RECYCLING OF SPENT MUSHROOM SUBSTRATE (SMS) IN AVOCADO ORCHARDS

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ABSTRACT

Spent mushroom substrates (SMS), are usually treated as wastes. One of the main beneficial uses of SMS is as soil amendment, after further composting for horticulture. Avocado orchards in northern Israel, are grown mainly on heavy clay soils, suffering from poor drainage and limited aeration. This situation can cause yield decrease and lead to tree's degeneration. Two soil cover (mulch) treatments were compared**,** in an avocado orchard**:** fresh spent mushroom substrate (SMS) and cattle manure compost (CMC). The yield of the two avocado varieties of this orchard was higher on SMS than CMC mulch. The yield of one of the varieties was highest on control (uncovered) soils. Thick growth of avocado roots was found in and under both mulch types. Enhancement of avocado root growth into and under the mulch, will lead to improvement of avocado trees growth, especially on heavy un-drained soils. . Soil's EC values were higher under both mulch types, although they decreased due to annual rainfall. There are treatments (leaching etc.) that can be used, for minimizing the increase of soil's salinity after SMS application. There are advantages of the use of SMS, especially since it's price is only 20% of cattle manure compost due to less transportation costs and no need for composting. Therefore its use is advantageous for both avocado and mushroom growers. The commercial utilization of SMS in avocado orchards should be done carefully, with monitoring its impact on soil's EC (salinity) and taking the needed measures to avoid unnecessary damages.

Keywords: SMS, Avocado, Heavy clay Soils

INTRODUCTION

Production of "Champignon" mushrooms (*Agaricus bisporus*) is done on composts covered with casing soil. At the end of the cultivation cycle, these substrates, known as spent mushroom substrates (SMS), are moved from the growing rooms and treated as wastes. They can pollute the environment (soil, air and water) on one hand, but can be beneficial if they are treated and used properly [1,2,3,4,5]. One of the main uses of SMS is organic fertilizer for horticulture. It serves as supplier of both, organic matter that improves soils' structure and as source of macro and micro elements for plants nutrition [5,6]. The use of SMS as retardant of soil born plant diseases and notorious fungi was also demonstrated [5,7,8].

The substrates used for mushroom production in Israel are compost, made mainly of poultry manure, wheat straw and gypsum and casing soil, composed of black peat amended with lime. Most of the growers are located in northern Israel, producing, 8000 tons of mushrooms and 100,000 cubic meters of SMS, annually. The SMS are moved from the farms to remote locations for further composting treatment. Avocado orchards located close to the mushroom farms, are grown mainly on heavy clay soils, suffering from poor drainage and limited

aeration, since for good development of Avocado roots the soil must be well aerated, The present situation can cause yield decrease and lead to tree's degeneration.

MATERIALS AND METHODS

In a three years experiment in an avocado orchard two soil cover (mulch) treatments were compared: fresh spent mushroom substrate (SMS) and "conventional" agricultural cattle manure compost (CMC).

In both treatments the soil was covered with 40 m^3 mulch for hectare placed on one side of the tree line (150 liter for a tree) The first application was done on June 2008, after SMS leaching, The second application was done on January 2009 on the other side of the trees . The third application was done on January 2010 on the same side of the trees as on 2008 The control was uncovered soil, all treatments in four replicates, with two avocado varieties : Hass and Ethinger. The plots were irrigated with reclaimed effluents and fertilized according to the recommended protocol for avocado orchards in northern Israel. Data loggers (Hobo 4 Chanel) were used to collect temperature data year around. The temperature detectors were placed in the mulch cover on both sides of the trees row, in the soil under the mulch between two trees in the row and 20 cm above the mulch. Temperatures were recorded every 30 minutes. Chemical analyses of the mulch covers were made annually for: ash and total N, C/N ratio, pH and EC. In all treatments soil's chemical analysis were made once a year for: N, P, K, Cl, Na, Ca, Mg, Bo, content, pH, SAR,EC at the depths of 0-30 and 30-60 cm. Chemical analysis of avocado leaves: for N, P, K, Cl, Ca, Mg, Bo, content were also made annually. The amount of roots in the top soil (0-30cm.) was weighed in 200 gr. soil samples. Pictures were taken of avocado roots growth into the mulch. Yields of both varieties were measured annually. Yield quality was identified according to the portion of the fruits above certain dimensions.

