AIR TEMPERATURE VARIATIONS AND THEIR REFLECTIONS ON SOIL HEAT AND SOIL TEMPERATURE PREDICTION AT DIFFERENT DEPTHS 0F ISMAILIA SOILS

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ABSTRACT:

The present study was conducted for three successive years in a sandy soil of Ismailia Agricultural Research Station (IARS). The abscissas of IARS are Latitude 30˚ 35′30″ N and longitude 32˚ 14′50″ E and its elevation 10.2 meter over the sea level. Three thermal sensors were placed in the soil at depths of 0.05m, 0.10m, and 0.30m from the soil surface, to study the reflection effects of variations in the temperature of air on the variation of temperatures of the soil in the studied depths.

The readings of air temperature (Air-T) were recorded with rate of one reading/hour, While soil temperature (Soil-T), at any soil depth was recorded with average of one reading/hour (*i.e.*24 readings/day). This means that, at any year, the recorded readings of (Air-T) or (soil-T) were 24 x365=8760 readings.

The monthly averages of soil temperatures of the three depths throughout the three years were 13.83, 14.41, 16.67, 20.45, 25.10, 29.37, 30.29, 30.30, 28.95, 24.40, 19.86 and 15.41°C for month of Jan., Feb., March, April, May, Jun., July, Aug., Sept., Oct., Nov., and Dec., respectively. The corresponding air temperatures were 13.69, 13.61, 16.07, 19.41, 23.22, 25.88, 27.78, 27.87, 26.01, 22.85, 18.31, and 14.02°C for the same previous months. The minimum air and soil temperatures were recorded at Dec., Jan. and Feb. months, while the maximum were noticed at July and Aug. months.

An obvious increase in T-soil of different depths was obtained in the second and third year. Temperatures of 0.05m, 0.10m and 0.30m, recorded increases of 3.07°C, 2.69°C and 2.83°C at the third year for the mentioned depths, respectively in respect to the first year. Whereas, the increments in T-air in the second and third year compare with those of the first year were 1.17 and 0.37°C, respectively.

The statistical correlation coefficient and regression equations between air temperature and soil temperature of the three depths were calculated to study the relationship between air and soil temperatures. The threshold value (a) of the regression equation was higher in summer and lower in winter months of the three depths. This was due to the higher temperature at summer. Moreover, air temperature showed more rapid change than soil temperature.

The total numbers of temperature readings were 2232 for months, Jan.,March, May, July, Aug., Oct., and Dec. while the regression rejected unusual numbers were 94, 123, 98, 56, 64, 199 and 146, respectively. It was 2016 for Feb. with rejected unusual number of 82. Also, they were

2160 for months April, Jun., Sept. and Nov. with rejected unusual numbers of 143, 96, 111, and 103, respectively.

Generally, the average fit numbers of temperature which used for calculating the regression were ranged from 93 to 98% from the total number of temperatures, which interpreted the highly significant coefficient of these regression equations and reflect the effective effects of air temperature on soil temperatures. Thus, soil temperature can be predicted, to some extent, using the air temperature and these regression equations. Also, the reported regression equations can be used for estimating the unrecorded (missing) soil temperatures or another year.

Key words: Air temperature, soil temperature, sandy soil.

INTRODUCTION:

The thermal regime of the soils is a combined product of energy and mass exchange between the atmosphere and the land surface. Soil temperature is a sensitive climate indicator and integrator and plays an important role in all the physical, biological and microbiological processes occurring in the soil. The need to understand the thermal conditions of soils and their relation to the environmental conditions have long been a preoccupation of scientists. **(Sharratt, 1992**).

There are four forms of heat transfer: conduction, where heat is transferred through solid material from molecule to molecule; sensible heat flux, where warmer air is transferred from one location to another; radiation, where heat is transferred as electromagnetic energy without the need for a medium; and latent heat flux, where sensible heat is converted to latent heat when water vaporizes and converts back to sensible heat when the water molecules condense or deposit onto a surface.

Soil temperature plays an important role in land surface processes, and it is critical in energy balance applications such as land surface modeling, numerical weather forecasting, and climate prediction **(Holmes et al., 2008)**. It is especially true for the soil surface. Accurate prediction of soil surface temperature requires a realistic understanding of the soil thermal properties.

Ghuman and lal (1982) used linear regression analysis to estimate soil temperature using daily mean air temperature as the independent variable. In estimating the linear regression relationship between N measurements of a dependent variable Y and an independent variable X.

The transfer function was then used in conjunction with the results of the spectral analysis to yield a relation for estimating the soil temperature at the 10-cm depth using the air temperatures as input. The residual variance of this estimation was 58.5% less than the residual variance using a linear regression equation **(Persaud and Chang 1983).**

The air temperature changes rapidly as compared to soil temperature, so that coarse correlations exist during these seasons**, (Balisky and Burton, 1993).**

Soil temperature and air temperature are interrelated and a warming world is expected to lead to warmer soils. Soil temperature changes have the most noticeable impacts in the permafrost regions at high latitudes, **(Kane et al., 1991).**

Soil and air temperature are highly correlated in the Mojave Desert region. Both of the soil and air temperature were found to be highly correlated with elevation and their spatiotemporal variations are highly positively correlated **(Bai 2009)**. The soil temperature in the studied region measured of 50-cm deep, increased at an average rate of 0.79°C per decade**, (Bai, et al 2014).**

The change in air temperature can translates into a change of soil temperature through three heat transfer mechanisms: (1) sensible heat flux; (2) latent heat flux (cooling the surface by evaporation); and (3) infrared heat flux (cooling by emission and warming by absorption), **(Seinfeld, 2008)**. The latent heat flux tends to be the dominant term in soil temperature calculations. In warm, wet areas, evaporative heat transfer is so effective that the surface temperature remains close to the overlying air temperature, and in-surface temperature follows that of the troposphere just above the surface. By contrast, the daytime surface of the desert soils tends to be much warmer than the overlying air, because in the absence of moisture, the relatively inefficient sensible and radioactive heat transfer requires a relatively large temperature difference to generate the necessary heat flux.

