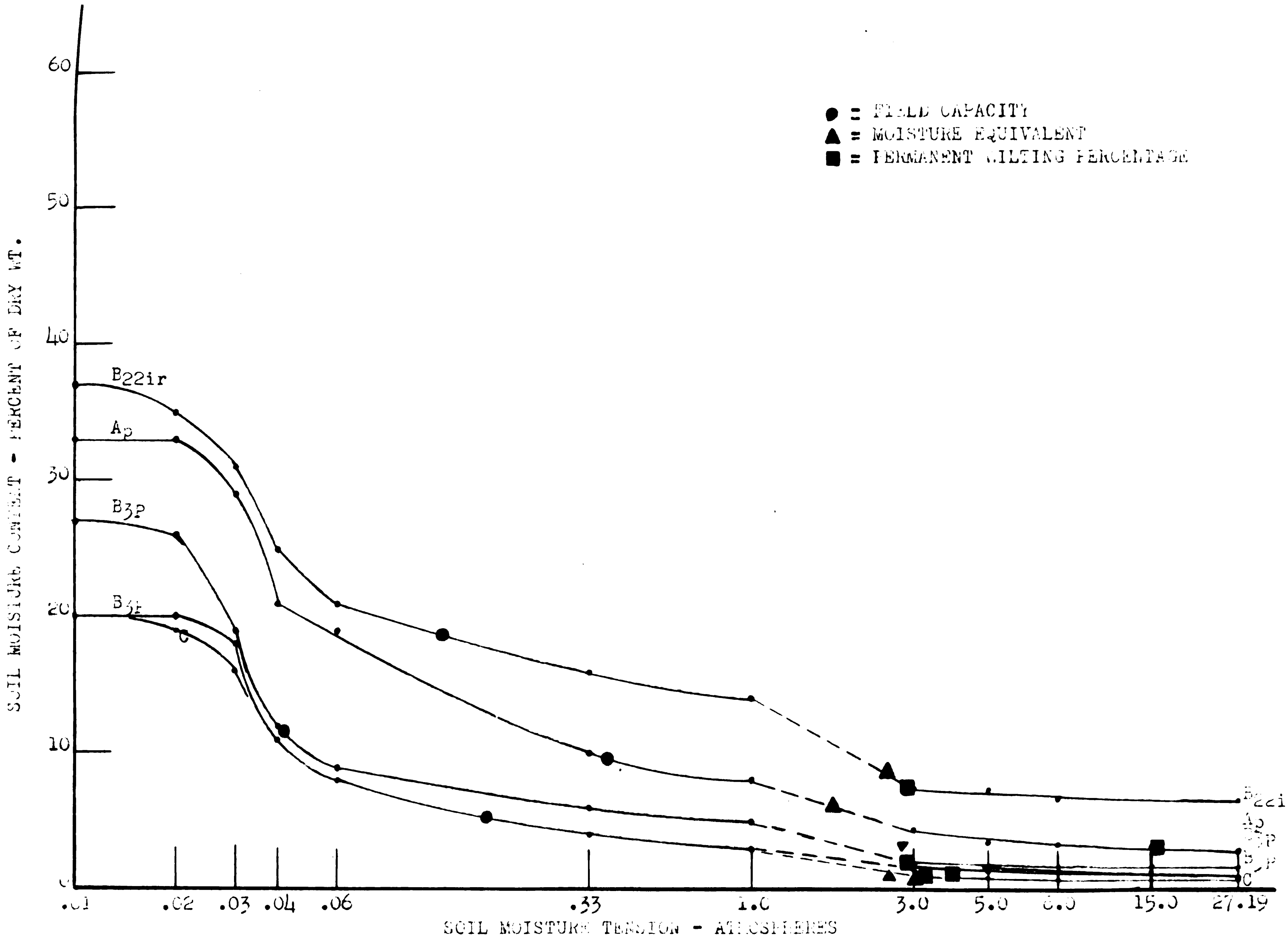


Figure 30. Moisture release curves for Saugatuck sand site number nineteen.

TABLE XXIV

BASIC DATA ON CONOVER SANDY LOAM SITE NUMBER TWENTY*

Sample Number	104	105	106	107	108
Horizon	Ap	A_{2g}	B_{1g}	B_{2g}	C
Depth (inches)	0-8	8-13	13-18	18-21	21
Hygroscopic Coefficient	1.4	0.69	1.4	1.5	0.90
Permanent Wilting Point	11.0	6.7	10.1**	11.9**	8.7
Field Capacity	19.7	17.7	18.1		17.0
Moisture Equivalent	19.9	12.4	17.5	17.8	15.9
Total Carbon	1.7	0.31			
Sand	49.1	60.1	45.8	40.3	58.4
Silt	30.5	27.9	35.3	32.0	27.0
2 μ Clay	14.6	10.0	19.3	23.6	16.5
.2 μ Clay			11.6	12.2	
Montmorillonite	<5	0	5	0	5
Illite	<10	20	50	20	60
Kaolinite	<2	10	14	6	20
Volume Weight (gms/cc)	1.4	1.6	1.6	1.7	1.7
Moisture Content at:					
0.00 Atms	29	22	23	20	20
0.01 Atms	27	20	21	19	19
0.02 Atms	27	19	20	19	19
0.03 Atms	26	19	20	19	18
0.04 Atms	26	18	19	18	18
0.06 Atms	24	17	18	18	17
0.33 Atms	21	15	16	17	15
1.00 Atms	19	14	15	15	14
3.00 Atms	12.3	7.4	11.7	13.0	10.5
5.00 Atms	11.0	6.6	10.4	11.9	9.1
8.00 Atms	9.3	4.7	9.1	10.7	8.0
15.00 Atms	7.8	4.4	8.5	9.3	6.7
27.19 Atms	6.4	4.3	7.4	8.2	5.8

* Except when noted figures indicate percent on an oven dry basis.

** Figures include only one determination.

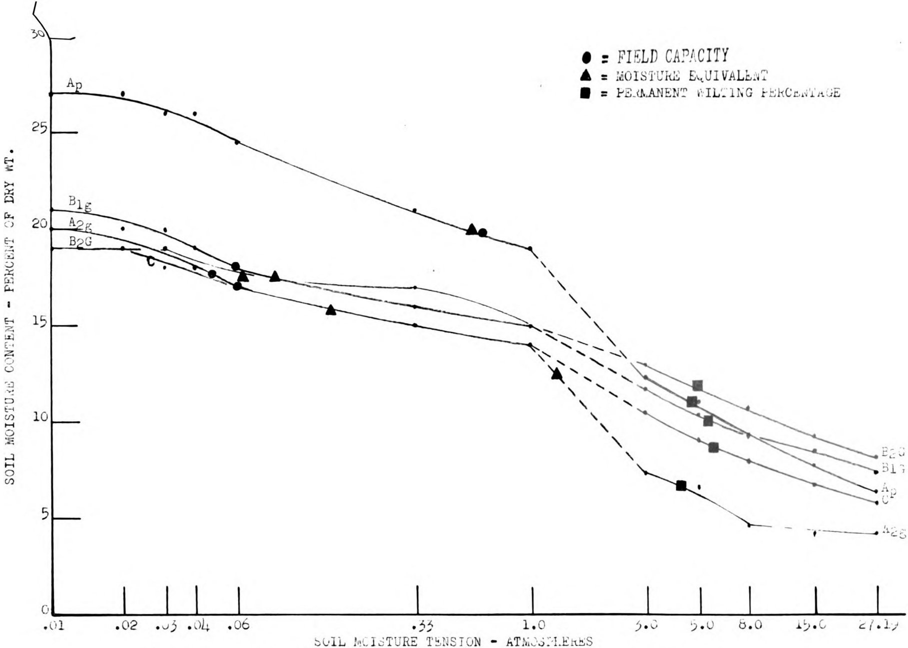


Figure 37. Moisture release curves for Conover sandy loam site number twenty.

TABLE XXV

BASIC DATA ON GRANBY SANDY LOAM SITE NUMBER TWENTY-ONE*

Sample Number	109	110	111	112	113
Horizon	A1	A2G	BG	C	D
Depth (inches)	0-7	7-13	13-21	23-29	29-37
Hygroscopic Coefficient	0.72	0.08	0.11	0.10	0.10
Permanent Wilting Point	4.9	0.66	2.0	0.65	0.60**
Field Capacity	17.6	6.5	6.9	7.5	
Moisture Equivalent	9.0	2.3	3.0	1.3	1.2
Total Carbon	1.8	0.05			
Sand	82.9	96.8	92.6	98.1	98.0
Silt	9.7	3.6	4.8	0.63	0.74
2 μ Clay	3.9	1.1	2.0	0.76	0.39
.2 μ Clay					
Montmorillonite	5		0		
Illite	30		10		
Kaolinite	6		6		
Volume Weight (gms/cc)	1.2	1.6	1.7	1.7	1.7
Moisture Content at:					
0.00 Atms	36	20	17	19	20
0.01 Atms	36	19	15	18	20
0.02 Atms	33	18	15	17	19
0.03 Atms	30	15	14	14	15
0.04 Atms	28	12	11	9	8
0.06 Atms	28	9	9	6	6
0.33 Atms	20	5	5	3	3
1.00 Atms	18	5	5	2	3
3.00 Atms	6.7	1.1	2.1	0.79	0.76
5.00 Atms	6.2	1.1	1.8		
8.00 Atms	5.5	1.0	1.5	0.68	0.62
15.00 Atms	5.2	0.86	1.2	0.62	0.56
27.19 Atms		0.75	1.0	0.58	0.56

* Except when noted figures indicate percent on an oven dry basis.

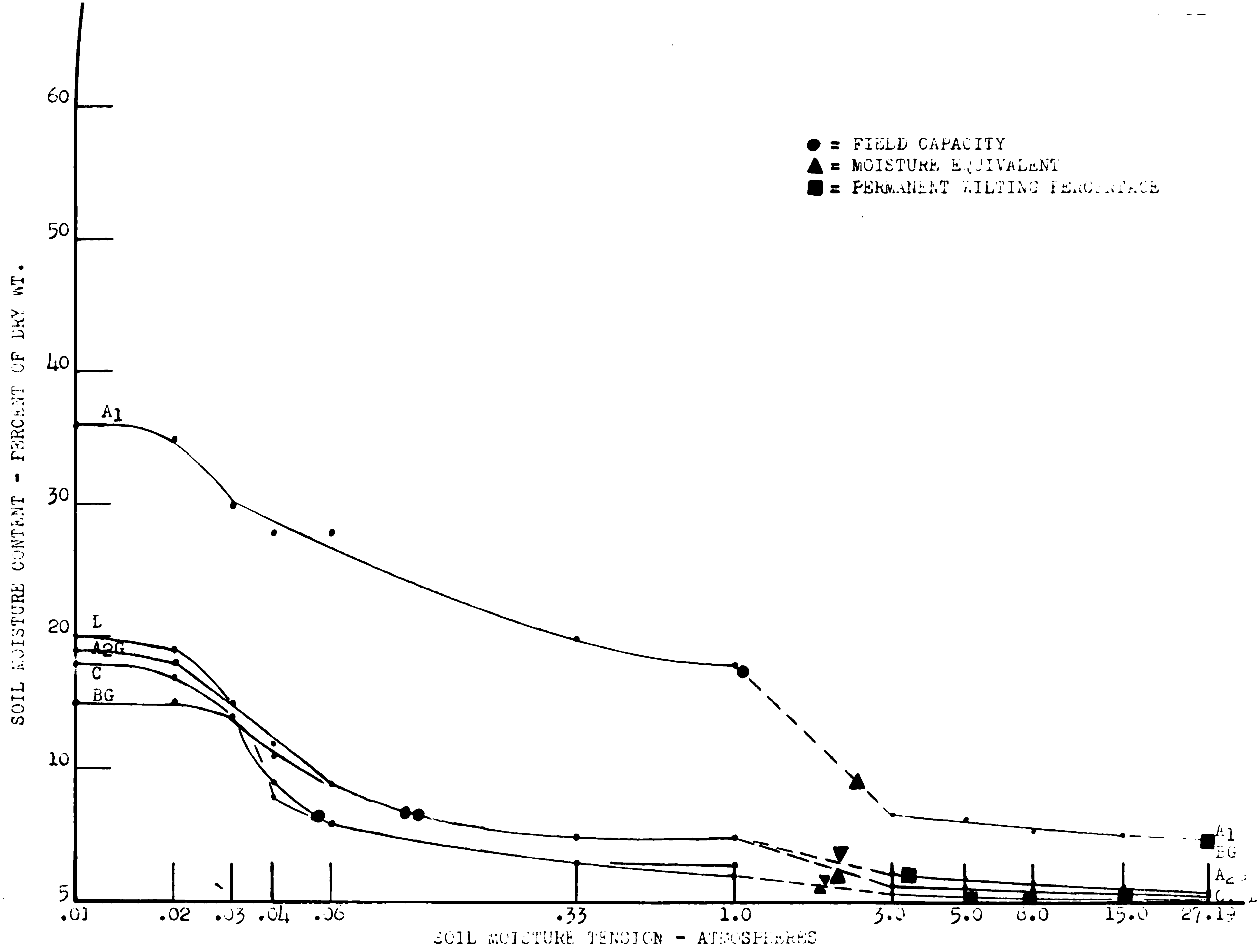


Figure 36. Moisture release curves for Granby sandy loam site number twenty-one.

