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Abstract - Co-composting oil palm wastes, particularly the empty fruit bunch (EFB), frond and trunk with sewage sludge could be potentially converted into value added product. The objective of this study was to determine the best formulation using oil palm wastes and sewage sludge in producing a composted material to be used as a potting media in horticulture. Shredded oil palm wastes (EFB, frond and trunk) were mixed with sewage sludge in 3 different ratios (1:0, 3:1 and 4:1 ratio) using a polystyrene box and adjusted to 60% moisture content. At week 12, oil palm trunk with sewage sludge at 4:1 ratio was found to be the most optimum compost as potting media for ornamental plants because of its texture suitable for potting media, not stringent or stiff, had high nutrient contents (2.05 % N, 0.640 % P, 1.39 % K, 0.705 % Ca, 0.229% Mg), pH 6.2 and low C/N ratio, 19. Oil palm trunk + sewage sludge compost (OPTSC) was used as as a complete or partial substitute to peat and possible enhancing effect with Agroblend and Grofas chemical fertilizer in the production of potted chrysanthemum. The design used was a randomized complete block design (RCBD) with 9 treatments, replicated 5 times giving a total of 45 pots.

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Strictly as per the compliance and regulations of:

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Abstract - Co-composting oil palm wastes, particularly the empty fruit bunch **(EFB),** frond and trunk with sewage sludge could be potentially converted into value added product. The objective of this study was to determine the best formulation using oil palm wastes and sewage sludge in producing a composted material to be used as a potting media in horticulture. Shredded oil palm wastes (**EFB**, frond and trunk) were mixed with sewage sludge in 3 different ratios **(1:0, 3:1** and **4:1** ratio) using a polystyrene box and adjusted to 60% moisture content. At week 12, oil palm trunk with sewage sludge at **4:1** ratio was found to be the most optimum compost as potting media for ornamental plants because of its texture suitable for potting media, not stringent or stiff, had high nutrient contents **(2.05 % N, 0.640 % P, 1.39 % K, 0.705 % Ca, 0.229% Mg), pH 6.2** and low C/N ratio, **19.** Oil palm trunk + sewage sludge compost **(OPTSC)** was used as as a complete or partial substitute to peat and possible enhancing effect with Agroblend and Grofas chemical fertilizer in the production of potted chrysanthemum. The design used was a randomized complete block design **(RCBD)** with 9 treatments, replicated 5 times giving a total of 45 pots. Three types of potting media were compared; peat + vermiculite **(3:1 w/w)** as standard medium, **OPTSC** and **OPTSC** + peat. In this study, potted chrysanthemum exhibited better vegetative growth (increase in lateral shoots, top dry weight and total leaf area) and flowering qualities (early buds and blooms production, higher number and bigger diameter of flowers) in **OPTSC** and **OPTSC** + peat potting media, than the standard medium. However both **OPTSC** and **OPTSC** + peat media performed similarly. Application of both Agroblend and Grofas, or Agroblend alone, produced similar growth performance with an increase in nutrient uptake and growth of the potted chrysanthemum. Therefore, it is concluded that **OPTSC** could be used as a soilless potting medium with Agroblend alone, for potted chrysanthemum, as a complete or partial substitute for peat with reduced fertilizer cost.

Keywords: oil palm waste, sewage sludge, soilless media, chrysanthemum.

