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Impact of composts prepared from olive waste on the growth and production parameters of some fruit trees

I. Atemni(a)*, I. Mehdaoui(a), A. Ainane(b), Y. Gaga(c), T. Ainane(b), A. Chetouani(d), B. Hammouti(d), M. Taleb(a), Z. Rais(a)

(a) Engineering Laboratory of Organometallic, Molecular, and Environmental Materials. Faculty of Sciences Dhar Mahraz, Sidi Mohamed Ben Abdellah University, Fez, Morocco
(b) Superior School of Technology, University of Sultan Moulay Slimane, PB 170, Khenifra 54000 MoroccoUniversité Mohammed VI P
(c) Laboratory of Biotechnology, Conservation, and Valorization of Natural Resources -LBCVRN. Faculty of Sciences Dhar Mahraz, Sidi Mohamed Ben Abdellah University, Fez, Morocco
(d)Laboratoire de Chimie Analytique Appliquée, Matériaux et Environnement (LC2AME) Faculté des Sciences Oujda Morocco.

** Corresponding author:*
ibrahim.atemni@usmba.ac.ma
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Abstract

In agriculture, the use of organic amendments allows a better sustainability and productivity of the crop by improving the quality and structure of the soil, due to their richness in organic matter and nutrients such as phosphorus, nitrogen, potassium, etc. This study aims to evaluate the effect of two composts of different compositions on the growth and yield of three types of trees: peach, pear and orange. The experimental design used is a randomized block with three replications. The treatment of trees was carried out by four types of amendments which were composts with olive waste (OW), olive mill wastewater (OMW), manure (M) and NPK fertilizer (F) of type 10-15-12. Their fertilizing power was evaluated by monitoring the morphological parameters of plant growth: height, trunk diameter, number of branches, and those of production including size, weight of fruit and yield. The obtained outcomes reveal that the two composts have a very highly significant effect on the investigated parameters. The production was recorded only in peach trees with a total yield of 31.5 t/ha; 25.5 t/ha; 22.5 t/ha; 18.5 t/ha, respectively for OW, OMW, F and M.

Keywords: *Composts, Olive waste, Trees, Fertilizing power, ANOVA.*

1. Introduction

Plants need nitrogen, phosphorus and potassium in large quantities to accomplish their growth cycle, which makes it essential to periodically replenish the soil reserves of these elements to maintain a high productivity. [1]. In addition, the decrease in soil fertility due to over-intensive or inappropriate agriculture, and therefore a loss of organic matter, and an increased sensibility of plants to diseases, causing an important decrease in agricultural productivity [2,3]. Recent concerns about the negative effects of the increasing use of synthetic fertilizers on the environment, their impacts on soil fertility and their high costs have made it urgent to find an alternative solution to minimize the risks of contamination of food and natural resources by synthetic chemical residues, and also to improve the soil fertility [1]. Currently, the composting is considered as one of the efficient alternatives for the recycling and the integral valorization of the organic waste [4-6]. The literature showed that the use of compost in agriculture has a positive impact on the soil-plant system in terms of their nutrition because of the fertilizing elements that they contain (N, P, K, Ca, Mg and S). The effect of the doses applied, the types of soils or the modes of experimentation in the fields on the growth and the production of the crops were also studied [7-9]. The objective of this work is to evaluate the effects of two composts produced from olive waste (olive pomace and olive mill wastewater) on the growth and yield of peach, pear and orange trees. After a growth period of ten months, the effect of each amendment on the trees was examined by studying some morphological and production parameters. All the recorded results were statistically analyzed by ANOVA.

2. Materials and methods

2.1. Study area

The study was carried out in a field in Douar Aghbalou Aqorar, rural commune of the province of Sefrou about 15 km northwest of the city of Fez. The geographical coordinates are 33°55'23.8 "N 4°48'30.4 "W, with an altitude of 702 m. This site has a warm Mediterranean climate with dry summer (Csa) according to the classification of Köppen-Geiger. Over the year, the average temperature in Aghbalou Aqorar is 17.1 ° C and the average rainfall is 468.2 mm.

