EFFECT OF SOIL SOLARIZATION AND COMPOST ON UCUMBER GROWTH AND YIELD UNDER PLASTIC TUNNELS

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ABSTRACT

The experiment was conducted in the experimental farm of the Faculty of Agriculture Kafr El-Sheikh, Tanta University during the winter seasons 1998/1999 and 1999/2000, on cucumber plants cv. "Nile F1". The experiment consisted of 4 treatments as follows: Soil solarization + compost, Soil solarization + mineral fertilizers, Non-soil solarization + compost, Non-soil solarization + mineral fertilizers.

The results indicated that plants grown in the solarized soil with compost fertilizer mostly increased vegetative growth and growth attribute values. The highest early and total yield were obtained from plants grown in the solarized soil with compost fertilizer (4.16 Kg/m^2), while the lowest one was obtained from the non-solarized soil with compost (1.87Kg/m^2).

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is a favorite vegetable crop in Egypt. It is used as a salad and pickle. It occupied about 4931 and 4886 hectare in winter season of 1999 and 2000, which yielded 97232 and 76968 tons, respectively. Within the last years, cucumber has become the main crop in greenhouses in Egypt, due to the higher production and monetary returns. Cucumber is a warm season vegetable. The best growth is obtained at temperatures between 18^0C and 24^0C. The faster growth and higher yield are resulted in the spring, compared to those plants sown during the cold months (Benzioni et al., 1991). In Egypt, cucumber production under such conditions is usually low, hence, more expensive. There are some problems which may face cucumber production in plastic greenhouses such as soil borne diseases, insufficient organic matter contents in soil, excessive use of mineral fertilizers and chemicals, soil salinity, and excessive low temperature in winter even under plastic cover. Using some treatments such as soil solarization and compost fertilizer might overcome such problem.

Soil solarization is a non-chemical approach to improve the control of soil borne diseases (Stevens et al., 2000 a&b). Soil solarization is a good method of soil disinfestation because it is effective, easy to apply, safe and economical (Al- samarria et al., 1988).

Compost manure produced from surplus agricultural waste products positively affected food quality, improved storage performance and significantly reduced nitrates (Vogtmann et al., 1993). Using compost as an organic farming method has economic (30-50% higher price) and environmental advantages in comparison with conventional farming method (Kim, 1996). Furthermore, composting increased micro elements in the soil, but the heavy metals (Zn, Cu, Ni, Pb, Cd, and Cr) content in cucumber fruit did not reach the toxic level (Pinamonti et al., 1997).

In Egypt, researches relating the response of cucumber to solarization, and compost, especially in winter, have not been sufficiently reported.

Hence, the purpose of this investigation was to study the effect of using soil solarization, and fertilizer sort, aiming to improve cucumber growth, and productivity under plastic greenhouse in North of Delta area, Egypt.

MATERALS AND METHODS

The experiments were carried out in the Experimental Farm of the Faculty of Agriculture, Kafr EL-Sheikh, Tanta university, during the winter seasons of 1998/1999 and 1999/2000 using cucumber (*Cucumis sativus* L.), cv Nile hybrid plants. Seeds of cucumber were sown into seedling trays under plastic on October 13th in the first season and October 3rd in the second one. Seedlings were transplanted under plastic on November 3rd (first season) and October 25th (second season). The ridges were 6 meters in length and 1 meter in width. Plant spacing was 40 cm. i.e., plant density was about 2.5 plants per square meter.

Treatments used

The experiment included 4 treatments, as following:

1- Soil solarization + compost
2- Soil solarization + mineral fertilizers.
3- Non-soil solarization + compost.
4- Non-soil solarization + mineral fertilizers (control).

Soil solarization was carried out, for 5 weeks, during August and September. The experimental plots were irrigated heavily. Four days latter, they were covered with a single layer of transparent polyethylene (25 µm thick), which stayed for 5 weeks (Al- Masoum et al., 1993 and Abd El Aziz, 1998).

Compost fertilizer was added at the rate of 5 Kg per square meter (50 m^3 / faddan). Chemical analysis of compost was determined according to Jackson (1967). Determination of compost pH was achieved in a 1: 5 (compost: water) suspension according to Cottenie et al. (1982). The obtained data are presented in Table (1).

