INFLUENCE OF TILLAGE DEPTH, SOIL MULCHING SYSTEMS AND FERTILIZERS ON SOME THERMAL PROPERTIES OF SILTY CLAY SOIL

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ABSTRACT: *A field experiment was conducted to study the effect of three factors; the first factor, tillage depth with three levels (15,25 and 45 cm), the second factor ,soil mulched system with three levels (single sheet plastic, double sheet plastic and no mulch), third factor ,fertilizer type (chemical, organic and without fertilizer) upon thermal flux (w/m^2), soil thermal conductivity (w/m.k) and soil volumetric heat capacity (*J/m^3. k)*.The effect of tillage depth and mulched system upon soil bulk density (Mg/m^3) and volumetric moisture content (cm^3/cm^3) was conducted. The results showed significant differences between tillage depths on the soil thermal properties, it was observed that increasing tillage depth causes decrease in soil thermal flux while soil thermal conductivity was increased. The highest volumetric heat capacity (8.22* X *10^5* J/m^3. k *) obtained at tillage depth 25 cm .,The increase of tillage depth causes increase in soil bulk density at 25 cm depth then decrease at 45 cm depth .The results showed no significant differences between fertilizer systems on soil thermal properties. The results showed significant differences between soil mulched system on soil thermal properties , the double mulch system obtained the highest thermal flux(26.29 w/m^2), high soil* thermal conductivity (0.822 *w*/m.k), high *soil volumetric heat capacity (9.703* X *10^5* J/m^3. k *)and high volumetric moisture content (0.231 cm^3/cm^3).*

KEYWORDS: Tillage Depth, Soil Mulching System, Soil Thermal Flux, Soil Volumetric Heat Capacity, Soil Thermal Conductivity.

INTRODUCTION

Soil solarization is a process in which soil temperature is increased by using solar radiation as an energy source. It was initially intended as a method for controlling soil pathogens (Katan et al., 1976), but research has shown that it has other effects on soil characteristics that can influence the performance of crops, such as nutrient concentration (Chen et al., 1991) and soluble organic matter content (Chen et al., 2000). Gutkowski and Terranova (1991) and Mahrer (1991) discussed the mechanisms that affect the soil energy balance on bare and mulched soils. The soil heat flux influences the heat storage capacity of the soil, as it determines, how deep the heat wave can penetrate into the soil during exposure to solar radiation. It depends on the thermal conductivity and the specific heat capacity of the soil properties that are influenced by the soil water content. Heat conductivity is higher in soils with higher water content. (Julio, E, H., 2002), Mulching reduces sensible heat fluxes because air circulation between the soil and the atmosphere is limited.

In mulched soils, sensible heat exchanges take place through the air layer trapped between the soil and the mulch and by convection from the mulch to the ambient air. Sensible fluxes depend on the heat transfer capacity and the temperature of the mulch (determined by its optical properties), and on the thickness of the air layer between the soil and the mulch. These fluxes can be affected by heat leaks due to a loss of integrity of the mulch. Agricultural management practices including irrigation, drainage and tillage have the potential to affect the thermal properties of soils and therefore a soil thermal regime. In particular, the effect of tillage and management on soil heat flux has been the subject of several studies. Tillage is one of the most important field methods for managing soil thermal properties and heat flow partitions between air and soil. Changes resulting from tillage can have significant effects on soil temperature and moisture environments of bare soil as well as on the microclimate of plants, Allmaras, et al(1977) and Vries, (1952) showed that thermal conductivity and heat capacity of soil depend on organic matter, mineral composition, porosity and water content (the latter two are readily changed by tillage). They also showed the importance of tillage for creating a layered system. Willis & Raney, (1971) considered compaction (reduced porosity) and water content effects on soil thermal properties. Soil temperature shows a pronounced fluctuation with time and soil depth. Abu-Hamdeh & Reeder, (2000) showed that the thermal conductivity decreases with the increasing content of organic matter. Conclude (Abu-Hamdeh & Reeder, 2009) increasing the percentage of soil organic matter decreased thermal conductivity, Showed Abu-Hamdeh, (2003) and Khaled & Abu-Hamdeh, (2013) showed that volumetric heat capacity increased with increased moisture content and soil density. Thermal conductivity and volumetric heat capacity increase with Increasing water content (Arshad & Azooz, 1996). Heat flux is faster on the top layer than in the deeper layer (Zhang ,S.I& Zhang,X , 2009).The distribution of soil temperature and moisture content are key a variable in the investigation of soil include thermal properties areas of concern include thermal conductivity, thermal diffusivity and volumetric heat capacity (zhiqiu.g ,et al, 2003).Thermal conductivity and volumetric heat capacity are also affected by the tillage practices (Allmaras et al.,1977; Abu-Hamdeh & Redder, 2000; Tyson et al., 2001) because of the tillage-induced soil compaction including wheeling, which increases the bulk density and the penetration resistance but creates a platy structure, which affects the water movement in the first centimeters of soil.

