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Distributional behavior and growth performance of *Trianthema portulacastrum* L. (Aizoaceae) in Nile Delta

Kamal Shaltout[(1)], Dina Mohsen Baraka[(2)], Mohamed Nour Shehata[(2)], Dalia Ahmed[(1)], and Omnia Mohamed Arief [(2)]
[(1)] Botany Department, Faculty of Science, Tanta University
[(2)] Botany Department, Faculty of Science, Benha University

The present study aims to determine the distribution of *Trianthema portulacastrum* L. in Nile Delta, to assess the factors that affect its invasion to the study area, and to determine the associated species and plant communities. It aims also at assessing its germination capacity and morphological plasticity through studying several morphological traits. One hundred and thirty stands (each of about 50 m^2) were sampled during summer 2009 – 2010 to represent its population in 4 habitats in Nile Delta (orchards, fields of summer crops, irrigation canals and waste lands). The total number of associated species was 63 species, belonged to 56 genera and 22 families. TWINSPAN classification was applied to the floristic composition of 130 stands and led to identify of 18 vegetation groups. Soil of orchards have the highest sand (39.1 %) and organic matter (9.3 %), while the fields of summer crops have the highest EC (440 μScm^{-1}) and phosphorus (6.9 %). In addition, irrigation canals have the highest silt (28.4 %), clay (58.6 %), pH (8.1), nitrogen (0.22 %) and $CaCO_3$ (8.1 %), while the waste lands have the highest potassium (40.3 mg/L). The most effective elements according to CCA were determined. The dispersal type of *Trianthema* belongs to the anemochores, flowering time extend from February to September, while fruiting time extends from June to September. Seed characteristics were studied. The germination percentage of *Trianthema portulacastrum* seeds was the highest in waste lands (74 %); while it attained the lowest value in corn fields (50 %).

Key words: *Trianthema portulacastrum* L., seed morphology, germination, habitats

Introduction

Trianthema portulacastrum L. is an indigenous plant to South Africa, tropical and subtropical regions (Aneja *et al*., 2000 and Boulos 1999). Zohary (1966) and Hassib (1956) did not record it in Palestine and Egypt. Regarding the distribution along the world, *T. portulacastrum* has a pentatropical distribution: In Africa, it is known from Mauritania, Senegal, Egypt, Sudan, Upper Guinea, Cape Coast, Christiansburg, Belgian Congo, Angola, Gold Coast, Gambia, Ivory Coast, Togo and Nigeria. In Asia, it is known from Tropical Arabia, Yemen, Aden, West Pakistan, India, Delhi, Sri Lanka, Malaya and Java. In South and Central America it is recorded in Mexico, Cuba, West Indies, Argentina, Peru, and Paraguay. It is recorded also in Southern part of USA.

In Australia, it is found in Central and Southern Queensland (Kosinova 1984). it is an annual succulent glabrescent herb; stem 15 - 50 cm, prostrate or ascending; leaves 0.5-5 X 0.5-4 cm, rounded or apiculate; petiole 0.2-2 cm, expanding into a sheathing membrane and connate with that of the opposing leaf; flowers white or pink, sessile, solitary, partly hidden by the leaf-bases; perianth-lobes 3.5-4.5 mm, narrowly obovate, mucronate; stamens 10-20; capsule 3- to 10 seeded, the lid flattened (Bolous 1999).

Trianthema portulacastrum was originally known in Egypt as a very rare species recorded in Gebel Elba (Täckholm 1974), after that, it had been reported to be widely *distributed*, spread rapidly in crop fields of Egypt. Kosinova (1984) reported it in the cultivated fields north of Cairo. In Nile Delta, it was firstly recorded by El-Shayeb (1984 and 1989) and Shalaby (1995). Recently, it was recorded in the books of Egyptian flora: Boulos 1995 and 1999 and El-Hadidi 2000 and subsequent studies of Ahmed (2003), Shehata (2004), El-Masry (2007), Shaltout *et al*. (2005), Shaltout, *et al*. (2010a).

Introduced species was identified as the plant taxa in a given area whose presence there is due to intentional or accidental introduction as a result of human activity (Synonyms: alien, exotic, non indigenous or non-native plants) and it becomes naturalized. Some of the naturalized species become invasive which produce offspring, often in very large numbers at considerable distances from parent plants and thus have the potential to spread over a considerable area (Richardson *et al*. 2000). The invasion and potential for widespread impact make *T. portulacastrum* a timely and important subject for the study of the process of biological invasion in crop fields ecosystem. It may become one of the problematic terrestrial summer weeds in Egypt due to competition with in various agricultural crops.

The present study aims to determine the distribution of *Trianthema portulacastrum* L. in the Nile Delta; to assess the factors that affect its invasion to the study area, and to determine the associated species and plant communities. It aims also at assessing its germination capacity and morphological plasticity through studying the following traits: area occupied by the plant, stem length, width and perimeter, leaf length and width, internodes length at main and lateral branches, number of main and lateral branches, number of internodes for main and lateral branches, and number of flowers and fruits for the main and lateral branches.

Study area

Nile Delta is a classic delta with triangular shape; its length from south to north is 170 km, and from west to east is 220 km (Fig. 1). The area of this region (about 22000 km^2) comprises about 63% of Egypt productive land (Abu Al-Izz 1971). Most cultivated lands in this region are irrigated by River Nile through a net of and drainage canals (Al-Sodany 1998). The vegetation in Nile Delta includes the plant communities of uncultivated lands along the water courses, railways and roadsides, swamps and marshes, abandoned fields and cultivated lands. Nile Delta has a Mediterranean climate, characterized by little rainfall. Only 100 to 200 mm of rain falls on the delta area during an average year, and most of this falls in the winter months. Nile Delta experiences its hottest temperatures in July and August 30 °C, winter temperatures are normally in the range of 10° to 19 °C, with some rain, the Nile Delta region becomes quite humid during the winter months. The relative humidity varies between 51% at Banha (Southern Delta) in June and 70% at Tanta in August. The evaporation varies between 7.2 mm-1day in August and September at Tanta (Middle Delta) and 12.2 mm-1day in June at Banha (Shaltout et al. 2010a).

