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The Potential of using Olive Pomace as Soilless Growing Medium for Crop Cultivation Inside Greenhouse

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ABSTRACT

Background: The improper disposal of olive pomace causes a serious environmental issue in Palestine because of its negative effects on soil, environment and ground water. The current study was aimed to investigate the potential of using olive pomace as soilless growing medium.

Methods: During the period 2016-2017 two field experiments were conducted at the experimental farm of Palestine Technical University Kadoorie, Tulkarm, Palestine. In the first experiment, olive pomace was mixed with peat moss as follows (Op:Pt2:1, Op:Pt1:1, Op:Pt1:2 and Op100%). In the second experiment, olive pomace was mixed with peat moss and compared with different known growing medium as follows (Op:Pt1:1, Op:Pt1:3, Pt:Vr1:1 and Pt:Pr1:1).

Result: Results of the first experiment indicated that the olive pomace treatment (Op:Pt1:2) produced the highest plant height compared to the other treatments. In the second experiment the (Pt:Vr1:1) and (Pt:Pr1:1) treatments produced the highest yield of cucumber without significant difference between those two treatments. The (Op:Pt1:1) treatment produced higher plant height, root depth, dry weight, yield production and fruit number of cucumber compared with (Op:Pt1:3) treatment.

Key words: Cucumber crop, Olive pomace, Peat moss, Perlite, Vermiculite.

INTRODUCTION

Soilless plant culture is any method of growing plants without the use of soil as a rooting medium known as a substrate or growing medium (Savvas *et al.,* 2013). Compared with soil based cultivation, soilless production can be more cost effective (Grafiadellis *et al.,* 2000; Sindhu *et al.,* 2010), producing higher yields and prompter harvests from smaller areas of land (Raviv and Lieth, 2008; Khalaj *et al.,* 2011; Nejad and Ismaili, 2014). Soilless systems also have generally higher water and nutrient use efficiencies (Van Os, 1999). As a result, they have become increasingly important globally over the last 50 years (Schmilewski, 2009).

Effective soilless growing medium must have a physical structure that creates an appropriate balance of air and water for healthy root development. This balance must be maintained over an entire crop production cycle, which can last from several weeks to more than a year. Growing medium structure is determined by the size, shape, texture and physical arrangement of the particles from which it is composed (Bilderback *et al.,* 2005). Chemical properties as pH, electrical conductivity, cation exchange capacity and nutrient availability have been measured across a diverse range of growing media and are extensively reviewed (Lemaire, 1995; Argo, 1998; Silber, 2008; Murumkar *et al.* 2013). Biological properties are also an important consideration for organic materials, as they can have large impacts on growing medium performance (Carlile and Wilson, 1991; Alsanius and Wohanka, 2009).

Nowadays, a wide range of soilless culture techniques have been developed and commercially introduced for intensive production of horticultural crops, particularly vegetables under greenhouses condition. Replacing soil with other growing medium for growing vegetable crops especially cucumber, pepper, tomatoes *etc.* resulting in better control of plant nutrition and eliminate of plant diseases that caused by soil (Olympios, 1995; Kurup *et al.,* 2011). It helps to avoid problems related to monoculture of plants in the same land for years (Fecondini *et al.,* 2011). Furthermore, it would address the problems related to proliferation of soil borne pathogen in the soil cultivation.

Two types of waste are generated from the process of olive oil extraction; one is a solid residue called olive pomace (or Jift as locally named) and a liquid waste which is olive mill wastewater or Zibar as named locally in Palestine. Olive pomace retains a small amount of olive oil and consists mainly of water, olive skin, olive flesh, fragments of pulp and pieces of kernels. Olive pomace chemical composition is generally characterized by a high content of crude fiber and sugars (mainly polysaccharides) and moderate values

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of crude protein, fatty acids (oleic acid), polyalcohols, polyphenols and other pigments which may affect plant growth and development (Saviozzi *et al.,* 2001; Muik *et al.,* 2004; Brunetti *et al.,* 2005). However, the chemical composition of olive pomace may vary widely in relation to the agronomic and technological conditions of production.

