Evaluation The Efficiency of Green Shelterbelts to Control Shifting Sands at Toshka Region, South Egypt

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ABSTRACT

In Toshka, South of Egypt, the extremely arid conditions reflect vast areas covered by the aeolian deposits. To control the shifting sand along El-Sheikh- Zayed canal, which convey water to the newly reclaimed lands, one kilometer of a greenbelt was established as an experimental pilot area for sand encroachment control along the main irrigation canal. In such area, four tree species namely *Acacia saligna*Lind, *Casuarina equisetifolia* L, *Prosopis juliflora* (sw.) Dc *and Tamarix articulata* Vahl were cultivated as a shelterbelt and arranged in plots including different plant distributions of variable spacing.

The results achieved show that tree species gave superiors growth behavior in hyper arid conditions of the study area. The shelterbelts play an important role in the control of shifting sand and soil improvement. The physical , chemical and fertility properties of experimental soil showed positive responses in relation to plant species compared with the barren soil. The efficiency of shelterbelts to control the shifting sand was decreased when far distance and vice versa the efficiency of shelterbelts to control the shifting sand was increased when the distance was decreased. The reduction percentage of shifting sand down wind the shelterbelt varied from 11.9 to 92.8%. The highest efficiency was 92.8% for 10m distance, whereas the lowest efficiency was 11.9% for 120m distance. The above mentioned design is recommended for large scale application.

Key words: Control of shifting sand, efficiency of shelterbelts, *Acacia, Casuarina, Prosopis, Tamarix,* Porosity, growth characteristics, Toshka, Egypt.

INTRODUCTION

In Egypt, the aeolian sand deposits are one of the main major land forms. It covers almost 16.5% of the total surface area. Misak and Draz (1997).

Toshka is an extremely arid region located in South Egypt, West of Nasser Lake. The national program for development and rehabilitation in Toshka vast areas are affected by the migration of shifting sand. Many studies such as space photographs and topographic maps mentioned that sand dune zones represent 150.000 km^2 at Toshka. Many researchers estimated sand dune movement rates at Toshka region and found that sand movement rates were 10-20 m/year according to wind speed and soil topographic. Satellites showed that at Toshka region sand dune accumulations present at the north of the project. Sand dunes at Toshka region affect on El-Sheikh Zayed canal and basal constructions of project.

It is well known that the afforestation is the main method for biological fixation of aeolian sand. Afforestation plays an important role for improvement of both fertility and chemical properties of the soil.

The shelterbelts could play an important role in the control of shifting sand, also enhance the deposition of the aeolian sand at a reasonable distance from the infrastructure. Limited information is available regarding the relationship between plant cover and soil properties in the respective sites. Mann (1985) reported that, the reduction in wind speed through the plantation of shelterbelts were effective in the wind erosion and sand movement control. Also, the efficiency of the shelterbelt in the control of shifting sand is governed by its height, width and porosity of the shelter. 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 plant cover. Bolds and Maranon (2001) showed that herbaceous double row shelterbelts with larger overall density exhibit a dramatically better average reduction for wind and turbulence intensity than the single row shelterbelt. Hegazi *et al* (2001) reported that *Casuarina equisetifolia* and *Eucalyptus camaldulensis* windbreaks had an effective role in the protection of Thompson seedless grapevine from wind damages compared with unprotected ones. Zhang *et al.* (2004) found that planting of *Artemisia halodendron* was considered to be the most proper way for stabilizing moving sand dunes. Draz and Zaghloul (2007) showed that the shelterbelts could play an important role in the control of shifting sand. The rate of improvement was much controlled by the vegetation type. *Acacia saligna* and *Tamarix articulata* have the most precede role. Therefore, the aim of this investigation is monitoring and evaluating of different shelterbelts designs to control shifting sand at Toshka region.