Material and Methods

a- Field study:

One hundred and thirty stands (each of about 50 m^2) were sampled during summer 2009 - 2010 to represent the variation in the population of *Trianthema portulacastrum* in Nile Delta (Fig. 1). These stands represent its distribution in four Governorates (10 stands in Kafr El-Shiekh, 8 in Minufya, 23 in Gharbia and 89 in Qaliubiya) and four different habitats (orchards, summer crops fields, waste lands and irrigation canals). In each stand, associated species were recorded, plant cover was estimated following Braun-Blanquet cover-abundance scale and life forms following Raunkiaer (1937). The flowering times of the recorded species were assessed in the field and checked with those indicated in Shaltout *et al*. (2010a). Growth variables were estimated during the Second season (summer 2010) for 7 locations representing the 4 habitats where *Trianthema* present. In each habitat, trait was scored as mean value of 5 individuals in 5 stands. In each sampled stand, three randomly distributed soil samples were collected as a profile from three holes each of 0 – 50 cm depth below the soil surface. The soil samples were brought to the laboratory in plastic bags shortly after collection, spread over sheets of papers, air dried, grinded and passed through 2 mm sieve to separate gravels and debris, and then packed in plastic bags ready for physical and chemical analysis.

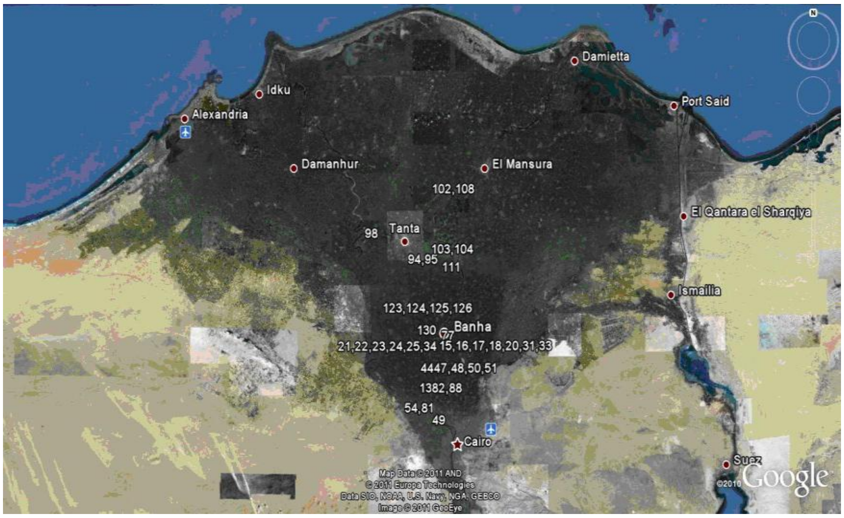


Fig. 1. Map of Nile Delta indicating the 130 sampled stands of *Trianthema portulacastrum* L. (map was prepared using Google Earth Program).

b- Soil analysis

Soil texture analysis was carried out by the Bouyoucos hydrometer method and organic matter by loss-on-ignition at 450 °C. Determination of calcium carbonate was carried out using rapid titration method with Ph indicator. Soil water extracts of 1:5 were prepared for the determination of soil salinity (EC) and soil reaction (pH) using electric conductivity (mS.Cm-1) and pH meters. K and P contents were determined using a spectrophotometer, while N content was determined using Micro-Kjeldahl apparatus (Allen *et al*. 1989).

c- Seed germination

Seeds are selected from 7 locations: citrus, banana, waste land, cabbage, sweet potato, corn and irrigation canal. Fifty seeds were prepared after removing the capsule. These seeds were distributed in 10 Petri dishes (5 seeds $dish^{-1}$) in a regular pattern. Filter papers were placed in the Petri dishes and then seeds were put and a few tap water were added to moisten the filter paper and more water were added if required. Germination tests were carried out under Lab temperature that ranging from 23 to 25°C. The variation in the germination percentage of its seeds was observed under uniform conditions during five months (October 2010 - February 2011) before the dormancy of the seeds. The numbers of germinated seeds were recorded daily until no new seeds germinate. Germination *percentage* (GP) was calculated as follows: (GP) = Number of germination seeds × 100 / total number of seeds. The evaluation of morphological characteristics of *Trianthema portulacastrum* was estimated under field conditions during July, August and September (2011).

d- Statistical analysis

Two trends of multivariate analysis were applied in the present study: two-way species analysis (TWINSPAN), as a classification technique (Hill 1979a), and detrended correspondence analysis (DECORANA), as an ordination one (Hill 1979b). Both trends have their merits in helping to understand the vegetation and environmental phenomena. Canonical correspondence analysis (CCA), as a weighted averaging direct ordination whose axes are constrained by environmental variables, was applied to the same sets of vegetation and soil data. The performance of this technique is best when the species have a unimodal response to the environmental gradients (ter Braak 1986 and 1987). One-way analysis of variance (ANOVA-one) was applied to assess the significance of variation in many floristic, vegetation and soil variables in relation to types of habitat and vegetation. This technique was according to SPSS software (SPSS 1999).

