The Impacts of different Substrates on the Growth, Yield and Fruit Quality of Greenhouse- Grown Cherry Tomato

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Abstract: In Egypt, a considerable amount of crop residues and industrial products, including peanut shells (PN), rice hulls (RH) and sawdust (SD) are available without being used as alternative substrates to the costly, imported media viz, peat moss (P) and coconut coir (Coc) in soilless culture. With the high value and increasing demand of cherry tomato fruits for export, this study was conducted to examine the growth and yield potential of cherry tomato plants in eight different substrate mixtures: P+RH, P+SD, P+ Vermiculite (V), Coc+RH, Coc+V, PN+RH, PN+V, PN+Coc and a control (sand+compost). Plants were grown in 4L pots from Oct, 2016 to May, 2017 in unheated greenhouse, fertigated via spaghetti tubes, trellised and pruned to one main stem. Results showed that plants on Coc+V or P+V had the highest stem length, while those on Coc+RH and PN+Coc had the highest leaf area. Plants on PN+Coc had also the highest shoot/ root ratio. Fruit yield, number and mean fruit weight were the highest on PN+V or PN+Coc. Fruit harvested from plants on RH-amended media had the highest TSS and EC, while fruit vitamin C content was not affected by medium type. The results suggest that PN and RH mixed with Coc are suitable substrates for soilless culture of cherry tomato.

Keywords: Medium, soilless culture, peanut shells, rice hulls, coco coir

INTRODUCTION

During the past two decades, cherry tomatoes (*Solanum lycopersicon* var. *ciraciforme*) have been grown extensively in Egypt under protected cultivation for export to the EU and Gulf state markets, especially with the current expansion in greenhouse industry. About 100,000 acres of greenhouses are being constructed, of which, >20,000 acres are devoted for cherry tomato production. However, tomato plants grown in the soil are exposed to several soil-borne diseases and pests, as well as to soil salinity and low fertility which represent a major drawback in tomato cultivation. Soilless culture in suitable growing media could provide better alternative to the traditional soil cultivation. Peat moss and coconut fibers are the major organic substrates utilized (Abad *et al.,* 2005; Halmann and Kobryn, 2003), however these materials are not locally available and have shown wide swings in price worldwide.

In Egypt, a considerable amount of organic crop residues, such as rice hulls (20% of the kernel) and peanut shells (35% of the pod) are produced annually. However, the use of such materials as growing media is not well documented in soilless culture of tomato. Numerous researches have utilized different organic (Costa *et al.,* 2018) or un-organic (Al-Ajmi *et al.,* 2009) substrates. We have previously reported on the effects of different growing media on transplant quality in cucurbits (Mohamed *et al.,* 2002), banana (Bitar and Mohamed, 2009) and strawberry (Mohamed *et al.,* 2019). In the current study, the objective was to examine growth, yield and fruit quality of greenhouse-grown cherry tomato in response to different substrates.

MATERIALS AND METHODS:

This study was conducted in unheated greenhouse at the Department of Horticulture, Faculty of Agriculture, Suez Canal University, Egypt during Oct., 2016 to May, 2017. Cherry tomato seedlings (cv. 522) were transplanted into 4 L pots filled with a mixture (1:1 v/v) of the substrate treatments: (1) Peat moss (P)+ Rice Hulls (RH), (2) P + Saw Dust (SD), (3) P + Vermiculite (V), (4) Coco coir (Coc) + RH, (5) Coc+ V, (6) Peanut Shells (PN) + RH, (7) PN + V, (8) PN + Coc, and (9) Sandy loam soil + 10% compost (Fig. 1). Pots were arranged in a complete randomized design with four replications. Substrate treatments were analyzed for physical and chemical properties as well as mean temperature of each substrate during the experimental period (Table 1).

Cherry tomato plants were irrigated using spaghetti drip tube and fertilized with the nutrient solution described by Al-Ajmi *et al.* (2009). Plants were trellised and pruned leaving one main stem. Data were recorded 120 days after planting on plant height, leaf area (leaf on the 4^{th} truss from the base). Leaf, stem and root fresh weight and dry weight (oven drying at $70^{\circ}C$ for 48 h) were determined. Tomato fruit yield, number and mean fruit weight were recorded weekly after excluding un- marketable fruits. Fruit vitamin C content was measured according to Helrich (1990), TSS by a digital refractometer and EC with an EC meter.

Statistical analysis was performed by SPSS, and DMR test was used to determine significant substrate treatment effects at $P \leq 0.05$.

