Testing peat-free growing media based on olive wood residues for olive saplings

A.Kir[1,a], A.K.Løes[2], B. Cetinel[3], H.S. Turan[1], E.Aydogdu[1], R.Pecenka[4], C.Dittrich[4], R.Cáceres[5], M.Lennartsson Turner[6], F.Rayns[6], J. Conroy[6]and U.Schmutz[6]

[1]Ministry of Agriculture and Forestry (MoAF), Olive Research Institute (ORI), Izmir, Turkey;[2]Norwegian Centre for Organic Agriculture (NORSØK),Tingvoll, Norway; [3]Ministry of Agriculture and Forestry (MoAF), Plant Protection Institute (PPRI) Izmir, Turkey;[4]Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Potsdam, Germany;[5]Food and Agricultural Research Institute(IRTA), Barcelona, Spain; [6]Centre for Agroecology, Water and Resilience, Coventry University, Coventry, UK.

Abstract

For environmental conservation, peat-based growing media are being phased-out in many countries. Peat-free alternatives need to be developed, preferably from local biomass ingredients. This paper describes the performance of peat-free substrates containing olive branch pruning materials in comparison with commercial growing media controls for olive saplings grown during April-October 2020 at the Olive Research Institute (ORI) in Turkey. The trial was conducted using a randomised plot design with 4 replications and 4 treatments: 1)(COMP) compost made of locally available plant materials with 70% olive prunings (100%, v.v^{-1}; 2)(FIBRE) mixture of chipped and extruded olive prunings (50% chipped+50% extruded, v.v^{-1}); 3)(SAND) a commercial mixture(sand 90%+vermiculite 10%, v.v^{-1})(control); and 4)(PEAT+) a commercial mixture (peat 40% +coco coir 40% +perlite20%, v.v^{-1})(control). The vegetative growth parameters and weed status (density and coverage) were recorded and root fungal diseases commonly found in Turkey were analysed. After the first six months of growth, there were statistically significant differences between the treatments ($p \leq 0.05$); COMP and PEAT+ were comparable and produced the largest plants with 100% survival rate. 98% of plants survived in SAND, and 81% in FIBRE.FIBRE, which was the only treatment with no weed growth, had about 30% reduced growth as compared to SAND, which had 90% and 78% growth compared with PEAT+ and COMP. Still, it was remarkable that it was possible to grow olive saplings in treated olive prunings. It is very promising that a peat-free growing media like COMP performed as well as the commercial growing media with 40% peat. During the extrusion of olive material, the temperature rose to ca. 120°C and during composting the COMP reached 65-70°C; temperatures at which the materials are expected to be effectively sanatised from any fungal diseases.

Keywords: compost, wood fibre, extrusion, olive young tree, organic farming

INTRODUCTION

Organic agriculture aims to be a sustainable production system, refraining from the use of non-renewable resources like peat in growing media. One of the targets of the Organic-PLUS project (EU funded, GA774340) is to find economically and ecologically efficient growing media substratesto replace peat, because; (a) peatlands are important habitats for many plants, birds, animalsetc.; (b) peatlands conserve and sequesterconsiderable amounts of carbon, and are also important for storage of excess precipitation; (c) peatlands are situated predominately in shallow wetland areas which areirreplaceable in a short time period (Aleandri et al., 2015; Carlile et al., 2015); and (d) peat resources are rapidly declining and non-renewable. During the last two decades, governments and consumers in different countries have increasingly pressed for a significant reduction in the use of peat in horticulture; for example, clear targets for the complete phase-out of peat in horticulture were establishedby the UK Government in 2011, stating that no peat should be used by amateur growers by 2020 and by commercial growers by 2030, and in response to this much research and development have been undertaken to support an effective transition away from peat (DEFRA, 2018; Bek et al., 2020). In countries such as Turkey with scarcity of water, especially in winter and spring, the planting of olive saplings with a well-developed root system is important to ensure that the saplings can benefit efficiently from irrigation or precipitation water. Olive is a plant that has a wide distribution all over Turkey. Thearea of olive production has increasedby approximately 2% annually since 2015 anda large number of olive saplings arerequired to sustain this growth. Certified olive sapling production amounts to about 70,000 plants per year. In 2019 organic olive production, including those in theconversion period was more than 200,000 tonnes in about 3,000 ha (TUIK, 2021). The need to identify and develop alternatives to peat for growing olive saplings is common for both organic and conventional olive production. In Turkey, the pruning of horticultural crops produced about 3.6 million tonnes of plant material in 2016 (FAOSTAT,

