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Use of Sewage Sludge and Fiber Palm Co-compost as Components of Substrates *Lycopersicum esculentum* and *Cucumis melo* Cultivated in Soilless Crop

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ABSTRACT

The use of different waste materials, Sewage Sludge (SS), Palm Fiber (PF) and Topsoil (TS) as substrates in the production vegetable plants were studied with a special interest on the suitability of palm fiber as growing substrate plants. It was composted during 60 days at equal volume (1:1) with SS. The five substrate mixtures were, T1 = 50% (SS and PF)+50% TS, T2 = 35% (SS and PF)+65% TS, T3 = 25% (SS and PF)+75% TS, T4 = 20% (SS and PF)+80% TS and T5 = 15% (SS and PF)+85% TS. The plant species tested were *Lycopersicum esculentum* and *Cucumis melo*. Electritical conductivity and pH substrate were periodically tested along the experiment. The mixture of T1 represented the most convenient substrate to use for L. *esculentum* regarding the other treatments. For *C. melo*, the mixtures of T1 and T2 gave the best relative performances. Therefore, it is important to consider the use of sewage sludge and palm fiber can influence positively the physico-chemical properties of horticultural substrate.

Key words: Electritical conductivity, *C. melo*, *L. esculentum*, palm fiber, pH, sewage sludge

INTRODUCTION

Sewage sludge is waste resulting from a sewage treatment from domestic or industrial origin. They are rich in organic matter, trace elements and nutrients such as nitrogen and phosphorus. They have a vested interest in agriculture and other areas (Chatha *et al*., 2002).

Composting of sewage sludge has the benefits of reducing environmental risks associated with waste management by reducing the volumes and destruction of pathogenic organisms (Saebo and Ferrini, 2006). In addition, composting provides an amendment consisted of a stable and humified organic matter containing nutrients (Guittonny-Larcheveque, 2004; Hanapi *et al*., 2011). Its incorporation into the soil fight against the degradation of the soil surface (Bresson *et al*., 2001) and it increases its porosity and structure (Pagliai *et al*., 2004).

Organic substrates like coco fiber or wood fiber have been introduced in hydroponic culture in order to substitute peat (Muro *et al*., 2005; Domeno *et al*., 2009). Because, it is a non-renewable resource and in less rockwool or perlite due to their problematical recycling. Therefore, the co-composting of palm fiber and sludge substrates plants is a natural way of development with many benefits (Suradi *et al*., 2010).

In soilless crop, the major problem concerns the nutritional imbalance caused by an incompatibility in the combination [nutrient solution/substrate/plant species grown] (Latigui *et al*., 2011). This imbalance may cause salinity in the substrate inducing, therefore, phytotoxicity. It can also cause mineral deficiencies harmful to the desired production (Choi *et al.*, 2011). Therefore, the success of this technique depends mainly on characteristics of horticultural substrate like pH and EC.

To ensure optimal uptake of all major elements, the leaching solution must have K/Ca+Mg about 0.67 (Latigui, 1992). The pH should range between 5.5 and 6. Because, this slight acidity is beneficial to absorption of all micronutrients (Babiker *et al.*, 2004). The Electritical Conductivity (EC) should range between 1.5 to 2.5 mS^{-1} cm to avoid the substrate salinity (Skiredj, 2005).

The objective of this work was to find the best relative substrate of palm fibers and sewage sludge of the plant species tested *Lycopersicum esculentum* and *Cucumis melo* by controlling the EC and pH of the drainage. Because, they are the main references for determining the behavior of the substrate (Latigui *et al.*, 2011). It controlled, also growth and development characteristics: fruit weight of the first bouquet stage of *L. esculentum* fruit set and height plant of *C. melo*.

MATERIELS AND METHODS

Treatments substrates: Five combinations were made from sewage Sludge (SS) and Palm Fibers (PF) on the one hand and Topsoil (TS) on the other. They represent the five treatments T1, T2, T3, T4 and T5 (Table 2). Each combination was repeated 7 times or 35 pots.

The sewage sludge (SS) was collected in the wastewater station of Tiaret city. It is characterized by a pH = 7.20, EC = 3.34 mS^{-1} cm and an organic matter content of 7.91%. The micronutrients composition was (ppm): 143 Cu, 850 Zn, 177 Mn and 94 Fe. The Topsoil (T) used has a sandy-clay texture. It is characterized by a Ph = 7.93, EC = 1.16 mS^{-1} cm and an organic matter content of 0.86%. The Palm Fibers (PF) used were taken from the trunk of the palm from an orchard of palms located at Ouargla city (south of Algeria). According to Ukoima *et al.* (2009) Palm fiber is considered the most suitable farm waste for growing plant.

Plants and experimental device: The experiment was carried out in experimental greenhouse located in Tiaret (35-15N, 001-26E) Algeria. The trial with the crop was part of a comparative experiment for five substrates for the soilless crop of greenhouse *L. esculentum* and *C. melo*.

The plug-grown Trois chants *(L. esculentum)* and Jaune canari *(C. melo)* seedling at three true leave's stages aged 40 days, were planted into plastic pots with a volume of 1600 mL in different substrates representing different treatments.

