J. Agric. Sci. Mansoura Univ., 31 (4): 2435 - 2444, 2006

EVALUATION OF SOIL SOLARIZATION IN COMBINATION WITH GREEN MANURE AMENDMENT ON SURVIVAL OF SOIL FUNGI, WEEDS AND YIELD OF TWO VARIETIES OF ZUCCHINI PLANTS

Sunbol, Y. H.
Department of Arid Land Agriculture, Faculty of Meteorology Environment and Arid land Agriculture, King Abdulaziz University, Jeddah, Saudi Arabia. e-mail. ysunbol@hotmail.com

ABSTRACT

An Experiment was conducted in 2004 at King Abdulaziz University Agricultural Experimental Station, in the Western region of Saudi Arabia to evaluate the effect of soil solarization, by mulching the soil with transparent polyethylene sheets in combination with three different green manure amendments by adding cabbage, conocarpus or neem leaves to soil prior to solarization on population densities of soil fungi, weed growth and yield of two varieties of zucchini plants. The total number of soil fungi was declined by 63% immediately after solarization then increased at the end of the first and second season to 80% of the initial pre-solarization soil samples. Soil amendment with conocarpus, neem or cabbage decreased the populations of soil fungi by 40.1, 30.9 and 30.3%, respectively. Weed growth was declined by 92.5% in solarized soils, and to a less extent by manure amendment that ranges from 26-40% reduction. Yield of zucchini plants was increased by 13.4% in solarized soils as compared to non-solarized soils. Amendment with green manure alone, however, increased yield by 14.5-19.8%. More yield of zucchini plants and more control of weeds was obtained in solarized amended soils than in solarized or amended soils alone.

INTRODUCTION

Under the severe climatic conditions, especially high temperatures during summer seasons, soil solarization is effective in controlling soil pets. The technique, as described by Stapleton (2000) is a soil disinfestation method that uses passive solar heating by mulching the wet field soil surface with transparent plastic sheeting to reduce soil-borne inoculm of crop pathogens. Soil temperature can reach as maximum as 68° C at 5 cm below the soil surface, 16° higher than in non-solarized soil (Sunboul and Al-Solaimani, 1999). In another study by Sunbol (2002), soil temperature was increased by 17.8° at 10 cm soil depth.

Many soil-borne plant pathogens (Katan, 1987; Ghini *et al.* 1993; Chellimi *et al.*, 1994; Lopez-Herrera *et al.* 1997) and weeds (Egley, 1990; Campiglia *et al.* 1998; Defilippi *et al* 1998; Benlioglu *et al.*, 2005) have been controlled by this method. In most cases, an increase in growth and yield of planted crops are resulted. Benlioglu *et al.* (2005) reported 100% increase in strawberry production in solarized soils when compared to production in non-solarized soils. Many other researchers indicated the same results (Bourbos and Skoudridakis, 1996; Haeebrrahman and Hosmani, 1996; Ismail *et al.*, 1997; Lopez–Herrera *et al* ., 1997).

The effect of soil solarization on populations of soil microorganisms in general was discussed by Stapleton and DeVay, (1982) and (1984), Ristaino *et al.* (1991), Sadik *et al.* (1994) and Sunbol (2006). Ristaino *et al.* (1991) found that the Population density of *Agrobacterium* sp., fluorescent pseudomonads, gram-positive bacteria and fungi were greatly reduced immediately following solarization. Sunbol (2006) reported 99% decrease in the total number of soil fungi at 10 cm as compared to 78 % decrease at 20 cm below the soil surface after four weeks of solarization.

