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EFFECT OF SOIL ORGANIC ADDITIVES ON GROWTH AND YIELD OF TOMATO UNDER EL-ARISH REGION CONDITIONS

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ABSTRACT

Field experiments were carried out in summer season of 2017 and 2018 at the Experimental Farm, Faculty of Environmental Agricultural Sciences, Arish University, North Sinai, Egypt. This study aimed to study the effect of some soil organic additives (without application, application of biochar of citrus pruned branches alone at a rate of 4 ton fed $^{-1}$, application of crashed wheat straw mulch at a rate of 1.25 ton fed $^{-1}$, and application of biochar + crashed wheat straw mulch both at a ratio of 1:1(in weight basis) from their previous doses per fed. on growth and yield of tomato crop. Seeds of "GS_{12} F_1" hybrid were used and seedlings were transplanted on 23rd April. Plants were irrigated using drip irrigation system; the plot area was 14.4 m^2 (12 m length and 1.2 m width), the distance between the plants in the same row was 50 cm; planting density was 1.67 plant/m^2. Treatments were randomly distributed in a randomized complete block design in three replications. Results cleared that soil organic additives resulted in gradually reduction in soil pH and EC during all periods of plant growth, with recording the lowest values in the late period. Also, the application of biochar + crashed wheat straw mulch followed by biochar alone recorded the lowest values in both seasons. The highest values of soil cation exchange capacity (CEC), soil cations and anions, and the lowest soil osmotic pressure were recorded with application of biochar + crashed wheat straw mulch followed by biochar alone in both seasons. Also, results indicated that the highest values of all studied vegetative growth traits, fresh and dry weight traits, and content photosynthetic pigments; viz, chlorophyll a, chlorophyll b, and carotenoids were recorded with application of biochar + crashed wheat straw mulch followed by application of biochar alone. The highest value for each of grade a, grade b, and total marketable tomato fruit yield per fed. were recorded with the application of Biochar + crashed wheat straw mulch followed by application of biochar alone in both seasons. On the other hand, the highest unmarketable yield was recorded with the control treatment (without organic additives) in both seasons, while the lowest values were recorded with application of biochar + crashed wheat straw mulch followed by application of biochar alone. Also, significant effects for organic additives were recorded for most studied fruit quality traits in both seasons.

KEYWORDS: Biochar, wheat straw, mulch, tomato, organic additives

1. I NTRODUCTION

Arish soil is in general characterized as sandy soil, which is very poor soil in mineral nutrients, has low moisture holding capacity, has single grain structure, susceptibility to erosion as well as low levels of organic matter content and microorganisms. Many studies investigated how to solve these problems. The application of organic materials to sandy soil was used to enhance soil physical and chemical properties. Increased attention of biochar (BC) as soil amendment was due to its role as a soil amendment in saving nutrient from leaching and water-use efficiencies as reported by Singh *et al.* (2010) and Barrow (2012). The positive effects of amending the soil with BC include increased crop productivity and improve soil structure as reported by Liu *et al.* (2014) and Jeffery *et al.* (2015), mainly through improved quality, infiltration, and water holding capacity of soil (Mukherjee *et al.*, 2014). Also, Novak *et al.* (2016) reported that biochar can does immobilize and remove soil and water contaminants.

The large internal surface area of BC expands the organic and inorganic compound adsorption capability of soil, such that the supply of mineral nutrients and energy to microbes is increased (Lehmann *et al*., 2011; Gul *et al*., 2015). Mukherjee and Lal (2013) found that addition of BC increased great surface area of amended soil, also, can favor microbial communities and overall soil sorption capacities. In addition, they found that the high internal surface area of BC improves water retention directly and soil structure indirectly). In this direction, Mukherjee *et al.* (2014) reported that the sandy soil amended with adding BC which has higher water holding capacities than do loamy and clay soils, while increased soil aeration is mainly observed in fine-textured soil. Also, Chia *et al.* (2015) reported that soil amended with biochar increased plant water availability, nutrient retention capacity, root diffusion, and aeration So, improved soil physical properties (structure, surface area, porosity, bulk density, and water holding capacity). In addition, Schmalenberger and Fox (2016) and Subedi *et a*l. (016) reported that biochar amendment can positively modify the physical, chemical, and biological properties of soil.

