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Impact of Organic-amended Surface and Sub-surface Soil Layers on Cumulative Evaporation, Water Redistribution and Conservation in Sandy Soil Columns*

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Abstract: A glass house sandy soil column experiment was conducted for three months to investigate the impact of organic amendments on cumulative evaporation, water redistribution and conservation. The treatments consisted of a control and three organic amendments: chicken manure (CHM); dry sewage sludge (DS) and farm yard manure (FYM), each incorporated in two soil depths: 0-5 and 25-30 cm, at a rate of 20 ton/ha. The treatments were arranged in a randomized complete block design with three blocks and seven treatments. The results show that the weekly, monthly and overall rate of evaporation was consistently in the following order: control > sub-surface organic-amended layer > surface organic-amended layer. Consecutively, the surface and subsurface organic amendments significantly ($P \leq 0.05$) reduced the overall cumulative evaporation (TEc) by 38.5% and 31.9% for CHM, 37.9% and 29.1% for DS, and 36.5% and 33.5% for FYM. The soil moisture distribution in the control columns depicted initial increase in moisture content followed by leveling off thereafter, whereas that of the surface organic-amended soil columns were mirror image of that of the control columns. The sub-surface organic amendment showed a distribution curve with maximum soil moisture content at the amended depth. The soil water conserved in the soil columns ranged between154% and 171% due to surface application and between 199% and 324% due to subsurface application of organic amendments. Farm yard manure proved to be superior because of

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its inherent higher water retention capacity. The relationships between TEc and time for all treatments gave highly significant linear relationships that pass through origin and with very high accountability (r^2) ranging between 93.7 and 100.0%.

Key words: Evaporation, soil water conservation, organic amendments

INTRODUCTION

Sandy soils are prevalent in the arid and semi-arid zones in Sudan. Their inherent productive capacity is constrained by some soil physical, chemical and microbiological constraints. Their low organic matter, clay content and specific surface area cause the formation of relatively high proportion of macro-pores that promote high infiltration rate, and excessive internal drainage. The latter process causes deep percolation losses of water, inherent nutrients and added inorganic fertilizers. Their low negative and positive charge due consecutively to their low clay content and organic matter causes their low water and nutrient retention capacities (Mustafa, 1979; Mustafa, 2007). Furthermore, these soils are further constrained by mal-distribution of moisture in their profile due to relatively high evaporation loses in the top soil.

The optimum use of such soils is contingent on proper water and soil management. Thus, appropriate management should enhance the water and nutrient holding capacities, reduce evaporation, improve soil moisture redistribution and fertility status of these soils. Addition of clay content to a sandy soil can fulfill the first three physical requirements. However, organic matter can fulfill both the physical and fertility requirements. Furthermore the handling of clay may pose some logistic and economic problems. Thus, addition of organic amendments is practical and economically feasible (Kononova, 1961; Oertli, 1979; Mustafa, 1979; Hillel, 1980, Gupta and Gupta, 2008).

Previous research showed that some synthetic soil conditioners, with functional polymers similar to natural soil polymers, can reduce deep water percolation losses and enhance the water holding capacity of sandy soils (Hemyari and Nofziger, 1981; Mustafa *et al*., 1988; 1989). However,

the use of such conditioners may not be economically feasible in developing countries.
In most studies organic amendments were applied on the soil surface as mulch or incorporated in the top soil to promote the availability of water and nutrients to plants. It is hypothesized that the redistribution of soil water and plant nutrients within the root zone will be affected by the depth of placement of the organic amendments. Thus, it is envisaged that layering of organic amendments in a sandy soil may optimize its physical conditions and fertility status.

To our knowledge no research was undertaken on the impact of layering organic amendments in some water-balance processes in sandy soils in Sudan. Thus, this research was undertaken to investigate the effect of layering of three organic amendments, each at two depths on cumulative evaporation, soil moisture redistribution and soil water conservation in a sandy soil.

