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EFFECT OF FERTILIZATION AND IRRIGATION BY MIXED INDUSTRIAL DRAINAGE WATER ON GROWTH OF JATROPHA

Sabreen K. Pibars, Hani A. Mansour* and Maybelle S. Gaballah
Water Relations and Field Irrigation Department, Agricultural and Biological Division, National Research Centre, Eldokki, Giza, Cairo, Egypt.
*Corresponding author: mansourhani2011@gmail.com

Abstract

A field experiment was conducted at the farm of Research and Production of the National Research Center at El-Nubria, El-Buhaira, Egypt in the summer season of 2018, to investigate the effect of potassium foliar fertilizer and irrigation by agricultural drainage water (ADW) on mineral status of Jatropha plants under drip irrigation system.

Continuous depression in plant height and area of leaves was observed as the increase in the percentage of IDW in the water for irrigation. However, number of leaves did not show any clear response to this irrigation treatment. Moreover, total dry as well as total fresh weight similarly responded. Chl.a, Chl.b and Chl.a+Chl.b concentrations did not affected by the increase in the percentage of industrial drainage water in mixed water used in irrigation. Carotenoid concentration slightly increased with the 1st mixing percentage of IDW and tended to decrease to its lower value when irrigation water contains 75 % IDW. All growth character responded positively to the application of combined fertilizer. The highest effect was detected with area of leaves and the lowest was shown in stem fresh weight**.** The increasing of the combined fertilizer enhancing the chlorophyll b or carotenoid concentrations in leaves of Jatropha plants, in spite of, the non significance of differences between treatments.

Keywords: Jatropha, Agricultural drainage water, NPK fertilizer, Growth, Chlorophyll, Carotenoid.

Introduction

The availability of fresh water is very scarce in the Middle East and North Africa. Yet, consequently, brackish water or recycled wastewater can be used for irrigation, minimizing the exploitation of natural water resources (Bedbabis *et al.,* 2010). Recreation in water is becoming an important part of many economies. The discharge of subsurface drainage water could affect the aesthetic or recreational value of a water body and impair that component of the economy. The impairment, in addition to the effects on aquatic life as discussed above, would be to restrict human contact with the drainage water due to high pesticide, sediment or bacteria levels. These impacts would generally come from surface drainage systems. A secondary concern with recreation and associated with subsurface drainage water is the discharge of nutrients that may cause eutrophication and stimulate aquatic plant growth. This leads to a loss of aesthetic values in recreational waters (FAO).

Reclaimed wastewater has been used to irrigate trees for many years (Zekri and Koo, 1993) and has several potential advantages. Reclaimed wastewater contains many essential nutrients for plant growth and its application may reduce fertilizer application rates In addition, uptake of plant nutrients in a reclaimed wastewater and reduction in fertilizer use may prevent surface water and/or groundwater contamination. Potential disadvantages of using reclaimed wastewater include accumulation of phytotoxic levels of heavy metals, high salinity and concern over the health risk associated with viruses and bacteria in the water (Rose and Gerba, 1991 and Muarer *et al.,* 1995). Industrial drainage water is considered one of the non-conventional resource of water can use in growing bio-fuel crops (Farook *et al.,* 2006; Glenn *et al.,* 2009 and Bedbabis *et al.,* 2010). Several researches had been done and observed that growth of biofuel, landscape and woody trees affected by Irrigation by industrial drainage water (Gou and Sems *et al.,* 2000; Evett *et al.,* 2011).

Application of fertilizers could be one of successful ways to improve growth and yield of trees irrigated by waste water (Segala *et al.,* 2011).

This study was conducted to investigate the effect of combined fertilizer and irrigation by mixed drainage water on the growth of Jatropha plants.

Materials and Methods

A field experiment was conducted at the farm of Research and Production of the National Research Center at El-Nubria, El-Buhaira, Egypt in the summer season of 2018, to evaluate the effect of spraying with foliar fertilizer and irrigated by mixed industrial drainage water on mineral status of Jatropha plants.

The treatments were as follows:

a) Irrigation by drainage water:
   1. Fresh water,
   2. 25% drainage water+75 % fresh water,
   3. 50 % drainage +50 % fresh water and
   4. 75 % water+25 % fresh water
b) Spraying of potassium foliar fertilizer in the rate of, respectively, more than tap water as a control.

