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IMPACT OF ORGANIC MATTER ON THE GROWTH OF *JATROPHA CURCAS* AND *MORINGA OLEIFERA* SEEDLINGS BENEATH WATER DEFICIT

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ABSTRACT: A field experiment was carried out in order to determine the proper irrigation rate and the best organic matter in a loamy sand soil to optimize the growth, biomass, and chemical composition of the seedlings of *Jatropha curcas* (poison nut) and *Moringa oleifera* (horseradish tree). Three irrigation deficits (100, 75, and 50% of field capacity F.C.) and three organic substance treatments [control, compost, and humic acid (HA)] were implemented in a split-plot design. Generally, increasing the irrigation deficit from 100% to 50% of F.C. decreased growth and biomasses for both plants. The 75% F.C. was the better treatment that enhanced the growth and biomasses parameters of *J. curcas* seedlings. Contrarily, HA exceeds compost in increasing these growth parameters but compost and HA were alike for increasing shoots (fresh and dry weights) and decreasing roots biomasses. HA and compost under 100 and 75% F.C. were significantly similar to the decreased roots biomass, as well as, the S:R ratio of *J. curcas* seedlings. The results revealed that regardless of their effects and mechanism to resist drought, both *J. curcas* and *M. oleifera* are well adapted to semi-arid regions when amended with HA or compost, under irrigation deficit 75% of F.C.

Key words: *Jatropha curcas*, *Moringa oleifera,* drought, compost, humic acid.

INTRODUCTION

Jatropha curcas (family Euphorbiaceae), a small tree or large shrub (Huerga *et al.,* 2014), Central and South America, Southeast Asia, India, and Africa have all grown it (Rodrigues *et al.,* 2015). This plant has multipurpose uses such as biofuel and biodiesel (Augustus *et al*., 2002 and Pandey *et al*., 2012), nanoparticles green synthesis (Bar *et al*., 2009), and, animal and fish feed (King *et al*., 2009; Nithiyanantham *et al*., 2012 and Makkar, 2016). This plant was cultivated as drought resistant and fitted to be able to develop on marginal lands and to grow in regions with minimum precipitation as 250 mm per year (Foidl *et al*., 1996). In developing countries, *Jatropha* is a promising biofuel and socioeconomic development plant (Romijn *et al*., 2014 and, Van Eijck *et al*., 2014). Seeds contain fixed oil, the primary requirement for soaps and biofuel production, are rich in N, a source of plant nutrients (Henning, 1996), to control erosion and restoration of the degraded ecosystems (Garg, 2011), and valuable green manure source (Behera *et al*., 2010).

Moringa oleifera Lam. (family Moringaceae), the indigenous species to south Asia, is fast growing tree planted for multipurpose uses, fodder trees, in medicine, animal nutrition (El-Hack *et al.,* 2018; Falowo *et al*., 2018; Jacques *et al*., 2020 and Pedraza-Hernández *et al*., 2021), biostimulant for enhancing medicinal and ornamental plants (Mohamed *et al*., 2020) and fruit trees (Mosa *et al*., 2021), with antimicrobial bioactivities and high nutritional value (Abbassy *et al*., 2020). Moringa can be used for biomass production, biogas, blue dye, and wood pulp and water purification (Fuglie,1999; Pritchard *et al*., 2010; Adebayo *et al*., 2011; Raman *et al*., 2018 and Tambone *et al*., 2020). In Egypt, the increasing demand will further reduce the amount of water available for irrigated crops. Although changes in irrigation practices led to improving plant production by conserving water, enhancing experimental research is an essential strategy to improve tolerance of plants to drought stress (El-Beltagy and Abo-Hadeed, 2008 and Boumenjel *et al*., 2021). Planting drought resistant tree species as well as is an important strategy, to control their irrigation quantity. Establishing new tree plantations in arid regions not only act as large s carbon sinks but also provide a source of non-wood forest products ranging from extractives to bio-diesel. Moisture limitation can affect enzyme activity to growth and yield reduction in the whole plant and increased vulnerability to other stresses. Drought resistance dryness delay and dryness tolerance can be achieved by increasing oncoming to water as well as reducing water loss through morphological or physiological drought adaptations or both combined (Pallardy *et al*., 1993; Grubb, 1998; Elansary and Salem, 2015; Oliver *et al*., 2020 and Pardo *et al*., 2020). Within this context, compost and humic acid (HA) application maintains ecological equilibrium and optimizes biological processes Pettit, 2004; Zhang *et al*., 2014 and Guo *et al*., 2019). The addition of composts enhances the chemical and physical properties of soil, in addition to preserving soil structure and microorganisms. It also improves the structure, holding capacity, and aggregates of the soil. On the other hand, reduced soil pH, increased cation exchange capacity (CEC), and increased availability of the most crucial nutrient for plant growth are the chemical properties (Adebayo *et al*., 2011). Compost is used extensively to stimulate plant production, maintain and improve soil fertility, and reduce pollution risks. Also, HA provides numerous benefits to soil properties and plant production. In this concern, Pettit (2004), indicated that HAs are important soil components, they can improve soil fertility and increases the nutrient's availability by holding them on mineral surfaces; increases cation exchange capacity, mineral elements are converted into plant-available forms. The study aimed to illustrate the resistance of *Jatropha curcas* and *Moringa oleifera* seedlings to water deficit and its interaction with applying organic substances after two successive seasons.

MATERIALS AND METHODS

Experimental location and tree seedlings plantation:

During the 2015 and 2016 seasons, this experiment was set up in the Experimental Farm of Soil Saline and Alkaline Research Laboratory (Salinity Lab) at Sabaheia, Alexandria, Egypt. The soil texture of the site was loamy sand with increasing clay proportion by depth. *Jatropha curcas* L. and *Moringa oleifera* Lam. trees seedlings (homologous, one-year-old) were studied individually in this study. Three replicates with a split-plot design were used for each species. Irrigation deficit three treatments namely: 100% of field capacity (F.C.), 75%, and 50%, represented the main plot, while the subplot represented the three treatments of organic substances (control, compost, and humic acid). In concrete basins, tree seedlings were planted with dimensions 0.7 × 0.7 × 1.0 m. First, both organic matters were plowed in the soil of the concrete basins all at once before planting to a depth of 60 cm. The one-year-old tree seedlings were then planted in the first week of March 2015 therefore, all seedlings were kept well-watered during the first month then, in April 2015 the irrigation deficit treatments were applied. The study, which lasted two growing seasons, finished in the first week of October 2016. Compost was prepared in the Soil Saline and Alkaline Research Laboratory backyard (USCC, 2002) (Table, 1) and applied at the rate of 20 m^3 fed^{-1} (1 kg $basin^{-1}$). Humic acid (HA), the commercial

Table 1. Main characteristics of dry compost used in the study.