Objective of the Study

Inasmuch as few studies related with thermal properties of soil in the middle of Iraq, thus the present study was conducted to evaluate the following objectives:

1. The effect of depth tillage, soil mulched systems and fertilizers on some soil thermal properties.
2. The effect of soil mulching systems (number of mulched) on bulk density and volumetric moisture content of the soil.

MATERIALS AND METHODS

1. Experimental design and Management

The field experiment is done to study the effect of tillage depth, Soil mulched system and fertilizers type upon some of the soil thermal properties, soil specifications illustrated in table.1, the experiment was carried at AL-Rabyaa date palm station /Zafaraniah /Baghdad located within

33°13'59.8"N 44°27'52.6"E, from 1/6/ to 1/10/2013, The experiment included the study of the effect of three experimental factors:

A. The first factor represents the tillage depth in three levels (15,25 and 45 cm),
B. The second factor represents the soil mulching systems in three levels (single, double and no mulching),.
C. The third factor includes three fertilizer types.

a) The chemical fertilizer type (Triple Super Phosphate TSP added 0.07 kg/ 2m^2 Equivalent 350 kg/ha)
b) The organic fertilizer (humic acid added 0.05 kg/2m^2 Equivalent 250 kg/ha)
c) Without fertilizers.

Table (1): - Some physical soil *properties*

Soil depth (cm)	Soil Physical Properties					
	Bulk density (Mg/m3)	Porosity (%)	Particle size distribution			Texture
			Clay gm/kg	Silt gm/kg	Sand gm/kg	Silty clay (SIC)
0-15	1.312	50.49	468	407	125	
15-25	1.334	49.66	454	408	138	
25-45	1.381	47.88	412	426	162	

2. Experiment procedures

A. Cleaning and disposal the field experiment from grass and plants.
B. Planning the field experience by the experimental treatments. Area treat (2 m^2), total area (162 m^2). Experiment included (27 treat* 3 replicates) total treatment 81 experimental units.
C. Use of farm tractor same explorer 85 DT and disc Plough For the purpose of plowing of three levels depth (15 ,25 and 45 cm).followed disc harrows to smoothen soil.
D. Distribution of fertilizer treatments by field of experience design, then mixed the fertilizer with soil mixing manually.
E. Installation of Thermocouple type (k) in the experimental units for the purpose of measuring soil temperature.
F. Irrigation of field to the level of field capacity
G. Mulch of experimental units by plastic sheets (single mulch, double mulch, without mulch) used Clear polyethylene film of various mode Iran thicknesses 0.5 mm. Width 6 m for the purpose of soil solarization.
H. Covering the mulched experimental from the date of 15/6/2013 to 1/9/2013.
I. Measurement of Soil temperature for every hour by Digital thermometer MT-4011.

J. Calculation of Soil bulk density, volumetric moisture content after removal mulch from the following equation (Blake, 1965) the total porosity (%) was calculated from the following equation (vomocil, 1965).

3. Statistical Analysis

Data was analyzed using SAS 9.1 Statistical Software .The procedure was used to perform the analysis of variance, which was appropriate for spilt –spilt plot under randomized complete block design, soil thermal flux (w/m^2), soil thermal conductivity (w/m.k), soil volumetric heat capacity (J /m^3. K), Means were separated using a least significant difference (LSD) when treatment effects were significant. Statistical significance was evaluated at $P \leq 0.05$.

