ARISTIDA PLUMOSA (LINN.): ITS ALLELOPATHIC EFFECTS AND SAND FIXING ABILITY AT BALOUZA, NORTH SINAI, EGYPT

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The present investigation aimed at focusing on the efficiency of *Aristida plumosa* Linn. as an ideal dune fixer at Balouza area, North Sinai, Egypt. Measurements of nebkha and canopy characteristics during different developmental stages in 2014 were accomplished, in addition, sand trapped mass, shoot and root biomass and sand aggregation adherent around roots were determined. The allelopathic effect of root and rhizosphere extracts of *A. plumosa* on seed germination percentage and early growth of *Portulaca oleracea* L. and on its shoot and root development was studied. In addition, phenolic compounds in root tissue and rhizosphere, microorganisms density in rhizosphere and non-rhizosphere soil beneath *A. plumosa* were studied. Dune plant communities were also surveyed and analysed at the studied region. Shoot elongation rate of *A. plumosa* exceed sand trapped rate, it recorded 2.67, 4.33 and 2.11 mm day^{-1} from sand deposition. Shoot biomass reached 165.8 g m^{-2}, root biomass was 12.82 g m^{-2} and sand aggregates around roots recorded 7.25 g m^{-2}. The negative effects observed in *P. oleracea* root growth traits were higher from root extracts than soil rhizosphere extracts, whereas shoot length and germination of *P. oleracea* were most affected by rhizosphere extracts than root extracts. Phenol extracted by methanol subjected to HPLC/UV qualitative analysis and revealed that coumaric and resorcinal acids were found in both root and rhizosphere extracts, but in higher concentrations in former one. Bacterial count was significantly higher than number of fungi in the soil near *A. plumosa* grass. However, total microorganisms density was significantly higher in rhizosphere soils compared with non-rhizospheric samples.

Keywords: sand dunes, vegetation, allelopathic activity, soil microorganisms

Sand dunes occupy most of the coastal zone of North Sinai, Egypt, and their plants are well adapted to grow in full sunshine and nutritionally poor soil, due to their extensive root system, which stabilize sandy soils in an unstable and harsh habitat. In these habitats, plants suffer several stresses and exhibit a unique adaptations to plant burial and exposure of roots by moving sand grains by the wind action, salt spray, dryness and nutrient deficiency (Danin, 1991, 1996a and 1996b and Hesp, 1991).

Several studies have been done on the floristic composition of North Sinai (Boulos, 1960; Täckholm, 1974 and Gazar et al., 2000). Plant species familiar to sand dune habitat of Balouza, North Sinai are as follow; *Zygophyllum album*, *Mesembryanthemum crystallium* in dune crest and dune slope, however, *Stipagrostis plumosa* was found in dune crest. Whereas, *Cornulaca monocantha* was found in the foot of dune. Nebkha of *S. plumosa* was the largest nebkha dimensions followed by nebkha of *Zygophyllum album*, while the lowest nebkha dimensions were recorded for *Mesembryanthemum crystallium* (Elkharbotly, 2013). The presence of rhizosheaths may be an adaptation to nutritional stress and dry conditions (Wullstein et al., 1979 and Barbour et al., 1987). Rhizosheaths are structures composed of mucilage secreted from plants and adherent soil particles that form a cylinder around the root and the attachment of sand grains to the roots in the dry regions (Metcalf, 1960). Perennial roots of *Lyginia barbata* are covered by a thick sheath of sand grains trapped tightly by long, tangled, persistent root hairs. This sand sheath effectively doubles the diameter of the root. Sand sheaths of *Lyginia* and other perennial monocotyledons growing in desert and sand dune habitats have been implicated in protection against desiccation and heat stress, especially during summer (Shane et al., 2010). The formation of the sheaths depends entirely on the numerous living root hairs, which extend into the sand and track closely around individual grains (Shane et al., 2011).

The growing plants secrets many chemical compounds as root exudates to communicate with rhizospheric microbes (Abhilash et al., 2012). Plants are not passive targets for associating organisms, but rather, actively affect the structure of rhizosphere communities by positive and negative effect from their roots (Prithiviraj et al., 2007). Mosse (1973) found that vesicular-arabuscular mycorrhizae improve plant initiation and vigor, especially in case of nutrient deficient in the soil. Mycorrhizal associated to roots have been studied in coastal dunes in several countries, while a few studies on the grasses of coastal dunes (Koske and Halvorson, 1981 and Sylvia, 1986). Bacteria associated with rhizosheaths of different grasses were observed using scanning electron microscopy (SEM) in grasses of *Achnatherum hymenoids*, *Calamovilfa longifolia*, *Hesperostipa comota* and *Pascopyrum smithii* in sand dunes area. The largest number of bacteria was

found on rhizosheaths of *Calamovilfa longifolia*. All examined grasses contained a higher density of bacteria than the surrounding soil (Bergmann et al., 2009).