MATERIALS AND METHODS

A green house column experiment was conducted to investigate the impact of layering organic amendments at two depths in a sandy soil on cumulative evaporation, water redistribution and conservation. The study was undertaken using soil columns, each 60-cm long. The treatments consisted of a control, three organic amendments: chicken manure (CHM); dry sewage sludge (DS) and farm yard manure (FYM), each of which was layered at two depths: 0-5 cm and 20-25 cm. Each treatment was replicated thrice and arranged in a randomized complete block design with three blocks and seven treatments randomly arranged in each block.

A bulk sample of a sandy soil was collected from El-Rawakeeb Desertification Research Station, the National Research Center. According to soil taxonomy (FAO, 1975) the soil was classified as mixed, koalinite, isohyperthermic, gypsic Typic Camborthid (El-Hag *et al.*, 2004).

Organic carbon (OC) was determined by the dry-aching method of Fredrick, described by Ibrahim (1991), and Organic matter (OM) was then calculated. Electrical conductivity of the saturation extract (ECe) was measured, using a conductivity meter. Calcium (Ca^{+2}) and magnesium (Mg^{+2}) were determined by titration against EDTA, according to the method described by Chapman and Pratt (1961). Sodium (Na^{+}) was determined by a flame photometer, and the sodium adsorption ratio (SAR) was calculated as follows: $Na^{+}/ \sqrt{[(Ca^{+2}+ Mg^{+2})/2]}$ (Table 1). Some of the quality variables of the saturation extract of the organic amendments are presented in Table 2.

These amendments were air-dried, crushed, passed through 4-mm sieve and retained in a 3 mm-sieve. The latter fraction was used in the study. The organic amendment was mixed with enough soil to fill a 5-cm section, either as a surface layer (0 - 5 cm) or a sub-surface layer (25-30 cm).

Table 1. Properties of the bulk sandy soil sample (0-10cm) collected from EL-Rawakeeb Desertification Station

Soil depth	Clay	Silt	Sand	OM	pH	ECe	SAR
(cm)		(%)				(dS/m)	$(me/l)^{1/2}$
0 - 10	7.9	0.0	92	0.34	7.2	0.4	1.25

Table 2: The pH, EC and SAR of the saturation extract of the organic amendments

Amendment	pH	EC	Na^{+}	$(Ca+Mg)^{+2}$	SAR
		(dS/m)	(me/l)	(me/l)	$(me/l)^{1/2}$
Chicken manure	7.5	3.1	2.20	0.32	5.50
Dry Sewage sludge	8.3	2.4	0.20	0.90	0.30
Farm yard manure	8.9	4.3	4.38	0.32	11.0

Twenty one plastic columns were constructed from polyvinyl chloride (PVC) tubes of diameter 10.5 cm. Each column was constructed from eight plastic sections differing in length. Each column was assembled as follows: a 20-cm section was placed on the bottom, followed successively by two 10-cm, four 5-cm sections and one 10-cm section. These plastic sections were held together with adhesive tape. The column was then closed at the bottom end by a piece of cloth firmly held with thin iron strings. Thus, the assembled column was 70-cm long. The soil was packed in the bottom 60 cm, and the top 10-cm section was left for adding water. The empty soil columns were weighed (Wc).

The soil columns were prepared by adding the soil in small aliquots to the column and packed lightly by dropping the column a known number of times over a vertical distance of 5 cm on the bench. This procedure was done several times till a soil column of 60 cm was prepared. The amount of specific organic amendment equivalent to 20 ton/ha was calculated and mixed with a soil sufficient to fill 5 cm depth of the soil column. For surface placement of the organic amendments, the soil columns were packed up to 55 cm and then the soil mixed with the organic amendment was placed on the top 5 cm. For layering the organic amendments at the 25-30 cm depth, the soil columns were packed up to 25 cm and then the soil mixed with a specific organic amendment was placed on the top at 25-30 cm depth and the column was then packed up to 60 cm height. For each organic amendment, three replicate columns were prepared with a surface-amended layer (0-5 cm), and three other replicate columns were prepared with a sub-surface-amended (25-30 cm) layer. Three control columns were also prepared. Thus, in total twenty one soil columns were prepared, 18 with amended-soil layers, 6 for each amendment and three columns with no amendments (control) were also prepared.