I. Introduction

Traditionally choices of potting media that are available in the market are limited mainly to peat and red clay soils. Recent research has sought to identify alternatives to peat and focusing on reusable and recycling materials not derived from non-renewable sources such as peat bogs (Hadar et al., 1985; Raviv et al., 1986; Verdock, 1988). Many studies have reported that organic wastes composts, such as from sewage sludge (Piamonti et al., 1997; Perez-Murcia et al., 2006), municipal solid waste (Ostos et al., 2008), animal manure (Atiyeh et al., 2001; Eklind et al., 2001), green waste (Grigatti et al., 2007; Ribeiro et al., 2007) and agro-industrial waste (Baran et al., 2001; Garcia-Gomez et al., 2002; Papafotiou et al., 2004; Bustamante et al., 2008) can be used with very good results as growth media instead of peat. Malaysia a major exporter of oil palm with a planted area of more than 3.9 million hectares in year 2005, created more than 51 million tonnes of oil palm wastes particularly the empty fruit bunch **(EFB),** frond and trunk **(MPOB, 2006).** These renewable organic wastes have great potential to be used as raw materials in composting into fertilizer, organic soil additive and crop substrate due to their high nutrient composition, particularly K, which are essential for plant growth (Wingkis, 1999 and Mohammed, 2000). Chan et al. (1980) reported that moisture retained in EFB mulch provided good environment for root development and increased nutrient release and plant nutrient uptake. Oil palm wastes, particularly the EFB, fronds and trunks compost were reported to have many characteristics that are equal or superior to peat as growing media (Lin and Ratnalingam 1980). Another organic waste that needs to be disposed off is the sewage sludge. Malaysia produces 5 million cubic meters of domestic sludge. By the year 2022, the amount will be increased to 7 million cubic meters per year (Indah Water 1997). Sewage sludge contain significant amounts of macro and micronutrients such as N, and is suitable for composting and as potting media for horticulture plants, (Akhtar and Malik 2000; Lazzari et al.,2000; Barrena et al. 2005), due to its high organic matter content (50% to 70%) of the total solids content (Smith 1992 and Ingelmo 1998; Rosenani et al. 2008; Zubillaga 2001 and Perez et. al. 2006). Due to high moisture content, sewage sludges need to be mixed with dry materials (such as sawdust,vegetal remains, straw), which act as bulking agents, absorbing the moisture and providing the composting mass with an appropriate degree of sponginess and aeration (Sanchez Monedero et al. 2001; Iranzo et al. 2004; Tremier et al. 2005). Therefore, there is a potential for

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composting oil palm wastes with sludge to produce composts, physically similar to peat. The resulting compost should be fine textured, odourless, rich in macro- and micronutrients and with acceptable levels of heavy metals. It may partially or fully substitute peat in the normally used potting media for ornamental plants. This paper reports the results of a study with the following objectives: a) to determine the optimum formulation of oil palm wastes (EFB, frond or trunk) and sewage sludge to produce compost that is suitable for use in potting media, (b) to investigate the effectiveness of the selected oil palm waste-sewage sludge compost as a partial or complete substitution of peat in potting medium for crysanthemum.

II. Materials and Methods

This study involved a co-composting experiment to determine the most appropriate formulation of oil palm waste and sewage sludge that will produce good compost for use in soilless potting media for ornamentals. Sewage sludge is a good N-source and is an easily available resource Co-Composting of oil palm wastes-sewage sludge The experiment was conducted in a glasshouse (28-31oC) and laid-out in a randomized complete block design using a white polystyrene box measuring 0.6 m in length, 0.5 m in width and 0.4 m in height. The treatments for this experiment consisted of EFB, frond and trunk, and each was mixed with sewage sludge in 3 different ratios (v:v), i.e. 1:0 (control), 4:1 and 3:1 with 5 replicates. Several whole EFB's, trunk chips and fronds were collected from an oil palm plantation, Durian Estate, Golden Hope Sdn Bhd, Selangor. They were first manually chopped into small pieces and then shredded with a mechanical shredder into smaller pieces of 6-10 cm to hasten composting process. Dewatered sewage sludge was collected from Indah Water Konsortium (IWK) wastewater treatment plant. The chemical compositions of the oil palm wastes and sewage sludge used in this experiment were as given in Table 1. Composting method was done according to Kala et al. (2009). At the end of 12 weeks of composting, samples were analysed for chemical properties (pH, total N, total C and macronutrients and heavy metals concentration).