Table 1. Chemical analysis of compost before conducting the experiments in 1998/1999 and 1999/2000 seasons.

Compost chemical analysis	1998/1999 season	1999/2000 season
Soluble cations and anions in a 1:5 (compost: water) suspension (meq / l)		
Na^{+}	58.00	57.00
K^{+}	33.08	31.50
Ca^{++}	18.00	27.80
Mg^{++}	18.00	28.20
CO_3^{--}	0.00	0.00
HCO_3^{-}	6.00	6.00
Cl^{-}	68.00	71.50
SO_4^{--}	53.08	67.00
Available N (g/kg^{-1})	0.18	0.17
Available P (g/kg^{-1})	0.04	0.05
Available K (g/kg^{-1})	10.14	10.14
Organic matter %	11.41	12.45
PH	6.45	6.38
EC (dsm^{-1})	12.70	14.30

Mineral fertilizers were added to soil at the following rates per feddan: [300 kg of ammonium sulphate (20.5% N), 200 kg of calcium superphosphate (15.5% P_2O_5), 100 kg of potassium sulphate (48 % K_2O)]

Data recorded

Vegetative growth characters were recorded at 45, 60, and 75 days after transplanting. Samples of 5 plants were randomly chosen from each experimental unit to determine the following characters: stem length (cm), plant leaf area (cm^2) and fresh weight of leaves.

Growth attribute characters as Crop Growth Rate (CGR), Relative Growth Rate (RGR) and Net Assimilation Rate (NAR) were determined using the dry weight of the shoot and leaf area per plant. They were determined in samples of 2 plants randomly chosen from each plot at the given dates.

Growth attributes were computed at two stages (6-8 and 8-10 weeks after transplanting) according to Watson (1952), Watson (1958), and Radford (1967).

Crop Growth Rate (CGR) was determined by the equation

$$CGR = W_2 - W_1 / T_2 - T_1$$

Relative Growth Rate (RGR) was determined by the equation

$$RGR = Log_e W_2 - Log_e W_1 / T_2 - T1$$

Net Assimilation Rate (NAR) was determined by the equation

$$NAR = (W_2 - W_1)(Log_e A_2 - Log_e A_1) / (A_2 - A_1) \quad (T_2 - T_1)$$

Where : W1, A_1 and W_2, A_2 refer to dry weight and leaf area at the time T_1 and T_2 in weeks, respectively.

Data of fruit yield included early and total yield. Early fruit yield was determined as weight (Kg) and number of fruits per square meter. It was determined on base of yield of the first 4 pickings. Total fruit yield was determined as weight (Kg) and number of fruits per square meter of all pickings.

Fruit characteristics included average of fruit weight (g), length (cm), and total soluble solids percentage. Total soluble solids (TSS %) were determined in fruit juice by a hand refractometer according to A.O.A.C. (1965).

Fruit characteristics were determined in fruits picked in the same day (which its flowers were previously labeled at the same opening day).

Dry matter samples of the fifth leaf from the plant growing tip were dried at 70 °C. The crude dry materials were wet digested with sulphoric acid and hydrogen peroxide mixture as described by Koch and Mc Meeking (1924) to determine the following constituents:

-Total nitrogen: was determined in the digestion product using the micro Kjeldahl method (Piper, 1947).

-Total phosphorus:was colourimetrically estimated using a spectrophotometer at 650 μm (Murphy and Riely, 1962).

-Total potassium: was determined using a flame photometer as described by Jackson (1967).

Experimental design and statistical analysis:

The treatments were arranged in complete randomize block design with 6 replications. Data were tested by analysis of variance (Little and Hills, 1972). Duncan's multiple range test (DMRT) was used for the comparisons among treatments means (Duncan, 1955).

RESULTS AND DISCUSSION

Data presented in Table (2) show that soil solarization with transparent polyethylene cover increased soil temperature values in the different soil depth (5, 10 and 20 cm) in comparison with non-solarized soil.

Table 2. Weekly average of solarized and non-solarized soil and air temperatures @ during solarization period (5 weeks).