---

[a] E-mail: alev.kir@tarimorman.gov.tr

2021). A significant proportion of this material is obtained from pruning olive orchards, as more than 80% of olive producers prune their trees once in every 1-2 years andthe prunings from an average sized tree amounts to approximately 9 kg of material on each occasion (TUIK, 2021). Currently, this material is commonly incinerated. Some horticultural growers have recently started to incorporate wood fibre at approximately 20-40% of the total substrate volume in growing media for olive saplings (Anonymous, 2021), though the use of this type of fibre in nurseries and greenhouses to produce saplings is a new concept (Bilderback et. al., 2013). The application of beneficial microorganisms in organic growing systems in Turkeyhas increased in recent years. Some commercially available strains of *Bacillus* spp. and mycorrhizal fungi have been shown to support the development of root systems and hence support uptake of nutrients from fertilisers (OECD, 2015). The use of animal manure from conventional livestock systems is a contentious input that the Organic-PLUS project aims to phase-out of organic agriculture, in addition to peat. Composting plant material, e.g. olive prunings, may provide an alternative to making compost from farmyard manure, which is currently used as an ingredient in growing media for organic production. The use of olive prunings as an alternative was studied in this investigation. One challenge linked to using olive prunings in growing media is phenolic compounds that is also present in woody materials may also inhibit plant growth (Makas et al., 2000). The extrusion process for making wood fibre applies heat and high pressure that are likely to sanitise the end product from any fungal disease present in the woody material. Successful composting may also produce temperatures that sanitise fungal disease, whereas the use of untreated chipped wood may increase those risks. The objective of the current study was to investigate the performance of olive pruning material, composted, chipped or extruded to fibre, as a substrate to replace peat in growing media applied to produce olive saplings.