Table (1): Some physiochemical properties of substrate treatments

Substrate	BD	WHC	N	EC	pH	Temperature	
	g/cm^3	g/100 g	%	dS/m^{-1}		Am	Pm
P+RH	0.260	510.2	1.08	0.65	6.30	14.70	25.5
P+SD	0.196	384.6	0.80	0.48	4.78	15.00	23.3
P+V	0.280	341.8	0.71	0.31	5.34	15.50	24.9
Coc+RH	0.180	511.0	1.32	1.40	5.66	16.00	25.2
Coc+V	0.256	382.8	0.56	0.78	7.43	17.20	24.7
PN+RH	0.178	360.0	1.06	1.60	7.20	17.20	21.2
PN+Coc	0.128	530.0	0.78	0.85	6.60	20.80	29.5
PN+V	0.170	560.0	0.98	0.97	7.60	20.50	27.7
Soil	1.410	27.1	-	1.92	8.20	16.30	24.6

BD=bulk density on a dry weight base, WHC=water holding capacity

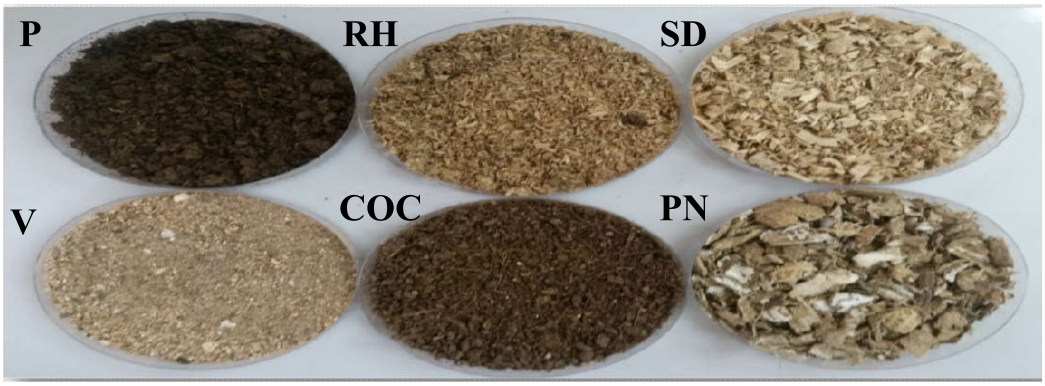

Fig. (1): Individual substrates row material

RESULTS AND DISCUSSION

Growth performance

Results demonstrated that cherry tomato growth was significantly affected by substrate type (Table 2 and Fig. 2). In this respect, plants on a mixture of P + V or Coc + V had the highest main stem height, followed by those on P + RH, Coc + RH and PN + Coc. Plants on PN + Coc and Coc + RH had the highest leaf area. Dry mass (DM) in different plant parts was significantly affected by the growing substrate. Plants on PN + V and PN + Coc recorded the highest % DM in foliage, while those on PN + RH recorded the highest stem DM. Root DM was greater in soil-grown plants. Estimated shoot (leaf+ stem) to root ratio was the highest on PN + Coc (2.27), followed by those on PN + V (1.85), and was the least (0.55) in soil-grown plants (data not shown). These results indicated significant improvement in growth of cherry tomato plants, especially those grown on Coc- and PN-based substrate, compared to soil-grown plants. These findings are in accordance with those of Mammadov and Khomami (2016), and Omidi *et al.* (2017) in other plant species.

Table (2): Effect of different substrates on cherry tomato plant growth

Treatment	Plant height	Dry mass (%)			Leaf area
	(cm)	Leaf	Stem	Root	(cm^2)
P+RH	254.67 ab	11.15 c	16.75 b	16.51 b	201.33 ab
P+SD	248.33 b	11.85 c	15.47 b	17.24 b	171.67 b
P+V	277.33 a	13.50 c	17.30 b	21.40 b	137.67 b
Coc+RH	274.33 ab	9.97 c	17.21 b	25.92 b	229.30 a
Coc+V	279.67 a	11.51 c	17.01 b	26.00 b	179.67 b
PN+RH	185.00 c	15.87 bc	26.40 a	24.52 b	171.33 b
PN+Coc	267.67 ab	20.92 ab	17.82 b	17.09 b	229.30 a
PN+V	207.67 c	21.95 a	17.05 b	23.12 b	185.33 ab
Soil	254.00 ab	9.52 c	16.27 b	46.69 a	206.60 ab
Significance	***	***	**	***	Ns

Fig. (2): Root growth pattern in different substrates

Fruit yield

Cherry tomato fruit yield was significantly the highest in plants grown on PN + V and PN + Coc, followed by those on Coc + V (Table 3). Fruit number was also the highest in these three substrates. In addition, plants on PN + Coc and PN + V produced the highest mean fruit weight. Therefore, the increase in fruit yield by the aforementioned substrates could be due to the increase in both fruit number and average fruit weight.