In Palestine, the only treatment that is done to the wastes of olive mills is the partial reuse of the overall produced olive pomace for the soap factories. The olive pomace is collected and then extracted by hydrocarbons to extract the remaining oil to be used for producing soap. The remaining olive pomace is dried and used as burning material to produce energy for the extraction process in the soap factories. The olive pomace is also used partly for combustion to heat houses during the winter season. In addition to using olive pomace for space heating and soap industry there are other reported potential uses of olive pomace such as fertilizer compost (Haddadin *et al.,* 2009), animal fodder (Haddadin and Abdulrahim, 1999), source for the manufacture of activated carbon (Mameri *et al.,* 2000), source of bio-pesticides (Cayuela *et al.,* 2008), co-firing with coal in power stations (Cliffe and Patumsawad, 2001). The improper disposal of olive pomace causes a serious environmental issue in Palestine because of its negative effects on soil and ground water (Tawarah and Rababah, 2013).

The objective of this study was to investigate the potential of using olive pomace as growing medium for horticulture crop cultivation and its behavior on growth performance of eggplant and cucumber production as case study inside greenhouse.

MATERIALS AND METHODS

Experiment 1

Two field experiments were conducted at the experimental farm of Palestine Technical University Kadoorie, located at Tulkarm, West Bank, Palestine during two growing seasons of 2016-2017. Tulkarm area is recognized by its moderate climate, with average yearly precipitation varies between 530-630 mm. The first experiment was carried out to investigate the potential of using olive pomace as growing medium for cultivating eggplant inside greenhouse. Olive pomace substrates were mixed with peat moss without leaching and prepared as growing medium. Eggplant seedlings were cultivated in pots with five replicates per each treatment on 9 May 2016 for a period of five months.

Experiment 2

The second experiment was conducted inside greenhouse to compare the olive pomace growing medium with other different known growing media (peat moss, perlite, and vermiculite). Olive pomace substrates were leached well with water and air dried then mixed with peat moss for preparing the growing medium. Different mixtures of known soilless growing medium of peat moss, perlite and vermiculite were used for comparing with the olive pomace substrate. Different mixtures of growing media during the first and second experiments are given in Table 1. Cucumber seedlings were cultivated in plastic pots, with five replicates per each treatment on 19 September 2016 for a period of four months. The experiments were designed using complete randomized design.

The particle size distribution of olive pomace is given in Table 2. The chemical properties of the growing medium used in the second experiment are given in Table 3. Electrical conductivity (EC_{dw}) and pH of the drainage water were monitored every two weeks during the growing period of eggplants and cucumber. Average plant height, average fruit number per plant, average fruit weight per plant, average fruit length per plant, average total yield, average root depth and distribution and average plant dry matter, were measured during the growing period.

RESULTS AND DISCUSSION

Growth of eggplant

Results of this study showed that the olive pomace treatment (Op:Pt1:2) indicated the highest plant growth compared to the other treatments. Moreover, as the percentage of olive pomace increased in the soilless substrate treatments, plant growth and development was inhibited (Fig 1). In addition to that, the olive pomace treatment (Op100%) produced the lowest plant growth compared to the other treatments. This is attributed to the fact that, the olive pomace had low pH and high level of salinity (Fig 2 and 3).

Growth of cucumber

Results of this study indicated that, the (Pt:Pr1:1) treatment indicated the highest plant height, followed by (Op:Pt1:1) treatment (Fig 4). The (Pt:Vr1:1) treatment had large vegetative growth and more branches than the other treatments. Moreover, the (Pt:Pr1:1) treatment indicated more root depth and distribution compared with the other treatments followed by (Pt:Vr1:1) treatment (Fig 5). There was significant difference in root depth between all treatments. This is due to the fact that perlite provided better root-zone aeration than the other growing media. This is agreed with the results of Gomez-Lopez *et al.* 2006. Dry matter of cucumber plant was measured for shoot and root

Table 1: Type of growing media used in the experiment and percent of substrate.

