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IMPACT OF ALTERNATIVE SOLID MEDIA ON YIELD AND QUALITY OF TOMATO GROWN UNDER LOW PLASTIC TUNNELS

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ABSTRACT

The objective of this work was to optimize unexpansive alternative media as growing system for tomato production. Field trials were conducted at The Experimental Farm, Faculty of Environmental Agricultural Sciences, Arish University, North Sinai Governorate, Egypt under low plastic tunnels during winter growing seasons of 2017/2018 and 2018/2019. This study included sixteen treatments, five substrate media, *i.e.*, sand, sawdust, pressed olive cake, crashed wheat straw and vegetative green waste compost and their combinations at a ratio of 1:1 V/V (volume: volume) as well as coco peat as a control medium. Results showed that among different growing media early yield increased with pressed olive cake + wheat straw medium in both seasons. While, marketable yield/plant and total yield (ton/fed) recorded the highest values with pressed olive cake +green waste compost medium in both seasons without significant differences than pressed olive cake medium in the second season. Pressed olive cake +green waste compost, sand, wheat straw, sand + sawdust medium were the superior treatments which recorded the highest value of fruit vitamin C content in the first season (28.0 mg / 100 gm). Meanwhile, pressed olive cake + green waste compost and sand + wheat straw medium recorded the highest value (27.3 mg/100gm) in the second season. In contrast, fruit shape increased with pressed olive cake + wheat straw medium in the first season, and with sand medium in the second season.

INTRODUCTION

In recent years, some problems in soil culture such as salinity, unsuitable soil characteristics and limitation of water resources in many countries, causes the expansion of soilless culture. Soilless culture is an artificial means of providing plants with support and a reservoir for nutrients and water **(Ghehsareh *et al*., 2011).**

Maboko *et al*. (2009) reported that, in Africa, the majority of tomato producers are still practicing open field production, while soilless cultivation in a protected environment has gained popularity due to improvement in yield and quality. In addition, almost all open field vegetable production is seasonal. Also, **Maboko and Du-Plooy (2014)** reported that, in Africa, with its diverse climatic conditions and soil types, growing plants in soil is unpredictable, with a range of challenges, such as changing temperatures, moisture holding capacity, available nutrient supply, poor root aeration as well as diseases and pest control. Soilless production using growing media alleviates some of these problems, while giving the farmer better control over plant growth and development.

A growing interest has been shown in the reutilization of organic by products and waste composts for agricultural use and this is the primary issue for sustainable waste

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management **(Baziramakenga *et al*. 2001).** Wastes can be turned in a different direction from landfills and can be used as substrate materials for plant production in nurseries, field, and greenhouse crops, replacing or reducing dependency on peat moss **(Bugbee, 2002).** Several studies reported the favorable effect of organic materials on plant growth **(Tehranifar *et al*. 2007; Tzortzakis and Economakis, 2008).**

The aim of this study was to identify some local alternative solid substrate media suitable for tomato production. So, the objective of this study was to contribute scientific knowledge on the utilization of some organic media such as sawdust, wheat straw, green waste compost, and pressed olive cake as growing media in tomato production. It also outlines the effect of using substrate media on the yield and quality of grown tomatoes.

MATERIALS AND METHODS

Experiments were carried out using low plastic tunnels during winter growing seasons of 2017/2018 and 2018/2019 at the Experimental Farm of Environmental Agricultural Sciences, Arish University, North Sinai Governorate, Egypt. The aim of this study was to evaluate different alternative solid media for tomato (Hybrid Firmont F_1) production to investigate the suitable growing and inexpensive medium for quantity and quality of tomato yield under low plastic tunnels. Different growing media were used as following: 1) coco peat growing medium as control treatment, 2) five media of sand, sawdust, pressed olive cake, wheat straw, and vegetable green waste as well as mixtures of these media at a ratio of 1:1 (V/V) for all possible mixtures of each two medium. The experiment designed in Randomized Complete Design (RCD) in three replications. Tomato seeds were sown in speeding trays on 23th October and transplanted 45 days later. Plants were transplanted in black plastic bags of 35 L size (100×25 cm dimensions) that were appropriate for two tomato plants. Drip irrigation system was used, each plot had one dripper line. The distance between plants in the same line was 50 cm. Plot area was 18 m^2 (15 m length and 1.2 m wide) planting density was 1.66 plants per m^2. The normal agricultural practices were carried out as commonly followed in El-Arish region. The chemical analyses of the irrigation water are presented in Table 1.

