Soil Solarization Duration and Animal Manure Effects on Soil Nutrients, Fungi, Weed and Yield of Eggplant *(Solanum melongena L.)* & Cabbage (*Brassica oleracea)*

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Abstract

A field experiment was carried out to evaluate the effect of soil solarization for (0, 4, 8 and 12 weeks), in combination with 30 t/ha animal manure (AM) on soil nutrients, weed growth and yield of eggplant and cabbage during two successive seasons (2011-2012). The addition of the (AM) significantly increased soil content of nitrogen (N) phosphorus (P) and potassium (K)) for pre and post soil solarization. Weed growth were increased pre-solarization, but were significantly reduced after soil solarization. Soil EC remained unaffected but pH was reduced with the combination of soil solarization and AM. Soil content of N, P and K increased up to 8 weeks with no significant difference between week 8 and 12, while fungi population was significantly reduced with increase in solarization periods from 0 to 12 weeks, and with depth from 0-15 to 15-30 cm. Soil solarization amended with 30 t/ha AM significantly increased yield and yield components of eggplant and cabbage. Number of eggplant flowers increased significantly and gradually (87.3%) up to 12 weeks solarization, and there were significant increases in the fruit number (79.1%), thickness (54.6%) and length (2.6%) up to 4 weeks, and in fruit weight (54.4%) as well as yield weight (45.4%) up to 8 weeks solarization compared to the non-solarized soil. However, head length, rotation index and stem diameter were significantly affected up to 12 weeks. Cabbage yield increased at a rate of 59.6%, up to 8 weeks solarisation compared to the uncovered soiladdition.

Key words: Soil Solarization , Animal Manure, Soil Nutrients, Fungi, Weed, Eggplant, Cabbage plant

1. Introduction

Addition of organic manure significantly increased soil pH and macro-elements such as N, P, and K contents [35]. Application of organic manure makes nutrients more available for better growth and yield due to microbial action and improvement of soil physical condition [30]. The availability of nutrients increased after addition of organic manure and resulted in good yield of rice [29]. Soil solarization increased yield, promoted early maturation of certain crops and controlled soil borne plant pathogens and weeds as reported by [30], [19], [2], [24], [27], [33], [34] and [4]. Melon yield was significantly increased due to solarization, giving an average of 29.39 t/ha (64% increase) in solarized plots, compared to 18.79 t/ha in non-solarized plots, and this difference was attributed in part to weeds competition for water, light and nutrients in the non-solarized plots [25]. Soil solarization increased plant growth due to the increase in concentration of nutrients released in soil [30], [1], [7], and [8]). Soil solarization for 65 days after sowing potato was ideal to optimize soil moisture and soil temperature and in turn to improve potato productivity and water use efficiency in the semi-arid region of China [37]. Lettuce plants grown in soil supplied with organic fertilizers showed better vegetative growth and yield compared to lettuce plants grown using inorganic fertilizers [28]. Disease and weed control by soil solarization was usually accompanied by an increase in yield and quality [10], [20], [21], [27], [8] and [31]. Soil solarization is one of the methods of soil disinfestations which based on solar heating of soil by covering (trapping or mulching) the soil with transparent polyethylene during the hot season or when appropriate climatic conditions prevail. The use of transparent polyethylene mulching is a way of capturing solar energy to heat the soil under field