Criterion	Value	Criterion	Value
Bulk density, Mg m^{-3}	0.54	**Total K*,%**	1.12
Moisture content at 65ºC, %	29.41	**Total P*,%**	0.66
Moisture content at105ºC, %	38.16	**Total N*,%**	1.14
Dry matter, %	61.84		
pH, 1:10'' (H_2O)	7.11	**Available K*, %**	0.45
EC, dsm^{-1} 1:10 (H_2O)**	3.25	**Available P*, %**	0.18
Soluble cations, m mol L^{-1}		**NH_4-N+NO_3-N*, mg/kg**	108.66
Ca^{++}	7.32		
Mg^{++}	2.66	**Organic carbon (O.C)*, %**	28.66
Na^{+}	11.91		
K^{+}	9.80	**C/N**	25.14
SAR	5.33	**C/P**	43.42
Soluble anions, m mol L^{-1}		**C/K**	25.59
HCO_3^{-}	1.32		
Cl^{-}	11.89		
SO_4^{--}	18.48		

*** Dry matter basis; ** compost air dry basis**

powder humate contains 86% HAs as a potassium Humate and 5% K_2O w/w, applied by the rate of 5 kg fed^{-1}.

Compost quality:

The results of dry matter, organic carbon and nitrogen, plant nutrients, pH and EC (Table, 1) were relatively compared to the correspondence mean value of compost samples collected from 22 farms (Piorr, 1996). The moisture losses of compost were 29.41% and 38.16% at 65ºC and 105ºC, respectively. The content of organic substrates (OM) reached 49.41% of dry matter and the other part consisted mainly of sand beside minor amounts of potash and rock phosphate. Low OM content in compost compared with the high OM mean value of 22 composts (72.0% dry matter) caused by high sand percentage. As a result, experimental compost suffers low content of C and N compared to the mean values of the nutrient content in the 22 composts. Compost C/N ratio of 25.14 was in the statistical range of the mean value 25.00 ± 1.83 of the reference composts. The values of compost pH, EC, and SAR were 7.11, 3.25 dSm^{-1}, and 5.33, respectively. No possibility of alkalinity, salinity, or sodicity problems is expected after applying the experimental compost to the concrete basin soil.

Soil characterization measurements:

The soil moisture content was measured using the direct gravimetric approach (IAEA, 2008) which was repeated every week interval (3 times per week) to modify the required water until the experiment is completed to confirm that stress levels were well maintained. The pH of the soil and its electrical conductivity were measured, soil texture was detected using the Hydrometer method (Gee and Bauder, 1979). The bulk density of the soil samples was determined using the core method described by (Blake and Hartge, 1986). The bulk densities were the average of three cores each of 34.2 ml from 0-60 cm soil depth. Volumetrically, soluble carbonates and bicarbonates were determined (Shaaban *et al.,* 2004) and soluble chlorides (Nayak and Sahoo, 2014). In addition, the value of the sodium adsorption ratio (SAR) in the soil calculated by the following formula:

$$SAR = \frac{[Na^{+}]}{\sqrt{1/2\,([Ca^{2+}] + [Mg^{2+}])}}$$

Available nitrogen in the soil was determined (Keeney and Nelson, 1982), total available N was determined by the Micro-Kjeldahl technique (Liu *et al.*, 2021), available phosphorous and potassium were determined according to (Soltanpour and Schwab, 1977). Also, the cation exchange capacity (CEC) was measured by the neutral (pH 7.0) NH_4OAc saturation method (Anderson, 1993). A wet oxidation technique was used to assess total organic carbon (TOC) in moist soil samples with adding potassium chromate (Lemma, 2018). Organic matter content (OM) in the soil samples was calculated according to the following relationship: OM. % = TOC % × 1.724, where: 1.724 = Conversion Factor; (Nelson and Sommers, 1996). Based on $KMnO_4$ oxidation, the samples were examined for soil texture, bulk density, pH, EC, organic matter content, available nitrogen, phosphorous, and potassium, cation exchange capacity (CEC), and soil labile carbon (LC) (Blair *et al*., 1995). Table (2) shows the values of the physical and chemical analyses of the experimental soil.

After two seasons, fresh leaves are collected in mid-August to determine total chlorophyll concentration (He, 2018), carotenoids (Robbelen and Wehrmeyer, 1965), free proline (Bates, 1973), and total phenolic compounds using the Folin-Denis method (Salem *et al*., 2016) as mg of Gallic acid/ g of leaves dry weight**.** At the end of experiment, leaves number, fresh and dry biomasses and shoot:root ratio were also calculated. Relative growth rate (RGR), was computed for each treatment's seedlings as

$RGR = (\log H_2 - \log H_1)/T$, where:
H_2 = Final seedling height
H_1= Initial seedling height
T = number of weeks

As well as, dried leaves of the two species were ground for chemical analysis after digestion according to Evenhuis and DeWaard (1980). Total nitrogen % was determined by using the micro-kjeldahl method as described by Jacobs (1968), total phosphorus was determined colorimetrically by the molybdenum blue-ascorbic acid method according to Murphy and Rily (1962), and potassium was measured against standard using a flame photometer (Page *et al*., 1982).

Statistical analysis:

The SAS statistical program for windows was used to conduct the randomized complete blocks statistical analysis. Effects of water deficit, organic substances, and their interactions were analyzed by Duncan's multiple range test (p= 0.05).

RESULTS AND DISCUSSION

1. Soil characteristics:

Bulk density:

Table (3) shows that the lowest bulk density values of the soil of *Jatropha curcas* seedlings were similar for moderate and

Table 2. Main characteristics of initial soil sample for the concrete basins soils.

Criterion	Value	Criterion	Value
Texture classes	loamy sand	**Soluble anions, mmol l^{-1}**	
Sand,%	79.85	**HCO_3^-**	0.56
Silt,%	8.64	**Cl^-**	1.57
Clay,%	11.51	**SO_4^{--}**	0.42
Bulk density, Mg m^{-3}	1.65	**SAR**	1.54
Field capacity (F.C.), %	10.00		
Saturation water content (S.P),%	25.8	**CEC, cmol(+) Kg^{-1}**	5.70
Moisture content, ϴw, %	1.31	**Organic carbon (O.C), g Kg^{-1}**	0.09
Total $CaCO_3$, %	0.20	**NH_4-N+NO_3-N, mg Kg^{-1}**	9.08
pH_w, 1:2.5 (water suspension)	7.73	**Ave. P, mg Kg^{-1}**	5.11
EC, 1:2.5 (water extract) dSm^{-1}	0.17	**Ave. K, mgKg^{-1}**	8.31
Soluble cations, m mol L^{-1}		**Labile carbon (LC), mg Kg^{-1}**	8.71
Ca^{++}	0.83		
Mg^{++}	0.31		
Na^+	1.16		
K^+	0.25		

Table 3. Influence of water deficit and organic amendments on the surface soil characteristics of *Jatropha curcas* seedlings after two seasons.