MATERIALS AND METHODS

The trial was carried out under controlled conditions at the Olive Research Institute (ORI) in Izmir, Turkey. This paper describes the first6 months of the growing period of the saplings, April-October 2019 and the saplings are expected to be ready for planting in field by the end of April 2021. 4-month-old saplings of cv. 'Gemlik' (*Olea europaea* L.) were planted as the propagation material. This is acultivar used widely in Turkey and it is known to be easily rooted (Ozkaya, 1997). The plants were grown in a greenhouse where the temperature was kept between 16 and 28^{0}C. The trial was conducted using randomised plot design and each replicate was composed of 48 pots; hence there were a total of 192 pots (4 replications x 4 treatments x 12 pots). Treatments: 1)(COMP) compost made from locally available plant waste material (chipped olive branch prunings 70%, v.v^{-1}, medicinal and aromatic plant residues 10%, v.v^{-1}, grass cuttings 18%,v.v^{-1} and horse manure 2%,v.v^{-1}; (compost used in pots: 100%,v.v^{-1}); 2)(FIBRE) mixture of chipped and extruded to fibre olive branch prunings (50% extruded + 50% non-extruded chipped material,v.v^{-1}), 3)(SAND) a commercial mixture (sand 90%+vermiculite 10%,v.v^{-1}) (control), and 4)(PEAT+) a commercial mixture (peat 40%+coco coir 40%+perlite 20%,v.v^{-1})(control). SAND and PEAT+ were both commercially available growing media for olive saplings used widely in Turkey. Both controls are permitted for use in certificated organic production and they were not amended with any mineral or organic fertilisers or any beneficial microorganisms. For the extrusion, chippedolive branch pruning material wassent to Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB) in Germany. After the extrusionwith a twin-screw extruder design for processing of woody biomass, the fibre material was sent back to Turkey (ORI) to be used in the study. The extruded fibre was subject to pre-testing in 10 pots with olive saplings, out of which no plant survived, whereasthe 10 by 10 saplings pre-tested with COMP, SAND, and PEAT+ had survival rates of 95%, 100%, and 100%. Chemicalanalysis of the substrates revealed a need to apply additional nutrients to the FIBRE treatment and this was done using freeze-dried fish powder andvermicompost tea, both inputs permitted for use in organic growing. No fertiliser was added to any of the other treatments at the start of the experiment. Young trees are known to need higher rates of Pand K than N to establish a strong growth. The fish fertiliser was derived from haddock (*Merlangius euxmus*) which had been freeze-dried and ground to a powder (supplying 75 mg P_2O_5 per 5 litre pot), before planting and 1 month after planting. Locally produced, commercially available and organic certified vermicompost tea (supplying 100 mg N, 200 mg P_2O_5, and 200 mg K_2O per 5 litre pot), *Bacillus* spp. (6x10^{7}cfu.mL^{-1}), and *Glomus* spp. (1x10^{4}cfu.g^{-1}) were applied. Glomus was only applied 1 month after planting, whereas the tea and *Bacillus* were applied at planting and after 1 month. During co-composting freshly cut grass from a lawn at ORI and 2% horse manure was applied as an activator to facilitate initiation of self-heating and aerobic decomposition by microorganisms. The compost windrow was set up on 1st March 2019. After 2 months, a *Trichoderma* isolated from forest soil was addedafter 2 months of composting. In September 2019; isolated bacteria from free-range goat stomach were applied to the windrow as described for *Trichoderma*. The extrusion procedure for five month aged chipped olive branch prunings was as follows: chipped olive prunings were conditioned to 50% (±5%) moisture content before extrusion by adding a prior calculated amount of water (based on initial moisture content) to the prunings inside a barrel. These barrels were tumbled for 24 hours so the chopped pruning could absorb the added water. The prepared wood chips where then put on a conveyor belt and transported through a hopper into the intermeshing, counter rotating twin-screw-extruder [Model MSZK B90e (Lehman Maschinenbau GmbH, Jocketa, Germany)]. This extruder ground and crushed the prunings into fibre by generating heat (up to 120 °C) and overpressure. The degree of comminution was determined by the setting (0-45mm) of the aperture (part of the extruder where fibre exits). Finally, the olive fibre was dried at 150 °C in a blow dryer (Dittrich et al., 2019). The following analyses were performed on all of the media (PEAT+, COMP, FIBRE) treatments at the initial stage and after 6months: pH, EC, OM (TSE, 1991). Total N was determined by Dumas Method (McGeehan and Naylor, 1988). Samples were digested with H_2O_2 and HNO_3 in a microwave oven, before determination of P, K, Ca, Mg, Fe, Cu, Mn, Zn and B in the filtrate with ICP-OES (Zarcinas et al., 1987). For the SAND, pH (1:2.5 soil/water) and EC (McLean, 1982) were measured as well as lime (Scheibler calcimeter, (Caglar, 1949); OM (Jackson, 1962), total-N (Dumas); Olsen-P (0.5 M $NaHCO_3$ pH: 8.5; Olsen et al., 1954), ammonium-acetate extractable K, Ca, and Mg; DTPA -extractable Fe, Cu, Mn, Zn (Lindsay and Norvell 1978); and B extracted by 0.01 M mannitol+calcium chloride (Kacar and Fox, 1966). Analysis of the physical characteristics; bulk density (BD),(picnometric) (Blake and Hartge, 1986), water holding capacity (WHC)(USDA, 1954), easily available water (EAW) and water buffering capacity (WBC) (Puustjarvi, 1969), air capacity (AC) (USDA, 1954 ve De Boodt vd. 1973), and particle density (PD) (Sheldrick and Wang, 1993) were determined in all growing media. The temperature of the pots was measured using a soil thermometer and the moisture in each pot was measured with a moisture-meter at 15 cm depthin the middle of the pot, monthly. The weed coverage of each pot was estimated by visual observation, monthly and was recorded as a percentage of pot's surface covered by weeds. The weed density (number of weeds/m^2) was calculated by counting the weeds on the surface and dividing by the area covered. The presence of plant pathogens that could potentially infect the olive saplings in the growing media was assessed initially and after 6 monthsby mixing dilutions of the growing media into Potato Dextrose Agar and Malt Extract Agar following Waksman, 1992. Fungal surface colonies were determined in all suspensions of growing media. Vegetative growth parameters of the olive saplings were recorded at the beginning and after 6 months. Half of the 12 pots in each plot were harvested after 6 months. The fresh olive sapling plant volume was calculated by multiplying plant diameter (cm) and plant height (above soil surface) (cm). Survival rate (%) of olive saplings was calculated as number of living saplings after 6 months/number of initial saplings x 100). The pots were irrigated regularly by applying to each pot a volume of water calculated to provide 50% of moisture of each substrate. Results were statistically evaluated by ANOVA followed by Tukey test using SAS.