conditions, by which the soil borne pests are killed. An early study by [23] showed that during the hot summer season, polyethylene mulching of irrigated soils prior to planting can be used for control of diseases caused by soil borne pathogens. Their results indicate that population of various kinds of fungi pathogenic to plant crops were eliminated or markedly reduced up to the depth of 25 cm after a period of two weeks, resulting in a significant decrease in incidence of various plant diseases. Soil mulching with transparent polyethylene is widely used to increase soil temperatures. [16] indicated a maximum increase of temperature in solarized soil up to 11^{o} C as compared to non-solarized soil. Another report by [13], reported an increase in solarized soil of 8.8, 7.8 and 4.9 C at soil depths of 5, 15 and 25 cm over non-solarized soil, respectively. Similar results were indicated by [20]. Polyethylene sheets application was also reported to warm the soil beneath the sheets and conserve soil moisture by reducing water loss by evaporation from the surface soil [1]. Soil solarization for 30 and 45 days reduced the population of *Meloidogyn* sp. By 66.6% - 100%, *Tylenchorhynchus* sp. By 50% - 80% and *Trichodorus* sp. by 83.5% - 87.5%, respectively [36]. [32] found complete eradication of the fungi *Pythium* and *Fusarium* after covering soil for two weeks, but in the uncovered soil their numbers were reduced at rates of 58 and 94% at 10 cm depth after 4 weeks, and after 4 weeks of solarization fungi numbers decreased significantly at rates of 50 and 38% respectively at depth 10 and 20 cm. Addition of AM to soil may reduce solarization period from 6-8 to 2-4 weeks [14]. *Escherichia coli* was rapidly decreased after one week of solarization and was completely eradicated after 8 weeks of solarization [9]. Soil solarization controls many annuals and perennial weeds specially winter annuals [17] [12]. *Escherichia coli* was rapidly decreased after one week of solarization and was completely eradicated after 8 weeks of solarization [9]. This research has an important application at the local level, especially for the environmental conditions of Kingdom of Saudi Arabia. High intensity of solar radiation and very high temperature during the summer provide the appropriate conditions for efficient solarization approach. This approach of soil borne control reduces the use of pesticide and herbicide and their pollutant effect on the crop, soil, and groundwater. In addition, solarization will increase the decomposition of organic matter which will improve the availability of nutrients for plant and increase the crop yield [5]. The aim of this study is to evaluate the effect of soil solarization at different periods (uncovered, 4, 8 and 12 weeks), and addition of 30 t/ha AM on some soil constituents, fungi population and on weed growth and yield of eggplant (*Solanum melongena L.*) and cabbage (*Brassica oleracea*).

2. Materials and Methods

The experiment was carried out in the Agricultural Research Station of King AbdulAziz University at Hada Al-Sham 120 km northeast Jeddah city, Saudi Arabia, during two seasons 2010-2011 and 2011-2012. Soil was ploughed twice at a depth of 30cm , leveled and then divided into 24 plots each (3x3m), 8 plots for each replicate, each 2 plots for one mulching treatment. Each covering treatment was represented by two AM rates (0, 30 t/ha). The plots were covered with the polyethylene sheets (transparent), 10microns in thickness. Each plot was divided into 3 rows, 70cm between rows and 60cm between plants and drip irrigation was used. soil experimental site was analyzed before and after covering the soil with the polyethylene sheets at both depths, 0–15 and 15- 30cm, for its electric conductivity(EC), pH using pH meter, the organic matter using Walkeley and Black method as mentioned by [22], total nitrogen(N) using Kjeletec Auto1030, total phosphorus(P) and potassium(K). Also the number of soil fungi was determined using the successive dilution method described by [15]. These parameters were also analyzed in the irrigation water and in the added AM. Eggplant and Cabbage seedlings were prepared in the nursery, and were acclimatized for one month before being planted in the site. Five plants were selected randomly from each plot after maturation, to take the different measurements on yield and yield components. The different measurements were (number of flowers, number of fruits, fruit characters, fruit weight, yield weight). All the remaining fruits in the plot were collected at last for determination of the total yield. The total fresh weight of weed growing in each replicate was determined after being collected three times by

hand during eggplant and cabbage growth. Soil temperature degrees were recorded in uncovered and covered soil at 5, 15 and 30 cm depth after 4, 8 and 12 weeks (Fig. 1).

2.1 Experimental Design and Statistical analysis

The experiment was implemented using the complete split randomized design with three replications, with the solarization periods(0, 4, 8, 12 weeks) representing the main-plots, and the animal manure (AM) rates (0 and 30 t/ha) the sub-plots. The statistical analysis of the data was carried out according to the type of the design (ANOVA) according to [26] running the analysis of variance, and comparison of means using LSD $p \leq 0.05$.

