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THE INFLUENCE OF SURFACE CONDITIONS ON SOIL TEMPERATURE AND MOISTURE CONTENT

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ABSTRACT

Field experiment was conducted at the east of Nile River in El-Menia Government to investigate the effect of soil surface condition (seed-bed preparation and mulching materials) on soil temperature and moisture content. The relation between soil temperature and air temperature was also to estimated. Treatments of seedbed preparation included ridges surface and flat surfaces. The mulching treatments materials included flat surface mulched with cucumbers residues, flat surface mulched with clear plastic sheets and flat surface mulched with black plastic sheets.

The results showed that maximum soil temperature values in ridge treatments, at any given depth were higher than that observed in a flat plot without mulching. On the other hand, the minimum soil temperature in ridges was lower than that observed in flat plot ones. Concerning the mulching materials effect, the black plastic sheets gave the highest values of maximum and minimum soil temperature followed by clear plastic sheets and cucumbers straw mulching. Theses differences decreased with depth. The data also showed that soil temperature is mainly a function of surrounded climatological conditions. Whereas, there are a positive and significant correlations between soil temperature and air temperature especially at surface soil depths.
Keywords: Thermal behavior, mulching, ridge tillage

INTRODUCTION

Soil moisture and soil temperature are the most important transient physical property of soil that affected crop growth. Several factors influence the variability of soil temperature in the field. Shumway *et al.* (1989) stated that tillage affects both the surface micro-topography and the subsurface soil thermal properties. Changes in surface micro-relief can greatly influence the local radiation characteristics, and hence the heat balance, because of changes in surface orientation and surface slop. Benjamin *et al.* (1990) reported that local soil orientation may or may not be toward the sun. Katual and Parlange (1993) explained that crop residues usually have reflective and conductive properties that differ from mineral soil, with concurrent changes in the surface net-radiation and soil heat flux density. Several researchers have shown that crop residue and others surface mulches modify mineral soil temperature (Bristow and Abrecht, 1989). Soil mulching with transparent polyethylene is widely used to increased soil temperature (Luis *et al.*, 2008), and many others have shown that soil mulching increases yields, promotes earlier maturing of certain vegetables and controls weeds. The finding of Mahrer (1979) and Mahrer *et al.* (1984), who determined soil temperature regime beneath different kinds of plastic sheets under a variety of climatic condition, guide current mulching methods. Knowledge of mulch changes, occurring during prolonged field usage, would permit better utilization of the method.

Unger (1988) found that the relationship between soil surface and air temperature were highly significant under residue management practices. Also, Ghali and Nakhlla (1996) found that moisture content of loamy sand soil decreased with decreasing of soil cover, also soil cover by plastic sheets generally resulted in increasing maximum soil temperature for all layers more than maximum air temperature. Increasing percent soil cover resulted in increasing heat energy for both stored water and soil mineral fraction.

Radke *et al.* (1993) stated that ridge tillage is a management strategy for improving the radiation climate and thermal and water regime in temperature regions. They also found that the soil dryness stored from the beak of ridges and moved downwards, so soil temperature increased rapidly where the soil become driest and evaporation terminate. Sharratt *et al.* (1996) found that ridged seedbeds absorbed more radiation energy than conventional level seedbeds. Furthermore, radiation absorption differed by as 50 % between opposing aspects of ridges.

It is well known that the soil thermal regime includes heat flux into the soils, the thermal properties of the soil and the heat exchange between soil and air. It is generally expressed in terms of soil temperature (Scott, 2000). Hillel (1998) showed that surface mulch can affect both of the diurnal and seasonal fluctuation of soil temperature. This may draw attention to the fact that the results of using mulches to modify the soil thermal regime are mixed and in most cases, stand upon qualitative sense. Mashour (2001) found that positive and highly significant correlation was obtained between soil temperature and air temperature. This relation is pronounced in the unplanted soil compared to the planted ones.