Ippolito *et al.* *et al.* (2012) and Mukome *et al.* (2013) reported that BC-amended soils have nutrient availability associated with the physico-chemical properties of the biochar and also directly linked to nutrient availability. Deluca *et al.* (2015) and Subedi *et al.* (2016) cleared that these effects are due to the mechanisms responsible for increasing plant nutrient availability are soil pH raise (in acidic soils), nutrient retention (due to increase in cation exchange capacity and surface area) or directly release of nutrients from the BC surfaces. Also, Vaccari (2015) reported that biochar application significantly increased the soil cation exchange capacity and the availability of NH4, P and K in the soil.

Karhu et al. (2011) and Novak *et al.* (2012) reported that a biochar application rate as low as 0.4% can be sufficient to improve available water holding capacity (AWC) or water holding capacity (WHC) of amended soils. Akhtar et al. (2014) found that addition of biochar increased the soil moisture contents, consequently improved physiology process, which repercussion on yield increased, and its quality of tomato as compared with the non-biochar treatment. Chia *et al.* (2015) reported that soil amended with biochar increased plant water availability, nutrient retention capacity, root diffusion, and aeration So, improved soil physical properties (structure, surface area, porosity, bulk density, and water holding capacity).

Soil amended with BC is expected to increase crop productivity by enhancing the supply of nutrients and by increasing the activity of soil microorganisms responsible for mobilizing soil nutrients and making them more available to crops (Camps-Arbestain *et al*., 2014; Lehmann *et al*., 2011 and 2015; Liu *et al*., 2013; Schmalenberger and Fox, 2016). Yilanga *et al.* (2014) studied the effect of BC and crop veil on the growth of tomato (*Lycopersicum esculentum* Mill.), they found that stem was significantly higher in tomatoe plants grown in a soil treated with biochar and covered with veil than traditional beds without biochar and veil covering. Also, they found that tomato fruit yield was significantly higher on beds with BC treatment than beds without BC.

Gandhi and Bains (2006) reported that mulches moderate hydrothermal regime of the soil and modify the microclimate by modifying soil temperature. Ojeniyi *et al.* (2007) found that cocoa husk mulch increased tomato fruits weight per plant compared to the control. Many researchers (Awal and Khan 2000; Samaila *et al.*, 2011; Sinkevičienė *et al.,* 2009) concluded that, soil mulching with organic material is one method of soil water protection and also helps maintain a constant soil temperature within the root system of plant. This is very important, because mulch, by maintaining proper moisture and decreasing soil warming in summer months as well as reducing daily temperature fluctuations, and improves soil conditions for plant growth and its development.

Bajorienė *et al.* (2013) reported that natural organic mulch eventually breaks down and adds organic material to the soil. The increase of the amount of soil organic carbon (SOC) is regarded as the main advantage of organic mulches. Kosterna (2014) indicated that by maintaining proper moisture and reducing daily temperature fluctuations, mulching improves soil conditions for plant growth and development, resulting in a positive effect on the tomato yield and found that the application of covers resulted in higher aboveground parts of plants and higher leaf area compared to cultivation without covers. Irrespective of whether a covering was used, all of the types of straw investigated in the experiment caused the acceleration of growth and development of tomato plants.

Moursy *et al.* (2015) reported that straw mulch affected soil temperature to make it higher during the colder seasons and lower during the warmer seasons when compared with the bare soil. In addition, Talaat *et al*., (2015) found that the actual temperatures of soil gradually decreased with soil studied depths, while the soil moisture contents increased with soil studied depths. The total heat content (soil heat + water heat) Cal/g soil increased with the studied soil depths. Soil mulching with organic material is one method of soil water protection and also helps maintain a constant soil temperature within the root system of plant. Additionally.

Davari (2016) concluded that mulching is the process of covering the soil surface around the plants with any material applied to the soil surface for protection or improvement of the covered area. Organic mulches have the advantage of being biodegradable, but decomposition may result in a temporary reduction in soil mineral nitrogen. Mulch regulate the temperature of soil by reducing the daily range and creating a more constant temperature suitable for root activity. The ability of organic mulches to regulate the soil temperature is closely correlated with its ability to reduce evaporative water loss.

So, this work aimed to study the effect of applying some soil organic mulch additives (application of biochar and crashed wheat straw) on growth and yield of tomato under El- Arish area conditions.