RESULTS AND DISCUSSION

The temperatures in the soil and mulch layers are presented in Fig 1.

During January – June 2009 CMC mulch increased soil temperature more than SMS mainly with the mulch of January 2009 application. This mulch was probably un-mature manure compost and therefore more active.

Ash content of mulch layers during the first year (2008 -2009) after mulch application is presented in Fig. 2. Ash content increased faster in SMS mulch than in CMC. Increase in ash content is an indication for degradation of organic matter. The decrease of ash content after a year is explained by penetration of avocado roots into the mulch.

Other chemical analyses were done during the same period in the mulch and the results are presented in Fig. 3 -5.

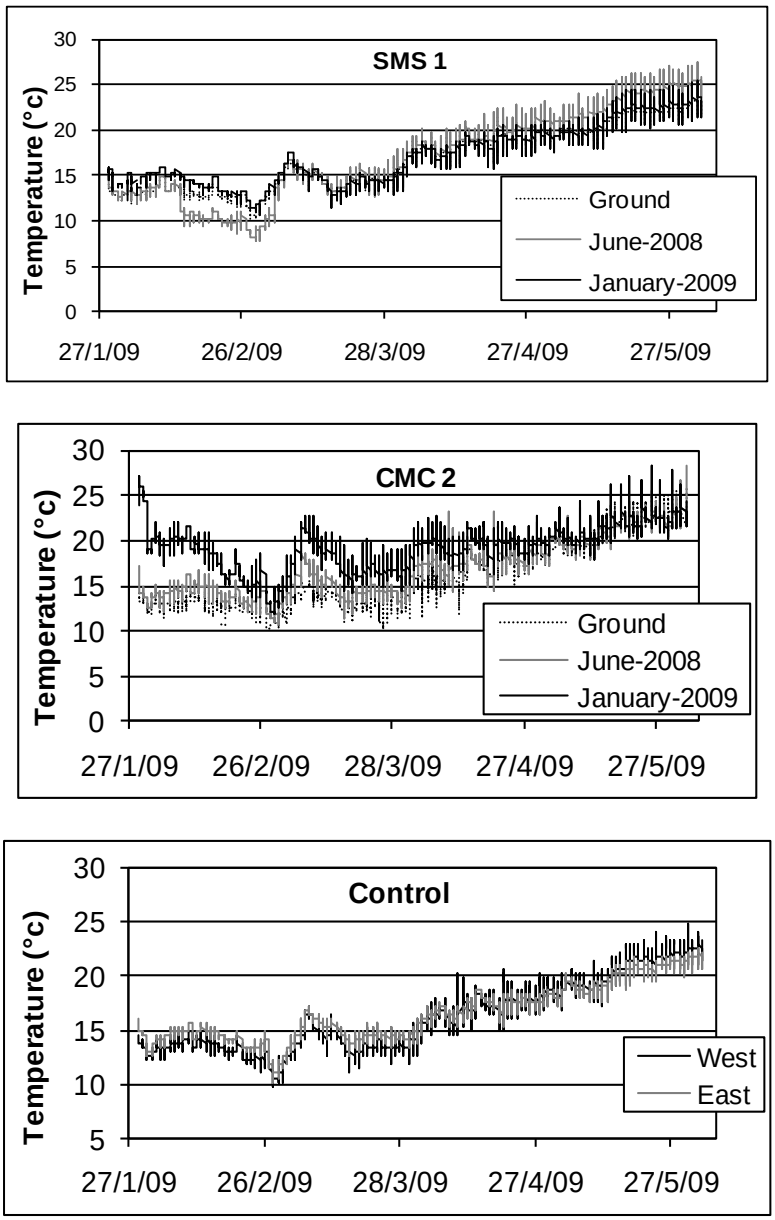

Figure 1. Temperatures in soil and mulch covers during 27.1.09 -27.5.09. Mulch was applied on June 2008 and January 2009.