The experiment included 4 percentages of mixed drainage water in combination with three foliar fertilizer treatments i.e. 12 treatments in 6 replicates. Filed plots were 25 m^2 area. Soil texture was sandy loam soil. Jatropha seeds were sown in at May, 1, 2018 in the summer season, plants were thinned twice, the 1st days after sowing and the 2nd two weeks later to leave three plants / plot. Calcium super phosphate (15.5 % P205) and potassium sulfate (48.5 % k20) in the rate of 3.0 and 1.50 g/pot were added before sowing.

Ammonium sulfate (20.5 % N) in the rate of 6.86 g / plot was added in two equal portions, the 1st after two weeks of sowing and the 2nd two weeks latter. Irrigation with mixed drainage water in different concentrations was started 21days days after sowing (one irrigation by drainage water and the next irrigation with fresh water alternatively. Spraying foliar fertilizer were applied twice, the 1st spray was after 21 days from sowing and the 2nd two weeks later. A drip irrigation system has been used to irrigate the all treatments, Figure 1 showing the components of drip irrigation system.

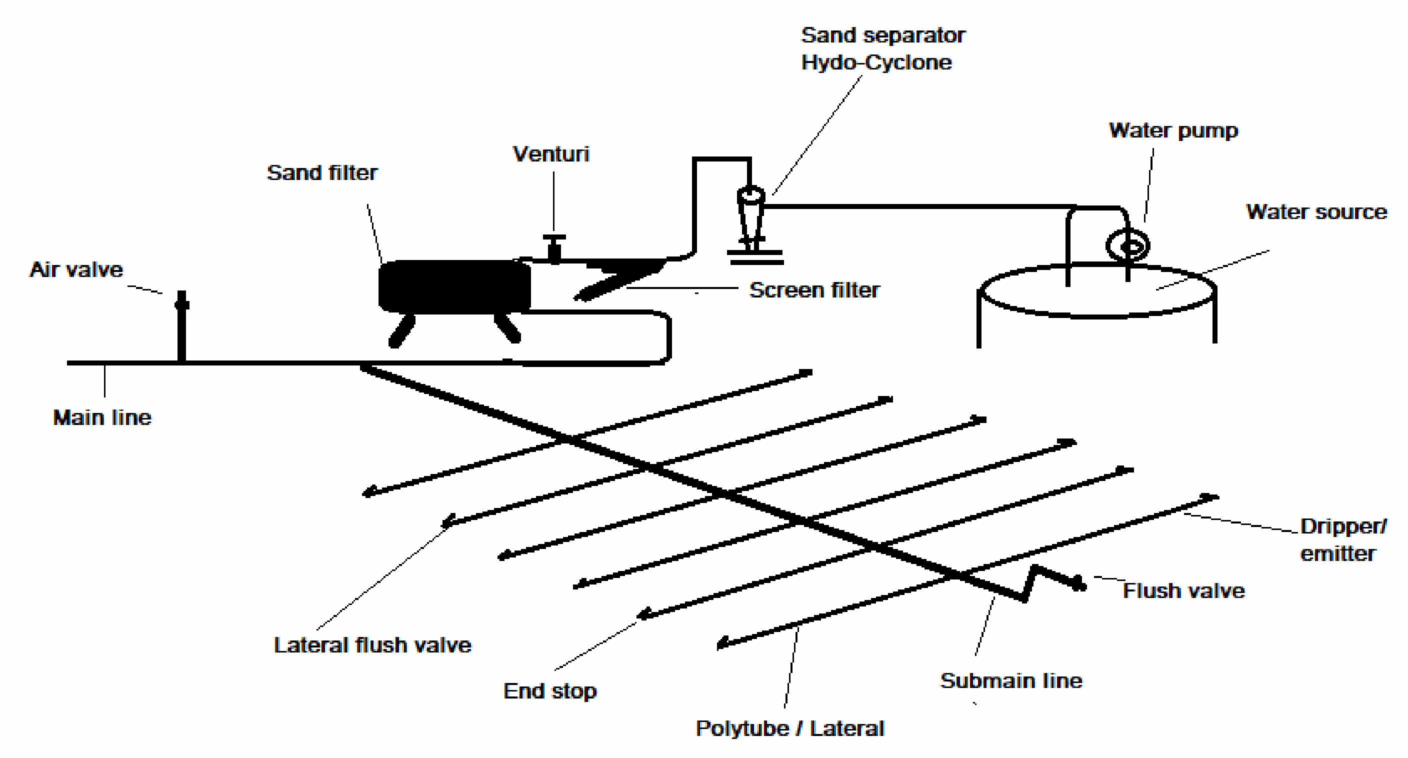

Fig. 1 : Drip irrigation system components

Table 1 : Physical and chemical analysis of the soil used

A. Soil physical analysis

Particle Size distribution, %				Texture Class	θS % on weight basis			HC (cm/h)	BD (g/cm³)
C. Sand	F. Sand	Silt	Clay		F.C.	P.W.P	A.W		
8.8	78.7	7.6	5.9	Sand	12	4.1	7.9	6.17	1.62

