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Co-composting as a Method to Produce Nutrient Rich Compost from Olive Mill Waste to Use as a Substitute for Growing Strawberries in the UK

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Abstract

A compost was produced by co-composting olive mill wastewater (OMW) and chicken manure (CM), with green waste as a bulking agent. Two different variants of OMW compost were used in growth trials during the 2014 season in the UK, one twice composted and one that was composted three times. The composting was on a pilot scale in windrows. During the first composting procedure these windrows were turned 14 times. For the second composting CM and OMW were added to the compost from the first stage used as the bulking agent; this was turned 8 times. This compost was used as a bulking agent for the third composting, with CM and OMW added. Amounts of this product in ratios of 10, 25 and 50% were combined with substrate to create a soilless medium suitable for the growth of strawberry (Fragaria x ananassa). Fruits were assessed for quality by measuring sugar content and flesh firmness using a refractometer and penetrometer respectively. The extent of these trials was not enough to get an understanding of any consistent differences in the production of strawberries when grown in different substrates. Trials in 2015 will have greater scope to clarify if this substrate has an impact on marketable crop quality.

INTRODUCTION

The process of olive and olive oil extraction is a worldwide industry, predominantly based in Mediterranean countries, but recently intensively cultivated in Argentina, Australia and South Africa. The olive tree (Olea europea) is one of the main Mediterranean crops with a cultivated area of approximately 8.2Mha (López-Piñeiro et al., 2008). This crop produces an annual volume of 10 million m^3 of olive mill wastewater and 6 million m^3 of solid olive mill by products; consisting of olive stones, leaves, and pomace (Nektarios et al., 2011)

Using the composted waste from olive production is not a new method of providing nutrients to crops. Altieri et al., (2010 and 2014) have completed similar trials using composted olive mill waste (OMW) on strawberries in Italy in 2010 and 2014. This work used OMW composted with wool waste, wheat straw and sawdust (Altieri et al., 2014; Altieri et al., 2010) and the product performed adequately when compared with peat. Similarly, solid olive mill cake when composted with cotton waste as a bulking agent gave a similar marketable yield when growing peppers (Alburquerque et al., 2006). Exhausted olive mill cake composted in combination with poultry manure has also shown to have beneficial effects on crop growth when compared to raw farm manures (Hachicha et al., 2006). A recent study reported positive results when comparing OMW co-composted with manures with inorganic fertilisers when they were applied on olive groves (Fernández-Hernández et al., 2014)

Olive mill waste (OMW) has distinctive characteristics by being high in phenolic compounds, with low pH and high salinity (Niaounakis and Halvadakis, 2006), the use of raw OMW on farmland can cause environmental problems (Di Bene et al., 2013).

MATERIALS AND METHODS

The OMW product used in these trials has been developed using repeated composting, there are two different composts being tested. The composts have been composted two and three times respectively with chicken manure as the base component. The product was initially composted in windrows with green garden waste as a bulking agent with OMW sprayed onto them to correct the moisture. During the first composting procedure these windrows were turned 14 times. For the second composting fresh manure was introduced and the compost from the first stage was used as the bulking agent. The 1m high and 1.5m windrows were turned 8 times with 2.8l of OMW added at each turning. A portion of the final product from the second composting was used as a bulking agent for the third round of composting, with fresh chicken manure added. The bulking agent was screened to separate into fine and coarse particles to allow for two variations of the final compost, using either fine or coarse material as the bulking agent. The compost used in these trials was the variant with the coarse bulking agent. This final composting took place in composters with 8 turnings over 96 days with 70l of OMW added in that time.

The compost was then dried by spreading in a thin (15-20cm) layer in a greenhouse and then turned and 84l of OMW added over a course of 55 days. The compost was then transferred into tanks for the final drying for 115 days being turned daily with 260l of OMW added.

