# Effect of Soil Solarization and Bio-fertilization on Strawberry Production and pathogenic Fungi under Siwa Oases Conditions

**BY**

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**Doi:10.21608/asajs.2021.143516**

استلام البحث : ١٦ / ١١ /٢٠٢٠          قبول النشر : ٢ / ١٢ / ٢٠٢٠

**Abstract:**

The present study was carried out during the two successive seasons of 2017-2018 and 2018-2019 in the experimental station, desert research center at Siwa oasis, Marsa Matrouh Governorate to evaluate the effect of soil solarization and bio-fertilization on soil borne microorganisms, weed characters, growth, yield and quality of strawberry. The experiment included two solarization treatments (solarize and non-solarize) and five bio-fertilizers treatments (Bio-fertilizers alone, bio-fertilizers + 0.25 mineral fertilizers, bio-fertilizers + 0.5 mineral fertilizers, bio-fertilizers + 0.75 mineral fertilizers as well as the traditional treatment as a control. The results indicated that, soil solarization increased average soil temperature and eradicated most annual broad and narrow-leaved weeds, increased microorganisms population and reduced rotted fruit caused by pythium or phytophthora as well as increasing of strawberry growth early yield and yield. Traditional treatment produced the highest yield followed by bio-fertilizers treatments with 0.75, 0.50 and 0.25 percent of chemical fertilizers compared with bio-fertilzers alone. On the other hand, bio- fertilizers produced the highest fruit quality and gave the lowest values of rotted fruits.

**Kay wards:** Solarization, bio-fertilization, pathogen fungi, total bacteria, pythium and phytophthora.

## INTRODUCTION

Strawberry (*Fragaria x ananassa* Duch.) has been widely cultivated in Egypt. It is one of the most important vegetable crops for local consumption and exportation (planted area is about 11072 hectar and total production about 407240 Ton, **FAO, 2017).** Cultivated area in Egypt has been increasing in recent years especially due to the mediterranean climate, fertile soils, and geographic location which support high production, early and profitability of such a specialty crop **(Abd-Elgawad, 2019)**.

Soil-borne diseases cause heavy losses to strawberry production *i.e. Macrophomina phaseolina* and *Fusarium spp*. (**Benlioglu *et al.* 2014)**, *Phytophthora cactorum* , *P. citricola* and *Verticillium dahlia* **(Hartz *et al.*, 1993**), *Pythium and Rhizoctonia,* **(Camprubi *et al.*,2007)**. Also, **Embaby, 2007; Khafagi, 1982; Tadrous, 1991** and **Tarek, 2004** under Egyptian conditions found that, *Alternaria spp., Aspergillus spp., Botrytis cinerea, Rhizopus stolonifer, Rhizoctonia solani, Phytophthora cactorum, Fusarium spp., Penicillium spp.* And *Sclerotinia sclerotiorum* are the most fungal isolates causing strawberry fruit rots.

Soil solarization is a nonchemical soil disinfestation method which harnesses solar energy for heating the soil. It involves hydro-chemical processes leading to physical, chemical and biological changes in the soil, which take place during and even after the termination of solarization, **Katan (1998)**. Solarization is a potential alternative practice for soil fumigation which has been phased out due to its environmental risks, where, solarization controlled a wide range of fungal pathogens and weed pests **(Himelrick and Dozier, 1991; Katan, 1981; Katan and DeVay, 1991; Pullman *et al.*, 1981; Stapleton and DeVay, 1986 and Gomaa, 2008)**. In this respect, **De vay (1991)** reported that, solarization commonly targets mesophyllic organisms, which include most plant pathogens and pests, without destroyed the beneficial mycorrhizal fungi and the growth promoting (*Bacillus spp*.). So, the lethal effects are most pronounced on microorganisms which have not good soil competitors and many plant pathogens fall in to this group, since they tend to have specialized physiological requirements which are more adapted to co-existence with the host plant **(Stapleton, 1991)**. Soil solarization is an effective soil disinfestation technique for most vegetable crops **(Candido *et al.*,2008)**, especially strawberry production **(Hartz *et al*., 1993; Camprubi *et al*., 2007 and Domínguez *et al*., 2014).**

In the last twenty years, ecological farms have been used environmentally friendly agricultural practices to improve plants yield and fruit quality. A real challenge in ecological fruit production and agricultural sustainability is the reduction of chemical fertilization and chemical treatments for pests and disease control. In this direction, scientists actively search for good agricultural practices and compounds of natural origin that are natural adaptors and do not disturb plants ecological balance **(Vasil'eva *et al.*, 2005, Caulet *et al*., 2013 and Gomaa, *et al*., 2016).**

Bio-fertilization has been widely used, especially with vegetable crops vs lettuce **(El Massiry, 2009)**, globe artichoke **(Ibrahim, 2009)**, Jerusalem artichoke **(Hafez, 2013)** and thyme **(Attia *et al*., 2006)** and strawberry **(El-Miniawy *et al.*, 2014** and **Gomaa *et al.*, 2016)**. On potato**, Gomaa, (2008)** found that organic and bio-fertilization improve yield and enhance the efficacy of solarization and unfortunately beneficial microorganisms (bio-fertilizers) which needed to add after solrization.

It could be a particularly attractive practice for strawberry production in Siwa oasis area which located in the northern part of the western desert of Egypt, where's strawberry crop is grown as an annual, with a very warm summer fallow period (ideal conditions for solarization) followed by a fall planting through October and November. So, this study was undertaken to document the ability of soil solarization to control annual weeds and soil borne pathogens and its effect on productivity of strawberry plants treated with bio-fertilizers in the warmer planting area of Egypt.

## MATERIALS AND METHODS

The present study was carried out during the two successive seasons of 2017-2018 and 2018-2019 in the experimental station, desert research center at Siwa oasis, Marsa Matrouh Governorate to evaluate the effect of soil solarization and bio-fertilization on soil borne microorganisms, weed characters, growth, yield and quality of strawberry.

**Experimental design:**

During July, soil experiment was ploughed and divided into rows, each one have 1.m width and 10.5m length. Organic fertilizers, rock phosphate and rock potassium (Felsibar) were applied for all plots except the traditional treatment plots (control) where contain organic fertilizers, calcium super phosphate, ammonium sulphate and potassium sulphate as recommended, then fertilizers were incorporated in rows and levelled before trickle irrigation lines were installed.

Soil experiment irrigated abundantly then the trickle lines were removed and soil covered with clear poly ethylene traps of 60 micron thickness for about 6 weeks during August and September, while an untreated soil was used as a control. Soil temperatures were measured weekly during 6 weeks of solarization, then the polyethylene traps were removed and directly soil samples has taken from 0-15 cm depth to determine the densities of microorganisms (total counts of bacteria, fungi, and pathogen fungi). Fresh strawberry transplants cv. Festival were hand transplanted in 4 rows and 30 cm apart on the med. of October in two seasons, then bio-fertilizers which purchased from the general authority of agricultural funds and equalization, namely Biogen (a symbiotic nitrogen fixing bacteria), Phosphorin (phosphate solubilizing bacteria) and Potassumage (potassium solubilizing bacteria) were applied directly after transplanting and monthly during growth stages for all experiment except the traditional treatment plots.