Each of these soil columns was weighed to get the weight of the column plus the air-dry soil (Wca). The oven-dry weight of soil (Wod) in the column was calculated by the following equation:

$$Wod = 100 \times (Wca - Wc) / (P\,\% + 100)$$

Where P % is the percentage of the air-dry soil moisture content. The soil bulk density (BD) was calculated by the following equation

$$BD = Wod/V$$

Where V is the volume of the soil = 86.6 x 60 = 51936 cm^3. The mean bulk density of each soil column was 1.55 g/cm^3.

Irrigation treatments

The irrigation treatment consisted of adding one water application rate (R) equal to 6.6 mm/day and one irrigation interval (I) equal to one week. Since the cross-sectional area of the column was 86.6 cm^2, the total quantity of water added (Q, ml) every week was calculated by the following equation:

$$Q = IRA = (7 \times 6.6 \times 86.6)/10 = 400 \text{ ml}$$

Thus, 400 ml of water were added every week for three months. After the addition of water, the column is weighed to obtain the moist weight of the column (Wmc).

Measurement of cumulative evaporation

Cumulative water evaporation in millimeter was determined by daily weighing of each column, subtracting this weight from the initial weight of the moist column and dividing the difference by the cross-sectional area of the column and multiplying by 10. In the successive weeks during the month, the moist weight of the column was measured after irrigation and the daily evaporation was added to final Ec value at the end of the previous week. This procedure was applied continuously till the end of the last week in the third month.

Measurement of soil moisture redistribution

By the end of the 12th week, each column was sectioned using a razor and the gravimetric moisture content of the soil contained in each section was determined.

Measurement of the total water conserved

The total water conserved in each column expressed in millimeters (d, mm) was obtained as the sum of the water contents conserved in the seven sections of the column using the following relationship:

$$d \text{ (mm)} = \sum_{i=1}^{i=7} 10 \times w \times BD \times D$$

Where w = the gravimetric moisture content in each section (gm/gm), BD = the bulk density of the soil column (gm/cm^3), and D = the depth of the section (cm).

RESULTS

The organic amendment treatments are referred to by acronym of the organic material and depth of the amended soil layer in parenthesis. Table 3 shows the effect of the amended surface and subsurface layer by CHM, DS and FYM on the total cumulative evaporation (TEc) by the end of each week in the first month. The results show that TEc by the end of each week for each organic amendment (OA) treatment was consistently in the following order: control > OA (25-30) > OA (0-5). Furthermore, it is evident that in each of the four weeks each organic amendment OA significantly ($P \leq 0.05$) reduced Ec.

Table 3: The effect of chicken manure (CHM), dry sewage (DS) and farm yard manure (FYM) amendments of surface (0-5 cm) and sub-surface (25-30 cm) soil layers on mean cumulative evaporation in each of the first four successive weeks

Treatment	First week	Second week	Third week
Control	30.0 a	57.0 a	86.6 a
CHM25	21.1 b	39.4 b	60.3 b
CHM5	17.9 b	36.0 b	56.8 b
DS25	20.8 b	41.8 b	63.7 b
DS5	19.4 b	40.6 b	61.0 b
FYM25	20.8 b	37.3 b	56.4 b
FYM5	17.5 b	33.9 b	57.5 b
$LSD_{0.05}$	3.8	4.7	6.9
$t_{0.05}$	2.179	2.179	2.179
MSE	4.5	6.9	14.9

* $t_{0.05}$ = the tabulated t value for the degrees of freedom for error, MSE = mean square for error, means with the same letter in each week are not significantly different according to DMRT.

However, in each of the three successive weeks, there was no significant difference due to depth of application or type of organic amendment.

The data show that TEc from treatments CHM (25-30) and CHM (0-5) in the successive weeks expressed as percentages of that from the control were 70.3 and 59.7%, 69.1 and 63.2%, and 69.6 and 65.6%, respectively. For treatments DS (25-30) and DS (0-5), TEc in the three successive weeks were in sequence 69.3 and 64.7%, 73.3 and 71.2%, and 73.6 and 70.4%.of that of the control. Also TEc for treatments FYM (25-30) and FYM (0-5) in the successive weeks were in sequence 69.3 and 58.3%, 65.4 and 59.5%, and 66.4 and 65.1% of that of the control.