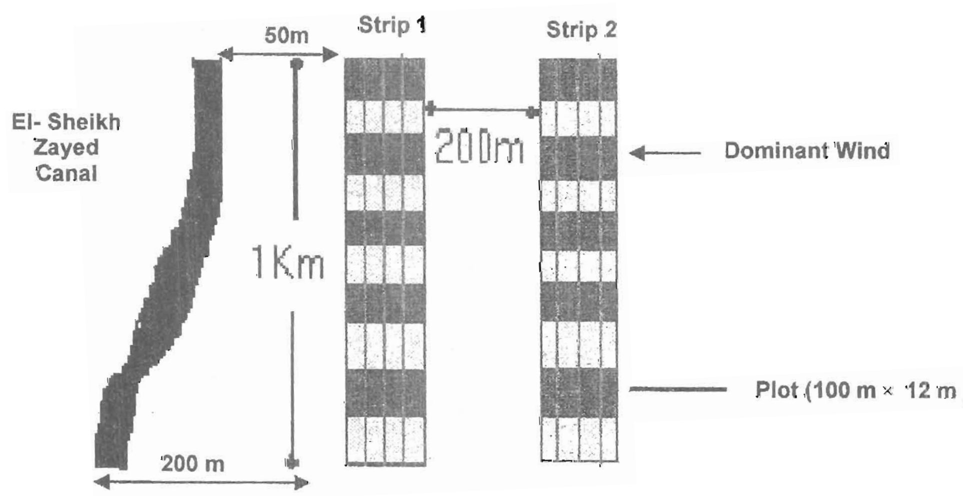
MATERIALS AND METHODS

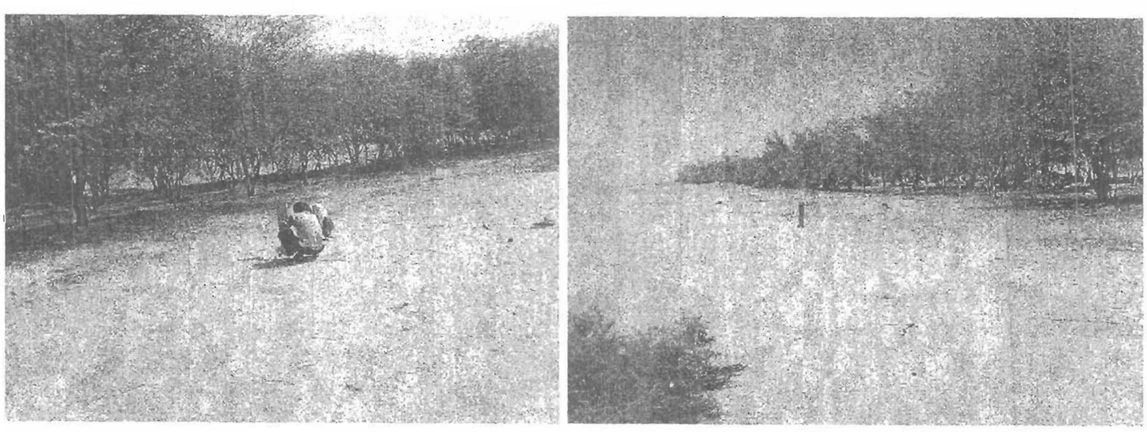
For one year the present study was carried out during the period from March 2010 to February 2011. The experimental pilot area was located at the El- Sheikh Zayed canal, far away 50 km from Lake Nasser. The layout of the experimental plot includes 1km of green shelterbelt includes double strips established perpendicularly to the dominant effective winds. The plant species were cultivated on February15th through 2002 year (Fig. 1).

The distance between the shelterbelt and the canal varied between 50 -200 m and the distance between the two strips was about 200m. Each strip included four tree species, namely *Acacia saligna, Casuarina equisetifolia* L. *Prosopis juliflora* and *Tamarix articulata.*

In each strip, one year old seedlings of each tree species were planted and arranged in ten plots. Each plot was 100m length and 12m width (as shown in Figure, 1). The plots were cultivated according to the following scheme:

Plot No.1: Five rows of *Tamarix articulata.*
Plot No.2: Five rows of *Casuarina equisetifolia.*
Plot No.3: Two rows of *Tamarix articulata.*
Plot No.4: Three rows of *Casuarina equisetifolia.*
Plot No.5: One central row of *Tamarix articulata* and four rows of *Prosopis juliflora* (two rows at each side of the central row).
Plot No.6: One central row of *Tamarix articulata* and four rows of *Acacia saligna* (two rows at each side of the central row).
Plot No.7: Three central rows of *Casuarina equisetifolia* and two rows of *Tamarix articulata* (one row at each side of the central rows)
Plot No.8: Five rows of *Prosopis juliflora.*
Plot No.9: One central row of *Prosopis juliflora* and four rows of *Acacia saligna* (two rows at each side of the central row).
Plot No.10: five rows of *Acacia saligna.*





Shelterbelt at Toshka during March 2010

Fig 1: Layout of the experimental pilot area at Toshka region.

With the exception of the plots No. 3 and 4, the tree species were planted in spaces of 3 m between plants and 3 m between rows. For the plots No. 3 and 4, the spaces between plants are 3 m and the spaces between rows were 12m for the former and 6m for the later plot, respectively .The cultivated trees were irrigated by the brackish ground water (2160 ppm) using drip irrigation system. The climatologically records of Abo Sembel Meteorological Station, the nearest to the study area, during the growth period are shown in Table (1). Toshka is located within the extremely arid zone of North Africa. Accordingly, the average monthly temperature varied between 16.6° in January and 34.3° in August. The rainfall is almost nil and the relative humidity varied from 21 and 44%.The effective wind (>5m/sec) represent values vary from 36.8% in December to52.9% in March of the total wind speeds. The prevailing wind directions are generally North/South.

Determinations:

1- Growth parameters: five individual plants of each species in the plot were chosen for the determination of the following parameters: plant height, crown cover (CC)and crown volume (CV). Crown cover and crown volume were calculated according to the formula of Thalen (1979).

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

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).
Soil moisture was measured in soil samples taken at depths 0-30, 30-60 and 60-90 cm at distance of one meter from the trees.
Soil temperature at depths 0-30, 30-60 and 60-90 cm of the soil surface were measured at the protected and open area at distance of one meter from the trees.

b- Electric conductivity, soluble cations, 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 was 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).

g- chemical analysis of irrigation water recorded in (Table, 2) was determined according to Black *et al* (1982).