The experimental design was split plot with 5 replicates. The plot area was 10.5 $m^2$ included 140 plants. Soil solarization was assessed in main plot while bio-fertilizers were assessed in sub plot. The experiment includes 10 treatments which were the combination between two solarization treatments (solarize and non-solarize) and five bio-fertilizers treatments (Bio-fertilizers alone, bio-fertilizers + 0.25 mineral fertilizers, bio-fertilizers +0.5 mineral fertilizers, bio- fertilizers + 0.75 mineral fertilizers as well as the traditional treatment as a control. The traditional treatment plots received 300 kg calcium super phosphate (15.5 % $P_2O_5$) applied during soil preparation then 300 kg ammonium nitrate (33.5 %), 50 kg phosphoric acid (85% $P_2O_5$) and 250 kg potassium sulfate (48.5 % $K_2O$) / feddan were divided into 10 equal parts and applied weekly through fertigation system during the growing season starting fifteen days transplanting later. Fertigation occurred four times every week and the bio treatments bio 4 (0.75%) , bio 3 (50%), bio 2 (0.25%) received the fertigation 3, 2, and 1 time every week respectively as well as no received for bio 1.

**Soil temperature**: during solarization period, soil temperatures at 0, 5, 10 and 15cm were recorded weekly during day hours at 8 am to 8 pm.

**Soil microorganisms**: soil samples were taken before and after solarization to determine total microbial counts using nutrient agar medium, PDA-Rose Bengal medium and PDA-PCNB medium to culture bacteria, total fungi and pathogen fungi, respectively. Samples were examined for total fungi and pathogen fungi using the dilution method **(Talyour, 1962)** and Plate count technique **(Johnson *et al*., 1959)**. Martine medium **Martine (1950)** and **Nash** and **Synder (1962)** were used to determine fungi and pathogen fungi respectively. Total bacteria was determined by using method of **Holt *et al*., (1994)**.

**Weed measurements**: during the second season broad and narrow-leaved were taken from a randomly quadratic meter after 4 and 8 weeks from transplanting to determine average number and total fresh weight.

**Growth characters**: Two weeks after transplanting, strawberry plants per plot were counted then survival ration were calculated. Six weeks after transplanting, randomly samples of 5 plants from each plot were taken to determine shoot high, shoot fresh weight and leaves number per plant.

**Yield components**: Strawberry fruits were harvested two times weekly during the growing seasons, counted, and weighed to calculate average fruit number and weight. The early yield per plant was determined as weights of all harvested fruits during the first five harvesting times. Total yield per plant was calculated.

**Fruit quality**: Twenty five fruits were randomly collected from each treatment in the middle of the growing seasons and fruit firmness was measured using Shatillon penetrometer. Soluble solid content (SSC) was determined by using digital refractometer (Abbe Leica model) and L ascorbic acid content was determined according to the methods described by **A.O.A.C. (2005)**.

**Disease incidence** Disease incidence was assessed as a total number of rotted fruits as compared with total fruits number from beginning to the end of harvesting time in all treatments.

The diseases of fruits were separated according to different symptoms: gray mold (*Botrytis cinerea*) and dry rot (*Rhizoctonia solani*). Number of fruits in each group were counted and total fruit rot numbers was counted, then the lost yield was calculated.

**Statistical analysis**: Data were subjected to statistical analysis by M-STAT C **(Russell, 1991)**. The differences among means were performed using least significant difference (LSD) at 5% level.

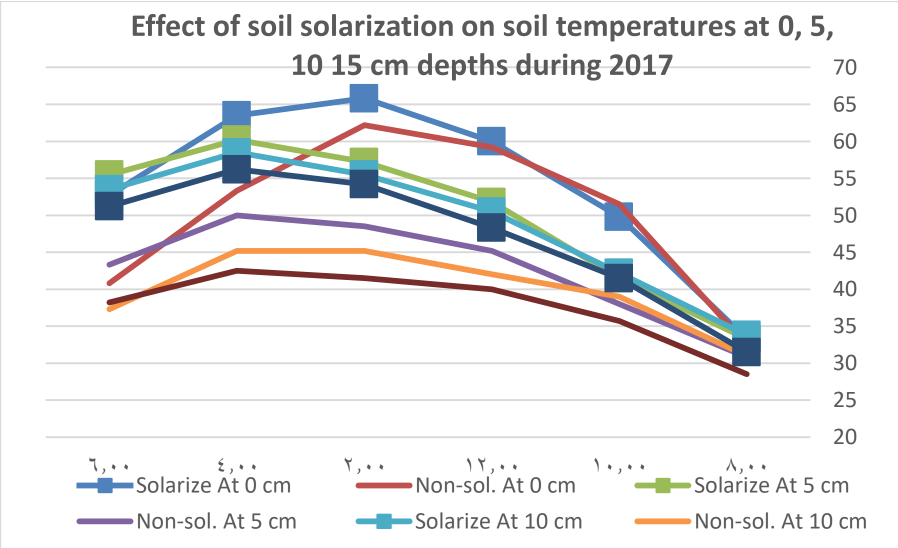
## RESULTS AND SISCUSSION

**Soil temperatures:** Temperature reading daily recorded every two hours at day time (8 am to 6 pm) ones every week during solarization period at four depths 0, 5, 10, and 15 cm (Fig 1). An increasing in the temperature of solarized soil was observed up to a maximum of 63.8 and 60.2 c$^{o}$ at 2 pm for soil surface compared to 60.2 and 56.6 c$^{o}$ for non-solarized soil surface in first and second seasons respectively. High temperatures at 5 cm depth were 57.2 and 55.8 at 4 pm in solarized plots compared with 49.0 and 49.2 for non-solarized at the same time and depth in two seasons respectively. At 10 and 15 cm depths solarized soil plots recorded (55.5, 54.2) and (52.4, 50.4) at 4 pm in the first and second season, while temperatures in non-solarize treatment recorded (44.2, 41.5) and (41.2, 40.0 c$^{o}$ for first and second season respectively. From the previous data, it was clearly that, covering soil with transparent plastic traps raised the average absolute soil temperatures at the four depths with an increment values (3.6, 8.2, 11.3 and 11.2 c$^{o}$) and (3.6, 6.6, 12.7 and 10.4) compared with bare soil in the first and second seasons respectively. Although maximum soil temperature decreased with increasing soil depth at all, the deferent between solarize treatments increased with increasing soil depth (Fig. 1). These results are similar with results obtained by other investigators

**(Bicici *et al.*,2000; Campiglia *et al.*,2000; Shukla *et al.*, 2000; Peachey *et al.*, 2001; Rieger *et al.*,2001)**.

**Soil microorganisms:** Data presented in Table (1) showed, total fungi, total bacteria and pathogen fungi before and justly after solarization treatment. Population of microbes at 15 cm of soil depth drastically reduced with solarize treatments compared with non-solarize. The reduction percentages were 72.37, 87.08 and 92.66 percent for total fungi, total bacteria and pathogen fungi respectively. **Similar results were found by Triki *et al.*, (2001); Hamada, (2002); El-Sheshtawy (2006) and Gomaa, (2008).**

Regarding bio-fertilization effect and development of total fungi, total bacteria and pathogen fungi counts throughout planting season, data presented in table (2) showed that, population of all microorganisms was relatively higher at end of season (April) compared with it at transplanting (October). Also, its counts with non-solarize treatment was higher than solarize. The most pronounced effect was pathogen fungi count, which increased on April compared with October and drastically decreased with solarization compared with non-solarization. Total count of bacteria sharply increased with solarization on April samples compared with October samples. It may be worth to mention that**,** most increment of bacteria population with solarization belonged to bio-fertilizers supplied which considered a beneficial organisms. From the previous data, we notice that, decreasing of soil microorganisms after solarization may be due to chemical and microbial activities, which led to generation of toxic compounds in vapor and liquid phases and consequently accumulate under plastic mulch especially near soil surface which in turn become more effective against soil flora **(Gamliel *et al.*, 2000)**. The effect of solarization was most pronounced on mesophyllic group which include most plant pathogens and pests **(Abu-Gharbieh, 1998)**. While most beneficial organisms belonged to thermophyllic group which can be survive and even flourish under solarization **(De Vay and Stapleton 1998)**.