III. Compost Characteristics After 12 Weeks

Results on composting of oil palm wastes (EFB, frond and trunk) with sewage sludge are published in Kala et. al. (2009). In this study, it was observed that the compost did not reach thermophilic stage (> 45^{o}C). This could probably be due to the dissipating of heat due to small volume. After 12 weeks, composts with added sludge had darker colour compared to the controls. The trunk+sludge composts had finer particle size similar to peat (< 20 mm)compared to the EFB and frond + sludge composts which were still fibrous with long strands (> 40 mm) and did not look matured. Final compost of oil palm wastes + sludge had total N content ranging from 1.18 to 2.05 % which was more than the recommended level by CEC (1986) for compost (0.6 % N). Phosphorus concentration was highest in the frond composts, F3:1 (1.025 %) followed by trunk compost, T3:1 (0.885 %). Generally, K concentration in this study was more than the recommended level by CEC (1986) in compost (0.3 % K). The percentage of K was highest in the EFB compost E3:1 (4.03 %). This could be due to the initial higher K in EFB than the frond and trunk. Calcium concentration was higher in composts with sewage sludge than the controls. This could be due to higher Ca content of sludge compared to the oil palm wastes. The Ca content was significantly higher ($p<0.05$) in the trunk + sludge composts, T3:1 and T4:1 (0.705 and 0.635%, respectively) followed by the frond + sludge compost, F3:1 and F4:1 (0.523 and 0.477%, respectively). However, the Ca and Mg content in this study was less than 2.0 and 0.3% respectively, which is the recommended level by CEC (1986). The trunk composts, T3:1 and T4:1 had Mg concentration of 0.237 and 0.229 %, respectively. The frond compost, F3:1 and F4:1 had 0.207 and 0.182 % Mg concentration, respectively. The composts, F1:0, F4:1 and T1:0 had lower Mg content than the other composts. Generally, addition of sludge to oil palm wastes had significantly increased the heavy metal contents of the oil palm wastes + sludge composts compared to the control due to the higher heavy metal contents in sewage sludge. Compost mixtures with 3:1 ratio had higher Pb, Zn and Cd concentrations than 4:1 ratio but were within the recommended level by CEC (1986), for compost.

IV. Use of Compost in Potting Media for Chrysanthemum

Oil palm trunk with sewage sludge compost (OPTSC) at 4:1 ratio was found to be the most optimum as potting media for ornamental plants because of its texture suitable for potting media, not stringent or stiff, had high nutrient contents (2.05 % N, 0.640 % P, 1.39 % K, 0.705 % Ca, 0.229% Mg), pH 6.2 and low C/N ratio, 19. Therefore three types of potting media were compared; peat + vermiculite (standard medium), OPTSC (as a complete substitute to peat) and OPTSC + peat (as a partial substitute for peat) (Table 2). These experiments were carried out under rain shelter at Universiti Putra Malaysia, Serdang, Selangor. The design used for this study was a randomized complete block design (RCBD) with 9 treatments, replicated 5 times giving a total of 45 pots. Treatments also included different rates of foliar and slow release fertilizers, to investigate if fertilizers could be reduced with the use of OPTSC. Data obtained in this study were subjected to analysis of variance (ANOVA). Where a significant F value ($p<0.05$) was obtained, Duncan's multiple range test was carried out to test for differences between the treatments means. The chemical characteristics of the three types of potting media are given in Table 3. Three rooted chrysanthemum cuttings were planted into a pot of 15.2 cm diameter. The plants were exposed to artificial long days for the first four weeks using 5 florescent Truelight® bulbs placed approximately 1 m above the pots. Long days were used to maintain vegetative growth by switching on the lights from 2300 hour to 0200 hour every night, controlled by a timer. To allow more side shoots, the terminal buds were pinched two weeks after commencement of the long days. A growth retardant, B-nine at the rate of 2500 mg/L was sprayed on the 37th day. Short day treatment was imposed four weeks after planting by covering with black polyethylene plastic. The treatment was from 1830 hour to 0830 hour every day until the flower buds start to show colour. The plants were watered twice daily using a sprinkler system. Foliar fertilizer, Grofas® was prepared in solution and sprayed weekly from day one. A slow release fertilizer, AgroBlend® (16:8:9:36+ MgO) was applied on the first and 8th week after planting. Insecticide and fungicide were sprayed weekly. The insecticide used was Ambush® (15-20 mL/4.5 L) and the fungicide used was Benlate® (1.5-3.0g/4.5 L). Weeds in the pots and the surrounding were controlled by hand weeding. Plant growth parameters measured during growth are as below. Plant height was measured weekly from the start until there was no change in plant height at the end of experiment (120 days after planting). It was measured from the soil surface to the shoot tip. The diameter of plant top was measured divided by the height of tallest stem for each plant and was recorded weekly as diameter : height ratio. Number of days to first visible bud was counted from the start of the short day treatment to the visible bud stage. Number of days to first bloom was taken as the days from the start of short day to the first opening of the outer most floret of the first flower in each pot. Number of bloomed flowers per pot was counted before harvest. Flower diameter was recorded as the average diameter of ten biggest flowers at harvest. All leaves that were fully opened were plucked to measure leaf areas using an automatic leaf area meter LI-COR Model LI-3100 and recorded as total leaf areas. Chrysanthemum plants were taken out from the media at the end of the experiment. The root was separated from the plant and washed to remove soil. The fresh weights of the plant (leaf, flowers and stem) and the root were recorded. These samples were oven-dried at 60 to 65°C for 48 hours to determine the dry matter weight (DMW). Leaf samples from first to fourth leave of the plant, when the flower bud first bloomed (Jones et al., 1991), were taken for foliar analysis. The leave samples were oven-dried at 60 to 65 °C until no changes were seen in the dry matter weight before grinding. Total N was determined by Kjeldahl digestion of 0.1 g sample with concentrated H_2SO_4 (Bremner and Mulvaney, 1982) and the solution was analyzed for N by an auto analyzer. Phosphorus, K, Ca and Mg contents were determined by dry ashing method. Briefly, 0.25 g of plant tissue was weighed and placed into a muffle furnace and temperature in the furnace was set at 500oC for 5 hours. The ash was moistened with distilled water and 2 ml of concentrated HCl was added and were heated on a hot plate at 100°C for an hour. Then, 10 ml of 20 % of HNO^3 was added and the sample was digested at 100oC in a water bath for an hour. The solution was then filtered and analyzed for P, K, Ca and Mg cations. Calcium and Mg were analyzed in the presence of Lanthanum chloride (1000 ppm). From the digest P content was read by the auto-analyzer while K, Ca and Mg by atomic absorption spectrophotometer (AAS).