The impact of substrates on crop performance is mainly due to their physicochemical characteristics. In the current study, bulk density of any PN-based substrate was lower, and water-holding capacity was higher than peat-based substrates (Table 1). In addition, the average day/night temperature was higher in PN + Coc and PN + V compared to the other tested substrates (Table 1), which could have provided suitable root zone temperature for better growth and yield performance. Similarly, the increase in yield of tomato grown in shredded maize stems was attributed to the high temperature of the organic substrate caused by the microbial decomposing activities (Tzortzakis and Economakis, 2008).

Table (3): Effect of different substrates on cherry tomato fruit yield and quality

Treatment	**Yield** (kg/m^2)	**Fruit** ($no./m^2$)	**Fruit Wt.** (g)	**Vitamin C** (mg/100 g Fw)	**TSS** (%)	**EC** (dS/m^{-1})
P+RH	3.28 c	503.3 abc	6.52 b	34.20 a	8.67 a	4.26 ab
P+SD	3.49 c	515.4 abc	6.78 b	34.87 a	7.33 b	4.11 ab
P+V	3.23 c	465.3 bc	6.95 b	32.77 a	7.73 ab	3.07 b
Coc+RH	2.66 d	404.8 c	6.58 b	34.43 a	8.67 a	3.05 b
Coc+V	4.12 b	591.2 a	6.98 b	32.60 a	7.73 ab	3.86 ab
PN+RH	1.77 e	253.3 d	7.01 b	34.87 a	8.30 ab	4.90 a
PN+Coc	5.19 a	593.7 ab	8.75 a	34.23 a	7.53 ab	4.30 ab
PN+V	5.49 a	610.3 a	9.01 a	33.27 a	7.80 ab	4.00 b
Soil	3.33 c	461.6 bc	7.23 b	35.50 a	7.83 ab	3.77 ab
Significance	***	***	***	Ns	*	*

Fruit quality

The tested substrates did not significantly affect vitamin C content in cherry tomato (Table 3). Fruit TSS was slightly affected by substrate, and was higher in P+RH and Coc+RH than P+ SD. The other TSS means were not statistically different. Fruit EC was also higher on PN + RH. The increase in fruit TSS and EC in plants grown on RH-based media could be due to the increase EC values of these media (Table 1), as indicated by Wu *et al.* (2004).

CONCLUSION

Locally available organic crop residues, such as peanut shells or rice hulls mixed with coco coir could be utilized as promising substrates in soilless culture of cherry tomato.

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تأثير مخاليط مختلفة من البيئات على نمو ومحصول وجودة ثمار الطماطم الكريزية النامية بالصوب

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تتوافر بكثرة في مصر العديد من مخلفات المحاصيل ومنتجات الصناعة ومنها قشر الفول السوداني (PN) وسرس الأرز (RH) ونشارة الخشب (SD) ولكن بدون استخدامها كبديل لمخاليط التربة المستوردة عالية الثمن مثل البيت موس (P) وألياف جوز الهند (COC) والفيرموكليت (V) في الزراعة بدون تربة. ومع زيادة القيمة والطلب المتزايد على الطماطم الكريزية للتصدير فقد أجريت هذه الدراسة لاختبار نمو ومحصول وجودة ثمار الطماطم الكريزية في ثمانية مخاليط من التربة: (١) P+RH ، (٢) P+SD ، (٣) V+P ، (٤) V+COC ، (٥) SD+PN ، (٦) V+PN ، (٧) COC+PN ، (٨) رمل + كمبوست (كونترول). تم إنماء النباتات في أصص سعة ٤ لتر في صوبة زجاجية غير مدفأة وتم الري والتسميد بمحلول مغذى من خلال خراطيم رفيعة (سباجتي) وتربيتها على أسلاك وعلى فرع واحد رئيسي. أوضحت النتائج أن النباتات النامية في مخلوط COC +V أو P+V أعطت أعلى طول للساق بينما تلك النامية في COC + RH أو COC + PN كانت الأعلى في المساحة الورقية. وقد أعطت البيئة المكونة من V + PN وكذلك COC + PN أعلى محصول للثمار وعدد ومتوسط وزن الثمرة وكانت أعلى نسبة للمواد الصلبة الكلية في الثمار الناتجة من مخلوط يحتوى على سرس الأرز (RH) بينما لم تؤثر معاملات مخاليط التربة على محتوى الثمار من فيتامين (C). وتخلص النتائج إلى أن مخلوط قشر فول السوداني أو قشر الأرز مع ألياف جوز الهند يعتبر بيئة واعدة للزراعة بدون تربة في الطماطم الكريزية.