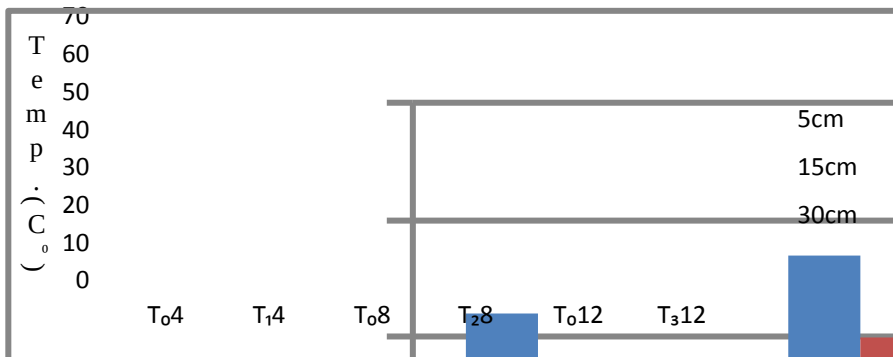

Figure (1). Maximum soil temperature degrees in uncovered and covered soil at 5, 15 and 30 cm depth in all periods.

3.Results

Significant increases were founded in soil content of N, P and K, and in number of fungi with the addition of animal manure up to 30 t/ha compared to control. Soil EC and pH were not affected by AM addition, but fungi population, EC and soil content of N, P and K decreased with increase in depth from 0-15 to 15-30 cm (table 1). However, after soil solarization there were significant increases of soil content of N, P and K with increase in solarization period up to the 8 week and a decrease in fungi numbers up to 12 weeks, and with addition of AM up to 30 t/ha compared to control, (table 2). Soil pH and EC were not affected by soil covering periods, but pH was significantly decreased with increase of AM to 30 t/ha . On the other hand N, P, K, fungi numbers and EC were significantly reduced with increase in depth from 0-15 to 15-30 cm. There were high growth of weeds during the second season than the first season . Weed growth (fresh weight) was significantly reduced by soil solarization, with the highest reduction in the 12 week solarization giving a reduction of 50% compared to the uncovered soil (table3). Weed fresh weight was also reduced significantly when the solarized soil was amended with AM up to 30 t/ha, reaching a reduction of up to 38.6% compared to the control.

Table(1): Effect of animal manure rates and soil depth on means of pH, EC, soil content of N, P, K and fungi number pre soil solarization

Characters Source of difference		pH	EC (d mose/m)	N (%)	P (%)	K (mg/kg)	Fungi No/gm dry soil
Animal manure (t/ha)	0	7.76a	1.7a	0.07b	0.018b	81.25b	59363b
	30	7.77a	1.77a	0.118a	0.029a	90.41a	88000a
Depth(cm)	0-15	7.76a	2.24a	0.106a	0.028a	90a	92433a
	15-30	7.77a	1.23b	0.086b	0.02b	81.66b	54929b

* Means followed by the same letter are not significantly different according to LSD at P≤ 0.05

Table(2): Effect of animal manure rates and soil depth on means of pH, EC, soil content of N, P, K and fungi numbers post soil solarization.

characters		pH	EC (d mose/m)	N (%)	P (%)	K (mg/kg)	Fungi No/gm dry soil
Soil cover weeks	uncovered	7.75a	1.78a	0.06b	0.018b	55.91c	28896a
	4	7.75a	2.01a	0.09b	0.025ab	74.66b	16758b
	8	7.78a	1.62a	0.1b	0.029a	95.33a	7943cb
	12	7.78a	1.53a	0.12a	0.03a	99.83a	5275c
Animal manure (t/ha)	0	8.57a	1.63a	0.07b	0.022b	69.62b	17028a
	30	6.96b	1.84a	0.12a	0.029a	93.25a	12408b
Depth(cm)	0-15	8.57a	2.34a	0.101a	0.027a	87.29a	17431a
	15-30	6.83b	1.13b	0.09a	0.024b	75.58b	12005b

* Means followed by the same letter are not significantly different according to LSD at P≤ 0.05

Table(3): Effect of different solarization periods and AM on fresh weight of weeds during two seasons.

