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Effectiveness of Growing *Kochia indica* Under Organic Farming in Combating Desertification

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Abstract

Desertification, exacerbated by climate change, represents one of the greatest environmental challenges of recent times. Various approaches have been taken to combat desertification. Among these, revegetation of the arid lands, using plant species that are more tolerated and adapted to harsh conditions dominated in the deserts. Halophytic plants are probably the most effective practice owing to its affordability in combating desertification. Vegetation cover not only prevents desertification process, but also significantly improves soil and, in turn, the environmental condition of the region, since these halophytic plants can bioremediate the soil. Halophytes are particularly effective in this regard by reducing salinity level of the soil via removing the salts or by utilizing saline and low quality waters for their growth. Growing halophytes for forage production on salt-affected soil under organic fertilization was suggested as a new approach to combat desertification. Field trials were carried out at private salt affected farm in Tamia , Faiyoum Governorate, Egypt to evaluate the growth and productivity of *Kochia indica* grown under drip irrigation system with saline water (EC : 6.6 dSm^{-1}). Five organic fertilization treatment were applied (control, chicken manures, cattle manures, Charcoal and green manure). Significant differences were reported for growth parameters and physiological aspects as well as nutritional values of the tested plants with superiority to chicken manures. Moreover, growing Kochia plants under organic fertilization have positive impact on soil bioremediation process by decreasing EC as well as the content of Na^+ and Cl^- in the soil. *Kochia indica*, seemed to be promising halophytic plants for feeding goats and sheep in desert area. It can be concluded that some halophytes may be used not only as a tool for combating desertification in arid and semi-arid regions through depleting soil salts, but also offering a new salt-tolerant forage crops can grow better under organic agriculture.

Keywords: Combating desertification, Saline habitats, *Kochia indica*, Organic fertilizers.

1 Introduction

Desertification is one of the greatest challenges facing humankind. Its extent and impact on human welfare and the global environment are now greater than ever before. Particularly, in arid and salt affected regions, the rate of desertification is frighteningly high and consequently, crop production and livestock husbandry are alarmingly at high risk [1]. In such circumstances, a whole mixture of initiatives should be undertaken to curtail further desertification processes. Desertification is a process of land degradation in areas vulnerable to severe edaphic or climatic aridity. This degradation leads to the reduction or destruction of the land's biological potential, to a deterioration of living standards and to the intensification of desert-like conditions [2]. Desertification is essentially a result of soil degradation. The direct effect of land degradation is either a decrease of land productivity or the complete abandonment of agricultural land, which leads to the food crisis confronted by arid regions [3].

Therefore, use of low-quality water for irrigation of some halophytic plant species will be a good solution under these circumstances. Using low-quality water imposes more stress on plants, which are already under stress. Thus, there is an urgent need for finding stress tolerant plant species to survive under such stressful conditions [4]. Since halophytic plants are already growing under such conditions and are adapted to these stresses, they are the most suitable candidates to be manipulated under the minimum cultural practices and minimum inputs for use under stress [5].

One of the main strategies to combat desertification is using organic fertilizer to help in building soil layers and reduce erosion. Organic manures apart from reducing moisture losses through evaporation can also have other positive effects on soil productivity, including reducing wind and water erosion, reducing the mechanical impact of rain, hail and wind, increasing water infiltration, slowing down runoff, reducing soil temperature fluctuations,

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reducing weed growth, increasing seed germination and improving plant growth [6]. Organic fertilizers help in building and maintaining soil fertility primarily through their basic farming practices. They depend on multicropping systems and crop rotations, cover crops, minimum tillage to maintain and improve soil quality [7]. The natural fertilizers they use, such as green manure, farmyard manure, compost and plant residues, build organic content and increase the soil's capacity to circulate nutrients, air and water [8 and 9].

The objectives of this study were to domesticate some salt tolerant halophytic plant species under organic agriculture systems, for using in salt affected arid regions, where limited water supplies coupled with saline soils result in salinity and aridity stresses.