2. MATERIALS AND METHODS

Field experiments were carried out in summer seasons of 2017 and 2018 at the Experimental Farm, Faculty of Environmental Agricultural Sciences, Arish University, North Sinai, Egypt. This work aimed to study the effect of some soil organic additives (without application, application of biochar alone at a rate of 4 ton fed $^{-1}$, application of crashed wheat straw (2-3cm pieces) mulch at a rate of 1.25 ton fed $^{-1}$, and application of biochar + crashed wheat straw (2-3cm pieces) mulch both at a ratio of 1:1 [in weight basis] from their previous doses per fed) on growth and yield of tomato crop. Biochar was obtained using citrus pruned branches. Seeds of "Gs_{12} F_1" hybrid were sown in plastic seedling trays on 14^{th} March and transplanting was carried out on the 23^{rd} April. Plants were irrigated using drip irrigation system; the distance between the plants in the same row was 50 cm, while the distance between dripper lines centers was 1.2 m. The plot area was 14.4 m^2 (12 m length and 1.2 m width), planting density was 1.67 plant/m^2.

Chemical analyses of irrigation water as well as initial physical and chemical analyses of experimental soil are shown in Tables 1 and 2. Soil parameters determined before conducting the experiments were particle size distribution (Pipper, 1947), total carbonate (titrimetrically using H_2SO_4 and phenolphthalein and methyl orange as indicator), and soil pH value was determined in 1: 2.5 soil water suspension. The soil water extract for 1:5 soil water ratio was chemically analyzed for electrical conductivity (EC) (Jackson, 1967), soil content of anions and cations (Richard; 1954 Jackson, 1967). Biochar was mixed with soil during soil preparation, and crashed wheat straw was added on soil surface after transplanting. The ffertilization program and the traditional agricultural practices were carried out as commonly followed in El-Arish region according the recommendations of the Ministry of Agriculture and Soil Reclimation.

Data recorded were determined at 60 days after transplanting as follows: 1) vegetative growth traits (plant height, root length, number of leaves plant^{-1} and number of branches plant^{-1}), 2). Fresh and dry weight traits (root, stem and leaves), the roots were taken out of the soil by collecting root system with the surrounding soil, washed with tap water, then air dried, 3) Leaves content of photosynthetic pigments; Viz, chlorophyll a, b and carotenoids that were determined according to the method described by Moran, 1982), and 4) Fruit yield and its component as well as fruit quality. During growth period stages(three stages), soil cation exchange capacity, soil osmotic pressure and soil content of anions and cations, as well as soil reaction and electrical conductivity were determined.

Table 1. Chemical properties of irrigation water

pH	EC dSm^{-1}	Soluble ions (me l^{-1})							
		Cations				Anions			
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	CO_3^{--}	SO_4^{--}
						First season (2017)			
7.55	5.56	20.50	16.80	18.50	0.24	45.92	2.90	-	7.58
						Second season (2018)			
7.60	5.71	21.00	17.00	18.80	0.25	46.77	2.99	-	7.29

Table 2. Initial physical and chemical properties of investigated soil profile of cultivated area

	First season (2017)	**Second season (2018)**
Particles size distribution (%)		
Coarse sand (%)	58.7	59.0
Fine sand (%)	19.3	19.0
Silt (%)	12.0	12.0
Clay (%)	10.0	10.0
Soil texture	**Sandy loam**	**Sandy loam**
Bulk density (Mgm^{-1})	1662	1661
Chemical properties (Soluble ions (in 1:5 soil water extract)		
Ca^+ (mel^{-1})	3.90	3.90
Mg^+ (mel^{-1})	3.42	3.43
Na^+ (mle^{-1})	2.54	2.55
K^+ (mel^{-1})	0.34	0.32
CO_3^- (mle^{-1})	-	-
HCO_3^- (mel^{-1})	4.30	4.40
Cl^- (mel^{-1})	4.40	4.35
SO_4 (mel^{-1})	1.50	1.45
EC ($dSml^{-1}$)	1.7	1.7
pH (in1:2.5 Soil water suspension extract)	8.10	8.13
Organic matter (%)	0.153	0.171
$CaCO_3$ (%)	22.43	22.48

Treatments were randomly distributed in a randomized complete blocks design in three replications. 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). M. Stat C programmer was used for analysis (MSTAT, 1989).