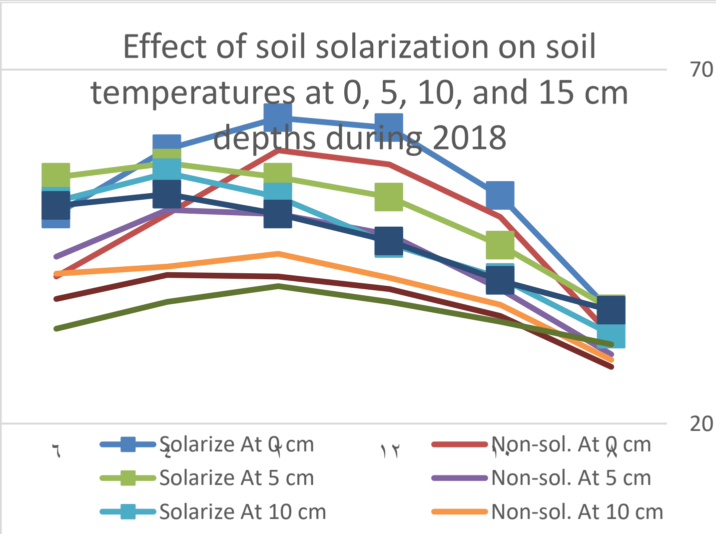



**Figure (1) Effect of solarization on soil temperatures at soil surface, 5 cm, 10 cm and 15 cm depth during 2017 and 2018 seasons.**

**Table (1): Effect of soil solarization on total count of fungi, bacteria and pathogen fungi (CFU/ g dry) pre and post solarization treatment (on July and September) at 15 cm depth.**

| | | Total Fungi ($10^4$) | Total Bacteria ($10^6$) | Pathogen Fungi ($10^4$) |
|---|---|---|---|---|
| **Solarize** | Before (July) | 188.35 | ٣٢٥,٨٦ | **12.64** |
| | After (September | ٥٤,٥٢ | ٤٤,٢٥ | ١,٣٧ |
| **Non-Solarize** | Before (July) | ١٨٤,٦٥ | ٣٣١,٣٤ | ١٢,٣٨ |
| | After (September | ١٩٧,٣١ | ٣٤٢,٣٦ | ١٨,٦٧ |

**Table (2): Effect of soil solarization, bio-fertilization and interaction on total count of fungi, bacteria and pathogen fungi (CFU, g dry) on October and April.**

| | | October (at transplanting) | | | April (end of season) | | |
|---|---|---|---|---|---|---|---|
| **Solarization** | | Total fungi ($10^4$) | Total bacteria ($10^6$) | Pathogen fungi ($10^4$) | Total fungi ($10^4$) | Total bacteria ($10^6$) | Pathogen fungi ($10^4$) |
| **Solarize** | Bio 1 | 53.5 | 43.18 | 1.61 | 47.5 | 268.22 | 4.36 |
| | Bio 2 | 48.3 | 44.42 | 1.64 | 45.5 | 261.15 | 3.38 |
| | Bio 3 | 47.5 | 44.51 | 2.11 | 44.3 | 255.57 | 3.68 |
| | Bio 4 | 46.3 | 46.41 | 1.34 | 46.6 | 214.38 | 3.92 |
| | Bio 5 | 45.7 | 45.13 | 1.67 | 52.4 | 86.47 | 6.18 |
| **Non-Solarize** | Bio 1 | 188.3 | 327.41 | 16.41 | 174.5 | 338.14 | 22.14 |
| | Bio 2 | 185.4 | 335.18 | 14.32 | 177.3 | 347.65 | 24.35 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Bio 3 | 178.3 | 312.08 | 16.42 | 178.6 | 365.15 | 24.22 |
| | Bio 4 | 185.6 | 314.21 | 17.17 | 178.6 | 344.81 | 22.35 |
| | Bio 5 | 188.4 | 315.42 | 16.54 | 214.5 | 317.45 | 26.15 |
| **L.S.D at 0.05 for solarization** | | 15.1 | 16.2 | 1.62 | 5.11 | 44.46 | 1.23 |
| **L.S.D at 0.05 for fertilization** | | N.S | N.S | N.S | 3.27 | 16.81 | 1.34 |
| **L.S.D at 0.05 for interaction** | | N.S | N.S | N.S | 4.62 | 23.77 | N.S |

**Weeds control:** The effect of soil solarization, bio-fertilization and their interaction on broad and narrow leaved numbers and fresh weight after four and eight weeks during 2017 growing season are presented in Table (3). Solarization significantly decreased broad-leaved and narrow-leaved numbers and fresh weight compared with non-solarize treatment. On other hand, fertilization treatment and interaction did not have significant effect except broad and narrow-leaved fresh weight after eight weeks from transplanting. Conventional fertilizer treatment produced heaviest, followed by bio 4, bio 3 and bio 2 treatments for broad-leaved or bio 4 and bio 3 for narrow-leaved as compared with bio 1 or bio 1 and bio 2 for broad and narrow-leaved respectively. Concerning interaction effect, conventional fertilizer treatment with non-solarize produced the heaviest broad and narrow-leaved fresh weight after eight weeks compared with other treatments. The most pronounced decreased weeds weight obtained when soil solarized with all fertilizer treatments or with bio 1 and bio 2 for broad and narrow-leaved respectively. Our results indicated that, soil solarization with clear poly ethylene has strong effect on weed germination, as well as fresh weight of broad and narrow-leaved weed after four and eight weeks (Table 3). The reducing of weed number and weight attributed to raising the temperature of soil to lethal levels for weed seed germination **(De Vay and stapleton, 1998)** or attributed to chemical, physical and biological changes which caused in the soil that provide effective management of weed control **(Abu-Gharbieh, 1998).** Moreover, we noticed that, increasing narrow- leaved weed numbers compared with broad-leaved after four and eight weeks as well as increasing number and weight of total weeds in general after eight weeks compared with four weeks. These results may be due to that, narrow-leaved seed weed is more tolerant and adapted to lethal effect of high temperature and relatively removing solarisation effect after eight weeks as compared with four weeks. Similar results were obtained by **(Hamada, 2002 and El-Sheshtawy, 20006)**.

**Table: (3) Effect of soil solarization and bio-fertilization on number and fresh weight of broad-leaved and narrow-leaved at 4 and 8 weeks after transplanting, 2018 season).**