2 Materials and Methods

Field trial was carried out at private salt affected farm in Tamia , Faiyoum Governorate, Egypt to evaluate the growth and productivity of *Kochia indica* grown under drip irrigation system with saline water (EC : 6.6 dSm^{-1}) Table (6). Kochia plants were transplanted at 15th March 2017. The experiment was laid out in complete randomized design (CRD) (0.5 x 1 m distance between plants) i.e. 8400 plants /fed. Five organic fertilization treatments were applied (chicken manures, cattle manures, Charcoal. and green manure), in addition to control treatment (recommended mineral fertilization). Each plant in the control treatment was fertilized with 50 g calcium superphosphate (15.5% P_2O_5) and 30 g potassium sulphate (48.0 % K_2O) and 60 g urea (46.5% N) for the control treatment. While it was 2 kg from the specified fertilization for each organic treatment. Fertilization dose was applied on three doses at transplantation and after 50 and 100 days from transplantation for all treatments. Chemical composition of organic manures are presented in Table (2). Physical and chemical analysis of the soil site was carried out before plant transplantation and after 6 months of growing Kochia plants (average values of different organic fertilizer treatments), by using the standard method described by (Klute, 1986) [10] (Table, 3). All agronomic practices were followed as recommended for production in this district. Four representative vegetative plant sample was taken after 180 days from sowing for each treatment from four replicates for measuring plant height (cm.), number of branch/plant, leaf area (cm^2) and stem diameter (cm). The following physiochemical measurements were determined in the fresh leaves: chlorophyll a+b (mg/g fresh weight) according to von Wettstein (1957) [11], proline according to Bates *et al*., (1979) [12] and soluble carbohydrates according to Dubois *et al*., (1956) [13]. Then the different parts of the plant were then dried to constant weight at 70° to determine the dry weight (g) of shoot and root as well as total productivity. The dried plants were then thoroughly ground to fine powder and total nitrogen percentage was determined according to the method described by A.O.A.C. (2010) [14]. Crude protein was calculated for each treatment. The content of sodium and potassium were determined in the digested material using Jenway flame photometer as described by A.O.A.C. (2010) [14] and K/Na ratio calculated. Crude fiber and ash % was determined according to A.O.A.C. (2010) [14]. The obtained results were subjected to statistical analysis of variance according to (Snedecor and Cochran, 2012) [15].

Table 1: Water analysis of irrigation water.

	pH	7.5
	EC dS^{-1}	6.6
Soluble cations Meq/L	K^+	0.5
	Na^+	55.2
	Mg^{++}	10.7
	Ca^{++}	18.7
Soluble anions Meq/L	SO4--	26.0
	Cl-	61.3
	HCO3-	2.8

Table 2: Chemical composition of organic manures

Organic manures	pH	EC (dSm^{-1})	C/N ratio	Organic matter %	Organic carbon %	Nitrogen %	Available P (ppm)	Available K (ppm)
Chicken manures	7.96	0.32	14.35	46.37	26.95	2.17	247	193.5
Cattle manures	7.29	0.34	14.88	40.67	23.64	1.98	225.2	171.3
Green Manure	7.65	0.31	16.91	33.87	34.6	1.02	165.3	139.8