RESULTS AND DISCUSSION

The physical and chemical characteristics of the treatments were all found to be within the limits of EU Ecolabel-EU Comission (2015) and were compatible with a Turkish law on compost andsoil conditioners that was legislated on February 23, 2018 with Turkish Legal Gazette No.30341 (Table 1). The WHC, AC, EAW, and WBC (Table 2) of the PEAT+were remarkablydifferent to the others, and indicated a bettergrowing media quality than on the other treatments. The results of the chemical and physical assessments of the substrates tested were comparable with results found in other studies. The charcateristics of the FIBRE were the least appropriate, especially due to a low water buffering capacity and toohigh air capacity. The AC of FIBRE was probably mostly effective among the physical properties in terms of its influence on the performance. After six months of growth, a decrease of volume was observed particularly in FIBRE pots, because of decomposition, as confirmed by a significant weight loss of about 400 g per pot (Table 3). The maximum temperature of FIBRE reached to 35^{0}C (Table 3), which is 9^{0}C above any other treatment and may indicate presence of some biological activity producing heat. The significant reduction in organic matter (OM, Table 2) as compared with COMP also points in this direction. The survival rate after 6 months in FIBRE, SAND, COMP, and PEAT+ was 81, 98, 100, and 100%. Hence, the applied fertilisers most likely increased the FIBRE survival rate to an acceptable level, while in the pre-evaluation trial no sapling survived in unfertilised FIBRE growing media. After six months growth, the saplings behaved some what differently in growth as shown by the min and max values referred in Table 4, but we still received statistically significant differences in many growth characteristics. The COMP and PEAT+ treatments gave the largest plants, but the root weight was largest in the FIBRE treatment, whereas the COMP treatment saplings had significantly more roots per plant. With respect to plant growth after 6 months, plants grown in the FIBRE had equal numbers of branches per plant and trunk diameter of sapling as those grown in the SAND and PEAT+ (Table 4). However, the FIBRE treatment (fertilised) resulted in higher fresh and dry weight of roots compared with that in SAND and PEAT+, whilst the number of roots was similar in treatments with FIBRE, PEAT+, SAND and COMP.

Saplings grown in COMP and PEAT+ had a similar plant height andbranch length, both of which were significantly greater than that recorded in FIBRE or SAND. The parameter of plant volume showed the most remarkable differencesbetween the treatments, with the greatest plant volume of samplings grown in PEAT, followed by that in COMP, with the growth in FIBRE being 90% and 78% less than that in PEAT+ or COMP, respectively. The plant volume of the saplings grown in SAND was also greater than those grown in FIBRE, but was less than for those grown in COMP or PEAT+. FIBRE was the only treatment without undesired weed growth. Interestingly, weeds were detected in the commercial controls (SAND and PEAT+) which were unusual, whereas in COMP the presence of weeds is a well-known problem (Table 5).The physical and chemical properties of compost mostly depend on added type of organic material and its quantity, which have a wide variability in the compost windrow on-farm co-composting procedure.

Table1.The chemical and physico-chemical properties of horse manure, freeze-driedfish, fresh chipped olive prunings, and initialand 6 monthCOMP, FIBRE, SAND, and PEAT+ samples. All values in % or ppm are given as proportions of dry weight.

