EFFECT OF SOLARIZATION AND AMENDMENTS ON THE PINE DAMPING OFF AND SOIL PROPERTIES

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ABSTRACT

The effects of solarization using polyethylene mulching for 45 and 60 days combined with soil amendments of chicken manures (CM), mixed fungicides of metalayxl 2g and benlate 1.5g L^{-1} (Met.&Ben.), biocontrol agent of *Trichoderma harzianum* (T.h.). and NPK fertilizers 180kg N h^{-1} on the pine damping off in Malta nursery had been ascertained in Summer 2008. Pre-emergence damping-off on the pine seedlings grown in dry soil was 83.33% with disease severity of 60%, while solar heating for 45 days reduced the disease occurrence to 45% and its severity 11.67%. Amendments of CM., Met. & Ben., and T.h. after 60 days controlled disease to a lesser extent than other treatments. Obvious increasing of organic matter, 2.63%, NH^{+}_{4}– N 0.08 g N and NO^{-}_{3} – N 0.05 g N $100g^{-1}$ soil in addition to soluble nutrients of P 8.91 mg and K 0.035 Meq K $100g^{-1}$ soil was recorded in the mulching soil. At the same time composted heating plots decreased C/N ratio to relatively optimal levels of 15.75 and 18.59 after both of solar periods, alkaline soil pH (8.41 – 9.56) did not incongruous with the efficiency of biocontrol T.h. in the decomposition of organic matter and availability of the most nutrients even in the solarized soil.

INTRODUCTION

The general climate of northern Iraq is mediterranean with cold to mild winter and hot dry summer. Vegetable transplants, forest or fruit and ornamental nursery stocks are produced in plasti-culture production system or raised polyethylene mulched beds in tunnels.

In intensive farming system with narrow rotation, soil borne plant pathogenic fungi frequently reaches high inoculum densities. Thus, threatening the profitability of crops. A crucial factor in the management of diseases caused by these pathogens is to reduce their inocula level below the critical threshold level before a susceptible crop is planted. Since 1960, chemical soil disinfested commonly has been used for this purpose. In recent years, however, it has become more widely recognized that chemical soil disinfestations is incompatible with sustainable agriculture and it's increasingly use becomes restricted (Blok *et al*., 2000).

Recently soil solarization and its combination with soil pesticides, fumigants (Dazomet, 400Kg h^{-1}, Metam sodium 1500Lh^{-1}), or organic soil amendments and manures or fertilizers are known to be effective alternative control method (Fritsch, 2002). However, soil solarization alone may not consistently effective to control these pests. Therefore, to increase its effect it's usually combined with cultural, biological and/or chemical (Preferably at reduced dosages) methods (Fuentes *et al*., 1997). Solarization is a hydrothermal soil disinfestations process that utilizes clear plastic mulch to trap solar radiation in moist soil during the hottest summer months,

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can increase soil temperature to levels that can kill soil borne pathogens and seed of weeds (Elmore *et al.*, 1993), increase the solubility of nutrients and changes in the microbial composition of the soil (Stapleton *et al*., 2000).

The ultimate goal of this study is to evaluate efficiency of soil solarization, amendments and biocontrol agents singly or in combination on the occurrence of the pine damping off and breakdown of organic material in the soil release of soluble nutrient and improvement of soil physical and chemical properties.

MATERIALS AND METHODS

Soil solarisation: Experiments were conducted in Malta nursery (Duhok) during the hottest summer months (July and August), rainy winter seasons of 2007- 2008. Soil physical and chemical properties were analyzed. The experimental site was earlier planted by susceptible vegetables of solanaceous and cruciferous and was under cultivation for the previous several years.

Combined application of solarization and soil amendments: Solarization treatments of about 8 weeks duration were applied during summer months from 5 July to 5 September as described elsewhere (Loannou and Poullis, 1990).The field levelled and irrigated to depth 40-50cm prior to solarization in the last June 2008, when the soil moisture reached an appropriate level to cultivate the land ploughed deeply (30-40cm), clods were broken and the surface was levelled. Plots were 2m×2m separated by a one meter buffer zone in randomized split plot design with three replications. Five plots covered with a clear, UV stabilized, 25µm, low density polyethylene mulch for 60 days, other five plots mulched for 45 days and the remaining five plots were left non mulched to test main plot effects (solarization) versus non treated against soilborne pathogens.