The Elsanta F. x ananassa variety of strawberry was the one chosen for these trials given its use by commercial growers and popularity with consumers in the UK market. Two strawberry plants were used in each pot with 5 replicates for each treatment, giving 10 plants for each treatment. Three different ratios of compost were used for each set of replicates along with a control. Treatments for the trials in 2014 are shown in Table 1.

The strawberries were supplied from cold storage by commercial grower and ready to grow. They were then transplanted following defrosting into 2l pots on the 9/7/14 and placed in a randomised arrangement in the polytunnel. A water dripper was placed in each pot for daily automatic watering. The weather and temperature were monitored so that plants were watered as required given the daily temperature, ranging from 3 times a day on the hotter days to once on cooler days as the season progressed.

Hourly temperature recording has been set up with the use of ibuttons® that were left in the polytunnel for 2 week periods before being downloaded and reset. The temperature following transplanting was high throughout the early weeks of growth, only dropping regularly below 20^{o}C during the day from the middle of September. The optimal day and night temperature for leaf and petiole growth is higher than that for root and fruit development in strawberries (Wang and Camp, 2000; Sønsteby et al., 2013). This pattern is provided by the enhanced natural conditions in the polytunnel during these trials.

Fertiliser was added to all the pots on day 20 when flowers had appeared on each of the plants. This was completed using a standard fertiliser for strawberry production, high in potassium for fruit development. The addition of fertiliser and management of the strawberry plants were done in accordance with guidance from MAFF(now DEFRA) (Hughes, 1970).

Productive analyses

Yield of strawberries in number per replicate and the average weight of 10 marketable fruits will be recorded. Assessing marketability of fruits was completed in accordance with the Class I standard as detailed in Council Regulation (EC) No 1234/2007 (European Council 2000). This is the standard used for high quality strawberries in the UK. Flesh firmness and sugar content will be measured on these 10 marketable fruits using a digital penetrometer and a refractometer. A Novanna FT02 penetrometer was used, this is ideal for strawberry flesh as it has a capacity of 1kg and a small gradation. For measuring sugars a Novanna MR200ATC Refractometer was used as it has a suitable range, resolution and accuracy for soft fruits. Total yield from each plant from all harvests will be calculated with intact fruits with a diameter greater than 18mm and a weight more than 4g representing marketable yield. Smaller fruits, malformed and rotten fruits will be counted, weighed and discarded.

Statistical analyses

Statistical analysis on the results of the strawberries produced was carried out using IBM SPSS Statistics 19. Data were subjected to multivariate analysis and the Least Significant Difference (LSD) and Tukey's test were used at a significance level of $p<0.05$.

RESULTS AND DISCUSSION

Quantitative results analysis

Fruits were harvested on 10 dates between 2 September and 15 October 2014. The length of time from transplanting to harvesting the first fruits was 55 days. The mean weight of marketable strawberries produced from each replicate with error bars showing standard deviation are shown in Fig. **1**. This shows that the 50 OMW2 treatment has the highest mean weight of 9.6g and the 25 OMW2 treatment has the lowest weight of 8.5. The results from the statistical analysis using an ANOVA on the normally distributed data show that none of the different treatments from either OMW product are significantly different from each other or the control for weight. All results for the LSD and Tukey's test were greater than $p<0.05$.

The total number and weight of marketable and discarded fruits is shown in Table 2. There is no significant difference between the number of marketable or discarded fruits produced when analysed using both Tukey's test and the test for LSD.

Qualitative results analysis

The comparison between the 10 marketable strawberries that were analysed in detail from each replicate can be subjected to a more critical statistical analysis. The results from the statistical analysis show that none of the different treatments from either OMW product are significantly different from each other or the control for width of fruit. All results for the LSD and Tukey's test were greater than $p<0.05$.

The results of the penetrometer test for the 10 marketable fruits from each replicate are shown as a mean average in Fig. **1**. The results of the penetrometer test in the Tukey's test showed that the control was significantly higher than treatment 2 and 6. Treatment 3 (50\% OMW3) was also significantly higher than treatment 6. Using the LSD analysis the average mean for the control was significantly higher than all other treatments bar 3 and 4. The 50% OMW3 treatment (3) was significantly higher than all treatments bar the control and treatment 4. The average for treatment 4 was significantly higher than that for treatment 6.