3 Results and Discussion

3.1 Bioremediation of salt affected soil through vegetation of Kochia indica under organic farming

Regardless to the applied organic fertilizer, data presented in Table (3) cleared that, K and organic carbon content increased by growing Kochia plants. On the contrary, all cations, all anions and electrical conductivity E.C. were decreased in the soil analysis after 6 months of growing Kochia plants as compared with the initials characters, this may be due to the leaching process and to the accumulation of salts by *Kochia indica*, since halophytic plants are capable of accumulating salts into their leaves' vacuoles. These results are in agreement with those obtained by (Zedler *et al*., 2003) [16]. In this concern, (Yan *et al*., 2006) [17] indicated that there are different adaptive strategies for halophytic seedlings in organic acid metabolism under salt and alkali stress. Furthermore, Ahmad and Chang, (2002) [18] stated that kallar grass accomplished the best removal of salts from the soil. Numerous suggestions have been advanced to remediate the effects of salts in the soil by some halophytic plant species by their ability to mitigate salts in soil solution either by plant uptake or by chemical alteration of the soil. Remediation methods as the most environmentally sustainable method in dealing with the saline-sodic conditions. In this concern, Ravindran *et al*., (2007) [19] hypothesized that beneficial effects of plants in reclamation are not well understood but appear to be related to the physical action of the plant roots, the addition of organic matter, the increase in dissolution of $CaCO_3$ and crop uptake of salts. They added that *Suaeda maritima* and *Sesuvium portulacastrum* exhibited greater accumulation of salts in their tissues as well as higher reduction of salts in the soil medium. However, addition of charcoal produced the highest values of organic carbon content as compared with other organic treatments. Meanwhile, addition of chicken manure recorded the highest K content and effectively recorded the highest reduction in EC and other cations and anions. On the other hand, no clear effect was detected in soil texture and HCO_3%. These results agrees with previous reports that organic amendments increase available C and K as w well as improve soil EC [20]. Organic amendments could likely be considered for soil remediation in the salt-affected areas due to their high organic matter content since, organic matter has several beneficial effects on agricultural fields, such as the slow release of nutrients, soil structure improvement, and the protection of soils against erosion [21]. In this regards, Kahlown and Azam (2003) [22] carried on experiments on salt affected soil (EC 2.25 $mS \cdot cm^{-1}$) stated that, addition of farmyard manure, improve infiltration rate by about 89%, and decreasing soil sodicity by 41.3%. Decreasing soil bulk density, allowing an enhancement of soil porosity and aeration, and improving saline water leaching. Recently, Gobarah *et al*., (2017) [9] stated that, *Leptochloa fusca*, *Spartina patens* and *Sporobolus virginicus* plant species have excellent potential to be used under harsh environmental conditions. These plant species can sufficiently remediate the land to the point where native plants can re-establish. As well as the potential benefits for nature conservation and agriculture and for rehabilitation and reclamation of salt-affected soil. Moreover, could be an appropriate option for alleviating desertification problems. On conclusion, data in Table (3) cleared that, *Kochia indica* are very useful on salt-affected soils as they can improve saline and alkaline conditions, they are good biological method for the reclamation of salt affected soils so that many commercial and forage crops can be grown. They excrete salts through specialized glands and is therefore reasonably palatable to farm animals. Moreover, organic fertilizer can restore soil quality in salt-affected soils.

Table 3: Soil analysis of the experiment site before transplantation and after 6 months of growing Kochia plants under different organic fertilizers

Soil characteristics	Before transplantation		After 6 months of chicken manure		After 6 months of cattle manure		After 6 months of charcoal		After 6 months of green manure		Average values of different organic fertilizer	
	0-30	30-60	0-30	30-60	0-30	30-60	0-30	30-60	0-30	30-60	0-30	30-60
EC (m mohs/cm)	8.1	6.6	5.36	4.65	6.58	5.78	7.5	6.42	7.3	6.1	6.69	5.74
HCO3%	3.6	3.4	3.15	3.02	3.02	3	3.35	3.17	3.23	3.09	3.19	3.07
SO4%	42.6	31.8	39.68	22.58	38.3	21.35	39.87	23.57	36.58	20.87	38.61	22.09
%Cl	112.7	55.8	77.88	32.58	88.35	38.65	102.36	42.36	98.32	41.25	91.73	38.71
Ca (ppm)	54.2	32.6	44.36	29.58	47.3	31.25	48.36	31.22	48.54	30.36	47.14	30.60
Mg (ppm)	35.2	31.8	28.69	25.99	28.69	25.99	31.02	26.87	28.69	25.99	29.27	26.21
K (ppm)	0.28	0.25	0.64	0.51	0.55	0.42	0.25	0.21	0.45	0.32	0.47	0.37
Na (ppm)	87.3	55.9	48.65	36.36	55.36	39.14	75.36	50.36	59.36	42.36	59.68	42.06
pH	7.8	7.8	7.7	7.6	7.4	7.5	7.9	7.7	7.4	7.5	7.60	7.58
Organic C	9.68	8.69	15.09	14.56	16.36	14.98	33.36	31.58	21.36	18.69	21.54	19.95
Soil Texture	Sandy soil		Sandy soil		Sandy soil		Sandy soil		Sandy soil		Sandy soil	