4. Calculations mathematical and laboratory

- **Soil Bulk Density ,volumetric moisture content and porosity**

The soil bulk density and porosity was calculated from the following equations (Blake, 1965):

$$Bulk\ density\ = \frac{Ms(Mg)}{Vt\ (m^3)} \ldots\ldots(1)$$

Where:

M_s= Oven dry weight of soil (Mg)

V_t =Volume of soil sample (m^3)

The volumetric moisture content (cm^3/cm^3) was calculated using the following equation (2)

$$\theta = \frac{pw*pb}{pw} \ldots\ldots(2)$$

Where:

Θ= volumetric moisture content (cm^3/cm^3)

ρw=moisture content by weight (%)

ρb=soil bulk density (Mg/m^3)

ρ_w =water density (Mg/m^3)

The total porosity was calculated using the following equation (Vomocil,1965)

$$Porosity\ (\%) = \left(1 - \frac{soil\ bulk\ density^{Mg}/_{m^3}}{particle\ density\ \left(^{Mg}/_{m^3}\right)}\right) x\ 100 \ldots\ldots (3)$$

- Soil thermal properties.

Calculated soil thermal conductivity of silty clay was calculated using the following equation (4). (Kersten, M.S, 1949)

$$k = [0.9logw - 0.2]10^{0.01\,\gamma d} \ldots\ldots (4)$$

W= moisture content (%)

γ= dry density (Mg/m^3)

Soil heat flux was calculated using the following equation (5) (Fourier’s law). (Steven R.et al, 2012)

$$qh = -k\frac{dT}{dx} \ldots\ldots (5)$$

qh = Heat flux density (w/m²)
k = Thermal conductivity (W/m.k)
T = Temperature (k)
x = Vertical distance (m)

Volumetric heat capacity ,Cv(J/m^{3}k) can be calculated with reasonable accuracy using the volumetric water content (θ) and soil bulk density (ρb). (Steven R.ets. 2012)

$$\boldsymbol{Cv} = \frac{2.01x10^6\ pb}{2.65+4.19x10^6\ \theta} \qquad (6)$$

RESULTS AND DISCUSSION

The influence of the studying factors on soil thermal flux (w/m^2)

Table (2)represents the influence of tillage depth, soil mulch systems and fertilizer type on the soil thermal flux, the results showed significant differences between tillage depths on soil thermal flux , thus when the tillage depth was increased from 15 to 25 cm, the thermal flux was decreased from 33.47 to 20.03 w/m^2 , the decreasing ratio was 40.20%,also when the tillage depth was increased to 45 cm, the soil thermal flux decreased to 10.03 w/m^2 with decreasing ratio 49.9 % in comparison with depth 25 cm .This result might be obtained as a result of increasing the soil temperature near the soil surface by solar radiation through the period of study especially in the afternoon .This result agreed with the result which was obtained by (Heitman et al ,2010).Also ,the thermal flux was faster on the top layer than in the deep layer(Zhang S,I & Zhang X, .2009),(Brady,1974),as a result of decreasing thermal gradient (dt/dx) that showed in equation (5) in lower soil depths in comparison with the upper soil depths.

The soil mulching systems showed significant differences in thermal flux , the soil with double mulch system showed the highest value of thermal flux (26.29 w/m^2)in comparison with the soil with single mulch ,without mulch showed the values (21.06 ,16.20 w/m^2) respectively. The reason for this result might be obtained because of the raise of temperature with increasing number of mulches by producing a relatively large net radiation at the soil surface by transparent mulches and the water drip condense under the transparent mulches at night ,that absorbed the reflected radiation from soil and maintained it to protect soil temperature .This result agreed with the result which was obtained by (Lamont,2005),(Ham et al ,1993) ,(Awadis et al ,2011).At night, the bare soil loses more heat than a mulched soil due to the lack of insulation because the mulch-air layer being a poorer heat conductor .This result agreed with the result which was obtained by (Liakatas et al,1986). The results showed non significant differences between the types of fertilizer on soil thermal flux.