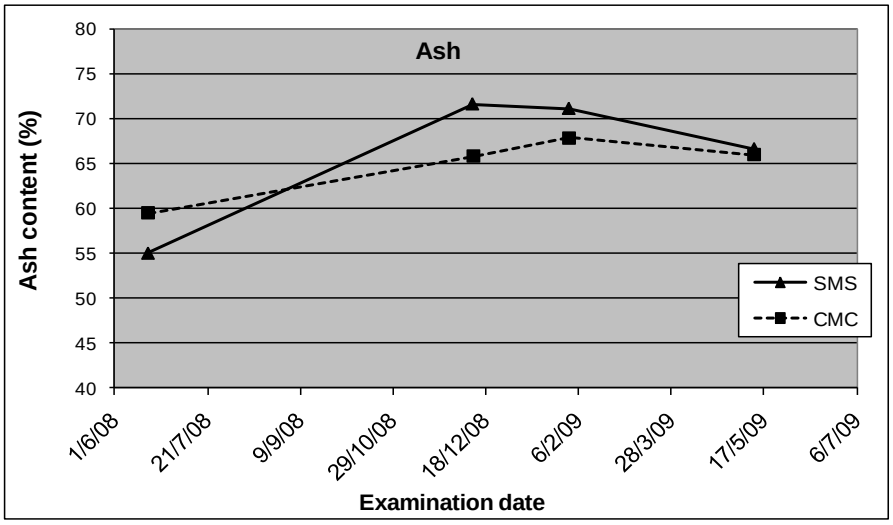

Figure 2. Ash content in mulch layers of June 2008 application.

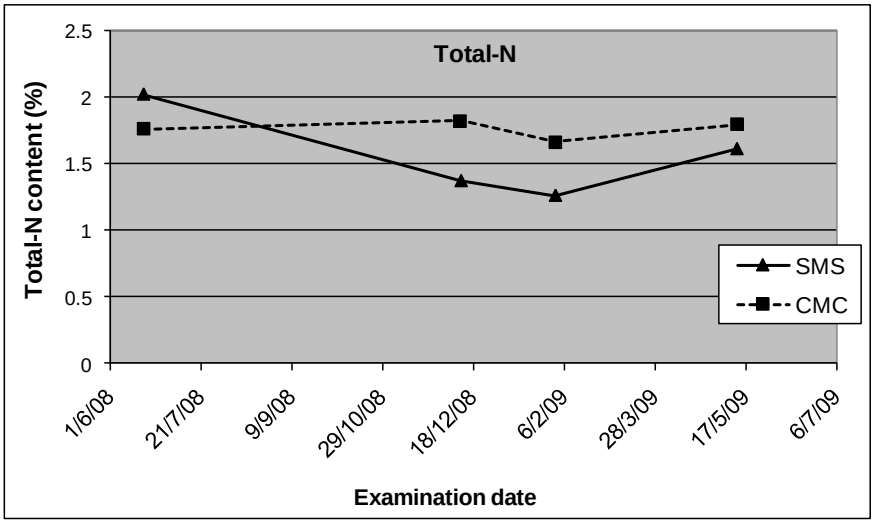

Figure 3. Total N content in mulch layers applied on June 2008.