Amendment of field soil with organic matter in Combination with soil solarization was studied lately to determine their effect on populations of soil fungi (Ramirez-Villapudua and Munnecke, 1988; Gamliel and Stapleton, 1993; Keinath, 1996). These studies showed that populations of some fungal species declined or where even eliminated but were not affected in non-solarized amended or non-amended soils. Ramirez-Villapudua and Munnecke (1988) reported a complete elimination or great decline of *Fusarium exosporium* f. sp. *conglutinans* in solarized soils amended with cabbage, mustard, kale or alfalfa hay, but with less effect when wheat straw or chicken manure were used. Similar results were obtained using chicken compost to control *Pythium ultimum* (Gamliel and Stapleton, 1993a). Another study by Gamliel and Stapleton (1993b), using soil solarization simulated controlled-environment system, populations of *Pythium ultimum* and *Sclerotium rolfsii* were dropped when soil amended with cabbage residue was heated.

Soil solarization has other side effects that might contribute to the increase in plant growth and yield such as the release of nutrients. Many reports have shown an increase in available nutrients of soils such as nitrate and ammonia nitrogen, calsium and magnesium following solarization (Adetunji, 1994; Arora, 1998; Arora and Yaduraju, 1998). This increase of nutrients are more obvious in pre-solarized amended soils with organic matter.

The objective of this study was to evaluate soil solarization in Combination with soil amendment with three green manures on population densities of total fungi, fresh weight of weeds and yield of two varieties of zucchini plants in two seasons.

MATERIALS AND METHODS

Experimental design and trial site:

An experiments was conducted at King Abdulaziz University Agricultural Experimental Station at Hada Al-Sham, 120 km North East of Jeddah, Saudi Arabia. Soil solarization was conducted during the period of July, 1 to Aug. 31, 2004. On the other hand, the two post-solarization planting dates of the experiment were as follows: first planting date from Oct. 10, 2004 to Nov. 25, 2004, and the second sowing date from Dec. 11, 2004 to Jan. 25, 2005.

A Split-split Plot Design was used with three replications combined over season. The main plot treatments were two varieties of zucchini plants, the sub-plot treatments were solarized and non- solarized and the sub-sub-plot treatments were four green manure treatments (control, no manure, Conocarpus, cabbage and neem). The sub-sub-plot size for all experiments were 3x3 m. Mechanical analysis of the texture of the soil shows loamy sand with 2.8, 13.5 and 85.3% clay, silt and sand, respectively. Chemical analysis shows 0.57% organic matter, 7.9 pH, 1.6 Ds^{-m} EC, 58.5 mg^{-kg} K and 0.02 and 17% N and P, respectively.

Solarization trials:

For preparation of the experimental field, the site was tilled using moldboard plow at a depth of 25 to 30 cm. The land was harrowed with disk harrows, leveled, and then divided into 48 plots, at 3x3 m, and dry leaves of cabbage (*Brassica oleracea*), conocarpus (*Conocarpus erectus*) or neem (*Azadiracta indica*) were added at the rate of 9 t/ha. Soil was flooded twice over 24 hrs to reach saturation level for 40 cm depth to improve heat conductivity.

Soil was mulched with 100µ transparent polyethylene sheets and was fixed by burying the edges in a shallow trench around each plot. The other plots were left un-mulched to serve as control.

Enumeration of soil fungi:

To measure the effect of soil solarization on the population density of fungi, soil samples were taken at four different dates, pre-solarization, post-solarization, end of the first season and end of the second planting seasons. Four soil samples were taken randomly from each treatment plot at a depth of 0-30 cm. All samples from each plot were pooled and mixed thoroughly in plastic bags, air dried then stored at room temperature for further tests.

For quantification of fungi in soil, serial dilution method was used as described by Dhingra and Sinclair (1985) on plates containing PDA (200 g potato, 15 g dextrose, and 15 g agar in 1000 ml distilled water amended with 200 mg streptomycin sulfate and 50 mg rose bengal). Plates were incubated at room temperature and fungal colonies were counted after 7 days.