characters	season		Solarization periods (weeks)				Depth (cm)	
	First	second	non	4	8	12	0	30
Weeds FW(kg/9plants)	1.38b	1.87a	2.34a	1.64b	1.37ab	1.17c	2.02a	1.24b

* Means followed by the same letter are not significantly different according to LSD at P≤ 0.05

Gradual and significant increases in eggplant flowers number of (up to 87.3%) under soil covering up to 12 weeks and in fruits number (79.1%) up to 4 weeks compared to uncovered soil , with no significant difference between the duration from 4 to 12 weeks. Also flower and fruit numbers increased significantly with increase in AM rate up to 30 t/ha giving increments of 53.5% and 58.8% respectively. Soil solarisation affected fruit characteristics with significant increase in fruit length and diameter of eggplant under solarised soil, with no significant difference between covering the soil for 4 to 12 weeks. Also additions of animal manure up to 30 t/ha have significantly increased fruit length and diameter compared to control. Significant increase in fruit weight and yield weight of eggplant under soil covered by the transparent sheets up to 8 weeks compared to the uncovered soil (control), with no significant difference between 8 and 12 weeks. The yield increased at a rate of 46.9 and 22.7% in solarised soil up to 12 and 4 weeks respectively. Consequently eggplant yield weight significantly increased with increase in AM rates up to 30 t/ha to reach 44.3% compared to the control soil (table 4).

Table(4): Means of number of flowers and fruits, fruit length and thickness, fruit and yield weight of eggplant under soil solarization and 30 t/ha AM rate during two seasons(2011-2012).

characters source of diff.	Flower number/5plants	Fruit number/5plants	Fruit characteristics(cm)		Fruit wt. Gm/5plants	Yield Kg/ha
			Length	Thickness		
Season						
First	59.71b	27.41a	7.96a	5.68a	3015.5a	7539a
Second	79.74a	27.17a	8.35a	5.76a	3737.9a	9345a
Solarization						
Uncovered	44.68c	13.21b	5.73b	3.9b	2622.9b	6557.4b
4 weeks	72.16b	23.66a	5.58a	6.03a	3217.2ab	8043ab
8 weeks	78.39ab	25.12a	8.72a	6.35a	3815a	9537.5a
12 weeks	83.68a	27.17a	9.59a	6.62a	3851.7a	9629.2a
Animal manure(t/ha)						
0	55.04b	17.35b	6.71b	4.5b	2764.7b	6911.7b
30	84.41a	27.22	9.6a	6.95a	3988.7a	9971.8a

* Means followed by the same letter are not significantly different according to LSD at P≤ 0.05

Cabbage results indicated gradual and significant increases in head stem and root characteristics, with increase in solarization period up to12 weeks. Head length and diameter increased by 69.5 and 69.2% under solarization up to 12 weeks and at rate of 40 and 45.5% in the soil covered up to 4 weeks respectively compared to uncovered soil. Also these characters were significantly increased with increase in AM up to 30 t/ha (table 5).

Results also indicated gradual and significant increase in cabbage yield weight and in leaf area of cabbage plant with increase in soil solarization period up to 12 weeks compared to un solarized soil. The yield increased at a rate of 51.3% and 8.6% compared to the uncovered soil on covering up to 12 and 4 weeks respectively. Yield also increased significantly at a rate of 81.5% when the solarized soil was amended with 30 t/ha AM (table 5).

Table(5): Means of head characters(head length and diameter-rotation index)and stem characters(stem length and diameter-inner stem dia.),root length ,LAI and yield of cabbage plants under soil solarization and different AM rates during two seasons(2011-2012).

