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SOIL TEMPERATURE OF BOTH OPEN FIELD AND UNDER TRANSPARENT POLYETHYLENE LOW TUNNELS AS AFFECTED BY AIR TEMPERATURE

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ABSTRACT

This investigation was conducted at EL-Borollous district, kafr EL-Sheikh Governorate, North Nile Delta area. The aim of this study was to find out the influence of air temperature on the corresponding transparent polyethylene low tunnel temperature as well as soil temperature at successive depths of 5, 10, 15 and 20 cm. Therefore, air and soil temperatures in the open field and under clear polyethylene low tunnel were recorded daily at 8 a.m., 11 a.m., 2 P.m. and 5 P.m. during the period of tunnel implementation (1st of Nov. through 31st of March, 2003 & 2004). Main results could be listed as follows:

- Both air and soil temperature raised gradually from 8.0 a.m. till 2.0 p.m. and then declined.
- The gap between maximum and minimum temperature was high for air at both open environment and under tunnel. This range was also higher at surface soil depth and it declined gradually with increasing soil depth.
- The most affected soil depth in relation with air temperature was the upper 5.0 cm.
- The relations between air and soil temperature could be expressed as follows:

1- Low air temp. under tunnel (8. a.m), T temp 8 = 0.9066 (low open air temp 8 a.m, A tem 8) + 1.4388
$R^2 = 0.8874$

2- Open field soil temp at 5 cm. depth = 0.7006 (A tem 8) + 4.6587
$R^2 = 0.9065$

3- Tunnel soil temp, tunnel at 5 cm. depth (STD5) = 0.7141 (A tem 8) + 4.6101
$R^2 = 0.759$

4- STD5 = 0.6407 (T tem 8) + 5.8751
$R^2 = 0.7022$

The listed equations provide the concern specialists of researchers, extension workers and / or farmers, with valuable knowledge about tunnel temperature for both air and soil as well as the corresponding values in the open surrounding conditions. Such data are useful to determine which crop should be cultivated based on soil temperature at the most dynamic depth of 5 cm.

INTRODUCTION

In Egypt, increasing population caused serious obstacles against the executive of the national agricultural development program. Although Egypt's effects in birth control have been acknowledged by the international community, the population still gained great momentum and will continue to grow. The population growth and escalated living standards have put more stress on water and land resources.

Vertical and horizontal expansions in agriculture are the two main bench marks of the policy of Ministry of Agriculture and Land Reclamation (MALR) towards increasing agricultural production.

Transparent polyethylene low tunnel cultivation as a type of protected agriculture have several purposes such as earliness of vegetable production in comparison with that of the out- door farming along with enhancing crop quality. Moreover, protection of the growing plants under tunnel against the severe conditions of the low winter temperature at surrounding open field could be achieved.

Soil temperature plays a vital role on good and complete germination, as each crop has its own optimal soil temperature. For example, 24-25^{0}C are the convenient soil temperature for germination of peper, while it is 25- 30^{0}C for cantaloupe and cucumber. For watermelon, it is ranged between 21-35^{0}C. On the other hand, 18-20^{0}C are the suitable soil temperature of pea seed germination (Denahue *et al*., 1977 Salman *et al.,* 1989 and Wilcox and Pfeiffer, 1990). Characteristics of soil temperature either at out- door and / or under the protected cultivation are investigated in Egypt and world wide, such as, Ibrahim and EL-Gohary, 1987, Ibrahim and Hosny, 2001 and Gazia and EL-Basuny, 2004.

Therefore the objective of this study was to find out the influence of air temperature in the open-door environment on that of the inside clear polyethylene low tunnel as well as soil temperature at successive depths of both open and protected tunnels. In addition, finding the derivation of the relation between air and soil temperature.

MATERIAL AND METHODS

This study was carried out at El-Borollous district, Kafr EL-Sheikh Governorate, North Nile Delta area, nearby the shore of the Mediterranean sea. The site lies at 30^0–33’N. latitude and 30^0-06‘E longitude. The soil is sandy in texture.