Furthermore, the values of TEc from the control in the three successive weeks were equivalent to 64.9, 61.7 and 62.5% of the added water. For CHM (25-30) and CHM (0-5) in sequence, TEc in the three successive weeks were equivalent to 45.9 and 38.7%, 42.6 and 39.0% and 43.5 and 41.0% of the added water.

For DS (25-30) and DS (0 -5) in the three successive weeks, TEc were in sequence equivalent to 45.0 and 42.0, and 45.2 and 43.9 and 46.0 and 44.0% of the added water. While for FYM (25-30) and FYM (0 -5) in the three successive weeks, TEc were in sequence equivalent to 45.0 and 37.9, and 40.4 and 36.7 and 41.5 and 40.7% of the added water.

Table 4 shows that the effect of the impact of treatments on TEc by end of each month was similar to that reflected by each of the three weeks. The control gave the highest and CHM (0-5) gave the lowest TEc value. In each of the three months, the control gave significantly ($P \leq 0.01$) much higher TEc than all organic amendment treatments. Furthermore, in the three months, sub-surface incorporation of each organic amendment resulted in higher TEc than surface incorporation. However, this effect was not significant in the first month, but it was significant for CHM and DS in the second month, and for the three organic amendments in the third month. The sub-surface organic amendment treatments were in the following significant order: Control > CHM (25-30) = DS (25-30) > FYM (25-30) in the second month, and Control > DS (25-30) > CHM (25-30) = FYM (25-30) in the third month. The surface organic amendment treatments were not significantly different in the first and second months and were in the following significant order in the third month: FYM (0-5) > DS (0-5) = CHM (0-5).

In the three successive months, TEc from treatments CHM (25-30) and CHM (0-5) expressed as percentages of that from the control were 71.2 and 68.2%, 73.0 and 65.5%, and 68.1 and 61.5%, respectively.

Table 4: The effect of chicken manure (CHM), dry sewage (DS) and farm yard manure (FYM) amendments of surface (0-5 cm) and sub-surface (25-30 cm) soil layers on mean total cumulative evaporation (TEc) by the end of each month

Treatment	First Month	Second month	Third month
Control	116.9 a	235.4 a	363.7 a
CHM (25-30)	83.2 b	171.8 b	247.5 c
CHM (0-5)	79.7 b	154.3 c	223.6 d
DS(25-30)	85.1 b	166.3 b	257.9 b
DS (0-5)	81.0 b	147.9 c	225.7 d
FYM (25-30)	82.6 b	154.9 c	241.6 c
FYM (0-5)	81.0 b	152.5 c	230.7 d
$LSD_{0.05}$	7.5	8.5	9.4
$t_{0.05}$	2.179	2.179	2.179
MSE	17.9	22.8	27.7

* $t_{0.05}$ = the tabulated t value for the degrees of freedom for error, MSE = mean square for error, means with the same letter in each week are not significantly different according to DMRT.

For DS (25-30) and DS (0 -5) in the three successive months, TEc were in sequence 72.8 and 69.3%, and 70.6 and 62.8 and 70.9 and 62.1% of that of the control. While for FYM (25-30) and FYM (0 -5) in the three successive months, TEc were in sequence 70.7 and 69.3%, and 65.8 and 64.8% and 66.4 and 64.8% of that of the control.

Furthermore, TEc from the control in the three successive months were equivalent to 63.3, 63.7 and 65.7% of the added water. For CHM (25-30) and CHM (0-5) in sequence, TEc in the three successive months were equivalent to 45.0 and 43.1%, 46.5 and 41.7% and 44.8 and 40.4% of the added water. For DS (25-30) and DS (0-5), TEc in the three successive months were 46.0 and 43.8%, 46.0 and 43.8%, and 46.6 and 40.8%. For FYM (25-30) and FYM (0-5), TEc in the three successive months were 44.7 and 43.8%, 41.9 and 43.8%, and 43.7 and 41.7%.