| Characters | Broad-leaved weeds No | | Narrow-leaved weeds No | | Broad-leaved weeds fresh weight | | Narrow-leaved weeds fresh weight | |
|---|---|---|---|---|---|---|---|---|
| **Seasons** | **4 weeks** | **8 weeks** | **4 weeks** | **8 weeks** | **4 weeks** | **8 weeks** | **4 weeks** | **8 weeks** |
| | | | | **Solarization** | | | | |
| **Solarize** | 1.80 | ٤,٧٢ | ٤,٢٦ | ٧,٤٣ | ١١٧,٠٩ | ٢٢١,٨٤ | ٤٦,٨٤ | ١١٢,٠٩ |
| **Non-solarize** | 13.02 | ٣٩,١٠ | ٤١,٣٠ | ٦٩,٩١ | ٥٧٢,٦٧ | ١٦٩٨,٧٢ | ٣٧١,٦٩ | ١٠٤٦,١٠ |
| **LSD at 0.05** | **1.20** | ١٠,١ | ٣,٢٦ | ٨,٣٧ | ٤٥,٢٣ | ٣٩٢,٢٠ | ٨٣,٤٣ | ٩٩,٢١ |
| | | | | **Bio-fertilization** | | | | |
| **Bio-1** | ٧,٠٢ | 20.46 | 21.85 | 35.30 | 327.36 | 724.80 | 200.11 | **317.66** |
| **Bio-2** | ٧,٦٢ | 22.62 | 22.74 | 37.60 | 356.01 | 880.94 | 209.36 | **338.37** |
| **Bio-3** | ٧,٥٤ | 22.69 | 24.18 | 42.00 | 351.01 | 986.49 | 221.97 | **629.98** |
| **Bio-4** | ٧,٤٢ | 22.33 | 23.10 | 39.61 | 345.23 | 989.38 | 212.42 | **665.91** |
| **Bio-5** | ٧,٤٥ | 21.45 | 22.03 | 38.84 | 344.80 | 1219.80 | 202.46 | **943.57** |
| **LSD at 0.05** | **N.S** | **N.S** | **N.S** | **N.S** | **N.S** | ١٧٣,٤٧ | **N.S** | ٥٧,٤١ |
| | | | | **Interaction** | | | | |
| **Solarize** | ١,٧٧ | 4.50 | 3.49 | 7.04 | 114.83 | 211.66 | 38.39 | **63.39** |
| | ١,٩٦ | 4.75 | 4.71 | 7.64 | 127.40 | 223.25 | 51.81 | **68.79** |
| | ١,٨٣ | 5.34 | 4.38 | 7.38 | 119.17 | 250.98 | 48.14 | **110.65** |
| | ١,٨١ | 4.62 | 4.49 | 7.49 | 117.43 | 217.30 | 49.39 | **112.35** |
| | ١,٦٤ | 4.38 | 4.22 | 7.60 | 106.60 | 206.02 | 46.46 | **205.29** |
| **Non-solarize** | ١٢,٢٧ | 36.41 | 40.20 | 63.55 | 539.88 | 1237.94 | 361.83 | **571.92** |
| | ١٣,٢٩ | 40.49 | 40.77 | 67.55 | 584.61 | 1538.62 | 366.90 | **607.95** |
| | ١٣,٢٥ | 40.05 | 43.98 | 76.62 | 582.85 | 1722.01 | 395.79 | **1149.30** |
| | ١٣,٠٢ | 40.03 | 41.72 | 71.73 | 573.03 | 1761.47 | 375.45 | **1219.47** |
| | ١٣,٢٥ | 38.51 | 39.83 | 70.08 | 583.00 | 2233.58 | 358.47 | **1681.84** |
| **LSD at 0.05** | N.S | N.S | N.S | N.S | N.S | ٢٤٥,٣٣ | N.S | ٨١,١٨ |
| **Characters** | Broad-leaved weeds No | | Narrow-leaved weeds No | | Broad-leaved weeds fresh weight | | **Narrow-leaved weeds fresh weight** | |
| **Seasons** | **4 weeks** | **8 weeks** | **4 weeks** | **8 weeks** | **4 weeks** | **8 weeks** | **4 weeks** | **8 weeks** |
| | | | | **Solarization** | | | | |
| **Solarize** | 1.80 | ٤,٧٢ | ٤,٢٦ | ٧,٤٣ | ١١٧,٠٩ | ٢٢١,٨٤ | ٤٦,٨٤ | ١١٢,٠٩ |
| **Non-solarize** | 13.02 | ٣٩,١٠ | ٤١,٣٠ | ٦٩,٩١ | ٥٧٢,٦٧ | ١٦٩٨,٧٢ | ٣٧١,٦٩ | ١٠٤٦,١٠ |
| **LSD at 0.05** | **1.20** | ١٠,١ | ٣,٢٦ | ٨,٣٧ | ٤٥,٢٣ | ٣٩٢,٢٠ | ٨٣,٤٣ | ٩٩,٢١ |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | **Bio-fertilization** | | | | |
| **Bio-1** | ٧,٠٢ | 20.46 | 21.85 | 35.30 | 327.36 | 724.80 | 200.11 | **317.66** |
| **Bio-2** | ٧,٦٢ | 22.62 | 22.74 | 37.60 | 356.01 | 880.94 | 209.36 | **338.37** |
| **Bio-3** | ٧,٥٤ | 22.69 | 24.18 | 42.00 | 351.01 | 986.49 | 221.97 | **629.98** |
| **Bio-4** | ٧,٤٢ | 22.33 | 23.10 | 39.61 | 345.23 | 989.38 | 212.42 | **665.91** |
| **Bio-5** | ٧,٤٥ | 21.45 | 22.03 | 38.84 | 344.80 | 1219.80 | 202.46 | **943.57** |
| **LSD at 0.05** | **N.S** | **N.S** | **N.S** | **N.S** | **N.S** | **١٧٣,٤٧** | **N.S** | **٥٧,٤١** |
| | | | | **Interaction** | | | | |
| **Solarize** | ١,٧٧ | 4.50 | 3.49 | 7.04 | 114.83 | 211.66 | 38.39 | **63.39** |
| | ١,٩٦ | 4.75 | 4.71 | 7.64 | 127.40 | 223.25 | 51.81 | **68.79** |
| | ١,٨٣ | 5.34 | 4.38 | 7.38 | 119.17 | 250.98 | 48.14 | **110.65** |
| | ١,٨١ | 4.62 | 4.49 | 7.49 | 117.43 | 217.30 | 49.39 | **112.35** |
| | ١,٦٤ | 4.38 | 4.22 | 7.60 | 106.60 | 206.02 | 46.46 | **205.29** |
| **Non-solarize** | ١٢,٢٧ | 36.41 | 40.20 | 63.55 | 539.88 | 1237.94 | 361.83 | **571.92** |
| | ١٣,٢٩ | 40.49 | 40.77 | 67.55 | 584.61 | 1538.62 | 366.90 | **607.95** |
| | ١٣,٢٥ | 40.05 | 43.98 | 76.62 | 582.85 | 1722.01 | 395.79 | **1149.30** |
| | ١٣,٠٢ | 40.03 | 41.72 | 71.73 | 573.03 | 1761.47 | 375.45 | **1219.47** |
| | ١٣,٢٥ | 38.51 | 39.83 | 70.08 | 583.00 | 2233.58 | 358.47 | **1681.84** |
| **LSD at 0.05** | **N.S** | **N.S** | **N.S** | **N.S** | **N.S** | **٢٤٥,٣٣** | **N.S** | ٨١,١٨ |

**Vegetative growth**: Effect of soil solarization, ferttization treatments and their interaction on transplant survival ratio, leaves number, plant height and plant fresh weight are presented in Table (4). Transplant survival ratio significantly affected by solarization treatment compared with non-solarize treatment, while fertilization treatments or interactions effects were not significant in both seasons.

Concerning vegetative growth characters, data in table 4 showed that, soil solarization affected positively on strawberry plant height and plant fresh weight compared with non- solarize treatment. While its effects on leaves number was not significant. All vegetative growth characters significantly affected by fertilization treatments. Conventional fertilizer produced the highest leaves number, highest plant height and weightiest plants followed by bio 4 treatment compared with bio 1 which produced the lowest values in this respect, followed by bio 2 and bio 3 in both seasons. Regarding to interaction, data showed non-significant effects on vegetative growth characters except plant fresh weight character, since conventional fertilizer treatment with solarization gave the heaviest plant fresh weight compared with bio 1 fertilizer with non-solarize treatment in both seasons.