3- The quantities of the blown sand derived from the prevailing direction were determined by using sand collectors that previously designed by Bagnold (1941).

4- For the determination of the shelterbelt efficiency, fifteen units of Bagnold sand collectors were fixed and oriented to the prevailing wind direction (North). The distribution of sand collectors was as follows:

-Three units were fixed at the wind- ward side at a distance of 30 m from the shelterbelt.

-Twelve units were fixed at the down after each of both strips of the shelterbelt at distances 10-20-30-40-50-60-70-80-90-100-110 and 120m from shelterbelt.

- The shelterbelt efficiency was calculated according to (Fryberger, 1979) using the following equation:-
The shelterbelt efficiency(%)= (Sand weight trapped in the windward
-Sand weight trapped in the leeward) of each distance / Sand
weight trapped in the windward x100.

Statistical analysis

Correlation coefficient was applied according to (Harvey, 1987).

Table 1: Means of the climatic normal of Abo Sembel station during the period from 2000-2007 years.

Months	Air temperature (c°)			Relative humidity (%)	Rain fall (mm)	Evaporation (mm/month)	Effective wind (%) (5m/sec)	Wind direction
	Max	Min	Aver					
January	22.0	11.1	16.6	43	-	12.0	39.2	N
February	23.4	12.4	17.9	36	-	13.1	47.6	N
March	28.2	16.3	22.3	30	-	16.1	52.9	N.w
April	34.2	21.6	27.9	25	-	19.3	50.5	N
May	37.6	26.2	31.9	21	-	23.9	48.1	N
June	37.9	27.0	32.4	21	-	25.1	45.5	N
July	39.9	28.1	34.0	22	-	24.3	42.8	N
August	39.9	28.6	34.3	23	-	22.7	51.5	N
September	37.9	26.7	32.3	26	-	23.7	50.2	N
October	34.4	23.9	29.2	30	-	19.8	48.5	N
November	28.6	17.5	23.1	38	-	13.4	40.6	N
December	23.5	11.9	17.7	44	-	10.7	36.8	N

Table 2: Chemical analysis of the irrigation water.

pH	EC ppm	Soluble cations (me / l)				Soluble anions (me / l)				SAR*
		Ca^{2+}	Mg^{2+}	K^+	Na^+	CO_3^{--}	HCO_3^-	SO_4^{--}	Cl^-	
7.74	2160	7.97	0.7	8.5	16.76	-	4.59	13.7	15.0	10.9

*S.A.R: Sodium adsorption ratio

RESULTS AND DISCUSSION

I-Growth parameters of the cultivated trees.

The results of the growth parameters are shown in Table (3):

- Tamarix articulata.

In both strips of the shelterbelt, *Tamarix* sp. stands showed variable differences as regard to the growth parameters: In winter 2010 after eight years of transplantation, plant height, crown cover and crown volume varied from 3.90 to 4.20 m, 8.32 to 8.52 m^2 and 21.62 to 23.61 m^3, for the first and second plots, respectively (Table, 3). The above mentioned growth parameters showed increasing trend during the study period (from winter 2010 to summer 2011).The ultimate records of various growth parameters values increased from 4.00 to 4.30m, 8.40 to 8.57 m^2 and from 22.82 to 27.29 m^3 for plant height, crown cower and crown volume, respectively.

On the basis of crown volume records, the growth of *Tamarix* trees at the end of study period was about 5.6% as compared with their growth at the initial study period.

-Prosopis juliflora.

The development of different growth parameters of *prosopis* trees which are shown in Table (3), elucidate that from winter 2010 to summer 2011 plant height increased from 6.00 and 6.35 m to 6.12 and 6.44m for the first and second plots, respectively. Meanwhile, the crown cover and crown volume developed from 36.50 and 36.98 m^2 to 36.55 and 37.13 m^2 and from 45.92 and 56.42 m^3 to 48.92 and 58.97 m^3, respectively .

On the basis of the recorded volume of the crown, the growth of *prosopis juliflora* trees at the end of the study period was about 5.4% as compared with the growth at the initial study.

- Acacia saligna

Plant height showed an increase trend from 3.80 to 4.05 m for the first and second plots, respectively, at the initial stage of growth during winter 2010 to 3.95 and 4.15 m at the end of the study period (summer 2011) .Concerning the crown cover in winter 2010, the recorded values varied from 21.58 to 21.71 m^3 while it reached to 21.67 and 21.90 m^3 in summer 2011.Crown volume at the initial stage of growth varied from 54.85 and 58.36 m^3 and reached to 57.22 and 60.12 m^3 at the end of the of the study period (summer 2011).On the basis of recorded crown volume, the growth of *Acacia* stands at the end of study period was about 3.6% as compared to the initial study.

The obtained results, so far, elucidates that the study indicate that the tree species gave superior growth behavior under hyper arid conditions of the study area. For this reason, such tree species are commonly used for the establishment of shelterbelts and windbreaks in arid and semi arid regions (Kaul, 1985 and Draz and El-Maghraby, 1997).