The spores of endomycorrhizal fungi were formed in the coastal sand dunes and their density being higher in stable than mobile sand (Koske, 1975). As much as 20% of a plant's net photosynthate is released into the rhizosphere. Large quantities of phenolic compounds are also released from plant roots; approximately 120 kg ha^{-1} plant-derived phenolics can be added into grassland soil annually. Many of these strongly affect neighboring plant and microbial communities (Grime, 1977). Extracts and leachates of the grass *Aristida adscensionis* inhibited the growth of *Rhizobium* in culture conditions. The results confirm previous studies of the effects of *Aristida adscensionis* on the nodulation of *Indigofera cordifolia* (Murthy and Nagodra, 1977). The allelopathic potentialities of *Aristida adscensionis* Linn. phytoextracted was investigated (Sarma, 1983). The ethyl acetate extracts of the leaves of *Aristida pungens* L. show a significant antibacterial activity on *Pseudomonas* and on a large spectra of fungi (Bouhadjera et al., 2005).

The present investigation aimed at studying development of phytogenic hummocks (nabkhas) and canopy of *Aristida plumosa*, the pioneer plant species in sand dune fixation in North Sinai, and the following sand trapped quantitatively, root and shoot biomass and microorganisms in the rhizosphere and in the surrounding soil. Finally, the allelopathic activity of *A. plumosa* against *Portulaca oleracea* weeds and their root exudates profile was determined.

MATERIALS AND METHODS

1. Nebkha and Canopy Characteristics

Nebkha characteristics of *Aristida* plants during different development periods (15 March, 15 May, 15 July and 15 October, 2014) were studied. 40 similar nebkhas were selected and labeled; nebkha and canopy dimensions were measured.

Nebkha and canopy characteristics were determined according to the procedure of Zhang et al. (2011), where;

Canopy Area (Ac) = ([π (Lc* Wc)]/4) ……..…….…….….(1)

Where, π =3.14

Lc; canopy length

Wc; Canopy width

Nebkha area (An) = ([π (Ln* Wn)]/4) ……..…….….…..(2)

Where Ln; Nebkha length

Wn; Nebkha width

Canopy volume (Vc) = ([π (Lc* Wc * Hc)]/6)……..……(3)
Where, Hc; Canopy height
Nebkha Volume (Vn) = ([π (Ln* Wn * Hn)]/6)……(4)
Where Hn is Nebkha height

Rate of shoot elongation, mm day^{-1} and subsequent sand accumulation rate, mm day^{-1} were recorded. Volume of trapped sand by nebkhas, m^3, (Vn) was multiplied by the sand density of the region (1640 kg m^{-3}) to obtain the mass of sand aggregates (kg). *A. plumosa* plants were gathered with their root system carefully, then sand adherent around roots are then immediately weighed, total length of roots and shoots of all plants constitute the nebkhas were measured. Roots and shoots air dried biomass were determined as m^2 in different development stages.

Fig (1). *Aristida plumosa*
The arrow shows new root formation from nodes (nodal roots) upper; and embryonic roots lower. Dash lines represent different soil levels as a result of sand accumulation.

2. Microorganisms in the Rhizosphere and the Surrounding Soil

Soil samples were collected from Baloza area, North Sinai, Egypt, for total microbial counts. Five grams of soil were taken around the *A. plumosa* rhizosphere from selected plant roots, obtained by shaking several times to remove the attached soil particles. Non-rhizosphere soil samples were also taken for microbiological analysis. One gram from each soil sample was placed into 10 ml of distilled water and shaked on a rotary shaker (100 rpm) for 30 min with five replicates. The resultant microorganism suspension was diluted according to the dilution plate technique (Johnson et al., 1959). Potato dextrose agar medium (PDA; 200.0 g l^{-1} potato , 15 g l^{-1} agar and 1000 ml distilled water) and nutrient agar

medium (3.0 g l^{-1} beef extract, 5.0 g l^{-1} peptone, 15 g l^{-1} agar, 1000 ml distilled water) were prepared according to Jacobs and Gerstein (1960) used for the account of fungi and bacteria, respectively. Incubation was performed at 25±1°C for five days for fungi and 30±1°C for 24 h for bacteria (Parkinson et al., 1971). The colonies were then counted and different strains were evaluated on the basis of their morphological properties for further investigation, and expressed as Colony Forming Units (CFU) g^{-1} soil.

