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THE ROLE OF SOME TREE SPECIES IN SOIL IMPROVEMENT AT TOSHKA, SOUTH EGYPT.

Zaghloul, A.K.
Sand Dunes Dept., Desert Research Center, El -Matareya, Cairo, Egypt.

A filed experiment was carried out at Toshka located at the west of Nasser lake south of Egypt. The main objective is to study the role of four tree species (*Prosopis juliflora, Acacia saligna, Tamarix articulata* and *Casuarina equestifolia*) in improvement of the under laying sandy soil. The results showed that the afforestation of soil play an important role in improvement of both fertility and chemical properties of the relevant soil. However, there are significant improvement of the soil properties which covered by *Prosopis juliflora* and *Acacia saligna*. Therefore, the above mentioned two species are recommended for a large scale afforestation and shelterbelts in the similar areas having the same conditions.

Keywords: tree species, Toshka, aeolian sand deposits, afforestation, shelterbelt, fertility, soil properties, control of sand shifting.

Toshka is an arid region located in south Egypt west of Nasser lake. It is intersected by Lat 22 N and Long 27 E. In such locations, the aeolian sand deposits are one of the main land forms. At present, Toshka is receiving a great of attention. The national program for development and rehabilitation in Toshka is considering vast areas affected by the migration of sand shifting. As a part of a long term program, one kilometer of a greenbelt was established as an experimental pilot area, for sand encroachment control along the main irrigation canal of the land reclamation project (215 thousand hectare). In view of the improved measures taken in desertification control, certain ecological and environmental modifications have been observed. Zhenda *et al.* (1988) gave evidence that the macro, micro environmental and climatic properties of the local aeolian soil have changed along few years after the implementation of the dune fixation program, at Beijing – Tongliao railway line. The rate and amount of changes correlated with the nature of vegetation plant cover. Aggarwal (1980) and Singh *et al.* (1992) showed that the soil conditions were improved in association with some various plant species beneath their canopies. Similar observations were made by Sharma

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and Gupta (1989) when they compared the growth of six tree species used as dune fixation in the arid land of India.

In Egypt, although the sand dunes fixation program had started since the beginning of this century, limited information are available regarding the relationship between plant cover and soil properties in the respective sites. Draz and El-Maghraby (1997) indicated that the afforestation of sand dunes plays a significant role in the improvement of both fertility and chemical properties of the relevant soil layers. The rate of improvement is much controlled by the vegetation type. *Acacia saligna* and *Atriplex nummularia* have the most precede role. Therefore, the present investigation aimed at adding more knowledge about the impact of some tree species, cultivated as shelterbelt, on the soil properties of Toshka area.

MATERIALS AND METHODS

The present study was carried out to clarify the relationship between the cultivated tree species and the changes of soil characteristics at Toshka during the period 2001 to 2004. In this location, the cultivated plant species includes, *Acacia saligna, Prosopis juliflora, Tamarix articulata* and *Casuarina equestifolia*. At early October 2001, five rows of each plant were cultivated as shelterbelt for control of sand shifting affecting EL-Sheikh Zayed canal. Drip irrigation system was used for irrigation of the cultivated plants. The plants received equal amount of water according to the irrigation schedule of the shelterbelt. The soil texture and the quality of the irrigation water are presented in tables (1 and 2). The fertilization program includes 25g/tree and 50gm/tree ammonium sulfate (20.5% N) in the first and second year, respectively in addition to 125gm/tree calcium super phosphate (15.5%P_2O_5) in both season. Fifteen trees of each plant species were arranged in a complete randomized block design (3 replicates of each 5 trees).To achieve the required objectives, data were periodically collected during the study in summer 2002, winter 2003, summer 2003 and winter 2004.

Growth characters of the cultivated plants included survival rate (%), plant height (m), stem diameter (cm), crown cover (m^2) and crown volume (m^3). The crown cover and crown volume were calculated according to the formula adopted by Thalen (1979).

Chemical analysis of both stems and leaves of different plant species including N,P,K and Na were determined according to Champan and Pratt (1961).

For investigation of the physical and chemical soil characteristics, samples were collected at different depths (0-30, 30-60 and 60-90cm) underneath of each plant species. The soil samples were analyzed for the following:

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a- Mechanical analysis was carried out by dry sieving for coarse textured samples (Piper, 1950) and by the pipette method for heavy textured ones (Kilmer and Alexander, 1949).

b- Electric conductivity, soluble cations and anions and pH were determined according to Richard (1954).

c- Total nitrogen was determined by the method described by Hesse (1971).

d- Organic matter content was determined according to the procedure of Piper (1950).

e- Phosphorus is determined by the method described by Olsen *et al.* (1954).

f- Available iron, manganese, zinc, cupper and potassium were determined according to Soltanpour and Schwab (1977).