Results

Sixty three species, belonged to 56 genera and 22 families, were associated with the distribution of *Trianthema portulacastrum* in four different habitats (Orchards, fields of summer crops, irrigation canals and waste lands) in Nile Delta. The determination of the life forms of the recorded species indicated that the therophytes are the most represented (42 species = 66.7% of the total species), followed by geophytes-helophytes (8 species = 12.7%), phanerophytes (5 species = 7.9%), hemicryptophytes (4 species = 6.3%), chamaephytes (3 species = 4.8%) and parasites (1 species = 1.6%) (Fig. 2). There is a gradual increase in the frequency of the flowered species from January (5 species = 7.9 % of the total species) till reaching the maximum in July and August (51 species = 80.9), then decrease again reaching a minimum in December (11=17.1%) (Fig. 3).

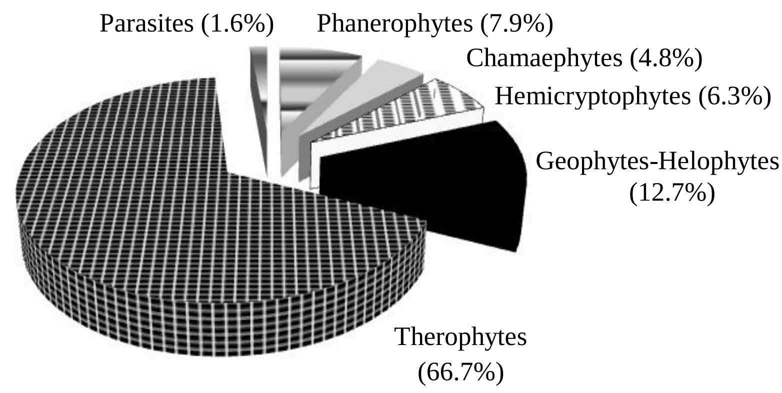


Fig. 2. Life form spectrum of the associated species with the distribution of *Trianthema portulacastrum* in Nile Delta.

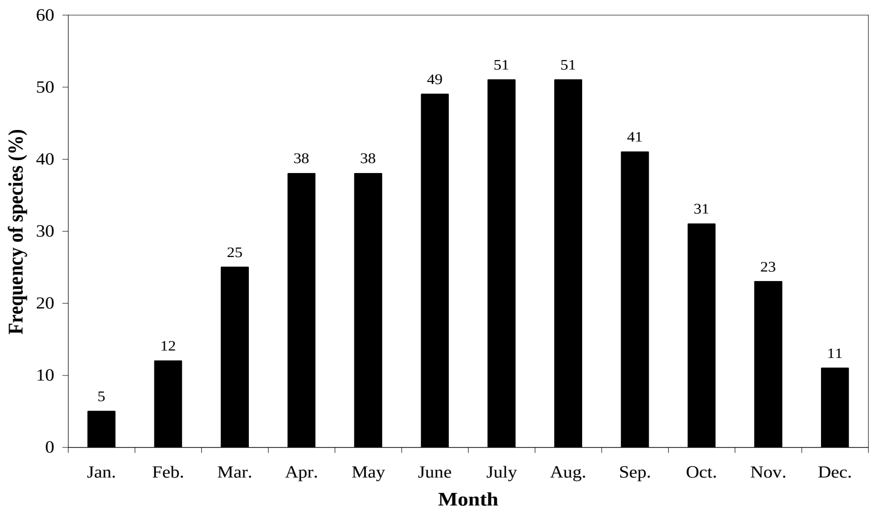


Fig. 3. Frequency of the associated species in the flowering stage with the distribution of *Trianthema portulacastrum* in Nile Delta.

The application of TWINSPAN classification on the floristic composition of the 130 sampled stands led to classify them into 18 groups at level six and six major groups (I - VI) at level three (Table 1). The segregation between the 18 groups along the ordination plane of the first and second axes of DECORANA is not obvious, while the segregation of the major six groups is obvious (Fig. 4). Group I includes 5 vegetation groups that characterize the fields of orchards, summer crops, and waste lands (dominated by *Trianthema portulacastrum*, *Portulaca oleracea*, *Phragmites australis* and *Cyperus rotundus* var. *rotundus*); while Group II includes 1 vegetation group that characterize, the fields of summer crops and waste lands (dominated by *Trianthema portulacastrum*).

Table 1. Characteristics of the 18 vegetation groups associated with the distribution of *Trianthema portulacastrum* in Nile Delta. Or: orchards, Sc: fields of summer crops, Ca: irrigation canals, Wl: waste land.

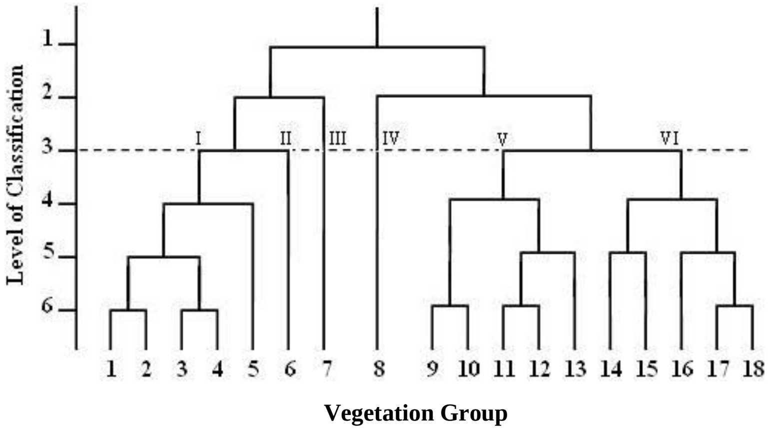
Level of classification		No. of stands	Total species	Habitat	First dominant species	Second Co- dominant species
3	6					
I	1	6	9	Or, Wl	*Trianthema portulacastrum*	*Digitaria sanguinalis*
	2	2	10	Sc	*Trianthema portulacastrum*	*Convolvulus fatmensis*
	3	4	20	Or, Sc	*Portulaca oleracea*	*Trianthema portulacastrum*
	4	1	7	Sc	*Phragmites australis*	*Trianthema portulacastrum*
	5	2	18	Sc	*Cyperus rotundus*	*Trianthema portulacastrum*
II	6	3	12	Sc, Wl	*Trianthema portulacastrum*	*Amaranthus hybridus*
III	7	1	12	Or	*Euphorbia heterophylla*	*Amaranthus spinosum*
IV	8	3	21	Or, Sc	*Trianthema portulacastrum*	*Portulaca oleracea*
V	9	67	15	Or, Ca, Wl, Sc	*Trianthema portulacastrum*	*Cyperus rotundus*
	10	12	13	Or, Sc	*Trianthema portulacastrum*	*Portulaca oleracea*
	11	7	32	Or, Ca, Wl	*Echinochla colona*	*Trianthema portulacastrum*
	12	5	30	Or, Ca, Wl, Sc	*Amaranthus viridis*	*Trianthema portulacastrum*
	13	2	27	Or	*Amaranthus viridis*	*Euphorbia heterophylla*
VI	14	3	34	Or, Wl,Sc	*Trianthema portulacastrum*	*Oxalis corniculata*
	15	2	12	Wl	*Amaranthus viridis*	*Trianthema portulacastrum*
	16	3	14	Or, Wl	*Amaranthus lividus*	*Trianthema portulacastrum*
	17	2	8	Or	*Trianthema portulacastrum*	*Cynanchum acutum*
	18	5	13	Sc	*Euphorbia retusa*	*Echinochla colona*

