FIELD MOISTURE CAPACITY AND WILTING POINT OF SOILS

W. L. POWERS

Oregon Experiment Station

Received for publication November 23, 1921

The storage capacity of the soil for usable moisture under field conditions affects the amount of irrigation, necessary while the drouth, or wilting, point affects the time of irrigation and defines the lower limit of field capacity of the soil for usable moisture. The field capacity of the soil for usable moisture has come to be regarded, therefore, as one of its most important, if not the most important of physical properties. These matters have come to be given careful study in connection with Oregon Soil Investigations.

The wilting coefficient is the moisture content of the soil at which the plant wilts permanently or at which it cannot maintain its turgidity. This point has been regarded as varying but slightly with different plants, not usually more than $1\frac{1}{2}$ per cent. It has commonly been regarded as varying widely with different soils. This wilting point represents the lower limit of available moisture. Briggs has shown (2) that it is approximately one and one-half times the hygroscopic coefficient. In coarse-textured soils the hygroscopic coefficient is very low and the wilting coefficient correspondingly low. In fined-texture soils these points are fairly high, the hygroscopic coefficient lying between 10 and 18 per cent, wilting occurring at 15 to 27 per cent. In some Oregon peat soils, the wilting coefficient has been found to be as high as 65 per cent. Oregon studies indicate that the wider the range in the different moisture points and the finer the texture, the greater is the difference between the wilting points of different crops grown on a given soil. With soils of coarse texture, where there is a narrow range of important moisture points, there is less difference in the wilting point of various crops. Oregon studies indicate that the difference is greater than was formerly supposed and reported (2).

WILTING POINT STUDIES UNDER FIELD CONDITIONS

The moisture history of dry-farmed and irrigated plats, including both meadow and cultivated plats, located on Willamette silty clay loam was obtained at the Oregon Station during 1910. From these data it appeared that the clover and other meadow crops did not require irrigation until the moisture content for the first two feet of soil dropped down to 14 or 15 per cent, dry weight. For potatoes the moisture content of the same strata did not

reach this low point during the entire growing season on dry plats, and the plats to be irrigated showed indications of drouth, when the moisture in the first two feet was still 20 or 21 per cent. An experiment was, therefore, planned determine the drouth point of potatoes and of clover, or the point at which it was best to apply irrigation water. A series of plats in duplicate was set aside, to be cropped to potatoes, one plat to be irrigated when the moisture content of the first two feet had dropped to twenty-three per cent point; the second when the moisture content reached the twenty-per cent point, and the third when the moisture had dropped to the seventeen-per cent point. After 1911

TABLE I.
Value of soil-moisture tests in determining the exact time to irrigate

CROP	TREATMENT	TOTAL YIELD PER ACRE	GAIN OVER DRY PLAT		GAIN PER ACRE- INCH OF WATER ADDED	WATER RE- QUIRE- MENTS
		bu.	bu.	per cent	bu.	lbs.
(1911)						
Potatoes (Recd. 3 by 3 inches)	Irrigated 23 per cent (or 9 inches)	292.5	157.4	117	17.5	1058
Potatoes (Recd. 2 by 3 inches)	Irrigated 20 per cent (or 6 inches)	308.5	173.4	128	28.9	799
Potatoes (Recd. 1 by 3 inches)	Irrigated 17 per cent	176.4	41.3	31	13.8	1326
(1913)						
Potatoes (Recd. 2 by 2 inches)	23 per cent	260.0	-40.5	-13.0	-10.1	973
Recd. 1 by 2 inches	20 per cent	342.0	41.5	18.0	10.4	655
Recd. none	17 per cent	300.5				629
(1911)						
Clover		tons	(green)		tons	
1 by 4 inches	20 per cent	17.05	6.60	63	1.85	338
1 by 4 inches	17 per cent	19.37	8.92	85	2.23	306
1 by 4 inches	14 per cent	19.62	9.17	88	2.29	303
(1913)						
2 by 5 inches	20 per cent	4.925		No dry plant,		514
1 by 5 inches	17 per cent	5.175		2nd crop year		539
1 by 5 inches	14 per cent	5.100				459

the points at which irrigations were applied were changed to 24, 21, and 18 per cent, respectively. At the same time clover plats were laid out to be irrigated which the moisture content dropped to the 20 per cent, 17 per cent, and 14 per cent points, respectively. An experiment was conducted for the years 1911, 1912, and 1913. Data were reported in Bulletin 122 of the Oregon Experiment Station. Since it is out of print, a summary of the more important data is presented in table 1.