Compost Production

The media of sand, sawdust, pressed olive cakes, wheat straw and vegetative green waste compost and their combinations were composted for three months before using aiming to complete the analysis to make C/N ratio between 1:20, where, media were mixed with recommended quantities of chicken manure; composting process took place in aerated piles. Piles were mechanically turned in accordance with temperature evolution, and water was added to maintain moisture content near 60%. Chemical characters of all media are presented in Table 2.

Data Recorded

Chemical properties of substrate media

Moisture content (MC)

Each medium was dried at 105° C until constant weight then percentage of moisture content was estimated.

The Electrical conductivity (EC) and pH

They were determined in a water extract (growing media sample: distilled water, 1:10 by weight/ volume); shaken for 15 min and left for 60 min, filtered, and the measurements were made using pH meter and EC meter, respectively.

Table 1. Chemical analyses of irrigation water

pH	EC	Soluble ions (meq l^{-1})						
		Cations				Anions		
	(ppm)	K^+	Na^+	Mg^{++}	Ca^{++}	Cl^-	HCO_3^-	CO_3^{--}
7.2	5170	21	44	25	10	95	5	--

Table 2. Some chemical properties of studied media after composting

	Organic Matter	Organic C	Moisture Content	EC	pH	N	P	C/N ratio
		(%)		(dS/m)		(%)		
Coco peat (control)	65.2	34.3	38.3	6.2	6.8	1.5	0.17	22.9
Sand	3.6	1.9	31.9	4.3	7.0	1.1	0.15	1.7
Sawdust	85.8	45.1	36.7	6.1	7.3	1.9	0.10	23.7
Wheat straw	52.2	27.5	40.0	7.8	7.3	1.9	0.49	14.5
Green waste compost	39.6	20.8	15.9	6.0	7.1	1.9	0.47	10.9
Olive cake	82.8	43.6	32.4	7.2	7.0	3.9	0.85	11.2
Sand + sawdust	19.3	10.2	18.6	3.7	7.1	3.2	0.18	3.2
Sand + wheat straw	4.1	2.2	25.0	6.2	7.4	2.3	0.10	1.0
Sand + green waste compost	6.8	3.6	14.1	4.2	7.3	1.3	0.06	2.8
Sand + olive cake	16.7	8.8	15.9	5.5	7.3	2.0	0.13	4.4
Sawdust + wheat straw	53.7	28.3	32.4	3.3	7.41	1.3	0.19	21.8
Sawdust +green waste compost	51.6	27.2	23.3	5.0	7.2	1.9	0.46	14.3
Sawdust + pressed olive cake	82.2	43.2	28.9	3.7	7.6	2.3	0.37	18.8
Wheat straw + green waste compost	22.9	12.1	17.5	6.5	7.2	2.5	0.21	4.8
Wheat straw + olive cake	76.1	40.0	31.2	6.6	7.5	3.1	0.54	12.9
Green waste compost + olive cake	54.2	28.5	18.0	4.7	7.3	2.6	0.56	11.0

Organic matter content (%)

It was determined after ashing in an oven at 550°C, and the organic C was calculated (TOC=OM/1.9) as described by **Nelson and Sommers (1996)**.

Nitrogen content (%)

Was determined according to the method described by **Bremner and Mulvaney (1982)**.

Phosphorus content (%)

It was calorimetrically determined using the Spectrophotometer (Model 6300 and 6100 Jenway Co.) according to **Olsen and Sommers (1982)**.

Yield and its components

Tomato fruits were harvested at proper marketable stage (Red stage) and the following data were recorded:

Early yield

It was calculated from the first three pickings and divided for two grades as follows:

a. Grade A fruits: fruits weighed more than 70 g.

b. Grade B fruits: fruits weighed < 70 g.

In all grades, number and weight of fruits / plant was recorded.

c. Total early yield/plant was calculated from the two grades.