Statistical Analysis

The data of growth parameters and nutrients content of different trees species were statistically analyzed according to Snedecor and Cochran (1980). The scoring evaluation concerning the data achieved was adopted according to the method described by Selim *et al.* (1975).

TABLE (1). Particle size distribution of the soil at Toshka.

Soil depth (cm)	> 2	2-1 mm	1-0.5 mm	0.5-0.25 mm	0.25–0.125 mm	0.125–0.063 mm	<0.063 mm	Texture class	Sand	Silt	Clay
0 – 30	-	-	-	-	-	-	-	SCL	64.7	12.2	23.1
30 – 60	-	-	-	-	-	-	-	SL	70.0	18.5	11.5
60 - 90	6.4	12.4	14.8	21.8	26.54	16.48	1.58	Sand	-	-	-

SCL=Sandy clayey loam, SL=Sandy loam

TABLE (2). Chemical analysis of the water used for irrigation in the study area at Toshka.

pH	EC dS/m^{-1}	Soluble cations (me / l)				Soluble anions (me / l)				SAR
		Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	CO_3^{--}	HCO_3^{-}	SO_4^{--}	Cl^{-}	
7.79	3.11	7.85	0.7	0.89	22.66	-	4.51	13.19	14.4	11.0

SAR=Sodium adsorption ratio

RESULTS AND DISCUSSION

The results of the current investigation can be discussed as follows:

1- The Growth Behavior of the Cultivated Plants

Acacia saligna

The survival rate, after about six months from cultivation (summer season 2002), shows a value of 98.3%. In the following seasons, replanting of the missed plant was cultivated.

Plant height, stem diameter, crown cover and crown volume show variable effective differences among the four seasons. The ultimate values were varied from 114.0 to 286.1cm for plant height, 0.12 to 6.72cm for stem diameter, 0.45 to 4.4m^2 for crown cover and 0.34 to 8.39m^3 for crown volume.

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Prosopis juliflora

The calculated values of survival rate after about six months from cultivation (summer season 2002) reached a value of 98.8%. In the following seasons, replanting of the missed plants was implemented. The different growth parameters indicated variable effective differences among the four seasons. The values varied from 120.0 to289.9cm for plant height, 0.10 to 6.9cm for stem diameter, 0.89 to 6.34m² for crown cover and 0.71 to 12.24m³ for crown volume.

Tamarix articulata

The values of the survival rate after about six months from cultivation (summer season 2002) reached about 96.5%. In the following seasons, replanting of the missed plants was established. The records of the values growth parameters show variable effective differences among the study seasons. The ultimate values varied from 76.0 to 213.4cm for plant height, 1.8 to 7.8cm for stem diameter, 0.45 to 2.17 m² for crown cover and 0.23 to 3.09m³ for crown volume.

Casuarina equstifolia

After six months from cultivation (summer season 2002) the survival rate show a value of 84.1%. In the following seasons, replanting of missed plants was fixed. Plant height, stem diameter, crown cover and crown volume show variable effective differences among the four seasons. The values varied from 74 to 290cm for plant height, 0.10 to 7.81cm for stem diameter, 0.14 to 3.1m² for crown cover and 0.07 to 5.99m³ for crown volume.

Of special interest and according to scoring evaluation of the different growth parameter of the various plant species, it is found that *prosopis juliflora* and *casuarina equstifolia* have superior growth behavior. For this reason such plant species are commonly used for sand dune fixation and afforestation in the arid and semi arid regions (Anonymous, 1980 and Kaul, 1985). The reason for this, is the fast growing and easy propagation and fit adaptability under the harsh environment of such area (Baumer, 1983).

2- Nutrients Content of the Trees

Values of N,P,K and Na content of both the stems and leaves of different trees species are shown in table (4). In the stems, the highest values of N and K were attained by *Acacia saligna* followed by *Casuarina equestifolia*. The recorded values of N and K were 1.12 and 1.25% for the stems of *Acacia saligna* and 1.04 and 0.89% for the stems of *Casuarina equestifolia*, respectively.

Meanwhile, the stems of *Prosopis juliflora* followed by the stems of *Casuarina equestifolia* show the highest phosphorus content compared to the other plant species. The values attained were 0.33 and 0.31%, respectively. With respect to the Na content, data indicated that the stems of *Tamarix*

articulata and *Prosopis juliflora* were superior quality. The recorded values were 40 and 32ppm, respectively.