For the open field, air and soil temperatures at different depths of 5, 10, 15 and 20 cm. were recorded four times daily at 8 a.m., 11.0 a.m., 2 p.m and 5 p.m. Parallel to these measurements, same temperatures of air and soil were recorded inside the adjacent clear polyethylene low tunnel, the temperature data were registered during 1st of January through 31st of March 2003 & 2004 i.e. during the period of the tunnel implementation for cantaloupe production. The relations between outside and inside tunnel air temperature as well as the influence of open-field air temperature on the corresponding soil temperature at both open environment and inside tunnel were derived, according to Pindyck and Rubinfeld (1976).

RESULTS AND DISCUSSION

I. Temperature regime:

1.1- Out-door and transparent polyethylene air tunnel temperature (^{0}C):

All measurements and statistical parameters of temperature; mean, standard deviation, maximum, minimum and range increased gradually from the lowest value at 8 a.m. till the peak value at 2 p.m and then declined at 5 p.m. (Table 1). This finding was similar to that obtained by Ibrahim and Hosny (2001).

1.2- Soil temperature (^{0}C):

As shown in Table (1), soil temperature at the surface 5 cm. soil depth for both outside environment and inside low tunnel have the same trend with that of air temperature. Moverover, soil temperature decreased with increasing soil depth. Meaningfully, the surface soil depth of 5 cm, is the most affected layer with air temperature. Ibrahim and EL-Gohery (1987) stated that the most dynamic soil depth that affected by air temperature was the top 5 cm. soil depth.

It was also noticed that the standard deviation (St. Dv.) under tunnel is less than that of the open-field, which expressed in offset the unfavorable climatic conditions of the surrounding out-door environment such as coldness and high wind speed. Such conditions are severly affected the growth of the cultivated young plants. In other words, implementation of low tunnel technique is considered as protecting cultivation against the severe hazard conditions of the out-door environment during the winter season. This finding is fully agreed with that obtained by Salman *et al.* (1989).

1-3. Temperature distribution:

Fig. 1 through 5 represent the temperature distribution of air and soil depths as well as standard deviation (ST. Dv.) at the out-door environment. It is clear that the difference between maximum and minimum temperature is the widest in air and in the surface soil layer of 5 cm., then decreased gradually with increasing soil depth. So, the greatest soil depth, the less difference between maximum and minimum temperature. This finding was similar to that obtained by Marshchner (1997). This finding could be attributed to that the most affected soil depth with air temperature is the surface 5 cm. at which the cultivation process is occurred.

The same picture of open field in relation with temperature distribution is presented under tunnel environment as shown in fig. 6 through 10. Therefore, the most affected soil depth under tunnel with air temperature was the surface layer. In general, soil temperature is not only a function with air temperature but also by the texture and the specific heat of the soil.

These results are in the same direction with that obtained by Gazia El-Basuny (2004), who stated that high temperature declined with the soil layer 0-20cm. This led to all the estimated statistics (Max. high, low. high, min. high, min. low, range high, range low, St. DV. high and ST. DV. low) to be declined along the soil layer 20cm. Consequently, soil temperature change was affected in the upper Layer (5 cm.) and then declined sequentially in the sequential layers.

2. Derived relation between air and soil temperature:

As mentioned above, the upper soil layer of 5cm. was the most responsive affected depth with air temperature. On the other hand, the sequent soil depths were less affected especially, those beyond the 10 cm – soil depth. Therefore, the linear relationship between air temperature of either open door or tunnels environment and soil temperature at 5 cm, for both environments are derived.

The relationship between the low open air temperature at 8 a.m.. (A temp 8) and the low tunnels air temperature (T tem 8) is presented by the equation 1 and Fig. 11-a:

T tem 8 = 0.9066 A temp 8 + 1.4388 (1)

R^2 = 0.8874

While R^2 is the coefficient of determination.

The relationship between A temp 8 and Soil temperature at the top depth of 5 cm. (SADS) at the out –door environment is expressed in equation 2 and illustrated in Fig. 11-b:

SAD5 = 0.7006 (A temp 8) + 4.6587 (2)

R^2 = 0.9065

While, the relationship between A temp 8 and soil temperature under tunnel at depth 5 cm. (STD5) is derived in equation 3 and presented in fig. 11-c:

STD5 = 0.7141 (A temp 8) + 4.6101 (3)

R^2 = 0.759

Lastly, the relation between T temp 8 and STD5 is quantified by equation 4 and Fig. 11-d as:

STD5 = 0.6407 (T temp 8) + 5.8751 (4)

R^2 = 0.7022

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درجة حرارة التربة بالحقل المكشوف وتحت الأقبية ومدى تأثرها بدرجة حرارة الجو

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****معهد بحوث الأراضى والمياه والبيئة – مركز البحوث الزراعية**

أقيمت هذه الدراسة بمنطقة البرلس – محافظة كفر الشيخ وهى تمثل شمال دلتا نهر النيل وذلك بهدف مدى استجابة درجة الحرارة داخل الأقبية البلاستيكية لحرارة الهواء الجوى . بالإضافة إلى مدى تأثير درجة حرارة التربة فى الطبقة الفعالة (٥سم) سواء بالحقل المكشوف أو داخل الأقبية بالحرارة بالحقل المكشوف.

وعليه فقد سجلت درجات الحرارة ٤ مرات يومياً : ٨ ص - ١١ ص - ٢م – ٥ م وسجلت قراءة التربة على أعماق ٥، ١٠، ١٥ ، ٢٠ سم.

وقد أوضحت الدراسة العلاقات التالية :-

1- T tem 8 = 0.9066 (A temp 8) + 1.4388
R^2 = 0.8874

2- SAD5 = 0.7006 (A temp 8) + 4.6587
R^2 = 0.9065

3- STD5 = 0.7141 (A temp 8) + 4.6101
R^2 = 0.759

4- STD5 = 0.6407 (T temp 8) + 5.8751
R^2 = 0.7022

حيث :

T tem 8 = درجة الحرارة الصغرى تحت النفق عند ٨ ص

A temp 8 = درجة الحرارة الصغرى للجو الخارجى عند ٨ ص

SAD5 = درجة حرارة التربة بالجو الخارجى عند عمق ٥ سم

STD5 = درجة حرارة التربة تحت النفق عند عمق ٥سم

وعليه :

فيمكن التنبؤ بدرجة حرارة التربة بعمق الزراعة (٥سم) سواء خارج أو داخل الأقبية البلاستيكية وبالتالى يمكن تحديد مواعيد زراعة المحاصيل المختلفة سواء بالحقل المكشوف أو تحت الأقبية البلاستيكية.

Table (1): Out-door inside, tunnel air temperature (ºC) and their soil temperatures at different depths along the day- time for the period, 1st Jan. – 31st March 2003 & 2004.

Temp. at	Temperature at recorded time																			
	8 a.m.					11 a.m.					2 p.m.					5 p.m.				
	M.	S.D.	Max.	Min.	R.	M.	S.D.	Max.	Min.	R.	M.	S.D.	Max.	Min.	R.	M.	S.D.	Max.	Min.	R.
Out door Air	17.9	4.78	26.4	10.7	15.7	24.7	5.28	32.6	13.8	18.8	24.9	5.94	36.8	15.2	21.6	19.5	4.86	32.6	11.4	21.2
Inside tunnel	17.6	4.60	25.3	10.7	14.6	24.6	5.29	32.6	13.8	18.8	25.1	6.03	36.8	15.2	21.6	19.0	3.86	28.6	11.4	17.2
Soil out door:- 5 cm	17.2	3.52	23.4	10.9	12.5	24.4	4.00	32.2	16.0	16.2	26.6	4.56	35.5	17.3	18.2	21.8	4.34	31.3	13.4	17.9
10 cm	16.1	3.45	22.8	10.0	12.8	20.6	2.87	25.9	15.4	10.5	24.2	3.43	29.1	16.9	12.2	21.9	3.76	29.6	14.3	15.3
15 cm	16.3	3.45	23.3	10.6	12.7	18.7	2.84	24.7	13.7	11.0	21.8	3.06	27.3	15.2	12.1	21.6	3.27	27.7	14.8	12.9
20 cm	16.9	3.54	23.9	11.4	12.5	18.2	2.96	24.5	13.0	11.5	20.4	2.68	25.7	14.6	11.1	20.8	3.03	26.6	14.8	11.8
Soil tunnel:- 5 cm	17.4	3.92	25.2	10.9	14.3	25.2	5.11	36.9	12.8	24.1	27.2	5.59	38.3	13.9	24.4	22.3	5.28	35.0	10.7	24.3
10 cm	16.1	3.25	22.4	10.3	12.1	21.1	3.52	29.3	15.4	13.9	24.6	4.07	33.4	16.9	16.5	22.5	4.49	32.3	14.3	18.0
15 cm	16.2	3.30	22.7	10.6	12.1	18.9	3.02	25.1	13.7	11.4	22.0	3.32	28.7	16.0	12.7	21.9	3.81	29.8	14.8	15.0
20 cm	16.8	3.26	23.2	11.4	11.8	18.2	2.99	24.0	13.0	11.0	21.0	3.57	28.7	14.6	14.1	20.1	3.23	28.3	14.8	13.5