B. Soil chemical analysis

Soluble Cations (me l^{-1})				Soluble Anions (me l^{-1})			
Na^+	K^+	Ca^{++}	Mg^{++}	CO_3=	HCO_3-	Cl-	SO_4=
1.12	0.48	1.32	1.04	0.00	1.82	0.58	1.57

Available macronutrients (mg 100 g^{-1} soil)			Available micronutrients (ppm)			
N	P	K	Fe	Mn	Zn	Cu
3.87	0.87	16.7	6.34	3.11	2.45	0.32

Table 2 : Industrial drainage water analysis

pH	7.19
EC (dS/m)	1.12
Soluble cations (mili equivilant/L):	
CO_3-	-
Ca^{++}	2.5
Mg^{++}	2.5
Na^+	6.5
K^+	2.0
Soluble anions (mili equivilant/L):	
HCO_3-	5.9
Cl-	5.0
SO_4-	0.8

Data collected were subjected to the proper statistical analysis with methods described by Snedecor and Cochran (1990).

Results and Discussions

Mixed drainage water

Growth

Table (3) shown that the continuous depression in plant height and area of leaves was observed as the increase in the percentage of IDW in the water for irrigation. However, number of leaves did not show any clear response to this irrigation treatment. Moreover, total dry as well as total fresh weight similarly responded. Yield was reduced for *Acacia confusa* (Acacia) under all concentrations of leachate treatments. Inhibition of root growth was also observed in the three species with 40% leachate treatment.

Subsurface drainage water generally shows increased of salts and sometimes certain trace elements and soluble nutrients. Salts and trace elements play a major role in the reuse of drainage water. Above a certain threshold value, high total concentrations of salts are harmful to crop growth, while individual salts can disturb nutrient uptake or be toxic to plants. A high sodium to calcium plus magnesium concentration ratio may cause unstable soil structure. Soils with unstable structure are subject to crusting and compaction, degrading soil conditions for optimal crop growth (Wong and Leung, 1989 and FAO, 2002). Guo, *et al.* (2000) noticed that waste water irrigation influenced soil properties, reducing soil pH and increasing soil nutrient concentrations. At the same time, it enhanced tree leaf area, biomass production, nutrient uptake and shoot:root ratio. However, the temperature and irrigation rates significantly influenced the effects of effluent irrigation.

Pinherio *et al.* (2008) mentioned that in fact, the negative effects of salt on dry matter accumulation were observed in both periods of evaluation (38 and 59 days after germination), when salt-stressed averages of dry matter accumulation of leaf blades (43.7%0, petioles (53.5%) roots (63.7%), Stems (48.1%), total dry matter (45%) and root of the above ground ratio (30.5%) compare to control seedlings. The depression in dry matter in stressed plants was commonly observed in different other crops such as in grain sorghum (Hussein *et al.,* 2010), tomato (Nguyen-Quoc and Foyer, 2001) and Olive (Segal *et al.,* 2011), Tayel *et al.* (2019a,b).

Chlorophyll and carotenoids

Data in Table (3) showed that Chl.a, Chl.b and Chl.a+Chl.b concentrations did not affected by the increase in the percentage of industrial drainage water in mixed water used in irrigation. Carotenoid concentration slightly increased with the 1st mixing percentage of IDW and tended to decrease to its lower value when irrigation water contains 75 % IDW. The effects of waste water irrigation on the chemical constituents were observed by several authors: Guo and Sims (2000); Bedbabis *et al.* (2010) and Segala *et al.* (2011). Salts which can be found in waste water could affect the photosynthetic pigments (Pinheiro *et al.* (2008) and Doganlar *et al.,* 2010; Tayel *et al.*, (2019 a,b).

Table 3 : Effect of mixed industrial drainage water and combined fertilizer on vegetative growth of Jatropha plants.