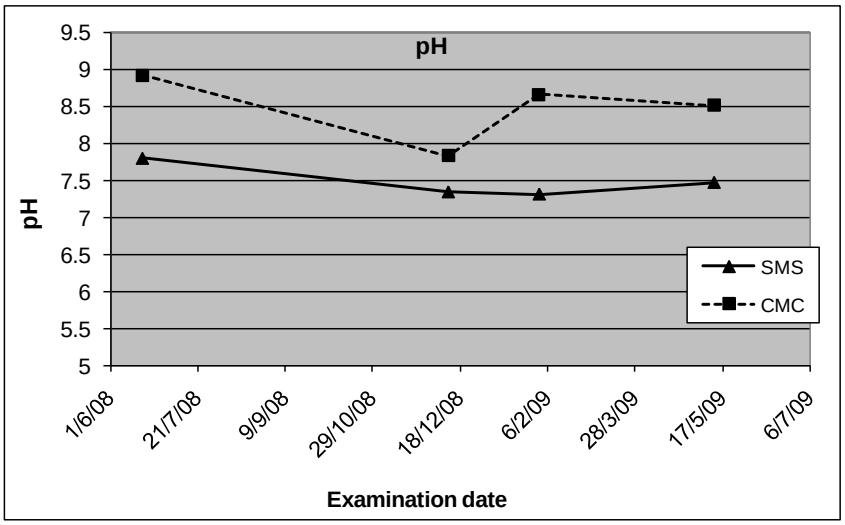

Figure 4. pH in mulch layers applied on June 2008

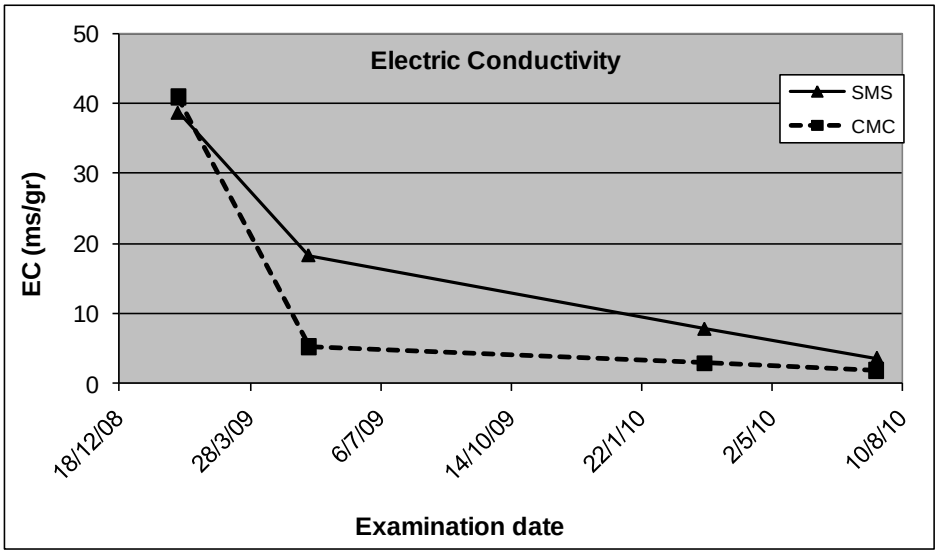

Figure 5. EC of mulch layers applied on June 2008

SMS was leached before its application to avocado orchard. CMC was un-leached compost and its EC decreased during the first winter, probably due to leaching by the rains.

Avocado yields were collected during two consecutive years. The results for the first year are presented in Figures 6 and 7.

Figure 6A and 6B : are yields of the two avocado varieties during 2009-2010 season.

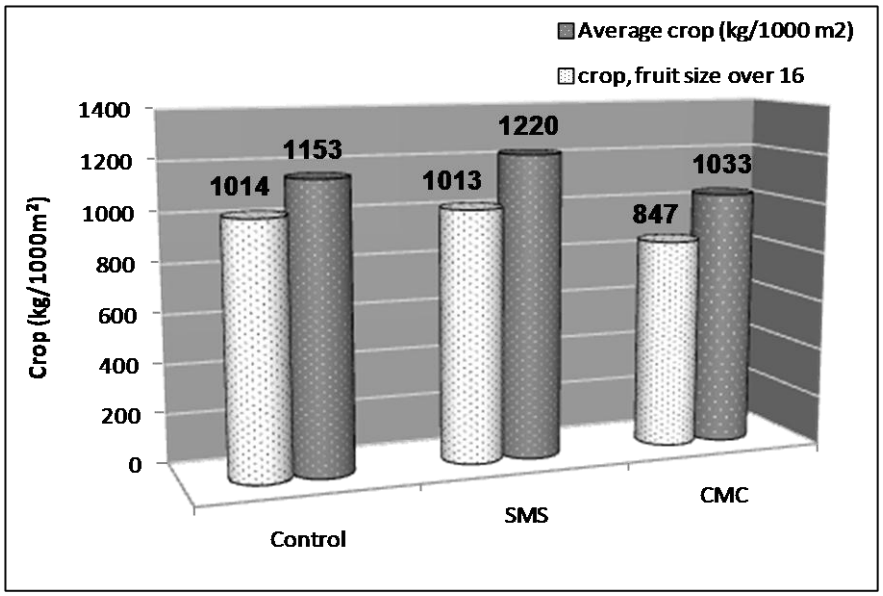

Figure 6A. Yield of Ethinger variety (first year)