						SAND (Initial)						
	Horse Manure	FreezeDried FishPowder (FDFP)	Fresh Chipped Olive Pruning	FIBRE (Initial)[a]	COMP (Initial)	Vermiculite	Sand	PEAT+ (Initial)	FIBRE*(6th month)	COMP* (6th month)	SAND* (6th month)	PEAT+* (6th month)
Moisture(%)	8.1	-**	33	-	39.4	-	-	-	5.8	5.5	-	5.8
pH	6.0	7.0	-	5.3	8.2	7.3	6.9	6.4	8.2	8,2	7.8	6.6
EC (µS/cm)	1039	-	-	844	570	86	116	1116	803	1038	1.2	1561
OM (%)	93.8	84.6	-	91.7	58	2.5	-	46.5	80.8	54.5	-	57.9
C (%)	41.5	42.7	44.5	44.2	26.9	0.5	-	26	39.6	25,5	0.6	27
N (%)	0.5	13.4	0.8	0.7	2.2	0.1	-	0.4	1.6	2.2	0.1	0.9
C/N	84.6	3.2	58.6	64.1	12.3	7.4	-	60.4	24	12	7.1	30
P (%)	0.1	1.2	0.1	0.1	0.1	0.1	-	0.1	0.1	0.3	0.1	0.1
K (%)	0.1	2.1	0.5	0.5	1.4	5.7	-	0.4	0.8	1.1	0.9	0.6
Ca (%)	1.4	0.8	0.5	0.9	2.9	1.7	-	1.5	2.3	3.4	0.3	2.3
Mg (%)	0.1	0.2	0.2	0.1	0.4	2.5	-	0.1	0.2	0.4	0.6	0.4
Fe (ppm)	712	299	4874	215	8132	71291	-	6957	3840	9652	29014	8240
Mn (ppm)	34.1	20	106.7	19	332.8	1405	-	129.6	96.3	294	339	151.4
Zn (ppm)	9.2	22.7	30.1	12.9	89.6	177.4	-	33.2	45.2	90.1	75	41.2
Cu (ppm)	11.1	3.6	11.9	5.4	28.7	60.2	-	22.9	11.7	15.8	15.9	19.7
B (ppm)	0.2	9	28.1	14.7	43.7	161.1	-	12.5	29	41	43.2	22.8
Na (ppm)	-	3891	-	353.2	-	1267	-	1088	105.8	131.1	51.5	229
Mo (ppm)	4.7	0.1	-	-	-	0	-	4.7	1.3	1.9	0.2	7.5
Cd (ppm)	-	-	-	0	0.3	2	-	0.1	0.2	0.3	0.6	0.2
Co (ppm)	0.1	-	-	0	4.1	85.1	-	1.9	0.6	3.6	12.9	3.4
Cr (ppm)	1.3	19.3	-	2.5	51.6	7.8	-	19.4	16.5	29.8	27.3	37
Ni (ppm)	0.9	5.4	-	1.5	28.2	117	-	8.1	16.5	33.6	37.8	31.9
Pb (ppm)	3.0	0.1	-	1.4	7.9	0	-	4.1	4.7	12.1	8.2	8.9
Al (ppm)	376	228	-	1153	12936	84607	-	5310	3013	9514	18055	4965

[a] The analysis of of the FIBRE (inital) was undertaken before the application of FDFP and vermicompost tea application; *Mean of 4 (four) replications; **(-), not determined.