Treatment	Cont.	Compost	Humic acid	Cont.	Compost	Humic acid
		Bulk density (mg m^{-3})			CEC (cmol (+) Kg^{-1})	
100%	1.64	1.62	1.56	4.89	6.96	8.56
75%	1.64	1.62	1.56	5.28	6.89	8.09
50%	1.65	1.63	1.59	5.00	6.67	7.53
		Available N (mg Kg^{-1})			Available P (mg Kg^{-1})	
100%	8.56	12.83	10.53	4.01	13.93	11.88
75%	9.00	12.83	10.45	4.32	13.89	11.61
50%	9.20	14.68	11.22	4.10	11.40	8.40
		Available K (mg Kg^{-1})			Labile carbon (mg Kg^{-1})	
100%	7.24	13.67	20.63	8.89	14.06	9.56
75%	7.83	14.00	20.12	8.72	13.97	9.36
50%	7.25	11.30	15.48	8.00	12.65	9.00

well-watered treatments among compost (1.62 Mgm^{-3}) and HA (1.56 Mgm^{-3}). Although both amendments could save 25% of irrigation water, however, humic improve bulk density better than compost.

Likewise, the soil bulk density of *Moringa oleifera* seedlings did not differ significantly among the three soil moisture contents (100, 75, and 50% F.C.) after the study (Table, 4). Both the compost and HA at the highest F.C. had achieved the lowest value of the bulk density meaning that, both organic treatments have equal improvement effects for soil bulk density. As a result, compost and HA at moderate watered treatment (75% F.C.) achieved the highest change of soil bulk density towards desirable effect and at the same time, this treatment had made provision in the amount of water added with increasing the and more water utilization efficient by 25% of soil F.C. Therefore, the reduction in irrigation's frequency and intensity may occur. Although compost and HA at moderate watered treatment were achieved a good desirable change of soil bulk density, the HA had a more positive impact. In this respect, Celik *et al*. (2004), reported that the addition of organic materials to soil showed great improvements in the physical properties of soil. Soil water evaporation rate was slowed, as HA was added with increasing its usage by plants in different soils (Zhang and Ervin, 2004). Moreover, soil's bulk density and moisture content were significantly improved by the addition of compost (Hussein and Hassan, 2011).

Cation exchange capacity (CEC):

Cation exchange capacity (CEC) was changed among organic amendments through the three soil moisture treatments for *M. oleifera* seedlings (Table, 4). The HA with well-watered treatment had the highest value of CEC (8.79 cmol Kg^{-1}), whereas, non-amended soil at moderate watered treatment showed the highest CEC value (5.1 cmol Kg^{-1}). In another word, organic substances have a large capacity to retain nutrients and water. These characteristics act to improve water and nutrients plant access through making noticeable improvements in the CEC of loamy sand soil. Likewise, Table (3) reveals that values of soil CEC of *J. curcas* seedlings have the same trend as the *M. oleifera* seedlings of the highest values of CEC were detected in well-watered level (100% F.C.) with HA and compost treatments. Also, HA was superior to compost in improving CEC values at the three water levels especially, the deficit one (50% F.C.) as its CEC value increased by 53.99% more than non-amended treatment. Doubtless, HA and compost at moderate deficit level had achieved the highest adjustment of the CEC value towards desirable impact, but HA had 15.96% more than that of compost treatment. This is probably due to, the nature of organic substances as well as their quantity that affecting the amount of carbon stabilized in

Table 4. Influence of water deficit and organic amendments on the surface soil characteristics of *Moringa oleifera* seedlings after two seasons.

Treatment	Cont.	Compost	Humic acid	Cont.	Compost	Humic acid
		Bulk density (mg m^{-3})			**CEC (cmol (+) Kg^{-1})**	
100%	1.64	1.56	1.57	5.10	7.21	8.13
75%	1.65	1.60	1.56	4.68	7.58	8.79
50%	1.65	1.61	1.63	4.62	6.48	7.61
		Available N (mg Kg^{-1})			**Available P (mg Kg^{-1})**	
100%	7.87	15.28	15.87	4.00	15.37	11.83
75%	8.47	15.22	15.76	4.06	14.31	11.74
50%	8.30	12.07	11.68	3.86	11.59	9.00
		Available K (mg Kg^{-1})			**Labile carbon (mg Kg^{-1})**	
100%	7.13	14.30	18.74	7.28	14.56	9.47
75%	7.11	13.96	18.70	7.24	14.40	9.30
50%	7.00	14.41	17.41	7.04	11.08	8.79

soil and accessibility by soil microbes, and therefore there are important variations in mineral composition of organic amendments, like what exists between compost and HA treatments (Hussein and Hassan, 2011 and Saison *et al*., 2006). In another word, the carbon fraction that remains unaffected (less sensitive) is considered to consist of the more stable carbon compounds like carbon fraction that are present in HAs (Gougoulias *et al.*, 2014). Based on the foregoing, there is a good relationship between cation exchange capacity (CEC) and soil organic carbon fractions. Within this context, as heterogeneous molecules of various sizes that self-organize in supramolecular formation, HAs are the major component of organic fertilizers (Bachmann *et al*., 2008), they're also the most reactive. In addition to that, Soil texture and CEC play a significant role in determining the amount of SOM that may be stabilized in soil (Piccolo, 2002).