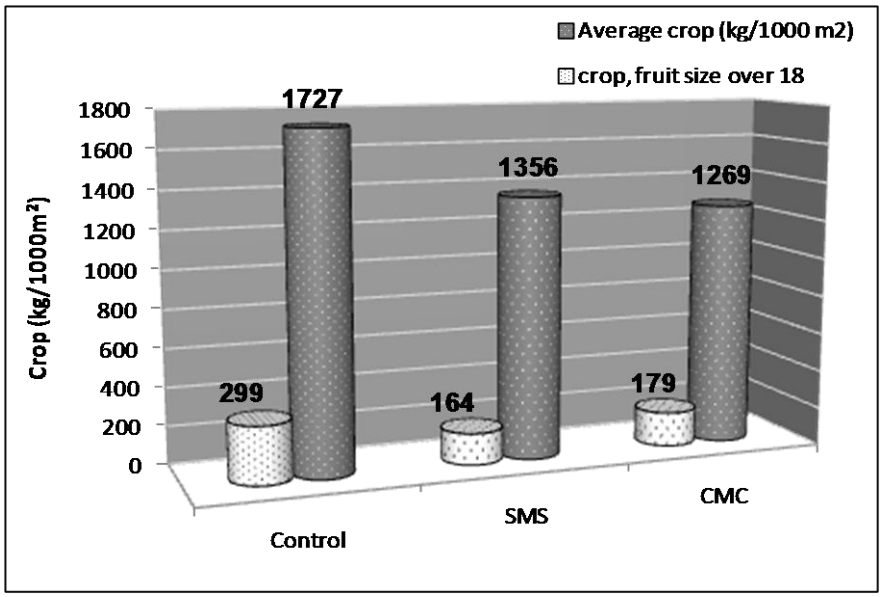

Figure 6B. Yield of Hass variety (first year)

In both avocado varieties yield of SMS plots were higher than those of CMC plots. The yield of the control was highest among the Hass variety plots.
Results for the second year (2010–2011) presented in Figures 7A and 7B.

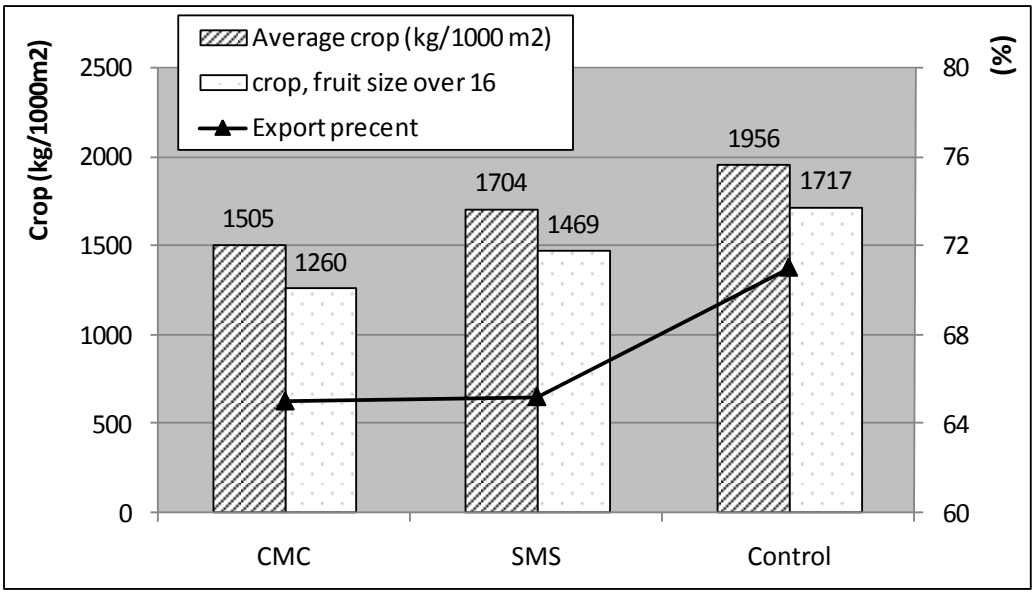

Figure 7A. Yield of Ethinger variety (second year)