Figure 1. Geographical location of the study area.

2.2. Plant material

2.2.1. Types of amendments

In the present study, two composts were previously elaborated by fermentation in aerobic medium of a mixture of studied composition, organic household waste, poultry droppings and olive mill wastewater (OMW) or olive pomace and olive mill wastewater (OW). The Manure (M) used is a bovine manure collected from a farm in the region of Sefrou. In addition, the chemical fertilizer (E) is a product commercialized as NPK (10-15-12). The soil, the manure and the composts were characterized by measuring physicochemical parameters such as pH, electrical conductivity (EC), humidity (% H), organic matter (% OM), Dry matter (DM), organic carbon (% OC), total Kjeldahl nitrogen

(TKN), mineral elements and fertilizers (N, P, K, Ca, Mg) and metallic trace elements (Cu, Cr, Cd, Co, Al, etc.) according to the AFNOR standards [10].

2.2.2. Types of trees

The study was conducted on three types of trees such as peach, pear and orange. For each one, 12 trees of different ages and local varieties cultivated by the producer were tested; three repetitions for each amendment.

2.3. Methods

2.3.1. Experimental design

The study was conducted on an area of 750 m2 (50 m x 15 m). The experimental design consisted of randomized blocks with four treatments and three replications, for a total of 12 trees in each. The planting density was 500 trees/ha with 5 m between lines and 4 m between plants in the same line. The treatments (OMW, OW, M, F) were mixed in the soil at a depth of 15 cm with a dose of 10t/h fractioned in two applications (at the beginning of the test and at flowering). The irrigation was done by the drip irrigation system by covering 100% of the needs of the plant throughout the experiment.

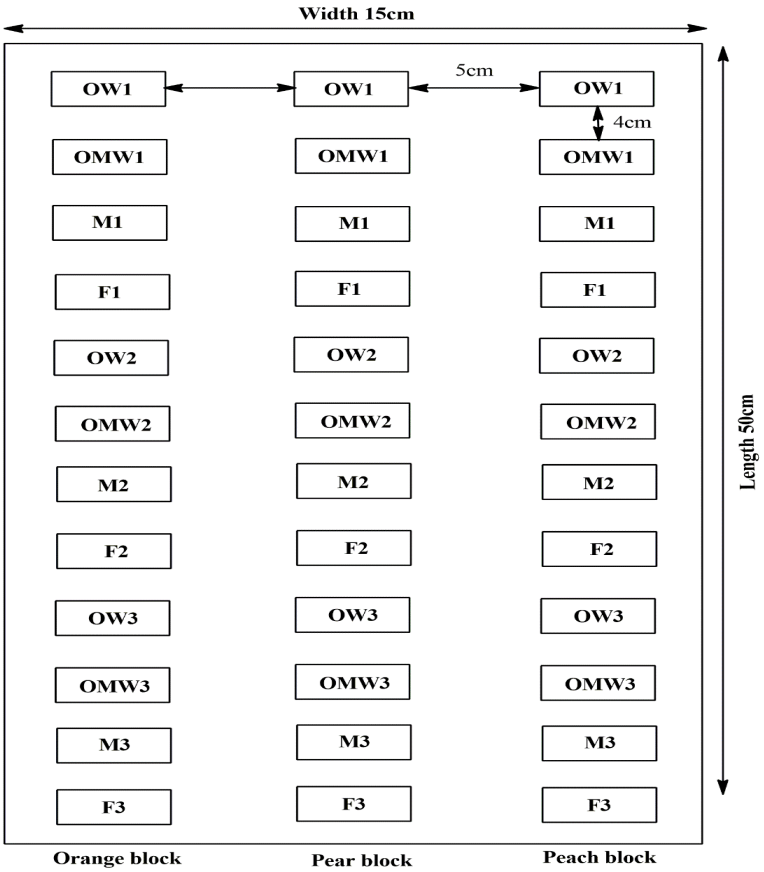

Figure 2. Sketch of the experimental design.