TABLE XXVI

BASIC DATA ON [illegible] LOAMY SAND SITE NUMBER TWENTY-TWO*

Sample Number	114	115	116	117	118	119	120
Horizon	Ap	A2	B1	B2	B3g	C	D
Depth (inches)	0-7	7-13	13-20	20-27	27-36	36-47	47-50
Hygroscopic Coefficient	0.58	0.40	0.24	0.39	0.19	0.45	1.1
Permanent Wilting Point	3.2**	2.8	2.0	2.2**	1.2**	3.0	11.3
Field Capacity	13.2	10.2	10.9	9.9	14.3		16.4
Moisture Equivalent	7.4	4.0	3.1	2.7	2.1	4.4	18.9
Total Carbon	0.88	0.28					
Sand	85.3	86.3	93.3	92.8	96.6	92.6	55.3
Silt	7.5	6.1	3.0	2.9	0.93	0.53	21.8
2 µ Clay	4.0	3.3	2.4	3.5	2.0	6.3	21.2
.2 µ Clay							
Montmorillonite	10	5	10	5	<5	5	<5
Illite	40	20	70	40	40	40	60
Kaolinite	10	6	12	6	10	6	10
Volume Weight (gms/cc)	1.5	1.6	1.6	1.7	1.7	1.7	1.7
Moisture Content at:							
0.00 Atms	26	21	20	19	19	19	18
0.01 Atms	25	21	20	18	18	19	18
0.02 Atms	24	21	19	18	18	18	17
0.03 Atms	24	20	18	16	16	18	17
0.04 Atms	22	17	15	14	15	16	16
0.06 Atms	20	15	13	12	12	13	15
0.33 Atms	11	6	4	3	3	3	8
1.00 Atms	9	5	4	2	2	3	7
3.00 Atms	4.4	2.9	2.0	2.3	1.2	3.2	13.0
5.00 Atms	4.3	2.7	1.9	2.1	1.2	3.1	11.4
8.00 Atms	3.7	2.6	1.9	2.0	1.2	3.0	10.0
15.00 Atms	3.4	2.1	1.5	1.3	0.92	2.6	8.3
27.19 Atms	3.1	1.8	1.4**	1.7	0.85	2.5	7.0

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.

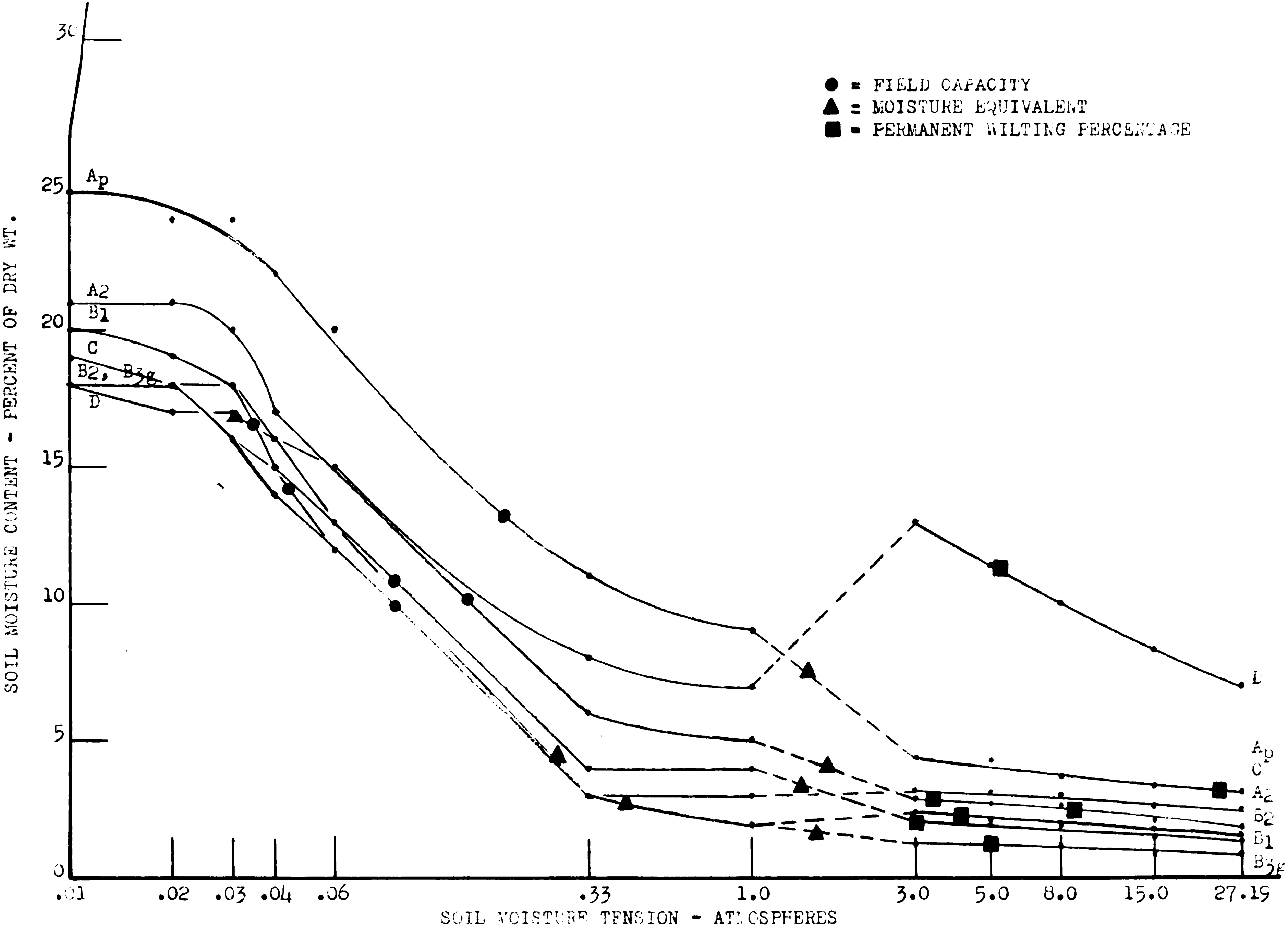


Figure 39. Moisture release curves for Berrien loamy sand site number twenty-two.

TABLE XXVII

BASIC DATA ON HILLSDALE SANDY LOAM SITE NUMBER TWENTY-THREE*

Sample Number	121	122	123	124	125	126
Horizon	A_p	A_2	B_{21}	B_{22}	B_3	C
Depth (inches)	0-8	8-14	14-21	21-33	33-47	47
Hygroscopic Coefficient	0.62	0.75	1.1	1.1	0.82	0.51
Permanent Wilting Point	5.3	7.6**	11.7	10.0	7.4**	4.5**
Field Capacity	17.8	[illegible]	15.4	14.2	12.7	14.2
Moisture Equivalent	12.9	15.6	16.5	15.7	13.7	12.1
Total Carbon	1.0	0.25				
Sand	62.7	55.2	51.8	51.6	58.3	54.6
Silt	28.6**	28.2	25.1	25.6	22.5	21.4
2 μ Clay	8.1	15.2	22.8	21.7	16.0	10.7
.2 μ Clay			10.6	11.6		
Montmorillonite	0	<5	<5	0	0	0
Illite	10	40	50	30	50	20
Kaolinite	8	10	12	10	12	8
Volume Weight (gms/cc)	1.5	1.8	1.8	1.7	1.6	1.6
Moisture Content at:						
0.00 Atms	25	17	17	18	20	21
0.01 Atms	22	15	16	17	19	20
0.02 Atms	20	15	16	17	18	20
0.03 Atms	20	14	16	17	17	19
0.04 Atms	19	14	15	16	17	18
0.06 Atms	18	13	15	16	16	17
0.33 Atms	15	12	14	15	12	13
1.00 Atms	13	11	13	13	11	11
3.00 Atms	6.7	9.1	12.3	11.5	9.2	7.3
5.00 Atms	5.5	7.8	11.1	10.4	8.2	6.3
8.00 Atms	4.6	6.8	9.9	9.4	7.4	5.5
15.00 Atms	3.7	5.6	8.8	8.3	6.5	4.5
27.19 Atms	3.7	4.5	7.2	7.2	5.5	3.6

* Except when noted figures indicate percent on an oven dry basis.

** Figures include only one determination.

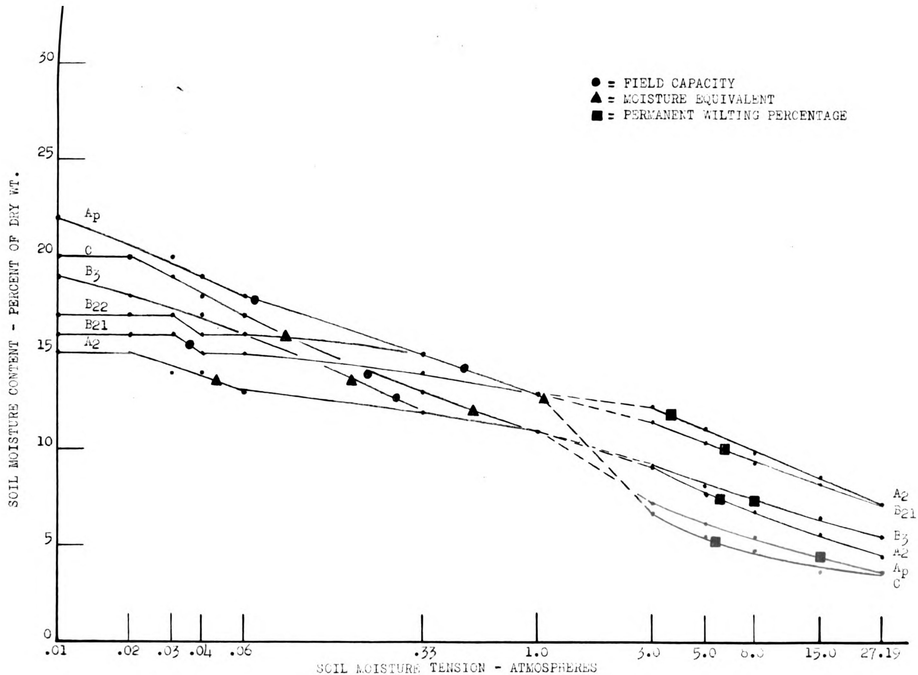


Figure 40. Moisture release curves for Hillsdale sandy loam site number twenty-three.

TABLE XXVIII

BASIC DATA ON GUELPH LOAM SITE NUMBER TWENTY-FOUR*

Sample Number	127	128	129
Horizon	A_p	B_2	C
Depth (inches)	0-7	7-14	14
Hygroscopic Coefficient	1.2	1.2	1.1
Permanent Wilting Point	12.0	9.7	10.0
Field Capacity			
Moisture Equivalent	19.0	18.1	15.0
Total Carbon	1.8	0.46	
Sand	55.9	47.0	55.4
Silt	39.4**	30.0	25.0
2 μ Clay	13.5	19.8	19.2
.2 μ Clay			
Montmorillonite	0	<5	5
Illite	10	30	60
Kaolinite	0	6	18
Volume Weight (gms/cc)	1.5	1.7	1.7
Moisture Content at:			
0.00 Atms	31	20	22
0.01 Atms	28	19	20
0.02 Atms	28	19	19
0.03 Atms	27	18	19
0.04 Atms	26	17	17
0.06 Atms	25	17	17
0.33 Atms	23	16	16
1.00 Atms	21	15	15
3.00 Atms	12.4	11.2	11.5
5.00 Atms	10.2	9.7	10.4
8.00 Atms	8.5	8.5	9.3
15.00 Atms	6.8	7.5	7.9
27.19 Atms	5.6	6.9	6.8

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.