Group III includes one vegetation group that characterizes the fields of orchards (dominated by *Euphorbia heterophylla*), Group IV includes 1 vegetation group that characterizes the fields of orchards and summer crops (dominated by *Trianthema portulacastrum*), while Group V includes 5 vegetation groups that characterize the fields of orchards, summer crops, canals and waste lands (two dominated by *Amaranthus viridis*, two dominated by *Trianthema portulacastrum*, and one dominated by *Echinochla colona*. Group VI includes 5 vegetation groups that characterize the fields of orchards, summer crops, and waste lands (dominated by *Trianthema portulacastrum*, *Amaranthus caudatus*, *Amaranthus lividus* and *Euphorbia retusa*).

The soil characteristics indicated that the orchards (orange and banana) have the lowest clay (35%) and silt (25.7); but have the highest sand (39.1%), organic matter (9.3%). Summer crops have the highest EC (440 µSCm-1) and phosphorus (6.9 %), but the lowest organic matter (6.0%) and $CaCO_3$ (7.8 %). Irrigation canals have the highest silt (28.4%), clay (58.6%), pH (8.1), $CaCO_3$ (8.1 %) and nitrogen

(0.22 %) and the lowest sand (12.9%), phosphorus (6.3 %) and potassium (23.3 mg/L). Waste lands have the highest potassium (40.3 mg/L); and the lowest pH (7.6) (Table 2).

a- TWINSPAN classification



b- DECORANA ordination

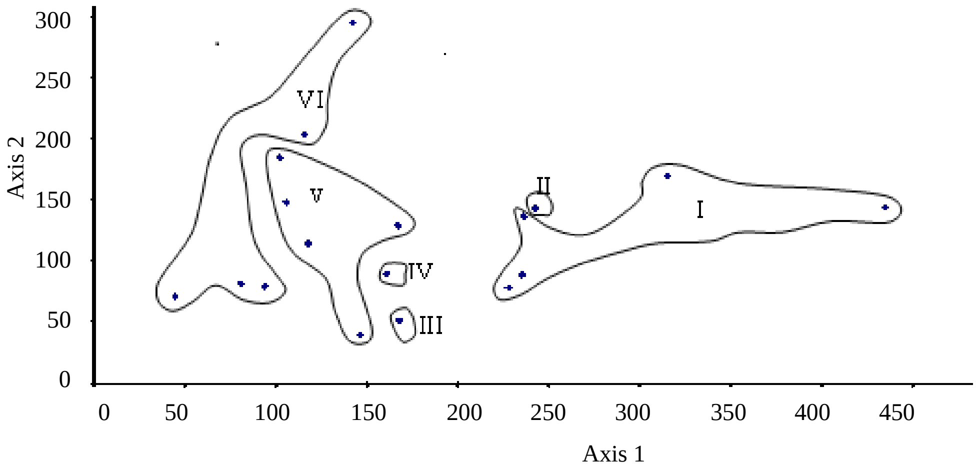


Fig. 4. TWINSPAN classification (a) and DECORANA ordination (b) of the 18 vegetation groups identified with the distribution of *T. portulacastrum* in Nile Delta. The vegetation groups that support each of the 6 major vegetation groups are encircled together (I -VI).

Table 2. Mean (M) and standard deviation (SD) of the soil characteristics of the 4 habitats supporting the sampled stands of *Trianthema portulacastrum* population in Nile Delta. OM: organic matter. The values between brackets are the number of stands in each habitat. Maximum and minimum values are underlined. Or: fields of orchards, Sc: fields of summer crops, Ca: irrigation canals, Wl: waste land.