Industrial drainage water %	Combined fertilizer g/pot	Plant height	Leaves No	Leaves area	Fresh weigh g				Dry weight g			
					Root	Stem	Leaves	Total	Root	Stem	Leaves	Total
0 (fresh water)	0	1250	26.5	455	11.0	58.4	51.8	120.8	2.75	5.67	7.40	1825.
	N2P2K2	1375	34.0	1472	10.0	76.0	101.0	101.0	4.54	18.44	20.02	43.18
	N4P4K4	1465	30.0	1084	12.6	98.7	106.0	217.3	5.43	15.46	19.96	40.45
25	0	945	24.0	445	11.6	59.7	50.2	121.5	2.33	6.84	5.90	15.07
	N2P2K2	1140	30.5	872	10.6	84.2	94.6	189.4	3.33	7.96	12.62	23.91
	N4P4K4	1260	40.5	1082	20.3	105.0	94.2	219.5	4.05	13.05	15.16	32.22
50	0	875	22.0	335	6.2	38.5	45.4	90.1	2.11	4.29	4.76	11.16
	N2P2K2	1130	30.0	695	15.2	90.5	101.2	206.9	3.59	20.30	7.50	31.39
	N4P4K4	890	340	1352	17.5	95.6	93.6	206.7	3.95	24.29	20.04	48.28
75	0	790	225	114	7.1	90.7	29.9	127.7	1.60	14.5	15.0	30.20
	N2P2K2	1080	320	611	8.3	91.4	58.3	158.0	2.32	5.13	9.29	16.74
	N4P4K4	1120	335	1189	7.4	90.2	77.6	175.2	3.30	10.37	14.67	28.07
Mean values of irrigation treatments	0	136.3	30.2	1004	11.2	77.7	86.3	175.2	4.24	13.19	15.79	33.22
	25	111.5	31.7	780	14.2	83.0	79.7	176.9	3.24	12.96	12.35	28.55
	50	96.5	28.7	792	13.0	74.9	80.1	168.0	3.22	16.29	10.77	30.28
	75	99.7	29.7	638	7.6	90.8	55.3	153.7	2,41	10.00	12.99	26.45
Mean values of NPK	0	95.50	23.75	337	9.0	61.8	44.3	115.1	2.20	85.8	8.27	19.05
	N2P2K2	92.34	32.40	912	11.0	85.5	88.8	185.3	3.46	12.96	12.36	28.75
	N4P4K4	118.3	34.50	1177	14.5	97.4	92.9	204.8	3.28	15.97	17.46	36.71
LSD at 5	IDW	31.75	آN.S	N.S	N.S	N.S	N.S	N.S	1.74	N.S	2.23	N.S
	CF	18.59	9.20	201.5	N.S	32.20	11.85	103.3	N.S	5.25	3.86	103.3
	IDWxCF	آN.S	آN.S	348.7	N.S	N.S	N.S	N.S	2.89	N.S	N.S	N.S

Combined fertilizer

Growth

All growth character responded positively to the application of combined fertilizer. The highest effect was detected with area of leaves and the lowest was shown in stem fresh weight (Table 3)

The improving effect of NPK fertilizer on growth characters may be related to enhancing of mineral absorption and distribution in different organs in plants and the effect of these elements in different metabolic processes in plant tissues and also on the environment, microbial activity and soil properties (Li *et al.,* 2010; Agbede *et al.* 2010 and Zahi *et al.,* 2011). Potassium is an essential element for plant growth and reproduction as it activates several enzymes especially in the metabolization of carbohydrates, Protein synthesis is especially dependent on potassium at several stages of amino acids activation, It plays a potential role in the transport of water and essential nutrient throughout the plant in the xylem and Plants also depend upon potassium to regulate the opening and closing of stomata (the pores through which leaves exchange carbon dioxide, water, vapour oxygen with the atmosphere (Marchener, 1995; Armengaud, *et al.* 2004 and Ashley *et al.,* 2005; Mansour *et al.* (2013); Mansour *et al*., (2014); El-Bassiouny *et al*., (2015), (2016a-c), (2019a,b), Abd-Elmabod *et al.* (2019); Leithy *et al*., (2010); Rezk *et al*., 2013; Mansour *et al.* (2014); Goyal and Mansour 2015; El-Hagarey *et al.* 2015; El-Bassiouny *et al*., (2015); (Bargaz *et al*., (2016); Mansour *et al*. (2019 a,b,c,d,); Hellal *et al*., 2019; Hu *et al.*, (2019a,b); Islam *et al*., (2019).