3.2 Effect of organic fertilization treatments on some growth parameter of Kochia indica in saline habitates.

Data illustrated in Table (4) revealed significant positive impacts of the different fertilization treatments on the studied growth parameters of kochi plants i.e., plant height (cm), number of branch/plant, leaf area (cm^2), and stem diameter (cm) as well as the dry weight of shoot and root (g) / plant with superiority for the chicken manure and control treatment which produced the highest values for all the previous characters. These findings are in harmony with those obtained by Diacono and Montemurro (2015) [23]. The increase in growth parameters can be explained through the fact that nitrogen has a vital role in building up metabolites and carbohydrates which transferred from leaves to developing roots enhancing root length, diameter and weight as well as yield characters. The superiority of both chicken and cattle manure could be because manure contains all the essential micro and macro elements required for plant growth. In this concern, Reddy and Crohn (2014) [24] stated that, application of animal manure increases soil organic matter and improves a number of soil properties including water-holding capacity, oxygen content, and soil fertility. It also reduces soil erosion, improves solar heat absorption, increases water infiltration rates, reduces nutrient leaching and decrease desertification.

This increase could be to the favorable condition as a result to addition of different organic treatments. Moreover, positive effects of organic manures on plant growth and yield were not only due to availability of essential minerals but also due to provision of plant growth influencing material such as auxin, amino acids and vitamins produced by their decay which promote the plant growth [25]. In this concern, Roy *et al*., (2006) [26] proved that, some amendments could likely be considered for soil remediation in the salt-affected areas due to their high organic matter content. They added, organic matter has several beneficial effects on agricultural fields, such as the slow release of nutrients, soil structure improvement, and the protection of soils against erosion. Moreover, Mahdy (2011) [27] stated that, compost (animal wastes and plant residues) decreasing EC and sodium adsorption ratios of the saturation extracts of the soils. Who added that, organic amendments co-applied with chemical amendments seemed to have a high value for reducing soil pH, soil salinity and soil sodicity. Kahlown and Azam (2003) [22] added that, farmyard manure + saline water (EC 2.25 $mS \cdot cm^{-1}$), cause improvement of infiltration rate by about 89% and decreasing soil sodicity by 41.3%. They also added, decreasing soil bulk density, allowing an enhancement of soil porosity and aeration, and improving saline water leaching. Furthermore, Wang *et al*., (2014) [7] stated that, mixture of green waste compost, sedge peat and furfural residue, decreasing bulk density, EC, and ESP and increasing total porosity and organic carbon. They also added, the combination of amendments had substantial potential for ameliorating saline soils, working better than each amendment alone. Recently, Gobarah *et al*., (2017) [9] stated that, *Leptochloa fusca*, *Spartina patens* and *Sporobolus virginicus* plant species have excellent potential to be used under harsh environmental conditions. These plant species can sufficiently remediate the land to the point where native plants can re-establish. As well as the potential benefits for nature conservation and agriculture and for rehabilitation and reclamation of salt-affected soil. Moreover, could be an appropriate option for alleviating desertification problems and providing alternative good quality and economic unconventional feed materials for animals. Therefore, proper selection of organic fertilizers as nutrient sources can help plants to grow better in saline habitats.