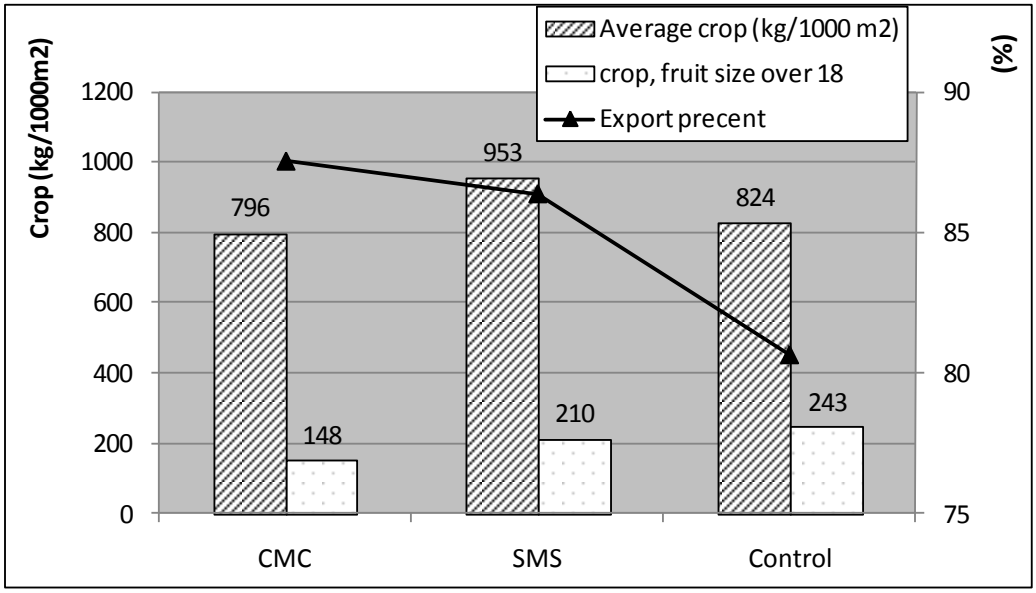

Figure 7B. Yield of Hass variety (second year)

The yield in the second year was also higher on SMS than CMC mulch in both varieties. The percentage of exported fruits is an indication for fruit quality.

No significant differences were found in avocado yields of both varieties (quantity and quality), between the above mentioned treatments, during the experiment period (the two years).

No significant differences, were also found in chemical analysis of avocado leaves, of the varieties, with the above mentioned mulch treatments.

Thick growth of avocado roots into both mulch types was documented (Fig.8).The weight of avocado roots in 200gr top soil were 4.1gr.under SMS mulch treatment and 4.8gr. under CMC mulch. In control soil only 2.0gr of roots were found

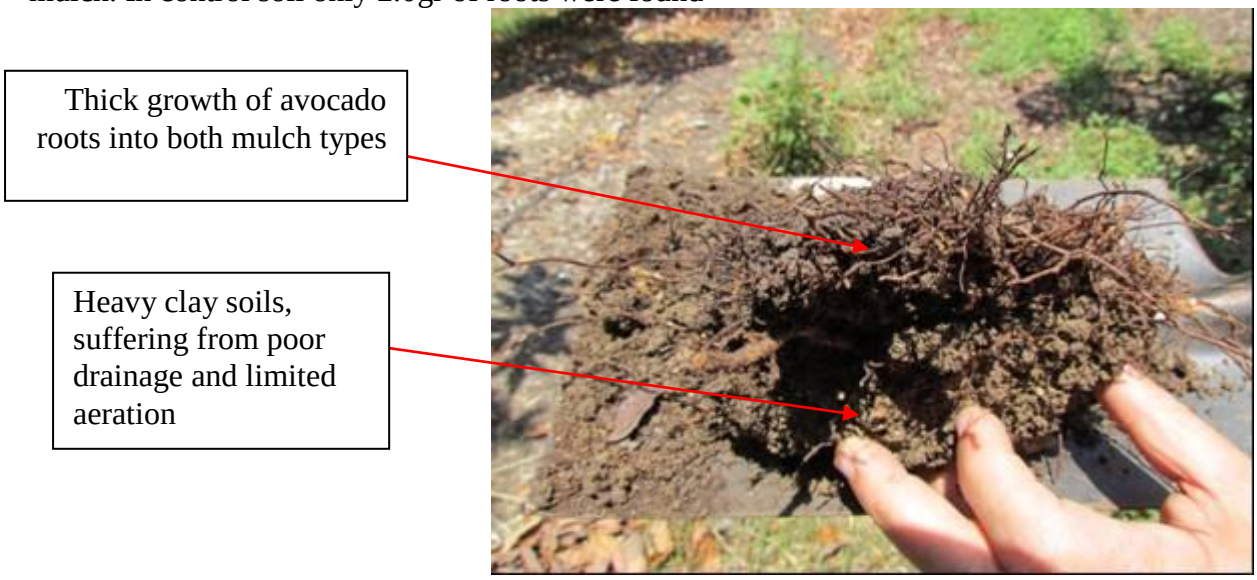

Figure 8. Growth of Avocado roots into SMS.