V. Results and Discussion

Chemical characteristics of potting media Addition of peat to OPTSC (3:1 w/w) in the growth media did not lead to substantial changes in its chemical characteristics, the only important effect being a slight lowering of the pH (Table 4). According to Bunt (1988) the optimal pH range of media and mixes for growing ornamental plants in container is 5.2 to 6.3. Total C content was over 28% in peat, 32% in OPTSC and 41% in OPTSC + peat; by contrast, total N in both OPTSC and OPTSC + peat more than doubled that of peat, though never exceeding 3%. The C/N ratio is widely used as an indicator of the maturity and stability of organic matter. In this experiment C/N ratio were 18.96, 23.25 and 34.36 in OPTSC, OPTSC + peat and peat potting media, respectively. Davidson et al (1994) reported that composts with a C/N ratio of less than 20 are ideal for nursery plant production. Ratios above 30 may be toxic, causing plant death (Zucconi et al.,1981). Peat growth medium had significantly highest Mg and Ca, but lowest K concentration when compared to OPTSC and OPTSC + peat media. The heavy-metal content in three potting media were within the recommended levels of CEC (1986) in compost.

VI. Vegetative and Flowering Growth Performance of Chrysanthemum Plant

Effects of potting media i.e, standard peat, OPTSC and OPTSC + peat with different combinations of fertilizers on plant growth and flowering of potted chrysanthemum are shown in Table 5. Plants in this experiment ranged from 23.5 to 28.3 cm which tended to lodge and had to be supported. According to Crater, (1992) an ideal height for potted chrysanthemum is approximately 2 to $2^{½}$ times the height of the pot. However the standard peat medium had a plant height of 27.2 cm with weak and slender stems. Therefore it is

