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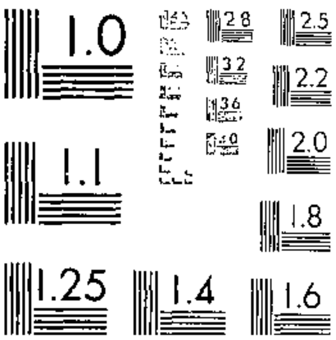

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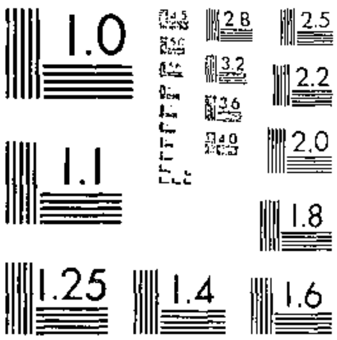

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TECHNICAL BULLETIN No. 532 — SEPTEMBER 1936

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

THE COMPARATIVE MOISTURE-ABSORBING AND MOISTURE-RETAINING CAPACITIES OF PEAT AND SOIL MIXTURES

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INTRODUCTION

The use of peat as a source of organic matter for improving the physical condition of mineral soils is becoming of increasing importance. Numerous publications have described such use and have shown, particularly in the growth of greenhouse crops and lawns, that definite benefits may be obtained when peat is mixed with certain soils. Peat improves the texture of clay and loose sandy soils, and, presumably, the benefits derived from its use result largely from improved physical conditions in the soil medium.

It is frequently stated by writers, in connection with soil-improvement work, that peat greatly increases the water-holding capacity of the soil with which it is mixed and thereby increases the available moisture supply. For example, it is known that a sphagnum-moss peat may absorb from 1,000 to 3,000 percent of water, whereas a mineral soil may absorb only 30 or 40 percent under the same conditions. On this basis the assumption has been made that the apparent increased moisture-holding capacity resulting from the admixture of peat to a mineral soil is of considerable value in supplying water to plants over a period of drought.

No thorough or extensive study has previously been made, so far as the authors are aware, of the capacity of peat and soil mixtures to absorb and retain moisture available to plants against evaporation losses as compared with the capacity of the soil alone. The purpose of the present study was to evaluate the effect of different types of peat in common use with respect to the moisture relationships involved in the incorporation of such material with soil. An effort was made to determine the effects obtained from the use of peat as a means of increasing the moisture-holding capacity of soil and also as a means of conserving moisture during extended dry periods. Information was also sought relative to the degree of dryness to which plants could extract water from peat and from peat and soil mixtures before undergoing permanent wilting.

REVIEW OF LITERATURE

In experiments on a mixture of peat with sandy soil, Krüger (*6*)[1] concluded that the peat held water too tightly for plants to obtain it, although the content of water in the mixture was greater than in the sand alone. Treatment of a sandy soil with low-moor peat, according to Nyström (*9*), gave large increases in crop yield under normal rainfall as well as under conditions of excessive precipitation. Alway and Neller (*1*) found, in working with a silt loam soil, that the plots richest in organic matter retained the most water during a cool wet summer, but that much smaller differences in moisture content occurred during a warmer and somewhat drier summer. Monteith and Welton (*8*) presented some evidence, in connection with studies on golf greens, that the increased water-holding capacity accompanying the presence of peat in mixtures of equal proportions by volume with soil has been overrated. Dachnowski-Stokes (*4*) and Longley (*7*) believe that the high moisture-holding capacity of peat plays a part in the improvement of physical conditions in the soil.

Sprague and Marrero (*10*) calculated the "available water-holding capacity" for various peats and for mixtures of these peats with several soils from the hygroscopic coefficient and the maximum water-holding capacity. The use of formulas, such as those developed by Briggs and Shantz (*2, p. 72*) for calculation of wilting percentages is as yet not justified in the case of peat because confirmatory experimental data are lacking. Some wilting percentages for peat, however, have been reported by Heinrich (*5*), which ranged from 49.7 to 52.87 percent, depending on the variety of plant used as an indicator. The character of the peat and the method employed were not described.

The literature, therefore, is rather vague, particularly with reference to actual data as to the part played by peat in the moisture relationships of peat and soil mixtures. The moisture conditions, improved or otherwise, resulting from the admixture of peat with soil have not been satisfactorily evaluated.

MATERIALS USED

Three varieties of peat were selected for this investigation, namely, an imported sphagnum-moss peat, a sedge peat from Michigan, and a cultivated reed peat from New Jersey. These materials represent a gradation from a coarsely fibrous material to one having very little fiber and in a more advanced state of decomposition. The moss

[1] Italic numbers in parenthesis refer to Literature Cited, p. 24.

peat was light brown, well preserved, and highly acid; the sedge peat was somewhat darker, more finely fibrous, and slightly less acid than the moss peat; and the reed peat was very dark brown, granular, and acid but markedly less so than the sedge and sphagnum peats. The content of mineral matter (ash), as shown in table 1, ranged from 1.62 percent in the moss peat to 10.22 percent in the reed peat. These materials can be purchased on the market and are representative of the types of peat most commonly sold for soil improvement and other purposes.

TABLE 1.—*Analyses of peats used in greenhouse experiments*

Type of peat	Source	Ash content	Acidity	Moisture content in air-dried condition
		Percent	*pH*	*Percent*
Sphagnum moss	Imported	1.62	3.70	12.5
Sedge	Michigan	5.26	3.90	12.3
Reed (cultivated)	New Jersey	10.22	4.85	13.5

A clay loam soil (Keyport clay loam) and a fine sandy soil (Norfolk loamy fine sand) were used in preparing the mixtures of peat and soil. The clay loam soil, which was obtained from the Arlington (Va.) Experiment Farm, contained 23.6 percent of clay, and the fine sandy soil, obtained near Gunston Hall, Va., contained 44.1 percent of fine sand and 26 percent of medium sand. A sample of pure quartz sand was included later during the course of the experiments. This was composed largely of coarse sand comprising 64.8 percent of the entire sample. Complete mechanical analyses are shown in table 2.

TABLE 2.—*Mechanical analyses of soils used in greenhouse experiments* [1]

Soil type	Fine gravel (2-1 mm)	Coarse sand (1-0.5 mm)	Medium sand (0.5-0.25 mm)	Fine sand (0.25-0.1 mm)	Very fine sand (0.1-0.05 mm)	Silt (0.05-0.005 mm)	Clay (0.005-0 mm)
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Keyport clay loam	0.8	1.4	2.5	10.9	15.8	43.0	23.6
Norfolk loamy fine sand	.1	6.2	26.0	44.1	8.3	7.5	6.7
Quartz sand	16.7	64.8	17.4	.9	.0	.0	.2

[1] Determinations by T. M. Shaw.

METHODS

PREPARATION OF MIXTURES AND PHYSICAL DETERMINATIONS

The peat and soil samples were air-dried and ground to pass a 2-mm. mesh sieve. It is essential that peat be ground to at least this state of fineness in order to make possible thorough incorporation with soil.

The volume weight of each sample was determined by means of a small glass cylinder filled with three successive layers of material. The cylinder was gently tapped after the addition of each layer. The material required to fill the container was then weighed and the average of a number of determinations recorded. The actual volume of the cylinder was estimated by filling with water. The volume weights of the mixtures were calculated from those of the separate materials and were considered sufficiently accurate for comparative purposes.

All mixtures of peat and soil were made on a volume basis as this seemed to be the most practical. The volume weights of different varieties of peat differ so widely that mixtures with soils on a weight basis have little comparative significance. For example, the sample of sphagnum-moss peat used weighed only 7 pounds per cubic foot, whereas the reed peat weighed approximately 24 pounds per cubic foot. It is obvious, therefore, that a 25-percent mixture by weight of moss peat with soil weighing 70 pounds would require more than 3 cubic feet of peat to 1 of soil. Only 1 cubic foot of the reed peat would be required to produce a mixture of the same percentage composition. Because of these differences it was believed that the various properties of peat and soil mixtures should be compared where the same volumes of peat were used, irrespective of their actual weights. The volume relationships could, of course, be readily converted to a weight percentage basis. The proportions of peat to soil used in all the experiments were in the ratio by volume of 1:1, 1:2, and 1:4, or one-half peat, one-third peat, and one-fifth peat, respectively. With the quartz sand only two of the peats were used, the moss and reed peats in one-half and one-fifth proportions. Materials were weighed for the preparation of mixtures in such a manner that the required volumetric relationships were obtained. Mixing was accomplished by rolling and thorough incorporation with a spatula.