Labile carbon (LC) and available (N, P, and K):

The soil easily oxidizable carbon (EOC), particulate organic carbon (POC), and light fraction organic carbon (LFOC) measurement of smaller and more active fractions of soil organic carbon (SOC) is essential to identify changes in soil organic carbon quality (Giller *et al*., 1997 and Haynes, 1999). These can be significantly influenced by soil management practices like both nutrient and water treatments. Through this relationship can discuss results of chemically oxidized labile carbon and soil availability of N and P and there were changes among soil organic treatments and a combination of three soil levels of water deficit. The compost treatment at a well-watered level has achieved the highest LC and available N and P of *M. oleifera* soil (Table, 4), where their values were 14.56, 15.28, and 15.37 mg Kg^{-1}, respectively. Doubtless, compost had improved on both values of LC and available N and P of *M. oleifera* soil. Also, Table (3) shows that LC, available N, available P, and available potassium (K) decreased with increasing water deficit regularly, from well-watered to severe at all treatments, in the soil of Moringa transplants. Nonetheless, compost amendment was superior to HA as increased LC, available N and P in the soil by 1.9, 1.8, and 3.5-fold more than control, respectively in the soil of Moringa transplants. Whereas, HA was better than compost by 1.3-fold to increase available K more than non-amended treatment. Table (4), also, show that LC, available P, and K declined with increased water deficit regularly, from well-watered to severe at all treatments, in the soil of *J. curcas* seedlings. The LC and available P and K in severe treatment declined by 8.86, 19.82, and 18.12% less than well-watered treatment, respectively, whereas, only available N has the opposite trend, this may be due to errors during the appreciation. Also, Compost raised LC, available N, and P by 1.6, 1.5, and 3.2-fold more than control, respectively in the soil of *J. curcas*.

Whereas, HA was better than compost by 1.4-fold to increase available K more than non-amended treatment. The priority of humic acid to increase soil available K against compost is probably that humic have higher potassium content. The variation of compost and humic is probably due to their content of EOC, POC, and LFOC as a percent of total soil organic carbon, which is significantly influenced by nutrients and water management. Humic acid has lower LC, available N, and available P values which reflect a higher percentage of more stable compounds of total organic carbon in the soil. It was reported that organic C of soil labile fractions was more subtle to soil management changes and the disturbance than total organic C (Chan *et al*., 2001; Bauhus, 1996; Bremer *et al*., 1994; Powelson *et al*., 1987 and Conteh *et al*., 1997). The Particulate organic C (POC), therefore, may be of greater importance for defining SOC turnover. Also, soil fertility is influenced by humus through water-holding capacity where its spongy structure can bind water and some inorganic molecules, which acting as micro- or macro-nutrients (Freixo *et al*., 2002).

2. Growth characteristics:

Table (5) illustrates that 75% F.C. was the better treatment that enhanced the growth of *J. curcas* seedlings. Whereas it is significantly similar with 100% F.C. Therefore, this treatment increased height growth, stem diameter, leaves number, and RGR per week, more than 50% F.C. treatment. At the same, humic acid exceeded the compost for increasing height growth and RGR per week whereas, humic and compost were significantly similar to enhance the stem diameter and leaves number (Table, 6).

Interaction of 75% F.C. and humic acid was the better treatment to increase growth parameters except, the leaves number which increased by irrigation the seedlings with 100% F.C. with HA (Fig., 1). Also, Table (5) demonstrates that 100% F.C. increased height growth, leaves number, and RGR per week for *M. oleifera* seedlings more than 75% and 50% field capacity. But, the stem diameter of the seedlings increased when field capacity progressively declined from 100% to 50%. On the other hand, Table (6) shows that compost and HC had the same significant effect where both increased the growth parameters of *M. oleifera* except leaves number that increased more by humic than compost. The interaction effects indicated that the seedlings treated with compost under 100% F.C. had the higher values of height growth and RGR per week whereas, humic under 100% F.C. was the best treatment that increased the leaves number of the seedlings (Fig., 1). The slower growth of *J. curcas* and *M. oleifera* could be related to survival under stress. Moreover, under water deficit, the increase in abscisic acid (ABA) biosynthesis in roots was transported to the shoot through the xylem (Zhu, 2002).

3. Biomass:

Table (7) shows that 75% F.C. treatment was significantly similar with 100% F.C. that increased shoots dry weight and S:R ratio as well as, decreased roots fresh and dry weights of *J. curcas* seedlings in comparison with 50% F.C. Similarly, compost and humic acid were alike for increasing shoots biomasses (fresh and dry) and decreasing roots biomasses in compare with 50% F.C. While, humic was the better to increase S: R ratio (Table, 8).

The interaction effects were irregular on *J. curcas* seedlings as humic under 100% F.C. increased shoots fresh and dry biomasses more than other treatments (Fig., 2). Both humic and compost under 100 and 75% F.C. were significantly similar to decreased roots fresh and dry biomasses as well as, the S:R ratio. Table (7) as well, showing that total F.C. (100%) recorded the highest fresh and dry shoots biomass of *M. oleifera* followed by 75% and more than 50% F.C. Conversely, the stressed treatment (50%) recorded the highest fresh and dry roots biomass followed by 75% then 100% F.C.

Table 5. Means of some growth parameters of *Jatropha curcas* and *Moringa oleifera* seedlings affected by drought stress treatments after two successive seasons.

Field capacity	Height growth (cm)	Stem diameter (cm)	Leaves No.	RGR cm/week	Height growth (cm)	Stem diameter (cm)	Leaves No.	RGR cm/week
	Jatropha curcas				*Moringa oleifera*			
100%	126.7 a	5.01 a	105.4 a	0.86 b	164.23 a	1.76 b	45.33 a	1.60 a
75%	128.0 a	5.04 a	103.7 a	0.91 a	151.29 b	1.92 ab	29.75 b	1.41 b
50%	114.5 b	4.73 b	72.0 b	0.75 c	134.76 c	2.16 a	26.40 c	1.18 c

Means followed by a similar letter within a column are not significantly different at the probability level 0.05 using Duncan's Multiple Range Test.

Table 6. Means of some growth parameters of *Jatropha curcas* and *Moringa oleifera* seedlings affected by organic substances after two successive seasons.

Organic substances	Height growth (cm)	Stem diameter (cm)	Leaves No.	RGR cm/week	Height growth (cm)	Stem diameter (cm)	Leaves No.	RGR cm/week
	Jatropha curcas				*Moringa oleifera*			
Cont.	111.7 c	4.62 b	89.6 b	0.71 c	140.71 b	1.85 a	28.67 c	1.30 b
Compost	120.0 b	5.09 a	94.7 a	0.80 b	154.68 a	1.99 a	32.89 b	1.46 a
Humic acid	137.5 a	5.08 a	96.9 a	1.00 a	153.04 a	2.03 a	39.56 a	1.44 a

Means followed by a similar letter within a column are not significantly different at the probability level 0.05 using Duncan's Multiple Range Test.

Table 7. Means of some biomass parameters of *Jatropha curcas* and *Moringa oleifera* seedlings affected by drought stress treatments after two successive seasons.