characters difference of source	Head characters			Stem characters(cm)			Root length (cm)	LAI (m^2/m^2)	Yield (kg/ha)
Season	Head length (cm)	Head diam. (cm)	Rotation index	Stem length (cm)	Stem diam. (cm)	Inner stem diam. (cm)			
First	13.5b	18.94a	0.71a	9.49b	5.77a	6.75a	22.61a	10095a	92748a
Second	15.98a	21.81a	0.73a	12.06a	5.32a	8.98a	19.31	9248.3a	92693a
Uncovered soil	10.5d	14.3c	0.51d	7.54c	3.89d	5.43c	14.99b	6947.4c	72633b
4 weeks	14.68c	20.78ab	0.7c	10.59b	5.53c	7.9b	21.86a	9680.1b	78915b
8 weeks	15.99b	22.25a	0.79b	12.36a	6.02b	8.76ab	22.95	10391.8ab	109415a
12 weeks	17.78a	24.16a	0.84a	12.61a	6.74a	9.36a	24.11a	11567.2a	109919a
0 t/ha AM	11.43b	15.84b	0.57b	8.63b	4.3b	6.09b	16.25b	2620.1b	65876b
30 t/ha AM	18.04a	24.9a	0.87a	12.92a	6.79a	9.64a	27.7a	11723.1a	119560a

Means with similar letters do not have significant differences between them at 5%

4.Discussion

The significant increase of soil N, P and K with no significant effect on soil EC and pH up to 12 weeks, is due to the release of nutrients in the soil by soil solarization and addition of animal manure, and this was administered by many researchers [3], [8] and [5]. The reduction in fungi population under solarization for (4, 8 and 12 weeks) is due to rise in temperature under the covered soil compared to the uncovered soil. Soil solarization up to 8 weeks, and addition of AM up to 30 t/ha significantly enhanced yield and yield components of eggplants and cabbage. These results may be due to soil enrichment created by animal manure, increasing nutrients especially N, P and K. Extending the solarization period up to 8 and 12 weeks extended the effect of rising temperature, which in turn had adverse effect on soilborne fungi, thus reducing their population in soil. Also soil covering and animal manure amendment, may increase soil water conservation, eradicate weeds, and making soil conditions more favorable for better plant growth. [16] indicated a maximum increase of temperature in solarized soil up to 11^{o} C as compared to non-solarized soil. [13] reported an increase in solarized soil of 8.8, 7.8 and 4.9 ^{0}C at soil depths of 5, 15 and 25 cm over non-solarized soil, respectively. [29] found reduction in pigweed (*Amaranthus retro*) population to <10% for year within 2 weeks of soil cover with transparent polyethylene sheets. [32] found complete eradication of the fungi *Pythium* and *Fusarium* after covering soil for two weeks. [14] admitted that addition of AM to soil may reduce solarization period from 6-8 to 2-4 weeks[37] pointed out that soil solarization with polyethylene sheets for 65 days was ideal for optimizing potato yield. [24] and [18] detected an increase in plant growth and yield with soil solarization combined with soil organic amendment. [11], [4] and [5] have shown that soil mulching increases yields, promotes early maturing of certain vegetables, and controls soil borne plant pathogens and weeds. [10] indicated that the yield of tomato was increased in solarized soil by 112.4% in comparison with non-solarized control.

5.Conclusion

Soil solarization with transparent polyethylene sheets for different periods (0, 4, 8, 12 weeks) and addition of AM up to 30 t/ha, when applied singly, significantly affected the chemical characteristics of soil , its fungi population , weed growth and both cabbage and eggplant yield and yield components. Incorporation of soil solarization with AM at a rate up to 30 t/ha impacted the studied parameters and were more pronounce particularly after solarization for 12 weeks. There were gradual and significant increases in soil contents of N, P and K and significant reduction in fungi population in soil, and in weed growth following elongation in solarization periods up to 12 weeks. No significant increases were noticed in EC and pH due to soil solarization and AM additions. The yield and yield components of both eggplant and cabbage were significantly enhanced, and there were increasing in eggplant flower and fruit numbers, length, thickness and weight of fruits and cabbage head and stem characters due to solarization compared to non –solarized soil. It is recommended to cover soil with transparent polyethylene sheets up to 8 weeks for control of weeds and fungi and for better yield of eggplant and cabbage.

References

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

[2] Ahmad, Y., Hameed A. and Islam M., *Effect of soil solarization on corn stalk root.* Plant and Soil 179 (1): 17 – 24, 1996.