3. Determination of Root Allelochemicals

The dried roots of *A. plumosa* (50 g) were ground and soaked in 350 ml of methanol (90%). The extracts obtained were shaked for 24 h and stored at 4°C. The extracts were centrifuged at 5,000 rpm for 10 min. Each of these steps were repeated three times and 350 ml of 90% methanol was added. Rhizosphere soil samples obtained from *A. plumosa* (50 g) were extracted with 350 ml of 80% methanol, three times by shaking for 5 h, at ambient temperature. The extracts were centrifuged at 5,000 rpm for 10 min. The supernatant was transferred with a pipette to a separate test tube. Supernatants were concentrated under vacuum and stored at 4°C. The weighed crude extracts were re-dissolved for bioassay and analyses by HPLC Thermo, USA). The HPLC SPECTRA SYSTEM was equipped with a dual pump, an auto sampler, and a UV detector. Samples were run on an analytical C_{18} column (5 um, 4.6 -150 mm) using gradient elution. Mobile phase consisted of 0.1% (v/v) acetic acid in water (Solution A)-MeOH (Solution B) using the following linear gradient: 10% to 90% B over 60 min. The flow rate of the mobile phase was 0.7 ml min^{-1} and the injection volume was 20 ul. UV detection was recorded at 280 nm.

4. Allelopathy

Pursalne (*P. oleracea*) seeds were sterilized using sodium hypochlorite (0.3% v/v) for 10-12 min and washed four times in sterile double-distilled water then placed in Petri dishes. The crude extracts from *A. plumosa* roots and their soil rhizosphere were redissolved in aqueous methanol to give 0, 100, 200, 300 and 400 µg ml^{-1} for treating plants' seeds. The solvent was replaced with sterilized distilled water, and after seven days from the treatment, seeds germination and seedling growth were recorded.

The effective dose (EC_{50}) for each growth parameter was calculated in a semi-log paper. The reduction (R %) was calculated from this equation:

Reduction percent = (C-T/C) × 100……..(5)

Where; C; control and T; treatments

5. Statistical Analysis

Statistical analysis was computed by using ANOVA according to Snedecor and Cochran (1990). Mean differences were conducted using Duncan Multiple Range using the program of Mstat-C.

RESULTS AND DISCUSSION

1. Natural Plant Species of Sand Dunes in North Sinai

The ecological analysis of the studied sand dune of Crest and Slope and interdunes revealed that, there were twelve species (*Mesembryanthemum crystallium, Aristida plumosa, Cornulaca monocantha, Zygophyllum album, Thymelaea hirsuta, Artemisia monosperma, Anabasis articulate, Fagonia indica, Thymus vulgaris, Carpobrotus edulis, Salsola vermiculata ,Cynodon dactylon)* within twelve genera belonging to six families (Aizoaceae, Poaceae, Amaranthaceae, Zygophyllaceae, Thymelaeaceae, Lamiaceae) as recorded at Balouza region. Most species were stated in the interdunes. However, only three species were recorded in both crest and the slope of the dunes. The most abundant species were *Mesembryanthemum crystallium* and *Zygophyllum album*, while Aizoaceae was the most abundant family recorded in the dune (Table 1).

Table (1). Natural plant species in the studied region.