The results from the refractometer test on the fruits for sugar content are shown in Fig. **3**. In the Tukey's test, no treatments were significantly different from each other or the control. The results from the LSD analysis show that treatments 2 and 3 are both significantly different from all the other treatments, but not the control.

There is no statistical difference between any of the compost treatments and the control for weight or width of fruit, or numbers of strawberries produced. These trials demonstrate that under these conditions compost produced from chicken manure and OMW can compare similarly when assessed against fruits grown in traditional peat-free compost.

The compost combinations compared similarly to standard peat-free compost for yield when comparing both the number of and weight of fruit produced. The control with 100% peat free compost yielded the firmest fruits and the treatment combinations with 25% and 50% of three times composted OMW produced the sweetest fruits.

CONCLUSIONS

There is no statistical difference between any of the compost treatments and the control for weight or width of fruit, or numbers of strawberries produced. These trials demonstrate that under these conditions compost produced from chicken manure and OMW can compare similarly when assessed against fruits grown in traditional peat-free compost.

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Tables

Table 1. The different treatments on the plants and compost composition within each

	Treatment	Combination
	Control	100% peat free compost
1	10 OMW 3	90% peat free compost + 10% 3 times composted OMW
2	25 OMW 3	75% peat free compost + 25% 3 times composted OMW
3	50 OMW 3	50% peat free compost + 50% 3 times composted OMW
4	10 OMW 2	90% peat free compost + 10% 2 times composted OMW
5	25 OMW 2	75% peat free compost + 25% 2 times composted OMW
6	50 OMW 2	50% peat free compost + 50% 2 times composted OMW

Table 2. Total number and weight of marketable and discarded fruits from each treatment

Treatment		Total number of fruits		Total weight of fruits	
		Marketable	Discarded	Marketable	Discarded
	Control	89	36	915.08	216.08
1	10 OMW3	107	45	1136.65	277.77
2	25 OMW3	109	36	1031.52	262.25
3	50 OMW3	115	44	1093.46	354.15
4	10 OMW2	105	41	1086.32	265.68
5	25 OMW2	91	45	871.8	287.289
6	50 OMW2	105	37	1102.1	257.38

Figures

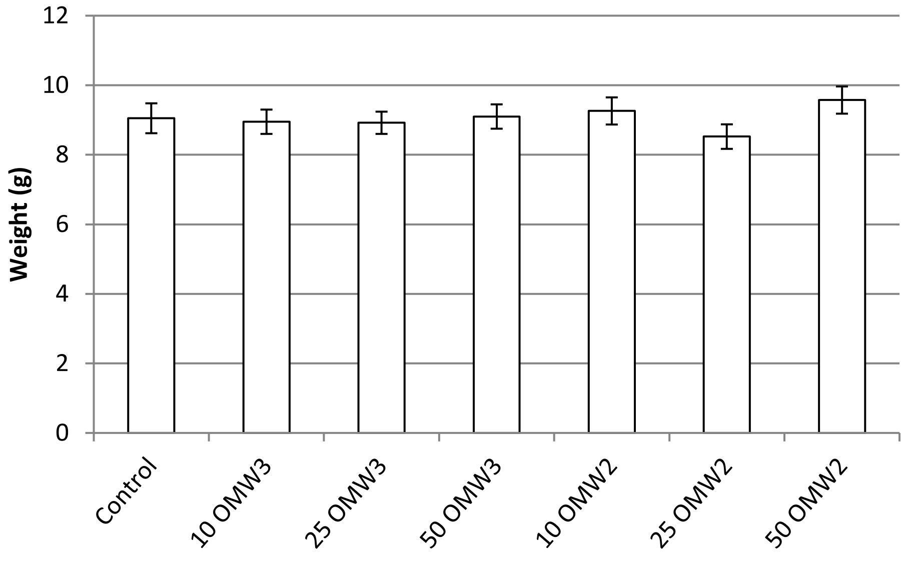

Fig. 1. The mean weight of marketable strawberries in grams (for treatment description see Table 1)