Table 4: Effect of organic fertilization treatments on some growth parameter of *Kochia indica*.

Fertilizer treatment	Plant Height (cm)	Number of branch/plant	Leaf area (cm^2)	Stem diameter (cm)	Shoot dry weight/plant	Root dry weight/plant	Total productivity / plant
Control	103.03	40.25	64.49	3.3	123.96	27.2	151.16
Chicken manures	103.59	41.12	66.67	3.32	128.6	27.09	155.69
Cattle manures	101.36	39.73	62.85	3.24	119.09	27.65	146.74
Charcoal	99.82	37.23	57.29	3.2	106.81	28.09	134.9
Green manure	95.83	35.77	53.28	3.07	101.18	29.2	130.37
LSD 5%	8.36	3.02	5.02	0.22	8.65	2.35	11

3.3 Effect of organic fertilization on some physiochemical parameter of Kochia indica.

Data presented in Table (5) revealed that different organic fertilization treatments have significant results on the studies content physiochemical parameters i.e. soluble carbohydrate %, proline content, chl.a+b, sodium content, potassium content and K/Na ratio in *Kochia indica* plants. The highest values of soluble carbohydrates % and proline were recorded under control treatment. On the other hand, treating plants with chicken manure produced the highest values for the content of chl.a+b and potassium as well as K/Na ratio in Kochia leaves .Similar results were obtained by Metin *et al.*, (2010) [22]. These increment may explain the efficiency of suitable quantity of organic fertilizers that can attract and hold nutrients and water on its surface to supply the plants with suitable amounts for a longer time and may be due to release of some nutrients; such as, Fe, Zn and Mn through the breakdown of organic manure in the soil and makes these elements in available forms and this in turn improves N and K and this reflects a beneficial effect on growth and dry weight (Diacono and Montemurro, 2015) [23]. Moreover, the increments in K as a result of organic fertilizers application may be attributed to their favorable effect on Kochia vegetative growth (4) as mentioned earlier. Moreover, the relative positive effect of organic fertilizer treatment on growth criteria may be attributed to their N_2-fixing activity and the production of plant growth promoting substances such as IAA, gibberellins and cytokinine-like substances (Wu *et al.*, 2005)) [29].

T able 5: Effect of organic fertilization on some physiochemical parameter of *Kochia indica*.

Fertilizer treatment	Soluble carbohydrates %	Proline (ug/g fresh wt.)	Chlorophyll a+b (mg/g dry wt.)	Sodium content (mg/g dry wt.)	Potassium content (mg/g dry wt.)	K/Na ratio
Control	40.72	362.01	3.01	11.57	10.26	0.89
Chicken manures	39.61	352.13	3.32	11.18	10.68	0.96
Cattle manures	39.06	347.24	3.14	11.51	9.99	0.87
Charcoal	38.02	339.92	3.22	11.71	10.02	0.86
Green manure	36.91	328.1	2.9	11.35	9.69	0.85
LSD 5%	3.69	25.65	0.26	1.02	0.91	0.08

3.4 Effect of different organic treatments on nutritional values of Kochia indica

The content of crude protein, crude fiber and crude ash in respond to different organic fertilization treatments are indicated in Figs (1). There were significant differences in the content of (CP), (CF) and (C ash) among the different organic fertilization treatments. These halophytic plant could be considered as good fodders because of their palatability for all animal species, in addition to their moderate content of fiber and ash. The highest values of CF and and ash amounted to 22.65 % and 32.87% respectively were recorded under treaatment with cattle manure. Similar results were obtained by [30 and 4]. Nutrient contents varied among all halophytic plants including. Major research topics are to identify and select plant species tolerant to salt stress by selecting and using biomarkers to characterize halophytes, to evaluate the possible use of non conventional water such saline water, to select halophytes of a potential importance in the field of human or animal nutrition [31]. Who added that, recent advances in selecting species with high biomass and protein levels and the ability to survive a wide range of environmental conditions including salinity. Recently, Gobarah *et al.*, (2017) [9] stated that, *Leptochloa fusca*, *Spartina patens* and *Sporobolus virginicus* are promising halophytic plants for feeding goats and sheep in desert area by using saline water in irrigation, offering a new salt-tolerant forage crops can grow better under organic agriculture.