Table (2), also showed that there was a significant effect of interaction between tillage depth and soil mulch system on the thermal flux .The tillage depth 15 cm and double mulch system showed the highest soil thermal flux with value (44.16 w/m^2), the lower soil thermal flux (9.03 w/m^2)was obtained by using tillage depth 45 cm and single mulch system. This result might be obtained as a result that the transparent mulch transmits most of the solar radiation which is in turn absorbed by the soil during the day especially at the surface soil then the double mulch reduces the energy exchange across the mulch-air layer in comparison with single mulch and without mulch. The results showed that there was a significant effect of interaction between tillage depth and fertilizer type on soil thermal flux .The higher soil thermal flux (38.84 w/m^2) was obtained at tillage depth 15 cm and organic fertilizer, while the lower thermal flux (8.6 w/m^2) was obtained at tillage depth 45 cm and without fertilizer. The reason for this result might be because both increasing soil temperature at soil surface and promoting decomposition of organic fertilizer by microorganism would increase soil heat flux at this tillage depth .The results showed that there was a significant effect of interaction between soil mulch system and fertilizer type on soil thermal flux .The higher soil thermal flux (29.83 w/m^2) was obtained at double mulch and organic fertilizer ,while the lower thermal flux (14.34 w/m^2) was obtained at without mulch and without fertilizer .The reason for this result might be the same reasons shown above and as a result of the soils covered with mulches usually retain a higher soluble minerals ,constant moisture content ,higher temperature ,and better aeration of the soil , all tend to favour higher microbial populations in the soil thus ensuring more complete nitrification (Hankin et al,1982), consequently the large proportion of potential energy of organic matter which is readily transferrable to other latent forms or is liberated as heat as shows by (Brady ,1974).Triple interaction between tillage depth ,soil mulch system and fertilizer type showed significant differences among treatments on soil thermal flux .The higher soil thermal flux (50.74 w/m^2) was obtained at tillage depth 15 cm ,double mulch system and organic fertilizer , while the lower thermal flux (7.46 w/m^2) was obtained at tillage depth 45 cm ,single mulch system and without fertilizer.The reason of this result might be returned to the same reasons shown above .

The influence of the studying factors on the soil thermal conductivity (w/m.k)
Table (3) showed a significant effect of tillage depth on soil thermal conductivity. The higher value of soil thermal conductivity (0.787 w/m.k) was obtained at tillage depth 45 cm in comparison with the tillage depth 15 cm and 25 cm which showed the values (0.688,0.773 w/m.k) respectively .The reason for this result might be obtained as a result of increasing the bulk density and water content of studied soil with depth as illustrated in fig.(2).This result agreed with the result obtained by (Abu-Hamdeh & Reeder,2000) and (Abu-Hamdeh,2001).The results showed a significant effect of soil mulch system upon soil thermal conductivity .The higher value of soil thermal conductivity (0.822 w/m.k) was obtained at double mulch in comparison with the single mulch and without mulch which showed the values (0.741,0.681 w/m.k) respectively. The reason for this result might be obtained as a result of increasing volumetric water content in studied soil that covered with double mulch as shown in fig (1), the soil double mulch system obtained the higher value of volumetric water content (0.231 cm^{3}/cm^{3}) in comparison with single mulch system and without mulch which showed the values (0.167, 0.103 cm^{3}/cm^{3}) respectively. Also, the double mulch reduces the amount of water lost due to evaporation compared with single mulch and without mulch. This result agreed with the result obtained by (Arshad and Azooz, 1996) and (Anikwe et al, 2007).

The results in table (3) showed no significant differences between the types of fertilizer on soil thermal conductivity. Table (3) showed that there was a significant effect of interaction between tillage depth and soil mulch system on the soil thermal conductivity . The tillage depth 25 cm and soil double mulch system showed the highest soil thermal conductivity (0.844 w/m.k), the lower soil thermal conductivity (0.629w/m.k) was obtained at tillage depth 15 cm and soil without mulch.

This result might be obtained as a result of the high effect of increasing volumetric water content (θ) in soil plots that covered with double mulch as illustrated above. The interaction between tillage depth and fertilizer type showed the highest value of soil thermal conductivity (0.834w/m.k) at tillage depth 45 cm and chemical fertilizer, while the lower soil thermal conductivity (0.661 w/m.k) was obtained at tillage depth 15 cm and without fertilizer. The reason for this result might be a result of decreasing the bulk density and volumetric water content at the surface soil as shown in fig(1) and fig(2)compared with down layer of soil . The interaction between soil mulch system and fertilizer type showed. The highest soil thermal conductivity (0.811 w/m.k) when using soil double mulch system and chemical fertilizer while the lowest soil thermal conductivity (0.651 w/m.k) was obtained at the soil treatment without mulch and organic fertilizer .The reason for this result might be a result of high effect of double mulch upon magnitudes of the temperature below the mulch and decrease of evaporation from mulched soil compared with bare soil, this result agreed with the result obtained by (Anikwe et .al ,2007) and (Ramakrishna et .al ,2006).Triple interaction between tillage depth 25 cm ,soil double mulch system and without fertilizer showed the highest soil thermal conductivity (0.911 w/m.k),while the lowest soil thermal conductivity(0.600 w/m.k) occured at treatments (tillage depth 15 cm ,without mulch and without fertilizer).The reason of this result might be returned to the same reasons shown above.