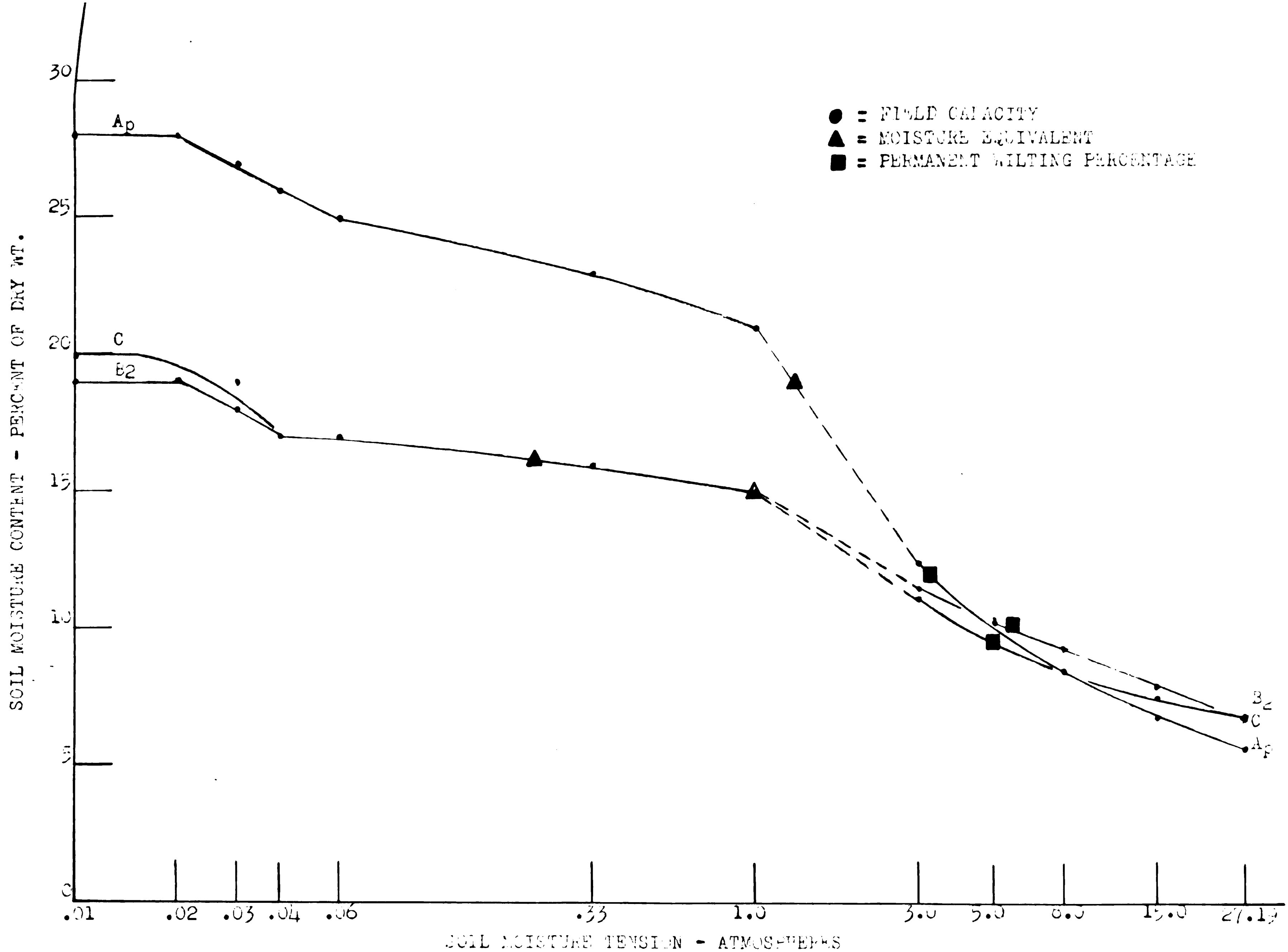


Figure 41. Moisture release curves for Guelph loam site number twenty-four.

TABLE XXIX

BASIC DATA [illegible] SITE [illegible] THIRTY-FIVE*

Sample Number	150	151	152	153	154
Horizon	Ap	B22p	B31p	B32p	C
Depth (inches)	0-6	6-13	13-18	18-28	28
Hygroscopic Coefficient	0.43	0.7[illegible]	0.54	0.33	0.10
Permanent Wilting Point	2.1	3.5**	2.2	1.5	0.40
Field Capacity	9.3	14.6	10.1		7.8
Moisture Equivalent	4.6	4.8	3.5	2.2	0.70
Total Carbon	0.57	0.92			
Sand	88.4	85.1	96.4	95.3	98.4
Silt	6.3	7.1	1.6	4.1	0.63
2µ Clay	2.1	2.9	2.3	1.6	0.90
.2µ Clay					
Montmorillonite	<5	0	<5	0	
Illite	10	10	10	10	
Kaolinite	2	4	10	8	
Volume weight (gms/cc)	1.5	1.5	1.5	1.5	1.6
Moisture content at:					
0.00 Atms	27	30	27	26	23
0.01 Atms	27	30		26	22
0.02 Atms	26	29	27	25	21
0.03 Atms	24	23	22	21	9
0.04 Atms	18	18	17	15	4
0.06 Atms	13	14	12	11	2
0.33 Atms	8	9	7	5	2
1.00 Atms	7	6	5	4	1
3.00 Atms	3.3	4.2	2.5	1.7	0.54
5.00 Atms	3.2	4.0	2.5	1.7	0.52
8.00 Atms	2.8	3.5	2.3	1.5	0.44
15.00 Atms		3.1	2.2	1.5	0.37
27.19 Atms	2.5	2.9	1.8	1.3	0.38

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.

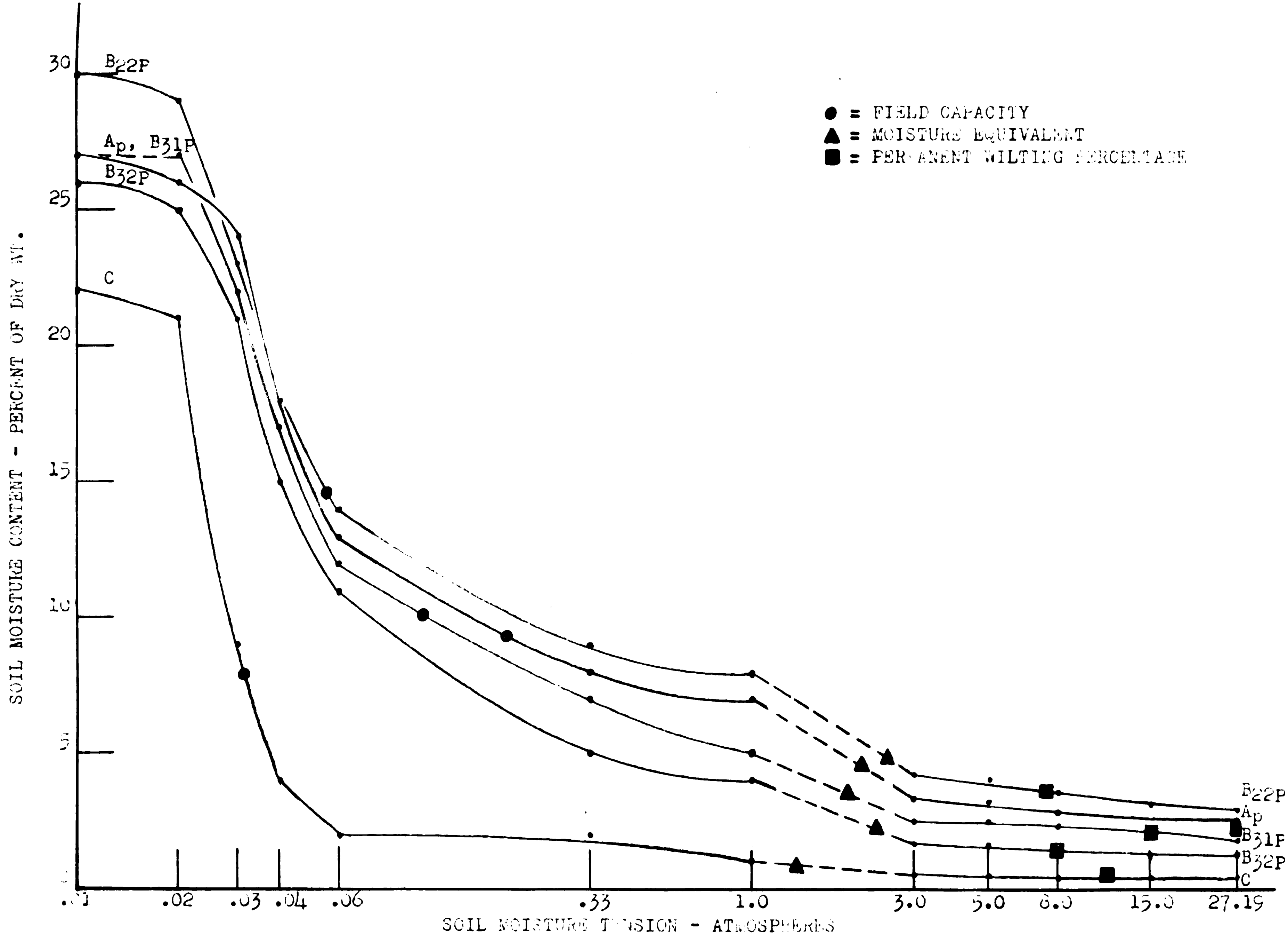


Figure 42. Moisture release curves for Kalkaska sand site number twenty-five.

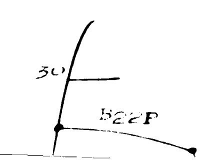
TABLE XXX

BASIC DATA ON KALKASKA SAND SITE NUMBER TWENTY-SIX*

Sample Number	135	136	137	138	139	140
Horizon	Ap	B_{21P}	B_{22P}	B_{3P}	C	D
Depth (inches)	0-8	8-12	12-18	18-30	30-45	46
Hygroscopic Coefficient	0.57	0.78	0.55	0.17	0.30	0.09
Permanent Wilting Point	2.1**	3.5	2.4	0.78	1.3**	0.54
Field Capacity						
Moisture Equivalent	4.7	5.5	3.9	1.2	2.3	0.67
Total Carbon	0.75	0.54				
Sand	88.9	88.4	90.2	97.3	91.5	98.2
Silt	7.1	7.1	5.4	1.2	4.8	0.55
2 µ Clay	2.2	3.9	2.4	0.69	2.1	0.56
.2 µ Clay						
Montmorillonite	<5	0	5		0	
Illite	10	0	20		20	
Kaolinite	2	4	8		6	
Volume Weight (gms/cc)	1.6	1.5	1.5	1.6	1.6	
Moisture Content at:						
0.00 Atms	25	27	28	25	21	
0.01 Atms	25	26	28	23	20	
0.02 Atms	24	25	27	22	19	
0.03 Atms	21	21	29	18	16	
0.04 Atms	16	15	14	11	11	
0.06 Atms	11	10	11	8	7	
0.33 Atms	7	6	6	3	3	
1.00 Atms	6	6	6	3	3	
3.00 Atms	2.9	4.0	2.8	0.53	1.7	0.47
5.00 Atms	2.8	3.9	2.6	0.54	1.5	0.45
8.00 Atms	2.7	3.5	2.3	0.50	1.5	
15.00 Atms	2.1	2.9	2.2	0.64	1.3	0.34
27.19 Atms	2.2	2.8	2.0	0.66	1.3	0.35

* Except when noted figures indicate percent on an oven dry basis.

** Figures include only one determination.



● = FIELD CAPACITY
▲ = MOISTURE EQUIVALENT
■ = PERMANENT WILTING PERCENTAGE

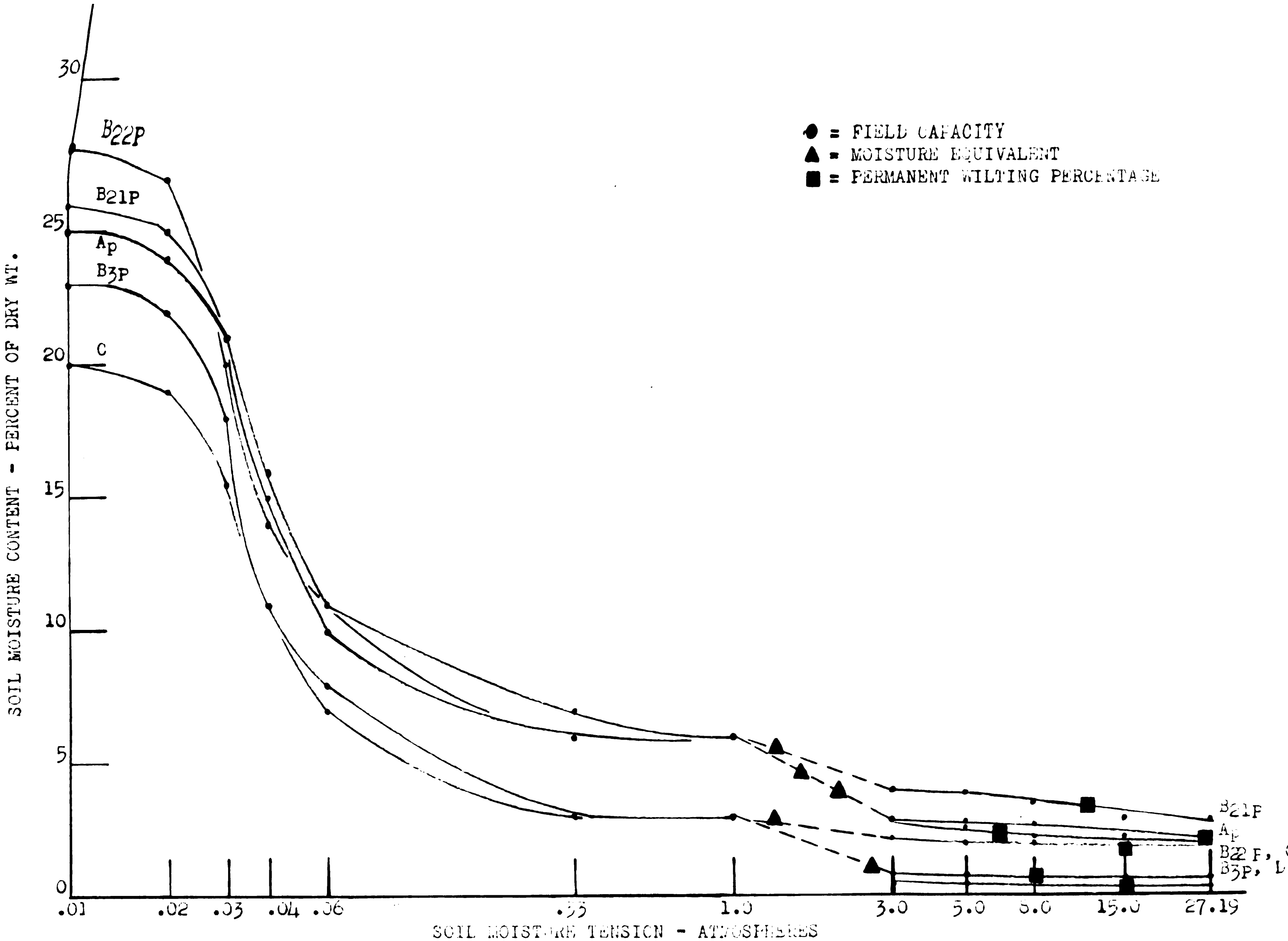


Figure 43. Moisture release curves for Kalkaska sand site number twenty-six.

