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NOTE

RAPID MEASUREMENT OF SOIL WATER BY GRAVIMETRIC METHOD

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ABSTRACT

Oven drying is used widely for soil water determination. its main disadvantage is that it requires about 24 hr to obtain soil water percentage. To reduce the drying period, an experiment was conducted on 6 different textured soils. Samples were taken from six potometers, each filled with one soil type. Samples were weighed and kept at 110°C in an oven. The loss of weight was determined after 3, 6, 9, and 24 hr for each soil sample. The weight loss is assumed to be due to evaporation of water from soil. Linear and power regression equations were found for the weight loss after 3, 6 and 9 hr and that after 24 hr. It was concluded that the power regression with height correlaiton coefficients ($r>0.95$, $P<0.01$) can be used to estimate the water content of a soil sample if the amount of evaporated water is known after 6 or 9 hr. This approach will result in reduced drying time.

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اندازه‌گیری سریع رطوبت موجود در خاک به روش جاذبه‌سنجی

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چکیده
روش خشک نمودن خاک با استفاده از آون در تعیین رطوبت خاک کاربرد وسیعی دارد. اشکال اصلی این روش که بدان روش وزنی نیز گویند، طولانی بودن زمانی است که نمونه‌های خاک در آون قرار می گیرند. برای کاهش این زمان، آزمایشی در ۶ نوع خاک با بافتهای مختلف انجام گرفت. در این آزمایش از ۶ پوتو متر (ظرف کاشت گیاه) که هر کدام از یک نوع خاک پر شده بود نمونه‌برداری شد. نمونه‌های خاک پس از توزین، در آونی با دمای ۱۱۰ درجه سانتی‌گراد قرار گرفت و مقدار آب تبخیر شده پس از ۳، ۶، ۹ و ۲۴ ساعت مشخص گردید. کاهش مقدار آب از خاک به عنوان آب تبخیر شده در نظر گرفته‌شد. سپس معادلات خطی و نمائی برای نشان دادن رابطه بین مقادیر آب از دست رفته پس از، ۳، ۶ و ۹ ساعت و آب تبخیر شده پس از ۲۴ ساعت ارائه گردید. از این آزمایش نتیجه گیری شد که رابطه نمائی دارای ضریب همبستگی (r) بالائی بوده و مقدار رطوبت خاک با استفاده از آب تبخیر شده پس از ۶ یا ۹ ساعت قابل تخمین می‌باشد.

INTRODUCTON

Determination of soil water content by oven-drying method is widely used on disturbed soil samples. In many situations, particularly in the field, determination of soil water by this method involves at least a period of 24 hr from the time of sampling until the results become available. Several methods have been proposed in the past to overcome the shortcomings of the oven drying method (1, 2, 3, 4). The principel disadvantage of the proposed methods is that they are fairly cumbersome and, therefore, suitable for only a small number of samples (2). A method is proposed by Dahiya *et al.*(2) which involves recording the weight of a wide-mouthed glass flask filled with water after placing in it a soil sample of known weight. The weight of the flask, and the predetermined density of the soil and weight of the water filled flask are then used to determine moisture percentage of the soil sample. The disavantges of this method are that it uses only 25 to 35 gr of soil, and air bubbles might not be expelled completely from soil.

The purpose of this study isto reduce the time required for soil water determination by gravimetric method.

MATERIALS AND METHODS

To decrease the 24 hr time needed in gravimetric method an experiment was conducted on six different textured soils of Isfahan, Iran. Some of the physical properties of th soils are shown in Table1. An electric oven (Heraeus, DVE), an electric balance (Metler PL 1200)with an accuracy of 0.01 gram, and 25 sampling cans (10 cm diameter and 4.5 cm long) were used in this experiment.

Table 1. Some of the physical properties of the soils used in this study.

Soil No.	Sampling depth (cm)	Field capacity(%) by wt.	Permanent wilting-point (%)	Organic matter (%)	% Sand 2-0.05 (mm)	% Silt 0.05-0.002 (mm)	% Clay <0.002 (mm)	Soil texture
1	0-20	30.7	13.9	2.905	19	37	44	Clay
2	0-20	24.6	13.5	1.162	15	55	30	Silty clay loam
3	0-20	23.6	13.1	1.743	29	43	28	Clay loam
4	0-20	15.0	10.8	0.581	47	31	22	Loam
5	0-20	12.8	6.5	0.582	50	24	26	Sandy clay loam
6	0-20	6.8	3.5	1,452	89	3	8	Sandy

Six potometers (50 cm diameter and 90 cm depth) were burried in the field so that their tops were at the same level as the ground surface. Each potometer was filled with one type of soil. To cover a broad range of soil moisture,each potometer was saturated and five soil samples were taken from the surface horizon (0-20 cm) with a hand auger every day, for five consecutive days . The first samples (five replicates) were taken one day after the saturation. The soil samples were placed in the cans and brought to the laboratory. The oven temperature was brought to 110°C. Soil cans were weighed and then placed in the oven. The samples were then weighed arter 3, 6, 9 and 24 hr of drying. The difference between the weights (at the beginning and end of each time period) shows the weight of water evaporated during the elapsed time. The weight of evaporated water was used to relate percent water contents after 3, 6, and 9 hr with that at 24 hr. The amount of evaporated water was also measured after 12, 15, 18 and 21 hr for one sample of each soil.