Mean annual air temperature increased slightly until the 1960s, while mean annual soil temperature increased steadily throughout the entire period. This leads to the conclusion that changes in air temperature alone cannot explain the changes in soil temperatures at this station. Soil temperature actually decreased during summer months by up to 4°C, while air temperature increased slightly. This cooling in the soil may be explained by changes in rainfall and hence soil moisture during summer due to the effect of a soil moisture feedback mechanism. While air temperature increased about 4°C to 6°C during winter, soil temperature increased by up to 9°C**, (Zhang, et al 2001).**

Annual average air and soil temperatures were projected to increase, but complex dynamics were projected on a seasonal scale**, (Jungqvist, et al 2014)**
The objective of this investigation is to study the variation in air temperature and its relation with soil temperature, as well as the role of air temperature in prediction the monthly mean soil temperatures.

MATERIALS AND METHODS:

The present study was conducted for three successive years in a sandy soil of Ismailia Agricultural Research Station (IARS), Agric. Res. Central (ARC). The abscissas of IARS are Latitude 30˚ 35′30″ N and longitude 32˚ 14′ 50″ E and its elevation 10.2 meter over the sea level. Soil properties of IARS were reported by **El-Raies et al (2013)**. Three thermal sensors were placed in the soil, at depths of 0.05m, 0.10m, and 0.30m from the soil surface, to study the reflection effects of variations in air temperature on the variation of temperatures of the soil depths under study. The readings of air temperature (Air-T) were recorded with rate of one reading every one hour, While soil temperature (Soil-T), at any soil depth, were recorded with average of one reading/hour (*i.e.*24 readings/day). This means that, at any year of study the recorded readings of (Air-T) or (soil-T) were 24 x365=8760 readings.

The relation between the monthly variations and annual variations for both air temperatures and soil temperature at the studied depths will be statistically analyzed as well as the statistical correlation coefficients and regression equations have been managed between air temperature and temperature of soil depths using Minitab program **(Barbara and Brian, 1994)**.

RESULTS AND DISCUSSION :

The near-surface soil temperature regime is an integrator of all natural processes and their interactions at the ground surface and within the soil. Essentially, all factors affecting the energy and water exchange between the atmosphere and the land surface and within the soil system have an influence on the ground thermal regime.

Data in Table (1) presented the values of the average monthly temperatures (T), ^{o}C for air and soil depths for the three successive years of study.

Variations in the average of temperatures (T) for air and different soil depths:

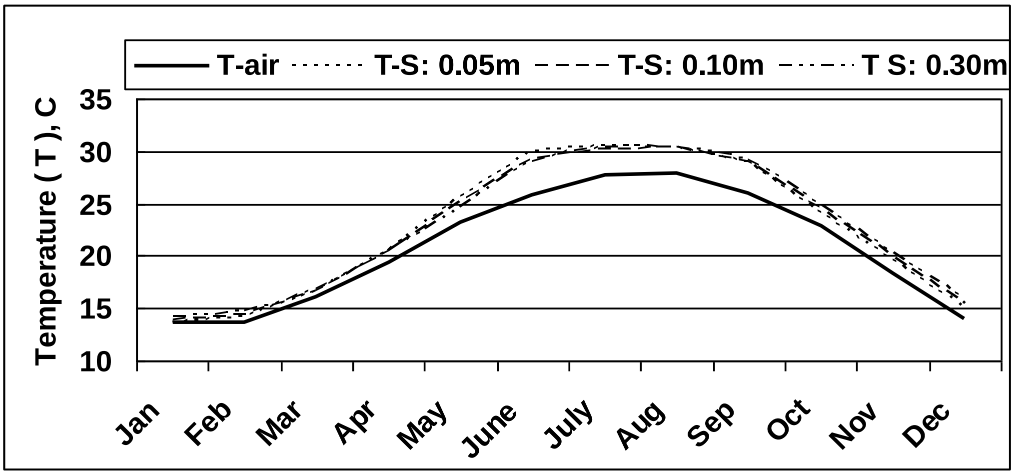
Monthly variations:

Data in Fig (1) represented the monthly variations in the average of temperatures (T), ^{o}C for air and soil depths (expresses as the mean of the three years of study).

Table (1) : The average of monthly temperatures (T), °C for air and soil depths of the three successive years of study.

Month (M)	T.air (°C)	T.soil depth(°C)		
		0.05m	0.10m	0.30m
First year				
Jan.	13.61	13.23	13.39	13.69
Feb.	12.84	13.02	13.13	13.31
March	15.72	15.75	15.82	15.79
April	18.19	18.79	18.77	19.01
May	23.24	24.33	24.21	23.92
June	25.51	26.67	26.82	26.96
July	27.67	28.53	28.60	28.72
Aug.	26.56	27.38	27.54	27.29
Sept.	24.95	25.96	27.07	26.44
Oct.	23.60	22.40	22.68	23.06
Nov.	17.60	18.31	18.77	18.93
Dec.	13.08	13.73	14.22	14.43
Second year				
Jan.	14.41	12.84	13.20	13.43
Feb.	14.43	14.41	14.64	14.79
March	15.99	15.62	15.73	15.77
April	21.07	20.80	20.49	20.19
May	23.37	25.27	24.14	23.42
June	26.10	30.95	29.37	28.45
July	28.06	29.74	29.46	29.42
Aug.	29.01	30.82	30.88	30.86
Sept.	27.00	29.38	29.53	29.76
Oct.	23.06	25.23	25.72	26.09
Nov.	19.28	21.62	22.01	22.25
Dec.	14.83	16.59	17.20	17.61
Third year				
Jan.	13.06	14.59	14.78	15.29
Feb.	13.56	15.29	15.33	15.80
March	16.48	18.55	18.39	18.57
April	18.98	22.19	21.89	21.97
May	23.06	27.19	26.84	26.57
June	26.04	32.30	31.68	31.11
July	27.63	33.04	32.50	32.54
Aug.	28.02	32.96	32.33	32.60
Sept.	26.08	31.32	31.04	31.07
Oct.	21.89	24.46	24.78	25.19
Nov.	18.04	18.57	18.88	29.35
Dec.	14.14	14.55	14.89	15.46

NOTES: Average of monthly (T) = (Summation of 24 readings/day throughout the days of month) / (number of days of month).