Planting experiment:

The plastic sheets were removed, the land then was retilled using moldboard plow, divided into 48 plots. Preplanting fertilizers were added as a single dose as follows: triple superphosphate (46% P_2O_5) at the rate of 300 kg/ha, potassium sulphate (50% K_2O) at 200 kg/ha. Urea (46% N) was applied as a side dressing at a rate of 435 kg/ha at three equal doses in 15 days intervals during the growth period. Each of the 48-bordered plots was divided into four ridges in 75 cm distance. Hills within ridges were 60 cm apart with a total of 20 plants per plot. At sowing, three zucchini (*Cucurbita pepo*) seeds (Hybrid Squasa or Lebanese cultivars) were planted per hill and after a full emergence they were thinned to a single seedling per hill. Irrigation was achieved using a PVC drip irrigation system. Crops were irrigated as needed.

Weeds were collected from each treatment plot and weighed weekly. At the end of each season, yield was measured by weighing the fruits from each treatment plot and was converted to ton/ha.

Statistical analysis for the analysis of variance and the LSD was achieved using SAS program.

RESULTS AND DESCUSSION

Total population of soil fungi was significantly affected at P≤0.01 level by Sampling date and green manure soil amendment and at P≤0.05 by soil solarization (Table 1). The table also shows no interaction between solarization and soil amendment.

Table (1): Analysis of Variance of the Population Density of Soil Fungi as Affected by Soil Solarization and Green Manure Soil Amendment (Cabbage, Conocarpus, Neem) Treatments at Four Soil Sampling Dates (Pre-, Post-solarization, First and Second planting Season).

Source of Variation	Degree of Freedom	Population of soil fungi
Sampling Date (D)	3	**
Solarization (S)	1	*
D*S	3	NS
Green Manure (M)	3	**
D*M	9	NS
S*M	3	NS
D*S*M	9	NS

* significant at P≤0.05, ** significant at P≤0.01, NS: Not Significant

The number of soil fungi was declined 63% immediately after solarization then increased at the end of the first and second season to 80% of the initial pre-solarization soil samples (Table 2). Soil amendment with three different green manures affected the populations of soil fungi; the density was decreased by 40.1, 30.9 and 30.3% when soil was amended with conocarpus, neem and cabbage, respectively. (Table 2).

Table (2): Mean Values of Population Densities of Soil Fungi as Affected by Four Soil Sampling Dates, Soil Solarization and Three Green manure Soil Amendments.

Treatment		Population of soil fungi (CFU/g soil) x 10^4
Soil Sampling Date	Pre-Solarization	14.88 A
	Post-Solarization	5.48 B
	First Season	11.64 A
	Second Season	11.97 A
Solarization	Non-Solarized	12.25 A
	Solarized	9.74 B
Green Manure	Non-Amended	14.73 A
	Cabbage	10.26 B
	Conocarpus	8.82 B
	Neem	10.17 B

* Values with the same letters are significantly not different at P≤0.05.

The decline of the population of soil fungi in this work agree with the results of many reporters Stapleton and DeVay, (1982) and (1984), Ristaino et al. (1991), Sadik et al. (1994). The high soil temperature under the plastic sheet is most probably the major factor in the decline of the fungal populations. A synergistic effect on the decline of soil fungi was found when soil solarization was combined with green manure soil amendment. Other researchers reported the same results (Lodha et al., 1997; Haidar et al., 1999; Coelho et al. 2000; Pinkerton et al., 2000). Coelho et al. (2000) reported that *Phytophthora nicotianae* was eliminated in solarized cabbage amended soils as compared to solarized or amended soils alone. Lodha et al. (1997) 93-99% elimination of *Macrophomina phaseolina* in mulched amended soils. However, only mulched soils partially eliminated the fungus. Pinkerton et al. (2000) reported that soil amendment with cover crops such as sudan grass, rape and barley alone were not effective in eliminating soilborne plant pathogens. When combined with soil solarization, however, a great declines of the pathogens was resulted.