Date	Solarized soil Temperature (°C)			Non solarized soil temperature (°C)			Air temperature (°C)
	Soil depth						
	5 cm	10 cm	20 cm	5 cm	10 cm	20 cm	
	1998/1999 season						
6/8 — 12/8	44.5	40.0	35.5	33.0	30.0	28.5	33.5
13/8 — 19/8	44.5	39.0	34.5	35.5	31.0	27.5	32.3
20/8 — 26/8	44.4	39.0	34.6	35.0	30.8	28.6	32.6
27/8 — 3/9	43.2	38.0	34.6	36.0	31.0	29.5	32.8
4/9 — 10/9	43.8	38.4	34.0	36.4	31.2	28.5	33.6
	1999/2000 season						
9/8 — 15/8	44.0	40.0	35.6	35.2	32.5	30.4	34.3
16/8 — 22/8	43.4	39.5	37.2	35.5	31.2	29.0	34.0
23/8 — 29/8	46.6	40.6	37.5	36.8	32.8	30.4	35.0
30/8 — 6/9	44.0	40.2	36.8	35.2	32.9	30.2	32.0
7/9 — 13/9	46.4	41.2	37.5	36.6	32.6	30.5	34.9

@ Air and soil temperatures were measured daily at 2 p.m.

From another hand, soil (solarized or non-solarized) temperature decreased with the increase in soil depth; and it tended to rise with the increase in air temperature.

The increase of soil temperature in solarized soil with transparent polyethylene cover may be due to the prevention of evaporation; the solar energy, which could, otherwise, be used in evaporating water from the soil, was stored as sensible heat in the irrigated-mulched soil. The formation of a thin water film on the underside of the polyethylene sheet increased the incoming short wave solar radiation but prevented the escape of the outgoing long wave radiation from the soil (Kumar and Yaduraju, 1992).

Vegetative growth characters (Table 3, and Fig 1.) were significantly affected by the different treatments at the 3 growth stages in both seasons. Soil solarization with compost fertilizer had the highest records in all vegetative growth characters, followed by soil solarization with mineral fertilizer. On the other hand, plants grown in non-solarized soil (with compost or mineral fertilizer) had, in general, the lowest values.

Table 3. Effect of soil solarization, and fertilizer sort on some vegetative growth parameters of cucumber plants in 1998/1999 and 1999/2000 seasons.

Treatments	Stem length (cm)			Plant leaf area (cm^2)			Leaves fresh wt./plant (g)		
	Stages(days after transplanting)								
	45	60	75	45	60	75	45	60	75
	1998/1999 season								
1- Soil solarization + compost	112.3 a	150.8 a	187.7 a	2801 a	3468 a	4145 a	97.1 a	175.3 a	193.1 a
2- Soil solarization + mineral	89.5 b	117.3 b	167.3 b	2106 b	2595 b	3414 b	75.5 b	107.7 b	126.5 b
3- Non-solarization + compost	68.4 c	91.5 d	128.8 d	1993 b	2330 c	2545 c	65.7 c	97.7 d	116.6 c
4- Non-solarization +mineral (control)	84.7 b	106.2 c	152.8 c	2011 b	2406 c	2887 d	66.9 c	100.0 c	110.3 d
	1999/2000 season								
1- Soil solarization + compost	121.3 a	150.7 a	197.9 a	3154 a	3851 a	4694 a	102.3 a	176.9 a	207.3 a
2- Soil solarization + mineral	108.6 b	130.1 b	180.5 b	2401 b	2976 b	3353 b	83.7 b	113.0 b	137.4 b
3- Non-solarization + compost	68.3 d	85.2 d	135.2 d	2334 b	2899 b	3046 c	68.1 d	103.8 c	124.5 c
4- Non-solarization +mineral (control)	90.8 c	109.1 c	161.8 c	2290 c	2665 c	2975 c	73.2 c	101.9 c	120.6 d

Means separation within columns and seasons by DMRT test, $P< 0.05$.