Fresh chicken manures at 12.5 t $h^{-1}$for , fungicides of Metalaxyl 2g plus 1.5g Benlate L^{-1} (fertell com.), Fungal biocontrol agent *Trichoderma harzianum* (20K1), compound fertilizer (NPK, 12.4%N, 7.3% NH_3, 5.1% NO_3, 11.4% P_2O_4, 17.7% K_2O, 2.7 %Mg_2O, 8% S) at a rate equivalent to 180kg N h^{-1} and no treatment (control) sub-plot treatments. Chicken manure and mineral fertilizer added to plots before solarization and uniformly distributed on the soil surface and incorporated into the top 15-20 cm layer of soil using a rake.

Drip irrigation pipes placed into plots with 25cm intervals after application each of the manures and fertilizers and then clear polyethylene mulch covered the soil surface. Following mulch removal, *T. harzianum* (1×10^7 $cfug^{-1}$) applied twice with one month interval. *T. harzianum* was multiplied on potato dextrose broth in nine 250 ml flasks incubated at 28 ± 2°C for 10 days. Contents of nine (T. h.) flasks blended for 30 sec. the liquid suspension was then mixed in 3kg soil. This soil divided equally into nine lots and uniformly mixed to a depth of 30 cm in plots of the treatment before planting.

Chemical properties of (organic matter, nitrogen, potassium and phosphorus) in addition to physical characters of pH, Ec and C/N ratio of the soil were measured before and after solarization.

Plant growth assays in the solarized soils: Seeds of *Pinus brutia* were grown in 15cm-diameter pots filled with the test soils in both field experiments, which were seeded directly and thinned after emergence to five plants / pot. Plants grew in the greenhouse (22-28°C) for 75 days without fertilization. Mortality due to pathogen pre and post emergence damping off of seedling were recorded, disease severity were also computed depending upon density of root growth. Seedlings were up root, and growth response was calculated as increased of wet and dry weight. Shoot and root length of seedling over untreated control. Experiment was carried out in a randomized split plot design with three replicates for each treatment. Data of all experiments were analyzed and the mean of studied characters were compared with each other according to Duncan multiple test.

RESULTS AND DISCUSSION

Effect of soil solarization and combined amendments on the occurrence of damping-off and the Pine vigor: Nursery predominate cropping system, favour climate and agro-ecological conditions raise the rapid developments and growth of various soilborne pathogens. Soil solarization, (Met.&Ben.) Fungicides, biocontrol agent of T.h. combined with solarization for the period of 45 and 60 days were reduced pre-emergence damping-off and its severity significantly. Detection of disease in non-solarized control plots was 83.33% with severity of 60%. Solar heating alone reduced pre and post emergence damping off to 50% with severity of 11.67% after 45 days, whereas theses infection reduced to 58.33% and severity to 10.42% after 60 days. However, (CM), (Met.& Ben.) fungicide, and biocontrol agent of T.h. after along solarization (60 days) controlled soilborne disease to a lesser extent than other treatments (Table 1), the effectiveness of these applications combined with solarization after 60 days on the disease infection were 29.17, 20, 15, and 31.66% respectively compared with 73.34, 62.6, 58.33, and 66.67% for the same treatments in control non-solarized soil. The current studies indicate that more carbon and nitrogen were requested as organic matter in the soil, possibly increasing the sustainability of the agroecosystem, regardless the organic amendment type (Drinkwater *et al*., 1998). In the post emergence, Seedlings grew healthy in the solarized soil combined with fungicides or T.h., propagules of *Trichoderma* spp. as antagonistic fungi may have attributed to reduce disease by direct parasitism, competition, or antibiotics, disease also was minimized on the seedlings grown in non-solarized soil amendments. Therefore, solarization provides economic control of pre-emergence damping-off and weeds, enhances the physical and chemical properties of the soil, and increases the yield (Stapleton and De Vay, 1995). Results indicated that roots of seedlings were relatively free from infection regardless of solar period, properties and the initial soil inoculum potential. It is worthy to mention that the root quality reported as the main criteria used by growers and foresters for assessment of disease severity and as a source of judging seedling health (McGovern *et al.,* 2002).