**Table: (4) Effect of soil solarization and bio-fertilization on plants survival ratio, average leaves number, plant height and fresh weight of strawberry plants, 8 weeks after transplanting**.

| Characters | Survival ratio | | Leaves No. | | Plant height (cm) | | Plant fresh weight (g) | |
|---|---|---|---|---|---|---|---|---|
| Seasons | 1St Season | 2nd Season | 1St Season | 2nd Season | 1St Season | 2nd Season | 1St Season | 2nd Season |
| **Solarization** | | | | | | | | |
| Solarize | ٩٣,٠٣ | ٩٢,٦٧ | ٨,٧٠ | ٨,٥٤ | ١٥,٢٢ | ١٥,٠٧ | ٣٥,١٠ | ٣٦,٤٥ |
| Non-solarize | ٧٨,٤٦ | ٧٦,٢٤ | ٨,٢٢ | ٨,١٥ | ١٣,٥٦ | ١٤,١٠ | ٢٨,٧٥ | 32.73 |
| LSD at 0.05 | ١,٤٨ | ١,٢٨ | N.S | N.S | ١,٢٦ | ٠,١٨ | ١,٧٢ | ١,٩٧ |
| **Bio-fertilization** | | | | | | | | |
| Bio-1 | 85.12 | 84.05 | 7.41 | 7.04 | 13.16 | 13.16 | 27.20 | 30.71 |
| Bio-2 | 86.38 | 84.40 | 7.87 | 7.77 | 13.52 | 13.64 | 28.63 | 33.56 |
| Bio-3 | 85.36 | 84.40 | 8.37 | 8.47 | 14.72 | 15.04 | 33.66 | 34.72 |
| Bio-4 | 85.95 | 83.33 | 9.28 | 9.03 | 15.32 | 15.37 | 34.61 | 36.49 |
| Bio-5 | 85.92 | 86.07 | 9.36 | 9.42 | 15.24 | 15.73 | 35.53 | 37.47 |
| LSD at 0.05 | N.S | N.S | 0.48 | ٠,٢٣ | 0.62 | 0.76 | 1.05 | ٠,٨٨ |
| **Interaction** | | | | | | | | |
| Solarized | 91.67 | 93.81 | 7.73 | 7.11 | 14.10 | 13.90 | 31.44 | 34.06 |
| | 93.00 | 92.38 | 8.07 | 8.00 | 14.39 | 14.35 | 33.32 | 35.44 |
| | 93.33 | 93.33 | 8.55 | 8.62 | 15.41 | 15.40 | 35.47 | 36.16 |
| | 94.05 | 90.00 | 9.55 | 9.31 | 16.21 | 15.75 | 36.95 | 37.94 |
| | 93.10 | 93.81 | 9.59 | 9.66 | 16.00 | 15.97 | 38.33 | 38.66 |
| Non-solarized | 78.57 | 74.29 | 7.09 | 6.98 | 12.23 | 12.41 | 22.96 | 27.36 |
| | 79.76 | 76.43 | 7.67 | 7.54 | 12.64 | 12.93 | 23.93 | 31.69 |
| | 77.38 | 75.48 | 8.18 | 8.32 | 14.03 | 14.67 | 31.85 | 33.29 |
| | 77.86 | 76.67 | 9.01 | 8.74 | 14.42 | 14.98 | 32.27 | 35.03 |
| | 78.74 | 78.33 | 9.13 | 9.17 | 14.48 | 15.48 | 32.73 | 36.28 |
| LSD at 0.05 | N.S | N.S | N.S | N.S | N.S | N.S | ١,٤٩ | ١,٢٤ |