The plants were irrigated with tap water for the first 40 days after planting. 500 mL/plant of water were provided every 2 days. From fortieth day until harvest 1000 mL/plant/day were provided in the form of nutrient solution (Table 1). During irrigation or fertigation the leaching percentage was controlled at 30 to 40% to avoid the salt accumulation in the root media (Latigui and Dellal, 2009; Munoz *et al.*, 2008).

The crop growth as influenced by the treatment solutions was checked 50 days after planting, by measuring the Ph, Ec leaching and the height plant of *C. melo* and weight fruit of *L. esculentum* at the firsts stage of fruit set.

An aerobically co composting at equal volume [1:1] of SS and PF was carried out for two months. This operation, according to El hammadi *et al.* (2007), Ros *et al.* (2006), Jamal *et al.* (2011) and Magram and Abdel Azeem (2008) allows the destruction of pathogens by means of the high temperature and quickly leads to the development of a stabilized and humified organic matter (Azmat *et al.*, 2007; Antizar-Ladislao *et al.*, 2006; Banaras *et al.*, 2002).

Table 1: Composition of the nutrient solution designed to *L. esculentum* and *C. melo*

Mineral elements	meq L^{-1}
NO_3^-	8
$H_2PO_4^-$	2
SO_4^-	2
K^+	5
Ca^{2+}	5
Mg^{2+}	2

Microelements composition (µg L^{-1}): 1.81 $MnCl_2{\cdot}4H_2O$, 2.86 H_3BO_3, 0.22 $ZnSO_4{\cdot}7H_2O$, 0.08 $CuSO_4{\cdot}5H_2O$, 0.09 $H_2MoO_4{\cdot}H_2O$ and 0.79 $Na_2FeEDTA$

Table 2: Composition of substrates representing the 5 treatments

Treatments	Sewage sludge+fiber palm (%)	Topsoil (%)
T1	50	50
T2	35	65
T3	25	75
T4	20	80
T5	15	85

Statistical analysis: Data pH, EC, weight fruit and height plant were subjected to a randomized complete block analysis of variance. The treatments means were separated via Duncan's test. Seven repetitions by treatment were used.

RESULTS AND DISCUSSION

Effect of substrates on Electritical Conductivity of Drainage (ECD): Controls of ECD were carried out during irrigation with tap water and after use of the nutrient solution. They were compared to the EC of the input solution (ECI).

The analysis of variance has shown a highly significant effect of different treatments on the concentrations of the two species studied drainages (Table 3, 4).

Equal or slightly superior of ECD compared to ECI explain that the plant has taken almost all of the nutrients in the solution (Latigui, 1992; Choi *et al.*, 2011). For a significant rise of ECD compared to ECI causes harmful salinity causing phytotoxicity and impair the product quality and quantity (Tabatabei *et al.*, 2006). We find (Table 3) that the largest proportion of the sewage sludge (T1) present in the substrate of *L. esculentum* and *C. melo* decreased the risk of salinity compared to other treatments. Because, their respective values 1.71 and 1.86 mS^{-1} cm are closer to the value 1.28 of input solution. According to Skiredj (2005) the standard parameter of EC for *L. esculentum* is between 1.5 to 2.5 mS^{-1} cm. In this case, T1 allows us to increase the concentration of nutrients in input solution without risk of increasing the substrate salinity.

From the fortieth day, the plants were irrigated with input solution presented in Table 1. It founded (Table 1) that apart T1 the other drainage treatments of *L. esculentum* are significantly higher than the standards required by the plants 2.15 mS^{-1} cm (Skiredj, 2005). They reached up to 4.03 mS^{-1} cm in T5, value higher than the input solution. This relatively high salinity reduced plant vegetative growth. But, at moderate levels, in T1, it improved fruit quality and antioxidant content (De Pascale *et al.*, 2001; Keutgen and Pawelzik, 2007; Choi and Latigui, 2008). Unlike in *L. esculentum*, it found that the ECD substrates of treatments T1, T2, T3 for *C. melo* were inferior to ECI. Plants have therefore, uptaken all the major elements. So, these substrates

Table 3: ECD after irrigation by tap water (EC = 1.28 mS^{-1} cm)

Treatments	L. esculentum	C. melo
T1	1.71^{c}	1.86^{d}
T2	2.41^{b}	2.15^{cd}
T3	3.31^{a}	3.45^{a}
T4	2.39^{b}	2.56^{b}
T5	2.25^{bc}	2.40^{bc}

Mean separation by Ducan's multiple range test at p<0.05. Values followed by the same letter within columns are not significantly different

Table 4: ECD after irrigation with nutrient solution (EC = 2.23 mS^{-1} cm)

Treatments	L. esculentum	C. melo
T1	2.90^{bc}	1.65^{c}
T2	3.32^{b}	1.80^{c}
T3	3.78^{b}	1.96^{bc}
T4	3.90^{a}	2.42^{a}
T5	4.03^{a}	2.45^{a}

Mean separation by Ducan's multiple range test at p<0.05, Values followed by the same letter within columns are not significantly different

Table 5: pH ECD after irrigation by tap water (pH = 7.86)

Treatments	L. esculentum	C. melo
T1	7.75^{a}	7.71^{ab}
T2	7.69^{a}	7.68^{ab}
T3	7.52^{b}	7.60^{b}
T4	7.67^{a}	7.65^{ab}
T5	7.69^{a}	7.73^{a}

Mean separation by Ducan's multiple range test at p<0.05, Values followed by the same letter within columns are not significantly different

have facilitated the metabolism of plants (Choi *et al*., 2011). Therefore, it is possible to increase the concentration of nutrients.