The mixtures, particularly those of the sandy soil and quartz sand, were moistened in preparation for the determination of the maximum moisture-holding capacity. This facilitated mixing and prevented segregation of the light particles of organic matter from the sand. The time required to reach the saturated condition of peat, or mixtures rich in peat, was found to be greatly reduced by preliminary moistening since air-dried peat absorbs water with difficulty.

The maximum moisture-holding capacity and moisture equivalent of each material and of each mixture of materials were determined in the usual manner. A layer of peat or soil approximately 1 cm thick, was placed in a small metal box having a perforated bottom. The material rested on a filter paper and was saturated by placing the box and contents in a shallow pan of water and allowing it to soak. After several hours the boxes were removed and allowed to drain overnight in a saturated atmosphere. Any excess water adhering to the bottom was then carefully wiped off and the weight of each box and contents recorded. The boxes were immediately placed in the moisture-equivalent apparatus and centrifuged at 1,000 gravity for 40 minutes. The samples were again weighed and finally placed in the oven at 105° C., to obtain the oven-dry weight. The percentage of water held by the peat in the saturated condition is termed the maximum moisture-holding capacity, and that held after centrifuging is termed the moisture equivalent. The oven-dry weights were used as a basis for all calculations.

EVAPORATION EXPERIMENTS

The evaporation experiments were carried out under three conditions: (1) With all peat and soil mixtures initially saturated; (2) with all materials having the same initial content of water; and (3) the same as the second but with growing plants. The experiments were conducted in a greenhouse using glazed earthenware pots of 1-gallon capacity.

The material for each pot was thoroughly mixed and moistened with approximately 500 cc of water. Pots were selected which had the same diameter or as nearly the same as possible and were filled to a depth of about 5½ inches. The material was added in three portions with gentle tapping and light hand pressure after each addition, so that a firm condition was obtained without excessive packing. Water was then added to the surface with a small sprinkler until the desired quantity was present.

In the first experiment, water was added until a thin film of water persisted on the surface after an hour or more of standing when covered to prevent evaporation. The amount of water required to saturate a given sample was less than that corresponding to the maximum moisture-holding capacity as determined in the laboratory, as is invariably the case when larger quantities of material are used. The weight of each empty pot, the total contents of dry material, and the total weight of each pot with the saturated contents were recorded. A beam balance with a sensitivity of about 2 g under full load was used for the weighings. The pots were placed on a bench and shifted daily to compensate for any possible variations in temperature or air currents in different locations in the greenhouse. Weighings were made periodically as the experiment continued, and the progressive losses of moisture by evaporation were obtained by the differences in the successive weights. Observations were made during a period of 92 days. All mixtures of materials and their respective checks were run in duplicate.

The second experiment was carried out on the same materials, but in this case each pot had the same initial content of water, an amount less than that required to saturate any of the materials, with the exception of the quartz sand. All the samples were allowed to become air-dry and were resieved through a 2-mm mesh screen. Five hundred cubic centimeters of water was mixed with the material, and the pots were refilled in the same manner as in the previous experiment. The water content of each pot was then made up to a total of 1,000 g by addition of water to the surface. The pots were covered for 3 days before evaporation was allowed to proceed, in order to allow distribution of the moisture. Weighings were then made at intervals over a period of 49 days, at which time some of the materials had reached the point of complete air-dryness.

The third experiment was conducted to demonstrate the comparative ability of peat and soil mixtures to supply water to growing plants over a period during which no water was added to compensate for losses through evaporation and transpiration. Each pot in this experiment contained 600 g of water which was entirely mixed with the contents at the beginning of the experiment. Sufficient fertilizer salts were added to produce good growth in such a medium as quartz sand. Lime was incorporated to correct acidity, in amounts which by previous experimentation were found to give a pH reading of 6.5 10 days after mixing with moist materials. Ceres spring wheat (*Triticum vulgare*) was planted, and eight selected plants were allowed to grow in each pot. The pots were kept at constant weight by addition of water for approximately 3 weeks, during which time the plants were growing. Water was then no longer added, and the condition of the plants was noted as the water supply gradually became depleted and wilting took place. Weights of the pots were periodically recorded, as in the previous experiments.

WILTING-POINT DETERMINATIONS

The last experiment mentioned yielded some information as to the ability of peat and soil mixtures to supply water to growing plants, but actual wilting percentages cannot be determined in this manner since the moisture is unequally distributed throughout the pot as a result of surface evaporation. Accordingly, direct wilting percentages of each separate peat and soil, as well as of the mixtures, were determined in order to ascertain more accurately the extent to which a plant could obtain readily available moisture from these materials.

The method[2] used was one recommended by F. J. Veihmeyer, of the University of California Agricultural Experiment Station at Davis. Tin-can containers with a capacity of approximately 1 pint each were filled with the desired soil material having a moisture content sufficient for good plant growth. Fertilizer salts and lime had been added as in the previous experiment. Dwarf sunflowers (*Helianthus annuus*, var. *nanus*) were then planted, and, after attaining a height of 1 inch or more, a single plant in each can was selected. A friction-top lid with a ½-inch hole through it was placed on each can, allowing the plant to grow through the hole. The cans were kept in the greenhouse at a constant moisture content until the plants had attained sufficient size to have four sets of leaves. At this stage cotton was placed in the hole around the stem to prevent evaporation, and the plant was allowed to wilt. The experiment was carried out in triplicate.

When permanent wilting occurred the plant was cut off at its base. The can and contents were weighed, also the wilted plant. The stage of permanent wilting was established by failure of the wilted lower leaves of the plant to recover in a dark saturated atmosphere overnight. This test was made with only part of the plants, as the condition of permanent wilting, as defined in a more or less arbitrary manner, was fairly easily recognized. After cutting the plants, the cans were placed in the oven and dried at 105° C., in order to obtain the dry weight of the soil.

The percentage of water remaining in the soil when permanent wilting takes place is termed the wilting percentage. The weight of the roots is stated by F. J. Veihmeyer to be approximately one-half the weight of the tops and, further, the roots contain about 80 percent of water. A correction was, therefore, made for the weight of the roots and their water content in calculating the actual

[2] Information privately communicated to the authors.

soil-moisture content at the wilting point. The tare weights of the cans had been obtained at the beginning of the experiment and were deducted from the gross oven-dry weight of soil and can to obtain the net contents. The corrected water content divided by the weight of the oven-dry soil and multiplied by 100 gave the wilting percentage.

MAXIMUM MOISTURE-HOLDING CAPACITY AND MOISTURE EQUIVALENT

The maximum moisture-holding capacity and moisture equivalent of each material and of each mixture are shown in the second and third columns of table 3. The remaining columns contain values calculated on the basis of these two columns and from the volume weights of the separate materials.

TABLE 3.—*Maximum moisture-holding capacity and moisture equivalent of peat and soil mixtures*

Material	Maximum moisture-holding capacity	Moisture equivalent	Moisture required to saturate 100 cm³ of dry material	Moisture required for moisture equivalent of 100 cm³ of dry material	Weight of 100 cm³ of air-dry material
	Percent	*Percent*	*Grams*	*Grams*	*Grams*
Clay loam soil	41.3	20.2	48	22	109
Loamy fine sand	30.9	6.5	42	8.8	135
Quartz sand	28.3	1.4	39	2	139
Moss peat	1,057	166	101	16	11
Sedge peat	374	112	91	27	27
Reed peat	289	110	99	38	39
Clay soil-peat mixtures:[1]					
One-half moss peat	111	31	67	18	60
One-third moss peat	74.8	26.3	56	20	76
One-fifth moss peat	57.3	21.6	51	19	89
One-half sedge peat	93.7	30.1	63	21	68
One-third sedge peat	69.9	31.1	56	25	82
One-fifth sedge peat	57.2	24.2	52	22	93
One-half reed peat	94.1	39.4	67	28	71
One-third reed peat	69.9	32	58	27	86
One-fifth reed peat	56.8	26.5	53	25	95
Sandy soil-peat mixtures:[1]					
One-half moss peat	101	16.9	73	12	74
One-third moss peat	64.3	11.7	60	11	93
One-fifth moss peat	48.4	9.4	53	10	110
One-half sedge peat	80.8	23.5	64	19	81
One-third sedge peat	57.7	15.7	57	16	99
One-fifth sedge peat	46	11.4	52	13	113
One-half reed peat	79.3	26.4	67	22	87
One-third reed peat	58.7	17.1	59	17	103
One-fifth reed peat	47.4	12.1	54	14	116
Quartz sand-peat mixtures:[1]					
One-half moss peat	89.1	12.7	67	9.5	75
One-fifth moss peat	47.8	5.6	54	6.1	111
One-half reed peat	79.5	21.8	71	19	89
One-fifth reed peat	41.5	9	49	11	119

[1] All mixtures were made on a volume basis.