RESULTS AND DISCUSSION

In Fig.1 the percent water content is shown versus time of oven drying for different soils. This figure shows that the sandy soil (No.6) reaches an equilibrium after about 9 hr drying time, but the clay soil (No. 1) losses water even after 24 hrs. Other textures are intermediate.

Table 2 shows the linear regression equations developed between the weight of water evaporated after 3, 6 and 9 hr and the water evaporated after 24 hr of oven drying. The correlation coefficients (r) of 3 and 24 hr of the soils No. 1 to 5 are very good. With increasing the time of oven drying, the coefficients increase. In soil No.6, which is a sandy soil, the water content after 24 hr could be estimated after only 3 hr of oven drying.

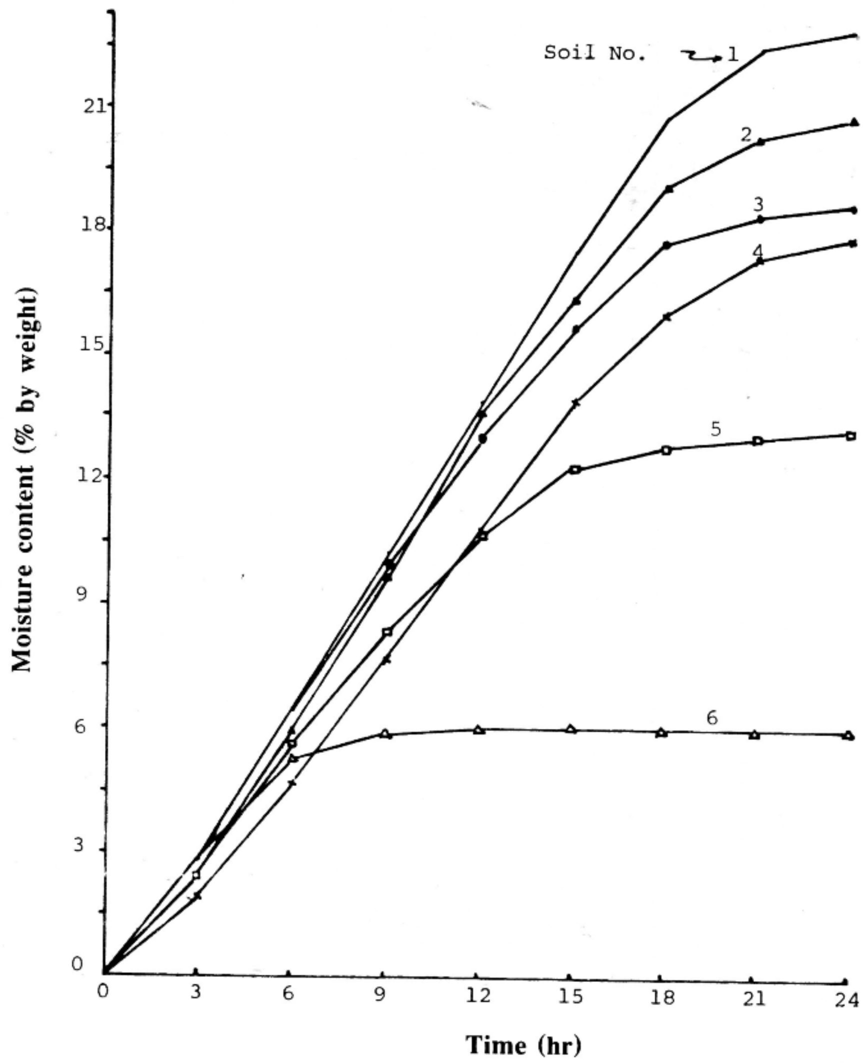

Fig.1. Percent moisture content versus time of oven-drying the different soils.

Table 2. Linear regression equations between the weight of water evaporated after 3,6 and 9 hr and 24 hr of oven drying.