2.3.2. Monitoring trees growth

2.3.2.1. Measurement of morphological parameters

The plant height, the trunk diameter and the number of branches by plant are the three morphological growth parameters that were measured every 15 days during a 10 months period. For each parameter, three measurements

were performed to ensure the reproducibility of the obtained findings. The value recorded is the average of the three measurements. The height of the plant was measured from the crown to the apex of the plant with a meter ribbon and expressed in cm. The diameter of the trunk was measured with a caliper and expressed in cm. Moreover, the number of branches was also counted visually.

2.3.2.2. Measurement of production parameters

The harvest period lasted 11 days. During this period, harvesting sessions were conducted at three-day intervals. At each session, the fruit size in (mm), the weight of the crop for each plant in (kg) and the yield (t/ha) were determined. The Size consists of measuring the length and width of the fruit. The measurements were performed with a graduated ruler. The weight of the crop for each plant was measured with a balance and expressed in kg. The yield (Y) was determined in t/ha using the equation 1:

$$R = P \times D \qquad (1)$$

With P is the weight (Kg/Plant) and D represents the planting density (number of trees/ha)

1.3.3. Statistical analysis

Two-factor analysis of variance (ANOVA) was performed on the collected data by using Statgraphics Centurion software (version 2018). The recorded means were compared by Duncan's test at $P<0.05$. Excel software (version 2010) was used to draw the plots.

3. Results and discussion

3.1. Characterization of the amendments

The results of the physico-chemical characterization of organic amendments OW, OMW and manure (M) are represented in Table 1. They are compared to the quality standards of an urban organic waste compost NF U44-051. From Table 1, it can be seen that both OW and OMW composts have a neutral pH and a C/N ratio between 10 and 15, which are signs of their maturity. The OW is richer in the mineral elements such as calcium, potassium, phosphorus, magnesium and sodium, which promote the growth of plants

3.2. Soil characteristics of the study area

The characteristics of the soil at the chosen site are given in Table 2.

Based on Table 2, the soil at the experimental site is neutral, non-saline, very rich in organic matter, with a very high C/N ratio. For major elements, this soil is very poor in nitrogen and phosphorus. This means that the application of amendments rich in organic matter and in nutriments will improve the formation of the clay-humus complex and the nutriment content of the soil in order to ensure a good plant growth.

Table 1. ***Physico-chemical characteristics of the used amendments***

Parameter	OW	OMW	M	Standard NFU44-051
pH	7.95	7.63	8.57	6.5-8.5
EC (Ms.cm^{-1})	2.69	4	3.87	ND
H (%)	16.7	12	20	>30
DM (%)	83.3	88	80	>30
OM (%)	56.65	62.95	74.68	>20
TOC (%)	29.82	33.13	37.72	ND
TKN (%)	2.59	3.15	2.97	0.88
C/N	11.51	10.51	12.7	>8
Polyphenols (mg/L)	6.5	7.5	0	ND
Mineral elements and fertilizers (mg/Kg)				
Na	8505	36225	10485	ND
K	88680	8410	85460	ND
Ca	14.83	7.79	6.71	ND
P	1.75	3.52	2.39	ND
Mg	2.9	2.2	3.16	ND
Trace metal elements (mg/Kg)				
Cd	0.08	0.085	0.085	3
Co	0.038	0.06	0.06	ND
Al	2.31	0.73	1.11	ND
Cr	0.04	0.9	0.34	120
Cu	0.04	0.14	0.48	300

Table 2. ***Physico-chemical characteristics of the study soil***

Parameter	Value	Soil classification according to NF EN ISO 14688-1
pH	6.88	6.5-7.3
CE (ms.cm^{-1})	0.198	Non-saline
H (%)	16	ND
DM (%)	84	ND
OM (%)	8	3-6
TOC (%)	4.21	ND
TKN (%)	0.105	ND
C/N	40.09	ND
Na (mg/Kg)	36720	ND
K (mg/Kg)	48100	>100 ppm
Ca (mg/Kg)	38.1	ND
P (mg/Kg)	0.69	>100 ppm
Mg (mg/Kg)	2491	ND