Sphagnum-moss peat has a higher moisture-holding percentage than any other material used and as much as three times that of the other peats. The relatively high value of 1,057 percent, however, has actually far less significance when the low volume weight is considered. On an equal volume basis, the differences between the peats are seen to be small with respect to the relative quantities of moisture which they are capable of absorbing. The total moisture-absorbing capacities of the peats are only two or three times those of the soils, including the quartz sand, which indicates a superiority of peat in moisture-absorbing capacity much less than that indicated by the corresponding percentages by weight. Considerable swelling takes place when peat is moistened, but this is not taken into account since all determinations and calculations refer to dry material as a basis.

The addition of peat to soil increases the moisture-holding capacity in proportion to the quantity of peat added. Except for minor variations, the values obtained for the mixtures are essentially those that would be expected from an inspection of values of the separate constituents. This fact is more readily apparent from the figures representing weight of water absorbed by 100 cm^3 of dry material than from the usual percentages by weight. No great variations occur in the quantity of water absorbed by the same proportions of different varieties of peat in a given soil. Thus, when the three varieties of peat are separately mixed with clay soil in the 1:1 ratio, the water required to saturate 100 cm^3 of each particular dry mixture varies only from 63 to 67 g. The mixture of equal proportions of moss peat and sandy soil has the corresponding value of 73 g of water. The reason that the latter is higher than that of the clay soil mixture is not apparent. A similar irregularity is noted in the 1:1 mixture of reed peat and quartz sand which holds somewhat more moisture on a volume basis than either of the mixtures of reed peat with soil.

According to the tabulated results the moss peat (in the one-half mixtures) caused a 40-percent increase in the moisture-holding capacity of clay soil, a 74-percent increase in that of the sandy soil, and a 72-percent increase in that of quartz sand. The corresponding values for reed peat are 40, 60, and 82 percent, respectively. Thus it may be seen, a greater advantage, with respect to moisture absorbed, from the addition of peat is obtained on sand or a sandy soil.

The moisture-equivalent values of the separate materials show significant differences among the peats as well as among the soils. The reed peat, being the most decomposed of the peats and having the greatest content of colloidal constituents, retained 38 g of water per 100 cm^3 of dry material compared with only 16 g for the fibrous moss peat. This fact immediately suggests a corresponding difference in the extent to which plants may extract water from these materials before wilting. That this is the case will be shown in a discussion of the wilting percentages. On a percentage basis, the moisture equivalents of the peats are not indicative of the true character of the materials and are even in the reverse order from values on a volume basis, which further emphasizes the necessity of taking into account the greatly varying volume weights. Percentage values of soils are, however, adequate for comparisons of one soil with another since the variations in volume weight are not so great as among different types of peat.

Mixtures of moss peat and quartz sand contain the least moisture-equivalent water and those of reed peat and clay soil the most among the mixtures studied. This is as would be expected, and the values for a given mixture can be anticipated from values of the separate constituents. The moss peat has a lower value on a volume basis than the clay soil, and accordingly the mixtures of clay soil and moss peat contain less moisture-equivalent water than the soil by itself. Owing to their higher original values, the sedge and reed peats increased the moisture equivalents of the soils with which they were mixed.

RESULTS OF EVAPORATION EXPERIMENTS

RATE OF EVAPORATION FROM PEAT AND SOIL MIXTURES INITIALLY SATURATED

The three varieties of peat which were in a saturated condition at the beginning of the experiment evaporated moisture as shown by the curves[3] of figure 1. At first little differences were found in

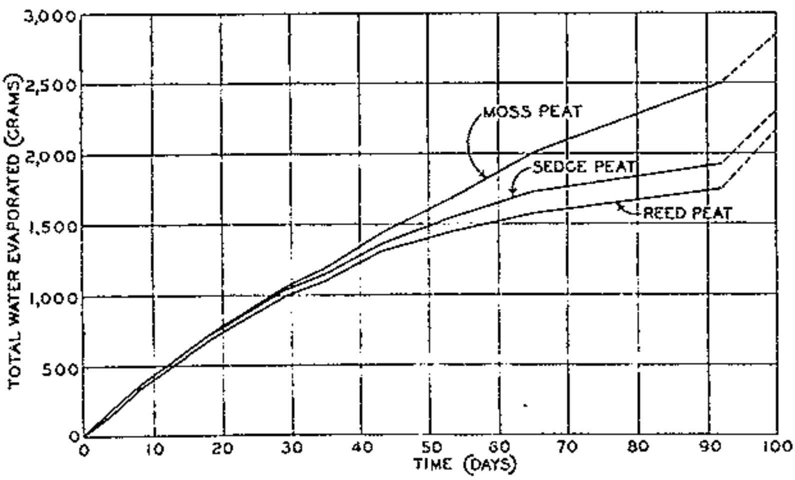

FIGURE 1.—Comparative rates of evaporation of moisture from different varieties of peat initially in a saturated condition.

the respective rates, but later the moss peat, which continued to lose water at nearly the same rate throughout, had a distinctly higher rate of evaporation than either the reed or sedge peats. The sedge peat was found to have an evaporation rate intermediate between those of the moss and reed peats, and it is of interest to note that throughout the experiments this relative order applied to the mixtures as well.

A comparison of the evaporation rate of clay loam soil with those of mixtures of this soil with peat is presented in figure 2. The peats separately lost water more rapidly than did the clay soil, and the effect of mixing peat with soil was to increase the rate of moisture loss, except during the early part of the evaporation period, when all the rates were very similar. Moss peat increased the rate of evaporation of the soil to the greatest extent and reed peat to the least. A comparable set of conditions was found in a study of the effect of peat

[3] The curves shown in connection with this investigation were drawn by means of straight lines from point to point and determinations made at the same regularity of intervals in each figure.

with sandy soil (fig. 3), except that at first the soil check lost moisture more rapidly than any of the peat mixtures. Later, as the dry condition was approached, the evaporation rates were in the same relative order as in the case of clay soil.

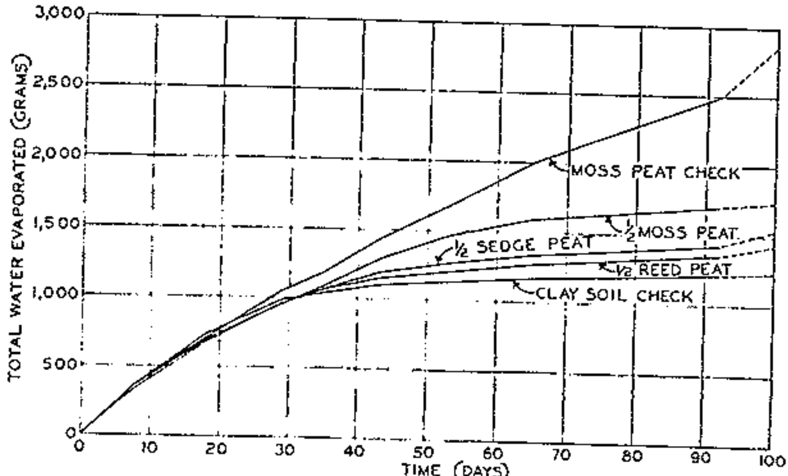

FIGURE 2.—Comparative rates of evaporation of moisture from peat and clay loam soil mixtures initially in a saturated condition.