Table 3 shows a significant effect of season, solarization and green manure amendment on weed growth and yield of zucchini plants at the $P\leq0.01$ level. There is also a significant interaction at the $P\leq0.01$ level of solarization in combination with green manure on weed growth and at $P\leq0.05$ level on yield of zucchini plants (Table 3).

Soil solarization greatly affected weed growth with a decrease of 92.5% (Table 4). Weed growth, however, was affected to less extent by manure amendment alone, ranging from 26-40% reduction. Yield of zucchini plants was increased by 13.4% in solarized soils as compared to non-solarized soils. Amendment with green manure alone, however, increased yield by 14.5-19.8% (Table 4).

More yield of zucchini plants and more control of weeds was obtained in solarized amended soils than in solarized or amended soils alone (Fig. 1, 2).

Better results concerning weed and increase in yield of many crops was reported when a combination of soil solarization and organic matter amendment was applied than either treatment alone Gamaliel and Stapleton, 1997; Campiglia et al. 1998). In a study by Gamliel and Stapleton, (1997), they suggested that soil solarization might have induced accumulation of toxic gases in soil amended with chicken and cruciferous residues. This process gave a better control of soil pathogens and hence a higher lettuce and tomato yield than each treatment alone.

Table (3): Analysis of Variance of Weed Growth and Yield of Two Zucchini Varieties as Affected by Soil Solarization, Green Manure Soil Amendment (Cabbage, Conocarpus, Neem) and two growing seasons.

Source of Variation	Degree of Freedom	Weed Fresh Weight (g/m^2)	Yield (t/ha)
Season (N)	1	**	**
Solarization (S)	1	**	**
N*S	1	**	NS
Variety (V)	1	NS	NS
N*V	1	NS	*
S*V	1	NS	NS
Green Manure (M)	3	**	**
N*M	3	NS	NS
S*M	3	**	*
V*M	3	NS	NS
N*S*M	3	NS	NS
S*V*M	3	NS	NS
N*S*V*M	3	NS	NS

*significant at $P\leq0.05$, ** significant at $P\leq0.01$, NS: Not Significant

Table (4): Mean Values of Weed Growth and Yield of Two Varieties of Zucchini Plants as Affected by Two seasons, Soil Solarization and Three Green manure Soil Amendment.

Treatment		Fresh Weight of Weeds (g/m^2)	Yield (t/ha)
Season	First Season	338.06 A	14.61 B
	Second Season	274.15 B	22.03 A
Solarization	Non-Solarized	569.43 A	17.00 B
	Solarized	42.78 B	19.64 A
Variety	1	297.89 A	18.88 A
	2	314.32 A	17.77 A
Green Manure	Non-Amended	417.37 A	15.80 B
	Cabbage	309.33 B	18.47 A
	conocarpus	248014 C	19.31 A
	Neem	249.58 C	19.71 A

* Values with the same letters are significantly not different at $P\leq0.05$.

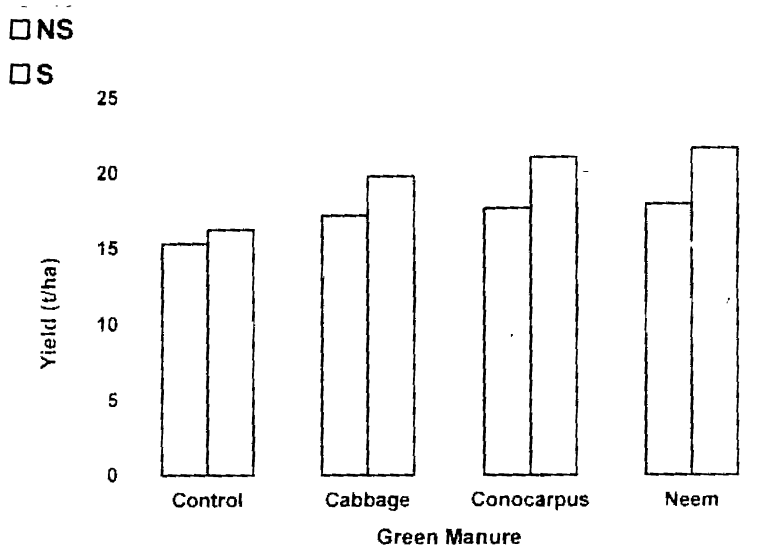

Fig. 1. Effect of Soil Solarization in Combination With Three Green Manure Soil Amendments on Yield of Zucchini Plants. NS: Non-Solarized Soil, S: Solarized Soil.