| Characters | Survival ratio | | Leaves No. | | Plant height (cm) | | Plant fresh weight (g) | |
|---|---|---|---|---|---|---|---|---|
| Seasons | 1St Season | 2nd Season | 1St Season | 2nd Season | 1St Season | 2nd Season | 1St Season | 2nd Season |
| **Solarization** | | | | | | | | |
| Solarize | ٩٣,٠٣ | ٩٢,٦٧ | ٨,٧٠ | ٨,٥٤ | ١٥,٢٢ | ١٥,٠٧ | ٣٥,١٠ | ٣٦,٤٥ |
| Non-solarize | ٧٨,٤٦ | ٧٦,٢٤ | ٨,٢٢ | ٨,١٥ | ١٣,٥٦ | ١٤,١٠ | ٢٨,٧٥ | 32.73 |
| LSD at 0.05 | ١,٤٨ | ١,٢٨ | N.S | N.S | ١,٢٦ | ٠,١٨ | ١,٧٢ | ١,٩٧ |
| **Bio-fertilization** | | | | | | | | |
| Bio-1 | 85.12 | 84.05 | 7.41 | 7.04 | 13.16 | 13.16 | 27.20 | 30.71 |
| Bio-2 | 86.38 | 84.40 | 7.87 | 7.77 | 13.52 | 13.64 | 28.63 | 33.56 |
| Bio-3 | 85.36 | 84.40 | 8.37 | 8.47 | 14.72 | 15.04 | 33.66 | 34.72 |
| Bio-4 | 85.95 | 83.33 | 9.28 | 9.03 | 15.32 | 15.37 | 34.61 | 36.49 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Bio-5** | 85.92 | 86.07 | 9.36 | 9.42 | 15.24 | 15.73 | 35.53 | **37.47** |
| **LSD at 0.05** | **N.S** | **N.S** | **0.48** | ٠,٢٣ | **0.62** | **0.76** | **1.05** | ٠,٨٨ |
| **Interaction** | | | | | | | | |
| **Solarized** | 91.67 | 93.81 | 7.73 | 7.11 | 14.10 | 13.90 | 31.44 | **34.06** |
| | 93.00 | 92.38 | 8.07 | 8.00 | 14.39 | 14.35 | 33.32 | **35.44** |
| | 93.33 | 93.33 | 8.55 | 8.62 | 15.41 | 15.40 | 35.47 | **36.16** |
| | 94.05 | 90.00 | 9.55 | 9.31 | 16.21 | 15.75 | 36.95 | **37.94** |
| | 93.10 | 93.81 | 9.59 | 9.66 | 16.00 | 15.97 | 38.33 | **38.66** |
| **Non-solarized** | 78.57 | 74.29 | 7.09 | 6.98 | 12.23 | 12.41 | 22.96 | **27.36** |
| | 79.76 | 76.43 | 7.67 | 7.54 | 12.64 | 12.93 | 23.93 | **31.69** |
| | 77.38 | 75.48 | 8.18 | 8.32 | 14.03 | 14.67 | 31.85 | **33.29** |
| | 77.86 | 76.67 | 9.01 | 8.74 | 14.42 | 14.98 | 32.27 | **35.03** |
| | 78.74 | 78.33 | 9.13 | 9.17 | 14.48 | 15.48 | 32.73 | **36.28** |
| **LSD at 0.05** | N.S | N.S | N.S | N.S | N.S | N.S | ١,٤٩ | ١,٢٤ |
| **Characters** | Survival ratio | | Leaves No. | | Plant height (cm) | | **Plant fresh weight (g)** | |
| **Seasons** | **1st Season** | **2nd Season** | **1st Season** | **2nd Season** | **1st Season** | **2nd Season** | **1st Season** | **2nd Season** |
| **Solarization** | | | | | | | | |
| **Solarize** | ٩٣,٠٣ | ٩٢,٦٧ | ٨,٧٠ | ٨,٥٤ | ١٥,٢٢ | ١٥,٠٧ | ٣٥,١٠ | ٣٦,٤٥ |
| **Non-solarize** | ٧٨,٤٦ | ٧٦,٢٤ | ٨,٢٢ | ٨,١٥ | ١٣,٥٦ | ١٤,١٠ | ٢٨,٧٥ | **32.73** |
| **LSD at 0.05** | ١,٤٨ | ١,٢٨ | **N.S** | **N.S** | ١,٢٦ | ٠,١٨ | ١,٧٢ | ١,٩٧ |
| **Bio-fertilization** | | | | | | | | |
| **Bio-1** | 85.12 | 84.05 | 7.41 | 7.04 | 13.16 | 13.16 | 27.20 | **30.71** |
| **Bio-2** | 86.38 | 84.40 | 7.87 | 7.77 | 13.52 | 13.64 | 28.63 | **33.56** |
| **Bio-3** | 85.36 | 84.40 | 8.37 | 8.47 | 14.72 | 15.04 | 33.66 | **34.72** |
| **Bio-4** | 85.95 | 83.33 | 9.28 | 9.03 | 15.32 | 15.37 | 34.61 | **36.49** |
| **Bio-5** | 85.92 | 86.07 | 9.36 | 9.42 | 15.24 | 15.73 | 35.53 | **37.47** |
| **LSD at 0.05** | **N.S** | **N.S** | **0.48** | ٠,٢٣ | **0.62** | **0.76** | **1.05** | ٠,٨٨ |
| **Interaction** | | | | | | | | |
| **Solarized** | 91.67 | 93.81 | 7.73 | 7.11 | 14.10 | 13.90 | 31.44 | **34.06** |
| | 93.00 | 92.38 | 8.07 | 8.00 | 14.39 | 14.35 | 33.32 | **35.44** |
| | 93.33 | 93.33 | 8.55 | 8.62 | 15.41 | 15.40 | 35.47 | **36.16** |
| | 94.05 | 90.00 | 9.55 | 9.31 | 16.21 | 15.75 | 36.95 | **37.94** |
| | 93.10 | 93.81 | 9.59 | 9.66 | 16.00 | 15.97 | 38.33 | **38.66** |
| **Non-solarized** | 78.57 | 74.29 | 7.09 | 6.98 | 12.23 | 12.41 | 22.96 | **27.36** |
| | 79.76 | 76.43 | 7.67 | 7.54 | 12.64 | 12.93 | 23.93 | **31.69** |
| | 77.38 | 75.48 | 8.18 | 8.32 | 14.03 | 14.67 | 31.85 | **33.29** |
| | 77.86 | 76.67 | 9.01 | 8.74 | 14.42 | 14.98 | 32.27 | **35.03** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 78.74 | 78.33 | 9.13 | 9.17 | 14.48 | 15.48 | 32.73 | **36.28** |
| **LSD at 0.05** | N.S | N.S | N.S | N.S | N.S | N.S | ١,٤٩ | ١,٢٤ |
| **Characters** | Survival ratio | | Leaves No. | | Plant height (cm) | | **Plant fresh weight (g)** | |
| **Seasons** | **1St Season** | **2nd Season** | **1St Season** | **2nd Season** | **1St Season** | **2nd Season** | **1St Season** | **2nd Season** |
| **Solarization** | | | | | | | | |
| **Solarize** | ٩٣,٠٣ | ٩٢,٦٧ | ٨,٧٠ | ٨,٥٤ | ١٥,٢٢ | ١٥,٠٧ | ٣٥,١٠ | ٣٦,٤٥ |
| **Non-solarize** | ٧٨,٤٦ | ٧٦,٢٤ | ٨,٢٢ | ٨,١٥ | ١٣,٥٦ | ١٤,١٠ | ٢٨,٧٥ | **32.73** |
| **LSD at 0.05** | ١,٤٨ | ١,٢٨ | **N.S** | **N.S** | ١,٢٦ | ٠,١٨ | ١,٧٢ | ١,٩٧ |
| **Bio-fertilization** | | | | | | | | |
| **Bio-1** | 85.12 | 84.05 | 7.41 | 7.04 | 13.16 | 13.16 | 27.20 | **30.71** |
| **Bio-2** | 86.38 | 84.40 | 7.87 | 7.77 | 13.52 | 13.64 | 28.63 | **33.56** |
| **Bio-3** | 85.36 | 84.40 | 8.37 | 8.47 | 14.72 | 15.04 | 33.66 | **34.72** |
| **Bio-4** | 85.95 | 83.33 | 9.28 | 9.03 | 15.32 | 15.37 | 34.61 | **36.49** |
| **Bio-5** | 85.92 | 86.07 | 9.36 | 9.42 | 15.24 | 15.73 | 35.53 | **37.47** |
| **LSD at 0.05** | **N.S** | **N.S** | **0.48** | ٠,٢٣ | **0.62** | **0.76** | **1.05** | ٠,٨٨ |
| **Interaction** | | | | | | | | |
| **Solarized** | 91.67 | 93.81 | 7.73 | 7.11 | 14.10 | 13.90 | 31.44 | **34.06** |
| | 93.00 | 92.38 | 8.07 | 8.00 | 14.39 | 14.35 | 33.32 | **35.44** |
| | 93.33 | 93.33 | 8.55 | 8.62 | 15.41 | 15.40 | 35.47 | **36.16** |
| | 94.05 | 90.00 | 9.55 | 9.31 | 16.21 | 15.75 | 36.95 | **37.94** |
| | 93.10 | 93.81 | 9.59 | 9.66 | 16.00 | 15.97 | 38.33 | **38.66** |
| **Non-solarized** | 78.57 | 74.29 | 7.09 | 6.98 | 12.23 | 12.41 | 22.96 | **27.36** |
| | 79.76 | 76.43 | 7.67 | 7.54 | 12.64 | 12.93 | 23.93 | **31.69** |
| | 77.38 | 75.48 | 8.18 | 8.32 | 14.03 | 14.67 | 31.85 | **33.29** |
| | 77.86 | 76.67 | 9.01 | 8.74 | 14.42 | 14.98 | 32.27 | **35.03** |
| | 78.74 | 78.33 | 9.13 | 9.17 | 14.48 | 15.48 | 32.73 | **36.28** |
| **LSD at 0.05** | **N.S** | **N.S** | **N.S** | **N.S** | **N.S** | **N.S** | ١,٤٩ | ١,٢٤ |

These results indicated that, the changes in soil properties due to solarization may have positive effect vegetative growth characters of strawberry plants, in addition that, soil temperature effects, soil microorganisms and weed control revealed, solarization caused beneficial conditions such as enhancement of soil physiology properties, availability of nutrients, weed eradication, inhibition of pathogens and stimulation of beneficial microorganisms which were add as a bio-fertilizers **(Stapleton,**

**1991; Hartz *et al*., 1993; Camprubi *et al*., 2007)**. However, conventional treatment produced the vigorous plants compared with other treatments especially bio-1 and bio-2 which received least amount of chemical fertilizers and consequently gave lowest vegetative growth. Similar results were found by **(El-Miniawy *et al.*, 2014** and **Gomaa *et al.*, 2016)**.