- Casuarina equisetifolia

The development of different growth parameters of Casuarina trees which are shown in Table (3), indicated that from winter 2010 to summer 2011 plant height increased from7.10 and 7.50 m to 7.20 and 7.60 m for the first and second plots, respectively. Meanwhile, the crown cover and crown volume developed from 6.72 and 6.83 m^2 to 6.79 and 7.22 m^2 and from 32.16 and 33.73 m^3 to 34.64 and 34.58 m^3, respectively.

II-Soil physical characteristics as affected by tree species

The effect of tree species on some soil physical characteristics, as soil moisture (%) and soil temperature (^{0}C), were shown in Table (4).

Concerning soil moisture content, data of the cultivated plots showed appreciable increases compared with the barren soil. This was obviously observed under all tree species. Regarding the effect of tree species on soil moisture, data showed higher soil moisture values for the plot cultivated with *Prosopis juliflora* followed by *Acacia saligna.* The average of soil moisture values of the soil beneath both species were 4.94 and 4.75%, respectively. In general, the deeper layers showed higher soil moisture values as compared with upper layers.

Data in Table (4) indicate that soil temperature under all plants decreased comparing to the barren soil. As regards to the effect of tree species on soil temperature in the cultivated area, showed lower soil temperature values for the plot cultivated with *Prosopis juliflora* followed by *Acacia saligna.* The average of soil temperature values of the soil beneath both species were 25.8 and 26.1^{0}C, respectively. In general, the deeper layers showed lower soil temperature values compared to the surface layer.

From the obtained results in Table(4) it is cleared that particles size distribution was affected by plant species comparing to the barren soil. Results on the particles size distribution of barren soil indicated that the percentages of sand size of the soil depth (60-90 cm) were 6.4, 12.4, 14.8, 21.8, 26.54, 16.48 and 1.58 under cultivated plants compared to 2, 2-1, 1-0.5, 0.5-0.25, 0.25– 0.125, 0.125–0.063 and <0.063 mm in barren areas, respectively. The texture class of soil for the cultivated trees arranged in barren areas sand clay loam and sand loam.

Table 3: Growth parameters of the tree species cultivated in different plots

Growth parameters		Eight years after afforestation						Nien years after afforestation					
		Winter 2010			Summer 2010			Winter 2011			Summer 2011		
tree species		Plant height (m)	Crown cover (m^2)	Crown volume (m^3)	Plant height (m)	Crown cover (m^2)	Crown volume (m^3)	Plant height (m)	Crown cover (m^2)	Crown volume (m^3)	Plant height (m)	Crown cover (m^2)	Crown volume (m^3)
Strip 1													
Plot 1-1	5 rows of *Tamarix sp.*	4.10	8.48	23.16	4.15	8.52	23.54	4.22	8.53	23.99	4.25	8.56	24.23
Plot 1-2	5 rows of *Casuarina* sp.	7.30	6.72	32.68	7.33	6.75	32.97	7.36	6.77	33.22	7.40	6.79	33.48
Plot 1-3	2 rows of *Tamarix* sp.	4.15	8.40	23.22	4.19	8.44	23.56	4.25	8.46	23.94	4.30	8.48	24.29
Plot 1-4	3 rows of *Casuarina* sp.	7.30	6.75	32.83	7.34	6.79	33.21	7.39	6.83	33.62	7.45	6.87	34.00
Plot 1-5	4 rows of *Prosopis* (bs)	6.10	36.91	50.04	6.12	36.97	50.75	6.18	36.99	52.30	6.20	37.01	52.88
	1 row of *Tamarix* (cent.)	3.90	8.32	21.62	3.94	8.36	21.94	3.99	8.37	22.24	4.10	8.40	22.94
Plot 1-6	4 rows of *Acacia* (bs)	3.80	21.67	54.85	3.85	21.71	55.67	3.91	21.72	56.58	3.95	21.74	57.22
	1 row of *Tamarix* (cent.)	4.00	8.32	22.22	4.04	8.34	22.44	4.10	8.35	22.81	4.15	8.36	23.11
Plot 1-7	2 rows of *Tamarix* (bs)	3.90	8.44	21.93	3.92	8.45	22.08	4.00	8.46	22.55	4.04	8.48	22.82
	3rows of *Casuarina* (cent.)	7.10	6.80	32.16	7.11	6.83	32.35	7.15	6.86	32.68	7.20	7.65	34.64
Plot 1-8	5 rows of *Prosopis*	6.20	36.82	52.08	6.24	36.83	53.12	6.30	36.84	54.63	6.36	36.86	56.17
Plot 1-9	4rows of *Acacia* (bs)	3.90	21.58	56.09	3.92	21.60	56.13	3.96	21.62	57.06	4.00	21.67	57.74
	1 row of *Prosopis* (cent)	6.00	36.50	45.92	6.03	36.52	46.71	6.08	36.53	47.96	6.12	36.55	48.99
Plot1-10	5 rows of *Acacia*	4.00	21.59	57.53	4.02	21.61	57.88	4.05	21.63	58.56	4.09	21.67	59.04
Strip 2													
Plot 2-1	5 rows of *Tamarix* sp.	4.15	8.52	23.55	4.17	8.53	23.68	4.20	8.56	23.94	4.24	8.57	24.21
Plot 2-2	5 rows of *Casuarina*	7.50	6.75	33.73	7.55	6.77	34.08	7.58	6.79	34.29	7.60	6.83	34.58
Plot 2-3	2 rows of *Tamarix*	4.20	8.44	23.61	4.22	8.45	23.77	4.25	8.48	24.00	4.30	8.52	24.40
Plot 2-4	3 rows of *Casuarina*	7.40	6.80	33.52	7.43	6.83	33.81	7.50	6.86	34.32	7.55	6.91	34.75
Plot 2-5	4 rows of *Prosopis* (bs)	6.20	36.97	52.73	6.22	36.98	53.25	6.25	37.02	54.15	6.30	37.10	55.52
	1 row of *Tamarix* (cent.)	4.00	8.48	22.59	4.02	8.49	22.75	4.05	8.52	22.98	4.10	8.56	23.37
Plot 2-6	4 rows of *Acacia* (bs)	3.90	21.71	56.62	3.92	21.72	56.37	3.95	21.74	57.22	4.00	21.78	58.05
	1 row *Tamarix* (cent.)	4.05	8.48	23.16	4.07	8.51	23.20	4.09	8.53	23.43	4.15	8.56	23.66
Plot 2-7	2 rows of *Tamarix* (bs)	4.10	8.49	23.20	4.11	8.52	23.32	4.15	8.53	23.59	4.20	8.56	23.94
	3rows *Casuarina* (cent.)	7.10	6.83	32.31	7.12	6.85	32.47	7.15	6.87	32.72	7.20	7.22	34.64
Plot 2-8	5 rows *Prosopis*	6.35	36.97	56.42	6.38	36.99	57.23	6.40	37.01	57.82	6.44	37.13	58.97
Plot 2-9	4rows *Acacia* (bs)	4.00	21.67	57.74	4.06	21.69	58.67	4.10	21.71	59.29	4.15	21.74	60.12
	1 row *Prosopis* (cent)	6.15	36.98	51.53	6.18	37.00	52.36	6.20	37.01	52.89	6.22	37.10	53.54
Plot2-10	5 rows *Acacia*	4.05	21.63	58.36	4.09	21.67	59.04	4.10	21.70	59.22	4.15	21.90	59.69