Soil's N and P content were higher under mulch treatments and highest under the CMC mulch. Soil's K and Ca+Mg was also higher under the mulch treatments. Soils' EC and Cl values, were higher under both mulch covers, than in the control (Table 1).

Table 1. Soil chemical analysis three years after first mulch application

CMC		SMS		Control		17.5.2011
15-30 cm	**0-15** cm	**15-30** cm	**0-15** cm	**15-30** cm	**0-15** cm	
14.3	32.9	**11.5**	25.8	6.7	14.3	N-NO3 (mg/kg)
37.9	67.2	12.4	41.6	11.3	31.8	P (mg/kg)
0.420	1.040	0.280	1.150	0.160	0.360	K in soil extract(mequ/L)
1.500	1.500	1.920	1.900	1.100	1.100	EC (dS/m)
5.00	3.60	7.50	3.40	3.20	2.30	Cl (mequ/L)
6.14	4.21	6.29	5.87	5.60	4.09	Na (mequ/L)
3.00	1.92	2.66	2.13	3.35	2.16	SAR
8.4	9.6	11.2	15.2	5.6	7.2	Ca + Mg (mequ/L)
2.60	3.50	1.30	1.80	0.70	1.00	Zn
50.7	47.3	63.6	36.0	36.2	43.2	Mn
5.3	4.7	13.5	5.8	5.4	4.6	Cu
19.6	20.0	15.7	12.7	18.6	14.5	Fe

The values of EC in these results, reveal the known negative impact of SMS and other composts on soils' salinity. There is evidence that this problem can be treated by SMS leaching or by changes in composts' composition [9]. The considerable growth of avocado roots into the mulch gives hope that this treatment will slow down orchards degeneration in the future.

Conclusions

Our results are from a three years experiment and two cropping years of an avocado orchard. This period is probably too short for evaluation of the impact of compost application, as mulch to an orchard. Nevertheless the results reveal potential advantages for recycling of SMS in this way :

a. Enhancement of avocado root growth into and under the mulch, will probably lead to improved growth, of avocado trees, especially on heavy un-drained soils. The presence of peat (from casing soil) in SMS improves soil's porosity and water holding capacity.
b. There are treatments (leaching etc.) for minimizing the increase of soil's salinity after SMS application. The annual rainfall decreases EC gradually.
c. SMS is a safe product for horticulture due to the heat treatments used during mushroom production cycle.
d. CO2 emissions of SMS utilization are lower than those of CMC, since this product is used fresh and is not produced through another composting process.
e. The yields of the SMS treated plots were higher than those of the CMC treated plots. CMC is the most widely used compost for agriculture.
f. Since the price of SMS is only 20% of cattle manure compost, its use is advantageous for both avocado and mushroom growers.
g. The commercial utilization of SMS in avocado orchards should be done carefully, with monitoring its impact on soil's EC (salinity).

References

[1] Levanon, D., Hadar, Y. and Wuest, P.J.(1994). Nature and use of spent mushroom substrate. *Compost Sc. & Util.* 2.3:22-23.

[2] Levanon, D. and Danai, O. 1995. Chemical, physical and microbiological considerations in recycling spent mushroom substrates. *Compost Sc. & Util*.3.1:72-80.

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[3] Levanon, D. and Danai, O. 1997. Recycling agricultural residuals in Israel. *BioCycle* 6:56-57.

[4] Levanon, D. and Danai O. 2004 Mushroom Production In: Encyclopeadia for Bioresource technology. Pandey A.(ed.) pp 265-276. Haworth Press USA.

[5] Bayer, D.(2006) Spent mushroom substrate (SMS) research in the US. *Mushrooms International*, 103: 19-21.

[6] Jordan, S. N. , Mullen, G. J. , Murphy, M. C. (2008) Composition variability of spent mushroom compost in Ireland. *Bioresource Technology* 99: 2 .411-418

[7] Davis, D. D. , Kuhns, L. J. , Harpster, T. L (2005) Use of mushroom compost to suppress artillery fungi. *Journal of Environmental Horticulture.* 23: 4.. 212-215

[8] Noble, R. (2006) Spent mushroom substrate - an alternative use. Mushrooms International.*103: 21-23*

[9] Wever, G. , Burg, A. M. M. and Straatsma, G.(2005) Potential of adapted mushroom compost as a growing medium in horticulture. *Acta Horticulturae.*. 697: 171-177.

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