TABLE XXXI

BASIC DATA ON KALKASKA SAND SITE NUMBER FORTY-SEVEN*

Sample Number	141	142	143	145
Horizon	Ap	B21P	B22P	C
Depth (inches)	0-8	8-15	15-22	20
Hygroscopic Coefficient	0.52	0.49	0.57	0.15
Permanent Wilting Point	3.1	2.8	3.0	0.90
Field Capacity	10.6	8.5		6.2
Moisture Equivalent	6.2	3.9	3.6	1.6
Total Carbon	0.81	0.57		
Sand	88.0	89.9	90.2	87.7
Silt	6.9	6.2	5.2	1.9
2 µ Clay	5.1	2.9	3.5	1.9
.2 µ Clay				
Montmorillonite	<5	0	5	<5
Illite	40	30	50	10
Kaolinite	2	4	10	6
Volume Weight (gms/cc)	1.5	1.5		
Moisture Content at:				
0.00 Atms	27	25		
0.01 Atms	24	24		
0.02 Atms	21	21		
0.03 Atms	17	15		
0.04 Atms	13	11		
0.06 Atms	11	9		
0.33 Atms	8	7		
1.00 Atms	7	6		
3.00 Atms	4.0	3.1	3.1	1.1
5.00 Atms	3.8	2.9	3.2	0.96
8.00 Atms	3.5	2.8	2.6	
15.00 Atms	3.1	2.3	2.3	0.91
27.19 Atms	3.1	2.5	2.2	0.96

* Except when noted figures indicate percent on an oven dry basis.

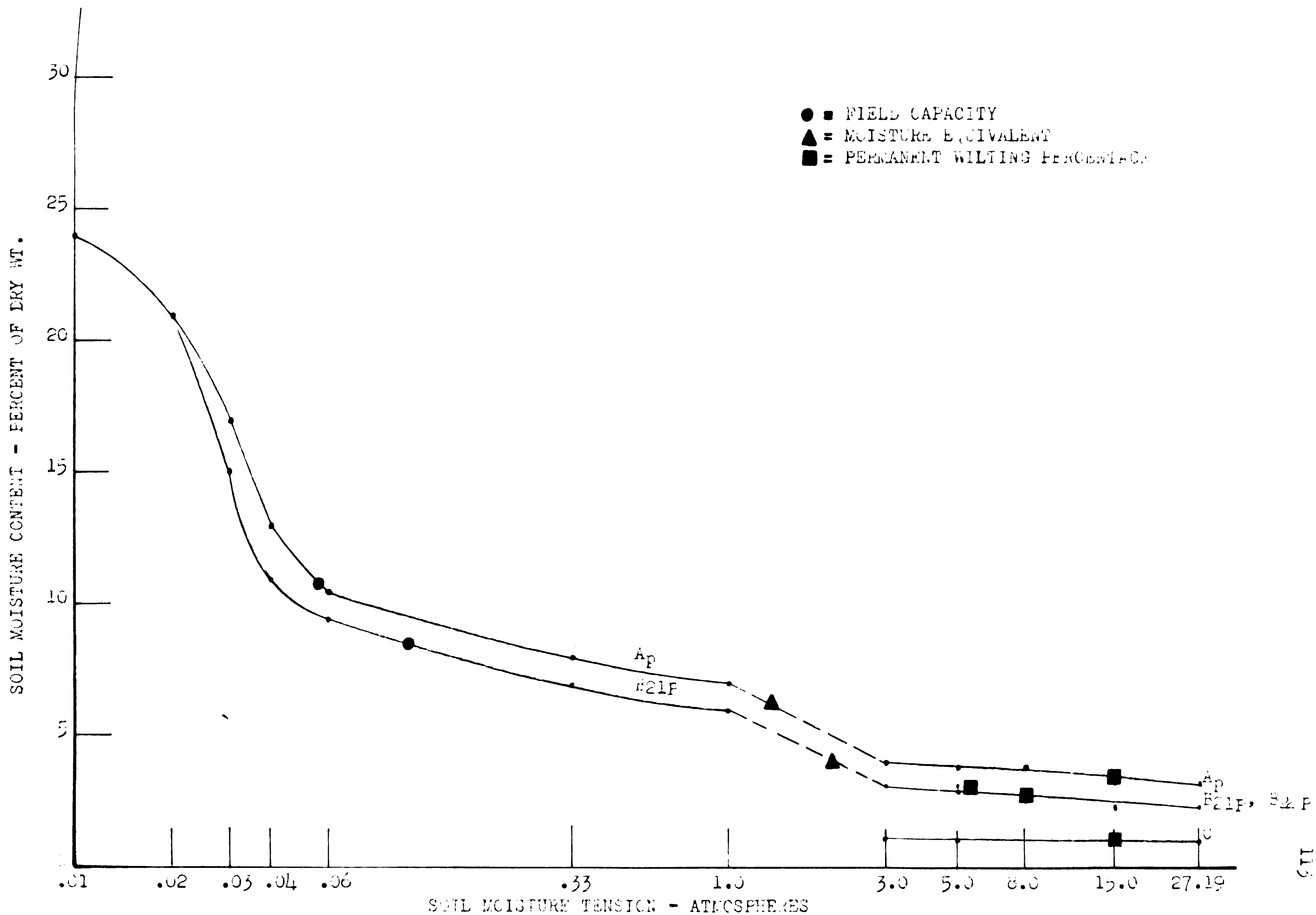


Figure 44. Moisture release curves for Mancelona sand site number twenty-seven.

TABLE XXXII

BASIC DATA ON [illegible] SANDY LOAM SITE NUMBER TWENTY-NINE*

Sample Number	149	150	151	152	153
Horizon	A_p	$A2_g$	$B1_g$	$B2_g$	C
Depth (inches)	0-8	8-12	12-19	19-30	30
Hygroscopic Coefficient	0.84	0.54	0.91	1.8	1.1
Permanent Wilting Point	5.9	3.9**	3.5**	10.7	8.5**
Field Capacity	19.4	15.1	16.0	17.6	17.3
Moisture Equivalent	13.7	9.4	12.1	17.1	14.3
Total Carbon	1.2	0.26			
Sand	66.6	68.4	61.0	55.5	47.4
Silt	22.3	22.7	22.6	18.6	17.6
2 μ Clay	7.3	8.1	15.0	24.0	16.6
.2 μ Clay				15.2	
Montmorillonite	0	0	0	0	0
Illite	0	10	20	20	20
Kaolinite	2	2	4	2	6
Volume Weight (gms/cc)	1.5	1.7	1.5	1.7	1.8
Moisture Content at:					
0.00 Atms	26	18	17	21	18
0.01 Atms	25	16	16	21	17
0.02 Atms	25	16	15	20	17
0.03 Atms	24	15	14	19	17
0.04 Atms	23	14	14	19	16
0.06 Atms	22	13	13	19	
0.33 Atms	19	11		17	15
1.00 Atms	18	10	13	16	15
3.00 Atms	6.8	5.2	8.0	11.5	9.7
5.00 Atms	5.6	4.0	6.6	10.6	8.7
8.00 Atms	4.6	3.3	5.9	9.9	7.9
15.00 Atms	4.1	2.7	4.8	8.9	6.8
27.19 Atms	3.5	2.5	4.2	7.8	5.6

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.

30

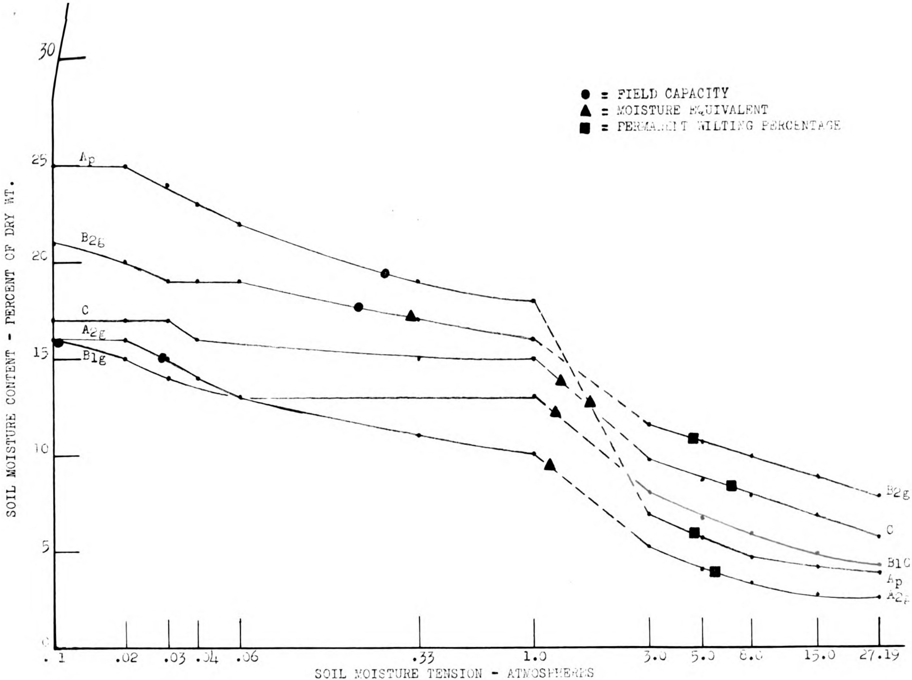


Figure 45. Moisture release curves for Coral sandy loam site number twenty-nine.

TABLE XXXIII

BASIC DATA ON PAULDING CLAY SITE NUMBER THIRTY*

Sample Number	154	155	156	157	158
Horizon	A_p	G_1	G_2	G_3	G_4
Depth (inches)	0-6	6-12	12-18	18-24	30-36
Hygroscopic Coefficient	3.2	3.1	3.0	3.2	3.4
Permanent Wilting Point	26.5	25.3	26.0	25.2	25.3
Field Capacity	38.6	38.9	37.4	36.2	
Moisture Equivalent	40.0	39.6	39.6	41.6	46.4
Total Carbon	2.9	1.3			
Sand	4.1	5.7	3.8	3.6	3.3
Silt	30.2**	25.8	26.3	25.8	24.7
$<2\mu$ Clay	59.2	64.2	62.9	67.2	70.3
$.2\mu$ Clay	30.8	29.2	33.0	25.8	30.3
Montmorillonite	0	0	0	<5	0
Illite	30	30	20	50	20
Kaolinite	8	6	4	6	2
Volume Weight (gms/cc)	1.2	1.4	1.4		
Moisture Content at:					
0.00 Atms	43	34	32		
0.01 Atms	41	33	32		
0.02 Atms	40	33	32		
0.03 Atms	39	33	32		
0.04 Atms	38	32	32		
0.06 Atms	37	31	31		
0.33 Atms	37	30	30		
1.00 Atms	36	30	29		
3.00 Atms	30.6	29.9	28.8	29.4	29.5
5.00 Atms	29.0	27.9	27.6	27.2	27.3
8.00 Atms	26.2	25.6	25.1	25.2	25.1
15.00 Atms	23.5	23.1	22.6	22.5	22.6
27.19 Atms	19.5**	19.8	19.4	19.7	20.2

* Except when noted figures indicate percent on an oven dry basis.