M = mean, S.D. = standard deviation, Max. = maximum, Min = minimum and R. = range.

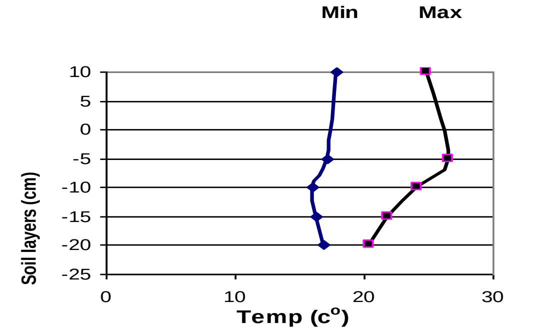

Fig 1: Air and soil temp. averages(C°) along soil profile(0-20

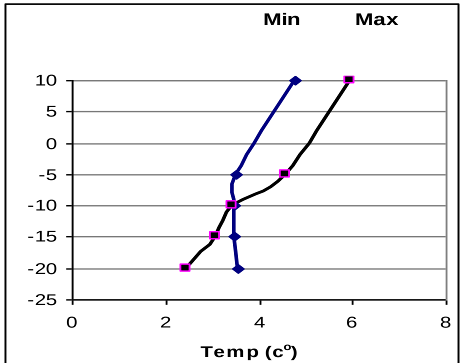

Fig 2: Air and soil temp. STDEV along soil profile (0-20 cm)

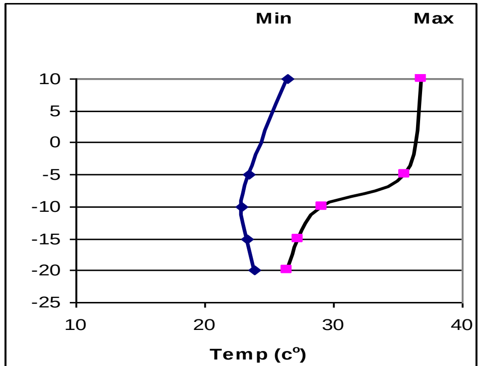

Fig 3: Air and soil max. temp,(C°) along soil profile (0-20 cm)

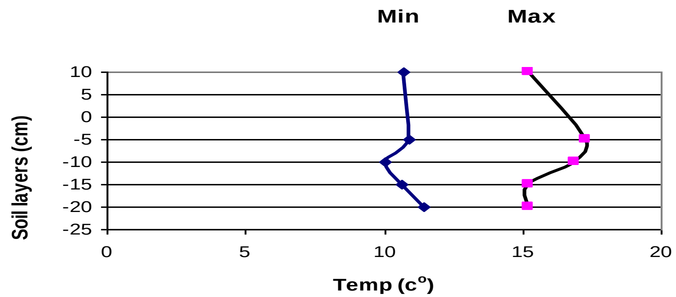

Fig 4: Air and soil min. temp.(C°) along soil profile (0-20 cm)

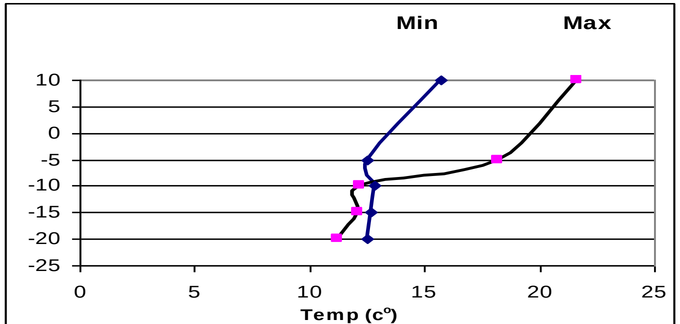

Fig 5: Air and soil range temp.(C°) along soil profile (0-20 cm)