[3] Al-Masoom, a. a., A. Saghir and S. Itani, *Soil Solarization for weed management in U.A.E.* Weed Technology 7: 507 – 510, 1993.

[4] Al-Solaimani, S. G. and Sunboul Y. H., *Effect of Soil Solarization and Chicken Manure Addition on Corn Yield and Nitrogen Uptake under Arid Zone Conditions*. Mansoura University J. of Agr. Sci. Vol 25 (1): 70-82, 2000 a.

[5] Al-Solaimani, S. G., Sunbol Y. H., Al-fasi F. A. and Bernawi M. B,. *Effect of soil solarization and animal manure addition on the growth and yield of okara plant (Hibisus esculentus L.)*. African Studies Review, 29: in press, 2007.

[6] Al-Solaimani, S.G. and Sunbol Y.H., *Effect of soil solarization and chicken manure addition on growth and nitrogen content of corn plant*, Mansoura University J. of Agr. Sci. Vol 25 (1): 53-69, 2000 b.

[7] Arora, A., *Soil solarization: Effects on soil moisture, soil temperature and chemical properties of the soil*. Crop Research Hisar 16 (1): 41– 49,1998.

[8] Arora, A. and Yaduraju, N. T., *High temperature effects on germination and viability of weed seeds in soil*. Journal of Agronomy and Crop Science 181 (1): 35 – 43, 1998.

[9] Berry, E. D. and Wells, J., *Soil solarization reduces Escherichia coli O157:H7 and total Escherichia coli on cattle feedlot pen surfaces*. J. of Food Protection, 75(1): 7-13, 2012.

[10] Bourbos, B. A. and M. T. Skoudridakis, Soil solarization for the control of *Verticillium* wilt of greenhouse tomato. Phytoparasitica 42 (4): 277 – 280, 1996.

[11] Campiglia, E., Temperini, O., Mancinelli, R., Marucci, A. and Saccardo, F., *Soil solarization in the Mediterranean environment: Effect on weed control and yield of lettuce (Lactuca sativa L., var longifolioa lam).* Italus-Hortus 5 (3): 36 – 42. 1998.

[12] Caussanel J. A., J, Trovelot, G. Vivant, S. Gianinazzi, *Effects of soil solarization on weed infestation and on mycorrhizas development. Abstracts Second International Conference on Soil Solarization and Integrated Management of Soil borne Pest*. ICARDA, (1997) Aleppo, Syria,1997.

[13] Chellimi, D. O., S. M. Olson and D. J. Mitchell, *Effects of soil solarization and fumigation on survival of soilborne pathogens of tomato in northern Florida*. Plant Disease 78: 1167 – 1172, 1994.

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

[15] Dhingra, O.B. and Sinclair, J., *Plant pathology methods.Plant Diseases Research Technique*, pp.355, 1985.

[16] Dubey, R. C., *Effects of soil solarization on the survival of Macrophomina phaseolina in fungicide amended and non amended soils*. Trop. Sci. 23: 275 – 279, 1992.

[17] Elmore C. L., J. J. Stapleton, C. E. Bell and J. E. DeVay, *Soil solarization a non pesticidal method for controlling diseases, nematodes, and weeds.* Univ. of Calif., Publication 21377, 1997.

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

[19] Ghini, R., W., Bettiol C. A. Spadotto, G. J. Morare, L. C. Paraiba and J. L. Mineiro, *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, 1993.

[20] Habeebrrahman, P. V. and Hosmani, M. M., *Effect of soil solsrization in summer on weed growth and yield of succeeding rainy-season sorghum (Sorghum biocolor).* Indian Journal of Agronomy 41(1): 54 – 57, 1996.

[21] Ismail, A. E., Ghali, M. H., Nakhlla, F. G. and Aboul-Eid H. Z., *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 – 87,1997.

[22] Jackson, M. L., *Soil Chemical Analysis.* Delhi, India: Prentice-Hall, India, 1973.

[23] Katan, J., A. Greenberger, A. Grinstein and H. Alon, *Additional studies on the control of Verticillium dahliae by polyethylene mulching.* Proc. 2nd Int. Verticillium Symposium, p.27, 1976.