3. RESULTS AND DISCUSSION

3.1. Effect of organic additives on Soil chemical properties

3.1.1. Soil reaction and electrical conductivity

Data in Table 3 show that soil organic additives resulted in gradually reduction in soil pH and EC during periods of plant growth, where the lowest values were recorded in the late period. Application of biochar + crashed wheat straw mulch followed by biochar alone recorded the lowest values in both seasons. These results may be due to the effects of biochar which enhanced soil physical and chemical properties and crashed wheat straw mulch that enhanced the conditions of the rhizosphere area as mentioned by Camps-Arbestain *et al.* (2014), Lehmann *et al*. (2015), Schmalenberger and Fox (2016)). In this direction, these results are due to the effect of soil organic additives where, biochar enhances the supply of nutrients and increases the activity of soil microorganisms responsible for mobilizing soil nutrients and making them more available to crops as reported by Camps-Arbestain *et al.* (2014), Lehmann *et al*. (2015), Schmalenberger and Fox (2016). On the other hand, Soil surface mulching with organic wheat mulch may reduce the amount of water that evaporates from soil, and improves the quality of soil throw allowing better water and air movement. Also, mulch provides nutrients to sandy soil and improves its ability to hold water, acts as an insulating layer on top of soil, keeping it cooler in the summer. These explanations are in agreement with Kosterna (2014), Moursy *et al*. (2015) and Davari (2016)

3.1. 2. Soil cation exchange capacity and osmotic pressure

Data in Table 4 show that the highest cation exchange capacity (CEC) values and lowest osmotic pressure were recorded with application of biochar + crashed wheat straw mulch followed by biochar alone in both seasons. These results may be due to the effects of biochar which enhanced soil physical and chemical properties besides the effect of mulching soil with crashed wheat that regulate the temperature of soil by reducing the daily range and creating a more constant temperature suitable for root activity as mentioned by Davari (2016)). Also, the ability of organic mulches to regulate the soil

Table 3: Effect of soil organic additives on soil reaction (pH) and electrical conductivity during growth stages of tomato plants

Parameter / Organic additives	Vegetative growth		Flowering stage		Mature stage	
	pH	EC (dSml^{-1})	pH	EC (dSml^{-1})	pH	EC (dSml^{-1})
			Second season (2017)			
Control	8.1	1.7	8.1	1.9	8.1	1.7
Biochar	8.0	1.5	8.0	1.4	8.0	1.5
Mulch	8.0	1.6	8.0	1.5	8.0	1.6
Biochar + mulch	7.9	1.4	8.0	1.4	7.9	1.4
			Second season (2018)			
Control	8.3	1.7	8.1	1.8	8.1	1.8
Biochar	8.0	1.6	8.0	1.4	8.0	1.5
Mulch	8.0	1.5	8.1	1.5	8.0	1.6
Biochar + mulch	7.9	1.4	8.0	1.4	7.9	1.4

Table 4: Effect of soil organic additives on soil cation exchange capacity and osmotic pressure.

Parameter / Organic additives	Vegetative growth		Flowering stage		Maturity stage	
	CEC (Mg g^{-1})	Osmotic pressure	CEC (Mg g^{-1})	Osmotic pressure	CEC (Mg g^{-1})	Osmotic pressure
			Second season (2017)			
Control	3.4	0.61	3.6	0.58	4.3	0.54
Biochar	3.9	0.54	4.1	0.50	4.9	0.50
Mulch	3.6	0.54	3.9	0.54	4.5	0.54
Biochar + mulch	4.1	0.47	4.3	0.50	5.5	0.50
			Second season (2018)			
Control	3.6	0.58	3.9	0.54	4.5	0.58
Biochar	4.1	0.50	4.3	0.50	5.1	0.50
Mulch	3.7	0.54	3.9	0.54	4.8	0.54
Biochar + mulch	4.2	0.47	4.5	0.50	5.7	0.50

temperature is closely correlated with its ability to reduce evaporative water loss as reported by Davari (2016). In addition, these results are in agreement with those of Vaccari (2015) who reported that biochar application significantly increased the soil cation exchange capacity.

3.1.3. Soil content of anions and cations during growth period

Data in Table 5 show that all cations and anions increased with application of soil organic additives in all periods of growth. Application of biochar + crashed wheat straw mulch followed by biochar alone in both seasons. These results may be due to the effects of biochar which enhanced soil physical and chemical properties and wheat straw mulch that enhanced the conditions of the rhizosphere area. as reported by Lehmann *et al*. (2015), Schmalenberger and Fox (2016).