Impact of amendments on soil water redistribution and conservation

Fig.1. shows the impact of organic amendments added to the soil surface layers on the soil moisture distribution in the soil columns. It is evident that the curve of the control is a mirror image of those of the organic amendment treatments.

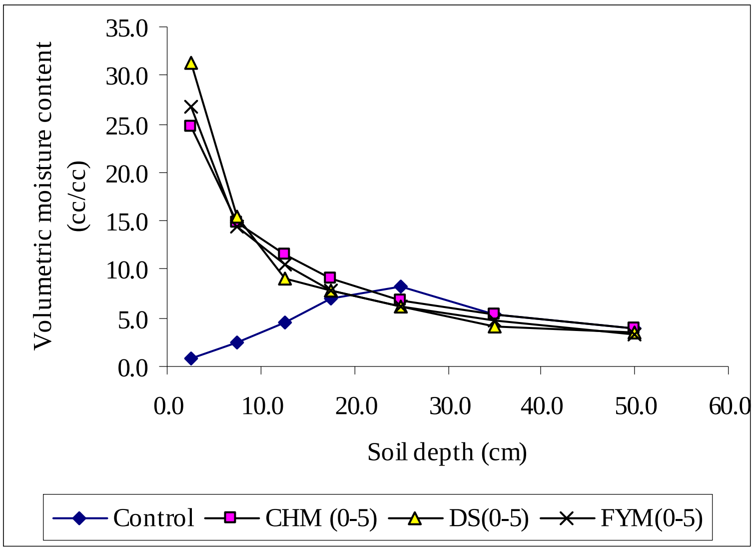

Fig. 1: The impact of surface applied organic amendments on the volumetric soil moisture distribution in the soil columns

The moisture content of the control increased with increase of soil depth from 0.8% at 2.5 cm to 8.2% at 25 cm and decreased thereafter with depth to 3.9% at 50 cm. While, the moisture contents of treatment CHM (0-5), DS (0-5) and FYM (0-5) decreased consecutively from 24.8, 31.2 and 26.8% at 2.5 cm to 4, 3.4 and 3.3% at 50 cm.

The weighted mean volumetric moisture content in the top 20 cm was 14.6% for the control, and 15.1, 15.9 and 14.9% for treatments CHM (0-5), DS (0-5) and FYM (0-5), respectively. While in the bottom 40 cm the volumetric moisture content was 4.4% for the control, and 5.0, 4.3, and 4.4% for treatments CHM (0-5), DS (0-5) and FYM (0-5), respectively.

Fig. 2 shows that the moisture content of the sub-surface organic-amendment treatments increased gradually from the first section to the fourth section, and then increased abruptly in the fifth section and finally decreased to the last section.

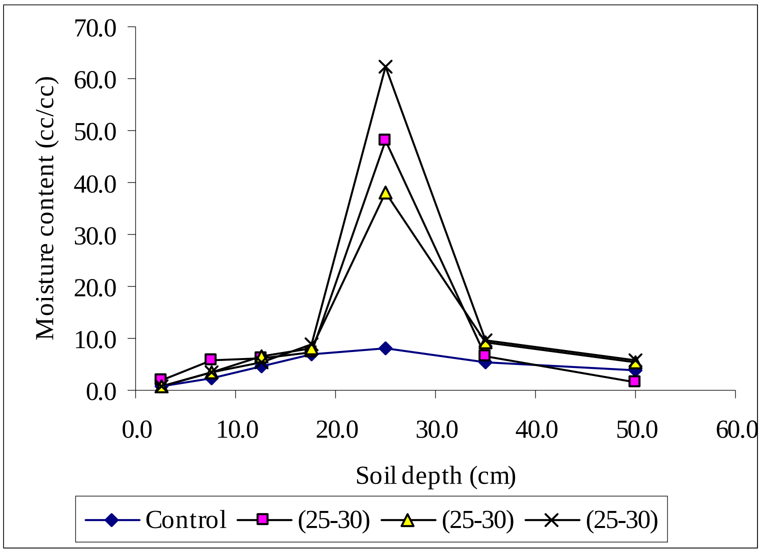

Fig. 1: The impact of sub-surface organic amendments treatments on the volumetric soil moisture distribution in the soil columns