Similar results were reported for ranges of BD, WHC, AC, EAW, WBC, PD of peat, coir, fresh and aged barks, coarse wood fibre, fine wood fibreand green compost (Carlile et al., 2015). In this study, the best plant volume was obtained in PEAT+ and COMP. The positive plant growth results for COMP, were in agreement with the reports from many previous studies suggesting that different composts can provide effective replacements for peat, and also in accordance with previous reports no diseases were observed on the plants grown in COMP (Aleandri et al., 2015; Rainbow, 2009 and Veeken et al., 2005).Possibly, there could be a risk of transferring fungal disease to the saplings via the pruning material, but no such disease has been detected so far in this study. The stable C/N ratio of the COMP growing media being 12.3 at the start and 12.0 and the end of the pot study shows that the material was mature after a treatment process of 8 months, due to goat stomach bacteria and *Trichoderma*species have cellulase enzymes, which are known to be beneficial in achieving a mature compost. *Coprinus* spp. species can also produce cellulase enzymes (Rai et al., 1989). Many different aspects possibly affected the performance of the FIBRE derived from of lignocellulosic materials, which was shown to be less suitable as a growing medium compared with the COMP and the controls: (a) the poor WHC and high AC created an unbalanced status of the medium resulting in poor root development (Papafotiou et al., 2004); (b) the presence of plant growth inhibitor(s), which are know to be present in olive bark, but there is a lack of research on olive bark inhibitors and thus a knowledge gap on this topic (Makas et al., 2000); (c) decomposition of the material and the temperature generated in the FIBRE treatment, which affected the root system, adversly; (d) an insufficient rate of fertiliser application; and (e) particle size. SAND showed better performance than FIBRE because of the low decompositation and the relatively low temperatures, which were better for root development. Even if the FIBRE saplings did not grow as fast as in other treatments, and 20% died off, it is remarkable that plant growth can be obtained in fertilised fresh fibre material from olive prunings. The WHC was about 9% lower than for PEAT+ (Table 1). A better water retention could likely have been obtained by increasing the proportion of extruded fibre, which had a much finer structure than the chopped material. However, as shown by the decomposition which was taking place, fresh plant materials are challenging to work with as a growing media. The applied fertilisation procedure was very tedious and not easy to conduct in practical growing. Plant pathogenic quarantine fungi *Roselliniasp., Veticilliumsp. and Armillaria sp*., were not idenfitied in suspensions for many growing media. This explains that the saplings did not show any disease symptoms during 6 months. Root, bark and wood tissues of the prunings were all healthy. Interestingly, *T. citrinoviride* (beneficial fungi isolated from forest and applied to the compost) was isolated from the suspensions of the COMP (initial) and COMP (6 months) samples, even if the temperature in the compost windrow reached 65-70 ^{0}C. Heat is likely the most important factor for elimination of any potential harmful organisms (Ryckeboer, 2001; Suárez-Estrellaet al., 2007), but heat could then be expected to also kill beneficial organisms. During the extrusion of olive material, the heat released during the process created a temperature rise to 120°C in the extruded FIBRE, which will sanitize any fungal disease being present in the woody material. No phytopathogenic fungi were isolated from any growing media, though it was not possible to deduce that the substrates had been effectively sanitized by either the extrusion process or the composting process as the presence of any potential pathogens in the feedstock material used for the different treatments was not determined.

Table 2. The physical properties of COMP, FIBRE, SAND, and PEAT+ samples at the start of the experiment.

	BD	WHC	AC	EAW	WBC	PD
FIBRE	0.2	73.7	31.5	7.8	8.4	0.7
COMP	0.1	77.5	22.0	6.1	10.1	0.7
SAND*	nd	nd	nd	nd	nd	nd
PEAT+	0.1	82.4	12.1	9.0	15.3	0.7

*nd: not determined

Table 3.The temperature (T) (^{0}C) and weights of pot (g) recorded two times per month between May 1st and October 31st 2020 in 0% and 50% moistures*.

	Temperature (^{0}C)			Difference of pot without sapling weight in 0% and 50% moisture (g)	6 month weight of pot planted with sapling (g) (50% moisture)
	Min.	Max.	Mean		
FIBRE	20	35	26	824b	2150d
COMP	20	26	25	902b	3010c
SAND	19	24	22	816b	8400a
PEAT+	20	25	24	1134a	4105b

*Tukey (p ≤0.05), CV: 24%. For each characteristic, values indicated by different letters (a, b, c, d) are statistically significantly different at the 5% level.

Table 4. Vegetative growth characteristics (plant height (PH)(cm), branch length (BL)(cm), number of branches per plant (NB), trunk diameter (TD)(mm), fresh root weight (FRW)(g), dried root weight (DRW)(g), fresh plant weight (FPW)(g), dried plant weight (DPW)(g), number of roots (NR), fresh plant volume (FPWol) (cm^3) after 6 months in COMP, FIBRE, SAND, and PEAT+*

	PH	BL	NB	TD	FRW	DRW	FPW	DPW	NR	FPVol
FIBRE	26.0d	14.2c	4.3a	12.9 ns	10.3a	4.5a	35.5b	20.8b	33.8b	387.7d
COMP	33.4ab	21.8a	3.8b	13.0 ns	9.8ab	4.6a	40.3a	25.9a	47.5a	1600.5b
SAND	28.0c	18.2b	4.3a	12.8 ns	7.5c	3.9b	37.8b	21.2b	31.3b	535.4c
PEAT+	36.9a	24a	4.5a	12.7 ns	8.2b	4.8a	43a	26.2a	32.8b	2651a

*Tukey (p ≤0.05), CV: 16.5%, ns: not significant. For each characteristic, values indicated by different letters (a, b, c, d) are statistically significantly different at the 5% level.