Open field

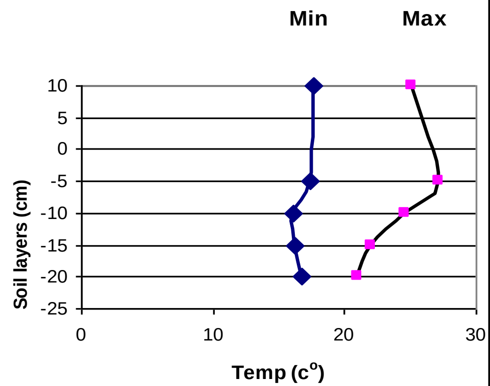

Fig 6: Under tunnel airand soil temp.(C°) averages along soil profile (0-20 cm)

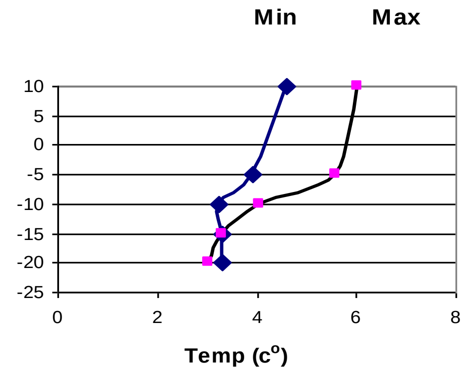

Fig 7: Under tunnel air and soil temp. STDEV along soil profile (0-20cm)

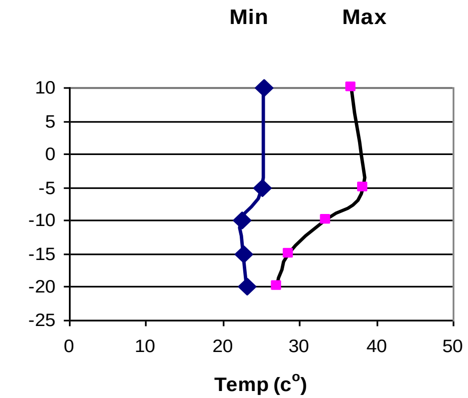

Fig 8: Under tunnel air and soil max. temp. (C°)along soil profile (0-20 cm)

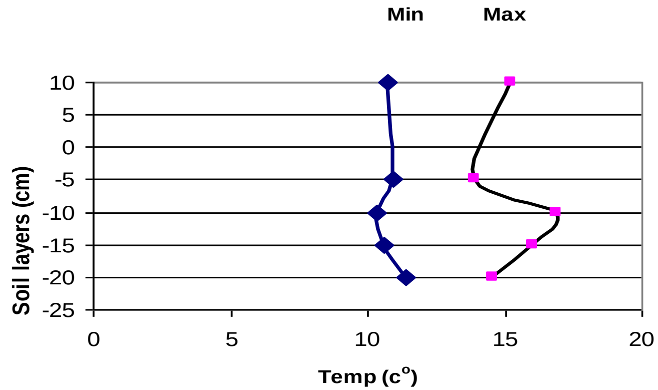

Fig 9: Under tunnel air and soil min. temp. (C°) along soil profile (0-20 cm)

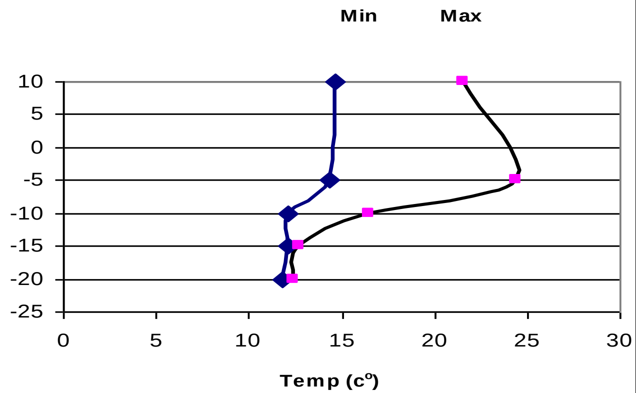

Fig 10: Under tunnel air and soil range temp. (C°) along soil profile (0-20 cm)

Under tunne