**Yield and its component:**

Data presented in Table (5) showed that, soil solarization and bio-fertilization significantly affected on early yield per plant, total yield per plant, total yield per plot and average fruit weight in both season, while interaction effects were not significant except early yield character in both seasons. Soil solarization increased early yield, total yield per plant, total yield per plot and average fruit weight as compared with non-solarize treatment in both seasons. Conventional fertilization and bio-4 treatments gave the highest early and total yield per plant followed by bio-3 compared with bio-1 treatment, which gave the lowest values in this respect. Also, conventional treatment significantly increased total yield per plot and average fruit weight followed by bio-4 then bio-3 treatment compared with bio-1 which gave the lowest values followed by bio-2 in both seasons. Regarding interaction effect on early yield, conventional and bio-4 with solarization produced the highest significant early yield compared with bio-1 with solarize or non-solarize in both seasons. Generally, solarization enhanced strawberry yield characters and the increment was most pronounced with increasing chemical fertilizer rate by one hundred percent and three quarter. Also, solarization superiority was evident on total yield per plot compared with other characters may be due to it's a positive effects on plants survival ratio, fruits rot percent and weeds growth suppression and consequently absent the competition especially at the early growing stage. In order to that, strawberry plants had advantage to increasing growth compared with non-solarize treatment. These results indicated that, the changing in soil properties resulted from solarization may have a positive effect on transplants standing and improve its survival which resulted more plants per unit area **(Candido *et al.*,2008)**, improvement vegetative growth **(Porras *et al*., 2007).** Our previus data on soil temperatures, soil microorganisms and weed control (Tables 1,2,3 and 4) revealed that, solarization caused a good conditions such as improving chemical and physical properties and availability of nutrients, eradication of annual weeds as well as inhibition of pathogens and stimulation of beneficial microorganisms. This conditions led stimulate strawberry growth especially at early stages and consequently increased growth, early yield and total yield of strawberry (**Domínguez *et al.*, 2014 and Ozyilmaz *et al*., 2016)**. Moreover, adding bio fertilizers relatively enhanced soil population of microorganism at end of season compared with transplanting time, where, the most counts of microorganisms in solarized plots belonged to beneficial groups **(Stapleton, 1991)**. So, adding bio-fertilizers enhance the efficacy of solarization and gave unfortunately for beneficial microorganisms (bio-fertilizers) to living and flourish **(Gomaa, (2008)**. Increasing strawberry growth

and yield and enhancement of its fruit quality were reported by many researchers **(El-Miniawy *et al.*, 2014 and Gomaa *et al.*, 2016).**

**Table: (5) Effect of soil solarization and bio-fertilization on average fruit weight, early yield/plant, total yield/plant and total yield/plot of strawberry plants.**

| Characters | Average fruit weight (g) | | Early yield/plant (g) | | Total yield/plant (g) | | Total yield/plot (kg) | |
|---|---|---|---|---|---|---|---|---|
| **Seasons** | **1St Season** | **2nd Season** | **1St Season** | **2nd Season** | **1St Season** | **2nd Season** | **1St Season** | **2nd Season** |
| | | | | **Solarization** | | | | |
| **Solarize** | ١٢,٢٩ | ١٢,٤٢ | ٢١٠,٩ | ٢٢٥,٦ | ٤١٦,٦ | ٤٢٢,٢ | ٥٤,٠٤ | ٥٤,٣٣ |
| **Non-solarize** | ١٠,٨٣ | ١١,٢٠ | ١٧٤,١ | ١٨٣,٨ | ٣٧٠,٤ | ٣٨٤,٥ | ٣٩,٥٧ | ٣٩,٥٠ |
| **LSD at 0.05** | ٠,١٥٤ | ٠,٤٢ | ١٢,٢ | ١٤,٦ | ٢٦,٨ | ٢٥,٩ | ٣,٨٧ | ٢,٢٥ |
| | | | | **Bio-fertilization** | | | | |
| **Bio-1** | 9.67 | 9.79 | 152.8 | 172.5 | 324.7 | 336.7 | 38.58 | **38.51** |
| **Bio-2** | 10.86 | 11.16 | 187.8 | 203.2 | 367.5 | 377.9 | 44.20 | **44.32** |
| **Bio-3** | 11.81 | 12.06 | 196.7 | 208.3 | 391.7 | 405.0 | 46.48 | **47.41** |
| **Bio-4** | 12.28 | 12.61 | 208.4 | 215.0 | 427.5 | 439.8 | 50.80 | **50.43** |
| **Bio-5** | 13.19 | 13.42 | 216.6 | 224.7 | 456.1 | 457.1 | 53.87 | **53.91** |
| **LSD at 0.05** | **0.48** | ٠,٥٧ | **8.6** | ١٢,٥ | ١٤,٤ | **24.9** | **2.27** | ٢,٩٧ |
| | | | | **Interaction** | | | | |
| **Solarize** | 10.50 | 10.16 | 155.3 | 175.3 | 341.8 | 341.1 | 43.67 | **44.63** |
| | 11.63 | 11.96 | 206.9 | 224.4 | 386.6 | 393.7 | 50.12 | **50.63** |
| | 12.51 | 12.68 | 218.6 | 235.3 | 417.6 | 430.9 | 54.30 | **56.00** |
| | 13.20 | 13.53 | 233.1 | 243.1 | 449.2 | 460.5 | 58.84 | **57.56** |
| | 13.63 | 13.76 | 240.4 | 250.3 | 488.0 | 484.4 | 63.09 | **62.84** |
| **Non-solarize** | 8.84 | 9.41 | 150.3 | 169.9 | 307.6 | 332.3 | 33.49 | **32.40** |
| | 10.09 | 10.35 | 168.8 | 182.2 | 348.4 | 362.1 | 38.29 | **38.01** |
| | 11.11 | 11.44 | 174.7 | 181.4 | 365.8 | 379.1 | 38.66 | **38.83** |
| | 11.36 | 11.69 | 183.6 | 186.9 | 405.8 | 419.0 | 42.75 | **43.29** |
| | 12.75 | 13.08 | 192.9 | 199.6 | 424.1 | 429.8 | 44.65 | **44.99** |
| **LSD at 0.05** | **N.S** | **N.S** | **12.1** | ١٧,٦ | **N.S** | **N.S** | **N.S** | **N.S** |

## Fruits quality:

The effect of soil solarization, bio-fertilization and interaction on strawberry fruit firmness, T.S.S and L. Ascorbic acid content are presented in Table, (6). Solarization significantly enhanced fruit firmness compared with non-solarize treatment, while the same treatment had not have significant effect on strawberry fruit T.S.S or L. Ascorbic acid content in both seasons.

Concerning of bio-fertilization effect, data in Table (6) showed that, fruit firmness, T.S.S and L. Ascorbic acid content significantly affected by bio-fertilization treatments. Bio-3 in first season, bio-3 with bio-2 in the second gave the highest fruit firmness followed by other bio-fertilizer treatments as compared with conventional treatment which produced the lowest fruit firmness in both seasons. Bio-3 alone or bio-3 and bio-2 gave the highest T.S.S values in first and second seasons respectively compared with conventional treatment which gave the lowest value. Moreover, Highest L. Ascorbic acid content obtained with bio-3 or bio-3 and bio-4 in the first and second seasons respectively compared with bio-1 and conventional treatments which produced the lowest fruit L. Ascorbic acid content in both seasons. All interactions effect on the tree characters were not significant in both seasons.

**Table: (6) Effect of soil solarization and bio-fertilization on Fruit firmness, T.S.S content and L. Ascorbic acid (mg/100g F.W.) in 2017 and 2018 seasons.**