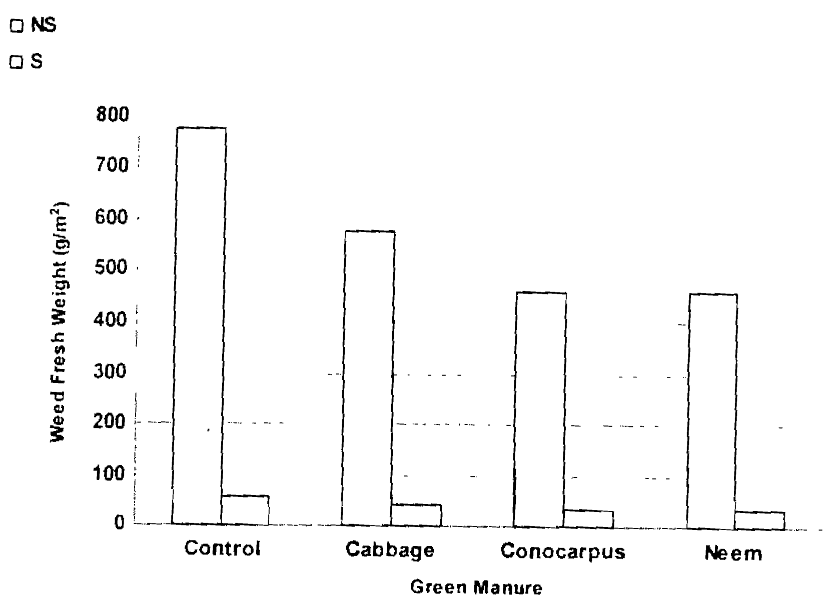

Fig. 2. Effect of Soil Solarization in Combination With Three Green Manure Soil Amendments on Weed Growth. NS: Non-Solarized Soil, S: Solarized Soil.

REFERENCES

Adetunji, I. A. 1994. Response of onion to soil solarization and organic mulching in semi-arid tropics. Scientia Horticulturae 60: 161 – 166.

Arora, A. (1998). Soil solarization: Effects on soil moisture, soil temperature and chemical properties of the soil. Crop Research Hisar 16: 41 – 49.

Arora, A. and Yaduraju, N. T. (1998). High temperature effects on germination and viability of weed seeds in soil. Joumal of Agronomy and Crop Science 181: 35 – 43.

Al-Solaimani, S. G. and Y. H. Sunboul, (2000). Effect of soil Solarization and chicken manure addition on corn yield and nitrogen uptake under arid zone conditions. Mansoura University Jou. of Agr. Sci. 25: 70-82

Benlioglu, S., O. Boz, A. Yildiz, G. Kaskavalci and K. Benlioglu (2005). Alternative soil solarization treatments for the control of soil-borne diseases and weeds of strawberry in the Western Anatclia of Turkey. Journal of Phytopathology, 153: 423-430.

Bourbos, B. A. and M. T. Skoudridakis (1996). Soil solarization for the control of verticillium wilt of greenhouse tomato. Phytoparasitica, 42: 277-280.

Campiglia, E., Temperini, O., Mancinelli, R., Marucci, A. and Saccardo, F. (1998). Soil solarization in the mediterranian environment: Effect or weed control and yield of cos lettuce (*Lactuca sativa* L., var longifolioa lam). Italus-Hortus, 5: 36–42.