TABLE (3). Growth characters of the tree species grown for sand encroachment control.

Characters / Species	No. of cultivated plants	Survival rate (%)	Score	Plant height (cm)	Score	Stem diameter (cm)	Score	Crown cover (m^2)	Score	Crown volume (m^3)	Score	Means of scores
	Winter 2002											
Acacia saligna	810	100	-	114.0	8.80	0.12	1.71	0.45	4.70	0.34	4.78	5.00
Prosopis juliflora	740	100	-	120.0	10.00	0.10	1.69	0.89	10.00	0.71	10.00	7.92
Tamarix articulata	515	100	-	76.0	1.20	1.80	10.00	0.45	4.70	0.23	3.23	4.78
Casuarina equstifolia	735	100	-	74.0	1.00	0.10	1.00	0.14	1.00	0.07	1.00	1.00
L.S.D 0.05		-	-	1.5	-	0.09	-	0.16	-	0.11	-	-
	Summer 2002											
Acacia saligna	810	98.30	9.7	224.3	10.00	2.62	10.00	3.27	9.1	4.89	9.85	9.73
Prosopis juliflora	740	98.80	10.0	224.2	9.99	1.55	5.51	3.57	10.0	5.33	10.00	9.10
Tamarix articulata	515	96.50	7.6	96.1	1.00	2.40	9.10	0.54	1.0	0.35	1.00	3.94
Casuarina equstifolia	735	84.10	1.0	127.5	3.25	0.47	1.00	1.34	3.3	1.14	2.10	2.13
L.S.D 0.05		1.99	-	2.7	-	0.08	-	0.35	-	0.18	-	-
	Winter 2003											
Acacia saligna	824	99.30	9.8	235.60	10.00	5.41	8.0	3.83	9.9	6.01	10.00	9.54
Prosopis juliflora	749	99.50	10.0	230.30	9.88	3.61	1.0	3.85	10.0	5.91	9.78	8.13
Tamarix articulata	533	96.90	8.0	189.30	7.68	3.83	1.8	1.22	1.0	1.54	1.00	3.89
Casuarina equstifolia	852	87.60	1.0	185.10	1.00	5.93	10.0	1.43	1.8	1.76	1.34	3.02
L.S.D 0.05		1.71	-	1.25	-	0.33	-	0.55	-	0.46	-	-
	Summer 2003											
Acacia saligna	816	99.60	9.86	273.40	10.0	6.06	7.6	4.20	6.5	7.66	7.62	8.31
Prosopis juliflora	744	99.70	10.00	253.60	7.5	5.39	4.5	5.55	10.0	9.38	10.00	8.40
Tamarix articulata	531	98.50	8.65	206.40	1.0	4.64	1.0	2.09	1.0	2.87	1.00	2.53
Casuarina equstifolia	826	91.80	1.00	219.30	3.0	6.58	10.0	2.29	1.6	3.35	1.67	3.45
L.S.D 0.05		1.48	-	1.68	-	0.28	-	0.28	-	0.16	-	-
	Winter 2004											
Acacia saligna	816	100	-	286.10	9.53	6.72	1.00	4.40	5.18	8.39	6.22	5.48
Prosopis juliflora	744	100	-	289.90	9.99	6.90	2.52	6.34	10.00	12.24	10.00	8.12
Tamarix articulata	531	100	-	213.40	1.00	7.80	9.99	2.17	1.00	3.09	1.00	3.24
Casuarina equstifolia	826	100	-	290.00	10.00	7.81	10.00	3.10	2.74	5.99	3.87	6.65
L.S.D 0.05		-	-	1.61	-	0.35	-	0.30	-	0.14	-	-

In the leaves, the highest values of N and P were attained by *Prosopis juliflora* followed by *Acacia saligna*. The recorded values of N and P were 2.03 and 0.36% for the leaves of *Prosopis juliflora* and 1.54 and 0.34% for

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the leaves of *Acacia saligna*, respectively. While, the leaves of *Prosopis juliflora* followed by *Casuarina equestifolia* show the highest potassium content compared to the other plant species. The values attained were 1.39 and 1.04%, respectively. With respect to the Na concentration, data show that the leaves of *Tamarix articulata* and *Prosopis juliflora* were of superior quality. The recorded values were 63 and 48ppm, respectively. These results are in accordance with those obtained by Anthony (2002). The various values of the nutrients content among the plant species can be explained on the basis of different capacity of the nutrient uptake from the soil (Sharma and Gupta, 1989).