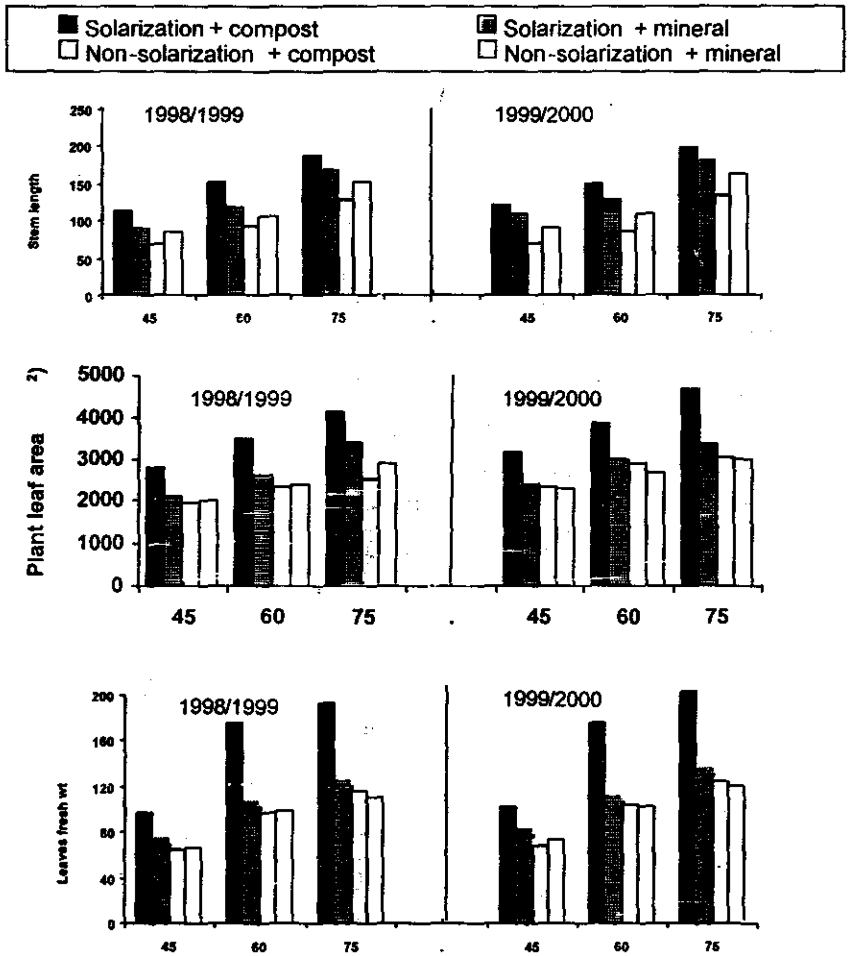

Fig. 1. Vegetative growth parameters of cucumber plants at different growth stages (45, 60 and 75 days after transplanting), as affected by soil solarization. and fertilizer sort in 1998/1999 and 1999/2000 seasons.

The increase in the vegetative growth parameters in solarized soil with compost may be a result of the combined favorable effects of both factors. In addition, applying both factors lead to further increase in soil temperature (Cartia et al., 1989). Such increase in temperature lead to release the bio-toxic volatile compounds which may decrease the efficiency of soil born diseases (AL-Masoum et al., 1998). Data on some growth attributes are presented in Table (4).

Table 4. Effect of soil solarization, and fertilizer sort on growth attributes of cucumber plants at 2 stages @ of vegetative growth in 1998/1999 and 1999/2000 seasons.

Treatments	Crop growth rate (g/m^2/week)		Relative growth rate (g/g/week)		Net assimilation rate (g/m^2/week)	
	Stage (week)					
	6-8	8-10	6-8	8-10	6-8	8-10
	1998/1999 season					
1- Soil solarization + compost	11.68 a	28.80 a	0.216 a	0.312 c	15.05 a	30.29 b
2- Soil solarization + mineral	7.87 b	25.38 b	0.187 b	0.353 a	13.16 a	34.21 a
3- Non-solarization + compost	4.15 d	11.28 d	0.140 c	0.255 d	7.43 b	18.80 c
4- Non-solarization +mineral (control)	5.02 c	19.05 c	0.147 c	0.331 b	9.49 b	29.06 b
	1999/2000 season					
1- Soil solarization + compost	8.95 a	26.53 a	0.154 b	0.299 a	10.10 a	26.15 a
2- Soil solarization + mineral	7.44 b	20.92 b	0.161 a	0.312 a	10.89 a	26.32 a
3- Non-solarization + compost	3.57 d	12.96 d	0.106 c	0.253 b	6.52 a	18.33 b
4- Non-solarization +mineral (control)	5.68 c	17.30 c	0.161 a	0.305 a	9.17 a	24.71 a