The moisture contents of treatment CHM (25-39) increased gradually from 1.9 at 2.5 cm to 7.3% at 17.5 cm, followed by an abrupt linear increase to 48.2 at 25 cm, and finally decreased to 1.7% at 50 cm. The moisture contents of treatment DS (25-39) increased gradually from 0.9% at 2.5 cm to 8.2% at 17.5 cm followed by an abrupt linear increase to 38.0% at 25 cm and finally decreased to 5.3% at 50 cm. For treatment FYM (25-30 cm), the moisture contents of treatment DS (25-39) increased gradually from 0.9% at 2.5 cm to 9.0% at 17.5 cm, followed by an abrupt linear increase to 62.3% at 25 cm and finally decrease to 5.7% at 50 cm.

The weighted mean volumetric moisture content in the top 20 cm was 3.7% for the control, and 5.3, 4.7, and 4.7% for treatments CHM (25-30), DS (25-30) and FYM (25-30), respectively. While in the bottom 40 cm the weighted mean volumetric moisture content was 4.4% for the control, and 14.5, 14.5, and 20.8% mm for treatments CHM (25-30), DS (25-30) and FYM (25-30), respectively.

Table 5 shows the amount of water conserved by end of the experiment. The results show that all organic amendment significantly ($P \leq 0.05$) increased the amount of water conserved in the soil columns. Furthermore, treatment FYM (25-30) gave significantly ($P \leq 0.05$) much higher AWC than all other organic amendment. Although the subsurface application of each organic amendment resulted in higher AWC, this effect was only significant in the case of FYM.

Table 5: The effect of chicken manure (CHM), dry sewage (DS) and farm yard manure (FYM) amendments of surface (0-5 cm) and sub-surface (25-30 cm) soil layers on the amount of water conserved in the soil columns (AWC) by the end of the experiment

Treatment	FYM25	DS25	CHM25	DS5	CHM5	FYM5	Control
AWC, mm	95.8 a	65.2 b	58.8 b	50.4 b	48.6 b	45.6 b	29.6 c
LSD	22.1						
$t_{0\text{-}5}$	2.179						
MSE	154.2						

* $t_{0.05}$ = the tabulated t value for the degrees of freedom for error, MSE = mean square for error, means with the same letter in each week are not significantly different according to DMRT.

DISCUSSION

Impact of organic amendments on cumulative evaporation

The graphic plots of Ec (mm) versus time (day) for all treatments during every week, month or 3 month fitted highly significant ($P \leq 0.01$) linear relationships that passed through the origin. The coefficients of correlation were very high ranging between 0.9679 and 0.9994 with a mean 0.9957 for the monthly data (n = 28), and between 0.9984 and 0.9998 with a mean of 0.99925 for the overall 3-month data (n = 84). It is evident that for the monthly or the 3-month pooled data the linear relationships were almost perfect indicating that the time is accounting for 99.9% of the variability of Ec. It was natural to find that Ec was directly proportional to the period the evaporation process that took place. The linear model may be attributed to the almost constant meteorological conditions and steady incremental increase in the rate of evaporation due to the relatively stable sandy soil system. Furthermore, the irrigation interval was not long enough for the second falling rate stage of evaporation to proceed (Hillel, 1980b). Other researchers reported significant relationships between Ec vesus √t (Black *et al.*, 1969; Hanks, 1979; Dahab *et al*., 1988; Abdelrahman *et al.*, 1989). Mustafa *et al.* (1983) investigated the relationship of Ec versus time from columns irrigated with a total quantity of irrigation water (Qi) of 160 mm or 320 every 5, 10 and 20 days interval. The cyclic Ec vesus t plots were almost linear when the irrigation interval was 5 days, and progressively became more curvilinear as the irrigation interval increased giving time for the second stage to occur. They reported that Ec, irrespective of Qi or interval, for each drying cycle was significantly a linear function of √t. However, Ec of the columns irrigated every 5 days could have given a significant linear relationship with t. Thus, the linear relationships depicted by the present results may be due the short irrigation frequency in addition to the stable sandy soil system.