3.3. Monitoring the growth of trees

3.3.1. Morphological parameters

3.3.1.1. Plant height

The curves in Figure 3 show the evolution of plant height in the three types of trees for all organic and chemical amendments used as a function of time. This parameter starts to increase only after two months of application of the

amendments; this is the time needed for the soil microorganisms to mineralize a sufficient quantity of organic matter. This period allowed these amendments to improve the level of elements necessary for plant growth, in particular nitrogen, carbon, phosphorus and potassium. Generally, all the amendments contributed to the development of the height of the studied trees. It is also noted that the plants amended with olive waste (OW) present the highest height compared to the compost (OMW), manure (M) and chemical fertilizer (F) with optimal values of 310 cm, 180 cm and 115 cm, respectively in peach, pear, and orange trees. This is due to its mineral composition that ensured the necessary ionic equilibrium for the absorption of nutriments that the plant needs for its growth. Therefore, its richness in calcium (Ca) has an important role in cell division and elongation, as well as in the metabolism of nitrogen and the translocation of hydrocarbons that allow the plants to grow better. Similar results were recorded by Medjahdi [11], showing that the composts fabricated from pomace and olive mill wastewater that marked the best increase in the length of their stems of wheat plantlets. The statistical analysis of these data show that all the applied amendments had very highly significant effects ($p < 0.001$) on the height of the three trees.