@ Stages are defined as 2 successive periods of 2 weeks (as weeks after transplanting)
Means separation within columns and seasons by DMRT test, $p < 0.05$.

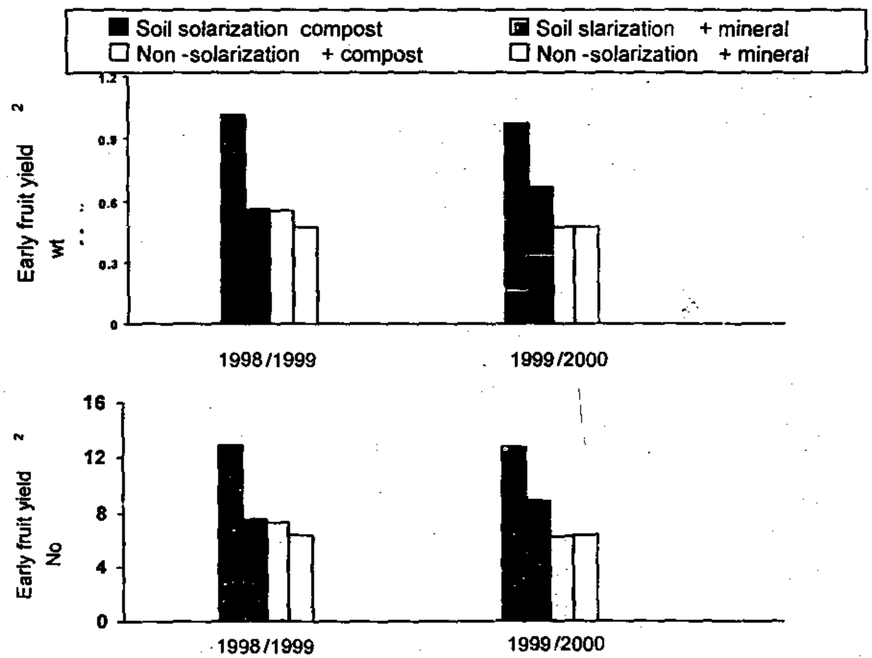

Fig. 2. Early fruit yield of cucumber plants as affected by soil solarization, and fertilizer sort in 1998/1999 and 1999/2000.

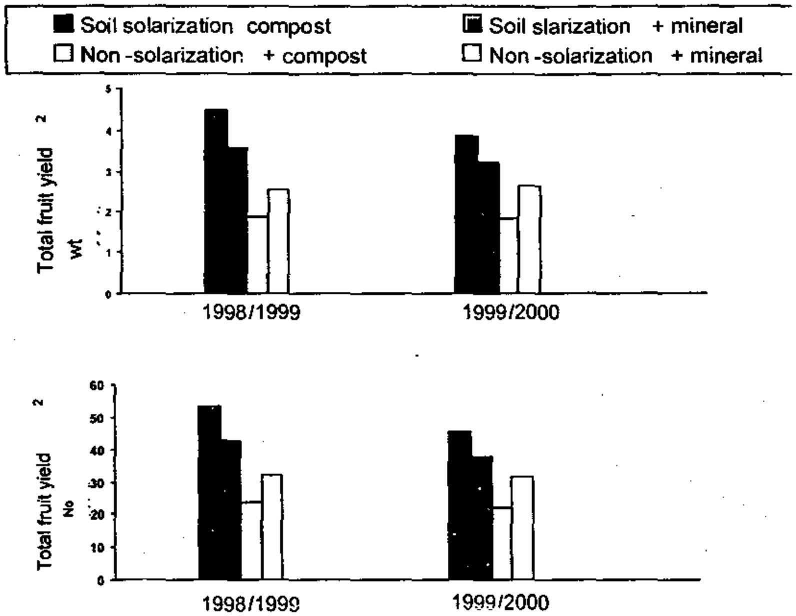

Fig. 3. Total fruit yield of cucumber plants as affected by soil solarization, and fertilizer sort in 1998/1999 and 1999/2000.