Hoda *et al.* (2007) showed that shading and mulching soil with plant residues can be advantageous for modifying its thermal regime. Straw mulching could provide a physical barrier between the soil and atmosphere and consequently improve soil moisture retention and heat conditions of the soil surface. Quanqi, *et al.* (2008) found that straw mulching enhanced the eddy thermal diffusivity and sensible heat flux, but decreased the latent heat flux. They also found that straw mulching increased the soil temperature at 5 cm depth from January to February, but decreased the soil temperature before January and after February.

The objective of this work is to investigate the effect of soil surface condition (seed-bed preparation methods and mulching materials) on soil temperature and moisture content. Also, to estimate the relation between soil temperature and air temperature under these conditions.

MATERIALS AND METHODS

Field experiment was plowed to a depth of about 20 cm and leveled before the experimental plots were prepared. Five plots, each measuring 2 x 3 m, were prepared with the following: flat plowing, ridge plowing (a ridge was about 25 cm height with a 50 cm base width), flat surface mulched with cucumbers residues (3 ton/f^{-1}) flat surface mulched with 2 x 3 m clear plastic sheets and flat surface mulched with 2 x 3 m black plastic sheets. The basic soil physical properties was determined after Klute (1986) and presented in Table 1. Soil temperature values were in the five soil management treatments in 20 observations at 1, 5, 10 and 20 cm depth. Soil temperatures were measured by thermocouple near the center of the flat seed-bed plots and at the top of the central ridge in the ridge plots. Simultaneously, air temperature was measured with a thermocouple; mounted on a plexiglass rod and shaded from direct solar radiation, 1 m. above the soil surface. In each plot, the soil moisture distribution with depth was determined by gravimetric sampling.

Table 1: Some soil physical properties of the investigated soils.

Soil properties	The value
Particle size distribution	
Coarse sand %	43.5
Fine sand %	30.5
Silt %	19.0
Clay %	7.0
Textural class	Loamy sand
Bulk density Mg m^{-3}	1.39
Particle density Mg m^{-3}	2.48
Total porosity %	44.0
$CaCO_3$ %	1.2
Organic matter %	0.6
Saturation percentage %	44.0
Hydraulic conductivity cm h^{-1}	4.32
Specific heat cal $g^{-1}c^{-1}$	0.191
Volumetric heat capacity cal $g^{-1}c^{-1}$	0.26

RESULTS AND DISCUSSION

The effect of soil surface condition on soil temperature and moisture content are shown in Table 2. Concerning the shape of soil surface, the results showed that the minimum soil temperature of the soil at any given depths were the lowest in the ridged treatments and increased in flat surface. On the other hands, the maximum soil temperature of ridge was higher than the flat surface by 4.6, 2.2, 1.9 and 1.3 at 1, 5, 10 and 20 cm depth, respectively. This may be attributed to increased soil exposure than with a flat surface; this exposure led to relatively more radiant energy absorption and loss during the day and night, respectively. Also, the excessive water evaporation from it, whereas the percentage of moisture content decreased in ridged surface more than flat ones by 26.1 % on the surface depths. These results are in agreement with those of Sharratt *et al.* (1992); who found that ridged seedbeds absorbed more radiant energy than conventional level seedbeds. Furthermore, radiation absorption differed by as much as 50 % between opposing aspects of ridges. Also, Radke *et al.* (1993) stated that ridge tillage is a management strategy for improving the radiation climate and soil thermal and water regime in temperature regions. We can conclude that, the mean maximum soil temperature, irrespective of the surface condition decreased, and the mean minimum was increased with depth, Table 2.

Table 2. The effect of seedbed preparation on soil temperature and soil moisture content distribution.