Character		Or (31)		Sc (44)		Ca (3)		Wl (13)		Total (91)	
		M	SD	M	SD	M	SD	M	SD	M	SD
Sand	%	39.1	22.7	18.2	25.4	12.9	1.66	31.5	22.6	25.4	11.1
Silt	%	25.7	2.8	27.8	27.0	28.4	1.47	25.9	4.01	27.0	12.2
Clay	%	35.0	20.4	53.8	47.5	58.6	2.18	42.6	19.1	47.5	18.8
OM	%	9.3	2.8	6.0	4.3	7.0	5.0	9.0	2.8	8.0	3.0
N	%	0.2	0.06	0.2	0.22	0.22	0.01	0.21	0.05	0.2	0.1
P	%	6.32	2.15	6.9	6.60	6.3	2.52	6.77	2.80	6.6	2.07
$CaCO_3$	%	8.0	0.3	7.8	8.02	8.1	0.55	8.04	0.58	8.02	3.8
pH		8.0	0.3	7.9	0.4	8.1	0.3	7.6	0.9	7.9	1.2
EC μScm^{-1}		290	8.4	440	111	210	21	400	94	330	39
K (mg/L)		29.8	37.4	35	32.1	23.3	3.06	40.3	37.9	32.1	16.6

The upper left quarter of the CCA bioplot indicated that *Amaranthus spinosus*, *Euphorbia retusa*, *Trianthema portulacastrum* and *Oxalis corniculata* concide with the organic matter and sand (Fig. 5). On the other hand, at the lower left quarter, *Cynanchium acutum*, *Euphorbia heterophylla*, *Convolvulus fatmensis* coincide with EC, nitrogen and calcium carbonate; while at the upper right quarter, *Phragmites australis* coincides with phosphorus. At the lower right quarter, *Amaranthus hybridus*, *Cyperus rotundus* and *Echinochloa colona* coincide with silt and clay.

Seed characteristics

The dispersal type of *Trianthema* belongs to the anemochores (light gliders). Flowering time extends from February to September, while fruiting extends from June to September. Seed shape is sub-rounded, seed color is black, hilum shape is groove, hilum elevation is sunken and hilum position is basal. Seed texture is rough, seed ornamentation is sculptures, while seed outline is curved (Fig. 6). The quantitative characters shows that the mean of the seed length is almost the same in all habitats. The seed width varies from 1.3 to 1.7 mm, seed thickness from 0.7 to 1.0 mm; while seed weight from 0.4 to 0.5 mg and seed size from 1.4 to 2.1 mm3 (Table 3). The germination of *Trianthema portulacastrum* seed is epigeal. The cumulative germination percentage was the highest in cabbage fields and waste lands (74 %) followed by sweet potato fields (64 %), while the lowest was in corn field (8 %) (Table 4).

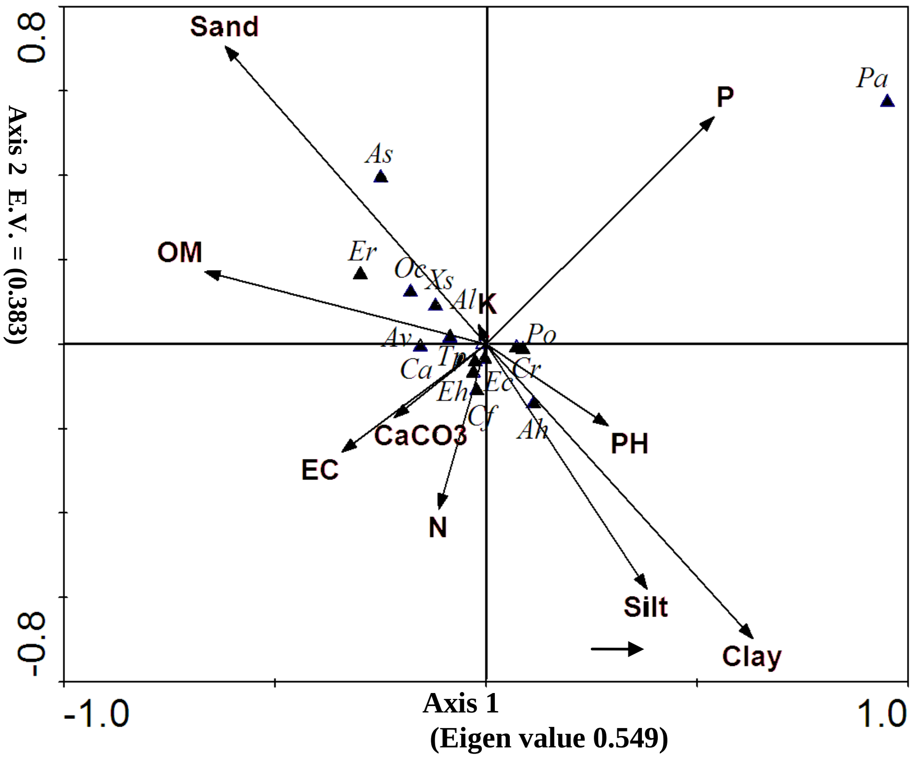


Fig. 5. CCA-biplot with the soil variables (⟶) and the characteristic species (▲).The characteristic species are coded as follows; *Ah*: *Amaranthus hybridus*, *As*: *Amaranthus spinosus*, *Al: Amaranthus lividus*, *Av: Amaranthus viridis*, *Ca*: *Cynanchium acutum*, *Cf: Convolvulus fatmensis*, *Cr*: *Cyperus rotundus*, *Ds*: *Digitaria sanguinalis*, *Eh*: *Euphorbia heterophylla*, *Er*: *Euphorbia retusa*, *Ec: Echinochloa colona*, *Oc: Oxalis corniculata*, *Po*: *Portulaca oleracea*, *Pa*: *Phragmites australis*, *Tp*: *Trianthema portulacastrum*, and *Xs*: *Xanthium spinosum.*

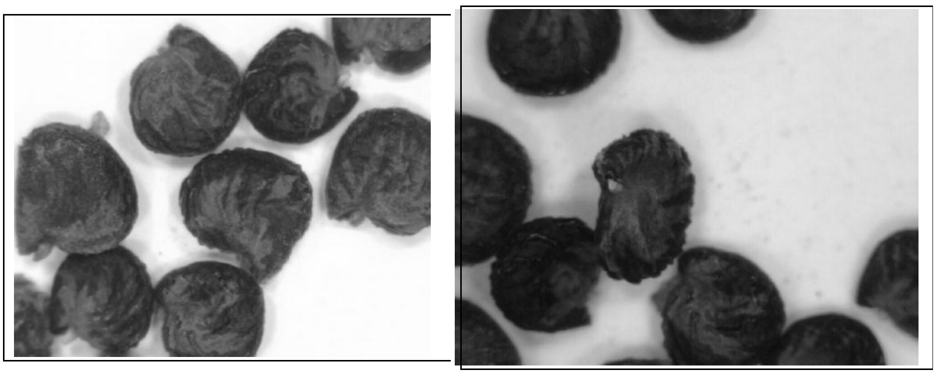


Fig. 6. *Trianthema portulacastrum* L. ornamentation as seen by magnifying lens and USB digital microscope (20-200 X magnification ratio).