Crop Growth Rate (CGR) was significantly affected by the different treatments. Plants grown in solarized soil with compost fertilizer had the highest values at the two measured growth stages (6-8 & 8-10 weeks) in both seasons, followed by plants grown in solarized soil with mineral fertilizer, while the lowest values were obtained from plants grown in non-solarized soil with compost fertilizer.

Concerning Relative Growth Rate (RGR), data show that, the highest values were obtained, in most cases, from solarized soil with mineral fertilizer, while the lowest values were obtained from non-solarized soil with compost fertilizer in both seasons.

Data on Net Assimilation Rate (NAR) show that, at the two growth stages, solarized soil with mineral or compost fertilizer had the highest values, while the lowest ones were obtained from non-solarized soil with compost fertilizer treatments. However, the differences were not significant at the first stage in the second season.

Early and total fruit yield per m^2 (as weight and number of fruits) was significantly affected by the treatments. The highest early and total yield was obtained from plants grown in the solarized soil with compost fertilizer, followed by plants grown in the solarized soil with mineral fertilizer.

Table 5. Effect of soil solarization and fertilizer sort on fruit yield of cucumber plants in 1998/ 1999 and 1999/ 2000 seasons.

Treatments	Early fruit yield		Total fruit yield	
	Wt. of fruit (Kg)	No. of Fruits	Wt. of fruit (Kg)	No. of Fruits
	1998/1999			
1- Soil solarization + compost	1.02 a	13.0 a	4.46 a	53.4 a
2- Soil solarization + mineral	0.56 b	7.5 b	3.54 b	42.8 b
3- Non-solarization + compost	0.55 b	7.3 b	1.88 d	23.4 d
4- Non-solarization + mineral (control)	0.47 c	6.3 c	2.56 c	31.9 c
	1999/2000			
1- Soil solarization + compost	0.97 a	12.8 a	3.87 a	45.5 a
2- Soil solarization + mineral	0.67 b	8.8 b	3.20 b	37.7 b
3- Non-solarization + compost	0.47 c	6.2 c	1.86 d	21.8 d
4- Non-solarization + mineral (control)	0.47 c	6.3 c	2.61 c	31.6 c

Means separation within columns and seasons by DMRT test, $p < 0.05$.

Data presented in Table (6) manifest that fruit weight and fruit length responded similarly to the treatments, where solarized soil with compost treatment led to the highest values, followed by solarized soil with mineral fertilizer, while non-solarized soil with the mineral fertilizers had the lowest values. However, the differences were not significant with fruit weight in the second season. In regard to TSS %, data indicate that it was not significantly affected in both seasons.

Data in Table (6) show that N, P, and K contents were significantly affected by the different treatments in both seasons. The highest N % values were obtained from solarized soil with mineral fertilizer in the first season and with compost in the second one, while, the lowest values were obtained from non-solarized soil with mineral fertilizer. Concerning P %, data show that non-solarized soil with mineral fertilizer treatment had the lowest values in both seasons, but no constant responses were observed among the other treatments. As for K % the solarized soil with compost treatment had the highest values followed by the solarized soil with mineral fertilizers, while the lowest values were obtained from the non-solarized soil with compost.

Net return

Data presented in Table (7) show the costs of different cucumber production elements in both studied seasons.

Table 6. Effect soil solarization, and fertilizer sort on some fruit characteristics and some leaf chemical contents of cucumber plants in 1998/1999 and 999/2000 seasons.