Cent = central row bs = both sides of the central row

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Table 4: Soil physical characteristics as affected by tree species at Toshka

Characters / Treatments	Soil depth (cm)	Soil moisture (%)	Soil temperature (°c)	Particles size (%)							Texture class	Sand	Clay	Silt
				> 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				
Barren soil	0 – 30	1.54	35.2	-	-	-	-	-	-	-	SCL	64.7	12.2	23.1
	30 – 60	1.72	32.6	-	-	-	-	-	-	-	SL	70.0	18.5	11.5
	60 - 90	1.82	30.5	6.4	12.4	14.8	21.8	26.54	16.48	1.58	Sand	-	-	-
Acacia saligna	0 – 30	4.12	27.0	-	-	-	-	-	-	-	SCL	64.2	12.8	23.0
	30 – 60	4.96	25.9	-	-	-	-	-	-	-	SL	68.2	18.0	13.8
	60 - 90	5.17	25.4	-	-	-	-	-	-	-	SL	72.6	11.1	16.3
Prosopis juliflora	0 – 30	4.44	27.2	-	-	-	-	-	-	-	SCL	65.1	12.1	22.8
	30 – 60	5.12	25.3	-	-	-	-	-	-	-	SL	68.9	18.9	12.2
	60 - 90	5.27	25.1	-	-	-	-	-	-	-	SL	72.1	11.5	16.4
Tamarix articulate	0 – 30	3.77	28.2	-	-	-	-	-	-	-	SCL	65.2	12.3	22.5
	30 – 60	4.08	25.5	-	-	-	-	-	-	-	SL	69.8	18.7	11.5
	60 - 90	4.35	25.0	-	-	-	-	-	-	-	SCL	65.6	12.0	22.4
Casuarina equisetifolia	0 – 30	4.01	27.9	-	-	-	-	-	-	-	SCL	66.7	11.5	21.8
	30 – 60	4.26	26.0	-	-	-	-	-	-	-	SL	70.1	17.9	12.0
	60 - 90	4.55	25.2	-	-	-	-	-	-	-	SCL	67.4	12.9	19.7

SCL=Sandy clayey loam SL=Sandy loam

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These results may be due to the increase in accumulation of silt and clay contents of soil with cultivated tree species. Brandle (1995) indicated that plant species composition was among the factors that control the efficiency of shelterbelts tended to reducing wind speed and altering microclimate. These results were similar to those obtained by El Hady *et al* (1991) and Fang, *et al* (2007).