Treatments	First experiment substrate mixture	Treatments	Second experiment substrate mixture
(Op:Pt2:1)	Olive Pomace: Peat Moss	(Op:P1:1)	Olive Pomace: Peat Moss
(Op:Pt1:1)	Olive Pomace: Peat Moss	(Op:Pt1:3)	Olive Pomace: Peat Moss
(Op:Pt1:2)	Olive Pomace: Peat Moss	(Pt:Vr1:1)	Peat Moss: Vermiculite
(Op100%)	Olive Pomace	(Pt:Pr1:1)	Peat Moss: Perlite

parts at the end of the growing period. It is indicated that the (Op:Pt1:1) and (Pt:Pr1:1) treatments produced higher shoot dry weight without significant difference, compared to the other treatments, while for root dry weight, (Pt:Vr 1:1) treatment produced the higher dry weight compared with the other treatments (Fig 6). There was no significant differences in shoot dry weight between (Pt:Vr1:1) and (Pt:Pr1:1) treatments, while there was a significant difference in root dry weight between all treatments. Djedidi *et al.* (1997) found that the highest flowering rate and dry matter of tomato fruit was achieved when perlite used as growing media compared with ziolite substrates.

Table 2: Particle size distribution of olive pomace.

Particle size	Percent (%)
2.0 - 1.0	44.50
1.0 - 0.71	12.10
0.71 - 0.50	12.94
0.50 - 0.35	10.68
0.35-0.25	8.72
<0.25	11.06

Yield parameters of cucumber

Results of the study indicated that, the (Pt:Vr1:1) and (Pt:Pr1:1) treatments produced the highest yield production of cucumber without significant difference as shown in (Fig 7). The (Op:Pt1:3) produced the lowest yield production of cucumber compared with the other media treatments. Moreover, the treatment (Op:Pt1:1) produced higher yield compared with (Op:Pt1:3) treatment. This may be explained by the high electrical conductivity and low pH of the olive pomace substrate which was negatively affected the plant growth and reduced the yield production (Figs 2 and 3). Mazahreh *et al.* (2015) found that the highest cucumber yield was observed in the perlite media which had highly significant

Table 3: The chemical properties of growth media used in the second experiment.

Treatments	PH	ECe (dS m^{-1})	Cl (ppm)	Na (ppm)	K (ppm)	Total hardness (meq/l)
Op:Pt(1:1)	5.5	0.9	556	10	60	29
Op:Pt(1:3)	5.4	2	947	13	97	29
Pt:Vr(1:1)	5	2	828	33	233	30
Pt:Pr(1:1)	5.19	2.3	1100.5	40	367	5
OP(100%)	5	8.5	—	—	—	—

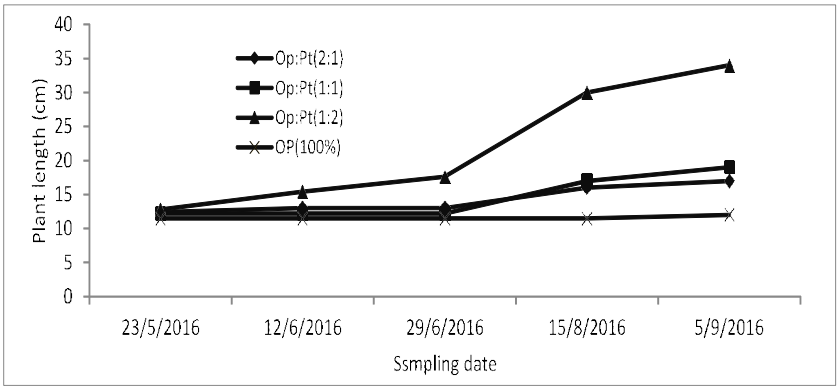


Fig 1: Plant height of eggplant crop cultivated in different olive pomace mixtures.