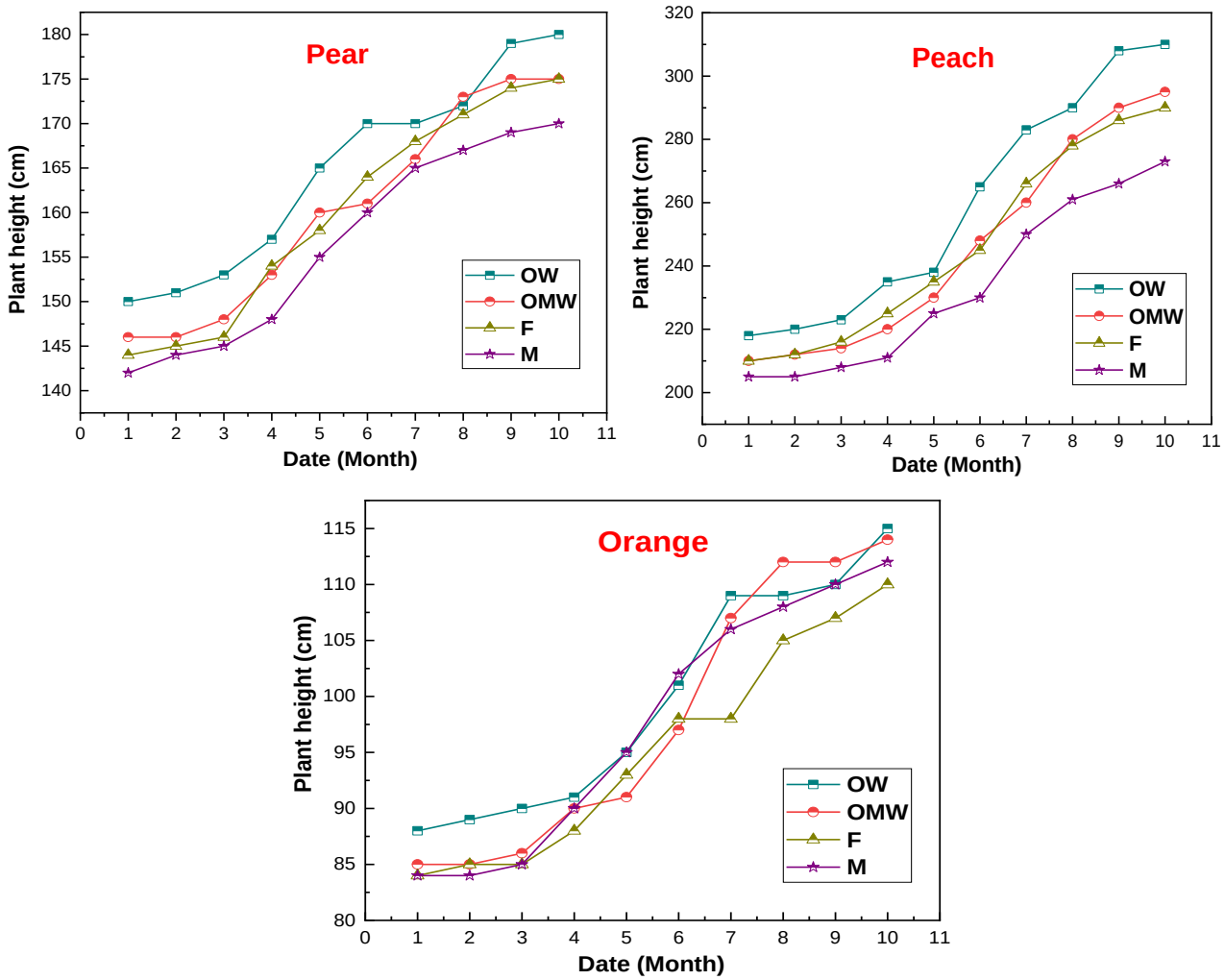

Figure 3. Evolution of plant height with time and type of amendment for peach, pear and orange trees

3.3.1.2. Trunk diameter

Figure 4 shows the variation in trunk diameter for peach, pear and orange trees as a function of time and amendment type. The curves presented in Figure 4 show that the trunk diameter increases in the same rhythm with the amendments, whatever the type of tree. After one month, a slight difference between the curves begins to appear. The largest trunk diameters were obtained for the OW and OMW amendments with optimum values of 24 cm and 22.5 cm

for peach, 12 cm and 11.5 cm for pear, 8 cm and 7.5 cm for orange, respectively. This is mainly due to the presence of oligoelements in these composts, which are involved in the synthesis of proteins such as starch which has a specific role in the metabolism of the hormone auxin responsible for cell elongation, especially the embryonic cells of the cambium which ensure the growth of tree diameters. Low values are noted in plants amended by chemical fertilizer as a result of the nature of the soils of the study site and the strong mineralization of the fertilizer provided. These results show the limited action of conventional fertilizer, which is subject to the risks of volatilization and leaching after rainfall, especially in sandy soils [12]. According to Serpantié and Ouattara [13], a fast mineralization favors the loss of assimilable mineral salts and the acidification of the soil, especially on tertiary sands. This led to a decrease in the growth rate of plants treated with the conventional chemical fertilizer compared to other organic amendments. The obtained results are statistically confirmed by the two-factor analysis of variance which represents a very highly significant "amendment" effect ($P<0.001$) on trunk diameter, for the three types of trees. Similarly, the analysis of variance revealed a very highly significant ($P<0.001$) interaction (amendment-tree type).