Treatments	Fruit characteristics			Some leaf chemical contents		
	Fruit weight (g)	Fruit Length (cm)	T.S.S (%)	N%	P%	K%
	1998/1999					
1- Soil solarization + compost	87.7 a	13.7 a	5.1 a	3.75 b	0.879 a	7.02 a
2- Soil solarization + mineral	83.8 b	13.4 b	4.4 a	4.10 a	0.659 b	6.64 a
3- Non-solarization + compost	79.5 c	12.4 d	5.0 a	3.30 c	0.890 a	5.01 b
4- Non-solarization +mineral (control)	78.0 d	12.7 c	4.7 a	3.30 c	0.595 c	5.36 b
	1999/2000					
1- Soil solarization + compost	86.0 a	13.5 a	5.1 a	4.10 a	0.862 a	7.59 a
2- Soil solarization + mineral	84.8 a	12.8 b	4.7 a	3.40 b	0.791 b	7.45 a
3- Non-solarization + compost	82.0 a	11.2 d	5.1 a	3.25bc	0.745 e	5.13 b
4- Non-solarization +mineral (control)	80.0 a	11.7 c	4.6 a	3.10 c	0.594 d	6.18 c

Means separation within columns and seasons by DMRT test, $p< 0.05$.

Table 7. Costs of different cucumber production elements in 1998/1999 and 1999/2000 seasons.

Elements cost*	Costs (L.E./m^2)	
	1998/1999	1999/2000
General costs Cucumber seeds + nursery + pesticides + labour.	1.71	1.65
Soil solarization Plastic mulch + labour.	0.13	0.14
Compost fertilizer	0.39	0.39
Mineral fertilizer	0.47	0.47

* Costs of wire and plastic tunnel were not calculated.

Net return data of early and total yield as affected by soil solarization, and fertilizer sort are presented in Table (8).

Table 8. Net return (m^2) of early and total fruit yield @ of cucumber plants as affected by soil solarization, and fertilizer sort in 1998/1999 and 1999/2000 seasons.

Treatments	Net return of cucumber crop (L.E./m^2)			
	Early fruit yield		Total fruit yield	
	1998/1999	1999/2000	1998/1999	1999/2000
1- Soil solarization + compost	1.79 a	1.70 a	4.46 a	3.63 a
2- Soil solarization + mineral	0.98 b	1.17 b	3.00 b	2.54 b
3- Non-solarization + compost	0.96 b	0.82 c	0.72 d	0.65 d
4- Non-solarization + mineral (control)	0.83 c	0.83 c	1.66 c	1.80 c

@ Costs of early yield were not calculated

Means separation within columns and seasons by DMRT test, $p < 0.05$.

NS, *, ** Not significant or significant at $p < 0.05$ or $p < 0.01$ respectively.

Solarized soil with compost had the highest net return of early and total yield, followed by solarized soil with mineral fertilizer. Such increase in net return was more noticeable among treatments with early than with total yield. However the net return values of total yield were, in general, higher than that of early yield. The lowest values were obtained from non-solarized soil with compost.

The increase in net return of early yield for the mentioned treatments was mainly due to the high early fruit yield of such treatments.

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الملخص العربي

أجـــريت تجربه علي نباتات الخيار -صنف هجين نيل- خلال موسم الشتاء تحت الصوب البلاســتيكية لموسمي ١٩٩٨/١٩٩٩و ١٩٩٩/٢٠٠٠ في مزرعة التجارب بكلية الزراعة بكفر الشيخ جامعة طنطا . تم دراسة تأثير ٤ معاملات كما يلي:-

الــتعقيم الشمســي+ ســماد المكموره ، والتعقيم الشمسي + السماد المعدنى ، و بدون تعقيم شمسي + سماد المكموره ، و بدون تعقيم شمسي + السماد المعدني.

أشـــارت النـــتائج إلى ان إســتخدام معاملة التعقيم الشمسي+ سماد المكموره أدى فى أغلب الاحيان لزيادة النمو الخضرى و الصفات المرتبطه بالنمو.

أدى استخدام النباتات الناميه فى التربه المعقمه مع سماد المكموره لأعلى زيادة للمحصول المــبكر و الكلى للثمار (٤,١٦ كجم /م٢) . بينما أقل النتائج كانت من المعامله بدون تعقيم شمسى مع إستخدام سماد المكموره (١,١٧ كجم /م٢).