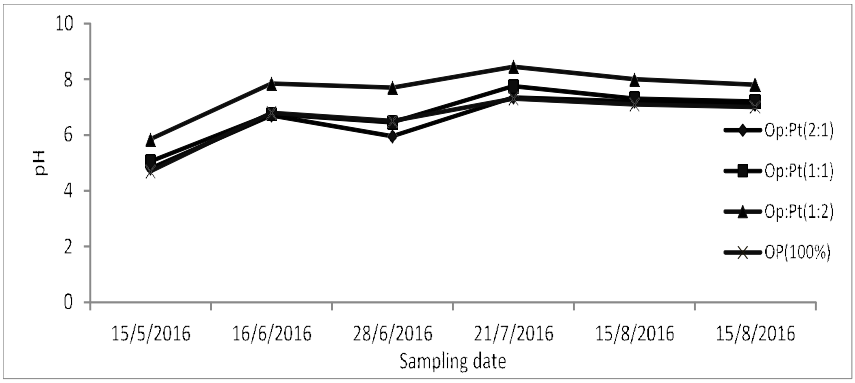


Fig 2: pH of drainage solution of different olive pomace mixture during the growing period of eggplants.

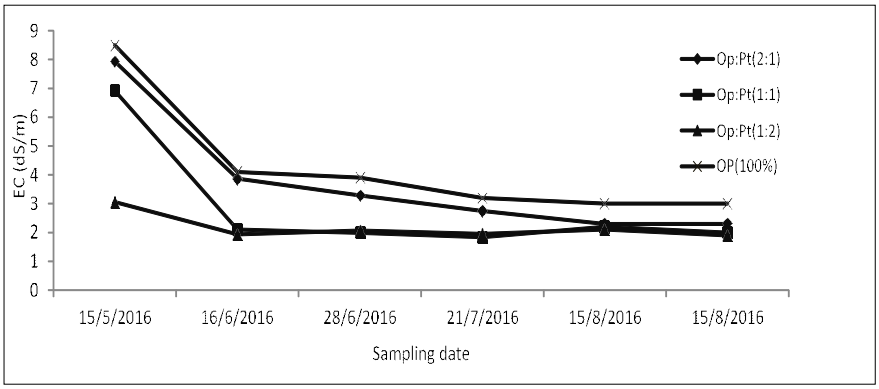


Fig 3: Electrical conductivity of drainage solution of different olive pomace mixture during the growing period of eggplants.

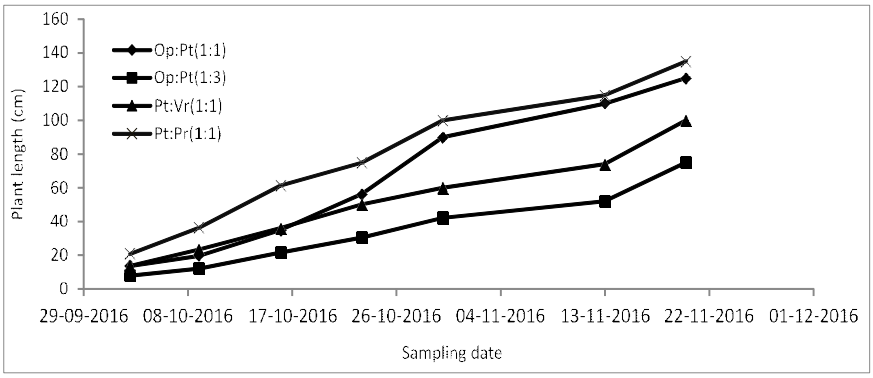


Fig 4: Plant height of cucumber crop cultivated in different soilless growing media.