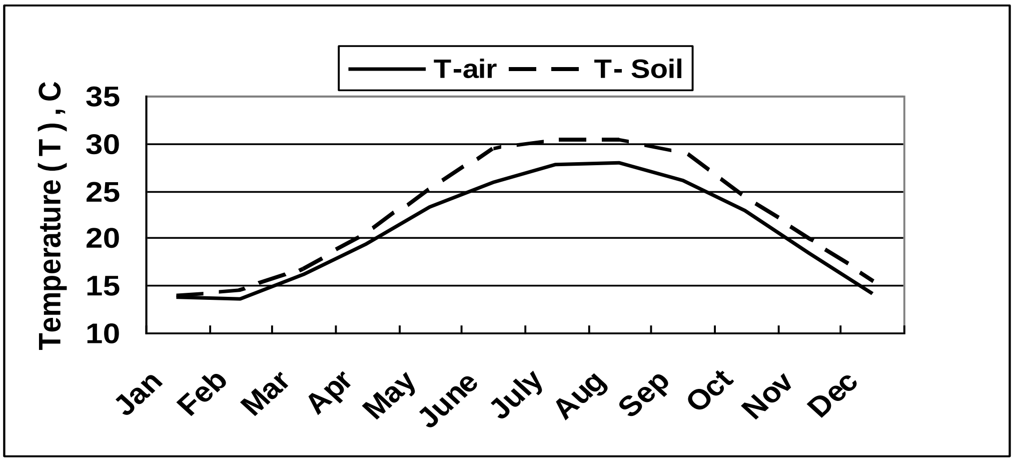


Fig. (1):The monthly variations in the average of temperatures (T), °C (expresses as mean of the three years of study) of "T-of different soil depths", "T-soil" and "T-air".

These data showed that the monthly average temperatures(°C) of the three soil depths (T- soil depths) were 13.83°C, 14.41°C, 16.67°C, 20.45°C, 25.10°C, 29.37°C, 30.29°C, 30.30°C, 28.95°C, 24.40°C, 19.86°C and 15.41°C for month of Jan, Feb, March, April, May, Jun, July, Aug, Sept, Oct, Nov, and Dec. respectively. The corresponding values of air temperature were 13.69°C, 13.61°C, 16.07°C, 19.41°C, 23.22°C, 25.88°C, 27.78°C, 27.87°C, 26.01°C, 22.85°C, 18.31°C, and 14.02°C for the same previous months, respectively.

The maximum monthly average of air and soil temperatures was recorded at the summer months of July and Aug.

In spite of (T-0.3m) showed soft increase than the other two depths in the most months of the year, as illustrated in Fig (1), the three soil depths showed slight differences between their monthly temperatures and these differences were $T \leq 1$°C.