Table 3. Mean of seed characteristics of *Trianthema portulacastrum* L. in Nile Delta. SD: standard deviation.

Habitat			Or		Sc			Ca	Wl	Mean ± SD
			Orange	Banana	Cabbage	Sweet Potato	Corn			
Length	(mm $seed^{-1}$)	Max.	1.7	1.6	1.7	1.6	1.7	1.6	1.6	1.6 ± 0.1
		Min.	1.4	1.6	1.5	1.2	1.5	1.2	1.6	1.4 ± 0.2
		Mean	1.6	1.6	1.6	1.4	1.6	1.4	1.6	1.5 ± 0.1
		SD	0.2	0.0	0.1	0.3	0.1	0.3	0.0	0.1 ± 0.1
Width		Max.	1.5	1.5	1.7	1.6	1.6	1.4	1.3	1.5 ± 0.1
		Min.	1.4	1.3	1.6	1.5	1.6	1.2	1.7	1.5 ± 0.2
		Mean	1.5	1.4	1.7	1.6	1.6	1.3	1.5	1.5 ± 0.1
		SD	0.1	0.1	0.1	0.1	0.0	0.1	0.3	0.1 ± 0.1
Thickness		Max.	0.8	0.8	1.1	1.2	0.9	0.8	0.7	0.9 ± 0.2
		Min.	0.7	0.6	0.9	0.6	0.7	0.6	0.6	0.7 ± 0.1
		Mean	0.8	0.7	1.0	0.9	0.8	0.7	0.7	0.8 ± 0.1
		SD	0.1	0.1	0.1	0.4	0.1	0.1	0.1	0.1 ± 0.1
Weight (mg $seed^{-1}$)		Max.	0.9	0.7	0.7	0.8	0.7	0.9	0.7	0.8 ± 0.1
		Min.	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1 ± 0.4
		Mean	0.5	0.4	0.5	0.5	0.4	0.5	0.4	0.5 ± 0.5
		SD	0.6	0.4	0.4	0.5	0.4	0.6	0.4	0.4 ± 0.1
Seed size (mm^3 $seed^{-1}$)		Max.	2.6	2.1	2.6	2.1	2.6	2.1	2.1	2.3 ± 0.3
		Min.	1.4	2.1	1.8	0.9	1.8	0.9	2.1	1.6 ± 0.5
		Mean	2.0	2.1	2.1	1.4	2.1	1.4	2.1	1.9 ± 0.3
		SD	0.9	0.0	0.6	0.9	0.6	0.9	0.0	0.6 ± 0.4

Table 4. Cumulative seed germination (%) in relation to the time and habitat type in the study area. SD: standard deviation.

Habitat	14/10/2010 28/10/2010	15/11/2010 29/11/2010	17/12/2010 31/12/2010	05/01/2011 15/01/2011	18/02/2011 27/02/2011
Orange Fields	14	30	44	50	52
Banana Fields	12	30	46	54	56
Cabbage Fields	30	44	56	74	84
Sweet Potato Fields	24	38	50	62	64
Corn Fields	8	26	44	48	50
Irrigation Canal	18	36	54	60	62
Waste lands Fields	24	44	62	70	74
Mean	18.6	35.4	50.9	59.7	63.1
SD	7.8	7.1	6.8	9.8	12.3

Morphological Traits

Regarding the variation in relation to habitats, area occupied by the plant varies between 1357 cm^2 (orange fields) and 393.6 cm^2 (cabbage fields), stem length between 37.6 cm (waste lands) and 19.1 cm (cabbage fields), stem width between 0.5 cm (orange fields) and 0.3 cm (banana and sweet potato fields), stem perimeter between 1.1 cm (fields of orange, sweet potato and corn, irrigaion canals and waste lands) and 0.6 cm (banana fields), leaf length between 3.6 cm (orange fields and irrigation canals) and 2.2 cm (sweet potato fields), while leaf width between 3.2 cm (irrigation canals and 2 cm (sweet potato fields) (as shown in Table 5). The number of main branches varies between 2.9 (corn fields) and 1.7 (orange fields), number of lateral branches between 6.7 (waste lands) and 3 (cabbage fields), number of internodes at main branch between 10.3 (corn fields) and 4.9 (cabbage fields), while number of internodes at lateral branch between 13.5 (orange fields) and 3 (cabbage fields). Length of internode at main branches ranges between 7.6 cm (waste lands) and 4.2 cm (cabbage fields), while internode length at lateral branches ranges between 8.4 cm (waste lands) and 2.9 cm (cabbage fields) (Table 6).

Table 5. Mean (M) and standard deviation (SD) of area occupied by the plant (cm^2), stem and leaf characters (cm) in relation to variation in habitats.