The influence of studying factors on soil volumetric heat capacity (J /m^3. K)

Table (4) Showed the influence of studying factors on the soil volumetric heat capacity (J/m3. k). The results showed a significant effect of tillage depth on the volumetric heat capacity ,the higher value of soil volumetric heat capacity (8.22 X 10^5 J/m^3. K) was obtained at tillage depth 25 cm in comparison with the tillage depth 15 cm and 45 cm which showed the values (5.49 X 10^5 ,7.74 X 10^5 J/m^3. K) respectively .The reason for this result might be because the tillage depth 25 cm showed the higher volumetric water content (0.196 cm^3/cm^3) as shown in fig.(2). The soil volumetric heat capacity was reduced to (7.74 X 10^5 J/m^3. K) when tillage depth increased to 45 cm in spite of this tillage depth showed the highest soil bulk density (1.317 Mg/m^3) as shown in fig.(2). The explanation of this result might be because of the increase of soil volumetric water content and bulk density with soil depth. This result agreed with the result obtained by (Abu-Hamdeh, 2003).

The soil mulching system showed significant differences in volumetric heat capacity , the soil mulch system obtained the highest value of soil volumetric heat capacity (9.703 X 10^5 J/m^3. k) in comparison with soil covered with single mulch , without mulch which showed the values (7.417 X 10^5 ,4.345 X 10^5 J/m^3. k) respectively . The reason for this result might be obtained because the soil volumetric heat capacity increases with increasing volumetric moisture content , the soil double mulch system obtained the highest moisture content (0.231 cm^3/cm^3) compared with other two treatments (fig.1).Also , the increase of soil moisture content increases the heat storage capacity of soil . This result agreed with the result obtained by (Khaled and Abu –hamdeh ,2013) and (Al-Kayssi et al ,1990). The results showed no significant differences between the types of fertilizer on soil volumetric heat capacity .Table (4)Also, showed a significant effect of interaction between tillage depth and soil mulch system on the soil volumetric heat capacity .The tillage depth 25 cm and soil double mulch system showed the highest soil volumetric heat capacity (1.1 X 10 ^{6} J/m^3.k),the lowest value of soil volumetric heat capacity (1.12 X 10^5 J/m^3.k

) obtained at tillage depth 15 cm with soil without mulch .This result might be obtained because the high moisture content in studied soil at treatment plots of tillage depth 25 cm and soil double mulch as shown in (fig.1,fig.2).Interaction between the tillage depth 25 cm and without fertilizer obtained the highest value of soil volumetric heat capacity (8.54 X 10^5 J/m^3.k) while the minimum value (5.22 X 10^5 J/m^3.k) resulting from the interaction of tillage depth 15 cm and without fertilizer .interaction between the soil double mulch system and without fertilizer showed the highest soil volumetric heat capacity value (1.00 X 10^6 j/m^3.k.) ,the lowest value of soil volumetric heat capacity (3.58 X 10^5 j/m^3.k) resulted from the interaction of no mulch and organic fertilizer.

In the triple interaction of studying factors, the highest value of soil volumetric heat capacity (1.09 X 10^6 j/m^3.k)obtained as a result of interaction of tillage depth 25 cm ,soil double mulch and without fertilizer , while the lowest value (2.61 X 10^4 j/m^3.k) obtained as a result of interaction tillage depth 15 cm, soil without mulch and organic fertilizer .The main reason of this result came of the importance of soil bulk density and moisture content upon soil volumetric heat capacity .

Table (2) shows the effect of tillage's depth, soil mulching systems and fertilizer type on the thermal flux (w/m^2)

Depth tillage (Cm)	**Soil mulching Systems**	**Interaction Triple**			**Interaction the depth tillage and soil mulching Systems**
		Fertilizer			
		Chemical	Organic	Without	
15	Single	34.19	39.80	25.51	33.16
	Double	44.66	50.74	37.10	44.16
	no covering	23.30	26.00	20.00	23.10
25	Single	22.21	22.50	18.17	20.96
	Double	22.74	25.93	21.86	23.51
	no covering	18.13	15.06	13.71	15.63
45	Single	9.42	10.21	7.46	9.03
	Double	11.77	12.82	9.02	11.20
	no covering	10.13	10.14	9.32	16.20
Average of fertilizer		21.84	23.69	18.01	LSD 0.05 Depth tillage =3.670 Soil mulched system =6.331 Fertilizer= N.S (6.640) Depth tillage X soil mulch system =2.165