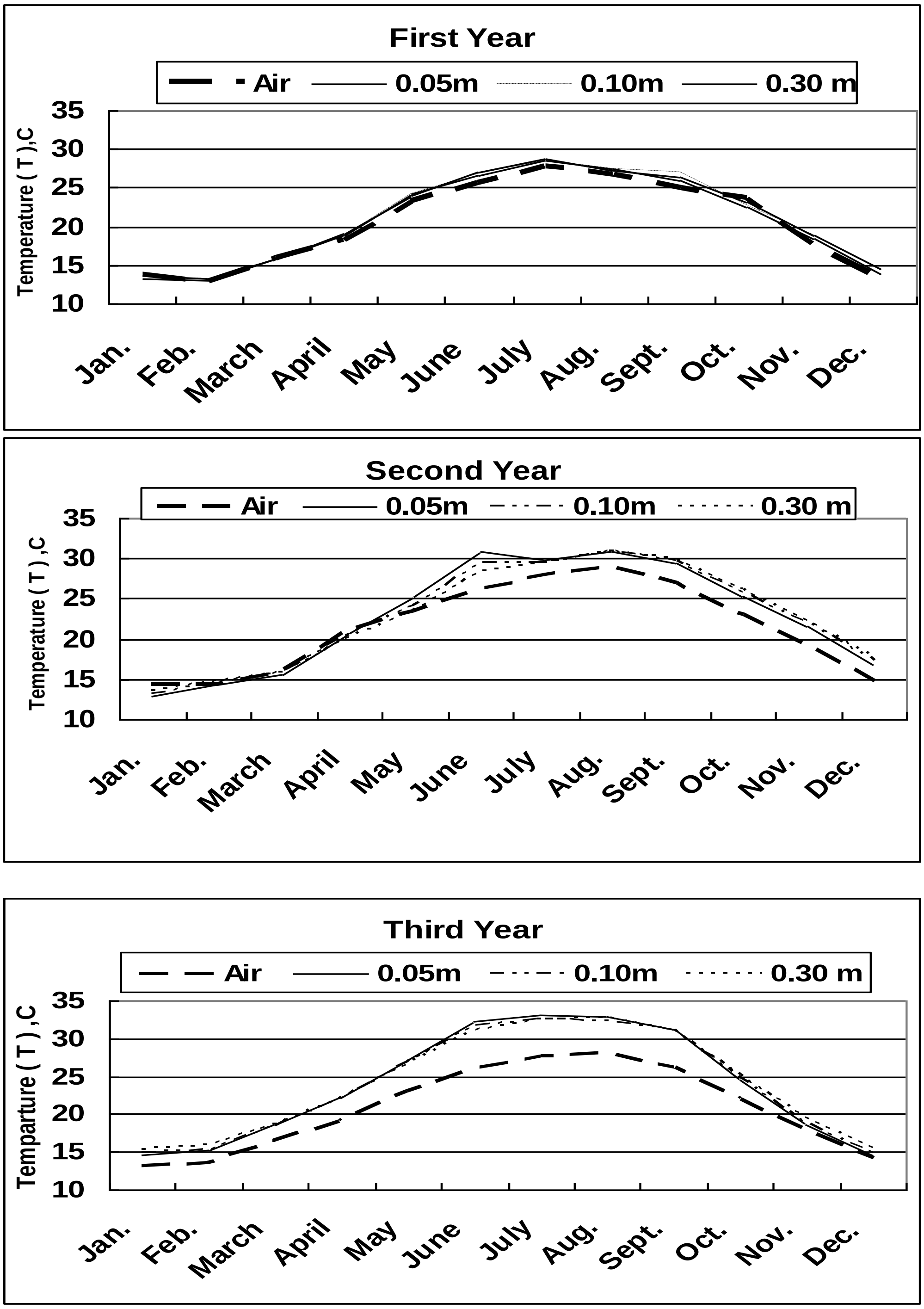


Fig.(2):The monthly variations in the average of temperatures (T), C of "T-of different soil depth" and "T-air" for every year of study individually.

Meanwhile, either the temperature at any studied depth or the mean temperature of all depths, i.e. (T-soil), behaved the similar trend with respect to their relations with (T-air). Generally, their values were higher than the values of air temperatures (T-air) along the months of the year. On the other hand, the differences between (T-soil) and (T-air) were the lowest during the months of Jan, Feb and March and the very nearest lowest difference (0.14°C) was recorded in the winter month of January. While, the highest differences were noticed through the months of June, July and Sept and the highest difference (3.49°C) was reported through the summer month of June.

Data of table (1), illustrated the monthly average temperatures (T) for different soil depths" and "T- air" for every studied year individually. However Fig (2), generally supported the aforementioned discussed trends. As a general trend, temperatures of all depths were higher than the values of air temperatures (T-air) along the months at any of the studied year. Also, it is noticed that the difference between T-soil, of all depths, and T-air was very low at the first year of study and increases gradually in the second and the third years.

The previous trends may be attributed to rapidly and continuously changes in air temperature as compared to the changes of soil temperature, which changes usually in a low way. These results were in agreement with those of **Balisky and Burton, (1993)**.

Annual variations:

Changes in T- soil at various depths and T-air in the studied years (Annual variations) were recorded in Fig (3). The results reveal that the increments in T-soil of different depths with progresses the years of study were more obvious than in T-air. The temperatures of 0.05m, 0.10m and 0.30m, compared with (T) of the first year , recorded increments of 2.09 °C, 1.78°C and 1.71°C at the second year and increments of 3.07°C, 2.69°C and 2.83°C at the third year for the mentioned depths, respectively. As for the increment of air temperatures, it did not show a certain trend and were less than the increments in T- of soil depths. However, the increments in T-air as compared with that of the first year were 1.17°C and 0.37 °C for the second and third year, respectively.

Zhang et al (2001) reported that the changes in the mean annual air temperature and soil temperature at 40 cm depth were about the same magnitude (2.0°C to 2.5°C) over the common period of record, but the patterns of change were substantially different. Mean annual air temperature increased slightly until the 1960s, while mean annual soil temperature increased steadily throughout the entire period.

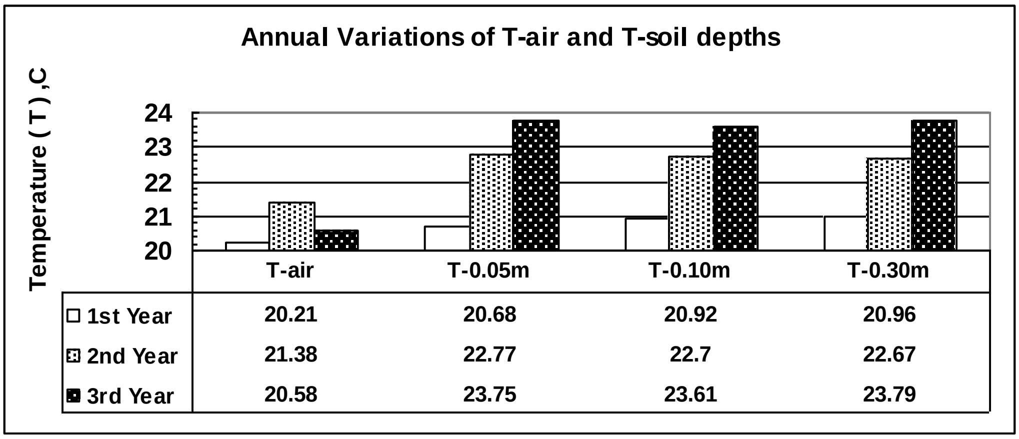


Fig.(3): The annual variations (through the three years of study) in the average temperature (T), of air and different soil depths.

This leads to the conclusion that changes in air temperature alone cannot explain the changes in soil temperatures at this station. Soil temperature actually decreased during summer months by up to 4°C, while air temperature increased slightly.

<u>Variations in the average of maximum temperatures (T-max) and inimum Temperatures (T-min):</u>

<u>Monthly variations:</u>

Maximum temperature (T-max) is considered as the temperature recorded at noon, while Minimum temperature (T-min) is the temperature which recorded at aurora before day light.

Data which figured in Fig (4) showed the monthly (T-max), (T-min) and the difference between those for air and for different soil depths, along the year. As a general trend and at all the months of the year, the differences between T-max and T-min of (T-air) were higher, average ≈ 25.17^{o}C comparison with the corresponding values at different soil depths, which recorded, averages ≈17.12 ^{o}C, ≈13.28 ^{o}C and ≈10.12^{o}C for the three studied depths respectively.