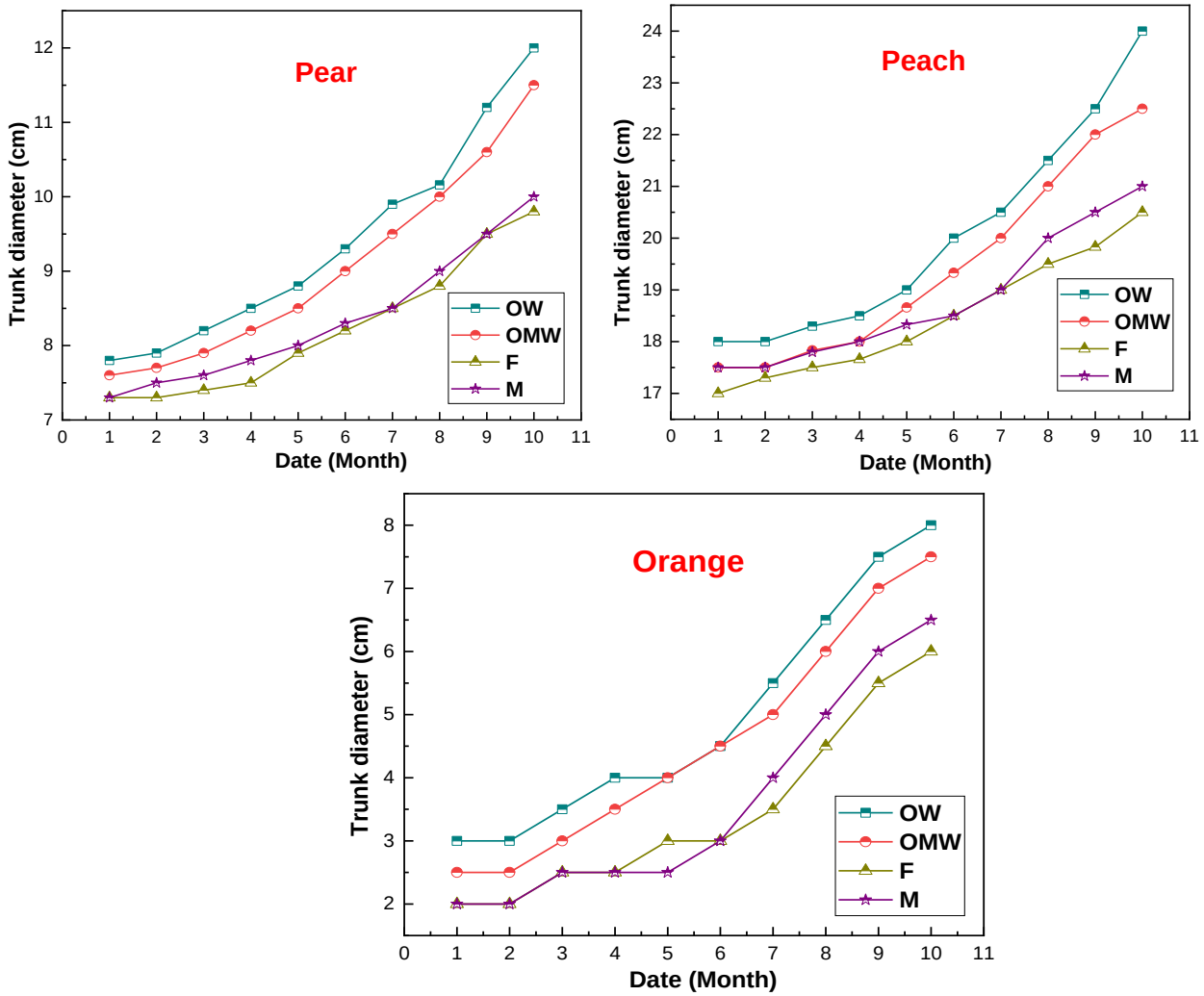

Figure 4. Evolution of trunk diameter as a function of time and type of amendment for peach, pear and orange trees

3.3.1.3. Number of branches

The results of counting the number of branches by plant in the different types of trees allows to draw the curves presented in Figure 5. The evolution of the number of branches for all types of amendments showed the same growth trend in the three types of trees. the birth of the branches was made by stages which stabilized after eight months for all the trees and with the different amendments. It can be noted also that the values obtained by the plants amended

with manure were significantly lower than the other organic and chemical amendments; 6 branches at peach tree, 4 at pear tree and 3 branches at orange tree. While the OW amendment gives an optimal value for the three trees (10 in peach tree, 7 in pear tree and 4 in orange tree). According to the literature, no work has been reported before on the effect of amendments on the branching of fruit plants, but there are some done on other types of plants. Lahlou et al [14], showed that the application of amendments to potato plants increases the yield in stem number. However, Aboubakar et al [15] have shown that fertilization significantly increases the number of branches by plant. The F-test of the analysis of variance (at the probability threshold x= 0.05) showed a highly significant effect **(P<0.001)** of the different types of amendments on the number of branches.