The daily Ec during each week, month or 3 months, as affected by surface and subsurface organic amendments were found to be in the following significant ($P \leq 0.05$) order: Control > OA (25-30) > OA (0-5). In the twelve weeks of the three months the control treatment gave the highest Ec. This was due to the high suction gradient between the evaporating bare soil surface and the relatively high hydraulic conductivity (HC) of the wetted subsoil making the water more available for evaporation. As the moisture content in the transmission zone increased by weekly addition of 46.2 mm of irrigation water, the HC increased and consequently Ec gradually increased.

The surface organic-amended layer reduced the intensity of the net solar radiation available for evaporation. Furthermore, it acted as a barrier to the downward movement water during the wetting cycle and as mulch during the drying cycle and thereby restricted the upward movement of water to the evaporating surface. For these three effects the soil columns with these surface organic-amended layers gave the lowest rate of evaporation and the lowest Ec, whereas, the addition of organic amendments to the sub-surface layer enhanced its water holding capacity and consequently limited the capillary rise of water to the evaporating surface but to a slightly less extent than its surface organic-amended layer. Furthermore, the enhanced retention of water in the sub-surface reduced the downward movement of water. The monthly and the overall impact of surface and sub-surface applied organic amendments on evaporation were cumulative daily effects.

Impact of organic amendments on soil moisture redistribution

The volumetric soil moisture (θ) profile by the end of the experiment depicted two linear relationships. The control profile showed a highly significant (r^2 =0.9707) linear increase in θ from 0.8 % at the surface section to 8.2% at the fifth section (20-30 cm) and thereafter it decreased significantly (r^2 = 0.9195) to 3.9% at the 8^{th} section.

For the CHM (0-5) the profile showed a highly significant (r^2 = 0.9813) power decrease from 24.8 at the first section to 4% at the seventh section. For DS the profile showed treatment, the moisture content was 16% at the surface section, dropped to 5.8% in the fourth section (15-20 cm) and then decreased gradually with depth reaching 2.6% at the final section. The surface incorporated chicken manure reduced the net incoming solar radiation, acted as mulch, and reduced Ec. Thus, the moisture content in the top four sections was much greater than that of the control and CHM25-30 treatment. The incorporation of CHM in the subsoil retained the soil moisture and restricted its movement downwards. As a consequence very high soil moisture content, i.e. 70.4% was retained at the amended section (25-30 cm), otherwise the soil moisture distribution was relatively similar to that of the control.

The water conserved in the top 20 cm was 8, 34.8 and 12.2 mm in the control, CHM (0-5) and CHM (25-30), respectively. Whereas in the top 30 the surface and subsurface treatments exchanged positions. The surface incorporation of the organic amendments promotes water conservation in the top 20 cm, while the subsurface incorporation promotes water conservation in the top 30 cm. Thus, appropriate layering of organic amendments in the soil depends upon the depth of the root system of the cultivated crops.

In general, the trend of the impact of the surface soil and subsoil incorporation of DS and FYM on the soil moisture redistributions were similar to those of CHM and may be explained similarly.