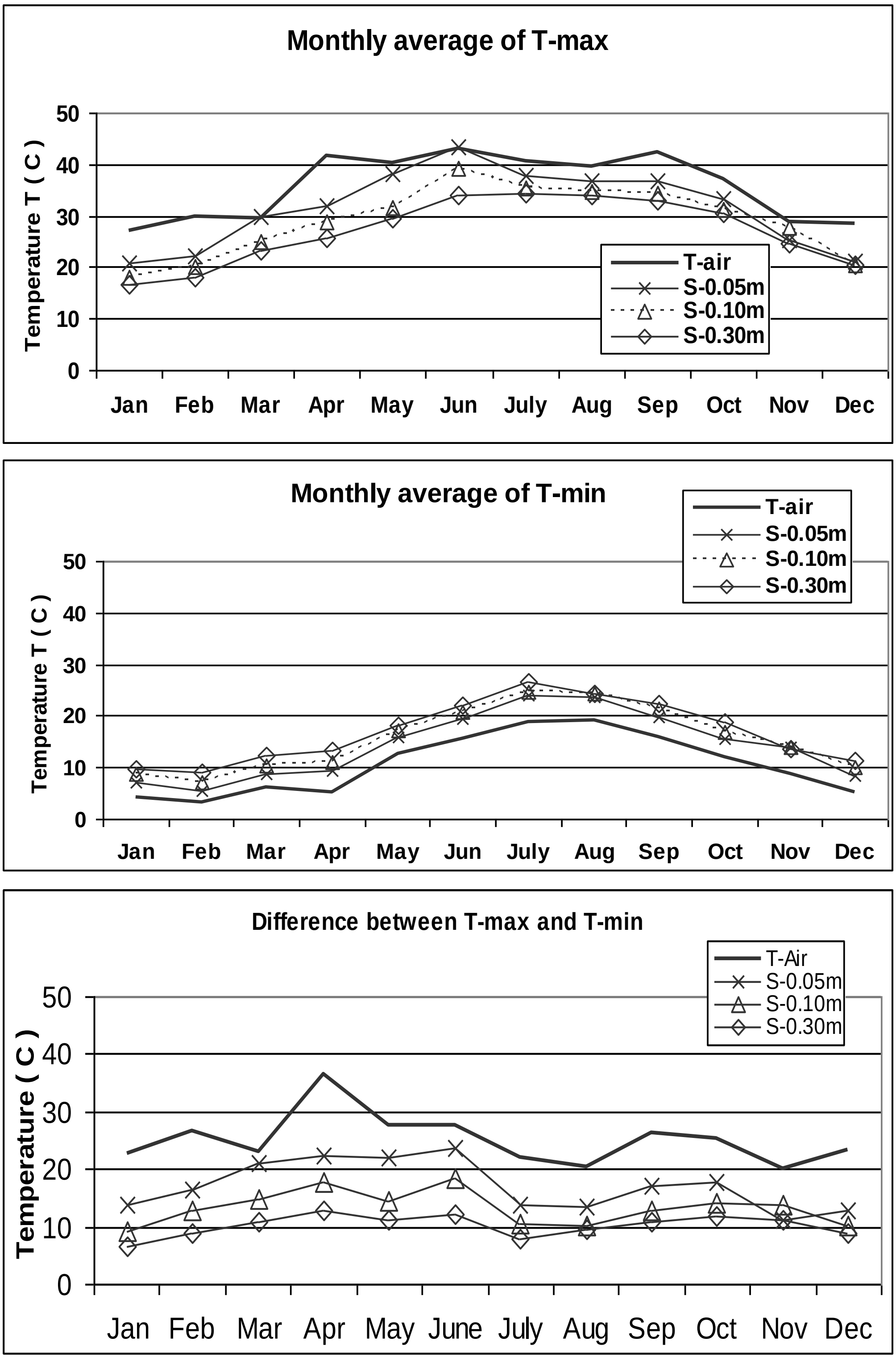


Fig.(4)The monthly variation in the average of max, min and difference temperature of the three years

Also, it is noticed that the T-max of air (average ≈35.76^{o}C) was higher than the T-max of all soil depths. Meanwhile T-max of soil decreased at lower layers than at upper layers, where, the average values were 31.45 ^{o}C, 28.89 ^{o}C and 27.08 ^{o}C at layers of 0.05m, 0.10m and 0.30m, respectively.

A contrary trend was noticed with respect to T-min of air and soil depths. Where, the T-min of air (Avg.≈ 10.58^{o}C) was lower than the T-min of all soil depths. Meanwhile T-min of soil increased at lower layers than at upper layers, where the average values were 14.33 ^{o}C, 15.61 ^{o}C and 16.81 ^{o}C at layers of 0.05m,0.10m and 0.30m , respectively.

Seasonal variations:

Seasonal variations in T-max and T-min (presented in Fig (5)), supported the previous discussion. The data declared that the highest T-max and T-min for air and different soil depths were recorded during summer season and their lowest values were recorded at winter season. While those of spring and autumn seasons were in between.

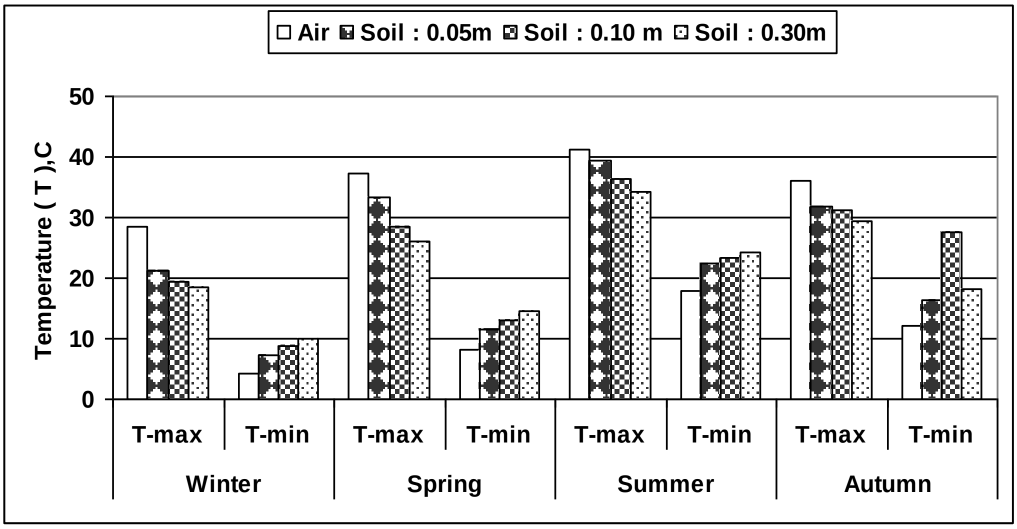


Fig.(5):Seasonal variations in (T-max) and (T-min) °C (expresses as mean of the three years of study) of different soil depths and air.