Scientific name	Family	Dune position	No. of plants/ 100 m^{-2}
Mesembryanthemum crystallium	Aizoaceae	Crest, slope and interdunes	10, 20 and 4
Aristida plumosa	Poaceae	Dune crest	15
Cornulaca monocantha	Amaranthaceae	Interdunes	5
Zygophyllum album	Zygophyllaceae	Crest, slope and interdunes	10, 20 and 5
Thymelaea hirsuta	Thymelaeaceae	Interdunes	8
Artemisia monosperma	Lamiaceae	Interdunes	10
Anabasis articulata	Aizoceae	Interdunes	15
Fagonia indica	Zygophyllaceae	Interdunes	11
Thymus vulgaris	Lamiaceae	Interdunes	3
Carpobrotus edulis	Aizoaceae	Interdunes	5
Salsola vermiculata	Amaranthaceae	Interdunes	5
Cynodon dactylon	Poaceae	Interdunes	7

2. Nebkha and Canopy Characteristics

Aristida plants increased in height from 28 cm in mid March to 89 cm in mid October with an increase in sand trapped. Maximum height recorded was 17 cm in mid March and 42 cm in mid October, while sand

mean height was recorded 5.6 cm in mid March to 13 cm in mid October (Fig. 2). With accumulation of sand around *Aristida* plants, they were accelerated their shoot elongation and recorded 2.67, 4.33 and 2.11 mm day^{-1} during periods of mid March to mid May, mid May to mid July and mid July to mid October, respectively. Whereas sand trapped rate was recorded 0.50, 1.67 and 1.33 mm day^{-1} during the previous periods, respectively (Fig. 3). *A. plumos*a nebkha height and root depth were recorded as 89 and 43 cm, respectively, on 15 October 2015. The nebkha length and width was found to be 75cm× 45cm for the same period, while number of branches recorded at 10 cm were 52 cm.

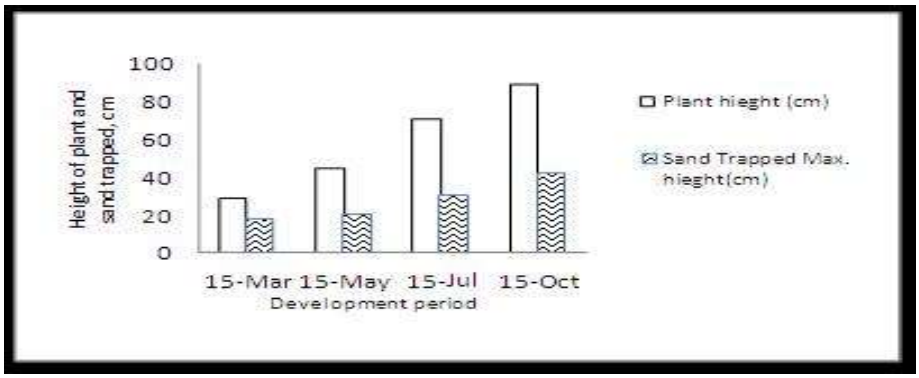

Fig. (2). Height of *Aristida* plants and sand trapped, cm.

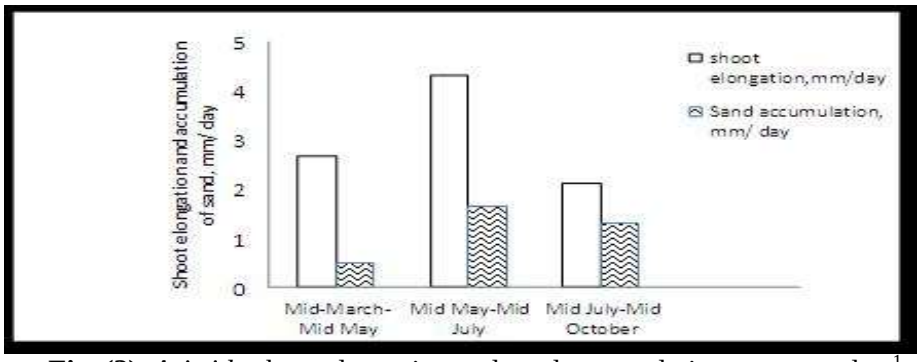

Fig. (3). *Aristida* shoot elongation and sand accumulation rate, mm day^{-1}.

Nebkha area (An) increased from 0.01 m^2 on 15 March to 0.027 m^2 on 15 October, whereas canopy area (Ac) increased from 0.07 to 0.42 m^2 in the same periods. However, nebkha volume (Vn) developed from 0.001 m^3 to 0.07 m^3 in the same time canopy volume (Vc) increased from 0.01 m^3 to 0.25 m^3, respectively. The sand accumulation recorded by nebkha was 68.8

kg, shoot air dried biomass was 165.8 g m^{-2}, root biomass was 12.82 g m^{-2} and sand aggregate adherent by roots was 7.25 g m^{-2} (Table 2).

Table (2). Nebkha characteristics and subsequent sand trapped in different development periods, 2015.