Habitat	Area (cm^2)		Stem character						Leaf character			
			Stem length		Stem width		Stem perimeter		Leaf length		Leaf Width	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Orange fields	1357	820.5	37.3	14.0	0.5	0.1	1.1	0.2	3.6	0.4	2.8	0.6
Banana fields	724.1	77.7	33.9	4.2	0.3	0.0	0.6	0.1	2.3	0.1	2.2	1.4
Cabbage fields	393.6	325.2	19.1	3.3	0.4	0.1	1.0	0.3	3.1	0.5	3.1	0.5
Sweet Potato fields	649.4	322.6	32.1	8.5	0.3	0.1	0.8	0.4	2.2	0.3	2.0	0.5
Corn fields	988.7	285.8	37.0	6.9	0.4	0.1	1.1	0.4	3.4	0.6	3.1	0.6
Irrigation Canals	618.2	149.9	30.3	1.1	0.5	0.1	1.1	0.1	3.6	0.1	3.2	0.1
Waste Lands field	903.6	361.6	37.6	8.9	0.4	0.1	1.1	0.4	3.2	0.6	2.9	0.5
Mean ± SD	804.9	237.9	32.5	4.3	0.4	0.04	1.0	0.1	3.1	0.2	2.8	0.4

Table 6. Mean (M) and standard deviation (SD) of number (No) and length (cm) of branches and internodes in relation to variation in habitats.

Habitat	Branch number				Internode character							
	Main branch		Lateral branch		No. at main branch		No. at lateral branch		Length at main branch		Length at lateral branch	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Orange field	1.7	0.7	4.9	3.6	6.9	2.6	13.5	13.1	6.3	1.2	4.7	1.5
Banana field	2.7	0.8	5.3	3.1	8.7	2.3	10.7	3.9	6.0	2.4	3.9	0.2
Cabbage field	2.0	0.1	3.0	1.0	4.9	1.4	3.0	1.2	4.2	0.6	2.9	1.2
Sweet Potato field	1.9	0.6	4.5	1.8	7.2	2.2	9.6	4.2	5.6	1.1	4.4	2.6
Corn field	2.9	0.3	5.9	1.9	10.3	0.5	12.2	2.1	7.0	1.1	5.9	2.2
Irrigation Canals	2.2	0.2	5.8	0.5	6.8	1.2	9.8	0.4	5.4	0.5	5.4	0.4
Waste Lands field	2.8	0.6	6.7	1.2	9.5	2.7	13.4	4.3	7.6	1.5	8.4	4.2
Mean ± SD	2.3	0.3	5.2	1.1	7.8	0.8	10.3	4.2	6.0	0.6	5.1	1.4

The number of flowers or fruits at main branch ranges between 7.6 (waste lands) and 2.6 (cabbage fields), while the number of flowers or fruits at lateral branch ranges between 6.7 (waste lands) and 3 (cabbage fields) (Table 7).

Table 7. Mean (M) and standard deviation (SD) of flowers or fruits in relation to variation in habitats.

Habitat	Main branch		Lateral branch	
	M	SD	M	SD
Orange field	7.4	1.6	7.8	4.2
Banana field	6. 4	1.1	6.3	3.1
Cabbage field	2.6	1.2	3.0	1.2
Sweet Potato field	5.1	2.3	5.5	2.0
Corn field	7.2	1.5	7.5	3.1
Irrigation Canals	6.9	0.4	4.2	0.3
Waste Lands field	7.6	2.3	9.7	1.2
Mean ± SD	6.1	0.7	6.3	1.4

Discussion

The studies that had been carried out on the associated weed flora in many crops in India indicated that *T. portulacastrum* is a prominent weed associate such as: sugarcane (Webb and Feez 1987), sunflower (Wanjari *et al*. 1999), cotton (Tewari and Singh 1991 and Cheema *et al*. 2003), onion (Rathore and Shekhawat 2004), sesamum (Chandawat *et al*. 2004), soybean (Bhattacharya *et al*. 2004) and mulberry (Isaiarasu and Ganesan 2005). The present study indicated that 14 species (out of the 63 recorded species), are associated with *Trianthema portulacastrum* in both Egypt and India: *Amaranthus spinosus*, *Amaranthus viridis*, *Chenopodium album*, *Corchorus olitorius*, *Cynodon dactylon*, *Cyperus rotundus*, *Digitaria sanguinalis*, *Echinochloa colona*, *Euphorbia heterophylla*, *Paspalum distichum*, *Portulaca oleracea*, *Solanum villosum*, *Sorghum species* and *Xanthium* species.

In Egypt, it is fair to say that *Trianthema portulacastrum* can be evaluated as invasive because this plant nowadays grows everywhere; the rapid growth rate; spread and adaptability from aquatic to xerophytic habitats indicate that this plant may become a potentially ecological disaster. Ahmed (2003) and El-Masry (2007), recorded it in orchards, summer crops, canal and drains; while Shaltout *et al*. (2005) recorded it along the terraces and slopes of waste coarses, gardens, ditches and crop fields. In the present study, it was recorded in 130 stands distributed over four governorates (Qaliubya, Minofya, Kafr El-Shiekh, and Gharbia) and many habitats (summer crops, orchards, canals, and waste lands), thus it is considered as a resistant species which have become able to grow in greatly increased densities and bigger individuals than before. This development is called compensation, resulting in weed communities poor in species, but with high densities of individuals. The second phenomenon is that resistant species are also able to enlarge their range of distribution and to fill the niches of the eliminated species, conquering new areas where they were not able to compete before (Holzner 1978).

Eighteen vegetation groups were identified in the present study, each of definite floristic and habitat characteristics: 8 of them are characterized by *Trianthema portulacastrum* (Shaltout *et al*., 2010a recorded it in Nile Delta with a wide environmental gradient), 2 groups are dominated by *Cyperus rotundus* which is a mesophyte dominating plant community in gardens nurseries and cropland (Shaltout *et al*. 2005), and two others by *Echinochloa colona* (see Shaltout *et al*., 1993 and Shaltout and Sharaf El-Din 1988 and Shaltout *et al*. 2005). In addition, 3 groups are dominated by Amaranthus viridis which is recorded in summer crops such as cotton and maize (Shaltout and El Fahar 1991 and Shaltout *et al*. 2005), and one group is dominated by *Portulaca oleracea* (Shaltout *et al*. 2005 and Shaltout *et al*. 2011). Another group is dominated by *Amaranthus lividus* and another by *Euphorbia heterophylla* (Shaltout *et al*. 2005). In addition, *Phragmites australis* dominated only one group despite the fact that *Trianthema* is xerophytic plant. Shaltout and Sharaf El-Din (1988), Shaltout *et al*. (1993 and 2011) and Shaltout and El Fahar (1991) recorded it along canals, field edges, and in the summer crops.