Treatments		Soil temperature °c *			T - T_f **	Moisture content %
		maximum	Minimum	Mean		
	Ridged without mulching					
Soil depth cm	1	45.9	24.8	35.35	1.65	4.6
	5	36.7	25.9	31.30	0.60	12.9
	10	33.6	27.3	30.45	0.50	12.0
	20	31.4	28.5	29.95	0.35	9.0
	Flat without mulching					
Soil depth cm	1	41.3	26.1	33.70	-	5.8
	5	34.5	26.9	30.70	-	13.6
	10	31.7	28.2	29.95	-	12.7
	20	30.1	29.0	29.60	-	10.8
Air temperature °c at 1- m height						
		35.5	18.7	27.1		

*** - Each value is an average of 20 observations (from 12 Augustus to 2 September 2009)**

**** -T is the mean temperature in straw-mulched, ridged, or plastic-mulched plots at a given depth. T_f is the mean temperature in a flat plot at a given depth.**

Regarding the effect of mulching materials on soil temperature and moisture content, the data of Table 3 reveal that the maximum soil temperature increased in the following order :- flat without mulching > flat mulched with black plastic sheet > flat mulched with clear plastic sheet > flat mulched with cucumber residual treatments. This may be due to the effect of mulching materials on providing the physical barrier between the soil and air atmosphere, consequently improved soil moisture retention and heat conditions of the soil surface, (Al-Kayssi, 2009). We can say that mean soil temperature in flat surface mulched with black sheet at all depths was the highest than the other treatments. This may be to the greenhouse effect produced under the plastic sheet and to the impeded ventilation of the soil surface. The data also revealed that soil under the plastic remained at higher water content due to the reduced evaporation caused by the sheet. This enhanced the soil thermal proportion of the energy absorbed at the surface was conducted to deeper layers. In this respect, Lamont (2005) showed that plastic mulch color has a direct effect on plant growth because it affects the absorption, reflectance and transmittance of both short wave and long wave radiation, and modifying soil temperature. The moisture content take the opposite trend of soil temperature values, whereas the treatments which gave the highest value of soil temperature gave the low moisture content (Table 2 and 3).

The relationship between soil temperature and air temperature measured 1.0 m. above the soil surface showed that soil temperature is mainly a function of surrounded climatological conditions. Whereas, there are positive and significant correlations between soil temperature and air temperature especially at surface soil depths. The correlation coefficient varied between 0.93 and 0.75. These data are in agreement with those of Unger (1988).

Table 3: The effect of mulching materials on soil temperature and soil moisture content distribution.

Treatments		Soil temperature °c *			T - T_f **	Water content %
		Maximum	Minimum	Mean		
	Flat without mulching					
Soil depth cm	1	41.3	26.1	33.70	-	5.8
	5	34.5	26.9	30.70	-	13.6
	10	31.7	28.2	29.95	-	12.7
	20	30.1	29.0	29.55	-	10.8
	Flat mulched with cucumber straw					
Soil depth cm	1	36.2	27.3	31.75	- 1.95	6.0
	5	32.8	28.5	30.65	- 0.05	14.5
	10	30.3	28.9	29.60	- 0.35	13.7
	20	28.9	29.3	29.10	- 0.45	10.3
	Flat with clear plastic sheets					
Soil depth cm	1	38.3	28.0	33.15	- 0.55	6.3
	5	33.4	28.2	30.80	0.10	14.0
	10	30.9	28.9	29.90	-0.05	13.5
	20	30.0	29.4	29.70	0.15	10.4
	Flat with black plastic sheets					
Soil depth cm	1	40.5	28.1	34.30	0.6	6.1
	5	33.9	28.4	31.15	0.45	14.2
	10	31.2	28.7	29.95	-0.00	14.0
	20	29.8	29.2	29.50	-0.05	10.5
Air temperature °c at 1- m height						
		35.5	18.7	27.1		

*** - Each value is an average of 20 observations (from 12 Augustus to 2 September 2009)**

**** - T is the mean temperature in straw-mulched, ridged, or plastic-mulched plots at a given depth. T_f is the mean temperature in a flat plot at a given depth.**

The effect of the surface conditions on diurnal soil temperature variations at 1 cm depth are shown in Fig 1. In the morning before sunrise, the minimum temperature of the soil was the lowest in the ridges and it increased in the other treatments.