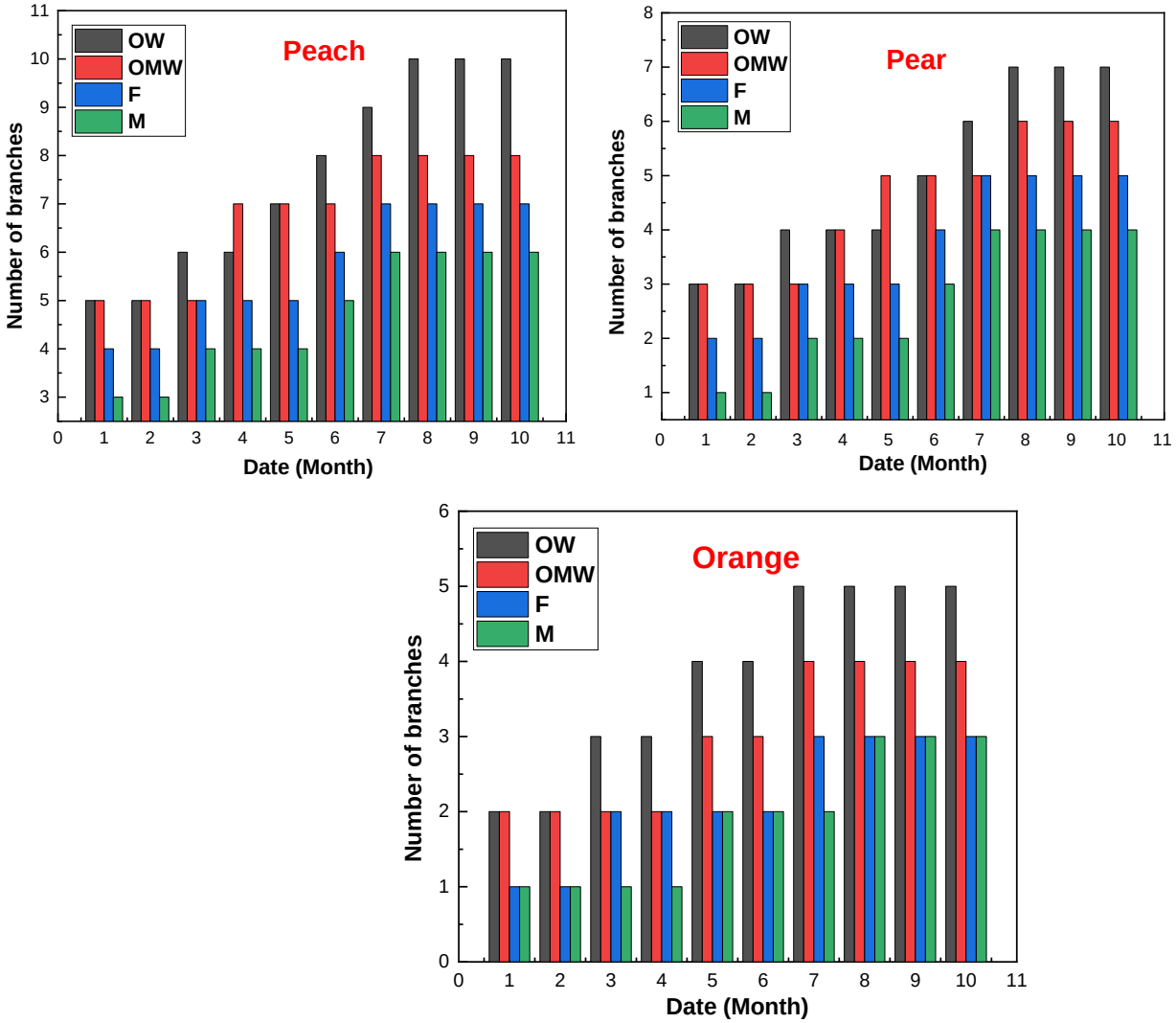

Figure 5. Number of branches per plant as a function of time and type of amendment for peach, pear and orange trees

3.3.2. Production parameters

The production parameters such as fruit size, fruit weight by plant and yield were evaluated only for the peach trees. The other two trees (pear and orange trees) are still young. The results for these parameters are shown in Table 3. From the analysis of variance, it appears that all applied amendments had highly significant effects on the production parameters ($p < 0.05$).