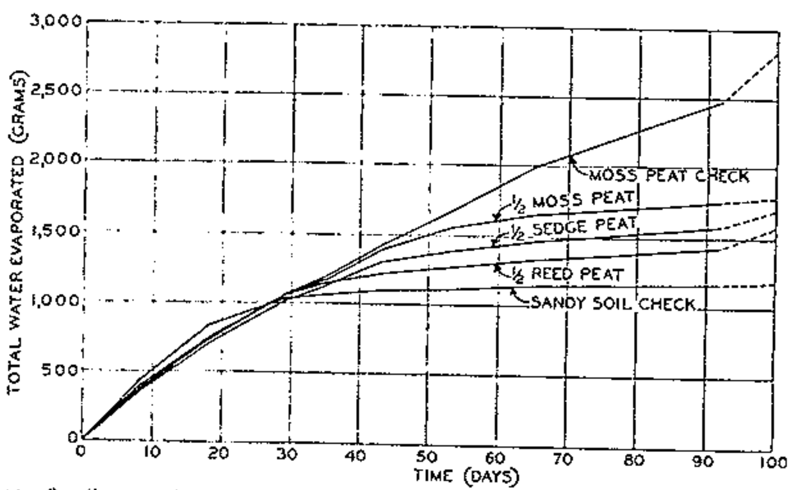

FIGURE 3.—Comparative rates of evaporation of moisture from peat and loamy fine sand soil mixtures initially in a saturated condition.

Curves for the mixtures containing less than one-half peat by volume are not presented. These were found to be intermediate in character, the evaporation rate approaching that of the respective untreated soil as the quantity of peat in the mixture was decreased.

The residual moisture content of each pot was recorded (table 4) at the end of 53 days and again at the conclusion of the experiment. The final residual moisture content is also indicated by the dotted portions of the curves of figures 1, 2, and 3, which extend the experimental curves to the corresponding points of complete air-dryness.

TABLE 4.—*Retention of moisture by peat and soil mixtures undergoing evaporation from an initially saturated condition*

Material	Weight of water per pot at saturation	Weight of moisture retained		Portion of initial moisture retained	
		After 53 days	After 92 days	After 53 days	After 92 days
	Grams	*Grams*	*Grams*	*Percent*	*Percent*
Clay loam soil	1,236	105	20	8.5	1.6
Loamy fine sand	1,194	68	17	5.7	1.4
Moss peat	2,843	1,168	346	41.1	12.2
Sedge peat	2,284	751	347	32.9	15.2
Reed peat	2,161	710	385	33.3	17.8
Clay soil-peat mixtures:					
One-half moss peat	1,731	259	22	15.0	1.3
One-third moss peat	1,684	209	39	12.4	2.3
One-fifth moss peat	1,452	148	16	10.2	1.1
One-half sedge peat	1,532	228	66	14.9	4.3
One-third sedge peat	1,530	202	47	13.2	3.1
One-fifth sedge peat	1,428	141	24	9.8	1.7
One-half reed peat	1,435	224	64	15.6	4.5
One-third reed peat	1,507	191	48	12.6	3.2
One-fifth reed peat	1,338	161	38	12.0	2.8
Sandy soil-peat mixtures:					
One-half moss peat	1,803	242	35	13.4	1.9
One-third moss peat	1,528	128	6	8.4	.4
One-fifth moss peat	1,359	74	0	5.4	.0
One-half sedge peat	1,717	323	127	18.8	7.4
One-third sedge peat	1,023	205	44	12.6	2.7
One-fifth sedge peat	1,489	155	24	10.4	1.6
One-half reed peat	1,579	290	134	18.0	8.5
One-third reed peat	1,371	188	56	13.7	4.1
One-fifth reed peat	1,324	165	45	12.5	3.4

At the expiration of the first-mentioned period of 53 days the soils had been dried to the extent that only 8.5 percent of the original moisture content of the clay soil remained and 5.7 percent of the content of the sandy soil. The peats, however, still retained comparatively large quantities of moisture, moss peat at this point retaining the most. Later, reed peat showed a slightly greater residual moisture content because of its lower evaporation rate, as previously mentioned.

The mixtures of peat with clay soil contained more moisture during the course of the experiment than did the soil alone but not in sufficient quantity to be of great significance. Very little difference was shown by the different varieties of peat when mixed with clay soil, with respect either to the actual content of residual moisture or to the percentage of the initial content of moisture retained.

Although the admixture of peat increases the ultimate evaporation rate from sandy soil as well as from clay soil, it will be seen from an inspection of the curves and from the values of table 4 that the sandy soil approaches its dry condition more rapidly than the clay soil. As a result, moisture contents of the mixtures relative to the corresponding soil checks are greater on sandy soil than on clay soil. Sedge and reed peats were more effective than moss peat in retaining moisture on sandy soil.

Throughout these studies the rate of evaporation was, in general, observed to be more or less independent of the nature of material undergoing evaporation as long as the surfaces remained moist. In other words the evaporation rate tended toward being constant during the time that moisture was supplied by capillarity to the surface as quickly as it was evaporated. It will be noted that in the various sets of curves all the rates at first tended to be similar, and the point at which the surfaces of the materials began to dry out is indicated by a falling off in the evaporation rate. The different effects of different types of peat, as regards their respective evaporation rates, must be attributed to corresponding differences in their capillary properties.

RATE OF EVAPORATION FROM PEAT AND SOIL MIXTURES HAVING THE SAME INITIAL MOISTURE CONTENT

As has already been stated, the quantity of water in each pot at the beginning of the experiment was 1,000 g. In this case more direct comparisons were made of the ability of peat to retain moisture against evaporation since the initial water content of each material was identical.

An inspection of the curves showing the results for the peats alone (fig. 4) indicates that the relative order of evaporation rate is the

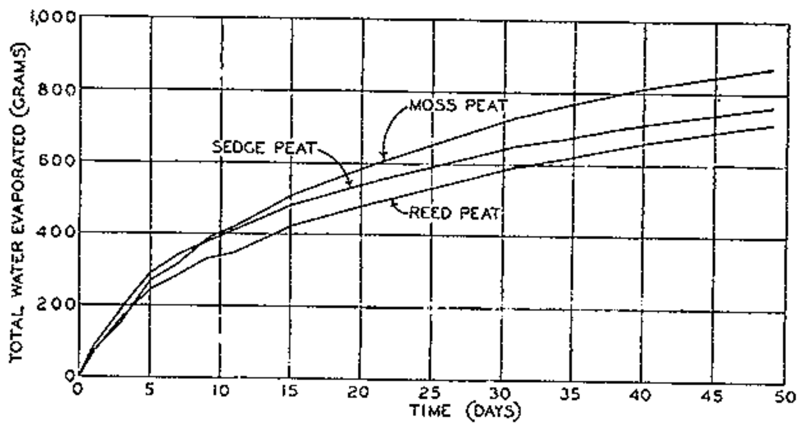

FIGURE 4.—Comparative rates of evaporation of moisture from different varieties of peat having the same initial water content (1,000 g).

same as when they were initially saturated. The reed peat is definitely more retentive of moisture than moss peat, and sedge peat is intermediate between the two. At the conclusion of this experiment reed peat held more than twice as much water as moss peat, 288 g compared with 131 g (table 5).

It may be noted in figure 5 that the mixtures of equal parts of peat with clay soil brought about a reduction in the evaporation rate as compared with the soil check, except in the case of moss peat, which slightly increased the rate toward the latter part of the experiment. This may seem contradictory to the results obtained when the materials were initially saturated, in which it was shown that the evaporation rates of the peat mixtures exceeded that of soil. It must be remembered, however, that in the earlier experiment initial contents of water in the peat mixtures were greater than in the soil checks, which caused an increase in the evaporation rate sufficient to exceed that of the soil rate. The general tendency in both experiments was for the peat mixtures, especially those containing the greatest proportion of peat, to maintain a residual content of water in excess of that of the soil check during the course of evaporation. When the initial contents of water were equal it was always found that reed-peat mixtures retained the most moisture and moss peat the least of the three varieties of peat mixtures.