The mean values of T-max for air were 41.12 ^{o}C, 37.14 ^{o}C, 36.19 ^{o}C and 28.57 oC at summer, spring, autumn and winter, respectively. While, the mean values of T-min for air were 17.73 ^{o}C, 12.20 ^{o}C, 8.05 ^{o}C and 4.34 ^{o}C for the same seasons respectively. However, the mean values of T-max for soil depths were 36.65 ^{o}C, 30.79 ^{o}C, 29.28 ^{o}C and 19.74 ^{o}C at summer, autumn, spring and winter, respectively. On the other hand, the mean values of T-min for soil depths were 23.32 ^{o}C, 20.72 ^{o}C, 12.99 ^{o}C and 8.69 ^{o}C at the same seasons respectively.

Statistical relations between (T-air) and T-soil at different depths:

Statistical relations were submitted on all the data recorded during the three years of study. Statistical relations included correlation coefficient and regression equations to insure the effect of air temperature (T-air) on the temperature of soil at different depths (T-soil depths).

Correlation coefficients

Correlation coefficients between T-air and T-soil depths during the three years of study were shown in Table (2) and declared highly correlations between T-air and T-soil at all the depths of study *i.e.*, 0.05m, 0.10m and 0.30m and along all months during the three years of study.

Table(2): Correlation coefficients between air temperature (T-air) and soil temperature (T-soil) of the three depths during the three years of study.

Month	T-air	T-soil depths			
		0.05 m	0.10 m	0.30m	
Jan	T-air	0.761 0.000	0.603 0.000	0.180 0.000	*Corr.* *P-value*
Feb	T-air	0.823 0.000	0.699 0.000	0.382 0.000	*Corr.* *P-value*
Marc	T-air	0.734 0.000	0.544 0.000	0.234 0.000	*Corr.* *P-value*
April	T-air	0.772 0.000	0.630 0.000	0.371 0.000	*Corr.* *P-value*
May	T-air	0.654 0.000	0.464 0.000	0.184 0.000	*Corr.* *P-value*
Jun	T-air	0.684 0.000	0.381 0.000	0.145 0.000	*Corr.* *P-value*
Jan	T-air	0.761 0.000	0.603 0.000	0.180 0.000	*Corr.* *P-value*
July	T-air	0.636 0.000	0.368 0.000	0.079 0.000	*Corr.* *P-value*
Aug	T-air	0.623 0.000	0.426 0.000	0.188 0.000	*Corr.* *P-value*
Sept	T-air	0.607 0.000	0.357 0.000	0.213 0.000	*Corr.* *P-value*
Oct	T-air	0.567 0.000	0.352 0.000	0.202 0.00	*Corr.* *P-value*
Nov	T-air	0.580 0.000	0.395 0.000	0.248 0.000	*Corr.* *P-value*
Dec	T-air	0.609 0.000	0.385 0.000	0.258 0.000	*Corr.* *P-value*

Regression equations

Fit% of readings of soil temperatures (T-soil) submitted to Regression equations

Soil temperatures (T-soil) at different depths for all months of the three years of study were submitted to the statistical analysis of regression where different results were obtained from month to another as shown in table (3).

Table (3): Total and Fit% of T-soil readings submitted to Regression equations of three depths for all months of three years of study.

Month	Soil depth	Readings of T-soil of three years				
		Total	Unusual soil reading		Soil reading Fit	
			No	%	No	%
Jan	0.05m	2232	96	4.30	2136	95.70
	0.10m	2232	96	4.3	2136	95.70
	0.30m	2232	91	4.08	2141	95.92
	Average	**2232**	**94**	**4.20**	**2138**	**95.77**
Feb	0.05m	2016	68	3.37	1948	96.63
	0.10m	2016	77	3.82	1939	96.18
	0.30m	2016	100	4.96	1916	95.04
	Average	**2016**	**82**	**4.05**	**1934**	**95.95**
March	0.05m	2232	137	6.14	2095	93.86
	0.10m	2232	124	5.56	2108	94.44
	0.30m	2232	109	4.88	2123	95.12
	Average	**2232**	**123**	**5.53**	**2109**	**94.48**
April	0.05m	2160	141	6.53	2019	93.47
	0.10m	2160	158	7.31	2002	92.69
	0.30m	2160	129	5.97	2031	94.03
	Average	**2160**	**143**	**6.60**	**2017**	**93.40**
May	0.05m	2232	96	4.30	2136	95.70
	0.10m	2232	96	4.30	2136	95.7
	0.30m	2232	102	4.57	2130	95.43
	Average	**2232**	**98**	**4.39**	**2134**	**95.61**
Jun	0.05m	2160	103	4.77	2057	95.23
	0.10m	2160	87	4.03	2073	95.97
	0.30m	2160	99	4.58	2061	95.42
	Average	**2160**	**96**	**4.46**	**2064**	**95.54**
July	0.05m	2232	73	3.27	2159	96.73
	0.10m	2232	57	2.55	2175	97.45
	0.30m	2232	37	1.66	2195	98.34
	Average	**2232**	**56**	**2.49**	**2176**	**97.51**
Aug	0.05m	2232	59	2.64	2173	97.36
	0.10m	2232	69	3.09	2163	96.91
	0.30m	2232	65	2.91	2167	97.09
	Average	**2232**	**64**	**2.88**	**2168**	**97.12**
Sept	0.05m	2160	144	6.67	2016	93.33
	0.10m	2160	98	4.54	2062	95.46
	0.30m	2160	92	4.26	2068	95.74
	Average	**2160**	**111**	**5.15**	**2049**	**94.85**
Oct	0.05m	2232	106	4.75	2126	95.25
	0.10m	2232	83	3.72	2149	96.28
	0.30m	2232	108	4.84	2124	95.16
	Average	**2232**	**199**	**4.44**	**2133**	**95.57**
Nov	0.05m	2160	78	3.61	2082	96.39
	0.10m	2160	112	5.19	2048	94.81
	0.30m	2160	119	5.51	2041	94.49
	Average	**2160**	**103**	**4.77**	**2057**	**95.23**
Dec	0.05m	2232	144	6.45	2088	93.55
	0.10m	2232	159	7.12	2073	92.88
	0.30m	2232	136	6.09	2096	93.91
	Average	**2232**	**146**	**6.56**	**2086**	**93.44**