The Increase in the foliage growth, and shoot biomass of the seedlings following solar heating soil might be related to increased amounts of available nitrogen or by reduction in pathogen population. In fact, the effect of the both factors is confounded and their separation is not possible. According to Stapleton *et al.* (1985) when mineral nutrition is the limiting factor for plant growth, increases in growth are resulted from control of less limiting factors such as soilborne diseases, only occurred after fertilization. Stapleton and De Vay (1984) believed that the

Table (1): Effect of soil solarization and combined treatments on the occurrence of damping-off and the Pine vigor.

Solar period	Soil amendments	% Damping- off		Disease severity %	Pine vigor			
		Pre-emergence	Post-emergence		Wet weight(g)	Dry weight(g)	Shoot Length(cm)	Root Length (cm)
Control (non solarized)	Control	83.33* a	10.00 a	60.00 b	0.31 de	0.06 e	6.10 a	12.47de
	Chicken manures	66.67 b	6.67 ab	81.00 a	0.33 cde	0.08 b-e	6.4 a	10.56 e
	Met.& Ben	60.00 bc	2.67 ab	32.33 c	0.29 de	0.07 cde	6.12 a	10.43 e
	T.harzianum.	53.33 cd	5.00 ab	16.50 d	0.28 e	0.06 de	6.27 a	10.40 e
	(NPK)Fertilizer	66.67b	10.00a	81.42a	0.27e	0.06e	5.97a	13.67de
45 day	Control	45.00 de	5.00 ab	11.67 de	0.48 a-d	0.09 a-e	6.83 a	24.20 ab
	Chicken manures	35.00 ef	3.33 ab	3.08 ef	0.56 ab	0.1 abc	6.97 a	26.47ab
	Met.&Ben.	35.0 ef	0.00 b	2.25 ef	0.52 abc	0.11 ab	6.77 a	22.73 ab
	T.harzianum	25.00 fgh	0.00 b	1.58 f	0.4 b-e	0.08 b-e	6.13 a	14.73cde
	(NPK) Fertilizer	41.67 de	5.00 ab	6.67 ef	0.51 abc	0.07 cde	6.2 a	18.63 bcd
60 day	control	53.33 cd	5.00 ab	10.42 def	0.51 abc	0.09 a-e	5.87a	23.87 ab
	Chicken manures	25.00 fgh	4.17 ab	1.67 f	0.54 ab	0.1 a-d	6.5 a	22.93 ab
	Met.& Ben.	20.00 gh	0.00 b	0.92 f	0.59 ab	0.10 abc	6.67 a	21.53 abc
	T.harzianum	15.00 h	0.00 b	0.50 f	0.64 a	0.11 ab	6.77 a	28.97a
	(NPK) Fertilizer	28.33 fg	3.33 ab	4.50 ef	0.57 ab	0.12 a	6.07 a	25.03 ab

*Mean in the same column followed by the same letter isn't significantly different ($p<0.05$)

increased plant growth following soil solarization resulted from not only availability of some soil nutrients plus reduction in number of soilborne pathogens, but may also be due to population shifts in favor of beneficial soil microorganism (antagonists) specially when crops are planted shortly after the plastic film is removed to prevent pathogens recolonization.

Physical and Chemical properties of the solarized soil: Solar was adopted as a non-chemical method to produce healthy seedlings through the improvement of soil/root health by controlling soilborne pathogens pressure and by nutrients availability. Concentration of organic matter was increased to 2.73 and 2.63% in solarized soil following 45 and 60 days respectively (Table 2). Researchers suggested that the processes taking place in solarized soil are involved mainly the insolubilization of low molecular weight humic substances instead of an increase in their formation (Chen *et al.,* 2000).