TABLE (4). Nutrients content of the different trees species.

Characters / Tree Species	Stems				Leaves			
	N%	P%	K%	Na ppm	N%	P%	K%	Na ppm
Acacia saligna	1.12	0.305	1.25	23.0	1.54	0.340	0.89	33.0
Prosopis juliflora	1.03	0.330	0.64	32.0	2.03	0.360	1.39	48.0
Tamarix articulata	0.98	0.300	0.83	40.0	1.05	0.295	0.90	63.0
Casuarina equstifolia	1.04	0.310	0.89	12.0	1.47	0.320	1.04	18.0
L.S.D 0.05	0.06	0.014	0.07	3.9	0.07	0.057	0.10	4.8

3- Effect of plant species on soil properties

The fertility and chemical properties of experimental soil show variable response in relation to plant species (Table 5). The results achieved can be presented as follows.

The detected records concerning organic matter and nitrogen content were higher in the cultivated plots compared to the barren soil. With the exception of *Acacia saligna*, values of the organic matter were higher in the surface layer compared to the deeper layers, On the contrary, the values of the total nitrogen of the top soil layer were higher in relation to the deeper layers. The higher content of organic matter and total nitrogen under the vegetated cover were previously reported by (Draz and EL- Maghraby, 1997). The higher content of the organic matter and total nitrogen under the vegetated cover is due to the accumulation of leaf litter and root decay in situ (Sharma and Gupta, 1989). In this respect, the content of organic matter is of the prime importance in the development and maintenance of soil fertility, because it improves the aeration and increases the moisture content of the soil. Moreover, organic matter affects on the activity of the microorganisms, reaction of soil and viability of the microflora especially the nitrifying microorganisms. The nitrogen content is also associated with the level of organic matter (Agrrawal, 1980).

Regarding the effect of plant species on the organic matter and nitrogen content, data revealed that the experimental plots covered with *Acacia saligna* and *Prosopis juliflora* have higher content of both constituents compared to the others. The increase of the content of both

substances is presumably due to higher litter fall of such plant species (Aggarwal, 1980).

Concerning pH values, data of the cultivated plots show slight decrease in the soil reaction compared to the barren soil. This is obviously observed in *Acacia saligna* and *Prosopis juliflora*. Such reaction in the plots covered with plant species can be explained on the basis of higher content of organic matter of the soil for such plots (Aggarwal and Lahiri, 1977).

The EC show slightly higher values in the vegetated plot compared to the barren soil. The values obtained, in average, are ranged from 0.23 to 1.55 dS/m^{-1} in the former and from 0.19 to 0.45 dS/m^{-1} in the latter. Concerning the effect of plant species on soil salinity, data show higher EC values for the plot cultivated with *Prosopis juliflora* followed by *Acacia saligna*. The averages of EC values of the soil beneath both species are 0.95 and 0.84 dS/m^{-1}, respectively. In general, the deeper layers show higher EC values compared to the surface layer. Higher EC values in the vegetated plots compared to the barren one can be explained on the bases of the brackish nature of water used in irrigation, in addition to high evapotranspiration in Toshka. Moreover, drip irrigation system push the accumulated salt around the plants to the deeper layers which explain the high EC values in such layers compared to the surface one. The variation of the EC values either under different plant species or among the different soil layers were previously outlined by (Draz and EL-Maghraby, 1997).

TABLE (5). Effect of different trees cover on chemical properties and nutrients availability of Toshka soil.