Depth tillage (cm)	**Fertilizer**	**Interaction depth tillage &fertilizer**	**Average the depth tillage**
15	Chemical	34.05	33.47
	Organic	38.84	
	Without	27.53	
25	Chemical	21.03	20.03

	Organic	21.16		Depth tillage X Fertilizer =3.822 Soil mulch system X Fertilizer =7.23 Depth tillage X soil mulch system X Fertilizer = 0.809
	Without	17.91		
45	Chemical	10.44	10.03	
	Organic	11.06		
	Without	8.60		
soil mulching systems	**Fertilizer**	**Interaction soil mulching systems and fertilizer**	**Average the soil mulching Systems**	
Single	Chemical	21.94	21.06	
	Organic	24.17		
	Without	17.04		
Double	Chemical	26.39	26.29	
	Organic	29.83		
	Without	22.66		
No covering	Chemical	17.18	16.20	
	Organic	17.07		
	Without	14.34		

Table (3) shows the effect of tillage depth, soil mulching systems and fertilizer type on the soil thermal conductivity (w/m.k)

Depth tillage (Cm)	**Soil mulching Systems**	**Interaction Triple**			**Interaction the depth tillage and soil mulching Systems**
		Fertilizer			
		Chemical	Organic	Without	
15	Single	0.641	0.663	0.589	0.631
	Double	0.837	0.761	0.795	0.798
	no mulch	0.635	0.650	0.600	0.629
25	Single	0.793	0.792	0.826	0.804
	Double	0.812	0.810	0.911	0.844
	no mulch	0.697	0.627	0.685	0.670
45	Single	0.838	0.681	0.852	0.791
	Double	0.785	0.789	0.902	0.826
	no mulch	0.810	0.676	0.745	0.744
Average of fertilizer		0.761	0.717	0.767	LSD $_{0.05}$

Depth tillage (cm)	**Fertilizers**	**Interaction depth tillage &fertilizer**	**Average the depth tillage**	Depth tillage =0.046 Soil mulch system =0.043 Fertilizer= N.S(0.053) Depth tillage X soil mulch system =0.031 Depth tillage X Fertilizer =0.051 Soil mulch system X Fertilizer =0.044 Depth tillage X soil mulch system X Fertilizer = 0.028
15	Chemical	0.705	0.686	
	Organic	0.692		
	Without	0.661		
25	Chemical	0.768	0.773	
	Organic	0.743		
	Without	0.808		
45	Chemical	0.834	0.787	
	Organic	0.716		
	Without	0.834		

soil mulching systems	**Fertilizer**	**Interaction soil mulching systems and fertilizer**	**Average the soil mulching Systems**
Single	Chemical	0.757	0.741
	Organic	0.712	
	Without	0.755	
Double	Chemical	0.811	0.822
	Organic	0.782	
	Without	0.677	
No mulch	Chemical	0.714	0.681
	Organic	0.651	
	Without	0.677	

Table (4) shows the effect of tillage's depths, soil mulching systems and fertilizer type on the soil volumetric heat capacity (J /m^3. K)

Depth tillage (cm)	Soil mulching system	Interaction Triple – Fertilizer: Chemical	Organic	without	Interaction the depth tillage and Soil mulching system
15	Single	5.75 X 10^5	6.54 X 10^5	4.87X 10^5	5.72 X 10^5
	Double	1.05 X 10^6	9.31 X 10^5	9.06X 10^5	9.63 X 10^5
	no mulching	1.39 X 10^5	2.61 X 10^4	1.72 X 10^5	1.12 X 10^5
25	Single	8.34 X 10^5	8.76 X 10^5	8.72 X 10^5	8.61 X 10^5
	Double	9.52 X 10^5	9.98 X 10^5	1.09 X 10^6	1.01 X 10^6
	no mulching	6.37 X 10^5	9.98 X 10^5	5.91 X 10^5	5.90 X 10^5
45	Single	6.17 X 10^5	9.45 X 10^5	8.09 X 10^5	7.91 X 10^5
	Double	8.81 X 10^5	9.14 X 10^5	9.98 X 10^5	9.31 X 10^5
	no mulching	6.96 X 10^5	5.08 X 10^5	5.96 X 10^5	6.00 X 10^5
Average of fertilizer		7.42 X 10^5	6.74 X 10^5	7.26 X 10^5	