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suggested that the plants should be pinched twice to reduce plant height and increase lateral shoots. According to Crater (1992), several cultivar of potted chrysanthemum is too sensitive to heat therefore plant height could not be controlled. Selecting heat tolerant varieties would be more feasible. However plants in OPTSC and OPTSC + peat potting media treated with Grofas only (foliar fertilizer) had retarded growth (23.5 and 23.8cm, respectively) and did not have many lateral shoots. This could be due to inadequate supply of macronutrient from foliar fertilizer for the vegetative growth. Plants grown in the standard peat medium took the longest time for the appearance of first visible bud (34 days) compared to other treatments which ranged from 22 to 25 days. According to Machin (1978), insufficient nutrient or unbalanced nutrient can delay buds and flower formation by a week or ten days. In this study however, peat growth medium had significantly highest Mg and Ca, but lowest K concentration when compared to OPTSC and OPTSC + peat media. Chrysanthemum plants in OPTSC and OPTSC + peat potting media were the earliest to produce first blooms (46.0 days) compared to the standard peat medium which took 66 days. These composts media also produced higher number of bloomed flowers (30 to 63) compared to the standard peat medium which produced smaller and the least number of bloomed flowers (14) despite applications of both fertilizers. Actually, the standard peat medium produced many buds but only a few bloomed at the time of harvest. According to Crater (1992) potted chrysanthemum which is suitable for sale should have qualities such as free from diseases and insects, bushy with dark green foliage, with a full, white, actively growing root system and a minimum of 20 to 25 flowers of good size. Salinger (1987) reported that high absorption of nitrogen and potassium occurs during early vegetative growth in chrysanthemum. Higher nutrient contents (N, K and micronutrients) in OPTSC, which slowly mineralized and released nutrients in the long term, could be the reason for their higher yields. Moreover these potting media also exhibited higher top dry weight and total leaf area compared to peat medium. Peat is in a stable form; therefore it does not mineralize and provide additional nutrients to plants like the compost. However the performance (vegetative and flowering) of potted chrysanthemum in OPTSC and OPTSC + peat potting media, were significantly influenced by the application of chemical fertilizers, Agroblend (slow release fertilizer) and Grofas (foliar fertilizer). The effect of Agroblend and both Agroblend and Grofas, on plant performance were similar and better compared to half the recommended concentration of these fertilizers in OPTSC and OPTSC + peat media. However the application of Grofas only, had negative effects on the potted chrysanthemum; stunted growth, late blooms, decreased number of flowers, flower diameters, top dry weight and leaf areas. These observations were similar to potted chrysanthemum grown on standard peat media.

VII. Foliar Nutrient Contents

There were significant differences ($p<0.05$) in foliar total nitrogen concentration between the treatments (Table 6). Foliars in OPTSC and OPTSC + peat medium with the application of Agroblend only had the highest nitrogen concentration compared to others. However, foliars in the standard peat medium, OPTSC and OPTSC + peat with application of Grofas only had lower than the recommended nitrogen concentration which is 4.0 to 6.0 % (Tandon, 1993). This explains the yellowing followed by necrosis of the leaves. The recommended foliar phosphorus concentration in chrysanthemum plants was 0.25 to 1.0 %. Chrysanthemum foliars in all the treatments studied had phosphorus within the recommended concentration. According to Eysinga et al. (1980), when potassium is below the recommended concentration (< 4.0 %) in chrysanthemum plant foliar/tissue, necrosis of older leaves occurs and longer time will be taken for the appearance of first visible bud and flowering. These symptoms in foliar were found in treatments which may be due to inadequate K supplied by foliar fertilizer (Grofas) only. There were significant differences ($p<0.05$) in foliar calcium concentration of chrysanthemum plant between the treatments. The recommended foliar calcium concentration is 1.0 to 2.0 %. However in all the treatments except the standard peat medium, OPTSC and OPTSC + peat medium with application of Grofas fertilizer alone, had Ca concentrations ranging from 1.08 to 1.20 % which is within the recommended level. According to Eysinga et al. (1980), lower concentration of Ca in chrysanthemum plants (< 1.0 %) will result in reduced flower diameter, petals not properly formed and the colour changing from yellow to brown. There were significant differences ($p<0.05$) in foliar magnesium concentration of chrysanthemum between the treatments. However foliars in the standard peat medium, OPTSC and OPTSC + peat media with the application of Grofas only, had lower Mg concentrations ranging from 0.212 to 0.244 %. The recommended Mg concentration in foliar is 0.25 to 1.0 %. According to Salisbury and Cleon (1991), lower concentration of magnesium causes yellowing of older leaves. These symptoms were observed in the treatments with application of Grofas (foliar fertilizer) only, where supply of Mg could be insufficient. There were significant differences ($p<0.05$) in foliar iron (Fe), manganese (Mn) and zinc (Zn) concentrations in the chrysanthemum plant between the treatments (Table 7). All the treatments in the OPTSC potting medium had lower foliar Fe concentration in chrysanthemum plants compared to the other treatments. This results is contrast to the Fe concentration in the original OPTSC potting media, (6310 mg.kg-1), which is lower than peat

(2398 mg.kg-1). According to Tandon (1993), chrysanthemum plants show toxicity symptoms when iron concentration is more than 250 mg.kg-1. However, no toxicity symptoms such as stunted growth or severe leaf chlorosis were seen in this experiment. Foliars in all the treatments had manganese concentration within the recommended concentration of manganese in chrysanthemum plants by Tandon (1993). However no toxicity symptoms, (clorosis of younger leaves) were found in chrysanthemum foliar where concentration of manganese was more than 250 mg.kg-1. The foliar zinc concentration in this study ranged from 306 to 442.8 mg.kg-1, more than the recommended zinc concentration (20 to 250 mg.kg-1) for chrysanthemum plants, except for the standard peat media (60 mg.kg-1).