Nebkha and canopy characteristics	15 March	15 May	15 July	15 October
Nebkha dimension, cm (Hn× Ln× Wn)	17×20×9	20×50×20	30×60×35	42×75×45
Canopy dimension, cm (Hc× Lc× Wc)	28×40×21	44×70×40	70×80×50	89×90×60
Root depth, cm	13.000	25.000	35.00	43.00
Branches no./nebkha at 10 cm height	6.000	23.000	40.00	52.00
at 20 cm height	12.000	42.000	105.00	143.00
Nebkha area (An), m^2	0.010	0.080	0.17	0.27
Canopy area (Ac), m^2	0.070	0.220	0.31	0.42
Nebkha volume (Vn), m^3	0.001	0.010	0.03	0.07
Canopy volume (Vc), m^3	0.010	0.060	0.15	0.25
*Sand trapped Mass (m), kg/ nebkha	1.640	16.400	49.20	121.36
Total shoot biomass (air dried), g/m^2	4.300	25.900	60.0	165.80
Total root biomass (air dried), g/m^2	0.280	1.750	2.80	12.82
Sand aggregated adherent by roots, g/m^2	0.190	0.812	1.35	7.25

*Density of sand particles of the region, p= 1.64 g/cm^2, then sand mass calculated by m = p * v

The results indicate that the increase of *A. plumosa* nebkha growth was increased their abilities to trapp sand by its foliage and catching sand by its roots. With increasing accumulation of sand around *Aristida* plants, canopy and nebkha dimensions and area are increased. These results are in accordance with Moreno-Casasola (1986), Barbour et al. (1984) and Greig-Smith (1964). In addition, rhizosheaths may be an adaptation to nutritional stress and dry conditions of sand dunes (Wullstein et al., 1979; Barbour et al., 1987 and Metcalf, 1960). This sand sheath in sanding roots may help in protection against desiccation and heat stress especially during summer (Shane et al., 2010). It was noticed that new roots were formed in the basal nodes of buried shoots (Fig. 1), which means increase in sand binding

ability, subsequently more dune stabilization capability. Consequently, it appears to be an ideal plant for sand dune fixation.

3. Allelopathic Effect of *A. plumosa* against *P. oleracea* Weed

As shown in table (3), the highest concentration of *A. plumosa* root extracts at 400 µg ml^{-1} completely suppressed *P. oleracea* seeds germination and seedling growth. The treatment with 200 and 300 µg ml^{-1} have significantly inhibitory effects upon *P. oleracea* reached 41.1 and 66.7% (germination), 52.9, 76.5% (root length) and 36.4 and 77.3% (shoot length), respectively. On the other hand, the extract of soil rhizosphere at 100, 200, 300 and 400 µg ml^{-1} were recorded a significant reduction in *P. oleracea* germination (21.5, 28.0, 67.7, 81.7%), root length (33.3, 72.2, 77.8, 88.9%) and shoot length (25.6, 53.8, 64.1, 74.4%), respectively. The overall mean shoot length, root length and germination of *P. oleracea* seeds did not differ significantly by both of root extracts and rhizosphere extractions. As the concentration increased from 100 to 400 µg ml^{-1} resulted in a significant reduction in the mean shoot, root length and germination of *P. oleracea*, comparing with the control. The obtained results revealed that increasing concentrations from 100 to 400 µg ml^{-1} for both root and rhizosphere extracts significantly increased the inhibition of root, shoot length and seed germination comparing with control treatment.

The EC_{50} of *A. plumosa* methanol extracts was 211±2, 200±1 and 240±2 µg ml^{-1} for *P. oleracea* shoot length (cm), root length (cm), and germination %, respectively. On the other hand, the EC_{50} of methanol soil rhizosphere extracts was 245±3, 186±4 and 248±3 µg ml^{-1} for *P. oleracea* shoot length, root length and germination %, respectively. According to EC_{50}, the negative effect observed in *P. oleracea* root growth traits was higher from root extracts than soil rhizosphere extracts, whereas shoot length and germination of *P. oleracea* were more affected by rhizosphere extracts than root extracts, as shown in fig. (4).

The root exudates secretion is one of the ways for plant communication to the neighboring plant and adjoins of microorganisms present in the rhizosphere of the roots. Secretion of such exudates may regulate the neighboring soil microbial community, cope with herbivores, inhibit the growth of competitive plant species and change the chemical and physical properties of the soil (Balah, 2015 and Shukla et al., 2011).