Total yield

Fruits of all pickings were counted, weighed, and the following data were calculated:

a. Number and weight/plant of marketable yield.

b. Number and weight/plant of unmarketable yield.

c. Total yield were recorded as (kg/plot) and lastly ton/fed. Was calculated.

Fruit Physical Measurements

Shape index

Fruit dimensions of tomato fruits were determined and fruit shape index was calculated as follow:

Shape index = Greatest equatorial diameter (cm) / polar diameter (cm).

The shape index is

1= Spherical fruits. 1 < Elongated fruits. 1 > Oblate fruits.

Fruit firmness

Manual penetrometer (Model St 207) was used to determine fruit firmness (kg/ cm^2).

Some fruit chemical properties

Total soluble solids (TSS%) content was determined by an Abbe hand refractometer with a scale of 0~32% was used in this respect.

Fruit vitamin Ccontent (Ascorbic acid)

It was determined by using titrimetric method with the titration of filtrate against 2, 6-dichlorophenolindophenol and the values of vitamin C content were expressed as mg/ 100 g of fruit fresh weight as described in **AOAC (1990)**.

Fruit pH

It was measured in tomato juice using pH meter

Statistical Analysis

The obtained data were subjected to statistical analysis of variance according to **Snedecor and Cochran (1980)**, and means separation was done according to **Duncan (1955).**

RESULTS AND DISCUSSION

Rustles presented in Tables 3 and 4 show significant differences among treatments on early yield, marketable yield / plant, unmarketable yield/plant and total yield (ton/fed.) of tomato plant in both seasons.

Table 3. Effect of different substrate media on early yield and total yield of tomato plant in the first season (2017/2018)

Parameter	Early yield/plant						Marketable yield /plant		Unmarketable yield /plant		Total yield (ton/fed.)
	Grade A		Grade B		Total						
Treatments	No. fruits	Weight (g)	No. fruits	Weight (g)	No. fruits	Weight (g)	No. fruits	Weight (g)	No. fruits	Weight	
Coco peat (control)	2e	161.2e	10def	361.0e-h	12efg	522.3e	33gh	1561.9hi	16abc	350.7a-d	10.934hi
Sand	4cde	232.8e	15bc	581.3bcd	19cde	814.1cde	43f	2150.3fg	17ab	411.0a	15.053fg
Sawdust	3de	232.2e	8efg	299.8gh	11g	532.0e	27i	1364.7ij	4h	88.6g	9.553ij
Wheat straw	3de	247.4de	13bcd	503.8c-f	16c-g	751.3cde	45ef	2397.3def	17ab	376.0abc	16.781def
Green waste compost	8bc	542.3b-e	9def	367.1e-h	17c-g	909.5b-e	47def	2492.9c-f	10ef	321.7b-e	17.450c-f
Olive cake	9b	706.6bc	11cde	499.3def	20bcd	1205.9bc	48c-f	3023.0b	8fg	306.4c-f	21.161b
Sand + sawdust	9 b	642.5bcd	5g	223.8h	14defg	866.3b-e	38g	1880.8gh	6gh	121.9g	13.166gh
Sand + wheat straw	6b-e	496.2b-e	20a	819.0a	26ab	1315.2b	50cde	2687.5bcd	10ef	252.7ef	18.813bcd
Sand + green waste compost	9b	730.0b	7fg	322.5gh	16c-g	1052.5bcd	23i	1180.0j	5h	130.6g	8.260j
Sand + olive cake	4cde	355.7b-e	11def	418.6d-g	15c-g	774.4cde	52bcd	2617.5cde	14cd	358.6abc	18.323cde
Sawdust + wheat straw	6b-e	395b-e	7efg	309.5gh	13efg	704.5de	47def	2435.6c-f	11de	317.0b-e	17.049c-f
Sawdust green waste compost	5b-e	322.6cde	7fg	344.5fgh	12fg	667.1de	32h	1672.1hi	9ef	225.1f	11.705hi
Sawdust + pressed olive cake	5b-e	377.2b-e	17ab	677.1abc	22bc	1054.4bcd	46ef	2328.8ef	10ef	266.0def	16.302ef
Wheat straw + green waste compost	5b-e	393.0b-e	13bcd	525.1cde	18c-f	918.2b-e	53bc	2752.1bc	18a	395.8ab	19.265bc
Wheat straw + olive cake	13a	1142.4a	15bc	731.1ab	28a	1873.5a	56ab	2966.2b	11de	366.6abc	20.764b
Green waste compost + olive cake	8bc	533.1b-e	12cd	567.3bcd	20cd	1100.5bcd	61a	3361.5a	15bc	304.5c-f	23.531a

Values having the same alphabetical letter(s) did not significantly differ at 0.05 level of probability according to Duncan's multiple range test.