VIII. Conclusions

The trunk + sludge compost (4:1) was selected to be the most ideal for use as a potting media for chrysanthemum. The trunk composts had finer particle size similar to peat. However the final composts of EFB and frond + sludge were still fibrous with long strands and did not look matured. The EFB and frond composts may need to be composted more than 12 weeks to achieve finer particle size. Total N and Ca contents were highest in the trunk + sludge compost at week 12. The P and K contents were also fairly high. The pH, C/N, macronutrients and micronutrients were within the recommended levels of (CEC, 1986) in compost. Potted chrysanthemum gave better vegetative growth (increase in top dry weight and total leaf area) and flowering qualities (early to produce buds and blooms, higher number of flowers and bigger flower diameters) in oil palm trunk compost (OPTSC) and OPTSC + peat potting media, than the standard peat medium. However both OPTSC and OPTSC + peat media performed similarly. A proper fertilization program is essential in the production of potted chrysanthemums. In general the application of both slow release fertilizer (Agroblend) and foliar fertilizer (Grofas), and Agroblend alone, produced similar growth performance of the potted chrysanthemum plants. Addition of fertilizers had also influenced the nutrient uptake and growth of the potted chrysanthemums. Application of Grofas alone did not produce good vegetative growth and flowering qualities of potted chrysanthemum. This seemed to indicate that the combined effect of Agroblend and Grofas seemed to give beneficial effect of Agroblend alone and not the latter. Thus, it is recommended that use of 100 % of oil palm trunk + sewage sludge compost with Agroblend alone, could be used in the production of potted chrysanthemum with reduced fertilizer cost. Therefore, it is concluded that oil palm trunk + sewage sludge compost could be used as a soilless potting medium for chrysanthemum, as a complete or partial substitute for peat. This would convert oil palm waste into a value-added product and provide an alternative disposal method for sewage sludge in Malaysia.

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Table 1 : Chemical characteristics of the raw materials used for the composting experiment (n=3).

Parameter	EFB	Frond	Trunk	Sludge
pH	7.30 a	6.70 a	6.80 a	5.24 b
C %	50.87 a	52.28 a	52.18 a	37.41 b
N %	1.10 b	0.75 c	0.77 c	2.82 a
C/N	46.25 b	69.71 a	67.77 a	13.26 c
Ca %	0.17 b	0.17 b	0.15 b	0.83 a
Mg %	0.13 a	0.12 a	0.13 a	0.09 b
K %	2.06 a	1.63 b	1.46 c	0.08 d
P %	0.11 b	0.08 b	0.05 c	0.63 a
Pb (mg.kg^{-1})	7.67 b	7.37 b	5.33 b	68.00 a
Cd (mg.kg^{-1})	1.30 b	1.33 b	0.56 c	3.50 a
Mn (mg.kg^{-1})	42 b	47 b	39 b	257 a
Zn (mg.kg^{-1})	37 b	38 b	94 b	1322 a
Fe (mg.kg^{-1})	1076 b	1090 b	51 b	19000 a
Cu (mg.kg^{-1})	8 b	9 b	13 b	178 a

Means with different letters within the row indicate significant differences ($p<0.05$) using Duncan's Multiple Range Test.

EFB - *Empty fruit bunch.*

Table 2 : Treatments comparing three types of potting media i.e, standard peat, OPTSC and OPTSC + peat with different combinations of fertilizers.

Treatments	Ingredients
P+V+Ag+Af	Peat:vermiculite (2:1) +15 g Agroblend* +15 ml Grofas^
OPTSC+Ag+Af	OPTSC + 15 g Agroblend +15 ml Grofas
OPTSC+ Ag	OPTSC + 15 g Agroblend
OPTSC + Af	OPTSC + 15 ml Grofas
OPTSC+½Ag+½Af	OPTSC + 7.5 g Agroblend + 7.5 ml Grofas
OPTSC+peat+Ag+Af	OPTSC + peat +15 g Agroblend +15 ml Grofas
OPTSC+peat+Ag	OPTSC + peat + 15 g Agroblend
OPTSC+peat+Af	OPTSC + peat + 15 ml Grofas
OPTSC+peat+½Ag+½Af	OPTSC + peat + 7.5 g Agroblend + 7.5 ml Grofas

Agroblend* (Ag) - slow release fertilizer.
Grofas ^ (Af) - foliar fertilizer.
OPTSC -{oil palm trunk + sludge (4:1) w/w}.
OPTSC + peat (3:1 w/w).