4. Phenolic Compounds Determination in Root Tissue and Soil Rhizosphere Extracts

Phenolic compounds were extracted with 90% methanol from *A. plumosa* roots and their rhizosphere soils. While, the authentic compounds were chosen depending on notable phytochemicals about *Aristida* species

literature (Sarma, 1983). The chromatographic analysis refers to the detected compounds, namely; gallic acid, catechin, ferulic acid, syringic acid, coumaric acid, resorcinol, caffeic acid, cinnamic acids, kaempferol in root parts. Whereas, rhizospheric soil profile presented ferulic acid, resorcinol, and coumaric acid. It is clearly indicated that root extracts had the higher amount than rhizospheric soil extracts from the same compounds as shown in table (4).

Table (3). Effect of *A. plumosa* on seed germination and seedling development of *P. oleracea* plants.

Treatment	Concentration (µg ml^{-1})	Germination (%)	Root length (cm)	Shoot length (cm)
Root parts extraction (A)	Control	90.00 (0.0)	1.70 (0.0)	4.40 (0.0)
	100	77.00 (14.4)	1.40 (17.6)	3.20(27.3)
	200	53.00 (41.1)	0.80 (52.9)	2.80(36.4)
	300	30.00 (66.7)	0.40 (76.5)	1.00 (77.3)
	400	0.00 (100.0)	0.00 (100.0)	0.00 (100.0)
	LSD 0.05	14.12	0.11	0.11
	Trend line equation	y = 25.222x - 31.222	y = 25.882x - 28.235	y = 25x - 26.818
Soil rhizosphere extraction (B)	Control	93.00 (0.0)	1.80 (0.0)	3.90 (0.0)
	100	73.00 (21.5)	1.20 (33.3)	2.90 (25.6)
	200	67.00 (28.0)	0.50 (72.2)	1.80 (53.8)
	300	30.00 (67.7)	0.40 (77.8)	1.40 (64.1)
	400	17.00 (81.7)	0.20(88.9)	1.00 (74.4)
	LSD 0.05	9.68	0.19	0.19
	LSD 0.05 A × B	13.68	0.27	0.27
	Trend line equation	y = 20.968x - 23.118	y = 22.222x - 12.222	y = 18.718x - 12.564

Y= Reduction % X = concentration (µg/ml)

Values between brackets is the reduction percent.

5. Microorganisms (Bacteria and Fungi) Density in Dune Sand of Balouza

Bacterial count was significantly higher than number of fungi in the soil near *A. plumosa* grass; it recorded 42.4 and 8.83 cfu g^{-1}, respectively. However, total microorganisms density was significantly higher in rhizosphere compared with non-rhizospheric samples, it recorded 36.83 and 14.42 cfu g^{-1}, respectively (Table 5).

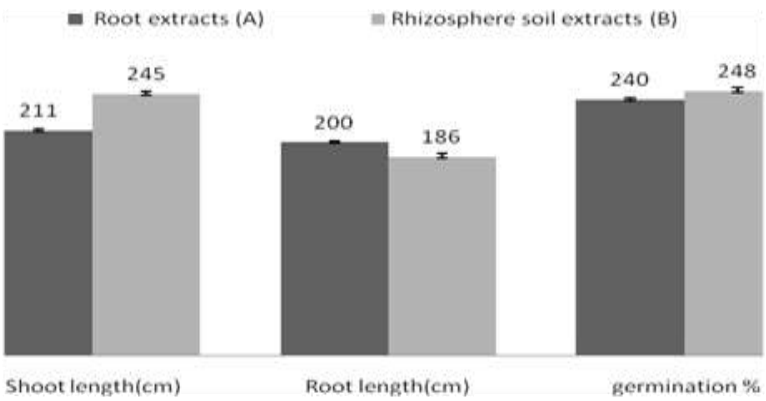

Fig (4). Dose response relationship (EC_{50}) of root and soil rhizosphere extracts of *P. oleracea* (µg ml^{-1} ± Standard division).

Table (4). The content of phenols in *A. plumosa* root tissue and associated rhizosphere soils.