Depth tillage (cm)	Fertilizers	Interaction depth tillage &fertilizer	Average the depth tillage
15	Chemical	5.89 X 10^5	5.49 X 10^5
	Organic	5.37 X 10^5	
	Without	5.22 X 10^5	
25	Chemical	8.08 X 10^5	8.22 X 10^5
	Organic	8.05 X 10^5	
	Without	8.54 X 10^5	
45	Chemical	8.41 X 10^5	7.74 X 10^5
	Organic	6.79 X 10^5	
	Without	8.01 X 10^5	

LSD 0.05
Depth tillage =1.47*10^5
Soil mulch system =9.903*10^4
Fertilizer= N.S(1.627*10^5)
Depth tillage* Soil mulch system =4.95*10^4
Depth tillage*Fertilizer =1.70*10^5
Soil mulch system *Fertilizer =1.13*10^5

				Depth tillage* Soil mulch system *Fertilizer = $5.63*10^4$
Soil mulching system	**Fertilizer**	**Interaction Soil mulching system and fertilizer**	**Average the Soil mulching system**	
Single	Chemical	7.86×10^5	7.417×10^5	
	Organic	7.16×10^5		
	Without	7.23×10^5		
Double	Chemical	9.61×10^5	9.703×10^5	
	Organic	9.47×10^5		
	Without	1.00×10^6		
No mulching	Chemical	4.91×10^5	4.345×10^5	
	Organic	3.58×10^5		
	Without	4.53×10^5		

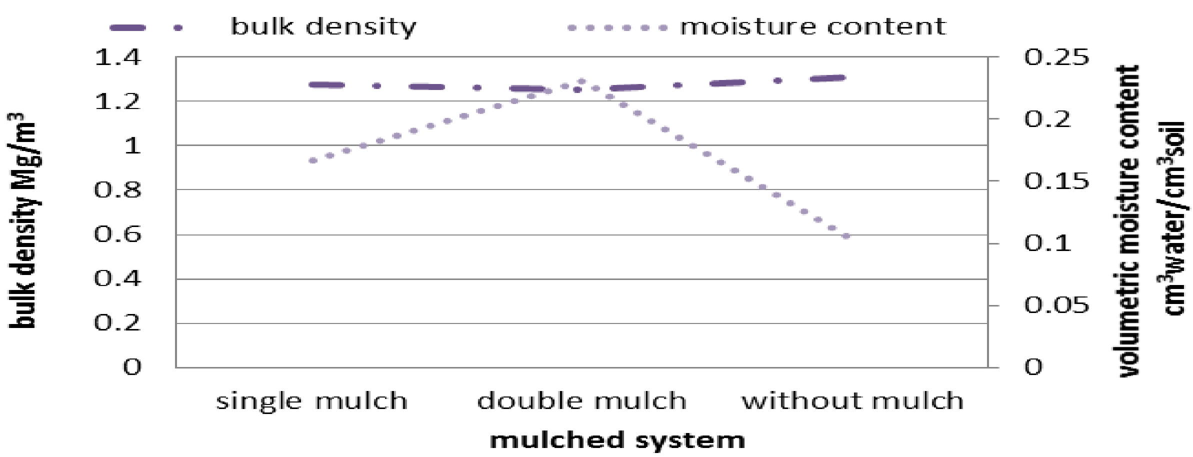

Fig.1. shows the effect of the mulched system on bulk density and volumetric moisture content