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Table 3 : Chemical characteristics of the oil palm wastes (E=EFB, F=frond and T=trunk) and sewage sludge at different ratios (1:0, 3:1 and 4:1) after 12 weeks of composting (n=5).

Parameter	$E_{1:0}$	$E_{3:1}$	$E_{4:1}$	$F_{1:0}$	$F_{3:1}$	$F_{4:1}$	$T_{1:0}$	$T_{3:1}$	$T_{4:1}$
pH	6.9 a	6.7 a	6.9 a	6.1 b	5.8 c	6.0 bc	6.3 b	6.1 b	6.2 b
Vol. red.	19.7 b	44.9 a	47.0 a	12.6 c	18.2 b	18.8 b	10.6 d	15.6 b	14.8 bc
N %	1.48 e	1.78 c	1.93 b	1.22 f	1.63 d	1.45 e	1.18 f	2.04 a	2.05 a
C/N	32.6 b	21.83 cd	22.16 cd	41.5 a	29.67 b	24.6 c	41.24 a	19.0 d	18.98 d
Ca %	0.320 g	0.440 e	0.420 e	0.350 f	0.520 c	0.489 d	0.287 h	0.645 b	0.702 a
Mg %	0.260 c	0.40 a	0.330 b	0.180 f	0.220 e	0.180 f	0.160 f	0.250 d	0.230 d
K %	2.11 bc	4.03 a	2.36 b	1.89 cd	2 21 bc	2.05 bc	1.32 f	1.66 de	1.39 ef
P %	0.428 e	0.585 d	0.469 e	0.444 e	1.025 a	0.808 c	0.330 f	0.885 b	0.64 d
Pb (mg.kg^{-1})	9.35 h	62 a	34.73 b	9.97 h	29.0 d	26.35 f	15.33 g	33.19 c	26.35 e
Cd (mg.kg^{-1})	1.53 e	3.9 a	3.43 b	2.0 d	3.32 b	2.97 c	0.96 f	2.78 c	1.63 e
Mn (mg.kg^{-1})	46.1 c	108 a	99.43 ab	52.8 c	98.46 ab	84.85 b	46.88 c	87.97 b	92.64 b
Zn (mg.kg^{-1})	112 g	881 a	723 c	66 h	675 d	495 e	188 f	829 b	671 d
Fe (mg.kg^{-1})	3163 cd	7335 a	5322 ab	1201 d	5239 ab	4692 bc	1205 d	6794 ab	6310 ab
Cu (mg.kg^{-1})	17.88 d	68.31 b	67.63 b	9.5 f	53.33 b	52.33 b	14.67 e	78.6 a	68.83 b

Vol. red - volume reduction.

Means with different letters within the row indicate significant differences ($p<0.05$) using Duncan's multiple range test.

Table 4 : Chemical characteristics of potting media involved in this study (n=3). Different letters indicate significant differences ($p<0.05$) using Duncan's multiple range test.

	Peat	OPTSC	OPTSC+ Peat (3:1w/w)
pH	5.83 a	6.20 a	5.90 a
C (%)	28.86 b	32.78 b	41.39 a
N (%)	0.84 c	2.04 a	1.78 b
C/N	34.36 a	18.96 c	23.25 b
P (%)	0.67 a	0.65 a	0.75 a
K (%)	0.07 c	1.40 a	0.71 b
Mg (%)	0.85 a	0.24 b	0.46 b
Ca (%)	1.53 a	0.70 c	0.96 b
Fe (mg kg^{-1})	2389 c	6310 a	3922 b
Mn (mg kg^{-1})	31 b	93 a	88 a
Zn (mg kg^{-1})	20 c	671 a	240 b
Pb (mg kg^{-1})	13 c	27 b	37 a
Cd (mg kg^{-1})	0.15 c	1.63 a	0.95 b
Cu (mg kg^{-1})	8.09 a	6.90 b	6.80 b

Table 5 : Effects of potting media i.e, standard peat, OPTSC and OPTSC + peat with different combinations of fertilizers on plant growth and flowering of potted chrysanthemum. Different letters in columns indicate significant differences ($p<0.05$) between treatment means in Duncan's multiple range test.