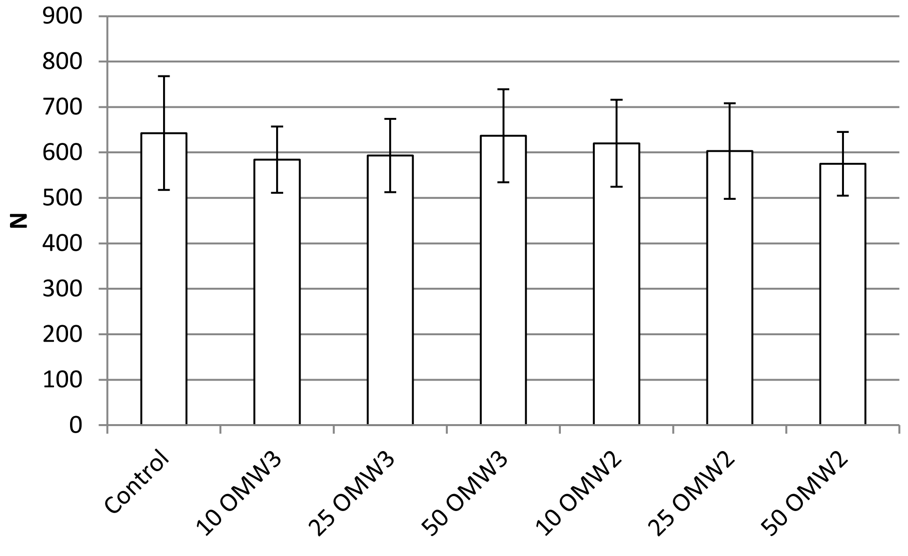

Fig. 2. Results of the penetrometer test with units in Newtons on the marketable strawberries harvested in 2014 (for treatment description see Table 1).

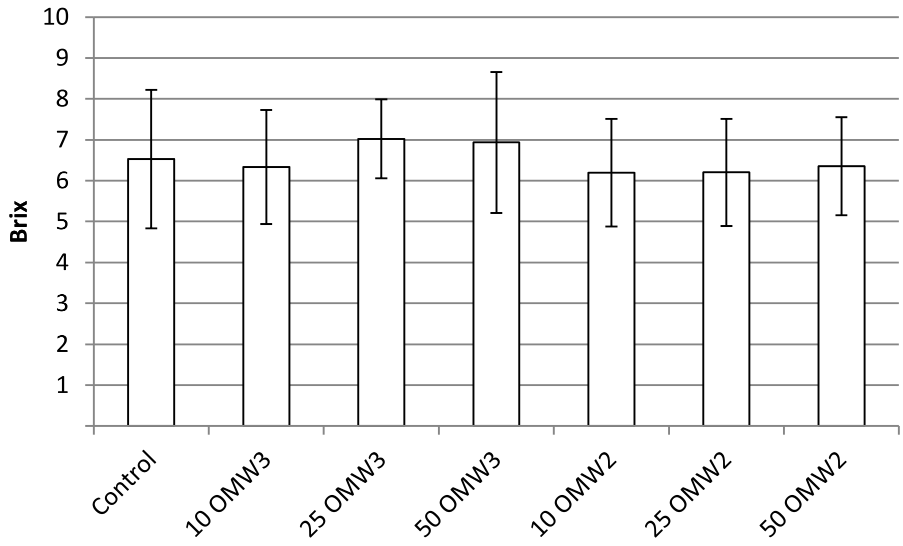

Fig. 3. The results from the refractometer test with units in Brix for the strawberries harvested in 2014 (for treatment description see Table 1).