CONCLUSIONS AND RECOMMENDATIONS

- For all treatments, cumulative evaporation (Ec mm/day) versus time (day) during a week, a month or three months consistently fitted a highly significant ($P \leq 0.01$) positive linear relationship that passes through origin and with very high coefficients of determinations.
- The control treatment significantly gave the highest Ec value.
- The results showed that CHM (0-5), DS (0-5) and FYM (0-5) significantly ($P \leq 0.05$) reduced Ec by 38.5%, 37.9% and 36.6%, respectively. Whereas CHM (25-30), DS (25-30) and FYM (25-30) reduced Ec by 31.9%, 29.1% and 33.5%, respectively.
- The organic amendments significantly modified the soil moisture distribution in the soil columns. In general, the weighted-mean soil moisture content (WMC) in the top 30% of the soil column, was in the following significant order: CHM0-5 > control = CHM25-30.
- In the top 50%, WMC was in the following significant ($P \leq 0.05$) order: CHM25-30 > CHM0-5 > control.
- For both DS and FYM treatments, the trends of the weighted mean soil moisture content (WMC) in the top 30% or 50% of the column were similar to those of CHM treatments.
- The incorporation of organic amendments enhanced the amount of water conserved (AWC) in the soil columns. The AWC by CHM25-30, DS25-30 and FYM25-30 were 199%, 220% and 324% that of the control, respectively. It is recommended to use layer of FYM placed at 50% of the root zone of a sandy soil at the rate of 20 ton/ha.
- The AWC by CHM0-5, DS0-5 and FYM0-5 were 164%, 171% and 154%, respectively. Restriction of upward movement of water by the sub-surface application of organic amendments was evidently more significant than inhibition of evaporation by surface incorporation of organic amendments.
- Placement of the organic amended layer depends on the desired soil moisture distribution. If higher weighted mean moisture content (WMC) is desired on the top 30% of the root zone surface application is recommended, but if higher WMC is desired in the top 50% of the root zone sub-surface application is recommended.
- In general, surface incorporation of organic amendments preferably FYM is recommended. However, initial washing of salts if there is any is also recommended.

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تأثير الطبقات السطحية وتحت السطحية المحسنة بالمادة العضوية على التبخر التراكمى و إعادة توزيع و حفظ الماء فى أعمدة تربة رملية*

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مستخلص البحث: أجريت تجربة أعمدة تربة رملية فى بيت الزجاج لفترة ثلاثة أشهر لدراسة تأثير المحسنات العضوية على التبخر التراكمى، وإعادة توزيع الماء وحفظه فى التربة. اشتملت المعاملات على شاهد و ثلاثة محسنات عضوية هى: سماد الدواجن البلدى، ووحل المجارى الجاف، وسماد المزرعة البلدى، حيث خلط كل واحد منها بمعدل 20 طن /هكتار مع التربة على عمقين: 0-5 سم و 25-30 سم. صممت المعاملات فى قطاعات عشوائية متكاملة بثلاثة مكررات وسبعة معاملات. دلت النتائج على أن معدلات التبخر الأسبوعية أو الشهرية أو لفترة الدراسة الكلية جاءت وفق الترتيب الثابت الآتى للمحسنات الثلاثة العضوية : معاملة الشاهد > الطبقة تحت السطحية المحسنة > الطبقة السطحية المحسنة. حيث خفضت المحسنات السطحية المحسنة وتحت السطحية المحسنة التبخر التراكمى الإجمالى على التتابع بـ 38.5% و 31.9% لسماد الدواجن البلدى، و 37.9% و 29.5% لوحل المجارى الجاف، و36.5% و 33.5% لسماد المزرعة البلدى. أعطى توزيع رطوبة التربة فى عمود الشاهدزيادة أولية ثم ثباتاً فى محتوى رطوبة التربة. و كان توزيع محتوى الرطوبة فى أعمدة التربة التى تم تحسين سطحها بالمادة العضوية صورة مرآة عكسية لذلك فى أعمدة الشاهد . وأدت إضافة المادة العضوية لطبقة تحت سطح التربة إلى ظهور محتوى رطوبة عظمى عند عمق التربة التى أضيفت لها المادة العضوية. تراوحت زيادة الماء المحفوظ فى قطاع أعمدة التربة نتيجة لإضافة المواد العضوية عند سطح التربة من 154% إلى 171% ، وتراوحت من 199% إلى 324% بإضافة المواد العضوية للطبقة تحت سطح لتربة. وقد تميز سماد المزرعة نتيجة لسعته العالية فى حفظ الماء. ولقد أعطت العلاقة بين التبخر التراكمى و الزمن لكل المعاملات علاقات خطية مارة بنقطة الأصل عالية المعنوية و ذات معامل تقدير (r^2)عالٍ جداً تراوح بين 93.7 و 100%.

كلمات مفتاحية: التبخر ، صيانة ماء التربة، محسنات عضوية

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