Field capacity	Shoots FW. (g)	Shoots DW. (g)	Roots FW. (g)	Roots DW. (g)	S:R ratio	Shoots FW. (g)	Shoots DW. (g)	Roots FW. (g)	Roots DW. (g)	S:R ratio
	Jatropha curcas					*Moringa oleifera*				
100%	1832.91 a	932.77 a	606.86 b	354.02 b	2.68 a	1002.48 a	361.44 a	249.81 c	129.80 c	3.56 a
75%	1731.18 b	903.72 a	602.85 b	361.71 b	2.60 a	838.09 b	301.70 b	310.47 b	163.62 b	2.34 b
50%	1365.12 c	674.22 b	776.00 a	484.17 a	1.44 b	670.85 c	234.89 c	395.76 a	204.35 a	1.46 c

Means followed by a similar letter within a column are not significantly different at the probability level 0.05 using Duncan's Multiple Range Test.

Table 8. Means of some biomass parameters of *Jatropha curcas* and *Moringa oleifera* seedlings affected by organic substances after two successive seasons.

Organic substances	Shoots FW. (g)	Shoots DW. (g)	Roots FW. (g)	Roots DW. (g)	S:R ratio	Shoots FW. (g)	Shoots DW. (g)	Roots FW. (g)	Roots DW. (g)	S:R ratio
	Jatropha curcas					*Moringa oleifera*				
Cont.	1359.02 b	709.30 b	772.51 a	470.42 a	1.58 c	784.49 b	277.80 b	338.66 a	178.49 a	2.06 b
Compost	1761.28 a	888.02 a	610.63 b	367.25 b	2.51 b	843.06 a	301.79 a	319.85 ab	164.65 b	2.48 a
Humic acid	1808.91 a	913.40 a	602.57 b	362.23 b	2.63 a	865.28 a	311.02 a	303.59 b	159.16 b	2.73 a

Means followed by a similar letter within a column are not significantly different at the probability level 0.05 using Duncan's Multiple Range Test.

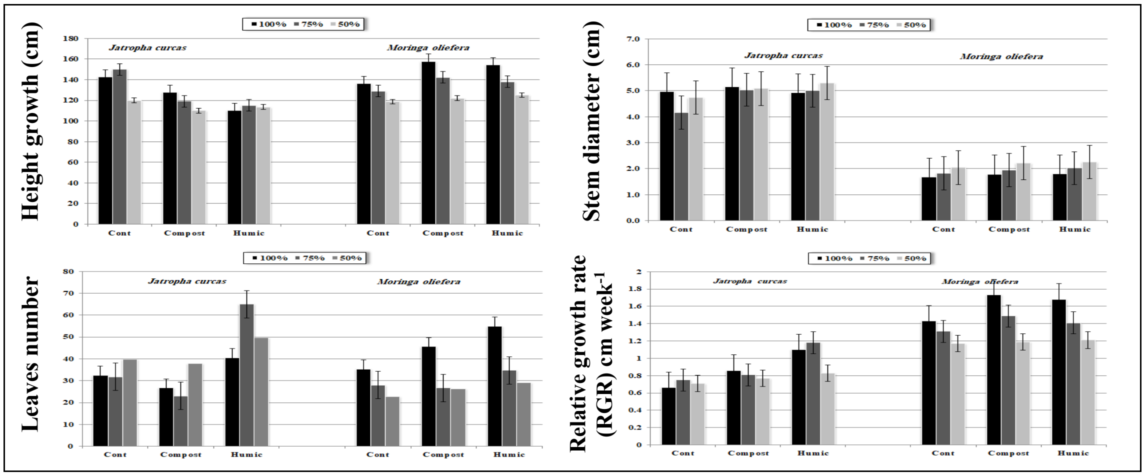

Fig. 1. Interaction of drought treatments and organic substance on some growth parameters of *Jatropha curcas* and *Moringa oleifera* seedlings after two successive seasons.

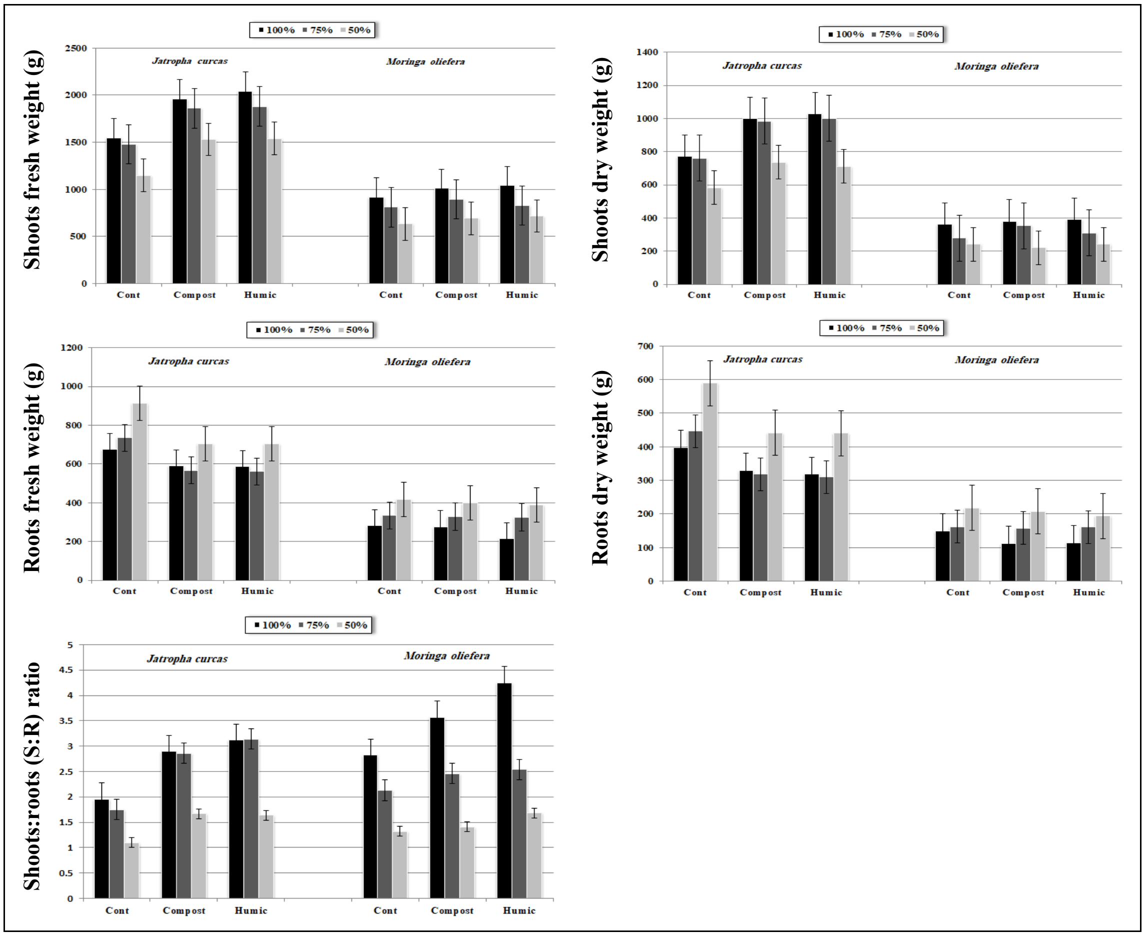

Fig. 2. Interaction of drought treatments and organic substance on biomass parameters of *Jatropha curcas* and *Moringa oleifera* seedlings after two successive seasons.