Table 4. Effect of different substrate media on early yield and total yield of tomato plant in the second season (2018/2019)

Parameter	Early yield/plant						marketable yield /plant		unmarketable yield /plant		Total yield (ton/fed.)
	Grade A		Grade B		Total						
Treatments	No. fruits	Weight (g)	No. fruits	Weight (g)	No. fruits	Weight (g)	No. fruits	Weight (g)	No. fruits	Weight (g)	
Coco peat (control)	3f	255.4g	13cd	547.0efg	16ef	802.4de	25hi	1184.5fg	16abc	341.5ab	8.3fg
Sand	5def	389.9efg	16bc	625.1cde	21cd	1015.0cd	37efg	1710.6d-g	17ab	409.1a	11.9d-g
Sawdust	3f	233.4g	10de	424.8gh	13fg	658.3e	19.1i	1048.1g	4.8h	103.3d	7.4g
Wheat straw	4f	303.0fg	8ef	344.1hi	12fg	647.3e	45.1c-f	2396.9cd	17.4ab	181.5cd	16.8cd
Green waste compost	8abc	558.6cde	10de	452.8fgh	18de	1011.5cd	44.6c-f	2491.3c	10.9ef	258.0bc	17.4c
Pressed olive cakes	4ef	274.4g	12d	482.4e-h	16ef	756.9de	58.5a	3190.3ab	14.3cd	400.0a	22.3ab
Sand + sawdust	8abc	587.5d	13cd	605.7def	21cd	1193.2bc	38d-g	1951.1cde	6gh	75.8d	13.7cde
Sand + wheat straw	8abc	670.4bcd	18ab	771.2abc	26ab	1441.6ab	50abc	2643.3bc	10ef	294.8abc	18.5bc
Sand + green waste compost	5def	345.3fg	5f	243.7i	10g	589.1e	29ghi	1506.6efg	5h	240.0bc	10.5efg
Sand + pressed olive cake	10a	900.7a	11de	489.3e-h	21cd	1390.1ab	45c-f	2611.9bc	8fg	113.3d	18.3bc
Sawdust + wheat straw	9ab	691.6bc	14cd	528.3efg	23bc	1219.9bc	37d-g	1942.1cde	11de	245.1bc	13.6cde
Sawdust + green waste compost	4ef	327.1fg	8ef	357.1hi	12fg	684.2e	34fgh	1748.3def	9ef	328.8ab	12.8def
Sawdust + pressed olive cake	6cde	494.4def	17ab	721.5bcd	23bc	1215.9bc	46cde	2278.6cd	10ef	241.5bc	15.9cd
Wheat straw + green waste compost	9ab	717.6abc	17ab	706.4cd	26ab	1424.1ab	47bcde	2365.8cd	18a	280.1bc	16.6cd
Wheat straw + pressed olive cake	10a	798.3ab	17ab	861.9ab	27a	1660.4a	48a-d	2534.6bc	15bc	269.5bc	17.7bc
Green waste compost + pressed olive cake	9ab	715.1abc	20a	875.5a	29a	1590.6a	57ab	3361.0a	11de	271.3bc	23.5a

Values having the same alphabetical letter(s) did not significantly differ at 0.05 level of probability according to Duncan's multiple range test.

Early yield increased with pressed olive cake+ wheat straw medium in both seasons. Marketable yield/plant and total yield (ton/fed) recorded the highest values with pressed olive cake +green waste compost medium in both seasons without significant differences than pressed olive cake medium in the second season. Concerning unmarketable yield/plant, the highest values were recorded with sand medium in both seasons.