They were 2232 (3 years x31 days/months x24 reading/day=2232) number of temperature reading for months of Jan., March, May, July, Aug., Oct., and Dec. While the regression analysis processes rejected the unusual numbers of 94, 123, 98, 56, 64, 199 and 146 from the T-soil readings of the above-mentioned months, respectively. On Feb. month, the total reading of T-soil was 2016 (3x28x24=2016), with rejected unusual number of 82. On the other hand, there were 2160 (3x30x24=2160) for months of April, Jun., Sept. and Nov. with rejected unusual numbers of 143, 96, 111 and 103 from the T-soil readings of the above-mentioned months, respectively, respectively.

Generally, the average fit numbers of temperature used in calculated regression were ranged from 93% to 98% of total number of T-soil readings used in regression analysis.

Regression equations between air temperature (x) and soil temperatures (Y) at the three depths through the three studied years were found in Table (4). Data in this table showed that values of (R^2) for different equations of all the months were significant.

These equations will be used to predict the monthly mean soil temperature (T-soil) at different depths with the help of air temperature (T-air) and can also be used for the estimation of missing data.

Finally, it can be concluded that regression equations between air temperature (T-air) and soil temperature (T-soil) at the three depths were highly significant, and the air temperature represented the main effect on soil temperature while other factors have little effect.

On the other hand, the threshold values (a) of regression equations of different soil depths, as noticed in Fig (6), were higher in summer and lower in winter months at the three depths. This leads to a conclusion that when air becomes worm the soil temperature increases. Also, the effect of air temperature was higher near soil surface and minimized with depth until the 0.03m depth in this study.

Table (4): Regression equations between air temperature (Independent, x) and soil temperatures (Dependent, Y) at the three depths, during the three years of study.

Month	(Y) (T-soil)	(X) a + b (T-air)	No. of observations	No. of Fit of soil T	r	P
Jan	0.05m	7.41 + 0.449 T-air	2232	2136	0.761	***
	0.10m	10.5 + 0.242 T-air	2232	2136	0.6.3	***
	0.30m	13.4 + 0.0525 T-air	2232	2141	0.182	***
Feb	0.05m	6.24 + 0.588 T-air	2016	1948	0.823	***
	0.10m	9.27 + 0.374 T-air	2016	1939	0.699	***
	0.30m	12.6 + 0.151 T-air	2016	1916	0.382	***
March	0.05m	8.12 + 0.531 T-air	2232	2095	0.734	***
	0.10m	12.4 + 0.266 T-air	2232	2108	0.544	***
	0.30m	15.2 + 0.0941 T-air	2232	2123	0.235	***
April	0.05m	10.8 + 0.504 T-air	2160	2019	0.773	***
	0.10m	14.5 + 0.305 T-air	2160	2002	0.629	***
	0.30m	17.4 + 0.153 T-air	2160	2031	0.371	***
May	0.05m	14.7 + 0.469 T-air	2232	2136	0.654	***
	0.10m	19.6 + 0.234 T-air	2232	2136	0.464	***
	0.30m	22.8 + 0.0798 T-air	2232	2130	0.184	***
Jun	0.05m	14.2 + 0.611 T-air	2160	2057	0.685	***
	0.10m	23.4 + 0.228 T-air	2160	2073	0.381	***
	0.30m	27.0 + 0.0694 T-air	2160	2061	0.145	***
July	0.05m	19.3 + 0.402 T-air	2232	2159	0.636	***
	0.10m	25.4 + 0.174 T-air	2232	2175	0.367	***
	0.30m	29.3 + 0.0321 T-air	2232	2195	0.077	***
Aug	0.05m	18.9 + 0.413 T-air	2232	2173	0.623	***
	0.10m	24.1 + 0.223 T-air	2232	2163	0.425	***
	0.30m	27.4 + 0.101 T-air	2232	2167	0.187	***
Sept	0.05m	17.7 + 0.429 T-air	2160	2016	0.607	***
	0.10m	23.7 + 0.199 T-air	2160	2062	0.356	***
	0.30m	26.2 + 0.109 T-air	2160	2068	0.212	***
Oct	0.05m	15.7 + 0.364 T-air	2232	2126	0.567	***
	0.10m	19.9 + 0.196 T-air	2232	2149	0.352	***
	0.30m	22.4 + 0.106 T-air	2232	2124	0.202	***
Nov	0.05m	13.3 + 0.337 T-air	2160	2082	0.581	***
	0.10m	16.2 + 0.203 T-air	2160	2048	0.395	***
	0.30m	18.0 + 0.119 T-air	2160	2041	0.249	***
Dec	0.05m	9.84 + 0.365 T-air	2232	2088	0.609	***
	0.10m	12.7 + 0.192 T-air	2232	2073	0.385	***
	0.30m	14.1 + 0.125 T-air	2232	2096	0.257	***