** Figures include only one determination.

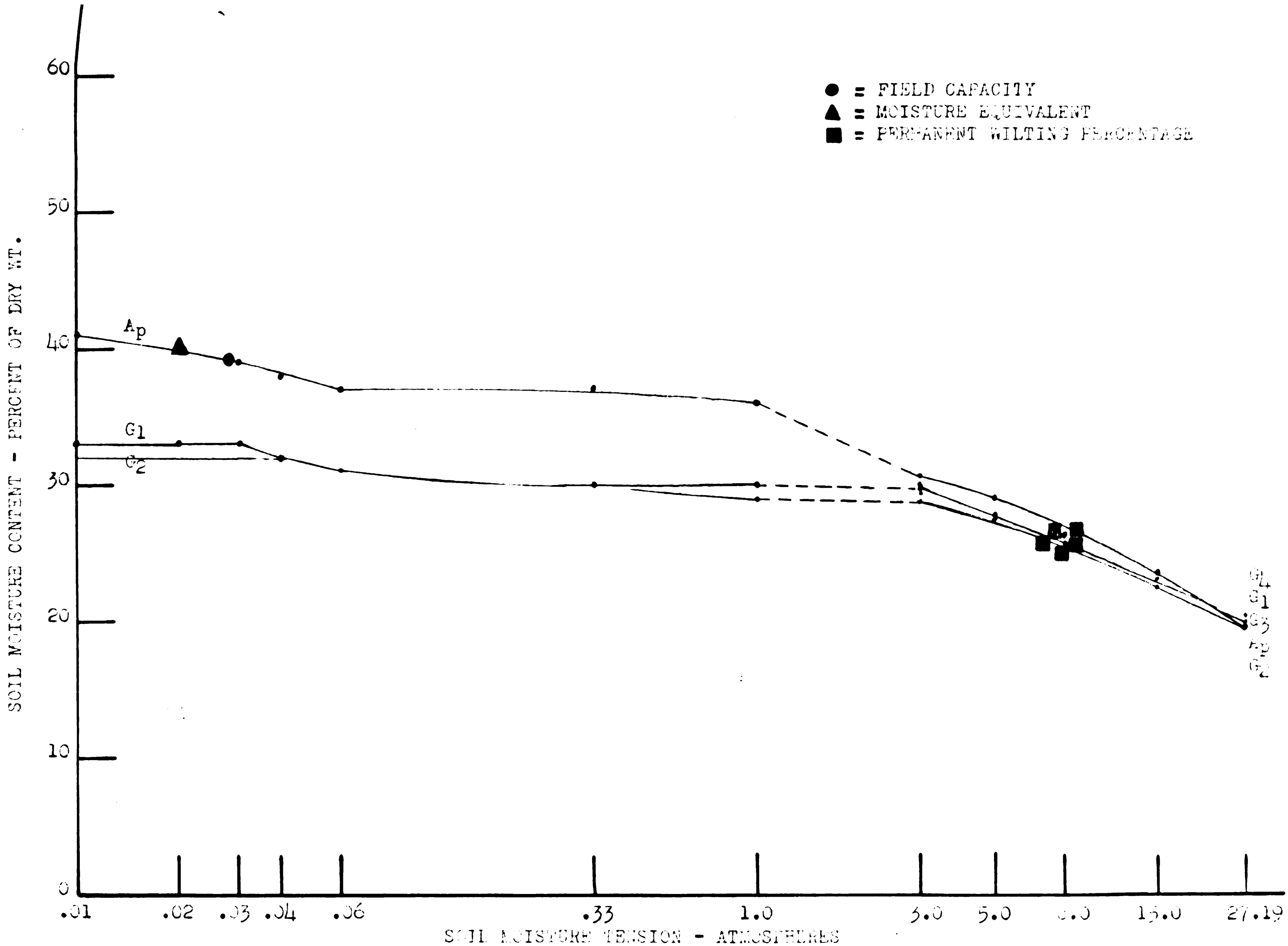


Figure 46. Moisture release curves for Paulding clay site number thirty.

TABLE XXXIV

BASIC DATA ON HOYTSVILLE CLAY LOAM SITE NUMBER THIRTY-ONE*

Sample Number	159	160	161	163
Horizon	A_p	AG	B21G	C
Depth (inches)	0-8	8-12	12-26	26
Hygroscopic Coefficient	2.5	3.0	2.9	2.5
Permanent Wilting Point	19.1	19.8	17.5	15.1**
Field Capacity***	25.7	25.6	21.5	
Moisture Equivalent	27.9	28.2	26.4	23.9
Total Carbon	2.8	1.1		
Sand	24.9	19.5	22.0	19.0
Silt	30.8	33.3	32.9	29.6
2μ Clay	35.2	42.5	41.3	38.6
$.2\mu$ Clay	19.8	23.3	25.4	
Montmorillonite	0	<5	0	<5
Illite	30	30	20	40
Kaolinite	2	4	4	4
Volume Weight (gms/cc)	1.3	1.5	1.6	1.6
Moisture Content at:				
0.00 Atms	39	34	27	25
0.01 Atms	[illegible]	31	25	23
0.02 Atms	35	31	24	22
0.03 Atms	34	30	24	22
0.04 Atms	32	29	24	22
0.06 Atms			22	21
0.33 Atms	31	27	21	19
1.00 Atms	31	27	19	18
3.00 Atms	20.2	21.2	20.8	19.0
5.00 Atms	19.2	20.0	19.4	17.4
8.00 Atms	17.0	18.0	17.4	15.9
15.00 Atms	15.5	16.4	15.6	15.9
27.19 Atms	13.0**	14.5**	13.7**	12.4

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.
*** Initial moisture determinations used as field capacity.

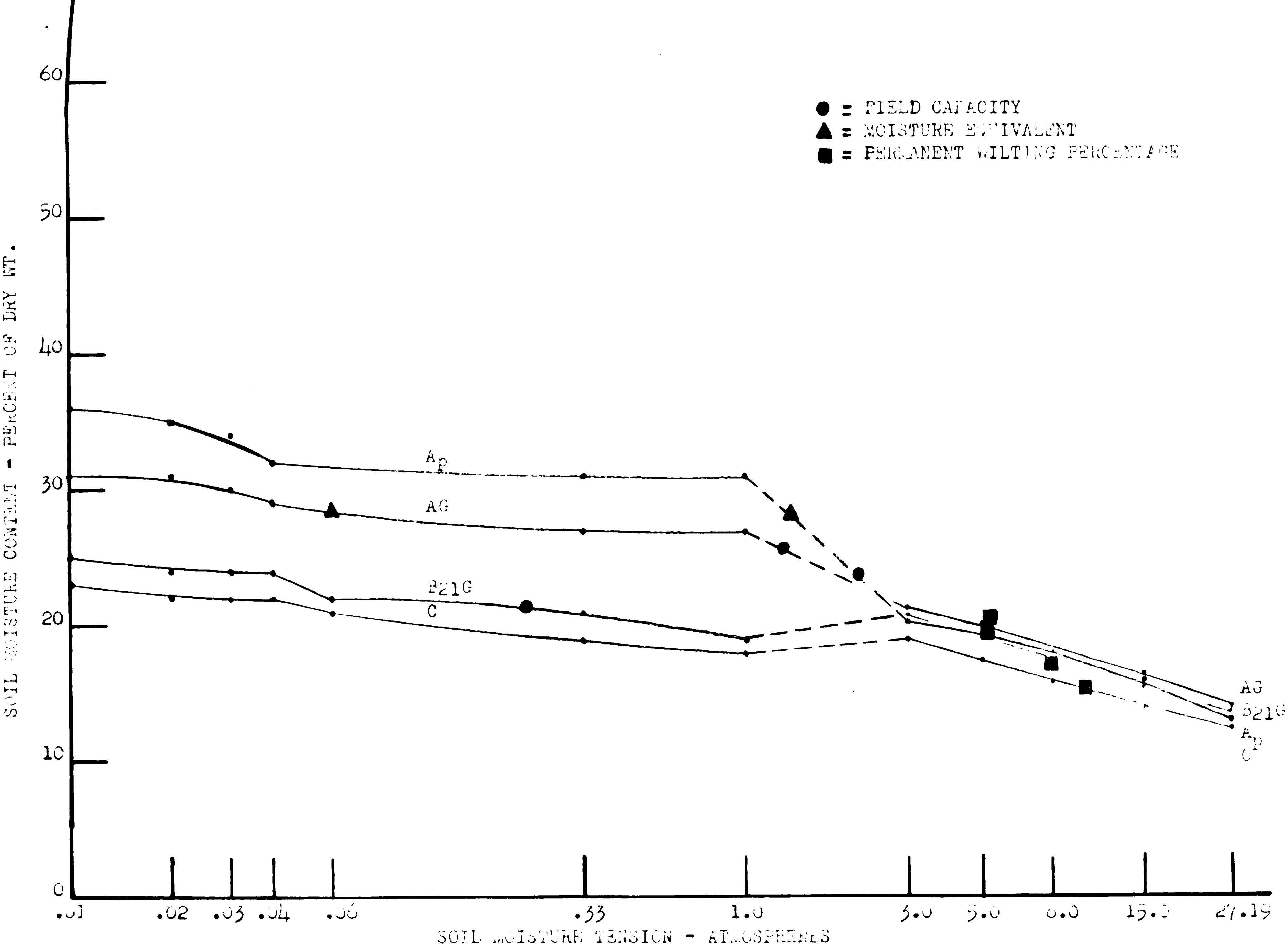


Figure 47. Moisture release curves for Hoytsville clay loam site number thirty-one.

TABLE XXXV

BASIC DATA [illegible] SILT LOAM [illegible] *

Sample Number	104	105	106	107
Horizon	Ap	A2g	B2	C
Depth (inches)	0-8	8-14	14-31	31
Hygroscopic Coefficient	1.1	1.3	1.0	0.78
Permanent Wilting Point	7.8	[illegible]	9.5	8.8
Field Capacity	20.0	1[illegible].8	15.2	
Moisture Equivalent	16.6	17.5	15.4	12.9
Total Carbon	1.4	0.51		
Sand	53.5	41.8	50.1	55.2
Silt	29.6	37.7	29.0	24.1
2 μ Clay	11.2	17.4	16.8	15.0
.2 μ Clay				
Montmorillonite	<5	10	10	5
Illite	40	20	50	70
Kaolinite	6	6	14	16
Volume weight (gms/cc)	1.4	1.6	1.8	1.8
Moisture Content at:				
0.00 Atms	30	27	19	15
0.01 Atms	27	25	18	13
0.02 Atms	26	24	18	13
0.03 Atms	26	24	17	13
0.04 Atms		22		12
0.06 Atms	24	22	16	12
0.33 Atms	21	16	15	10
1.00 Atms	20	18	14	10
3.00 Atms	9.5	10.8	11.0	9.0
5.00 Atms	8.1	9.4	9.9	7.6
8.00 Atms	7.0	8.4	9.0	6.6
15.00 Atms	6.2	7.1	7.9	5.4
27.19 Atms	5.4	6.1	7.0	4.3

* Except when noted figures indicate percent on an oven dry basis.