These results are in agreement with the findings of Akhtar *et al*. (2014), who found that addition of biochar increased the soil moisture contents, consequently improved physiology process, which repercussion on yield increased, and its quality of tomato as compared with the non-biochar treatment. Also, Deluca *et al.* (2015) and Subedi *et al.* (2016) reported that the effects of biochar are due to the mechanisms responsible for increasing plant nutrient availability are soil pH raise (in acidic soils), nutrient retention (due to increase in cation exchange capacity and surface area) or directly release of nutrients from the BC surfaces. In addition, Vaccari (2015) reported that biochar application significantly increased the soil cation exchange capacity and the availability of NH4, P and K in the soil.

3.2. Vegetative growth

Data in Table 6 show significant effects for the organic additive treatments on all studied traits in both seasons. The highest records of all studied traits were obtained by application of biochar + wheat mulch followed by application of biochar alone, where the lowest values were recoded with the control treatment (without application organic additives) in both seasons.

Table 5: Effect of soil organic additives on soil anions and cations in growth stages of tomato Plants.

A. Vegetative growth stage:

Parameter / Organic additives	Cations (mel^{-1})				Anions (mel^{-1})			
	Ca^{+}	Mg^{+}	Na^{+}	K^{+}	CO_3^{-}	HCO_3^{-}	Cl^{-}	SO_4
				Second season (2017)				
Control	3.75	3.50	2.65	0.35	-	4.33	4.42	1.50
Biochar	3.80	3.80	2.65	0.37	-	4.40	4.61	1.61
Mulch	3.79	3.70	2.60	0.36	-	4.37	4.55	1.53
Biochar + Mulch	3.90	3.82	3.70	0.39	-	4.55	4.65	1.60
				Second season (2018)				
Control	3.90	3.50	2.75	0.37	-	4.50	4.42	1.60
Biochar	3.99	3. 58	2.88	0.39	-	4.66	4.52	1.66
Mulch	4.95	3.55	2.67	0.38	-	4.55	4.48	1.52
Biochar + Mulch	4.01	4.70	2.90	0.40	-	4.68	4.67	1.66

B. Flowering stage

Parameter / Organic additives	Cations (mel^{-1})				Anions (mel^{-1})			
	Ca^{+}	Mg^{+}	Na^{+}	K^{+}	CO_3^{-}	HCO_3^{-}	Cl^{-}	SO_4
				Second season (2017)				
Control	3.98	3.74	2.59	0.39	-	4.50	4.59	1.61
Biochar	4.01	3.80	2.73	0.42	-	4.63	4.62	1.69
Mulch	3.99	3.80	2.59	0.39	-	4.58	4.59	1.68
Biochar + Mulch	4.03	5.82	2.75	0.42	-	4.66	4.67	1.69
				Second season (2018)				
Control	3.99	3.76	2.60	0.39	-	4.55	4.57	1.61
Biochar	4.10	3.83	2.75	0.41	-	4.70	4.69	1.70
Mulch	4.01	3.81	2.61	0.39	-	4.53	4.61	1.68
Biochar + Mulch	4.3	3.83	2.78	0.42	-	4.86	4.79	1.70

C: Maturity stage

Parameter / Organic additives	Cations (mel^{-1})				Anions (mel^{-1})			
	Ca^{+}	Mg^{+}	Na^{+}	K^{+}	CO_3^{-}	HCO_3^{-}	Cl^{-}	SO_4
				Second season (2017)				
Control	4.01	3.80	2.79	0.40	-	4.65	4.67	1.68
Biochar	4.09	3.83	2.82	0.41	-	4.73	4.72	1.70
Mulch	4.03	3.81	2.80	0.40	-	4.67	4.68	1.69
Biochar + Mulch	4.1	3.90	2.92	0.42	-	4.80	4.83	1.71
				Second season (2018)				
Control	4.03	3.81	2.78	0.40	-	4.66	4.67	1.69
Biochar	4.09	3.85	2.82	0.41	-	4.68	4.69	1.70
Mulch	4.05	3.82	2.80	0.40	-	4.76	4.72	1.69
Biochar + Mulch	4.01	3.92	2.94	0.42	-	4.85	4.82	1.71

Table 6: Effect of organic additives on vegetative growth of tomato plant at 60 days after transplanting.