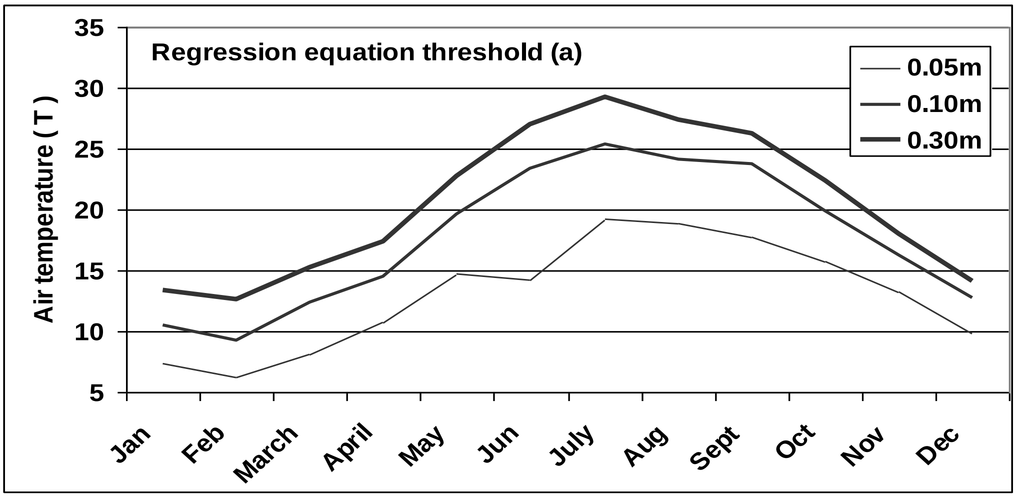


Fig.(6):Threshold values (a) of regression equations of different depths of soil along the months of the three years of study.

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التغير فى درجة حرارة الهواء الجوى وإنعكاساتها على حرارة التربة وفى التنبؤ بدرجة حرارة اعماق مختلفة من التربة فى الإسماعيلية

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تم اجراء هذا البحث على الأراضي الرملية فى محطة بحوث الإسماعيلية، مركز البحوث الزراعية (إحداثيات هذا الموقع : خط عرض ٣٠° ٣٦َ ٣٠" شمالا وخط طول ٣٢° ١٤َ ٥٠" شرقا) ويرتفع عن سطح البحر بـ ١٠.٢ متر. تم وضع ثلاث موصلات حرارية فى ارض رملية على ثلاثة اعماق (٠.٠٥، ٠.١٠ و ٠.٣٠ متر) من سطح الأرض لدراسة تأثير حرارة الهواء على الأعماق السطحية وكذلك الأكثر عمق . تم تسجيل بيانات درجات حرارة الهواء كل ساعة وأيضا سجلت حرارة التربة عند أى عمق بمتوسط قراءة كل ساعة وهذا يعنى ان قراءات حرارة الهواء او التربة السنوية (٣٦٥×٢٤=٨٧٦٠ قراءة/سنة). تم عمل دراسة إحصائية للارتباط وكذلك للانحدار بين حرارة الهواء وكل من حرارة التربة فى كل عمق.

متوسط درجات حرارة التربة فى الثلاث اعماق خلال ثلاث سنوات كانت ١٣.٨٣، ١٤.٤١، ١٦.٦٧، ٢٠.٤٥، ٢٥.١٠، ٢٩.٣٧، ٣٠.٢٩، ٣٠.٣٠، ٢٨.٩٥، ٢٤.٤٠، ١٩.٨٦، ١٥.٤١م° وذلك للأشهر يناير، فبراير، مارس، ابريل، مايو، يونيه، يوليه، اغسطس، سبتمبر، اكتوبر، نوفمبر و ديسمبر على التوالى. اما عن متوسط درجات حرارة الهواء فقد كانت ١٣.٦٩، ١٣.٦١، ١٦.٠٧، ١٩.٤١، ٢٣.٢٢، ٢٥.٨٨، ٢٧.٧٨، ٢٧.٨٧، ٢٦.٠١، ٢٢.٨٥، ١٨.٣١، ١٤.٠٢م° للأشهر السالف ذكرها على التوالى. وأن

اقل درجة حرارة تربة وهواء كانت فى اشهر ديسمبر، يناير وفبراير واعلى درجة حرارة كانت فى يوليه و اغسطس.

لقد زادت متوسط درجات حرارة التربة فى العام الثالث مقارنة بالعام الأول خلال الثلاث اعماق. اما عن درجات حرارة الهواء فقد تختلف من عام لأخر ولكن المتوسط العام قد ازداد فى العام الثانى والثالث بمقدار ١.١٧، ٠.٣٧ درجة مئوية مقارنة بالعام الأول.

فى معادلات الانحدار فأن الجزء المقطوع (أ) كان عاليا فى اشهر الصيف و منخفض فى اشهر الشتاء للأعماق الثلاثة وذلك راجع للتغير السريعة فى درجات حرارة الهواء من الصيف الى الشتاء بعكس ما هو حادث فى التربة.

عدد مجموع قراءات درجات الحرارة خلال شهر فى الثلاث سنوات هو ٢٢٣٢ فى أى من أشهر يناير، مارس، مايو، يوليه، اغسطس، اوكتوبر، ديسمبر، بينما كانت ٢٠١٦ فى اشهر فبراير، وايضا ٢١٦٠ فى أى من أشهر ابريل، يونيه، سبتمبر، نوفمبر. وبصفه عامه فأن عدد القراءات المناسب للمعادلات المطبقة هو من ٩٣ الى ٩٨% من اجمالى أعداد القراءات الكلية ، وذلك يفسر ارتفاع معنوية معامل الانحدار ومدى التأثير الفعال لحرارة الهواء على حرارة التربة.

وبمعرفة المتوسطات الشهرية لدرجات حرارة الهواء الجوى وبإستخدام معادلات الانحدار الواردة فى البحث – ولحد كبير – يمكن التنبأ بالمتوسطات الشهرية لدرجات حرارة إعماق مختلفة التربة ، وكذلك يمكن باستخدام تلك المعادلات فى تقدير القيم التى لم تسجل (المفقودة) من درجات حرارة التربة او الأعوام التى لم يذكر فيها درجات حرارة التربة.