4 Conclusion

Obtained results proved that, *Kochia indica* have excellent drought and salinity tolerance features with a great potential to be used under harsh environmental conditions. These plant species can sufficiently remediate the land and decreasing soil salinity to the point where native plants can re-establish. As well as the potential benefits for nature conservation and agriculture and for rehabilitation and reclamation of salt-affected soil. Moreover, growing Kochia, could be an appropriate option for alleviating desertification problems and providing alternative good quality and economic unconventional feed materials for animals. Organic Agriculture should be a key component of programs aimed at stopping land degradation processes and bringing degraded lands back into production.

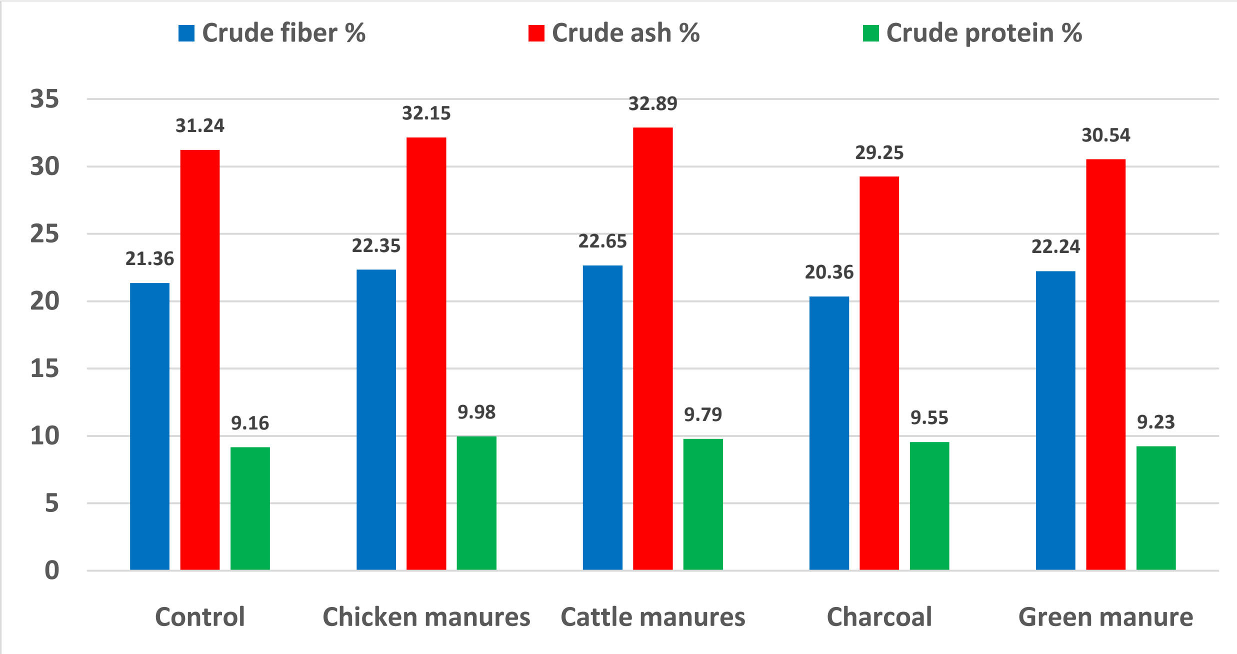

Figure 1: Effect of different organic treatments on crude protein %, crude fiber % and crude ash % of *Kochia indica* (combined analysis of 2016-2017 seasons) (LSD 5% crude protein 0.52 crude fiber: 1.23 & crude ash: 1.98)

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