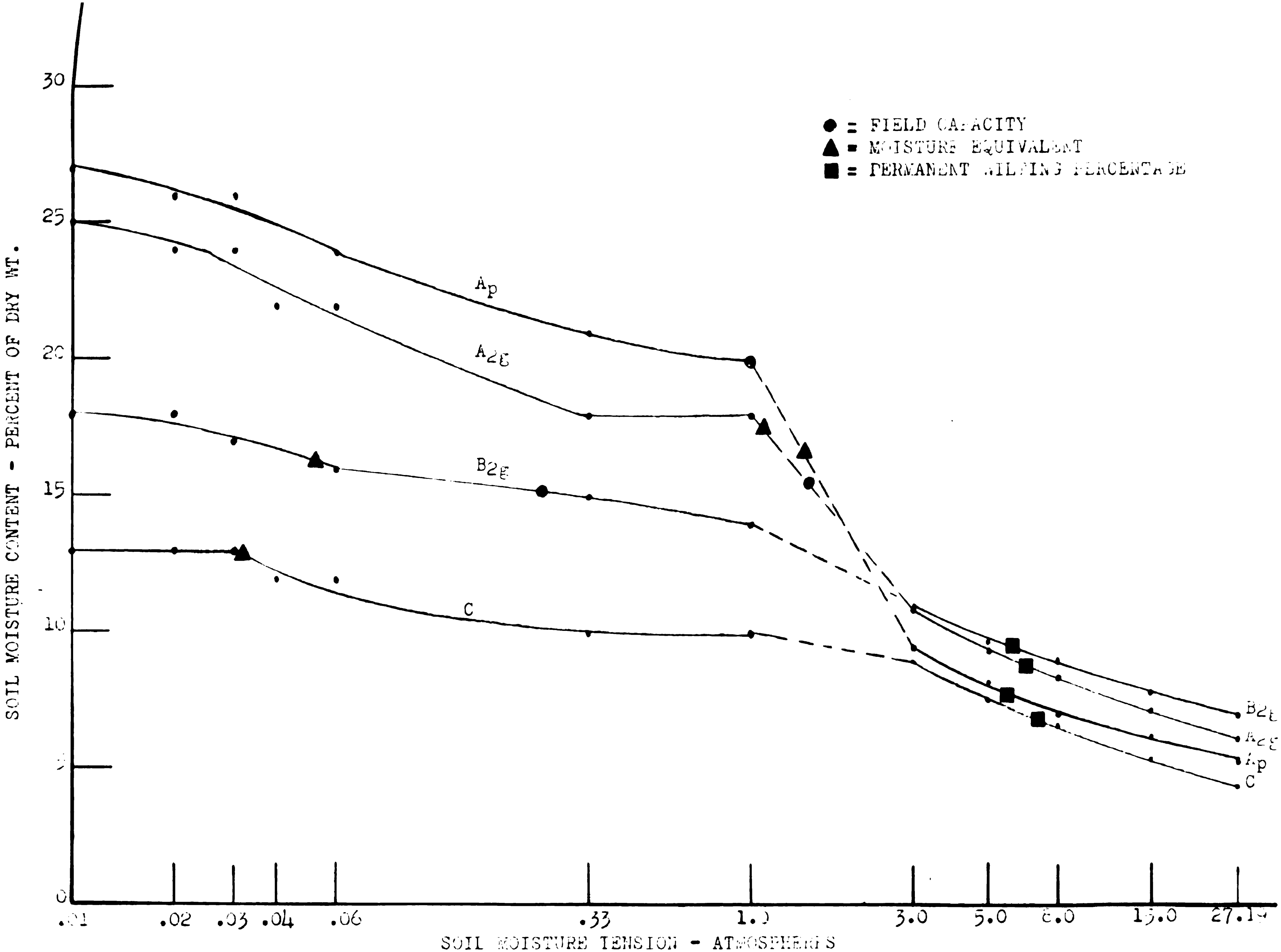


Figure 48. Moisture release curves for Coldwater silt loam site number thirty-two.

TABLE XXXVI

SOIL DATA ON [illegible]

Sample Number	168	169	170	171
Horizon	A_p	B_{2g}	C_1	C_2
Depth (inches)	0-6	6-12	12-22	22
Hygroscopic Coefficient	2.1	2.2	2.5	1.7
Permanent Wilting Point	[illegible]	1[illegible].6	17.2	15.6
Field Capacity	30.5	25.6	21.6	25.0
Moisture Equivalent	30.5	27.3	[illegible].1	25.0
Total Carbon	2.8	0.94		
Sand	19.2	13.0	14.4	[illegible].9
Silt	45.8	42.3	37.1	34.3
2μ Clay	27.5	39.6	40.0	41.4
.2μ Clay	9.7	1[illegible].5	17.2	17.8
Montmorillonite	5	5	5	<5
Illite	50	30	70	[illegible]
Kaolinite	8	6	10	12
Volume Weight (gms/cc)	1.2	1.6	1.7	1.7
Moisture Content at:				
0.00 Atms	[illegible]	24	22	21
0.01 Atms	43	22	21	21
0.02 Atms	41	21		
0.03 Atms	39	21	21	21
0.04 Atms	[illegible]	21	[illegible]	20
0.06 Atms	37	20	19	20
0.33 Atms	35	[illegible]	[illegible]	[illegible]
1.00 Atms	33	[illegible]	[illegible]	17
3.00 Atms	22.2	[illegible]	21.3	[illegible]
5.00 Atms	[illegible]	19.4	19.7	19.2
8.00 Atms	15.7	17.3	18.2	17.7
15.00 Atms	13.3	[illegible]	[illegible]	14.8
27.19 Atms	10.5	12.3	13.6**	12.3

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.

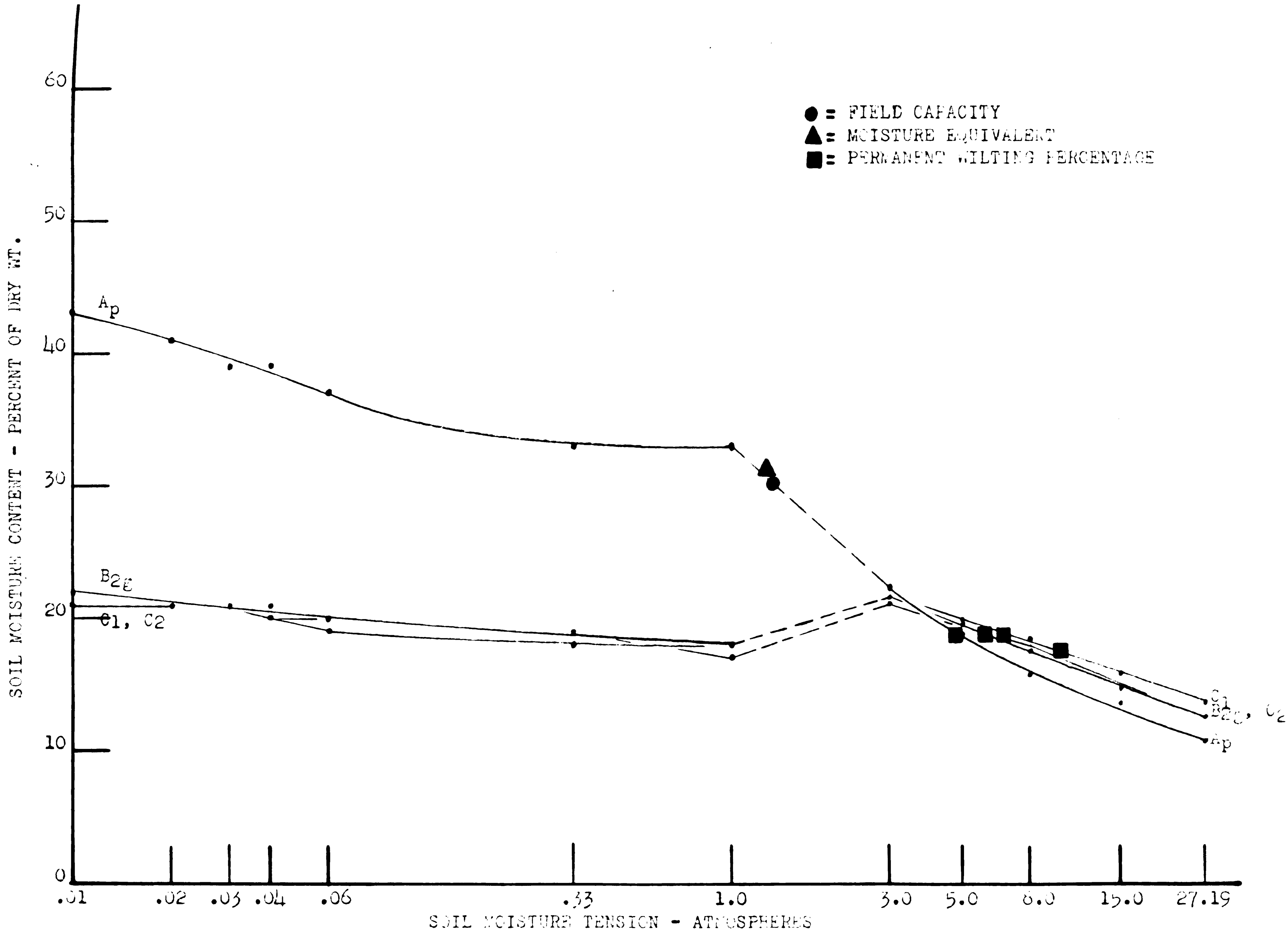


Figure 49. Moisture release curves for Nappanee silty clay loam site number thirty-three.

TABLE XXXVII

[illegible] NAPPANEE CLAY L[illegible] [illegible] THIRTY-FIVE*

Sample Number	172	173	174	175
Horizon	Ap	A2g	Bg	C1
Depth (inches)	0-8	8-11	11-36	36-39
Hygroscopic Coefficient	1.6	1.7	2.2	2.4
Permanent Wilting Point	15.5	20.3	22.3	16.8**
Field Capacity***	24.5	24.2	26.7	
Moisture Equivalent	26.2	27.8	31.8	26.2
Total Carbon	2.2	1.2		
Sand	27.3	21.9	17.0	19.3
Silt	34.1	35.8	26.8	27.3
2 μ Clay	33.7	40.3	53.9	50.2
.2 μ Clay	11.6	16.0	20.4	21.1
Montmorillonite	0	<5	0	0
Illite	40	50	50	40
Kaolinite	6	10	6	6
Volume Weight (gms/cc)	1.3	1.5	1.5	1.7
Moisture Content at:				
0.00 Atms	35	25	27	19
0.01 Atms	32	25	26	19
0.02 Atms	29	23	26	19
0.03 Atms	29	23	25	19
0.04 Atms	28	23	25	19
0.06 Atms	27	22	24	18
0.33 Atms	27	21	24	17
1.00 Atms	26	21	22	17
3.00 Atms	21.5	21.8	25.6	22.2
5.00 Atms	19.2	19.3	23.3	20.4
8.00 Atms	17.7	18.4	22.0	19.6
15.00 Atms	14.0	15.4	19.1	17.3
27.19 Atms	10.6	11.9**	16.0**	15.1**

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.
*** Initial moisture determinations used as field capacity.

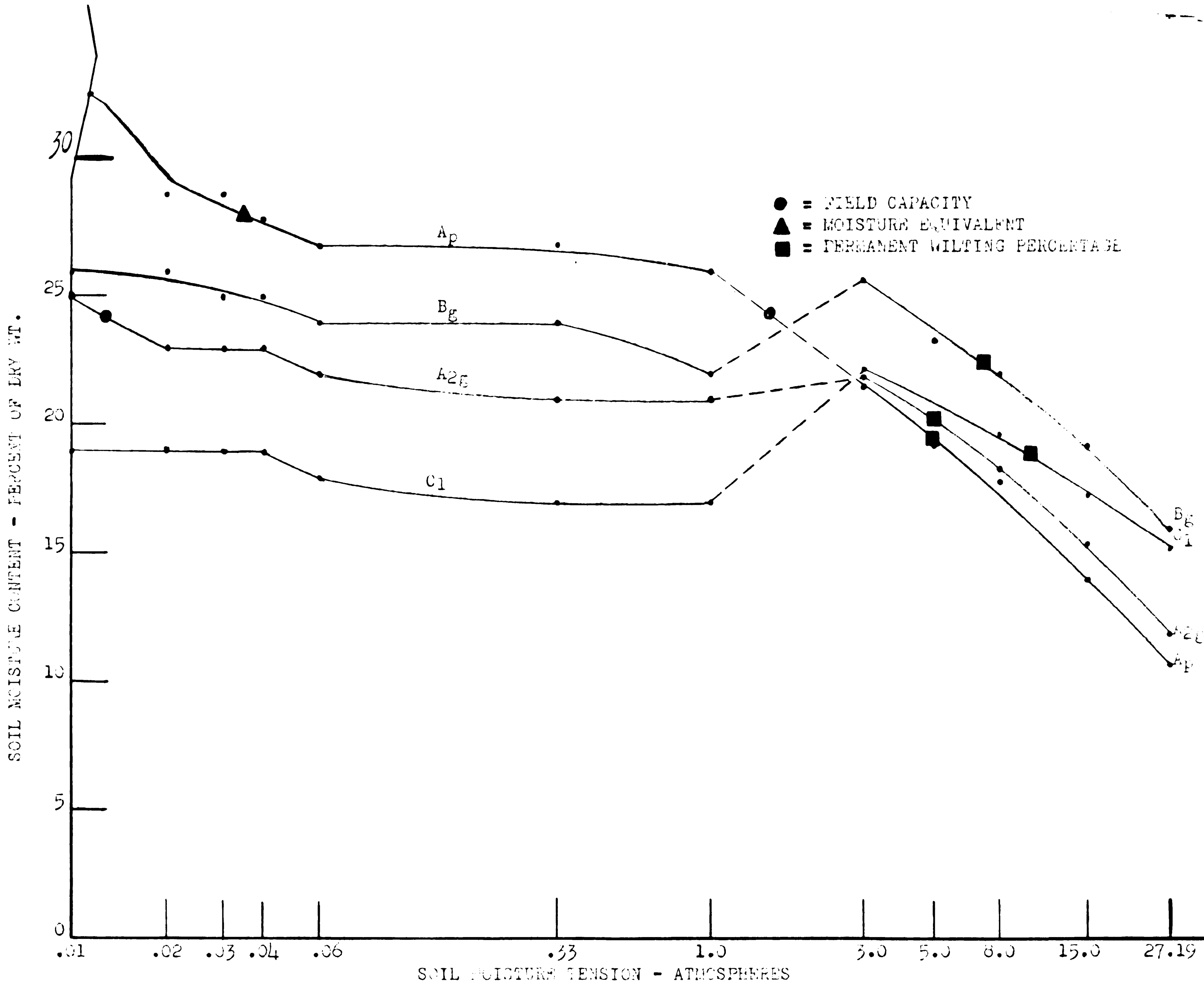


Figure 56. Moisture release curves for Nappanee clay loam site number thirty-five.