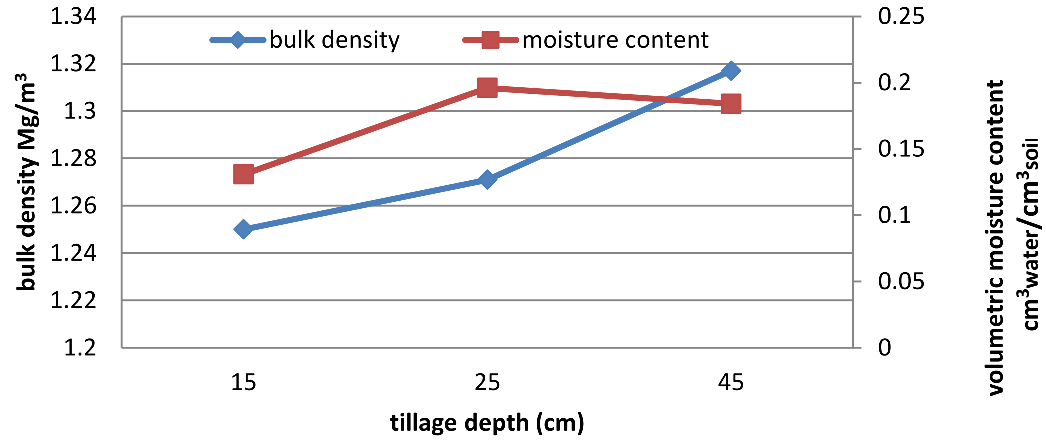

Fig.2. shows the effect of tillage depth on bulk density and volumetric moisture content

CONCLUSIONS & RECOMMENDATIONS

Conclusions

The results obtained from the experiment lead to the following conclusions:

1. The tillage depth has significant effect upon soil thermal properties, when the tillage depth increases both the thermal conductivity and soil bulk density increase, and the lower thermal flux obtained at tillage depth 45 cm. The highest soil volumetric heat capacity (8.22 X 10^5 J/m^3. k.) obtained at tillage depth 25 cm.
2. The soil double mulch system obtained the highest values of soil thermal flux 26.29 w/m^2, volumetric water content 0.231 cm^3/cm^3, soil thermal conductivity 0.822 w/m.k, and volumetric heat capacity 9.703 X 10^5 J/m^3. k
3. There is no significant effect of type of fertilizer upon the soil thermal properties.
4. Interaction between tillage depth 25 cm and soil double mulched system yielded the highest values of soil volumetric heat capacity and soil thermal conductivity 1.01 X 10^6 J/m^3. k, 0.844 w/m.k) respectively, while the interaction between tillage depth 15 cm and soil double mulch system yielded the highest soil thermal flux 44.16 w/m^2.The interaction tillage depth 15 cm with organic fertilizer obtained the highest thermal flux 38.84 w/m^2
5. Triple interaction between tillage depth 25 cm, soil double mulch system and organic fertilizer obtained the highest soil thermal conductivity and soil volumetric heat capacity (0.911 w/m.k, 1.09 X 10^6 J/m^3. k) respectively.

Recommendations

1. The soil double mulch system is preferable to be used in mulch system because it obtained a high soil thermal flux, soil thermal conductivity and soil volumetric heat capacity.
2. The effect of tillage system and soil mulch system on the soil thermal properties must be studied in the future at the studied location
3. The soil thermal losses of the tillage depth are an interesting subject for studying.

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تاثير عمق الحراثه ونظم تغطيه التربه والتسميد على بعض الصفات الحراريه لتربه غرينيه طينيه

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الخلاصه

اجريت التجربه لدراسه تاثير ثلاثه عوامل:العامل الاول تمثل بعمق الحراثه بثلاثه مستويات (15،25،45 سم) و العامل الثاني تمثل بثلاثه مستويات من تظم التغطيه(مفرد،مزدوج،بدون تغطيه) ،العامل الثالث نوع السماد المستخدم بثلاث انواع (كيمياوي ،عضوي ،بدون سماد) على بعض الصفات الحراريه لتربه غرينيه طينيه (التدفق الحراري w/m2، الموصليه الحراريه w/m.k، السعه الحراريه الحجميه $J/m^3.K$) ،اظهرت النتائج وجود فروق معنويه عند تغير عمق الحراثه على الصفات الحراريه التربه المدروسه حيث لوحظ ان زياده عمق الحراثه ادى الى انخفاض التدفق الحراري لتربه في حين تزداد الموصليه الحراريه لتربه ،حصل عمق الحراثه 25سم على اعلى سعه حراريه حجميه 8.22×10^5 . وتزداد كثافه التربه الظاهريه بزياده عمق الحراثه ،كذلك لوحظ عدم وجود فروق معنويه لنظام التسميد على الصفات الحراريه ،بينما نظم تغطيه التربه كانت لها تاثير معنوي ،اذ سجل نظام تغطيه مزدوج على اعلى تدفق حراري $26.29\ w/m^2$. واعلى موصليه حراريه w/m.k 0.822 واعلى سعه حراريه حجميه $9.703 \times 10^5\ J/m^3.K$ واعلى محتوى رطوبي حجمي $0.231\ cm^3/cm^3$