Parameter / Organic additives	Fresh weight(gm)			
	Root	Stem	Leaves	Total
		Second season (2017)		
Control	30.65d	34.65d	188.92d	256.02d
Biochar	46.59b	62.49b	268.11b	384.84b
Mulch	39.41c	41.05c	211.55c	293.56c
Biochar + Mulch	72.03a	77.36a	297.16a	463.78a
		Second season (2018)		
Control	31.09d	36.41d	189.72d	257.28d
Biochar	48.98b	64.58b	289.73b	402.43b
Mulch	40.18c	42.52c	214.44c	295.12c
Biochar + Mulch	73.73a	78.31a	326.88a	476.85a

Means having the same alphabetical letter (s) are not significantly differ at 0.05 level according to Duncan's multiple range test.

It could conclude that all vegetative growth traits were enhanced due to application of amendment treatments. This may be due to that biochar as a soil additive which had an important role to enhancing nutrient- and water-use efficiencies as reported by Singh et al. (2010) and Barrow (2012). Also, our results are in the same direction of results obtained by many researchers who indicated that effects of biochar are due to the mechanisms responsible for increasing plant nutrient availability are soil pH raise (in acidic soils), nutrient retention (due to increase in cation exchange capacity and surface area) or directly release of nutrients adsorbed from the BC surfaces as reported by Mukome et al. (2013), Deluca et al, (2015), Ippolito et al. (2015) and Subedi et al. (2016).

3.3. Fresh and dry weights

Data in Tables 7 and 8 show significant effects for soil amendment treatments on fresh and dry weight of tomato plant in both seasons. The highest records of all studied traits were recorded by application of biochar + wheat mulch in both seasons followed by application of biochar alone, while the lowest records were with untreated treatment.

These results may be due to reducing soil temperature as a result of application of amendments (mulch or biochar) as reported by **Nkansah *et al.* (2003)** who indicated that organic mulches (grass straw, rice straw, rice husk and sawdust) were more effective in reducing soil temperature compared to the control. **Chakraborty *et al.* (2008)** reported that soil temperature mulched with rice straw was lower at a depth of 7 and 14 cm during all growing periods, especially during measurements in the afternoon hours**.**

3.4 Leaves content of chlorophyll and carotenoids

Data in Table 9 show significant effects for soil amendment treatments on all studied traits in both seasons, except, leaves content of chlorophyll b in the first season. The highest content of chlorophyll a, chlorophyll b and carotenoids were recorded with application of biochar + wheat straw mulch without significant differences than application of biochar alone in in both seasons. Our results are in accordance with the findings of Ashrafuzzaman et al. (2011).

Table7: Effect of organic additives on fresh weight of tomato plant at 60 days after transplanting.

Parameter / Organic additives	Plant height (cm)	Root length (cm)	Number of leaves plant^{-1}	Number of branches plant^{-1}
		Second season (2017)		
Control	58.50d	35.42d	7.16 c	4.75 d
Biochar	84.42b	48.08b	13.08 a	7.58 b
Mulch	68.00c	39.33c	8.51 b	6.25 c
Biochar + Mulch	91.08a	51.75a	14.8 a	8.83 a
		Second season (2018)		
Control	59.00d	36.67d	8.41d	5.91c
Biochar	85.50b	49.33a	14.58b	8.88b
Mulch	66.83c	40.67c	10.25c	7.00c
Biochar + Mulch	92.58a	52.92a	16.08a	10.00a

Means having the same alphabetical letter (s) are not significantly differ at 0.05 level according to Duncan's multiple range test.

Table 8. Effect of organic additives on dry weight of tomato plant at 60 days after transplanting.

Parameter	Dry weight(gm)			
Organic additives	Root	Stem	Leaves	Total
		First season (2017)		
Control	9.04d	8.70c	18.88c	36.07c
Biochar	18.70b	17.75a	53.27b	91.71a
Mulch	11.18c	10.94c	26.60b	49.11b
Biochar + Mulch	23.51a	16.89b	51.41a	92.36a
		Second season (2018)		
Control	10.18c	9.96d	19.17d	37.09d
Biochar	19.83b	18.60a	55.25a	92.71b
Mulch	13.51c	11.12b	28.99c	51.23c
Biochar + Mulch	24.92a	17.43a	56.72a	98.53a

Means having the same alphabetical letter (s) are not significantly differ at 0.05 level according to Duncan's multiple range test.

Table 9. Effect of organic additives on chlorophyll and carotenoids content of tomato leaves at 60 days after transplanting.