TABLE XXXVIII

BASIC DATA ON PICKFORD SILT CLAY LOAM SITE NUMBER THIRTY-SIX*

Sample Number	176	177	178	179
Horizon	A_p	A_2G	B_2G	C
Depth (inches)	0-8	8-13	13-23	23
Hygroscopic Coefficient	2.6	2.5	3.2	3.1
Permanent Wilting Point	17.7	18.1	24.2	21.3**
Field Capacity	35.4	22.5	28.9	33.7
Moisture Equivalent	35.2	26.3	34.1	36.3
Total Carbon	6.0	0.27		
Sand	11.2	7.5	5.6	2.2
Silt	48.1	39.6	27.1	19.3
2 μ Clay	26.3	47.8	60.0	63.4
.2 μ Clay	11.5	16.6	22.6	16.1
Montmorillonite	0	0	0	0
Illite	10	0	0	10
Kaolinite	0	<2	2	2
Volume Weight (gms/cc)	1.1	1.6	1.4	1.4
Moisture Content at:				
0.00 Atms	51	27	36	35
0.01 Atms	48	26	35	34
0.02 Atms	47	26	35	34
0.03 Atms	46	25	34	33
0.04 Atms	45	25	33	33
0.06 Atms	44	24	33	33
0.33 Atms	43	24	32	32
1.00 Atms	34	23	31	31
3.00 Atms	23.9	19.7	25.8	27.7
5.00 Atms	20.5	18.0	23.7	25.0
8.00 Atms	18.4	16.9	22.5	24.1
15.00 Atms	16.0	15.0	20.2	21.9
27.19 Atms	12.1**	13.4	17.9	19.7

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.

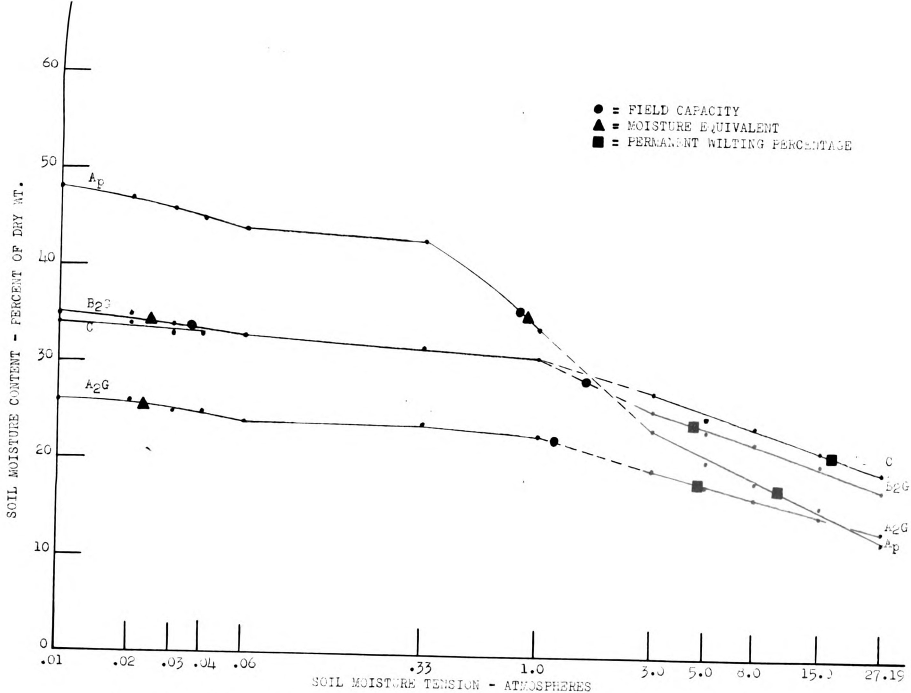


Figure 51. Moisture release curves for Pickford silt clay loam site thirty-six.

TABLE XXXIX

BASIC DATA ON ONTONAGON SILTY CLAY SITE NUMBER THIRTY-SEVEN*

Sample Number	180	181	182
Horizon	A_p	B_{21}	B_{22}
Depth (inches)	0-5	5-9	9-22
Hygroscopic Coefficient	2.4	3.5	3.8
Permanent Wilting Point	19.8**	24.5	25.3
Field Capacity	29.4	38.9	39.1
Moisture Equivalent	31.6	35.1	38.4
Total Carbon	2.3	0.85	
Sand	8.2	1.7	1.3
Silt	41.5	28.1	25.5
2 μ Clay	41.0	67.7	68.8
.2 μ Clay	14.8	24.1	32.6
Montmorillonite	0	0	0
Illite	10	10	0
Kaolinite	4	2	2
Volume Weight (gms/cc)	1.3	1.4	1.5
Moisture Content at:			
0.00 Atms	37	27	23
0.01 Atms	36	27	23
0.02 Atms	35	27	22
0.03 Atms	33	26	22
0.04 Atms	32	26	22
0.06 Atms	31	26	22
0.33 Atms	31	25	22
1.00 Atms	31		21
3.00 Atms	23.4	27.5	27.7
5.00 Atms	20.8	25.8	25.8
8.00 Atms	18.7	24.4	24.5
15.00 Atms	18.1	21.7	22.3
27.19 Atms	11.8	18.4	19.7

* Except when noted figures indicate percent on an oven dry basis.

** Figures include only one determination.

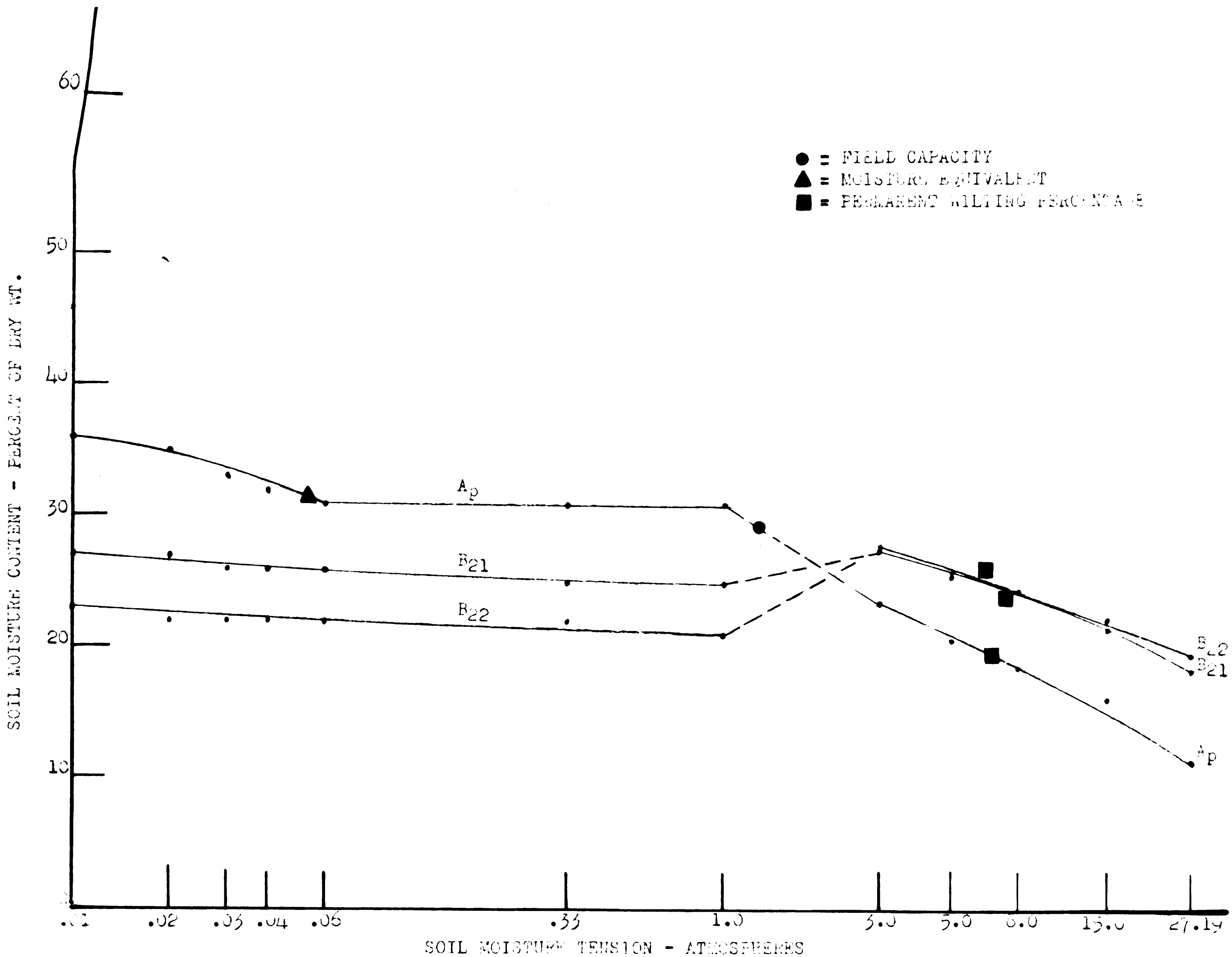


Figure 52. Moisture release curves for Ontonagan silty clay site number thirty-seven.

Sample No
Horizon
Depth (inc
Hygroscopi
Permanent
Field Capa
Moisture
Total Car
Sand
Silt
2% Clay
<2% Clay
Montmorill
Illite
Kaolinite
Volume
Moisture

*

**

***

TABLE XXXX

[illegible] DATA [illegible] SILTY CLAY LOAM SITE [illegible] THIRTY-EIGHT*

Sample Number	103	104	105
Horizon	Ap	B2g	Cg
Depth (inches)	0-8	8-1[illegible]	18
Hygroscopic Coefficient	1.9	2.6	2.3
Permanent Wilting Point	16.2	17.3	17.5**
Field Capacity***	23.7	27.4	24.4
Moisture Equivalent	[illegible]	25.8	26.4
Total Carbon	1.8	0.61	
Sand	10.7	12.0	5.8
Silt	[illegible]	37.2	22.8
2 µ Clay	31.4	49.9	44.0
.2 µ Clay	13.4	24.6	21.3
Montmorillonite	0	10	0
Illite	30	70	20
Kaolinite	10	14	6
Volume Weight (gms/cc)	1.4	1.5	1.6
Moisture Content at:			
0.00 Atms	31	25	25
0.01 Atms	30	23	24
0.02 Atms	28	21	22
0.03 Atms	27	20	22
0.04 Atms	27	20	22
0.06 Atms	26	19	21
0.33 Atms	25	19	
1.00 Atms	24	19	
3.00 Atms	18.0	19.9	20.5
5.00 Atms	15.4	18.4	19.1
8.00 Atms	13.4	17.1	17.8
15.00 Atms	10.8	15.6	16.0
27.19 Atms	8.9	13.8**	14.2

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.
*** Drained for only 25 hours before samples were taken.