These data reflected that total F.C. (100%) recorded the higher S:R ratio for *M. oleifera*. Table (8) reveals that compost and humic had the same significant effects on the seedlings where they increased the fresh and dry shoots biomass as well as, both increased S:R ratio of the seedlings. In contrast, both organic substances decreased the fresh and dry roots biomass of *M. oleifera* seedlings. According to the interaction effect, it seems that compost under 100% F.C. was the best treatment, which recorded the highest significant biomass of shoots and roots also, the highest S:R ratio (Fig., 2). The decline of shoots as a result of drought could be clarified throughout the reduction of photosynthetic rate thus disrupt carbohydrate metabolism in leaves (Attila *et al*., 2016). The results of increasing roots biomass (fresh and dry) by water deficit treatment (50% F.C.) is compatible with Pallardy *et al.* (1993) and Grubb (1998). Moreover, the high results of humic on shoots biomass agree with those obtained by (Pelleschi *et al*., 1997 and Cacco *et al*., 2000). The enhancement of biomasses by adding organic substances could be explained as the lack of organic matter lead to nitrogen depression as a result of decrease the soil microorganisms (Zachariakis *et al*., 2001) that able to decompose a sufficient amount of organic material to provide the needed nitrogen (Haouvang *et al*., 2017). The decreasing shoot: root ratio of *J. curcas* and *M. oleifera* with increasing irrigation deficit, is considered one of the avoidance mechanisms enabling plants to maximize the water uptake under drought stress conditions as concluded by (Craul, 1992).

4. Chemical composition:

Leaf nutrient composite:

Table (9) reveals that the total content of N, P, and K of *M. oleifera* seedlings significantly affected by water deficit where its contents in severe water deficit declined by 21.31, 49.24, and 23.41% less than well-watered treatment, respectively. Alternatively, both amendments enhanced the total content of N, P, and K, of M. oleifera more than control with the priority of humic acid by 1.39 % than compost for K, whereas, both amendments were significantly similar to increase total N and P of *M. oleifera* (Table, 10).

Macro-nutrients in the leaves of *J. curcas* had the same trend where, the total content of P and K in severe water deficit declined by 16.36 and 16.53% less than well-watered, respectively (Table, 9). Whereas only total N had a reverse trend this may be due to errors during the appreciation. Also, Table (10) indicates that humic acid was the better amendment for improving the total content of N, P, and K followed by compost. As a result, adding humic acid under well-watered was the better treatment to increase total nutrients for *J. curcas*. The different effects between compost and humic are probably that humic acid is not a fertilizer, but instead a complement to fertilizer. It essentially helps in the movement of micronutrients from soil to plant. These results are compatible with (Celik *et al*., 2004; Chaves *et al*., 2003 and Chen *et al*., 2004), who stated that humic acid improves the growth in numerous ways as, clay disaggregation, water penetration enabled, micronutrient transference, and microorganism stimulation. Also, humic acid has a great role in improving soil fertility (Pettit, 2004). Compost addition has a great role in drought resistance and more efficient water utilization and the irrigation frequency and intensity reduced. Goncalves and Carlyle (1994) mentioned that the nitrogen mineralization rate generally increased as soil moisture increases. In this respect, Eghball *et al*. (2002) detected greater soil NO_3 contents in non-organic fertilized soils than organically amended when precipitation was 56% and 80% below the average. They concluded that this was due to decreasing the microbial activity in the amended soils. Nutrient mineralization in compost is attributed to the active carbon pool where

Table 9. Means of some chemical composition parameters of *Jatropha curcas* and *Moringa oleifera* seedlings affected by drought stress treatments after two successive seasons.

Field capacity	Total nitrogen g Kg^{-1} DW	Total phosphorus g Kg^{-1} DW	Total potassium g Kg^{-1} DW	Total chlorophyll mg 100g^{-1} FW	Total nitrogen g Kg^{-1} DW	Total phosphorus g Kg^{-1} DW	Total potassium g Kg^{-1} DW	Total chlorophyll mg 100g^{-1} FW
	Jatropha curcas				***Moringa oleifera***			
100%	22.47 c	6.42 a	9.74 a	202.56 a	30.55 a	9.22 a	8.33 a	225.00 a
75%	26.71 b	6.10 b	8.66 b	182.20 b	30.06 a	7.14 b	7.76 b	185.86 b
50%	27.69 a	5.37 c	8.13 c	133.63 c	24.04 b	4.68 c	6.38 c	169.34 c

	Total carotenoids mg 100g^{-1} FW	Proline mg g^{-1} DW	Phenols mg g^{-1} DW	Total carotenoids mg 100g^{-1} FW	Proline mg g^{-1} DW	Phenols mg g^{-1} DW
100%	22.26 a	0.235 b	0.47 c	33.40 a	0.015 b	0.35 c
75%	21.85 a	0.264 b	0.60 b	28.86 b	0.039 ab	0.45 b
50%	20.07 b	0.312 a	0.69 a	25.79 c	0.059 a	0.53 a

Means followed by a similar letter within a column are not significantly different at the probability level 0.05 using Duncan's Multiple Range Test.

Table 10. Means of some chemical composition parameters of *Jatropha curcas* and *Moringa oleifera* seedlings affected by organic substances after two successive seasons.