Parameter / Organic additives	Chlorophyll a (mgg^{-1}FW)	Chlorophyll b (mgg^{-1}FW)	Carotenoids (mgg^{-1}FW)
		First season (2017)	
Control	3.113b	1.639c	2.132c
Biochar	4.085a	1.969ab	2.655ab
Mulch	3.367b	1.665b	2.471b
Biochar + Mulch	4.383a	2.160a	2.869a
		Second season (2018)	
Control	3.233d	1.756d	2.247c
Biochar	3.870b	1.971a	2.539a
Mulch	3.673c	1.856c	2.452b
Biochar + Mulch	4.545a	2.314a	3.016a

Means having the same alphabetical letter (s) are not significantly differ at 0.05 level according to Duncan's multiple range test.

3.5 Yield and its components

3.5.1 Marketable and unmarketable yield

Data in Table 10 show significant effects for organic additive treatments on all marketable yield and its component traits in both seasons, except number of fruits of grade a and grade b in both seasons. Application of biochar+ wheat straw mulch treatment recorded the highest values of all studied traits in both seasons followed by application of biochar alone, while, the lowest values were recorded with the control treatment (without organic additives).

Concerning unmarketable yield, data in Table 11 show significant effects for soil amendment treatments on all unmarketable yield traits in both seasons. The control treatment (without organic additives) recorded the highest unmarketable yield in both seasons.

Our results are due to that organic additives, where, BC increased crop productivity by enhancing the effect of supply nutrients and by fostering the activity of soil microorganisms responsible for mobilizing soil nutrients and making them more available to crops as reported by many researchers (Lehmann *et al*., 2011, 2015; Camps-Arbestain *et al*., 2014; Schmalenberger and Fox, 2016) In addition, Talaat *et al*., (2015) reported that tomato fruits yield parameters and nutrients contents increased with increasing rates of two mulching types, where, mulching by bituminous emulsion was superior for fruit yields and nutrients, followed by rice straw and control treatment (without organic additives).

Table 10: Effect of organic additives on marketable yield of tomato plants.

Parameter / Organic additives	Grade A fruits			Grade B fruits		Total Yield	
	Mean fruit weight (g)	No. fruits/ m^2	Weight of fruits (ton fed^{-1})	No. Fruits/ m^2	Weight of fruits (ton fed^{-1})	No. Fruits/ m^2	Weight of fruits (ton fed^{-1})
				First season (2017)			
Control	71.79d	34.33a	9.12d	17.83a	3.17d	52.16d	12.29d
Biochar	79.21b	34.67a	12.82b	17.42a	4.26b	52.09b	17.08b
Mulch	73.93c	34.67a	11.22c	17.83a	3.81c	52.50c	15.03c
Biochar + Mulch	88.93a	35.08a	13.86a	16.92a	4.98a	52.00a	18.84a
				Second Season (2018)			
Control	72.54d	35.12a	10. 27d	17.83a	3.01d	52.83d	13.28d
Biochar	78.78b	35.16a	12.48b	17.42a	4.63b	52.58b	17.11b
Mulch	74.65c	35.20a	11.62c	17.83a	3.47c	53.03c	15.09c
Biochar + Mulch	90.53a	35.25a	13.46a	17.92a	5.12a	53.23a	18.85a

Means having the same alphabetical letter (s) are not significantly differ at 0.05 level according to Duncan's multiple range test.

Table11. Effect of organic additives on un-marketable yield of tomato plants.

Parameter / Organic additives	Number of fruits/m^2	Yield/fed. (ton)	Number of fruits/m^2	Yield/fed. (ton)
	First Season (2017)		Second Season (2018)	
Control	12.76 a	1.545 a	12.78 a	1.589 a
Biochar	9.581c	1.118 c	9.511 c	1.139 c
Mulch	11.06 b	1.371b	10.97 b	1.412 b
Biochar + Mulch	8.211d	1.048 c	8.257 d	1.047 c

Means having the same alphabetical letter (s) are not significantly differ at 0.05 level according to Duncan's multiple range test.

3.5.2 Fruit quality

Data in Table 12 show significant effects for organic additives on all studied traits in both seasons, except fruit shape in the first season and pH in the second season. The highest values of all studied traits were recorded with application of biochar + wheat straw mulch treatment without significant differences than biochar treatment alone in both seasons for most traits, while the lowest values were recorded with control treatment (without soil amendment). Our results are in agreement with the findings of Iftikhar *et al.* (2011) and Dauda belel (2011) who reported that mulch recorded the maximum pepper fruit length.

Table 12: Effect of organic additives on quality of tomato fruits.