III-Soil chemical characteristics as affected by tree species:

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

Concerning pH values, data of the cultivated plots showed slight decrease in the soil reaction comparing to the barren soil. This is obviously observed with all plant species. 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 showed slightly higher values in the vegetated plots as compared with the barren one. The obtained average values, ranged from 0.26 to 0.99 dSm^{-1} in the former and from 0.30 to 0.47 dSm^{-1} in the latter. Concerning the effect of plant species on soil salinity, data showed higher EC values for the plot cultivated with *Prosopis juliflora* followed by *Acacia saligna*. The average of EC values of the soil beneath both species were 0.86 and 0.82 dSm^{-1}, respectively. In general, the deeper layers showed higher EC values compared to the surface layer. Higher EC values in the vegetated plots as compared with the barren one can be explained on the bases of the brackish nature of water and to high evapotranspiration in Toshka. Moreover, drip irrigation system push the accumulated salt around the plants to the deeper layers which explains the higher EC values in such layers comparing 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) and (Zaghloul, 2006).

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 layers as compared with the deeper ones. Similady, the values of the total nitrogen of the top soil layers were higher in relation to the deeper ones. Regarding the effect of plant species on the organic matter and nitrogen content, data in Table (5) revealed that the experimental plots covered with *Acacia saligna* and *Prosopis juliflora* had a higher content of both constituents comparing to the others. 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 are 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 prime importance in the development and maintenance of soil fertility. It improves the aeration and increases the moisture content of the soil. Moreover, organic matter affects 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 .The increase of the content of both substances is presumably due to higher litter fall of such plant species (Aggarwal, 1980).

As for the macronutrients, the values presented in Table (5) showed 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 to the concentrations of the macronutrients in the different

Table 5: Effect of different tree species on chemical properties and nutrients availability under the trees at Toshka region

Characters / Treatments	Soil depth (cm)	pH	EC dSm^{-1}	O.M* (%)	Total Nitrogen (ppm)	Available nutrients (ppm)					
						P	K	Fe	Cu	Mn	Zn
Barren soil	0 -30	8.8	0.30	0.08	25.1	1.84	37	1.89	0.07	1.55	0.49
	30-60	8.6	0.39	0.09	32.5	2.30	44	2.34	0.13	2.14	0.68
	60-90	8.6	0.47	0.09	39.9	2.35	56	2.81	0.17	2.39	0.66
Acacia saligna	0-30	8.5	0.65	0.55	176.4	5.80	99	3.52	0.19	4.54	0.97
	30-60	8.3	0.85	0.30	74.5	6.09	110	8.70	0.45	8.93	1.44
	60-90	8.3	0.96	0.28	65.3	6.93	166	12.61	0.66	12.88	2.19
Prosopis juliflora	0-30	8.4	0.73	0.35	148.9	5.08	91	7.33	0.58	16.20	1.99
	30-60	8.3	0.86	0.30	85.6	5.88	99	7.66	0.69	14.91	1.99
	60-90	8.2	0.99	0.25	48.6	5.79	123	7.15	0.69	13.86	1.66
Tamarix articulate	0-30	8.4	0.27	0.24	49.9	5.86	85	7.81	0.48	3.68	0.68
	30-60	8.3	0.29	0.19	48.3	5.67	74	12.23	0.79	5.19	0.99
	60-90	8.1	0.71	0.18	48.0	5.54	70	14.17	0.95	5.17	1.25
Casuarina equisetifolia	0-30	8.5	0.26	0.20	69.8	5.70	81	5.97	0.28	5.13	1.36
	30-60	8.3	0.45	0.19	65.3	5.47	75	7.69	0.37	6.77	1.38
	60-90	8.2	0.47	0.15	64.7	5.26	73	12.33	0.45	6.98	1.41

*O.M=Organic matter

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 barren sand dunes. In the current investigation, the highest values of N, P, and K were found in plots covered by *Acacia* and *Prosopis* trees. The average values are 105.4 and 94.4ppm for the total nitrogen, 5.94 and 5.92 for P and 125.0 and 104.3ppm for K, respectively. Higher N, P and K concentrations underlying *Acacia* and *Prosopis* trees and followed by *Tamarix* trees 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 showed apparent differences with regard to the cultivated and uncultivated plots. In general, the soil of cultivated plots contained higher amounts and more than 3 folds of such micronutrients in uncultivated ones. Besides, the highest concentrations were found in the deeper layers as compared with the upper ones. The highest amount of Fe was found underlying *Tamarix* trees followed by *Casuarina* trees, while, the soil which is covered by *Prosopis* trees followed by *Tamarix* retained higher concentrations of Cu. Concerning Mn and Zn there were indications of higher concentrations in soil covered by *Prosopis* trees and *Acacia* trees. The variation of fertility under various plant species was previously outlined by Sharma & Gupta (1989) and Anthony (2002).

IV-The efficiency of shelterbelts on the control of shifting sand

Data in Table (6) show that the efficiency of shelterbelts was expressed by the reduction percentage of periodical cumulative amounts of the collected sand by Bagnold sand collectors at the leeward side compared to that of the wind- ward side at the different distances.

The efficiency of shelterbelts to control the shifting sand was recorded during the study periods.