TABLE 5.—*Retention of moisture by peat and soil mixture undergoing evaporation from a condition of an equal initial moisture content of 1,000 g of water per pot*

Material	Water remaining after 40 days evaporation	Water remaining after 40 days evaporation, expressed as percentage of initial content
	Grams	*Percent*
Clay loam soil	31	3.1
Loamy fine sand	0	.0
Quartz sand	0	.0
Moss peat	131	13.1
Sedge peat	237	23.7
Reed peat	288	28.8
Clay soil-peat mixtures:		
One-half moss peat	16	1.6
One-third moss peat	22	2.2
One-fifth moss peat	24	2.4
One-half sedge peat	71	7.1
One-third sedge peat	65	6.5
One-fifth sedge peat	47	4.7
One-half reed peat	101	10.1
One-third reed peat	97	9.7
One-fifth reed peat	72	7.2
Sandy soil-peat mixtures:		
One-half moss peat	10	1.0
One-third moss peat	0	.0
One-fifth moss peat	0	.0
One-half sedge peat	102	10.2
One-third sedge peat	50	5.0
One-fifth sedge peat	25	2.5
One-half reed peat	115	11.5
One-third reed peat	73	7.3
One-fifth reed peat	66	6.6
Quartz sand-peat mixtures:		
One-half moss peat	51	5.1
One-fifth moss peat	12	1.2
One-half reed peat	211	21.1
One-fifth reed peat	60	6.0

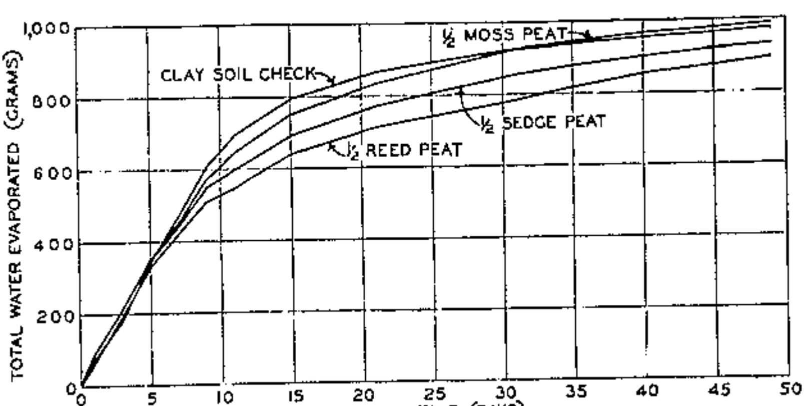

FIGURE 5.—Effect of different varieties of peat on rate of moisture evaporation from clay loam soil.

The effect of varying proportions of moss peat on the evaporation of moisture from clay loam soil is shown graphically in figure 6. These curves show little differences except that the mixture containing one-third moss peat has a slightly higher rate than either the soil check or the other mixtures. The curve for moss peat alone is shown for comparison. Corresponding results on sandy soil (fig. 7) indicate that the mixture of one-half moss peat reduced the evaporation rate of this soil materially. The mixture of one-fifth moss peat had essentially no effect on the evaporation rate of either clay or sandy soil.

The effects of reed peat in the different proportions on clay soil (fig. 8) are in contrast with those of moss peat on the same soil. Each of the reed-peat mixtures, including even that of one-fifth peat, caused a definite decrease in evaporation. On sandy soil (fig. 9) the effect of reed peat in reducing the rate of evaporation is greater

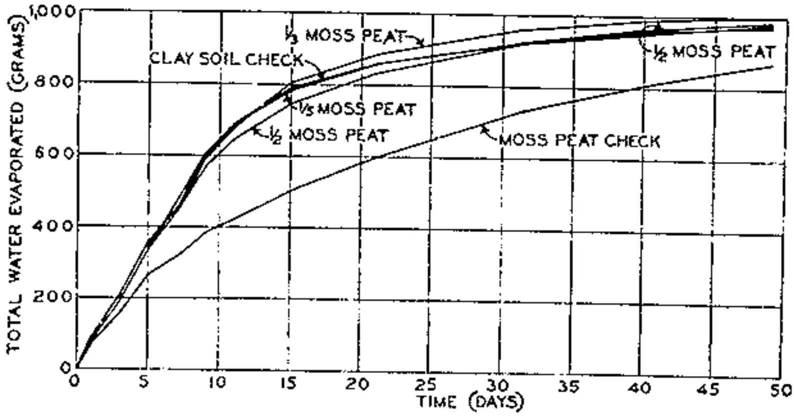

FIGURE 6.—Effect of varying proportions of moss peat on rate of moisture evaporation from clay loam soil.

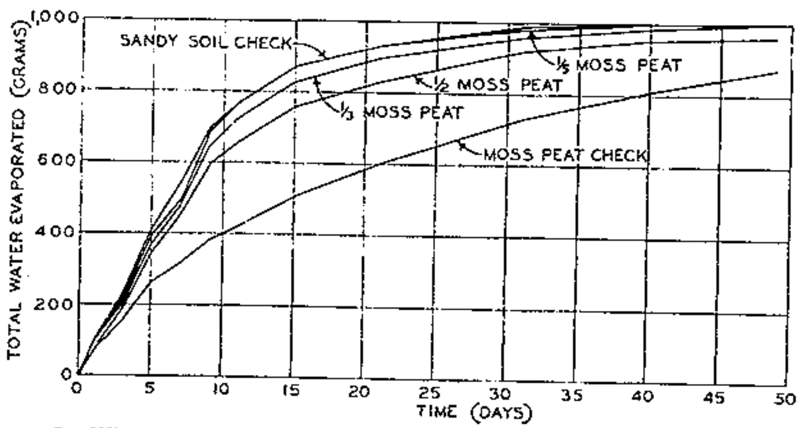

FIGURE 7. Effect of varying proportions of moss peat on rate of moisture evaporation from loamy fine sand soil.

than on clay soil. The one-third and one-fifth mixtures showed essentially identical ability to retain moisture, but the one-half mixture had a considerably lower evaporation rate. In general the order of evaporation decrease was in the order of increasing quantity of peat in the mixture with soil.

A comparison of the effect of different varieties of peat on sandy soil is shown in figure 10. These evaporation curves show that the tendency for each peat is to reduce evaporation to a greater extent on sandy than on clay soil. This conclusion is in harmony with the

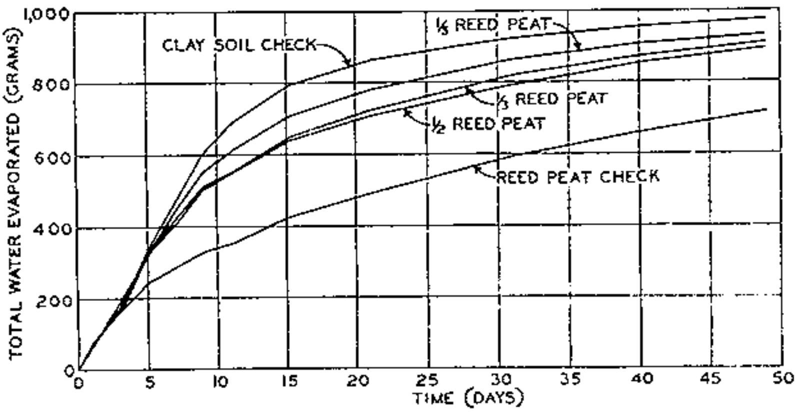

FIGURE 8. Effect of varying proportions of reed peat on rate of moisture evaporation from clay loam soil.

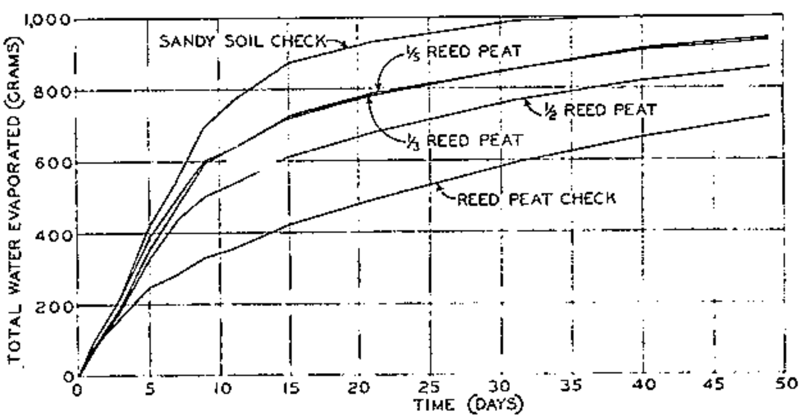

FIGURE 9.—Effect of varying proportions of reed peat on rate of moisture evaporation from loamy fine sand soil.