Organic substances	Total nitrogen g Kg^{-1} DW	Total phosphorus g Kg^{-1} DW	Total potassium g Kg^{-1} DW	Total chlorophyll mg 100 g^{-1} FW	Total nitrogen g Kg^{-1} DW	Total phosphorus g Kg^{-1} DW	Total potassium g Kg^{-1} DW	Total chlorophyll mg 100 g^{-1} FW
	Jatropha curcas				***Moringa oleifera***			
Cont.	22.53 c	5.64 c	7.70 c	158.28 c	25.46 b	6.45 b	6.79 c	140.94 c
Compost	26.76 b	5.98 b	9.27 b	174.86 b	29.66 a	7.25 a	7.79 b	205.74 b
Humic	27.57 a	6.27 a	9.55 a	185.26 a	29.53 a	7.35 a	7.90 a	231.68 a

	Total carotenoids mg 100 g^{-1} FW	Proline mg g^{-1} DW	Phenols mg g^{-1} DW	Total carotenoids mg 100 g^{-1} FW	Proline mg g^{-1} DW	Phenols mg g^{-1} DW
Cont.	18.25 c	0.287 a	0.63 a	23.29 c	0.048 a	0.48 a
Compost	22.60 b	0.271 a	0.56 b	30.55 b	0.033 a	0.42 b
Humic	23.34 a	0.258 a	0.57 b	33.87 a	0.032 a	0.43 b

Means followed by a similar letter within a column are not significantly different at the probability level 0.05 using Duncan's Multiple Range Test.

is easily mineralized by microbes and serves as an available nutrient source to plants and microorganisms. The relative stability of compost (*i.e.* its resistance to rapid mineralization) is due to the presence of a stable carbon pool, where decomposed biomass is in a humified semi-final state. Humification occurs during composting and is the transformation of organic material into high molecular weight molecules termed humic substances (Adani *et al*., 1999). Fig. (4) concluded that the treatment of 100% F.C. significantly, increased total chlorophyll and decreased phenols contents of *J. curcas* seedlings. Afterward, 75 and 100% F.C. treatments were similar to increase total carotenoids and decrease proline contents of the seedlings. Humic acid gave the higher T. chlorophyll and total carotenoids more than compost but both humic and compost were significantly similar in decreasing phenols content without any effect on proline content. Interaction between compost or humic under 100% F.C. resulted from the higher total chlorophyll and the fewer phenols content for the seedlings. While,

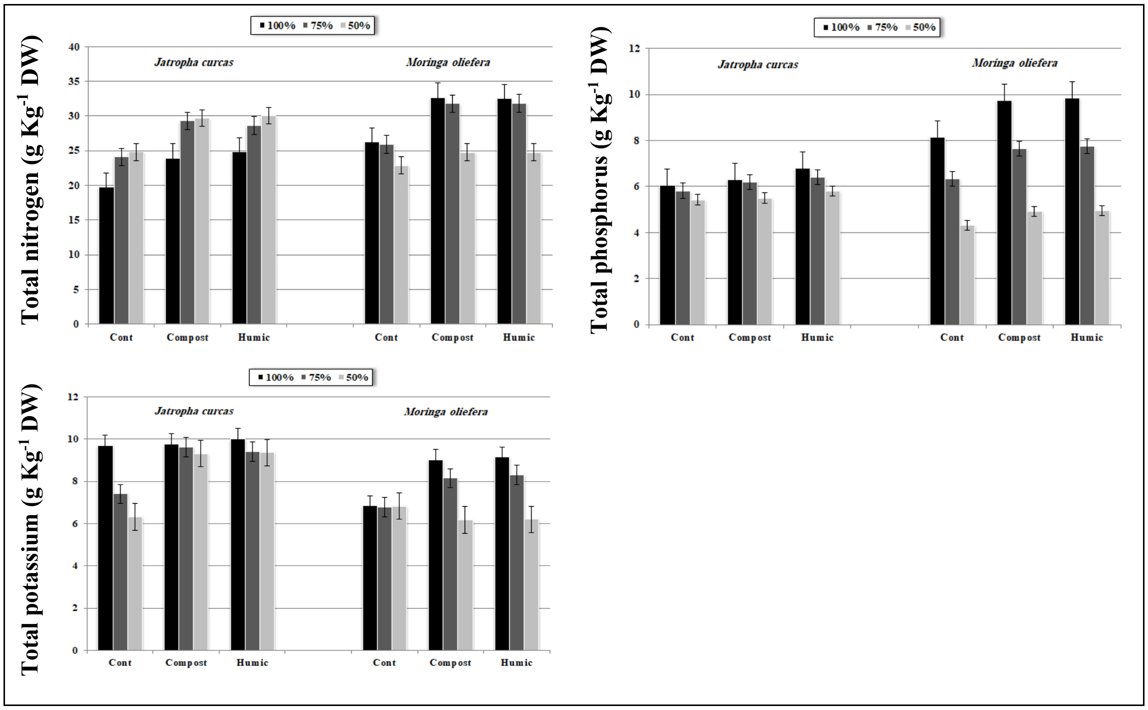

Fig. 3. Interaction of drought treatments and organic substance on foliar total nitrogen, phosphorus, and potassium of *Jatropha curcas* and *Moringa oleifera* seedlings after two successive seasons.

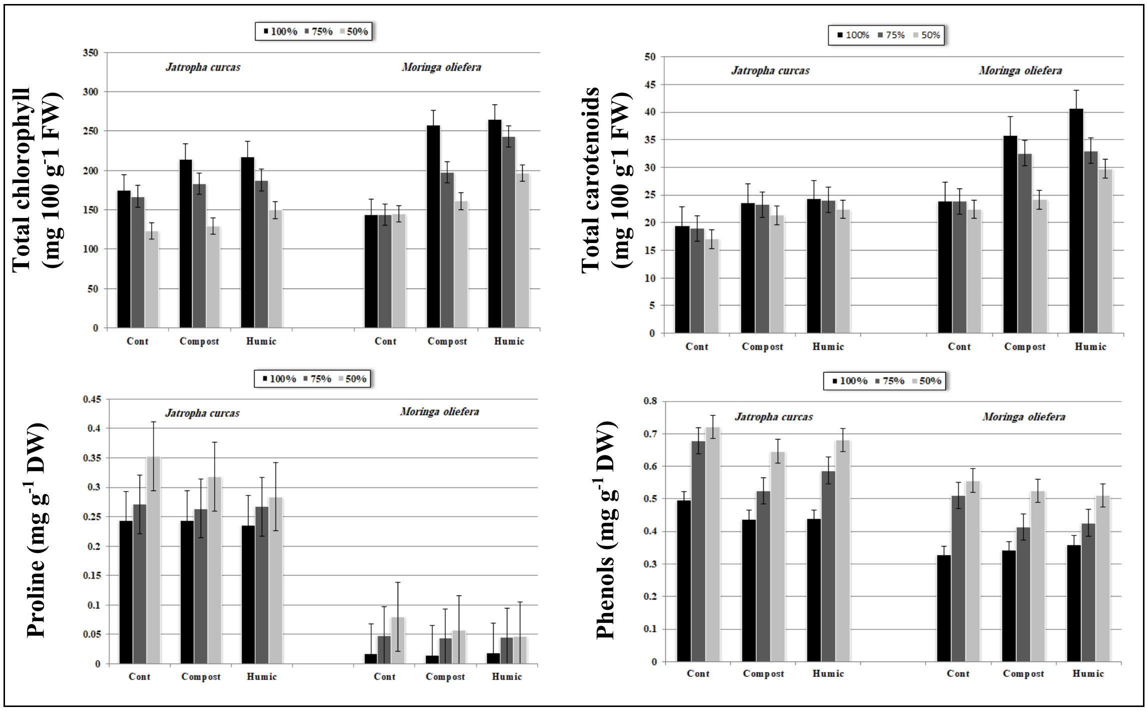

Fig. 4. Interaction of drought treatments and organic substance on some chemical composition parameters of *Jatropha curcas* and *Moringa oleifera* seedlings after two successive seasons.

humic under 75% F.C. resulted in the higher total carotenoids for the seedlings.