After winter 2010, the efficiency of the shelterbelts decreased as follows: 93.0, 92.7, 92.4, 82.7, 74.1, 74.1, 66.2, 56.1, 40.7, 32.8, 30.9 and 16.5 for 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110 and 120m distances, respectively (Table, 6). The highest efficiency was attained with 10 m distance, whereas the lowest value was attained with 120m.

After summer 2010, the difference of shelterbelts efficiency ranged from 92.6 to 5.2% with 10 and 120 m distances. The highest efficiency was observed with10m distance, whilst the lowest efficiency was recorded with 120m distance. The efficiency of shelterbelt decreased with increased distance between plants.

After winter 2011, data in Table (6) indicate that the efficiency of the shelterbelts decreased as follows: 92.7, 92.6, 83.8 72.9, 64.9, 54.9, 39.1, 31.4, 23.7, and 15.3% for 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110 and 120m distances, respectively.

After summer 2011, the difference of shelterbelts efficiency ranged from 92.2to 8.8% with 10 and 120 m distances. The highest efficiency was observed with10m distance. However, the lowest efficiency was shown with 120m distance.

The total efficiency of shelterbelts to control the shifting sand decreased as follows: 92.8, 92.3, 91.9, 85.7, 75.4, 75.1, 66.9, 55.4, 38.1, 29.7, 20.5 and 11.9% for 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110 and 120m distances, respectively (Table, 6). The highest efficiency was 92.8% for 10m distance, whereas the lowest efficiency was 11.9% for 120m distance. Generally, data in Table (6) show that the efficiency of shelterbelts to control the shifting sand decreased with increased distance. These results may be attribute to the increase in the growth specially the height and crown volume of shelterbelts (Table, 3). Similar results were obtained by (Mann, 1985) who indicated that the shelterbelt would be effective up to a distance of 15-20 times the tree height depending upon the particular conditions. On the other hand, it could be mentioned that the combination of more than one species in the shelterbelt is more effective in the control of shifting sand, compared to the single species. Brandle (1995) indicated that the species composition is among the factors that control the efficiency of shelterbelts in reducing wind speed and altering microclimate.

The simple correlation coefficient between the total sand accumulation with different distances and shelterbelt efficiency were calculated and the regression equations for each are illustrated in Fig (2). It is clear that the correlation coefficient of sand accumulation with different distances and shelterbelt efficiency differed significantly.

Significant simple correlation coefficients (r) ranged from 0.532 to 0.660 and high significant was 0.661 and over. After winter 2010, summer 2010, winter 2011, summer 2011 sand accumulation, showed highly positive significant correlation indicating between the total sand accumulation after different distances and shelterbelt efficiency. Values of, r were 0.979, 0.963, 0.981, 0.958 and 0.973 in different periods, respectively.

CONCLUSION AND RCOMMENDATION

In view of the given results, the shelterbelts could play an important role in the control of shifting sand at EL-Sheikh Zayed canal. The shelterbelts enhance the deposition of the aeolian sand at a reasonable distance from the irrigation canal. The reduction percentage of shifting sand down wind with the different plots of shelterbelt varied from 92.8 to 11.9 %. The above mentioned design is recommended for large scale application.

Table 6: Shelterbelts efficiency of sand accumulation ((g/cm width)

Distances	Sand accumulation (g/cm width)									
	After winter 2010	Shelterbelts efficiency (%)	After summer 2010	Shelterbelts efficiency (%)	After winter 2011	Shelterbelts efficiency (%)	After summer 2011	Shelterbelts efficiency (%)	Total	Shelterbelts efficiency (%)
Before shelterbelt	1338		1054		1297		1110		4799	
After 10m	93	93.0	78	٩٢.6	95	92.7	75	93.2	341	92.8
After 20m	97	92.7	87	91.7	96	92.6	88	92.1	368	92.3
After 30m	101	92.4	95	91.0	99	92.4	93	91.6	388	91.9
After 40m	231	82.7	123	88.3	210	83.8	121	89.1	685	85.7
After 50m	347	74.1	244	76.9	351	72.9	235	78.8	1177	75.4
After 60m	347	74.1	246	76.7	360	72.2	240	78.4	1193	75.1
After 70m	452	66.2	343	67.5	455	64.9	336	69.7	1586	66.9
After 80m	587	56.1	489	53.6	585	54.9	478	56.9	2139	55.4
After 90m	793	40.7	698	33.8	790	39.1	690	37.8	2971	38.1
After100m	899	32.8	797	24.4	890	31.4	785	29.3	3371	29.7
After110m	925	30.9	925	12.2	990	23.7	975	12.2	3815	20.5
After120m	1117	16.5	999	5.2	1099	15.3	1012	8.8	4227	11.9