Characters / Treatments	Soil depth (cm)	pH	EC dS/m^{-1}	O.M (%)	T.N (ppm)	Available nutrients (ppm)					
						P	K	Fe	Cu	Mn	Zn
Barren soil	0-30	8.7	0.19	0.07	24.0	1.75	35	1.87	0.06	1.66	0.43
	30-60	8.4	0.38	0.08	32.3	2.20	40	2.28	0.11	2.25	0.61
	60-90	8.3	0.45	0.08	39.1	2.25	55	4.70	0.17	2.37	0.63
Acacia saligna	0-30	8.1	0.73	0.42	166.4	4.90	82	2.43	0.08	13.38	0.90
	30-60	8.1	0.83	0.16	64.7	5.11	102	8.30	0.42	7.95	1.15
	60-90	8.5	0.96	0.14	55.5	5.44	154	11.60	0.63	3.76	2.13
Prosopis juliflora	0-30	8.0	0.45	0.12	148.0	5.11	78	6.35	0.56	15.30	0.91
	30-60	8.2	0.86	0.21	83.2	4.90	90	6.64	0.64	14.00	0.99
	60-90	8.4	1.55	0.37	46.2	4.90	112	6.11	0.66	12.80	1.27
Tamarix articulate	0-30	8.5	0.25	0.12	46.2	4.99	74	6.70	0.38	3.00	0.63
	30-60	8.5	0.26	0.12	46.2	5.02	66	11.21	0.43	4.74	0.99
	60-90	8.1	0.67	0.21	43.2	5.10	56	13.06	0.88	5.07	1.02
Casuarina equstifolia	0-30	8.5	0.23	0.09	66.7	4.80	72	4.88	0.13	4.66	1.04
	30-60	8.7	0.41	0.14	52.1	4.88	68	6.27	0.22	6.25	1.05
	60-90	8.5	0.45	0.17	37.0	4.96	67	11.70	0.37	6.28	1.05
L.S.D. 0.05 depth		0.14	0.03	0.01	1.6	0.07	66.9	0.09	0.01	0.22	0.03
L.S.D. 0.05 plant		0.19	0.03	0.01	2.1	0.09	86.4	0.12	0.01	0.29	0.04

O.M=Organic matter T.N=Total nitrogen

As for the macronutrients, the values presented in table (5) show that soil samples of the cultivated plots contained, two to three folds of N,P and K more than that of the barren soil. Variable effective differences were detected as regard the concentrations of the macronutrients in the different soil layers of the cultivated plots compared to the uncultivated plot. Such results are not in harmony with the finding of Zhang *et al.* (2004) who indicated that there were no significant differences in available P content and total K content between the vegetated and active sand dunes. In the current investigation, the highest values of N and K were found in plots covered by *Acacia* and *Prosopis* species. The average values are 95.5 and 92.5 ppm for the total nitrogen and 112.7 and 93.3 ppm for K, respectively.

On the other hand, data show that the soil underlying of *Acacia* followed by *Tamarix* had higher concentration of phosphorus. The average recorded values are 5.15ppm for *Acacia* and 5.04ppm for *Tamarix*. Higher N.P,K concentrations underlying the *Acacia, Prosopis* and followed by *Tamarix* can be attributed to relatively high organic matter in the soil and high content of the macronutrients in the leaves of such species.

Concerning the micronutrients, the data revealed that Fe, Cu, Mn and Zn are significant variable differences as regard to the uncultivated and vegetated plots. In general, the soil of vegetated plots contained higher amounts (2 to 7 folds) of such micronutrients. The highest concentrations were found in the deeper layers compared to the surface layers. The highest amount of Fe was found underlying the *Tamarix* followed by the *Casuarina*, while, the soil which covered by *Prosopis* followed by *Tamarix* had higher concentrations of Cu. Concerning Mn and Zn there are indications of higher concentrations in soil covered by *Acacia* and *Prosopis* species. The variation of fertility under various plant species was previously outlined by Sharma and Gupta (1989).

CONCLUSION AND RCOMMENDATIONS

In the view of the above mentioned growth behaviours and according to the scoring evaluation of the different parameters among the plant species, it is of special interest to mention that although the four plant species effectively act in soil improvement under the conditions of Toshka, *Prosopis juliflora* and *Acacia saligna* are of superior quality. Such plant species are recommended for afforestation on a large scale .

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دور بعض الأنواع النباتية في تحسين التربة في توشكي بجنوب مصر

عبد الله قاسم زغلول
قسم الكثبان الرملية-مركز بحوث الصحراء- المطرية-القاهرة – مصر.

أجريت هذه التجربة الحقلية بتوشكى والتي تقع غرب بحيرة ناصر في جنوب مصر في الفترة من ٢٠٠١-٢٠٠٤. وتهدف الدراسة إلي التعرف علي الدور الذى تلعبه أشجار البروسوبس والأكاسيا والكازورينا والتاماركس في تحسين خواص وخصوبة التربة. وتشير النتائج إلي أن التشجير يلعب دورا هاما في تحسين خواص التربة وزيادة خصوبتها مقارنة بالأراضي غير المنزرعة. كما أشارت النتائج إلي أن تحسن خواص التربة كان معنويا بزراعة أشجار البروسوبس والأكاسيا علي التوالي. لذلك يمكن التوصية باستخدام هذه الأنواع النباتية في برامج تشجير وإنشاء مصدات الرياح بالمناطق الصحراوية المشابهة لنفس الظروف.

الممسوحة ضوئيا بـ CamScanner