Table 3. ***Effect of the different treatments on the production parameters of the peach***

Treatment	Size (mm)		Weight (kg/plant)	Yield (t/ha)
	L	l		
OW	73±0.05	69±0.07	63±0.30	31.5±0.30
OMW	68±0.01	67±0.5	51±0.21	25.5±0.21
F	70±0.06	61±0.12	44±0.05	22±0.05
M	65±0.1	55±0.08	42.5±0.15	21.25±0.15
Probability P	0.001	0.001	0.005	0.005

L: Fruit length in mm; l: Fruit width in mm

Regarding the fruit size, the peach trees amended with olive waste (OW) presented the greatest length and width of fruit compared to those amended with other treatments with an average value of 73mm and 69mm, respectively. This can be explained by the richness of olive waste in organic matter and mineral elements, particularly potassium, which essentially influences the size of the fruit, or its presence in the soil limits transpiration and increases the concentration of mineral elements in the sap. The results thus obtained are in agreement with those presented by Boularouf [16], which has noted that the addition of compost to olive waste (OW) significantly improves the size of potatoes.Regarding peach production, the highest weights by plant were recorded in soils enriched with (OW) and (OMW) amendments with 63 kg/plant, and 51 kg/plant respectively. On the other hand, the plants planted on soil enriched with chemical fertilizer (F) recorded a low average value of 44 kg/plant, almost similar to manure which recorded 42.5 kg/plant. Furthermore, the results obtained on the yield per hectare show that the highest yield is obtained in the plants having been amended by (OW), that is 31.5 ton/ha. The lowest yield is noticed in the plants having received organic matter based on manure (21.25 ton/ha). These results can be justified by the fact that composts based on olive waste would improve the physicochemical properties of the soil in major elements as described by Ognalaga et al [17] on crops. According to Ognalaga et al [18], phosphorus and nitrogen are major fertilizing elements that ensure good performance for plant growth and yield. Mukendi et al [19] highlight that the growth of a crop depends on the availability of nutrients through soil amendments. These organic amendments modify the characteristics of the characteristics of the soil by acting as a cation exchange capacity and water retention capacity [20]. The effects observed in Table 3 are consistent with those of Rusan [21] and Belaqziz [22] showing that olive waste amendments increase crop productivity and farm income. According to Luca et al [23], compost from olive waste contains high levels of essential elements such as Ca, Mg, P, K and N for plant nutrition. Several works support these results, explaining that organic matter all have an influence on the yield of olive trees [23-30].

4. Conclusion

All the achieved outcomes have highlighted the effect of the addition of composts, based on olive growing waste, on the development and the growth of the crops of three type of trees which are peach, pear and orange. The morphological and production parameters were monitored and studied in order to elucidate the action of different amendments. The results of this study showed that all the organic (OW, OMW, M) and chemical (F) amendments constitute significant sources capable of enriching and improving the quality of a soil in fertilizing elements responsible for plant growth. This provides information on their ability to provide the nutriments to the plant and therefore determine their level of fertility. However, the amendments based on olive waste (OW) and olive mill wastewater (OMW) recorded better results regarding the evolution of morphological parameters (length of the plant, diameter of the trunk and number of branches/plants) and production (weight/plant, size, and total yield). The analysis of the results showed that these composts had a highly significant influence on the investigated growth parameters. For

the three selected plants, these effects are mainly due to the contribution of organic matter and the improvement of the physico-chemical and biological properties of the soil which influenced the supply of nutrients to the plants.

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