Table 5. Weed status of COMP, FIBRE, SAND and PEAT+ during growth stage*.

	Weed density (number of weed/m^2)	Weed coverage (%)
FIBRE	0 c	0 c
COMP	20.3a	20 a
SAND	20.5 a	21 a
PEAT+	15.3b	12 b

*Tukey (p ≤0.05), CV: 10%, for each characteristic, values indicated by different letters (a, b, c, d) are statistically significantly different at the 5% level.

CONCLUSION

It was concluded that the olive saplings grown in COMP (0% peat) performed as well as those grown in PEAT+ (40% peat), whilst in SAND (0% peat) the performance was inferior. Still, we find it remarkable that it can be possible to raise olive saplings in fresh olive pruning material, after certain amendments. Further research is neededto optimise the fertilisation regimeof the FIBRE (0% peat), as although the addition of the fertiliser to this substrate had a positive effect on the performance. Results also calls for further research into how a decomposition phase can be avoided, since this may have a negative effect on plant growth, and how fertilisation can be carried out in a practical way. A very promising result was the 100% peat free mature compost made from 70% of chopped olive prunings, and otherwise locally available materials.

ACKNOWLEDGEMENTS

This research has been financially supported by the Horizon2020 EU Funded project “Pathways to phase-out contentious inputs from organic agriculture in Europe ”Organic-PLUS (GA774340).

Literature cited

Aleandri, M.P., Chilosi, G., Muganu, M., Vettraino, A., Marinari, S., Paolocci, M., Luccioli, E., and Vannini, A. (2015). On farm production of compost from nursery green residues and its use to reduce peat for the production of olive pot plants. Scientia Horticulturae *193*, 301–307.

Anonymous (2021),https://www.greenhousegrower.com.

Bek, D., Lennartsson Turner, M., Lanari. N., Conroy J., and Evans, A. (2020). Transitioning towards peat free horticulture in the UK; an assessment of policy, progress, opportunities and barriers. Coventry University, Coventry, UK. https://growingmedia.co.uk/research.html, pp. 96.

Bilderback, T.E., Riley, E.D., Jackson, B.E., Kraus, H.T., Fonteno, W.C., Owen, Jr., J.S., Altland, J., and Fain, G.B. (2013). Strategies for developing sustainable substrates in nursery crop production. Acta Hortic., 43–56.

Blake, G.R., and Hartge K.H. (1986). Bulk Density. In: A. Klute, ed., Methods of Soil Analysis , Part I. Physical and Mineralogical Methods : Agronomy Monograph no. 9 (2nd ed.), 363-375.

Caglar, K. O. (1949). Soil Science, Ankara University Publications, No:10, Ankara, Turkey, 68-72.

Carlile, W. R., Cattivello, C., and Zaccheo, P. (2015). Organic Growing Media: Constituents and Properties. Vadose Zone Journal, *14(6), 0.*

De Boodt, M., Verdonck, O., Capparet, I. (1973). Method for Measuring the Water Release Curve of Organic Substrates. Proceeding Symposium Artifıcal Media in Horticulture, 2054- 2062.

DEFRA, (2018). A Green Future: Our 25 Year Environment Plan Report. Department for Environment, Food and Rural Affairs London, UK, pp. 151.

Dittrich C., Pecenka R. , Løes A-K, Schmutz U. (2019). Twin screw extruder processing technology for fibres as raw material for peat substitution. Technical Paper/Deliverable No. 5.3, https://organic-plus.net, pp.14.

EU Commission. (2015). Comission Decision 2015/2099 of 18 November 2015 establishing the ecological criteria for the award of the EU Ecolabel for growing media, soil improvers and mulch. Official Journal of the European Union (20–11–2015) L 303–75.

FAOSTAT (2021), http://www.fao.org/faostat.

Jackson, M. L., (1962). Soil Chemical Analysis. Prentice Hall Inc. Eng. Cliffs, Newyork, U.S.A., 183-187.

Kacar, B. and Fox, R. L., (1966). Boron Status of Some Turkish Soils. Uni., Yearbook, Ankara, 9-11.