Chellimi, D. O.; S. M. Olson and D. J. Mitchell (1994). Effects of soil solarization and fumigation on survival of soilborne pathogens of tomato in northern Florida. Plant Disease 78: 1167-1172.

Coelho, L., Mitchell, D.J. and Chellemi, D.O. (2000). Thermal inactivation of *Phtophthora nicotianae*. Phytopathol., 90: 1089-1097.

Defilippi, B., Montealegri, J. and Diaz, V. (1998). Control of weeds by soil solarization and methyl bromide in Sanpedro, metropolitan region, Chile. Agro-Sur 26: 26–35.

Dhingra, O. D. and Sinclair, J. B. (1985). Basic plant pathology methods. CRC Press Inc. Boca Raton, Florida. 335 pp.

Egley, G. H. (1990). High temperature effects on germination and survival of weed seeds in soil. Weed Science 38: 429-435.

Gamliel,A.and Stapleton,J.J.(1993a).Effect of chicken compost or ammonium phosphate and solarization on pathogen control, rhizosphere microorganisms and lettuce growth.Plant Disease,77:886-891.

Gamliel, A. and Stapleton, J. J. (1993b). Characteristics of antifungal volatile compounds evolved from solarized soil amended with cabbage residues. Phytopathology, 83: 899-905.

Gamliel, A. and Stapleton, J. J. 1997. Improvement of soil solarization with volatile compounds generated from organic amendments. Phytoparasitica 25: 31–38.

Ghini, R.; W. Bettiol; C. A. Spadotto; G. J. Morare; L. C. Paraiba and J. L. Mineiro (1993). Soil solarization for the control of tomato and eggplant Verticillium wilt and its effect on weed and micro-arthropod comunities. Summa Phytopathologica, 19: 183–189.

Habeebrrahman, P. V. and M. M. Hosmani (1996). Effect of soil solarization in summer on weed growth and yield of succeeding rainy-season sorghum (*sorghum biocolor*). Indian Journal of Agronomy, 41: 54-57.

Haidar, M.A., Iskandarani, N., SidahmedM. And Baalbaki, R. (1999). Response of field dodder (*Cuscuta campestris*) seeds to soil solarization and chicken manure. Crop Protection, 18: 253-258.

Ismail , A. E., M. H. Ghali, F. G. Nakhlla and H. Z. Aboul-Eid (1997). Effect of soil solarization with polyethylene sheets on growth of navel orange and control of citrus nematode Tylenchulus semipenetrans. Pakistan Journal of Nematology, 15: 71-87.

Katan, J. (1987). Soil solarization. In "Innovative approaches to plant disease control". I. Chet, ed. John Wiley & sons, NY.

Keinath, A. P. (1996). Soil amendment with cabbage residue and crop rotation to reduce gummy stem blight and increase growth and yield of watermelon. Plant Disease 80: 564 – 570.

Lodha, S., Sharma, S.K. and Aggarwal, R.K. (1997). Solarization and natural heating of irrigated soil amended with cruciferous residues for improved control of *Mcrophomina phaseolina*. Plant Pathology, 46: 186-190.

Lopez-Herrera, C. J., Perez-Jimenezrm, R. M., Basalotte-Ureba, N. J., Zea-Bonilla, T., and Melero-Vera, J. M. (1997). Effect of soil solarization on the control of Phytophthora root rot in avogado. Plant Pathology 46: 329–340.

Pinkerton, Ivores, K.L., Miller, M.I. and Moore, L.W. (2000). Effect of soil solarization and cover crops on populations of selected soilborne plant pathogens in Western Oregon. Plant Dis., 84: 952-960.

Ramirez-Villapudua, J. and D. E. Munnecke (1988). Effect of solar heating and soil amendments of crucifrous residues on *Fusarium exosporium* f. sp. *conglutinans* and other organisms. Phytopathology, 78: 289-295.