Soil	Texture	3 and 24 hr		6 and 24 hr		9 and 24 hr	
No.		$W_{24}=A+BW_3$	r	$W_{24}=A+BW_6$	r	$W_{24}=A+BW_9$	r
1	C	$W_{24}=-25.4+5.5W_3$	0.77	$W_{24}=-23.9+2.9W_6$	0.97	$W_{24}=-14.4+1.8W_9$	0.98
2	Si.C.L.	$W_{24}=-15.7+4.4W_3$	0.71	$W_{24}=-13.5+2.3W_6$	0.94	$W_{24}=-5.5+1.5W_9$	0.98
3	C.L.	$W_{24}=-6.4+3.5W_3$	0.74	$W_{24}=-11.1+2.1W_6$	0.96	$W_{24}=-4.5+1.3W_9$	0.99
4	L	$W_{24}=-15.3+4.2W_3$	0.83	$W_{24}=-12.0+2.1W_6$	0.97	$W_{24}=-5.3+1.4W_9$	0.97
5	S.C.L.	$W_{24}=-4.1+3.2W_3$	0.70	$W_{24}=-5.2+1.9W_6$	0.96	$W_{24}=-1.1+1.3W_9$	0.98
6	S	$W_{24}=-1.7+1.5W_3$	0.98	$W_{24}=0.7+1.0W_6$	1.00	$W_{24}=0.5+1.0W_9$	1.00

Table 3. Power regression epuations between the weight of water evaporated after 3,6 and 9 hr and 24 hr of oven drying.

Soil No.	3 and 24 hr		6 and 24 hr		9 and 24 hr	
	$W_{24}=AW_3^B$	r	$W_{24}=AW_6^B$	r	$W_{24}=AW_9^B$	r
1	$W_{24}=0.495W_3^{1.764}$	0.79	$W_{24}=0.231W_6^{1.657}$	0.97	$W_{24}=0.344W_9^{1.384}$	0.99
2	$W_{24}=0.601W_3^{1.661}$	0.75	$W_{24}=0.460W_6^{1.425}$	0.95	$W_{24}=0.666W_9^{1.192}$	0.98
3	$W_{24}=1.539W_3^{1.257}$	0.71	$W_{24}=0.445W_6^{1.415}$	0.96	$W_{24}=0.731W_9^{1.141}$	0.99
4	$W_{24}=0.835W_3^{1.481}$	0.80	$W_{24}=0.428W_6^{1.412}$	0.98	$W_{24}=0.662W_9^{1.174}$	0.99
5	$W_{24}=1.243W_3^{1.316}$	0.72	$W_{24}=0.826W_6^{1.215}$	0.97	$W_{24}=1.116W_9^{1.040}$	0.98
6	$W_{24}=1.106W_3^{1.089}$	0.99	$W_{24}=1.266W_6^{0.940}$	1.00	$W_{24}=1.151W_9^{0.968}$	1.00

Table 4. Mean, standard deviation and the estimated amount of water evaporated after different times for different soils.

		3 hr			6 hr			9 hr			24 hr	
Soil No.	Texture	$\bar{X}_m$†	SD§	X_e¶	$\bar{X}_m$	SD	X_e	$\bar{X}_m$	SD	X_e	$\bar{X}_m$	SD
1	C	12.2	1.9	40.8	23.0	4.5	41.7	32.1	7.5	41.8	42.5	13.6
2	Si.C.L.	10.8	1.5	31.3	19.4	3.8	31.5	25.9	6.2	31.7	32.0	9.3
3	C.L.	12.0	2.0	35.0	21.9	4.3	35.1	30.0	7.1	35.4	35.4	9.6
4	L	12.8	2.9	36.4	23.7	6.8	37.4	31.3	10.4	37.7	38.3	14.8
5	S.C.L.	12.9	2.5	36.0	22.7	5.8	36.7	28.9	8.3	36.9	37.0	11.2
6	S	12.0	3.9	16.6	15.6	6.0	16.7	15.9	6.0	16.7	16.7	6.1

† $\bar{X}_m$= measured average amount (grams) of water eveporated.

§ SD= Standard deviation for 25 soil samples.

¶ X_e= estimated average amount (grams) of water evaporated after 24 hr, using equations of Table 3.

Table 3 shows power regression relations between the weight of water evaporated after 3, 6 and 9 hr and that after 24 hr. Comparison of the correlation coefficients of Table 3 with those of Table 2 shows, in most cases, little improvement over Table 2. The amount of water which will evaporate after 24 hr is estimated (Table 4) using Table 3. For example, for soil No.1 the mean measured amount of water lost after 24 hr is 42.5 gr. The estimated values are 40.8, 41.7 and 41.8 gr after 3, 6 and 9 hr of oven drying, respectively. The difference between the actual and estimated values are, then, 4, 1.8 and 1.6 percent, respectively. For soil No.6, the estimated values are closer to the actual value. The maximum differnce in this table is that of soil No.4, which is 5.0 percent.

CONCLUSION

It was concluded that power regression equations could be developed and used to estimate the soil water content, after 24 hr if the value at 6 or 9 hr is known. For sandy soils, only 3 hr of oven drying is enough to estimate the water content after 24 hr. Since soil texture, density and organic matter affect the amount of water that can be evaporated from the soil, thus it is necessary to obtain regression equation for every texture.

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