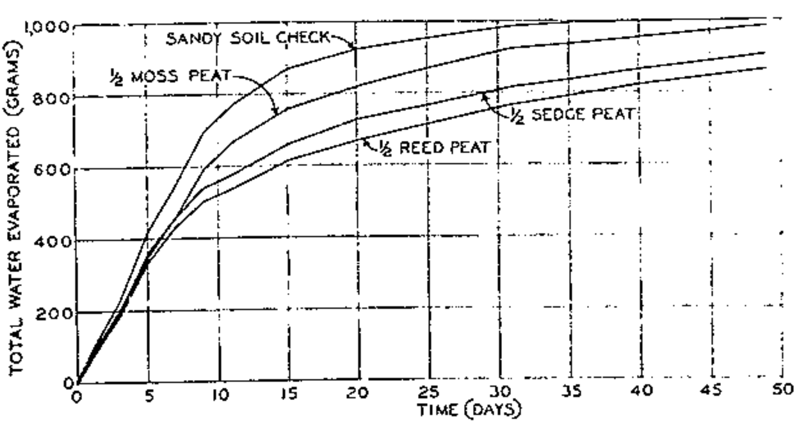

FIGURE 10.—Effect of different varieties of peat on rate of moisture evaporation from loamy fine sand soil.

results previously discussed in connection with the evaporation rates from initially saturated materials. In the latter it was also evident that peat and sandy soil mixtures were more retentive of moisture with respect to soil alone than were peat and clay soil mixtures. The effect of moss and reed peats on quartz sand (fig. 11) is somewhat greater than their respective effects on sandy soil.

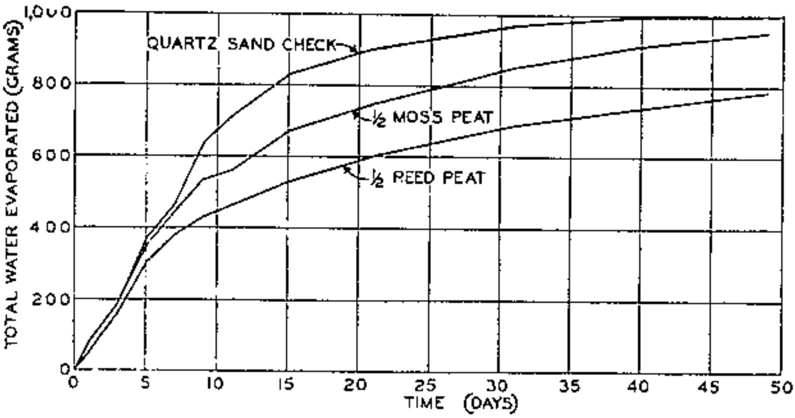

FIGURE 11.—Effect of different varieties of peat on rate of moisture evaporation from quartz sand.

The mixture of equal quantities of reed peat and quartz sand retained nearly as much moisture at the conclusion of the experiment as the reed peat check and even more than the moss peat check (table 5). The sandy soil and the quartz sand alone were found to be entirely dry at this point. This was also true of the one-third and one-fifth mixtures of moss peat with sandy soil.

EFFECT OF PEAT ON RETENTION OF MOISTURE AVAILABLE TO PLANTS

The pot experiments, which thus far have not dealt with vegetation, were next conducted with growing wheat plants. Each pot contained 600 g of water and was maintained at this moisture content for approximately 3 weeks, after which no additional water was supplied. Soon after watering ceased some of the plants showed signs of being wilted in the afternoon but recovered during the night. It was very difficult, however, to determine a point at which it could be said that any wheat plant was definitely wilted. The results (table 6) show only the condition of the plants after considerable time had elapsed, when there was little doubt about the relative conditions. After 28 days the plants on quartz sand were dead and completely dried. All were wilted, but the plants on the reed peat check and those on the one-half reed peat mixture with quartz sand were still in fair condition. These observations represent the extremes, and the plants on the other materials were intermediate in stage of wilt. Until just a few days before these observations were recorded the plants on the moss and sedge peat checks appeared to be in as good condition as those on the reed peat. The plants of the entire experiment which survived the longest were those on the reed peat check.

TABLE 6.—*Relative condition of wheat plants and water content of pots after 28 days' evaporation*

Soil medium	Water content of pots after 28 days [1]	Condition of wheat plants
	Grams	
Clay loam soil	107	Very badly wilted.
Loamy fine sand	48	Do.
Quartz sand	12	Dead.
Moss peat	131	Wilted.
Sedge peat	237	Do.
Reed peat	310	Fair condition.
Clay soil-peat mixtures:		
One-half moss peat	76	Very badly wilted.
One-third moss peat	82	Do.
One-fifth moss peat	75	Do.
One-half sedge peat	153	Do.
One-third sedge peat	168	Do.
One-fifth sedge peat	131	Do.
One-half reed peat	210	Wilted.
One-third reed peat	203	Badly wilted.
One-fifth reed peat	178	Do.
Sandy soil-peat mixtures:		
One-half moss peat	107	Essentially dead.
One-third moss peat	22	Do.
One-fifth moss peat	10	Do.
One-half sedge peat	122	Badly wilted.
One-third sedge peat	111	Do
One-fifth sedge peat	33	Do.
One-half reed peat	177	Wilted.
One-third reed peat	120	Do.
One-fifth reed peat	132	Do
Quartz sand-peat mixtures:		
One-half moss peat	58	Very badly wilted.
One-fifth moss peat	39	Essentially dead.
One-half reed peat	201	Fair condition.
One-fifth reed peat	52	Wilted.

[1] Each pot contained 600 g of water at start, having been maintained thus for 3 weeks.

Moss and sedge peats had no beneficial moisture-holding ability when mixed with clay soil, but reed peat in the one-half mixture showed a slight advantage. The reed peat proved to be more advantageous on sandy than on clay soil. Sedge peat also proved of some advantage on sandy soil, but moss peat hastened wilting of the plants. Moss peat however was beneficial when mixed with quartz sand. The comparative effects of moss peat and reed peat on quartz sand are shown in figure 12. The plants on the one-fifth mixture of reed peat were in better condition than those on the one-half mixture of moss peat with quartz sand, although this is not so readily apparent from the illustration.

The average content of water in each pot, as recorded in table 6, indicates the extent to which the respective materials were dried, but such values cannot be used for calculating the wilting percentages. The moisture contained in the pots was not equally distributed throughout the mass of soil but was present only in the lower part.

FIELD OBSERVATIONS

Field plots for experimentation with lawn grasses were prepared by the United States Golf Association Green Section, in cooperation with the Bureau of Plant Industry and this Bureau. Different types of peat were mixed with a clay loam soil to study the effect of such mixtures on the general condition of a lawn grass. Through the courtesy of John Monteith, Jr., the authors were permitted to make some moisture observations of the plots, in connection with greenhouse studies. Accordingly, samples were taken to determine the relative amounts of moisture absorbed by the peat and soil mixtures, as compared with the soil check. The rate at which the water supply became depleted during a dry period was also determined. The plots had been in operation approximately 3 years at the time these experiments were made.

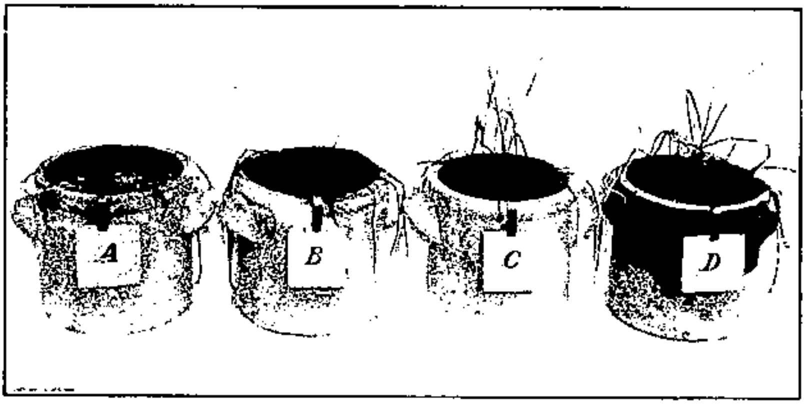

FIGURE 12. Effect of different varieties of peat on retention of available moisture in quartz sand as indicated by the relative condition of wheat plants: *A*, Pure sand; *B*, one-half moss peat: *C*, one-half reed peat; *D*, one-fifth reed peat.