In a summer of low precipitation, 1911, and in a summer of high precipitation, 1913, irrigation of potatoes when the moisture content reached 20 per cent seemed to give the greatest increases on the Willamette silty clay loam

soil, on the Corvallis experiment field, and this moisture content has come to be taken as an indicator of the exact time to irrigate this crop. During the same years it developed that clover was best irrigated when the moisture point dropped to 14 or 15 per cent for the first 2 feet; the moisture did more good when applied at these points, as the water requirement per pound of dry matter was generally lower under such conditions.

In order to check the drouth points of these crops and to eliminate any reinforcement of moisture from the subsoil secured by the deep roots of the clover plants, a series of Briggs type tanks were arranged in duplicate in 1918, and each of these crops grown in six tanks. Two tanks were irrigated when the crop was distinctly wilted, a second pair when the crop was but slightly wilted, and third pair when the crop was still in a fresh condition. Experiments were conducted in 1918 and the following year additional tanks were added for beets and alfalfa. After the crop growth was well under way, the tanks were allowed to dry down to the drouth point as indicated by the appearance of the crop at 3:00 p.m. Samples were then taken for soil-moisture determination from cores extending throughout the depth of the soil tank. The tanks were then given different amounts of irrigation to revive the plants and allowed to dry down until the average tank should again show slight wilting and the minimum tank distinct wilting, whereupon they were re-sampled. Representative tests are shown in table 2.

Some lack of uniformity in the data appears on account of interference of war conditions and the pressure of other work, but the average point at which the clover was found to wilt in these tanks was 16 per cent, for potatoes it was 17.5, for beets 20.3. This is the mean drought point by crops for this soil. The lower wilting point for all crops early in the season is due to low temperature (5) and relative humidity which was about 60 per cent, while later determinations were made with summer temperatures of 80° to 90°F. and a relative humidity of about 30 per cent. The water requirement was determined for potatoes and beets. The water requirement was generally lower for the crops in the average tanks. The data are sufficient to indicate strongly that the wilting point of the different crops varies more than has formerly been supposed. The indications are that it varies more widely in soils of heavy texture and wide range of important moisture points.

The wilting point as determined by laboratory methods for wheat seedlings in this Willamette silty clay loam has been found to be 15 per cent.

FIELD MOISTURE CAPACITY

The usable water capacity of nearly a score of important irrigated soils in different irrigated valleys of the state has been studied in connection with duty-of-water investigations (3) in order to secure definite information as to the best amount to apply at one time. Various factors affecting this field capacity have been measured. Cylinders 6 inches in diameter and 1 foot long.

or of approximately one-fifth cubic foot capacity were forced into the soil to a depth of 1 foot and the samples thus secured were saturated in a damp enclosure in the laboratory, drained to constant weight, and the total moisture content determined. This practice also afforded opportunity to determine the volume weight per cubic foot. Field samples taken for soil-moisture

TABLE 2
Wilting points of different crops

CROP	TANK NUMBER	COMPAR- ATIVE MOIS- TURE AT SAMP- LING	ACTUAL MOIS- TURE JULY 17	CONDITION OF PLANTS	ACTUAL MOIS- TURE AUG. 9	CONDITION OF PLANTS	ACTUAL MOIS- TURE SEPT. 10	CONDITION OF PLANTS	WATER RE- QUIRE- MENT
			<i>per cent</i>		<i>per cent</i>		<i>per cent</i>		<i>lbs.</i>
Clover	1	Min.	9.5	Firing	13.3	Dwarfed	17.8	Matur- ing	
	3	Min.	8.3	Firing	12.4	Dwarfed	16.3		
	3	Ave.	10.5	Wilting	17.3	Plump	16.5		
	4	Ave.	11.2	Wilting	16.2	Limp	18.5	Growing	
	5	Max.	12.4	Growth	21.4	Thrifty	16.3		
	6	Max.	13.0		Checked	20.4	Thrifty		
Average			10.8		16.7		17.5		
Potatoes	7	Min.	12.4	Firing	14.5	Wilted	15.9	Matur- ing	497
	8	Min.	14.9	Checked	13.5	Wilted	14.0		260
	9	Ave.	24.9	Not	19.0	Thrifty	17.2		278
	10	Ave.	20.0		Checked	15.3	Wilted	18.7	406
	11	Max.	20.5	Thrifty	16.9	Fair	17.7	Growing	456
	12	Max.	21.5	Fallow	18.0	Fallow	20.2		
Average			17.4		17.1		17.9		
Mangels	13	Min.	19.9	Limp	18.5	Wilted		Blight- ing	580
	14	Min.	19.9	Limp	14.2	Some fired			501
	15	Ave.	20.0	Thrifty	19.7	Some wilted			347
	16	Ave.	20.9	Thrifty	20.9	Plump			499
	17	Max.	26.5	Plump	21.7	Plump			486
	18	Max.	25.7	Plump	20.2	Plump			623
Average			20.4		20.3				
General Average			15.0		17.5		20.3		

determinations before and after irrigation have given indications of the maximum and minimum range of soil moisture under field conditions, and these, used in connection with the maximum field capacity tests and other data, aid in determining the usable moisture capacity in percentage and in inches on these important irrigated soils. The data so secured are presented in table 3.