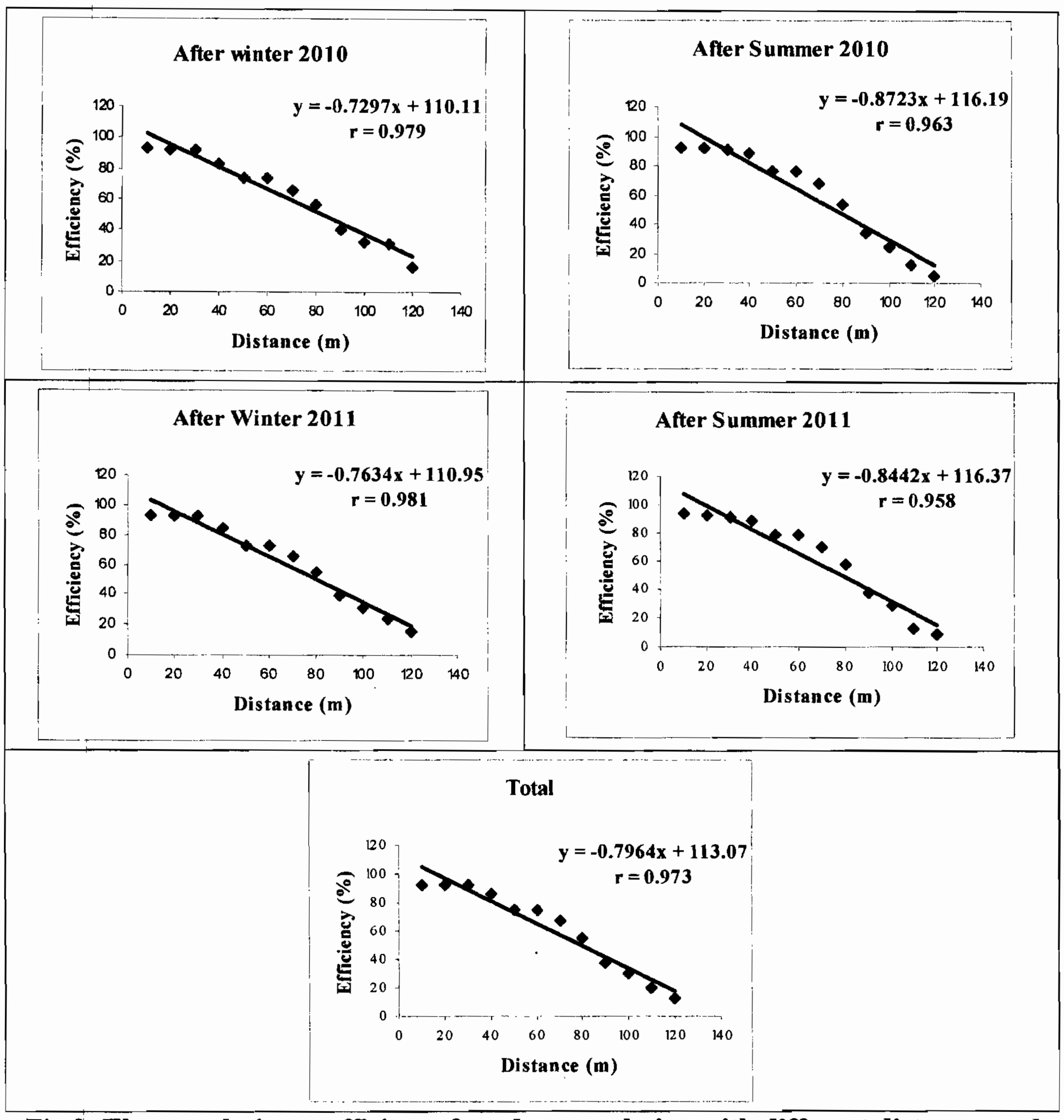

Fig 2: The correlation coefficient of sand accumulation with different distances and shelterbelt efficiency.

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الملخص العربى

تقييم كفاءة الأحزمة الخضراء للتحكم فى زحف الرمال بتوشكى، جنوب مصر

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اقليم توشكى فى جنوب مصر من المناطق شديدة الجفاف والتى توجد بها مناطقَ واسعةً مغطـاه بالرواسـب الرملية. ولمقاومة زحف الرمالِ المتحركةِ على طول قناة الشّيخ زايد التى تروى الأراضي المُستَصلحة حديثاً. اقـيم حزام أخضر بطول واحد كيلو مترمكون من أربعة أنواعٍ نباتيةٍ منزرعة فى تراكيب ومسافات مختلفة.

وكانت أهم النتائج المتحصل عليها مايلى:

- أعطت الأنواع النباتية أعلى صفات نمو خضرى تحت ظروف منطقة الدراسة.
- الأحزمة الخضراء تلعب دورا هاما فى مقاومة زحف الرمال وتحسين خواص التربة.
- الصفات الطبيعية والكيميائية وخصوبة التربة المنزرعة بالأنواع الشجرية شهدت استجابة ايجابية مقارنة بالأرض الغير منزرعة.

-تزيد كفاءة الأخزمة الخضراء فى مقاومة زحف الرمال عند الاقتراب من الحزام نفسة والعكس صحيح حيث كانت النسبة المئوية للنقص كانت منْ ١١,٩ إلى ٩٢,٨ %. أعلى كفاءة كانت ٩٢,٨% عند مسافة ١٠م بينمـا أقـل كفاءة كانت ١١,٩% عند مسافة ١٢٠م لذا نوصى باستخدام التصميم المذْكُورِ أعلاهِ على نطاق واسع.