Increasing of NH^{+}_{4}– N and NO^{-}_{3} – N in solarized soil in the present work was attributed to the enhanced microbial synthetic activity due to high temperature. Thus, soil pH, E.C. and C/N ratio were decreased relatively as compared with control. Increases of soluble mineral nutrients P, K^{+}, NH^{+}_{4} and NO^{-}_{3} in addition to Ca^{+2}, Mg^{+2}, Mn^{+2}, Fe^{+3}, Cl^{-1}, and Cu^{+2} have been detected in solarized soils in several studies (Chen *et al*., 1991) although sometimes inconsistently (Moura and Palminha, 1994; Coates-Beckford *et al*., 1998) especially for the minor elements (Stapleton, 1998). This suggests that heating causes the release of soluble mineral nutrients, although mulches can also increase nutrient concentrations by reducing leaching of solutes (Stevens *et al*., 1991). Therefore, Stapleton *et al.,* (1985) reported that wet soils covered with plastic mulch and protected from solar irradiation and heating did not differ in chemical properties from untreated control soils.

Physical and Chemical properties of amended soil: Soil of the experiment and amendments had alkaline pH, ranged 8.2 – 8.4, composted plots were similar in contents of total N although their high composition of organic matter. Therefore, C:N ratio was exceeded to 25.04 (Table 3). Traditional NPK fertilizers increased soil NH^{+}_{4}, NO^{-}_{3}, N, P, K and soil electrical conductivity (EC) to 2.96. However, solarized soils commonly undergo an increase in soluble substances particularly in fertilized plots that can be detected as arise in the soil EC(Chen *et al.,* 1991). This change has been attributed to an increase in the rate of decomposition of organic matter at high temperature (Chen and Katan, 1980). Similar studies comparing commercial fertilizer application and compost only since 1990 and demonstrated that composted plots were similar or higher in soil C, Ca, Mg, Cu, and Zn although P and K were higher in mineral fertilizer plots (Warman, 2002; Ozores-Hampton *et al*., 2005).

Physical and Chemical properties of solarized and combined soil amendments: The fertility of the soil was improved with solarization. The amount of soluble minerals and organic materials in NPK fertilized heating plots (60 days) were increased significantly in the NO^{-}_{3} to 0.11 g N, phosphate PO^{-}_{4} 18.73 mg, and potassium K^{+} 0.081 Meq K 100g $^{-1}$ soil (Table 4). Obvious increasing of ammonium nitrogen NH^{+}_{4} – N was detected in the various solarized soil amendments. This might be a sequence of killing the microbial biomass. The NH^{+}_{4} – N accumulation

Table (2): Physical and chemical properties of the solarized soil.

Solar period	%O.M*	Nitrogen ($gN100g^{-1}$soil)			Potassium ($MeqK100g^{-1}$soil)	Phosphorus ($mgPg^{-1}$soil)	E.C. ($dS.m^{-1}$)	pH	C/N
		Total N	No3	NH4					
Before Mulching	1.22	0.028	0.02	0.013	0.016	5.23	2.7	8.3	25.09
Control	1.49** b	0.049 b	0.02 c	0.024 b	0.023 c	6.3 c	3.0 a	8.24 c	22.91 a
45	2.73 a	0.113 ab	0.04 b	0.066 a	0.029 b	8.2 b	2.5 b	8.34 a	15.58 b
60	2.63 a	0.205 a	0.05 a	0.078 a	0.035 a	8.91 a	2.49 b	8.27 b	10.59 c

Table (3): Physical and chemical properties of combined soil amendments.

Soil amendment	% O.M.	Nitrogen ($gN100g^{-1}$soil)			Potassium ($MeqK100 g^{-1}$ soil)	Phosphorus ($mgPg^{-1}$ soil)	E.C. ($dS.m^{1}$)	pH	C/N
		Total N	NO3	NH4					
Control	2.47* b	0.09 a	0.028 b	0.054 b	0.022 c	5.7 d	2.77 b	8.3 ab	18.02 b
Chicken manures	2.95 a	0.18 a	0.03 b	0.043 b	0.023 b	5.99 c	2.71 b	8.29 ab	25.04 a
Met.& Ben.	1.98 c	0.18 a	0.029 b	0.047 b	0.023 b	6.28 b	2.44 c	8.25 b	15.0 c
T.harzianum.	2.04 c	0.08 a	0.028 b	0.056 b	0.023 b	6.34 b	2.45 c	8.36 a	16.85 bc
(NPK) Fertilizer	1.99 c	0.17 a	0.07 a	0.079 a	0.056 a	14.71 a	2.96 a	8.23 b	6.93 d

* Mean in the same column followed by the same letter isn't significantly different ($p<0.05$)

Table (4): Physical and Chemical properties of solarized and combined soil amendments.