These results may be due to that physical and chemical properties of different media differ in their abilities for providing plants with nutrients and aeration (Table 2). Also, results are in agreement with those of **Tzortzakis and Economakis (2008)** who studied the performance and suitability of different substrates for the soilless culture of tomato plants and found that the addition of maize in perlite and pumice could improve inorganic substrates properties for tomato soilless culture, leading to higher yields and better fruit quality. In the same trend, **Bustamante *et al*. (2008)** and **Tittarelli *et al*. (2009)** reported that the higher nutrients content of compost and the potential presence of hormone-like compounds with growth promoting reflected on good growth and productivity.

Results in Table 5 show the effect of different substrate media on tomato fruit quality in both seasons. Pressed olive cake +green waste compost, sand, wheat straw, sand + sawdust medium were the superior treatments which recorded the highest value of fruit vitamin C content in the first season (28.0 mg / 100 gm). Meanwhile, olive cake + green waste compost and sand + wheat straw medium recorded the highest value (27.3 mg/100gm) in the second season. Coco peat medium recorded the highest value of fruit pH in the first season, while, the pH of tomato fruit was not significantly differed in the second season, which is in accordance with **Islam *et al.* (2002) and Tzortzakis and Economakis (2008)** who found that the pH of the tomato fruit juice was not significantly different in tomato cultivation with different substrates.

Fruit TSS % content recorded the highest value with green waste compost + sand medium in the first season, while in the second season no significant differences among treatments were observed. Results are in agreement with **Tzortzakis and Economakis (2008)** who found that TSS% content of the fruits was inversely related to the total fruit yield per plant; the higher the yield, the lower the TSS%. In accordance with the present study, **Islam *et al*. (2002)** recorded no differences between organic and inorganic substrates in TSS% of tomato fruit juice.

Fruit firmness was approximately superior with application of sand medium and significantly exceeded the remaining treatments in the first season, while sand, green waste compost and sand + green waste compost showed the highest fruit firmness value in the second season. However, fruit shape recorded highest values with pressed olive cake + wheat straw medium in the first season, while with sand medium in the second season.

Conclusion

This study introduced suitable growing and inexpensive local media for tomato soilless solid media cultivation under low plastic tunnels in El-Arish area and similar conditions. Total early yield increased with pressed olive cake + wheat straw medium in both seasons. While, total marketable yield/plant and total yield (ton/fed) recorded the highest values with pressed olive cake +green waste compost medium in both seasons compared with the control treatment. Also, some fruit characteristics were improved with these local alternative solid substrate media used.

Table 5. Effect of different substrate media on tomato fruit quality in both seasons

Parameter / Treatments	Vit. C (mg/ 100gm)	Fruit pH	Fruit TSS (%)	Fruit firmness (kg/cm2)	Fruit shape[z] (L/D)	Vit. C (mg/ 100gm)	Fruit pH	Fruit TSS (%)	Fruit firmness (kg/cm^2)	Fruit shape[z] (L/D)
	First season (2017/2018)					Second season (2018/2019)				
coco peat (control)	26.6ab	4.5a	5.2ab	1.6def	1.27ab	23.8abc	4.7a	4.7a	1.6e	1.31a
Sand	28.0a	4.3ab	5.3a	2.0a	0.92b	25.2abc	4.7a	5.2a	2.0a	1.32a
Sawdust	21.9de	4.4ab	5.0 ab	1.7cdE	1.27ab	22.4c	4.6a	4.5a	1.8bc	1.31a
wheat straw	28.0a	4.3ab	5.1 ab	1.5g	1.26ab	22.4c	4.7a	4.6a	1.5f	1.28abc
green waste compost	25.9abc	4.4ab	5.2ab	1.5fg	1.17ab	25.9abc	4.7a	4.7a	2.0a	1.19abc
olive cakes	22.8de	4.4ab	4.6b	1.8b	1.21ab	25.2abc	4.7a	4.5a	1.4f	1.21abc
sand + sawdust	28.0a	4.2b	5.3a	1.1i	1.25ab	22.4bc	4.5a	4.6a	1.0g	1.22abc
sand + wheat straw	25.9abc	4.3ab	4.9ab	1.1i	1.23ab	27.3a	4.5a	4.4a	1.0g	1.23abc
sand + green waste compost	21.7de	4.3ab	5.5a	1.8b	1.16ab	23.1bc	4.8a	4.7a	2.0a	1.18abc
sand + olive cakes	26.3ab	4.2b	5.1ab	1.6def	1.26ab	26.6ab	4.7a	4.6a	1.9ab	1.24abc
sawdust + wheat straw	24.0bcd	4.3ab	4.9ab	1.3h	1.18ab	24.5abc	4.8a	4.4a	1.6de	1.15bc
sawdust green waste compost	22.1de	4.2b	5.1ab	1.6fg	1.19ab	17.5d	4.5a	4.6a	1.6de	1.21abc
sawdust + olive cakes	23.1de	4.3ab	5.4a	1.5g	1.17ab	25.9abc	4.7a	4.5a	1.6de	1.15c
wheat straw + green waste compost	21.0e	4.4ab	5.4a	1.7bcd	1.28ab	21.7c	4.7a	4.9a	1.6de	1.30ab
wheat straw + olive cakes	23.5cde	4.2b	5.1ab	1.7cdE	1.30a	25.9abc	4.6a	4.6a	1.8bc	1.31a
green waste compost + olive cakes	28.0a	4.3ab	5.0ab	1.8bc	1.13b	27.3a	4.6a	4.8a	1.7cd	1.15c