The soil used was similar to that used in the greenhouse and previously described, as were also the moss and sedge peats used in the mixtures. Additional varieties of peat materials included a slightly decomposed fibrous sawgrass peat from Florida, and two samples of reed muck—one well decomposed, from Illinois, and the other, somewhat less decomposed, from Ohio. The ash contents of the reed mucks from Illinois and Ohio were 24.04 and 18.31 percent, respectively. The materials were used in equal proportions by volume and were thoroughly mixed with the topmost 4-inch layer of soil. The area occupied by the plots was graded to provide adequate surface drainage. Preliminary data and a more detailed description have already been published (*4*, *8*).

All samples were taken with the aid of a special volume-weight sampler previously described (*3*). A core of definite volume (43.2 cm^3) was taken from the soil. This core extended from a point immediately beneath the turf sod to a depth of approximately 2 inches. The borings were made in duplicate from different locations on each plot, and all samples were immediately placed in small containers with tight-fitting lids. The containers and contents were then taken to the laboratory, weighed, dried in the oven at 105° C., and again weighed to determine the content of moisture. The holes in the plots from which the cores had been taken were refilled with the proper soil mixture, and the sod replaced.

At the beginning of the evaporation experiment the plots had received a heavy rain and also had been sprinkled as evenly as possible to obtain a moisture condition near the field-saturation capacity of each plot. Samples were taken at this point and periodically for a period of 14 days to determine the relative rates of moisture loss. At the end of this time, continued rains (more than 11 inches of rainfall within 14 days) occurred, making further evaporation studies impossible. After this period samples were again taken to determine the amount of moisture capable of being absorbed under field conditions. Additional determinations of the maximum moisture-holding capacity, volume weight, and air-dry moisture were made in the laboratory by methods previously described in this bulletin.

The results of observations made on the golf-green plots are shown in tables 7 and 8. The first column of figures in table 7 gives the percentage values, on a weight basis, for the maximum moisture-holding capacity as determined in the laboratory. With respect to these percentages the soil check is very inferior to the peat mixtures, particularly the mixture containing moss peat. The moisture contents were recalculated on a volume basis of 100 cm³, and the resulting values are shown in the second column. According to these figures the soil check is still inferior in moisture-holding capacity to that of any of the peat mixtures, but the differences are much less marked. In this case the moss-peat mixture held only 37.5 percent more water than the check, although the percentages on a weight basis indicate an absorbing capacity of the latter of nearly three times that of the check. The sample capable of absorbing the most water, according to the laboratory determinations, namely, the well-decomposed reed-muck mixture, contained nearly 60 percent more moisture than the check.

TABLE 7.—*Moisture-holding capacity of peat and soil mixtures used in golf-green field plots*

Type of peat used in mixtures [1]	Maximum moisture-holding capacity	Maximum moisture absorbed by 100 cm³ of dry material [2]	Maximum moisture content of 100 cm³ of moist material in the field	Weight of 100 cm³ of air-dry material	Moisture per 100 cm³ of material on an air-dry basis
	Percent	*Grams*	*Grams*	*Grams*	*Grams*
Moss peat, poorly decomposed	104.6	64.9	56.9	62	1.4
Sawgrass peat, poorly decomposed	76.0	59.3	53.7	78	1.6
Sedge peat, partly decomposed	88.1	64.3	55.8	73	2.1
Reed muck, largely decomposed	67.9	63.8	56.7	94	3.2
Reed muck, well decomposed	76.0	74.5	56.5	98	4.0
Clay loam soil (check)	38.7	47.2	37.3	122	.9

[1] All mixtures consisted of equal proportions by volume.
[2] Calculated from laboratory results.

The moisture determinations made on the thoroughly moistened plots (after more than 11 inches of rain) may be taken to represent the total field-saturation capacity of the materials. A marked similarity is seen in the moisture content of all the mixtures in a comparison of the volume proportions of water per 100 cm³ of moist sample. The values ranging from 53.7 to 56.9 g of water contained in the peat mixtures compare with 37.3 g in the soil check (table 7). The lower magnitude of these values, compared with the laboratory determinations, is due to the fact that the field-moisture capacity is always less than the capacity as determined by the laboratory method used. The peats increased the field capacity approximately 50 percent, which is considered to be in general agreement with the present and previously discussed laboratory results. The moss-peat mixture, according to field results as well as in laboratory determinations, possesses no significant superiority to any of the other peat mixtures with regard to moisture-holding power, although this has been assumed by many to be the case. The different varieties of peat must be regarded essentially equivalent in their ability to increase the moisture-holding capacity of the soil when mixed in volumetric proportions.

TABLE 8.—*Effect of admixture of peat on evaporation losses from golf-green field plots*

Type of peat used in mixture[1]	Moisture initially held by 100 cm³ of moist material	Moisture held by 100 cm³ of material after 14 days	Loss of moisture during 14-day period	Moisture held by 100 cm³ of material after prolonged dry period
	Grams	*Grams*	*Grams*	*Grams*
Moss peat, poorly decomposed	50.5	21.4	29.1	13.9
Sawgrass peat, poorly decomposed	54.1	36.3	17.8	
Sedge peat, partly decomposed	60.6	29.1	31.5	
Reed muck, largely decomposed	52.5	35.1	17.4	
Reed muck, well decomposed	53.9	37.5	16.4	22.4
Clay loam soil check	31.0	20.8	10.2	12.0

[1] All mixtures consisted of equal proportions by volume.

The samples taken at the beginning of the evaporation experiment had not received as much water as those taken after 11 inches of rainfall, and, consequently, the contents of moisture were somewhat lower, except in the sedge-peat mixture. The loss of water by evaporation and transpiration from the plots was recorded over a 14-day period, during which time only one brief shower of rain fell. The total moisture loss is reported in table 8 and shows clearly that the water loss from the plots containing peat was definitely greater than that from the soil check.

The plots containing the more fibrous peats lost water at a more rapid rate than those containing the more decomposed varieties. These observations are in agreement with the greenhouse experiment dealing with the saturated mixtures.

The moisture content of three plots was determined the following year after a prolonged dry period when the grass appeared to be suffering from drought on all the plots. These values are given in the last column of table 8. The moss peat had only a slightly greater moisture content than the soil check, but the well-decomposed reed peat had nearly twice that of the soil, 22.4 g, as compared with 12 g. This difference is necessarily of less significance than the figures indicate, since the wilting percentage, or content of unavailable moisture, is distinctly greater in this type of peat mixture, in fact, approximately twice that of the soil alone as will be shown later. The condition of the grass indicated no readily discernible advantage of any of the peat mixtures with respect to moisture availability during dry periods. The fact that peat and mixtures of peat with soil are difficult to moisten, once they have been allowed to become dry, places peat at a disadvantage under conditions of limited watering or rainfall, as previously pointed out by Sprague and Marrero (*10*).

RESULTS OF WILTING-POINT DETERMINATIONS

The wilting percentage, or content of moisture not readily available to plants, was determined according to the method already described, using dwarf sunflowers as indicator plants. The so-called point of permanent wilting was defined arbitrarily, as this condition would otherwise have been indefinite. However, the rate of moisture transpiration is greatly reduced when wilting begins, and variations in recognizing the state of permanent wilting causes comparatively small errors in the wilting percentage.

The results of determinations made on the separate materials and on the mixtures are recorded in table 9. The wilting percentages of each of the peats was found to be very high, whereas that of quartz sand was extremely low. The clay soil had a value significantly higher than the sand or sandy soil, but it did not compare in magnitude with the percentages of the peats.