Solar period	Soil amendments	% O.M.	Nitrogen($gN100g^{-1}soil$)			Potassium (MeqK $100g^{-1}soil$	Phosphorus ($mgPg^{-1}$ soil)	E.C. ($dS.m^{1}$)	PH	C/N
			Total N	NO3	NH4					
Cont.	Control	1.19* d	0.04 b	0.015 e	0.019 de	0.017 g	5.23 i	3.17 c	8.3 bc	20.1 cd
	Chicken manures	2.3 c	0.033 b	0.02 de	0.011 e	0.0221 ef	5.53 hi	3.13 c	8.33 bc	24.79 a
	Met.& Ben.	1.32 d	0.033 b	0.016 e	0.017 de	0.022 f	5.85 fgh	3.67 a	8.18 cd	23.3 bc
	T.harzianum.	1.28 d	0.032 b	0.013 e	0.022 de	0.022 f	5.79 gh	2.3 e	8.1 d	23.1 bc
	(NPK) Fertilizer	1.35 d	0.11 b	0.04 c	0.05 cd	0.034 c	9.11 c	2.74 d	8.28 bc	7.32 h
45	Control	3.9 a	0.091 b	0.03 cd	0.05bc	0.024 d	5.73 gh	2.87 d	8.29 bc	24.97 b
	Chicken manures	2.62 b	0.1 b	0.03 cd	0.05bc	0.0236 de	6.15 efg	2.68 d	8.30 bc	15.75 def
	Met.& Ben.	2.31 c	0.092 b	0.034cd	0.06 bc	0.0236 de	6.4 de	1.9 f	8.22 cd	14.53 ef
	T.harzianum.	2.47 bc	0.093 b	0.033 cd	0.063 abc	0.0238 d	6.43 de	2.32 e	9.56 a	15.44 ef
	(NPK) Fertilizer	2.35 c	0.19 b	0.07 b	0.09 ab	0.052 b	16.28 b	2.74 d	8.34 bc	7.19 h
60	Control	2.3 c	0.15 b	0.038 c	0.082 abc	0.0238 d	6.13 efg	2.28 e	8.3 bc	9.03 gh
	Chicken manures	3.93 a	0.13 b	0.0363 c	0.06 bc	0.024 d	6.32 def	2.33 e	8.22 cd	18.59 de
	Met.& Ben.	2.29 c	0.18 b	0.036 c	0.065 abc	0.0238 d	6.60 de	1.75 f	8.34 bc	7.02 h
	T.harzianum.	2.38 c	0.12 b	0.037 c	0.083 abc	0.024 d	6.79 d	2.72 d	8.41 b	12.1 fg
	(NPK) Fertilizer	2.26 c	0.21 a	0.107 a	0.097 a	0.081 a	18.73 a	3.39 b	8.08 d	6.27 h

*Mean in the same column followed by the same letter isn't significantly different ($p<0.05$)

as nitrifying bacteria were also killed and (when introduced) were inhibited by toxic products presumable from killed biomass. Similar results were achieved with other technique of soil solarization such as steaming (Dawson *et al.*, 1985). Significant increases in PO^{-}_{4} and K^{+} were found in the solarized soil similar to those reported by Chen and Katan (1980).