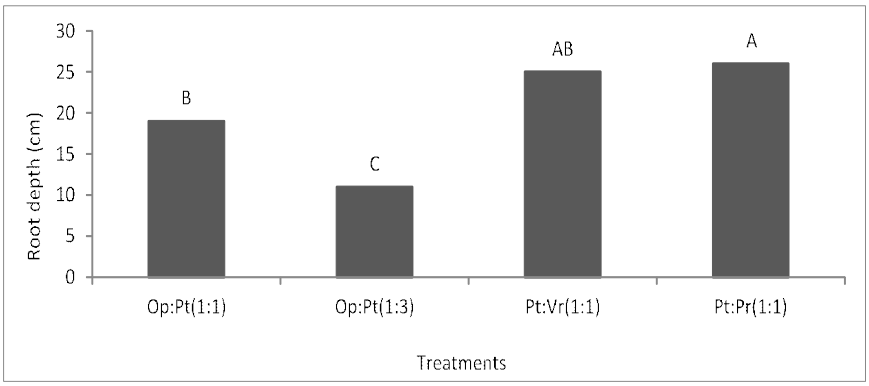


Fig 5: Root depth of cucumber crop cultivated in different soilless growing media.

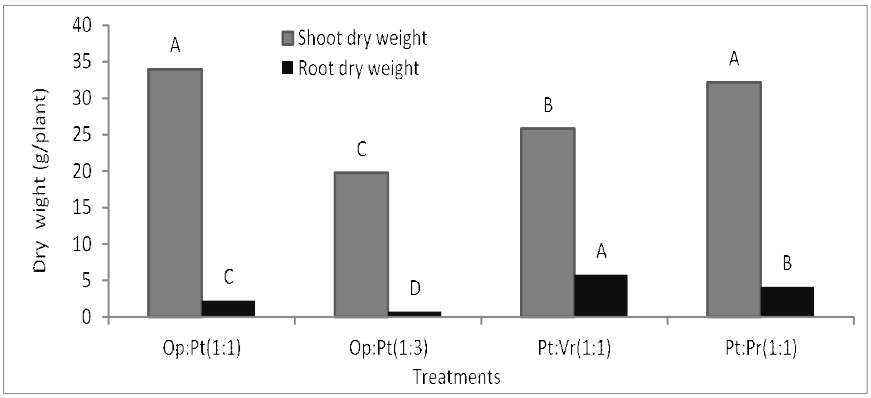


Fig 6: Dry weight of cucumber crop cultivated in different soilless growing media.

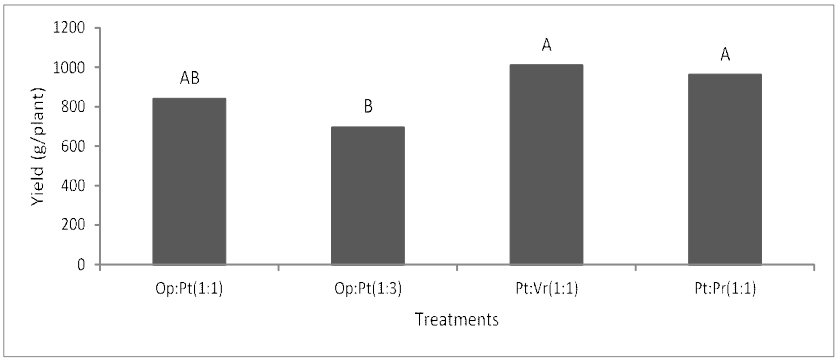


Fig 7: Yield production of cucumber crop cultivated in different soilless growing media.