Authentic samples	**RT (min.)**	**Roots tissue (mg/kg)**	**Rhizosphere soil (mg/kg)**
Gallic acid	3.80	0.5000	ND
Catechin	6.00	0.382	ND
Ferulic acid	15.80	0.409	0.0122
Syringic acid	24.30	0.270	ND
Coumaric acid	32.80	1.330	0.8770
Resorcinol	34.50	1.106	0.4870
Caffeic acid	45.10	0.820	ND
Cinnamic acids	46.63	0.170	ND
Kaempferol	48.90	0.230	ND
Total amount		5.217	1.3760

Table (5). Microorganisms density near *A. plumosa* in dune sand of Balouza.

	Fungi	**Bacteria**	**Rhizosphere**	**Non-Rhizosphere**
Count (CFU)	8.83 b	42.42 a	36.83 a	14.42 b
LSD 0.05	5.25		5.25	

Bacteria in rhizosphere recorded the highest significant value followed by bacteria in the non-rhizosphere, as compared to fungi in both rhizosphere and non-rhizosphere; it recorded 61.83, 23.00, 11.83 and 5.83

cfu g^{-1}, respectively. Bacteria at dilution of 10^{-3} recorded the highest significant value, followed by bacteria at dilution of 10^{-4} compared with fungi at both dilutions of 10^{-3} and 10^{-4}, it recorded 52.0, 32.8, 12.3 and 5.3 cfu g^{-1}, respectively. It is obvious that bacteria in the rhizosphere at dilution of 10^{-3} recorded the highest value, followed by rhizosphere bacteria at dilution of 10^{-4}, it recorded 74.00 and 49.67 cfu g^{-1}, respectively. However, non-rhizosphere fungi at dilution of 10^{-4} recorded the lowest value of 3.33 cfu g^{-1} (Table 6). The results are in agreement with those obtained by Bergmann et al. (2009) and Koske (1975).

Table (6). Microorganisms density near *A. plumosa* plants in dune sand of Balouza.

	Fungi			**Bacteria**		
Dilution	R	NR	Mean	R	NR	Mean
10^{-3}	16.33 d	8.33 de	12.33 c	74.00 a	30.00 c	52.00 a
10^{-4}	7.33 de	3.33 e	5.33 d	49.67 b	16.00 d	32.83 b
Mean	11.83 c	5.83 c		61.83a	23.00 b	

LSD 0.05 ABC =9.23, AB=7.43, AC=6.53 A= microorganism (fungi, bacteria), B= distance from root (R,NR), C= concentration (10^{-3}, 10^{-4})

The mycorrhizal fungi may contribute to sand dune stabilization by linking sand grains in aggregates with fungal hyphae, which may serve in drought resistance and improve plant establishment in desert dunes as studied by Sutton and Sheppard (1976). In this study, the fungal isolates were identified according to Anonymous (2003 and 2005), five isolates were *Aspergillus* and *Penicillum* in addition six Actinomycetes isolates (mostly *Streptomyces*). On the other hand, the eleven bacterial isolates need further studies to be identified**.**

CONCLUSION

Natural plant vegetation plays an important ecological role in sand dune areas especially in sand dune stabilization. The majority of dune plant species in the study region was situated in the interdunes. However, only three species were found in both crest and the slope of the dunes. During the present study, *A. plumosa* (Poaceae) attracted attention through their growth characters, especially root formation and root sheaths ability to catch sands. This plant has the ability to generate new adventitious roots from nodes at the base of buried nodes to produce new plants attached with the mother plants; that permits plants to share the assimilation products. In addition to their root exudates with their associated microbes that adhering sand

particles around roots resulting in binding sand layers. All these formations increased the ability of *A. plumosa* to catch sands and stabilize the dune. The allelopathic activity of *A. plumosa* root parts was evaluated against *P. oleracea* weeds, in which increasing concentrations of root parts and soil rhizosphere extracts increased the suppressive ability against *P. oleracea* root, shoot length and seed germination. Total microorganisms density was significantly higher in rhizosphere compared with non-rhizospheric samples. However, the bacterial count was significantly higher than the number of fungi in the soil near *A. plumosa* grass. Quantitative analysis by HPLC/UV showed nine phenol compounds in root parts. However, only three compounds were detected in rhizospheric soil extracts. Further study are needed to identify all phytochemicals and soil microorganism. On the other hand, *A. plumose* exhibited superior natural growth characteristics (vegetative and subterranean growth, their rhizosheath, root branches, structural and exudates) that facilitate its ability to form nebkha sands and face the scarcity of water, nutrient deficiency making this an ideal plant for stabilizing sands.