[24] Keinath, A. P., *Soil amendment with cabbage residue and crop rotation to reduce gummy stem blight and increase growth and yield of watermelon.* Plant Disease 80 (5): 564 – 570, 1996.

[25] Lira-Saldivar R. H., M. A. Salas, J. Cruz, A. Coronado, F. D. Hernandez, E. Guerrero and G. Gallegos, S*olarization and goat manure on weed management and melon yield.* Phyton(B.Aires) v.73 , Vicente Lopezene/dlc., 2004.

[26] Little, T. M. and F. J. Hills, *Agricultural experimental design and analysis*. London Group Ltd., 1977.

[27] Lopez-Herrera C. J., R. M. Perez-Jimenezrm, N. J. Basalotte-Ureba, T. Zea-Bonilla and M. J. Melero-*Vera, Effect of soil solarization on the control of Phytophthora root rot in avogado*. Plant Pathology 46 (3): 329 – 340, 1997.

[28] Michael T. M., M. M. Bekhumusa, P, K. Wahome and O. O. Tajudeen, *Effects of Kraal Manure, Chicken Manure and Inorganic Fertilizer on Growth and Yield of Lettuce (Lactuca sativa L. var Commander) in a Semi-arid Environment*, Asian Journal of Agricultural Sciences 4(1): 58-64, 2012.

[29] Muhammad I., *Response of wheat growth and yield to various levels of compost and organic manure*. Pak. J. Bot., 40(5): 2135-2141, 2008.

[29] Ozores-Hampton, M., P. A. Stansly, R. McSorley and T. A. Obreza, *Effects of long-term organic amendments and soil solarization on pepper and watermelon growth, yield, and soil fertility.* HortScience, 40 (1): 80–84, 2005.

[30} Sarker, M. R., M. A. Pramanik, G. M. Faruk and M. Y. Ali, *Effect of green manures and levels of nitrogen on some growth attributes of transplant adman rice.* Pakistan J. Biol. Sci., 7:739-742, 2004.

[30] Stapleton, J. J., J. Quick and J. E. De Vay, *Soil solarization: Effects on soil properties, crop fertilization and plant growth.* Soil Biol.Biochem., 17: 369-373, 1985.

[31] Stevens, C., V. A. Khan, L. Rodriguez-Kabana, L. D. Ploper, P. A. Backman, D.J. Collins, J. E. Brown, M. A. Wilson, and E.C.K. Igwegbe, *Integration of soil solarization with chemical, biological and cultural control for the management of soilborne diseases of vegetables.* Plant and Soil, 253: 493-506, 2003.

[32] Sunboul, Y. H., *Effect of soil solarization on population densities of Pythium aphanidermatum, Fusarium oxysporum and total soil fungi in the Westren region of Saudi Arabia*. Egypt. J. Sci, 19: 24-35, 2004.

[33] Sunboul, Y. H. and Al-Solaimani S. G., *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. Vol: 37(4):2655-2666, 1999 a.

[34] Sunboul, Y. H. and S. G. Al-Solaimani, *Weed Growth as Affected by Combination of Soil Solarization and Chicken Manure Amendment under Corn Plantation,* Journal of Zagazig University (Banha Branch). Annals of Agricultural Science Moshtohor. Vol: 37 (4) : 2643-2654. 1999 b.

[35] Tang C. Yu. Q., *Chemical composition of legume residues and initial soil pH determine pH change of a soil after incorporation of the residues.* Plant Soil, 215: 29-38,1999.

[36] Zaid, A. M., A. Ismail, A. Khader and M. Mayof, *Control of soilborne pathogens with soil solarization in the southern region of Liybian Jamahiriya.* Proceedings of the First International Conference on Soil.FAO Corporate Documentry.Ch18, 2005.

[37] Zhao, H., Y. C., Xiong, F. M., Li, R. y., Wang, S. C., Qiang, T. F. and F. Mo, *Plastic film mulch for half growing-season maximized WUE and yield of potato via moisture-temperature improvement in a semi arid agroecosystem.* Agricultural Water Management, vol.104, :pp.66-78, 2012.