Ristaino, J. B., Perry, K. B., and Lumsden, R. D. (1991). Effect of solarization and *Gliccladium virens* on sclerotia of *Sclerotium rolfsii*, soil microflora, and incidence of southern blight of tomato. Phytopathology, 81:1117 – 1124.

Sadik, E. A., Fyzalla, E. A., Elwakil, M. A. and Gomak, A. A. (1994). Soil solarization as amethod for controlling some common soil inhabiting fungi. Egyptian J. Phytopath, 22: 159–170.

Stapleton, J. J. (2000). Soil solarization in various agricultural production systems, Crop Protection, 19: 837-841.

Stapleton, J. J., and DeVay, J. E. (1982). Effect of soil solarization on populations of selected soilborne microorganisms and growth of deciduous fruit tree seedlings. Phytopathology, 72:323 – 326.

Stapleton, J. J., and DeVay, J. E. (1984). Thermal components of soil solarization as related to changes in soil and root microflora and increased plant growth response. Phytopathology, 74: 255 – 259.

Sunboul, Y. H. and S. G. Al-Solaimani (1999). Soil Chemical Composition and Fungal Populations as Affected by a Combination of Soil Solarization Chicken Manure Amendment. Journal of Zagazig University (Banha Branch). Annals of Agricultural Science Moshtohor, 37: 2655-2666.

Sunbol, Y.H. (2006). Solarization of commercial peat in transparent polyethylene bags and its effects on survival of some plant pathogenic fungi. J. King Abdulaziz Univ.: Facult. Sci., 17: (in press)

تقييم تشميس التربة بالإضافة إلى خلط التربة بالسماد الأخضر على حيوية فطريات التربة و الحشائش و على محصول صنفين من نبات الكوسة

يحيى حمزة سنبل
قسم زراعة المناطق الجافة، كلية الأرصاد و البيئة و زراعة المناطق الجافة، جامعة الملك عبد العزيز، جدة، المملكة العربية السعودية، بريد إلكتروني ysunbol@hotmail.com.

تم إجراء تجربة في عام ٢٠٠٤ في محطة الأبحاث الزراعية التابعة لجامعة الملك عبد العزيز بالمنطقة الغربية للملكة العربية السعودية و ذلك لتقييم تشميس التربة و ذلك بتغطيتها بشرائح البلاستيك الشفافة مع إضافة ثلاثة أنواع من السماد الأخضر و ذلك بخلطها بأوراق الكرنب، الكونوكوربس أو النيم على أعداد فطريات التربة، نمو الحشائش و على إنتاجية صنفين من نبات الكوسة. فقد انخفضت الأعداد الكلية لفطريات التربة بنسبة ٦٣% مباشرة بعد التشميس ثم ارتفعت أعدادها في نهاية الموسم الأول و الثاني إلى ٨٠% بالنسبة لأعداد الفطريات في عينات التربة ما قبل التشميس. و قد أدت إضافة أوراق البازاروميا (كونوكاربس)، النيم أو الكرنب إلى خفض أعداد الفطريات في التربة بنسبة ٤٠,١، ٣٠,٩ و ٣٠,٣%، على التوالي. كما انخفض نمو الحشائش بنسبة ٩٢,٥% في التربة المشمسة، و بنسبة أقل في التربة المضاف إليها السماد الأخضر بنسبة تتراوح بين ٢٦-٤٠%. أما بالنسبة لمحصول نبات الكوسة فقد ارتفع بنسبة ١٣,٤% في التربة المشمسة مقارنة بغير المشمسة، بينما ازداد المحصول بنسبة ١٤,٥-١٩,٨% عندما خلطت التربة بالسماد الأخضر فقط. كذلك تم الحصول على زيادة في المحصول و مكافحة أفضل للحشائش في الترب المشمسة المضاف إليها السماد الأخضر عن الترب المشمسة أو المضافة كل على حدة.