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الأريستيدا بلوموزا: التأثير الأليلوباثي والقدرة على تثبيت الرمال في بالوظة، شمال سيناء، مصر

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يهدف هذا البحث إلى إلقاء الضوء على أهمية نبات *Aristida plumosa* كنبات مثالي لتثبيت الكثبان الرملية في بالوظة، شمال سيناء، مصر. تم قياس خصائص النبكة والمجموع الخضري للنبات خلال مراحل نمو مختلفة لعام ٢٠١٤ م. كما تم تقدير كمية الرمال المترسبة حول النبكة والناتج الحيوي للأفرع والجذور وكمية الرمال الملاصقة للجذور. كما تم دراسة التأثير الأليلوباثي لمستخلص جذور نبات *A. plumosa* والتربة الملاصقة لها علي نسبة إنبات بذور نبات الرجلة وعلى طول الساق والجذر، المركبات الفينولية في أنسجة الجذر والتربة الملاصقة لها. كما تم تقدير كثافة الكائنات الدقيقة في عينات التربة الملاصقة للجذور والأخرى البعيدة عنها. أشارت دراسة الأنواع النباتية المتواجدة إلى وجود ١٢ نوع نباتي ينتمي ل ١٢ جنس يتبع ٦ عائلات نباتية.

معظم الأنواع النباتية وجدت في المناطق بين الكثبان الرملية وعدد قليل منها وجدت في كل من قمة ومنحدر الكثيب. أكثر الأنواع النباتية إنتشارًا *Mesembryanthemum crystallium* و*Zygophyllum album* بينما أكثر العائلات وجودًا هي عائلة Aizoaceae.

لوحظ زيادة إرتفاع نبات *A. plumosa* من ٢٨ سم في منتصف مارس إلى ٨٩ سم في منتصف أكتوبر ٢٠١٤ م. مع زيادة أقصي إرتفاع لتراكم الرمال من ١٧ سم في منتصف مارس إلى ٤٢ سم في منتصف أكتوبر ٢٠١٤ م. كما تفوق معدل إستطالة الأفرع على معدل تراكم الرمال حولها حيث سجل ٢.٦٧، ٤.٣٣ و٢.١١ مم/ يوم بينما سجل معدل تراكم الرمال ٠.٥، ١.٦٧ و١.٣٣ مم/يوم خلال الفترات الممتدة من منتصف مارس – منتصف مايو، منتصف مايو- منتصف يوليو ومنتصف يوليو- منتصف أكتوبر ٢٠١٤ م، على الترتيب.

سجل الناتج الحيوي للمجموع الخضري ١٦٥.٨ جم/م٢ وللجذور ١٢.٨٢ جم/ م٢ بينما سجلت الرمال الملاصقة للجذور ٧.٢٥ جم/م٢. أثر مستخلص الجذور والتربة الملاصقة لها سلبًا على نسبة إنبات بذور الرجلة وعلى نمو الساق والجذر بزيادة التركيز من ١٠٠ إلى ٤٠٠ ميكروجرام/مل. أثر سلبًا بصورة أكبر مستخلص الجذور على نمو الجذور بينما أثر مستخلص التربة الملاصقة للجذور سلبًا بصورة أكبر على كل من نسبة الإنبات وعلى نمو الساق لنبات الرجلة. تقدير المركبات الفينولية في أنسجة جذر نبات *A. plumosa* والتربة الملاصقة لها أظهر وجود كل من Coumaric acid وResorcinal acid في كلًا من الجذور بنسبة أكبر (١.٣٣ و١.١١ جم/ كجم) والتربة الملاصقة لها بنسبة أقل (٠.٨٨ و٠.٤٩ جم/كجم، على الترتيب). كما وجد حمض Cinnamic acid بنسبة قليلة في الجذور (٠.١٧ جم/ كجم) وأيضًا وجد حمض Ferulic acid بنسبة قليلة في مستخلص التربة الملاصقة للجذور (٠.٠١٢ جم/ كجم). كثافة البكتريا في تربة الكثبان الرملية الملاصقة لنبات *A. plumosa* كانت أعلى من كثافة الفطريات، كما زادت الكثافة الكلية للكائنات الدقيقة في التربة الملاصقة للجذور عنها في التربة البعيدة عن الجذور. تم عزل ٥ أنواع فطرية، ٦ أنواع أكتينوميستات و١١ نوع بكتيري.