Table 4 : Effect of mixed industrial drainage water and combined fertilizer on chlorophyll and carotenoids in leaves of Jatropha plants

Industrial drainage water %	Combined fertilizer g/plot	Chl.a	C.hl.b	Carot.	Chl.a+Chl.b	Chl.a:Chl.b	Chl.a:Chl.b: Carotenoids
0 (fresh water)	0	5.21	1.16	3.78	6.37	4.49	**1.69**
	N2P2K2	5.10	1.82	3.90	6.92	2.90	1.77
	N4P4K4	5.07	1.66	2.47	6.73	3.05	2.73
25	0	5.09	1.78	3.05	6.85	2.89	2.25
	N2P2K2	5.24	1.66	2.45	6.90	3.16	2.82
	N4P4K4	6.09	1.84	2.47	7.93	3.13	3.20
50	0	4.74	1.48	2.80	6.22	3.20	2.22
	N2P2K2	4.80	1.98	2.51	6.78	2.42	2.70
	N4P4K4	5.28	1.65	2.41	6.93	3.20	2.88
75	0	5.13	1.96	2.96	7.89	2.62	2.67
	N2P2K2	4.18	1.84	2.45	6.02	**2.27**	2.46
	N4P4K4	3.75	1.05	1.94	4.80	3.57	2.47
Mean values of irrigation treatments	0	5.13	1.68	3.38	6.81	3.05	2.02
	25	5.47	1.75	2.66	7.22	3.13	2.71
	50	4.94	1.70	2.57	6.64	2.91	**58ز2**
	75	5.05	1.62	2.45	6.67	3.12	2.72
Mean values of NPK	0	5.01	1.69	3.02	6.70	2.97	2.22
	N2P2K2	4.83	1.83	2.83	6.66	2.64	2.38
	N4P4K4	5.05	1.55	2.32	6.60	3.26	2.84
LSD at 5	IDW	N.S	N.S	0.81	N.S.	**..........**	**.........**
	CF	N.S	N.S	0.62	N.S	**...............**	**.........**
	IDWxCF	14.9	0.71	N.S	N.S	**.........**	**........**

Nitrogen is an important component of many important structural, genetic and metabolic compounds in plant cells. It is a major component of chlorophyll, the compound by which plants use sunlight energy to produce sugars from water and carbon dioxide (i.e. photosynthesis). It is also a major component of amino acids, the building blocks of proteins. Some proteins act as structural units in plant cells while others act as enzymes, making possible many of the biochemical reactions on which life is based. Nitrogen is a component of energy-transfer compounds, such as ATP (adenosine triphosphate) which allows cells to conserve and use the energy released in metabolism. Finally, nitrogen is a significant component of nucleic acids such as DNA, the genetic material that allows cells (and eventually whole plants) to grow and reproduce (Marchener, 1995; Carelli *et al.,* 2006 and Tcherkez and Hodges, 2008).

Examination of Data in Table (4) indicated that increasing the combined fertilizer enhancing the chlorophyll b or carotenoid concentrations in leaves of Jatropha plants in spite of the non significance of differences between treatments. During both growing periods, mineral fertilization increased carotenoids and chlorophyll concentrations as compared to control (Koton and Baran, 2008). Mihalovic *et al.* (1997) reported that both forms of nitrogen increased the pigment concentration, however, ammonium ions in nutrient solution increased concentration of chlorophylls a and b in wheat leaves in comparison with nitrate ions. Moreover, chlorophyll a, chlorophyll b and carotenoid content of poinsettia leaves were the highest when the standard rate of nitrogen, phosphorus and potassium fertilizer application. Also, Bojovic and Stojanvic (2005) concluded that chlorophyll and carotenoid status could be considered as a function to the mineral fertilizers.

Mixed drainage water x combined fertilizer

Growth

Data in Table (4) expressed the interaction effect of mixing industrial drainage water and combined fertilizer on the growth of Jatropha plants. Data showed that the improving effect of combined fertilizer gave its higher values under high percentage of mixing IDW in water of irrigation followed by that under 50% treatment. Under using fresh water in irrigation, the highest effect of NPK fertilizer by adding N2P2K2 treatment. All other growth characters did not show any significant response to combined fertilizer under different mixing IDW percentages.