Lindsay, W. L. and Norwell, W. A. (1978). Development of a DTPA Soil Test for Zinc, Iron, Manganese and Copper. Soil Science Society of America Journal, 42,421-428.

Makas, M., Windeisen, E., & Wegener, G. (2000). Substitution von Torf durch Holz in Pflanzsubstraten. Holz Als Roh- Und Werkstoff, 58(1-2), 125–126.

McGeehan, S.L. and Naylor, D.V. (1988). Automated Instrumental Analysis of Carbon and Nitrogen in Plant and Soil Samples. Journal of Comm. Soil Sci. Plant Anal., 19(4), 493-505.

Mclean, E. O., (1982). Soil pH and Lime Requirement in Methods of Soil Analysis (A. L. Page et al. editor). Part II, 2nd, American Society of Agronomy Inc. Publisher, Madison, Wisconsin, U.S.A., 199-224.

OECD (2015), Biosafety and the Environmental Uses of Micro-Organisms: Conference Proceedings, OECD Publishing. http://dx.doi.org/10.1787/9789264213562-en

Olsen, S. R., Cole, C. V., Watanabe, F. S. and Dean, H. C., (1954). Estimation of Available Phosphorus in Soils by Extraction with Sodium Bicarbonate. U.S. Dept. of Agr. Vir., Washington D.C., U.S.A Handbook., 139-141.

Ozkaya, M., (1997).The effects of various treatments on anatomical and biochemical structures of cuttings, in some Olive (*Olea europaea* L.) Cultivars. Ankara University, Ph.D. Thesis, 1997, pp. 136.

Rai, S. N., Walli, T. K., & Gupta, B. N. (1989). The chemical composition and nutritive value of rice straw after treatment with urea or C. fimetarius in a solid state fermentation system. Animal Feed Sci. and Tech., 26(1-2), 81-92.

Papafotiou, M., Phsyhalou, M., Kargas, G., Chatzipavlidis, I., & Chronopoulos, J. (2004). Olive-mill wastes compost as growing medium component for the production of poinsettia. Scientia Horticulturae, 102 (2), 167–175.

Puustjärvi, V. (1969). Fixing peat standards. Peat & Plant News 2 (1), 3–8.

Rainbow, A. (2009). The use of green compost in the production of container nursery stock in the UK: Challengies and opportunities. Acta Hortic. 819, 27-32.

Ryckeboer, J., 2001. Bio waste and yard waste composts: microbiological and hygienic aspects-suppressiveness to plant diseases. Katholieke Universiteit Leuven, Belgium, 1–245.

Sheldrick, B.H. and Wang, C. (1993) Particle Size Analysis. In: Carter, M.R., Ed., Soil Sampling and Methods of Analysis, Lewis Publishers, Boca Raton, 499-517.

Suárez-Estrella, F., Vargas-García, M.C., López, M.J., and Moreno, J. (2007). Effect of horticultural waste composting on infected plant residues with pathogenic bacteria and fungi: Integrated and localized sanitation. Waste Management *27*, 886–892.

TSE, 1991. Determination of Peat-Ash and Organic Matter, (TS 9103), 2p; Determination of Peat-pH (TS 9104), 3p.; Peat-EC Value and Determination of Salt Amount, (TS 9106), 3p.

TUIK, (2021), Turkish Statistical Institute,https://data.tuik.gov.tr.

U. S. Salinity Laboratory Staff U.S.D.A. (1954) Agricultural Handbook 60, Washington, D. C., Government Printing Office. 160 pp., Agron.j. *46*, 290–290.

Veeken, A.H.M., Blok, W.J., Curci, F., Coenen, G.C.M., Termorshuizen, A.J., and Hamelers, H.V.M. (2005). Improving quality of composted biowaste to enhance disease suppressiveness of compost-amended, peat-based potting mixes. Soil Biology and Biochemistry *37*, 2131–2140.

Waksman, S.A. (1922). A Method for Counting the Number of Fungi in the Soil. J Bacteriol *7*, 339–341.

Zarcinas, B.A., Cartwright, B., and Spouncer, L.R. (1987). Nitric acid digestion and multi-element analysis of plant material by inductively coupled plasma spectrometry. Communications in Soil Science and Plant Analysis *18*, 131–146.