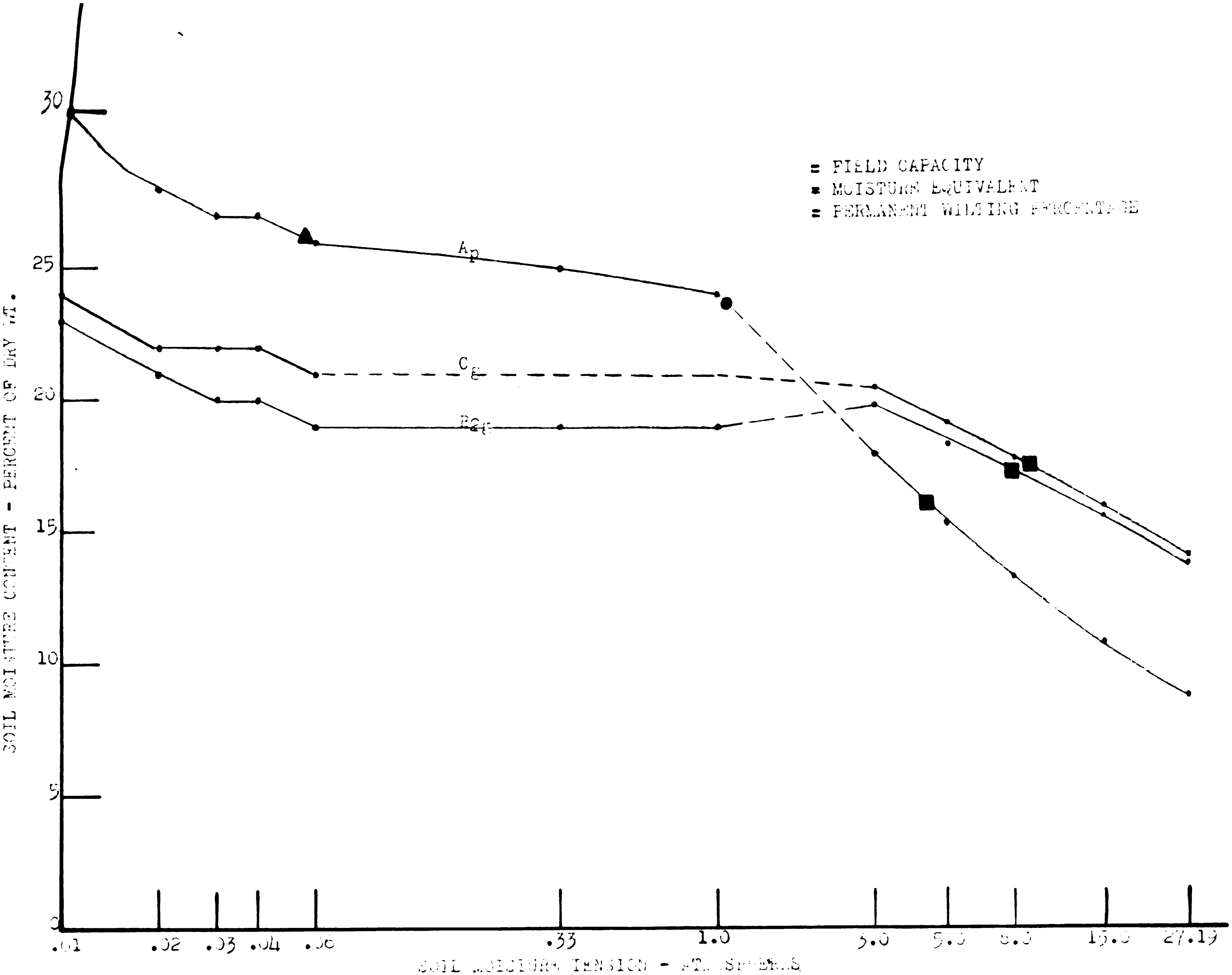


Figure 55. Moisture release curves for Selkirk silty clay loam site thirty-eight.

TABLE XXXI

BASIC DATA ON PICKFORD CLAY LOAM SITE NUMBER THIRTY-NINE*

Sample Number	106	107	108	109
Horizon	A_p	B_1G	B_2G	B_3G
Depth (inches)	0-6	6-11	11-15	15-36
Hygroscopic Coefficient	3.2	3.4	3.2	3.1
Permanent Wilting Point	20.3	20.4	16.9	19.7
Field Capacity	26.9	24.9		27.0
Moisture Equivalent	29.5	29.1	27.1	28.2
Total Carbon	2.9	1.2		
Sand	26.3	18.4	21.0	19.2
Silt	28.5	25.0	26.2	27.0
2 µ Clay	37.4	50.4	46.9	49.6
.2 µ Clay	17.7	24.2	23.9	24.3
Montmorillonite	0	5	<5	5
Illite	10	30	30	50
Kaolinite	4	8	6	10
Volume Weight (gms/cc)	1.4	1.4	1.5	1.4
Moisture Content at:				
0.00 Atms	32	27	28	33
0.01 Atms	29	25	27	31
0.02 Atms	28	25	27	31
0.03 Atms	28	24	27	30
0.04 Atms	27	24	26	30
0.06 Atms	27	24	26	29
0.33 Atms	26	23	26	29
1.00 Atms	26	23	25	29
3.00 Atms	20.9	22.0	20.7	20.9
5.00 Atms	19.6	20.2	19.5	19.6
8.00 Atms	17.9	18.6	17.8	17.9
15.00 Atms	16.4	17.2	16.8	16.6
27.19 Atms	13.9**	15.1**	14.4**	14.5**

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.

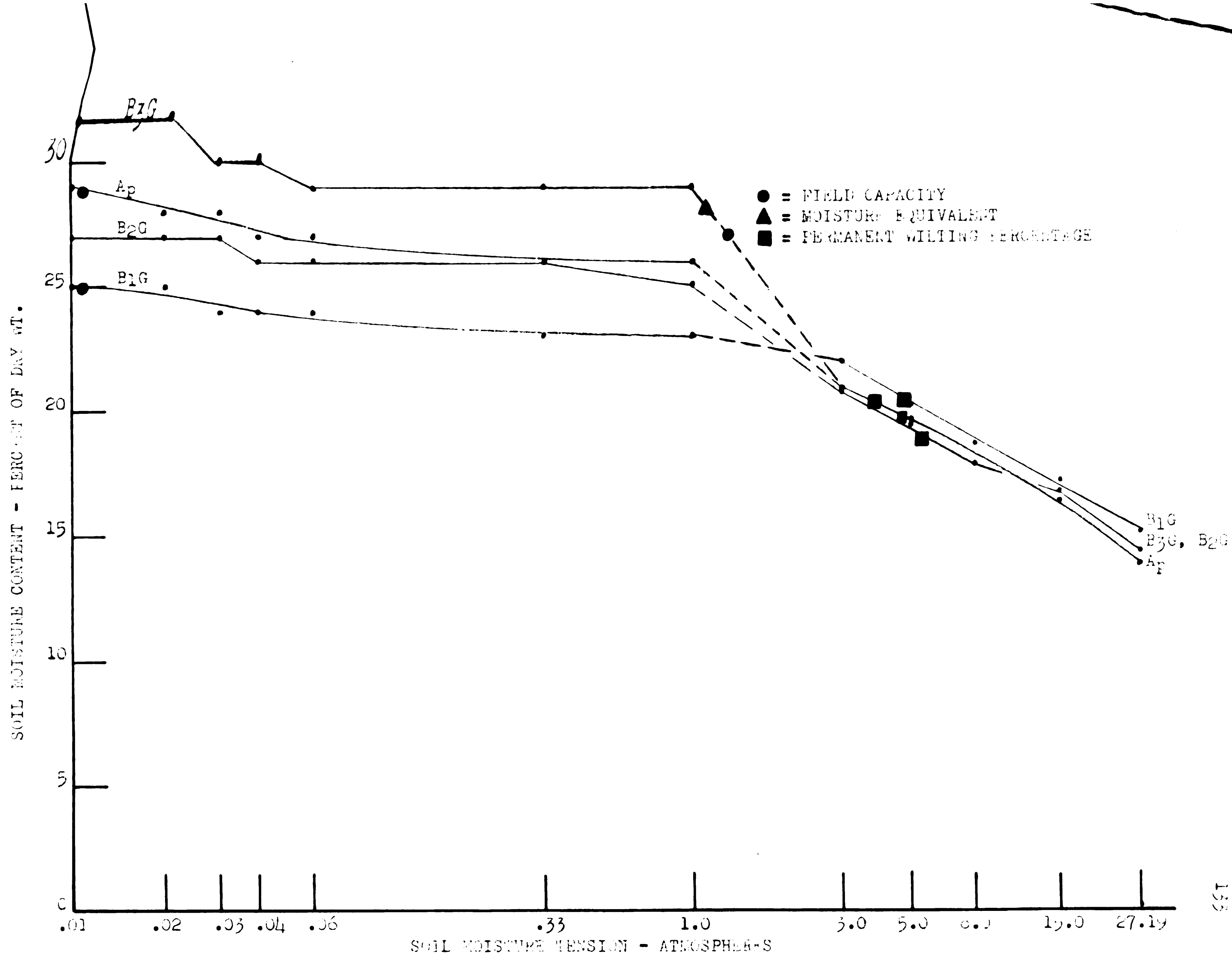


Figure 54. Moisture release curves for Pickford clay loam site number thirty-nine.

TABLE XXXXII

BASIC DATA ON SELKIRK SANDY CLAY LOAM SITE NUMBER FORTY*

Sample Number	190	191	192
Horizon	A_p	B_g	C
Depth (inches)	0-9	9-12	12-18
Hygroscopic Coefficient	1.4	2.5	1.7
Permanent Wilting Point	6.0**	15.1	15.2
Field Capacity	19.9	21.5	20.2
Moisture Equivalent	16.6	22.7	21.4
Total Carbon	1.3	0.48	
Sand	50.4	26.5	12.9
Silt	26.4	29.0	25.6
2 μ Clay	19.0	40.4	52.3
.2 μ Clay	8.9	24.9	
Montmorillonite	<5	0	<5
Illite	20	20	40
Kaolinite	6	2	10
Volume Weight (gms/cc)	1.6	1.6	1.6
Moisture Content at:			
0.00 Atms	23	23	24
0.01 Atms	21	22	23
0.02 Atms	20	21	23
0.03 Atms	20	21	21
0.04 Atms	19	20	21
0.06 Atms	19	20	20
0.33 Atms	19	20	20
1.00 Atms	18	15	16
3.00 Atms	11.2	16.6	16.5
5.00 Atms	10.4	15.5	15.4
8.00 Atms	9.3	14.5	14.0
15.00 Atms	7.7	13.1	12.6
27.19 Atms	6.5	11.7	10.8

* Except when noted figures indicate percent on an oven dry basis.
** Figures include only one determination.

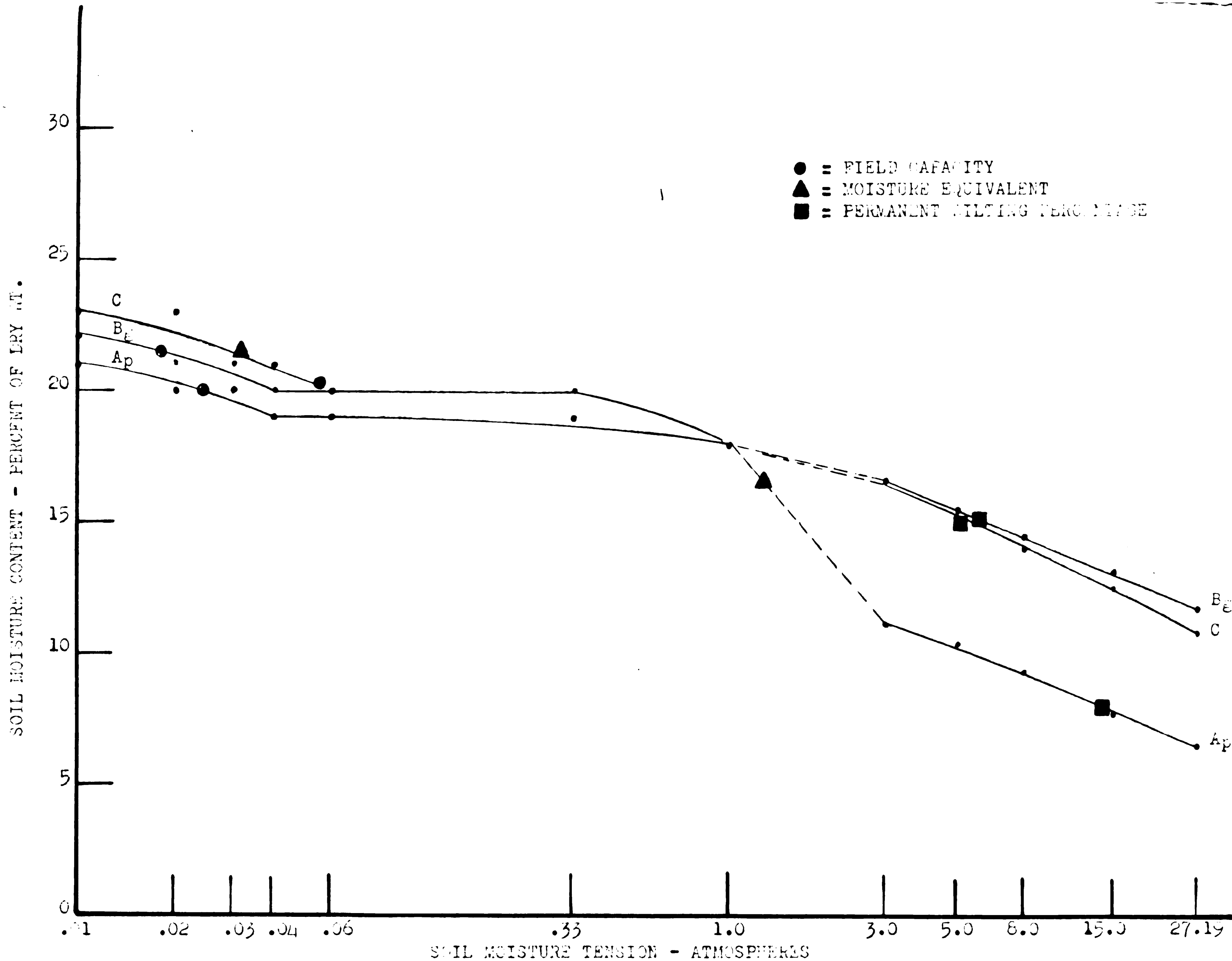


Figure 55. Moisture release curves for Selkirk sandy clay loam site number forty.