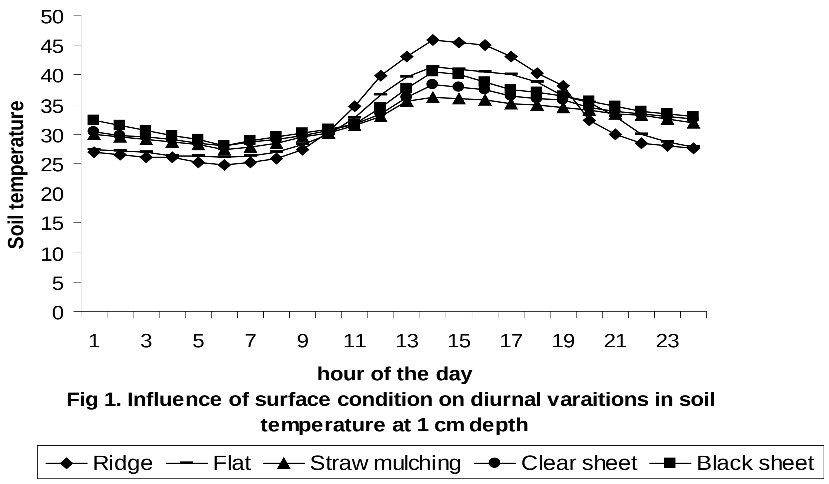

Fig 1. Influence of surface condition on diurnal varaitions in soil temperature at 1 cm depth

The highest was observed in the soil mulched with the plastic flat plot. After sunrise, the temperature in ridges at 1.0 cm started rising and reached the maximum values (45.9˚C) at 2 PM and the lowest values at this time was reached at the cucumber mulch (36.2 ˚C).

Generally, it could be concluded that, the thermal behavior of the soil could be changed duo to the soil surface conditions (seedbed preparation and mulching)

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تأثير ظروف السطح على حرارة التربة والمحتوى الرطوبى

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اجريت دراسة حقلية فى شرق نهر النيل بمحافظة المنيا لدراسة تأثير ظروف سطح التربة (طرق اعداد مهد البذور و تغطية السطح) على حرارة التربة والمحتوى الرطوبى لها . أيضا تقييم العلاقة بين حرارة التربة وحرارة الهواء تحت نفس هذه الظروف . وقد شملت المعاملات مايلى 1) تخطيط سطح التربة بدون تغطية 2) سطح التربة مستوى بدون تغطية 3) سطح التربة مستوى ومغطي ببقايا نباتات الخيار 4) سطح التربة مستوى ومغطي ببلاستيك شفاف 5) سطح التربة مستوى ومغطي ببلاستيك أسود

وقد أوضحت النتائج ما يلى :-

ارتفاع قيم درجات الحرارة القصوى (2ظهرا) فى معاملة تخطيط التربة تحت أى عمق مقارنة بمعاملة الأراضى المستوية. وعل صعيد أخر لوحظ انخفاض درجات الحرارة الدنيا (5 صباحا) تحت معاملة تخطيط التربة تحت أى عمق مقارنة بمعاملة الأراضى المستوية. وفيما يتعلق بتأثير مواد تغطية سطح التربة أعطت معاملة التغطية بالبلاستيك الأسود أعلى متوسط لقيم درجات الحرارة سواء القصوى أو الدنيا يليها التغطية بالبلاستيك الشفاف ثم التغطية ببقايا نباتات الخيار، وقد أوضحت النتائج أن حرارة التربة تعتبر دالة للظروف المناخية حيث لوحظ وجودارتباط موجب ومعنوي بين درجات حرارة التربة وحرارة الهواء فى جميع المعاملات وخصوصا فى الأعماق السطحية.

قام بتحكيم البحث

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