In this table the humus content was determined by the ammonium method, and the moisture equivalent by the Briggs-Lane centrifuge or Briggs formula. In this table it appears that only the heaviest normal soils have as high a usable-water capacity as 2 inches per acre foot, these being silty clay loam, silt

TABLE 3

Relation of soil type and usable water capacity to irrigation requirement

LOCATION	SOIL TYPE	HUMUS	HYGROSCOPIC MOISTURE	MOISTURE EQUIVALENT	MOISTURE CONTENT		TOTAL WATER-HOLDING CAPACITY		WEIGHT OF OVEN-DRY SOIL PER CUBIC FOOT	ESTIMATED EXCESS POINT		ESTIMATED DROUTH POINT		ESTIMATED USABLE-WATER CAPACITY	
					Mean maximum	Mean minimum									
		per cent	per cent	per cent	per cent	per cent	per cent	in.	lbs.	per cent	per cent	per cent	per cent	in.	
Paisley	Medium peat	60.00			140	35	147	7.6	28	110	40	70	3.8		
Paisley	Peaty silt loam	10.00	3.60	9.75	50	18	64	6.5	52	45	20	30	2.5		
Paisley	Silt loam	7.60			40	16	50	5.8	63	34	16	18	2.1		
Corvallis	Silty clay loam	5.50	3.75	10.16	30	12	36	5.5	80	27	14	13	2.0		
Talent	Silty clay loam		3.53	9.57	24				75	22	10	12	1.7		
Burns	Silt loam		5.24	14.20	45	20	36	4.9	66	35	18	17	2.1		
Haines	Loam	7.65	2.60	7.05	29	12	38	4.0	68	27	12	15	2.0		
LaGrande	Loam	*3.20	3.50	9.49	30	10			27	12	12	1.7			
Burns	Very fine sand loam	2.49	5.78	15.66	40	17	38	4.6	64	33	18	15	1.8		
Haines	Fine sandy loam	5.89	2.30	6.23	30	10	33	4.9	68	26	12	14	1.8		
Grants Pass	Fine sandy loam	2.50			18	8	23	4.3	85	18	9	9	1.5		
Joseph	Fine sandy loam	8.85	2.20	5.96	40	10	47	5.7	64	30	15	15	1.9		
Paisley	Sandy loam	2.18	3.76	10.19	28	12	30	4.7	84	22	12	10	1.6		
Redmond	Medium sand		3.50	9.49	30	12	39	4.1	66	24	12	13	1.6		
Lakeview	Medium sand				27	10	28	4.5	84	20	11	9	1.5		
Paisley	Coarse sand	2.65	2.26	6.12	15	5	21	3.5	85	14	7	7	1.1		
Hermiston	Coarse sand	trace			12	6	18	3.0	88	11	7	4	0.7		

* Determined by Brigg's formula instead of centrifuge.

loam of high organic content. Peat, however, retains 3-4 inches of usable water per acre foot. The field capacity of usable water for silty loam soil is $1\frac{3}{4}$ inches; for sandy loam, $1\frac{1}{4}$ - $1\frac{1}{2}$ for fine sand, about 1 inch; for medium sand, about $\frac{3}{4}$ inch; and for coarse sand as low as $\frac{1}{2}$ inch per acre foot.

FIGURE 1

SUMMARY

The wilting point or drouth point is a valuable indicator in connection with the determination of the exact moisture content at which to irrigate (the purpose of which is to maintain a favorable soil moisture content).

The wilting point varies more between different crops than has commonly been supposed when judged by field and tank studies of crop appearance, soil moisture and yields of dry matter.

The wilting point appears to vary more for different crops on a soil which is rather heavy in texture than on a soil of narrow moisture limits.

The wilting point marks the lower limit of usable water. Both affect the time and amount of irrigation.

The usable-field-moisture capacity as judged by samples taken before and after irrigation, cylinder tests of field moisture capacity, physical composition, and determination of other moisture points shows that only the heavier classes of normal soils are capable of retaining as much as two inches of usable water in the surface acre foot. The coarsest soils used for irrigation retain only half an inch per foot of depth while peat retains three or four inches of usable water per acre foot.

The irrigation requirement is greater for soils of coarse texture and low humus content and is largely due to unavoidable waste in connection with light frequent irrigation.

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