| Characters | Fruit firmness (g/cm$^2$) | | T.S.S content | | L. Ascorbic acid (mg/100g F.W.) | |
|---|---|---|---|---|---|---|
| Seasons | 1$^{St}$ Season | 2$^{nd}$ Season | 1$^{St}$ Season | 2$^{nd}$ Season | 1$^{St}$ Season | 2$^{nd}$ Season |
| | | | **Solarization** | | | |
| **Solarize** | ٤٤٣,٢ | ٤٥٢,٢ | ٨,٣٨ | ٨,٤٧ | ٦٤,٨٨ | ٦٣,٨٩ |
| **Non-solarize** | ٤٢٦,٨ | ٤٢٤,٦ | ٨,٢٣ | ٨,١٣ | ٦٣,٥١ | ٦٥,٤٣ |
| **LSD at 0.05** | ١٤,٩ | ١١,٦ | **N.S** | **N.S** | **N.S** | **N.S** |
| | | | **Bio-fertilization** | | | |
| **Bio-1** | 445.7 | 447.9 | 8.37 | 8.37 | 61.50 | **62.60** |
| **Bio-2** | 451.3 | 468.5 | 8.46 | 8.52 | 63.18 | **63.37** |
| **Bio-3** | 466.4 | 462.6 | 8.61 | 8.55 | 69.12 | **68.23** |
| **Bio-4** | 424.1 | 406.6 | 8.18 | 8.40 | 64.83 | **66.95** |
| **Bio-5** | 379.9 | 406.2 | 7.93 | 7.94 | 62.37 | **62.15** |
| **LSD at 0.05** | ١٣,٣ | ٩,١ | ٠,١٣ | ٠,١١ | ١,٩٨ | ٢,٦٤ |
| | | | **Interaction** | | | |
| **Solarize** | 450.9 | 469.2 | 8.41 | 8.47 | 61.86 | **60.67** |
| | 455.7 | 473.7 | 8.55 | 8.56 | 63.32 | **63.18** |
| | 472.4 | 476.8 | 8.77 | 8.71 | 68.75 | **68.36** |
| | 442.3 | 420.9 | 8.23 | 8.52 | 66.08 | **66.66** |
| | 379.5 | 420.2 | 7.97 | 8.12 | 64.41 | **60.58** |
| **Non-solarize** | 440.4 | 426.7 | 8.33 | 8.27 | 61.15 | **64.53** |
| | 446.9 | 463.3 | 8.36 | 8.49 | 63.04 | **63.56** |
| | 460.4 | 448.3 | 8.45 | 8.39 | 69.48 | **68.10** |
| | 405.8 | 392.2 | 8.12 | 8.29 | 63.58 | **67.24** |
| | 380.3 | 392.3 | 7.89 | 7.76 | 60.32 | **63.72** |
| **LSD at 0.05** | **N.S** | **N.S** | **N.S** | **N.S** | **N.S** | **N.S** |

**Fruit rot and absent yield:** Data in Table, 7 showed that, soil solarization significantly decreased rotted fruits even gray mold rot caused by *Botrytis cinerea* or dry rot caused by *Phytophthora cactorum* compared with non-solarize treatments in both seasons. This resulted in more lost fruit yield especially in the first season. Also, rotted fruits significantly affected by bio fertilizer treatments, where the rotted fruits increased with increasing chemical fertilizers ratio and bio 1 treatment (without chemical fertilzer) produced the lowest value compared with other treatments. On the other hand, control treatment (traditional) gave the highest number of rotted fruits in both seasons. Regarding lost yield per plot, data showed the same trend, where, control treatment produced the highest value compared with bio-fertilozers treatments and the lost yield was increased with increasing chemical fertilizer ratio in both seasons.

Decreasing of disease incidence due to solarization may be attributed to the production of NH3 and an increase in soil microbial activity, which can help control soilborne pathogens through competition, antibiosis, parasitism/predation, etc. **(Nunez-Zofio *et al*. 2011; Martinez *et al*. 2011)**. Most pathogens affected was *Verticillium dahliae* **(Daugovish *et al*. 2011),** *P. cactorum* **(Porras, *et al*., 2007)**. Microbiological changes in soil environment have also been documented as a mechanism of pathogen suppression and resulting improved crop productivity **(Mazzola, 2011)**.

**Table: (7) Effect of soil solarization and bio-fertilization on Total rotted fruit/ plot, Botrytis gray mold rot, Dry rot and Absent yield in 2017 and 2018 seasons.**

| Characters | Total rotted fruit/ plot | | Botrytis gray mold rot | | Dry rot | | Absent yield | |
|---|---|---|---|---|---|---|---|---|
| Seasons | 1St Season | 2nd Season | 1St Season | 2nd Season | 1St Season | 2nd Season | 1St Season | 2nd Season |
| | | | | **Solarization** | | | | |
| **Solarize** | ٢٤,٣٣ | ٢٩,٢٦ | ١٩,٥٨ | ٢٣,٤٩ | ٤,٧٤ | ٥,٧٧ | ٣٠٢,٦ | **419.7** |
| **Non-solarize** | ٩٣,٢٦ | ١٠٣,٣٢ | ٨٦,٠٢ | ٩٥,٦٩ | ٧,٢٤ | ٧,٦٣ | ٢٠٩٨,١ | ١٢٥٨,٢ |
| **LSD at 0.05** | ٧,٥٠ | ٢,٩٤ | ٧,٢٩ | ٣,٥٧ | ٠,٩٤ | ١,١١ | ١٣٢,١ | ٤٢,٠ |
| | | | | **Bio-fertilization** | | | | |
| **Bio-1** | 29.22 | 36.11 | 29.68 | 27.05 | 8.35 | 9.06 | 273.9 | **348.6** |
| **Bio-2** | 37.55 | 42.95 | 48.61 | 36.15 | 6.25 | 6.81 | 438.4 | **506.6** |
| **Bio-3** | 57.22 | 61.04 | 86.54 | 55.73 | 4.18 | 5.32 | 618.2 | **802.6** |
| **Bio-4** | 76.56 | 88.18 | 123.19 | 81.89 | 5.23 | 6.29 | 892.9 | **1072.4** |
| **Bio-5** | 93.44 | 103.17 | 142.09 | 97.14 | 5.96 | 6.03 | 1309.4 | **1464.5** |
| **LSD at 0.05** | ٣,٩٢ | ٥,١٩ | ٣,٥٢ | ٥,٠٣ | ١,٠٩ | ١,٢٢ | **72.6** | ٧٣,٢ |
| | | | | **Interaction** | | | | |
| **Solarize** | 18.76 | 22.42 | 12.05 | 15.38 | 6.71 | 7.04 | 196.7 | **228.21** |
| | 19.45 | 23.57 | 13.98 | 18.36 | 5.47 | 5.21 | 226.1 | **281.97** |
| | 22.43 | 25.76 | 19.53 | 22.24 | 2.90 | 3.53 | 259.7 | **370.35** |
| | 23.44 | 31.36 | 19.48 | 25.64 | 3.96 | 5.72 | 309.6 | **459.02** |
| | 37.55 | 43.18 | 32.87 | 35.84 | 4.68 | 7.34 | 520.7 | **759.03** |
| **Non-solarize** | 39.67 | 49.79 | 29.68 | 38.71 | 9.99 | 11.08 | 351.2 | **469.04** |
| | 55.65 | 62.33 | 48.61 | 53.94 | 7.04 | 8.40 | 650.7 | **731.32** |
| | 92.00 | 96.32 | 86.54 | 89.22 | 5.46 | 7.10 | 976.8 | **1234.89** |
| | 129.68 | 145.01 | 123.19 | 138.14 | 6.49 | 6.87 | 1476.2 | **1685.77** |
| | 149.32 | 163.16 | 142.09 | 158.44 | 7.23 | 4.72 | 2098.1 | **2169.96** |
| **LSD at 0.05** | ٥,٥٤ | ٧,٣٤ | ٤,٩٨ | ٧,١١ | **N.S** | ١,٧٢ | **102.6** | ١٠٣,٥ |

**Conclusion:** the present results indicate that soil solarization has the potential for nonchemical management of soilborne diseases of strawberry and it may be possible to grow strawberries at Siwa oasis with soil solarization and without chemical fertilizers or with limited amounts of fertilizers. Although the highest yield was obtained by soil solarization with adding recommended chemical fertilizers, we can achieve a proper strawberry yield with application of bio-fertilizers combine with half or one-fourth of recommended doses. Moreover, soil solarization with bio-fertilizers produced the highest fruits quality as well as lowest rotted fruits ratio. Finally, solarization has potential as a component in an integrated pest management program of fruit rot diseases in strawberry production, particularly at areas have hot summer like Siwa oasis.

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