TABLE 9.—*Wilting percentages of peat and soil and of mixtures thereof*

Material	Wilting percentage	Calculated wilting percentage[1]	Moisture retained by 100 cm³ of material at wilting point
	Percent	*Percent*	*Grams*
Clay loam soil	7.1	11.6	7.7
Loamy fine sand	2.1	3.5	2.8
Quartz sand	.57	.76	.8
Moss peat	82.3	90.0	8.0
Sedge peat	60.8	61.0	15.0
Reed peat	70.7	50.7	21.0
Clay soil-peat mixtures:			
One-half moss peat	14.5	16.8	8.5
One-fifth moss peat	8.5	11.7	7.5
One-half sedge peat	19.2	19.6	13.0
One-fifth sedge peat	10.0	13.1	9.1
One-half reed peat	21.2	21.2	15.0
One-fifth reed peat	10.8	14.1	10.0
Sandy soil-peat mixtures:			
One-half moss peat	6.6	9.2	4.8
One-fifth moss peat	3.1	4.9	3.5
One-half sedge peat	13.5	12.8	11.0
One-fifth sedge peat	4.6	6.2	5.3
One-half reed peat	16.2	14.5	11.0
One-fifth reed peat	5.6	6.7	6.1
Quartz sand-peat mixtures:			
One-half moss peat	5.2	6.9	3.9
One-fifth moss peat	1.8	3.0	2.1
One-half reed peat	17.2	11.8	15.0
One-fifth reed peat	5.1	4.9	6.4

[1] Calculated from the moisture equivalent, by the Briggs and Shantz formula (*5*, p. [illegible]).

The amount of moisture held by 100 cm³ of each material at the wilting point was calculated and tabulated for comparisons on a volume basis. The percentages of the peats in reality were found to have little significance when directly compared either with each other or with the soil percentages, as was the case when comparisons were made of maximum moisture-holding percentages. Moss peat had a higher wilting percentage than reed peat, but actually a marked difference existed in the reverse order on a volume basis. The volume content of moisture at the wilting point of moss peat was only slightly greater than that of clay soil, although the respective percentages by weight indicated an entirely different relationship.

Reed peat, being more decomposed and containing the larger proportion of colloidal constituents, retained 24 g of moisture per 100 cm³ at the wilting point compared with 8 g for the fibrous-moss peat. Sedge peat was intermediate, as would be expected from its physical character. These differences were reflected in the corresponding mixtures with soil.

The addition of peat to soil increased the wilting moisture content, and the greatest increases resulted from the largest proportions of peat in the mixture. Moss peat raised the wilting point to the least extent since it had the lowest amount of unavailable moisture to contribute to the soil mixtures. Reed peat, on the other hand, brought about the greatest increases, as would be expected from its original high value. Addition of equal parts by volume of reed peat to soil or to quartz sand raised the wilting point in each case to approximately the same value.

Wilting percentages calculated from the Briggs and Shantz formula (*2, p. 72*),

$$\text{Wilting percentage} = \frac{\text{Moisture equivalent}}{1.84},$$

are also shown in table 9. In most cases these values are somewhat greater than the experimental values but not consistently so throughout. In general, the agreement was appropriate, and the formula seems applicable to peat and peat mixtures in a qualitative manner.

GENERAL DISCUSSION

Moisture relationships must be considered primarily on the basis of equal volumes of material, in order to make accurate comparisons between different types of peat or between peat and mineral soils. The volume weights of these materials differ so widely as to make many of the comparisons on the usual percentage basis very misleading.

The evidence in connection with clay loam soil indicates little or no advantage to be gained in moisture economy resulting from the admixture of peat in quantities as large as equal proportions by volume. The types of peat used ranged from raw fibrous-moss peat to well-decomposed reed muck. Such mixtures with soil were capable of absorbing from 40 to 50 percent more moisture than the soil alone, but the increased evaporation rate and greater content of moisture at the wilting point largely counteracted the initially higher moisture-holding capacity. Lawn grasses on field plots appeared to suffer to the same extent during dry periods, whether growing on soil alone or on peat mixtures. A greenhouse experiment with wheat on similar mixtures showed no advantage of peat regarding retentiveness of available moisture, with a possible exception of decomposed reed peat. The choice of a particular variety of peat to be used for soil-improvement purposes with clay loam soil need not be concerned with relative moisture-holding percentages but should be governed by other desirable physical or chemical characteristics not considered in this study.

Improved moisture conditions may, however, be expected from the incorporation of peat with a sand. This was shown by the experiment with growing wheat, in which peat mixtures with quartz sand supported plants after those on the sand alone were dead from lack of moisture. The fibrous type of peat was less effective in this respect than the more decomposed material. As a result of incorporation of peat, the moisture-holding capacity of sand or of a sandy soil was increased to a greater extent than that of a clay soil. This increase amounted to as much as 80 percent in the case of quartz sand. Peat mixtures with sand were found to be more retentive of moisture relative to the sand alone than were corresponding clay loam mixtures, and, therefore, greater value is obtained with the sand in regard to moisture-supplying ability.

More favorable effects might possibly have been obtained by the use of peat in proportions greater than equal parts by volume, but such amounts are not considered practical or economical for general use as soil amendments.

Peats by themselves were superior to any mixture of peat with soil, not only in moisture-absorbing ability, but also in the retention of available moisture against evaporation loss. The relative order of evaporation rate of the peats, as well as of the respective mixtures, was always the same. Decomposed reed peat had the lowest rate and fibrous-moss peat the highest, with partly decomposed sedge peat intermediate.

Moss peat is somewhat comparable to a sponge. It can more readily transfer internal moisture by capillarity to the surface where evaporation is most rapid. Reed peat is more granular and its structure such that the capillary continuity is broken and hence tends to have an insulating effect on moisture immediately below the surface. These inherent characteristics were apparent even in the respective mixtures with either soil type or with quartz sand. The moisture contents of the peats at the wilting point were in the reverse order of magnitude to their respective evaporation rates.

The higher wilting point of soil, which resulted from the incorporation of peat, was proportional to the quantity of peat added and to the amount of unavailable moisture held by the particular peat over and above that held by the soil before mixing. In the event that a soil had a higher wilting point than that of a peat the result would undoubtedly be a lowering of the unavailable moisture content of the soil.

SUMMARY AND CONCLUSIONS

Moisture relationships of various types of peat and soil were determined with particular reference to the effect of incorporation of peat with soil in varying proportions.

The maximum moisture-holding capacity of peat is more than twice that of soil, compared on a basis of equal volumes of material. Mixtures of peat with soil in equal proportions by volume absorbed from 40 to 50 percent more moisture than the untreated soil in the case of a clay loam and as much as 80 percent more in the case of pure quartz sand. Values for a loamy fine sand soil were intermediate.

Evaporation rates from initially saturated soils and peat mixtures were similar during the first part of the evaporation period, but later the presence of peat resulted in a definite increase in the evaporation rate. Fibrous-moss peat lost moisture at a greater rate than the more decomposed and granular reed peat. This was characteristic also of the respective mixtures with soil. When the materials had a lower but identical initial moisture content, peat caused a reduction in the evaporation rate of soil, except in the case of moss peat with clay loam soil. Reed peat reduced evaporation to the greatest extent, whereas sedge peat was intermediate in its effects. Mixtures of peat with sand retained more moisture relative to the sand alone than did the corresponding clay loam soil mixtures.

Observations in connection with field plots and greenhouse pots indicated little or no advantage in the use of any variety of peat with clay loam soil with regard to the supply of moisture available to plants during a dry period, with the possible exception of decomposed reed peat. Beneficial effects in moisture economy, however, were obtained on quartz sand and to a less degree on loamy fine sand soil. Reed peat was more effective than moss peat.

Wilting-point determinations, using dwarf sunflowers (*Helianthus ánnuus*, var. *nánus*) as indicator plants, showed that a decomposed type of peat had a considerably greater content of unavailable moisture than fibrous varieties. Moss peat had a content only slightly greater than clay loam soil.

Addition of peat to soil increased the wilting moisture content by an amount proportional to the quantity of peat used and to the magnitude of unavailable moisture, as compared with that of the soil before mixing.

Wilting percentages of peat and of mixtures of peat with soil were found to be in general qualitative agreement with values calculated from the moisture equivalent by the Briggs and Shantz formula.

The use of peat as a soil amendment for the sole purpose of conserving a supply of available moisture is not recommended, except, possibly, in the case of a decomposed type of peat with a sand or a very sandy soil. The textural and other physical or chemical effects have not been considered in this study. These must be evaluated, however, in judging the benefit which may be realized from the addition of peat to soil.

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U. S. GOVERNMENT PRINTING OFFICE: 1936

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