Treatment	Plant Height (cm)	D:H	First Visible bud (days)	First bloom (days)	Bloomed flowers/pot	Flower Diameter (cm)	Total Leaf Area (cm^2)	Top Dry Matter Weight g/pot	Root Dry Matter Weight g/pot
P+V+Ag+Af	27.2 ab	0.709 d	34.4 a	66.0 a	14 f	5 f	399 c	8.5 c	2.24 b
OPTSC+Ag+Af	26.4 b	1.070 a	23.4 bcd	47.8 bc	55 cd	5.8 bc	815 ab	17.2 ab	2.74
OPTSC+ Ag	27.2 ab	0.880 bc	23.0 cd	46.2 d	63 a	5.6 cd	857 ab	18.0 a	2.77
OPTSC + Af	23.5 c	0.780 d	23.0 bcd	48.4 bc	30 e	5.4 def	387 c	8.4 c	2.78
OPTSC+½Ag+½Af	26.2 b	0.904 bc	22.6 cd	47.9 bc	53 d	6.0 ab	678 b	14.7 b	2.82
OPTSC+peat+Ag+Af	28.3 a	0.958 ab	23.8 bc	47.6 bc	61 ab	6.2 a	922 a	19.23 a	2.80
OPTSC+peat+Ag	28.2 a	0.828 bcd	22.2 d	46.2 d	57 bcd	5.5 cde	665 b	15.2 b	2.82
OPTSC+peat+Af	23.8 c	0.690 d	25.0 b	48.6 b	30 e	5.2 ef	378 c	7.1 c	2.74
OPTSC+peat+½ Ag+½Af	26.4 b	0.796 cd	23.8 bc	47.4 c	59 abc	5.8 bc	755 ab	14.8 b	2.76

Table 6 : Effects of potting media i.e, standard peat, OPTSC and OPTSC + peat with different combinations of fertilizers on foliar nutrient concentration (%) in chrysanthemum plant. Different letters in column indicate significant differences ($p<0.05$) in between treatment means in Duncan's multiple range test.

Treatment	Total N	Total P	Total K	Total Ca	Total Mg
	--------------------	--------------------	%	--------------------	
P+V+Ag+Af	3.34 e	0.240 d	4.93 a	0.987 bc	0.212 f
OPTSC+Ag+Af	4.61 a	0.355 a	4.95 a	1.20 a	0.366 a
OPTSC+ Ag	4.25 cd	0.300 bc	4.43 b	1.15 ab	0.273 de
OPTSC + Af	3.28 e	0.247 ab	3.27 e	0.971 c	0.231 ef
OPTSC+½Ag+½Af	3.98 d	0.315 ab	4.11 c	1.08 abc	0.296 cd
OPTSC+peat+Ag+Af	4.49 ab	0.330 ab	4.49 b	1.19 a	0.348 ab
OPTSC+peat+Ag	4.34 bc	0.295 bc	4.34 bc	1.13 abc	0.330 abc
OPTSC+peat+Af	3.49 e	0.257 cd	3.59 d	0.985 cb	0.244 ef
OPTSC+peat+½ Ag+½Af	4.1 cd	0.295 bc	4.11 c	1.07 abc	0.314 bcd

Table 7 : Effects of potting media i.e, standard peat, OPTSC and OPTSC + peat with different combinations of fertilizers on foliar micronutrient concentration (%) in chrysanthemum plant. Different letters in column indicate significant differences ($p<0.05$) in between treatment means in Duncan's multiple range test.

Treatment	Fe	Mn	Zn
	----------	mg.kg^{-1}	----------
P+V+Ag+Af	455 a	68 f	60 e
OPTSC+Ag+Af	317 c	387 a	442 a
OPTSC+ Ag	301 c	243 c	388 ab
OPTSC + Af	307 c	128 e	342 bc
OPTSC+½Ag+½Af	382 c	277 b	428 a
OPTSC+peat+Ag+Af	471 a	171 d	313 c
OPTSC+peat+Ag	434 a	170 d	396 ab
OPTSC+peat+Af	341 bc	79 f	207 d
OPTSC+peat+½ Ag+½Af	427 ab	129 e	306 c

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