Additional carbon (organic matter) 2.62 – 3.93% was increased in compost of (CM) solarized soil. Therefore, C:N ratio was exceeded significantly to 15.75 and 18.59 after 45 days of solar period. This process may reduce the amount of the available nitrogen to the crop. Allison (1965) reported that the soft wood sawdust can immobilize 6 Kg N/ton and dry hard word sawdust about 12 Kg N/ton. Thus, supplemental NPK fertilization may be necessary when certain organic amendments are made, but cover cropping in nurseries seldom increases the level of soil organic matter or soil N (De Vay and Krause, 1980), benefit the soil by conserving nutrients, otherwise lost by leaching and improving soil properties. It is worthy to mention that NH_4 – N is released in to solution though slow break down of organic matter by soil organisms, NH_4 is also nitrified to produce NO^{-}_{3}. Since slowly nitrification in the most non – mulched treatments, soil NO^{-}_{3} ranged 0.013 – 0.04 g N/100 g soil. Whereas augmented to 0.13 – 0-21 g $N100^{-1}$ g soil in the various soil amendments after 60 days of solarization. In any case, most conifer seedlings grew well with a predominantly NH^{+}_{4} – N source (Nelson and Selby, 1974), because its resistance to leaching compared with $NO3^{-}$ that is readily leached from the soil. Alkaline pH of the most soil amendments (8.1 – 9.56) affect the availability of nutrients to plants and influence the composition of soil flora and fauna including soilborne pathogens. Thus, macronutrients of N, K were the most available, in contrast of available PO^{-}_{4} which restricted at pH 6 – 7 in exception of the NPK fertilized mulching plots that contained 16.28 and 18.73 $mgPg^{-1}$ soil after 45 and 60 days of solarization compared with 6.4 – 6.79 mg P^{-1}g soil in other solarized soil amendments. However P become insoluble because its reaction with Fe, Al, and Ca in neutral and calcareous soil. In forest soils P deficiency has been detected after solarization and soil fumigation, this may lack attribute to destruction of mycorrhizal fungi essential to P uptake (Campanga and white, 1973). Influence of high soil pH in the present work was also incongruous with the efficiency of biocontrol of *T. harzianum* in the decomposition of organic matter and the most nutrients availability even in the solarized soil, since pH value was 9.56 and 8.41 after 45 and 60 days. Studies confirmed that the acid condition enhancing T. h. spore germination (Harman and Tylor, 1988), mycelial growth (Hadar *et al.,* 1984), and activity of lytic acid enzymes in addition of that low pH reduced the inhibitory effects of soil fungistasis on conidia of *Trichoderma* spp.(Schuep and Frei, 1969).

تأثير البسترة الشمسية والمصلحات على موت بادرات الصنوبر و خواص التربة

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الخلاصة

درست تأثير البسترة الشمسية باستخدام غطاء البولي ايثيلين لفترتين ٤٥ و٦٠ يوماً خلال صيف ٢٠٠٨ بالترافق مع مصلحات التربة لكل من مخلفات الدواجن (CM) وخليط المبيدين الفطريين ميتالاكسيل

٢غم + بنليت ١.٥ غم /لتر (Met. & Ben.) و المقاوم الحيوي *Trichoderma harzianum* و السماد المعدني NPK بمقدار ١٨٠ كغم N /هـ على موت بادرات الصنوبر و تقييم التغيرات في خواص التربة المعاملة. بلغت نسبة موت بادرات الصنوبر قبل ظهورها النامية في معاملات التربة غير المبسترة ٨٣.٣٣ % و شدة اصابتها ٦٠ % و أدت بسترة التربة لفترة ٤٥ يوماً الى تناقص ظهور المرض و شدتها الى ٤٥ % و ١١.٦٧ %على التوالي،و أدت اضافة مخلفات الدواجن و خليط المبيدين والمقاوم الحيوي الفطري الى التربة لفترة ٦٠ يوماً الى تقليل ظهور المرض الى نسبة أقل مقارنة ببقية المعاملات, كما حفز نشاط كلاً من المجموع الخضري و الجذرى و هي دلائل سلامة البادرة. ظهرت زيادة واضحة في المادة العضوية٢.٦٣% و $NH^{+}_{4}-N$ (٠.٠٨ غم N) و$NO^{-}_{3}-N$ (٠.٠٥ غم N ١٠٠ غم تربة) إضافة الى المغذيات الذائبة من الفوسفور (٨.٩١ ملغم) و البوتاسيوم (٠.٠٣٥ مليمكافى K / ١٠٠ غم تربة) في الترب المبسترة ، وفي نفس الوقت فإن الترب المبسترة و المضاف إليها السماد العضوي (CM) أظهرت نقصاً في نسبة C/N لتبلغ مستوياتها المثالية تقريباً ١٥.٧٥ – ١٨.٥٩ بعد كلا فترتي البسترة رغم قاعدية التربة pH =٨.٤١ – ٩.٥٦ والذي لم تؤثر على كفاءة الترب المعاملة بالمقاوم الحيوي الفطري في تحلل المادة العضوية ووفرة معظم المغذيات حتى عند بسترة التربة.

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