Parameter / Organic additives	Fruit Length (cm)	Fruit diameter (cm)	Fruit shape (L/D)	Pericarp thickness (mm)	Fruit TSS (%)	Vitamin. C (mg/100 g)	pH of fruits
				First season (2017)			
Control	45.60b	45.16b	1.01a	1.18b	5.91c	16.67d	4.52a
Biochar	52.25a	56.80a	0.92a	2.30a	6.25ab	20.17b	4.50a
Mulch	46.10b	47.71b	0.97a	1.97ab	6.33b	18.08c	4.58a
Biochar + Mulch	54.06a	58.44a	0.93a	2.20a	6.41a	21.58a	4.60a
				Second season (2018)			
Control	45.72b	45.66b	1.01a	1.33b	6.00b	16.00d	4.59a
Biochar	51.37a	57.14a	0.90b	2.35a	6.41b	19.50b	4.51a
Mulch	46.51b	46.02b	0.99ab	1.61b	5.91ab	17.42c	4.57a
Biochar + Mulch	52.25a	58.36a	0.90b	2.59a	6.58a	21.67a	4.57a

Means having the same alphabetical letter (s) are not significantly differ at 0.05 level according to Duncan's multiple range test.

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الملخص العربي

تأثير الإضافات العضوية للتربة علــى نمــو ومحصــول الطماطم تحت ظروف منطقة العريش

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نفذت تجربة حقلية في الموسم الصيفي لعامي ٢٠١٧، و٢٠١٨م بالمزرعة البحثية لكلية العلوم الزراعية البيئية- جامعة العريش بهدف دراسة تأثير استخدام أربع معاملات من الاضافات العضوية هى (بدون اى معاملة للتربة)، واضافة الفحم النباتى وحده (بمعدل ٤ طن للفدان)، وتغطية سطح التربة بقش القمح المجروش وحده (بمعدل ٢طن للفدان)، واضافة الفحم النباتى مع تغطية سطح التربة بقش القمح المجروش مناصفة بمعدل إضافة كل السابقة للفدان، وذلك على نمو وإنتاجية الطماطم. جرى شتل هجين الجيل الأول"حي إس ١٢" في ٢٣ أبريل في الموسمين، واستخدم نظام الري بالتنقيط، حيث كانت المسافة بين خطوط الري بالتنقيط ١.٢متراً، وبين النباتات في نفس الخط ٥٠سم، وكانت مساحة الوحدة التجريبية ١٤.٤م^{٢} (١٢م طول×١.٢م عرض)، وبذا فإن الكثافة النباتية كانت ١.٦٧نبات/م^{٢}. دلت النتائج على أنه نتج عن الإضافات العضوية للتربة نقص تدريجي في قيم تفاعل التربة ودرجة التوصيل الكهربي لها خلال كل مراحل نمو النبات، حيث تم تسجيل أقل القيم في المرحلة الأخيرة من مراحل النمو، وكانت افضل القيم مع معاملة إضافة الفحم النباتي + تبن القمح المجروش تلاها معاملة إضافة الفحم النباتي بمفرده في الموسمين. وقد كانت أعلى القيم للسعة التبادلية الكاتيونية للتربة، وكذا جميع قيم كاتيونات وأنيونات التربة، وأقل القيم للضغط الأسموزي للتربة مع معاملة إضافة الفحم النباتي+ تبن القمح المجروش تلاها إضافة معاملة الفحم النباتي وحده في جميع مراحل نمو النبات في الموسمين. أيضاً أوضحت النتائج أن أعلى القيم لكل صفات النمو الخضري، والوزن الطازج والجاف للنبات، وكذا محتوى الأوراق من صبغات كلوروفيل أ وب، والكاروتين كانت مع استخدام الفحم النباتى + تغطية سطح التربة بقش القمح المجروش وتلاها استخدام الفحم النباتى فقط. وقد نتج أعلى محصول قابل للتسويق من ثمار الدرجة الأولى والثانية والمحصول الكلي عند استخدام الفحم النباتى + تغطية سطح التربة بقش القمح المجروش في الموسمين. أما أعلى محصول غير قابل للتسويق فنتج من معاملة الشاهد (بدون اى معاملة للتربة). أيضاً نتج عن الإضافات العضوية للتربة تأثير معنوي لمعظم صفات جودة الثمار في الموسمين.

الكلمات المفتاحية: الفحم النباتي، تبن القمح المجروش، تغطية سطح التربة، الطماطم، الإضافات العضوية.