Values having the same alphabetical letter(s) did not significantly differ at 0.05 level of probability according to Duncan's multiple range test.

Z= Shape index = Greatest equatorial diameter (cm) / polar diameter (cm), where:

The shape index 1= Spherical fruits, 1 < Elongated fruits, and 1 > Oblate fruits.

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الملخص العربي

تأثير بيئات بديلة للتربة على المحصول وجودته للطماطم النامية تحت الأنفاق البلاستيكية المنخفضة

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الهدف من هذه لدراسة هو التوصل إلى نظام مثالي للزراعة لإنتاج الطماطم باستخدام بيئات زراعية صلبة بديلة غير مكلفة. تم تنفيذ تجارب حقلية في المزرعة البحثية بكلية العلوم الزراعية البيئية، جامعة العريش، بمحافظه شمال سيناء، مصر تحت الأنفاق البلاستيكية المنخفضة خلال الموسمين الزراعيين الشتويين 2018/2017 و2019/2018. اشتملت هذه الدراسة على ستة عشر معاملة عبارة عن خمس بيئات نمو صلبة (الرمل، ونشارة الخشب، والمخلفات الصلبة لعصر الزيتون (تفلة الزيتون)، وتبن القمح، وكمبوست المخلفات النباتية الطازجة)، وجميع التوليفات الثنائية الممكنة بينها بنسبة 1: 1 (حجم/حجم) بالإضافة إلى معاملة المقارنة وهي بيئة بيت جوز الهند. أوضحت النتائج أنه من بين بيئات الزراعة المختلفة زاد المحصول المبكر الكلي مع استخدام بيئة تفلة الزيتون + تبن القمح في الموسمين. أما المحصول الكلي/نبات والقابل للتسويق، والمحصول الكلي (طن/فدان) فقد تحققا مع استخدام بيئة تفلة الزيتون + المخلفات الزراعية الطازجة في كلا الموسمين، وبدون اختلافات معنوية عن استخدام بيئة تفلة الزيتون في الموسم الثاني. كانت أعلى القيم لمحتوى الثمرة من فيتامين ج فى الموسم الأول مع استخدام كلا من بيئة تفلة الزيتون+ المخلفات الزراعية الطازجة، الرمل، تبن القمح، مخلوط الرمل + نشارة الخشب. بينما في الموسم الثاني كان أعلى محتوى للثمار من فيتامين ج كان مع بيئات تفلة الزيتون +المخلفات الزراعية الطازجة وبيئة الرمل + تبن القمح أما بالنسبة لقيم شكل الثمرة فقد ازدادت مع استخدام بيئة تفلة الزيتون + تبن القمح في أول موسم ومع بيئة الرمل في ثاني موسم.

الكلمات الاسترشادية: بيئات النمو، نشارة الخشب؛ تبن القمح؛ كمبوست المخلفات الزراعية الطازجة، محصول الطماطم

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