Fig. (4) shows that the 100% followed by 75% F.C., increased total chlorophyll and total carotenoids of *M. oleifera* more than the seedlings irrigated with 50% F.C. Whereas, stressed irrigation treatment (50% F.C.) increased proline and phenols concentrations of *M. oleifera* seedlings. The results of applying organic substances exposed that humic acid is the best one that increases *T. chlorophyll* and *T. carotenoids* and decreased phenols content of the treated seedlings. The proline content did not affect by adding the organic substances. Humic acid under 100% F.C. was the best treatment that increased *T. chlorophyll* and *T. carotenoids* and decreased the proline and phenols contents (Fig., 4).

Data of total chlorophyll content are harmonized with (Cacco *et al*., 2000). Chlorophyll plays a key role in photosynthesis, which is the main process responsible for dry matter accumulation and consequently affects plant development and growth, which are strongly affected by the environment (McCree, 1986). Drought stress at its initial phase limits photosynthesis due mainly to stomatal closure (Miyashita *et al*., 2005) and stomatal control is one of the main mechanisms for adapting to water deficit (Laffray and Louguet, 1990). In a drought, plants usually increase carotenoid levels to cope with oxidative stress. Therefore, in this study, results of total carotenoids for both species are matched with (Young and Brittonm, 1990), who mentioned that in severe stress, carotenoids may be rapidly destroyed and therefore are no longer available to protect against oxidative damage. Also, the results of proline are comparable with (Kandowangko *et al*., 2009) who mentioned that the accumulated proline supports in minimizing osmotic potential in turn leaf water potential which renders the plant to sustain the photosynthetic apparatus by retaining elevated organ hydration and turgor pressure maintenance. Plants produce phenolic compounds to avoid the oxidative damage caused by drought (Varela *et al*., 2016). Carotenoids also play a critical role in the assembly of the light harvest complex and the radiation limited dissipations of excess energy associated with the conversion of violaxanthin to zeaxanthin (Streb *et al*., 1998).

CONCLUSION

We recommend that both Jatropha curcas and Moringa oleifera are well adapted to semi-arid regions when amended with humic or compost, under an irrigation deficit of 75% of field capacity

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تأثير المادة العضوية على نمو شتلات الجاتروفا والمورينجا تحت معاملات العجز المائي

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أجريت تجربة حقلية بمعمل بحوث الاراضى الملحية والقلوية بالصبحية بالإسكندرية. لتحديد معدل الري المناسب وأفضل مادة عضوية في تربة طمييه رملية بهدف تحسين صفات النمو والكتلة الحيوية والتركيب الكيميائي لشتلات الجاتروفا والمورينجا. تم تطبيق ثلاثة مستويات من العجز المائى (١٠٠ ، ٧٥ ، ٥٠٪ من السعة الحقليه للتربه) وثلاث معالجات بالمادة العضوية (كنترول ، كمبوست ، حمض الهيوميك). أظهرت النتائج أن قيمه الكثافة الظاهرية لتربة شتلات الجاتروفا والمورينجا لم تتأثر معنوياً بمعاملتي العجز المائي ١٠٠ و ٧٥٪ الا ان معامله العجز المائي ٧٥٪ يمكن أن يوفر ٢٥٪ من مياه الري المضافه مقارنه بالكنترول. معاملة حمض الهيوميك حسنت الكثافة الظاهرية للتربة بشكل أفضل من الكمبوست. أيضا معاملتي حمض الهيوميك والكمبوست عند مستوى عجز مائي معتدل (٧٥٪ من السعة الحقليه) حققتا أعلى تغيير في السعه التبادليه الكاتيونيه للتربه نحو التأثير المرغوب، لكن أفضلية لحمض الهيوميك بنسبة ١٥,٩٦٪ من الكومبوست. حققت معاملة الكمبوست عند مستوى عجزمائي جيد (١٠٠٪ من السعة الحقليه) أعلى نسبة تركيز لكل من الكربون المتحرك والعناصر الغذائيه المتاحه (النتروجين و الفوسفور) في تربة شتلات المورينجا والجاتروفا مقارنه بالكنترول. في حين أن حمض الهيوميك زاد من البوتاسيوم المتاح بالتربة أفضل من الكمبوست بمقدار ١,٣ ضعفاً. بصفة عامة، أدى تقليل الري من ١٠٠٪ إلى ٥٠٪ من السعة الحقليه، الى انخفاض النمو والكتلة الحيوية. كانت معامله العجزالمائي ٧٥٪ هي الأفضل حيث عززت النمو والكتلة الحيوية لشتلات الجاتروفا. وتفوق حمض الهيوميك على الكمبوست في زيادة قيم عوامل النمو ولكن كل من الكمبوست وحمض الهيوميك كانا متشابهين فى زيادة الكتلة الحيوية للمجموع الخضرى (الطازجة والجافة) وتقليل الكتلة الحيوية للجذور. أكدت النتائج أن العناصر الغذائية في أوراق الجاتروفا و المورينجا كان لها نفس الاتجاه حيث انخفض المحتوى الإجمالي للفوسفور والبوتاسيوم عند عجز المياه الحاد (٧٥٪) بالمقارنه بمستوى الري الجيد. اضافه كل من الكمبوست وحمض الهيوميك، عززا المحتوى الكلي من النيتروجين والفوسفور والبوتاسيوم في أوراق المورينجا والجاتروفا بالمقارنه مع الكنترول تفوق ظاهر لحمض الهيوميك في ظل الري

الجيد. (١٠٠٪ من السعة الحقلية). لذلك نوصي بأن شتلات كل من الجاتروفا *Jatropha curcas* والمورينجا *Moringa oleifera* يتكيفان جيداً مع المناطق شبه القاحلة عند تحسين تربتها باستخدام حمض الهيوميك أو الكمبوست، تحت معدل رى ٧٥ ٪ من السعة الحقلية.