The efficiency of fertilizer in salt-affected soils depends upon the nature and amount of fertilizer added. Soil salinity/sodicity levels (Chaudhry *et al.* 1989; Singhandhupe and Rajput, 1990 and Murtaza *et al.,* 2000). Murtaza, *et al.* (2000) subjected rice plants to different salinity treatments [So (ECe 1.6 dS m^{-1} + SAR 3.22), S1 (ECe 5.6 dS m^{-1} + SAR 29.3), S2 (ECe 6.1 dS m^{-1} + SAR 44.3) and S3 (ECe 6.3 dS m^{-1} + SAR 55.46)] and fertilized by 100, 125 and 150 kg/ha. Maximum plant height (112.33 cm) was obtained at S0 while minimum (98.88 cm) at S3. Maximum paddy yield was observed where N 150 mg kg^{-1} soil was applied. Overall, it was concluded that even at higher levels of salinity/sodicity, fertilizer N remained beneficial. Singhandhupe and Rajput (1990) noticed that the potassium was the major cation in the tissues at the low salinity; however, it was replaced by sodium as the salinity of the culture solution was increased. *Kandelia candel* absorbed ammonium-nitrogen luxuriously at all salinity treatments and some of the ammonium accumulated in the tissues could be part of cations as the osmotic inorganic solute. In addition, Aslam, *et al.* (1996) reported that external P, concentration up to 100 μM in the presence of NaCl caused stimulation of all growth parameters (shoot, root, tillering capacity), above this concentration P, had an inhibitory effect, Ayyad *et al.* (1990), Yassen *et al.* (2011); Mansour *et al.* (2013), Mansour *et al.* (2014), Mansour (2015); El-Hagarey *et al.* (2015); Yassen *et al.* (2018), Mansour *et al.* (2016a-c) and (2019a,b), Abd-Elmabod *et al.* (2019).

Chlorophyll and Carotenoids

The interactive effect of mixed drainage water irrigation and combined fertilizer on chlorophyll and carotenoid concentrations were recorded in Table (4). Data presented in Table (4) indicated that Chl.a, Chl.a+Chl.b and Chl.a+Chl.b: carotenoid concentration ratio gave its higher values by adding N4P4K4 and irrigated by mixed 25% drainage water, while chl.a: chl.b ratio showed this higher value in treatment without fertilizers and irrigated with fresh water. On reverse, the lowest values of chl.a, chl.b, carotenoids and chl.a+chl.b concentrations were obtained when adding the highest fertilizers used and irrigation by 75% mixed drainage water. However, Chla+chl.b: carotenoids ration was obtained in plants treated with fresh water and without fertilizers. The interaction between fertilizers and salinity and its effect on photosynthetic pigments were reported by: Ma *et al.* (1997); Sharma and Hall (1991) and Stoeva and Kaymakanova (2008). In this concern, Makus (2003) revealed that the addition of nitrogen fertilizer had beneficial effects on growth, chlorophyll concentration, Chl.a: Chl.b and Chl.s: Carotenoids ratios in amaranth plants. The high fertilizer rate decreased leaf photosynthetic pigment contents, gas exchange, and Chl fluorescence, under moisture stress, but it increased those values when soil moisture was sufficient. Zhu *et al.* (2011) noticed that short-term stimulation in photosynthetic rate occurred under 56 mmol(T-1) nitrate treatment, and then recovered to the level of 14 mmol nitrataent (CK). Photosynthetic rate of 140 mmol (T-2) treatment seedlings significantly decreased over the treatment course with respect to control treatment. The photosynthetic pigment content of T-1 and T-2 increased during the first 2 d, and gradually recovered to the level of CK thereafter. Chlorophyll a/b and carotenoids/chlorophyll of T-1 had no significant difference from CK during the treatment period Ayyad *et al.* (1990); El-Ghareeb *et al.* (1991); (Goyal and Mansour 2015; El-Hagarey *et al*., 2015; Bargaz *et al*., 2016; Mansour *et al.* (2019 a,b,c,d,); Hellal *et al*, 2019; Hu *et al*. (2019a,b); Yassen *et al*. (2011; 2018); Mansour *et al*. (2015, 2016; 2019); Abd-Elmabod *et al*. (2019), Abdalla *et al*. (2019).

Conclusion

All growth and quality characters responded positively to the application of combined fertilizer. The highest effect was detected with area of leaves and the lowest was shown in stem fresh weight.

It could be concluded that the increasing of the combined fertilizer enhancing the chlorophyll b or carotenoid concentrations in leaves of Jatropha plants, in spite of, the non significance of differences between treatments.

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