Effect of different substrates on pH leaching: Analysis of variance (Table 5-7) showed a highly significant effect of different substrates on the pH of ECD.

The pH of leaching is the principal factor that influences the uptake of all micronutrients for vegetables. It must vary between 5.5 to 6.5 (Urrestarazu *et al*., 2008; Gorbe and Calatayud, 2010). Table 5 shows that the pH of all treatments and for both crops after irrigation with tap water during 40 days is much higher than the standards. However, it found that the different substrates slightly decreased the pH of leaching solution regarding the input solution (Table 5). This high pH is due to consumption of NO_3^- and its lack in all treatments (Choi *et al*., 2011). It can also, due to the form of nitrogen present in the substrates (Domeno *et al*., 2009; Hussein, 2009). The contribution in the nutrient solution of an acidifying fertilizer as NH_4NO_3 allows the release of H^+ lowering the pH (Babiker *et al*., 2004).

After irrigation with the nutrient solution, the pH (Table 6) of all substrates *L. esculentum* decreased substantially without, however, reaching the 5.5-6.5 range necessary for optimal uptake of micronutrients. As for *C. melo*, the raising of pH explains the removal of all nitrogen fertilizers. Table 3 shows that ECD is less than ECI. Therefore, an enhanced input solution including nitrogen fertilizer is necessary.

Table 6: pH after irrigation with nutrient solution (pH = 8.25)

Treatments	*L. esculentum*	*C. melo*
T1	6.65[c]	7.06[b]
T2	6.77[b]	7.08[b]
T3	7.01[a]	7.28[ab]
T4	6.85[ab]	7.22[ab]
T5	6.87[ab]	7.36[a]

Mean separation by Ducan's multiple range test at p<0.05, Values followed by the same letter within columns are not significantly different

Table 7: Fruit weight of the first floral bouquet at fruit set stage of *L. esculentum* and plant height of *C. melo*

Treatments	Fruit weights *L. esculentum* (g)	Plant height *C. melo* (cm)
T1	104[a]	93[a]
T2	88[bc]	92[a]
T3	96[ab]	85[b]
T4	79[cd]	84[b]
T5	73[d]	68[c]

Mean separation by Ducan's multiple range test at p<0.05, Values followed by the same letter within columns are not significantly different

Effect on plant growth: The substrate of T1 (Table 7) gave the highest weight of the first floral bouquet stage fruit set of *L. esculentum*. The substrates T1 and T2 of *C. melo* gave the highest plant height. It recalls that during the experiment the EC of these two substrates did not exceed the standards required by the two species studied. They were also, close to the input solution or irrigation with tap water. So, mixed sewage sludge and palm fiber in proportions T1 = 50% (SS+PF)+50% TS and T2 = 35% (SS+PF)+65% TS presented the best performance throughout the growing period.

These results can be related to the, relatively, adequate pH and EC of these media. Because, the use of alternative soilless media for the production of plants result in the best conditions for plant growth (Chavez *et al*., 2008). It produces plants with a better quality, more rapidly (Calkins *et al*., 1997).

CONCLUSION

In soilless crop, the major problem concerns the nutritional imbalance caused by an incompatibility in the combination [nutrient solution/substrate/plant species grown].

In this study, it was found that the substrates of T1 and T2 gave the best production in fruits of *L. esculentum* and greater plant height of *C. melo*. However, the EC of the drainage is less or equal than that of input solution. In addition, the pH of the drainage was above the range 5.5-6.5. This explains a lack of acidifying fertilizer such as NH_4NO_3.

The input solution is consisted by (meq L^{-1}): $8NO_3^-$, $2H_2PO_4^-$, $2SO_4^-$, $5K^+$, $5Ca^{2+}$, 2 Mg^{2+} with Σcations = Σanions = 12. So, it is possible to increase it by adding 3 meq L^{-1} de $3NH_4^+$ and $3NO_3^-$ meq L^{-1}. This change lowers the pH and increase the concentration of supply without risk of salinity. Therefore, the substrate T1 can be used for *L. esculentum* with the new improved solution (meq L^{-1}) = $11NO_3^-$, $2H_2PO_4^-$, $2SO_4^-$, 5 K^+, $3NH_4^+$, $5Ca^{2+}$, $2Mg^{2+}$ with Σcations = Σanions = 15. For *C. melo*, the substrates T1 and T2 can be used with this new solution.

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