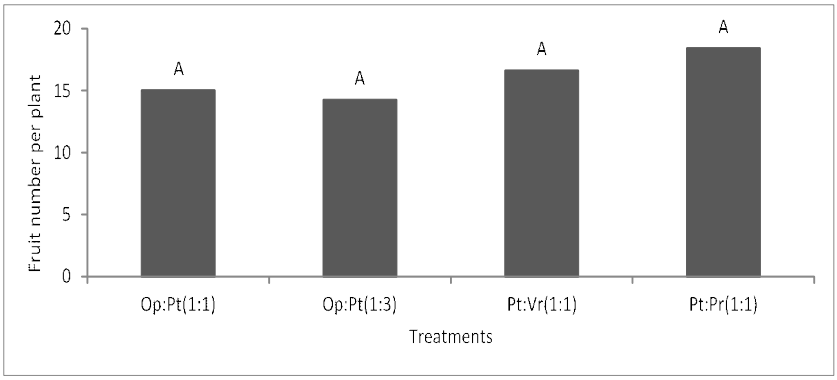


Fig 8: Fruit number of cucumber crop cultivated in different soilless growing media.

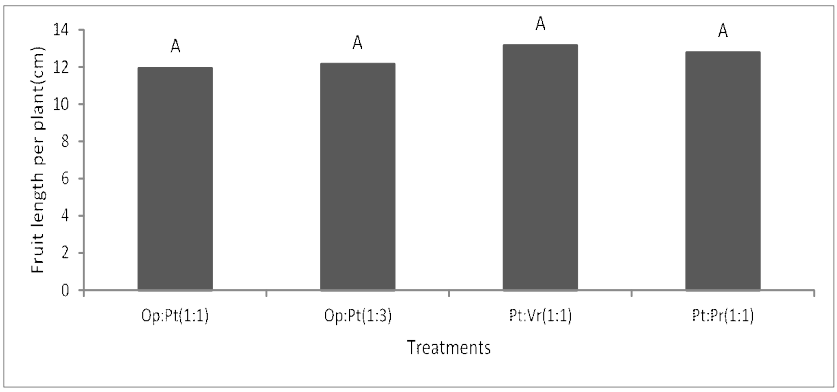


Fig 9: Fruit length of cucumber crop cultivated in different soilless growing media.

differences compared to other media treatments. In contrast, Alifar *et al.* (2010) indicated that the yield of cucumber fruit, plant stem diameter, biomass, fruit's number and fruit's size and diameter was obtained from cocopeat media compared with other media such as perlite. The results of this study indicated that the fruit numbers of plant cultivated in (Pt:Pr1:1) were higher than the other soilless substrate but the average fruit weight were less than the (Pt:Vr1:1) treatment. In addition to that the (Op:Pt1:1) treatment produced more fruit numbers than the (Op:Pt1:3) (Fig 8). Fruit length of plant cultivated in (Pt:Vr1:1) was higher than the other treatments (Fig 9). Khalaj *et al.* (2011) observed that the perlite plus peat and expanded clay mix (25:70:5) ratio produced significantly the maximum number of flowers per plant and other quality characteristics among different media used in the experiment. Statistically, there was no significant difference in yield production between (Pt:Vr1:1) and (Pt:Vr1:1) treatments, while there was a significant difference between (Pt:Vr1:1), (Pt:Vr1:1) treatments and (Op:Pt1:1) and (Op:Pt1:3) treatments. Also statistical analysis indicated that there was no significant difference in fruit number and fruit length between all treatments.

CONCLUSION

This study clearly indicated that the (Op100%) substrate treatment had high salinity level reached up to 8.5 dS m^{-1} and low pH value equals to 5. Treatment of olive pomace by leaching with clear water before mixing with peat moss could be a valuable tool to reduce the salinity level and improve the pH of olive pomace substrate. Mixing olive pomace substrate with peat moss (Op:Pt1:1) ratio increased the total

yield, the root depth and the shoot and root dry weight of cucumber compared with (Op:Pt1:3) ratio. The (Op:Pt1:1) treatment media produced higher plant length, root depth, dry weight, yield production and fruit number of cucumber compared with (Op:Pt1:3) treatment. Moreover, there was no significant difference in fruit number and fruit length of cucumber between (Op:Pt1:1) and the (Pt:Pr1:1) treatments under the experiment conditions.

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