El-Naggar *et al*. (2005) studied the taxonomic significance of seed morphology and seed coat sculpture of Aizoaceae, where *Trianthema portulacastrum* seed was a part of their study. Its seed is sub-orbicular with size 1.4 x1.2 mm3 seed-1, black and seed coat surface is concentrically ridged. Also, the epidermal cell shape is isodiametrical to penta-hexagonal, the anticlinal boundries are highly raised; straight to curved; smooth and periclinal cell wall is flat to concave and smooth. El-Masry (2007) reported that its seed had a length of 1.5 mm seed-1, width of 1.3 mm seed -1 and thickness of 1.2 mm seed -1. In the present study, *Trianthema* seed shape is subrounded, color is black, hilum shape is sunked groove, while the hilum elevation is sunken, hilum position is basal, texture is rough, ornamentation is sculptures and the seed outline is circular to semi-circular.

Thermophilous species are adapted to the germination condition and to the seasonal rhythm of the cereal species that had come from the same area. Devlin and Withan (1983) found that seed dormancy may be due to the absence of some external factor considered necessary for the process of the seed germination. Thus, in the absence of water, proper temperature, or proper mixture of gases, germination is inhibited. However, many seeds may be placed in an environment considered optimum for the germination and still not germinate because of some factor associated with seeds. This factor may be hard seed coat that is impermeable to water or gases or is physically resistant to embryo expansion, immature embryo, need for after ripening period, a specific light requirement, a specific temperature requirement, or the presence of a substance that inhibits germination. The external seed coat sculptures may give the seed a bigger surface area to absorb water and air, so its dormancy may be more likely according to after ripening period, or simply the plant is summer weed that germinates in a high temperature, so it doesn't germinate due to the lack of temperature requirements. El-Masry (2007) reported that *Trianthema portulacstrum* seeds did not needs after ripening period to germinate.

The morphological characteristics of *Trianthema portulacastrum* was estimated under field conditions during summer season (July, August and September). The present study indicated that the variation in the area occupied by the plant, stem width, stem perimeter, leaf length and number of internodes at lateral branches were the highest in orange fields, this may be interpreted in the view that the orange field is left for a considerable time without hand weeding or herbicidal spray, which allow the plant to grow vigorously. It may also due to the decomposition of plants and animal manure used as organic fertilizers, which lead to increase nitrogen and organic matter contents, which in turn stimulates microbial transformations, that are vital for decomposing of nitrogen compounds to absorbed forms by plants (Biswas and Mukherjee 1987). Clevering (1998) reported that, high nitrogen content of soil leads to high total dry weight, leaf area, leaf weight, and specific leaf areas of some species. On the other hand, Zhao *et al*. (2005) reported that, nitrogen deficiency decreases leaf area, chlorophyll content, net photosynthesis rate associated with decrease in stomatal conductance and intercellular carbon dioxide concentration rather mesophyllic activity of some other species.

Shaltout *et al*. (2010b), reported that of both leaf area and leaf consistency are related to the moisture conditions prevailing in the habitat occupied by the plant; leaves are often smaller in species occupying habitats with low light, low nutrients or low moisture availability. In the present study, the smallest leaf length and width was in *Trianthema* plants in the fields of sweet potato, compared with individuals from the other habitats, this may be due to low light intensity resulted from the shading of sweet potato leaves. Also the high consumption of nutrients by the dense banana and sweet potato cultivations often lead to decrease the nutrient availability for other associated weeds.

The variation in flowers or fruits at main and lateral branches had the highest value in waste lands, while the lowest in cabbage fields; that may be due to plant resist much difficult conditions in both cabbage and corn fields where the farmer shows much attention to his field and roundly do hand weeding and herbicides especially at the beginning of the growing season. Several factors seem to influence flower production, such as plant age, time of recruitment in colonization sequence and season (Law 1979).

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السلوك التوزيعى وكفاءة نمو نبات الرجلة البرى فى منطقه دلتا النيل

كمال شلتوت[1]، دينا بركة[2]، محمد شحاتة[2]، داليا احمد[1]، أمنية عارف[2]

1 قسم النبات – كلية العلوم – جامعة طنطا

2 قسم النبات – كلية العلوم – جامعة بنها

تهدف الدراسة الحالية إلى تحديد توزيع هذا النبات فى دلتا النيل وتحديد العوامل التى أدت إلى غزوه منطقة الدراسة، والمجتمعات النباتية التى ينمو فيها والنباتات المصاحبة له، وتعيين سرعة انباتة ومدى تأقلم صفاتة المورفولوجيه مع الظروف البيئية المصاحبة. تمت دراسة 130 موقع للدراسة (حجم الموقع حوالى 50م^2) خلال صيف 2009 إلى صيف 2011 لكى تمثل الاختلافات الطبيعية فى الجماعة بالنسبة للبيئات المختلفة الموجوده فى منطقة دلتا النيل. تم تسجيل النبات فى أربع بيئات مختلفة (البساتين، حقول المحاصيل الصيفية، القنوات المائية والأراضى المهملة). بلغ العدد الكلى للأنواع المصاحبة للرجلة البرى 63 نوعاً، تنتمى إلى 56 جنس و22 فصيلة. وبتطبيق التحليل الدليلى ثنائى الاتجاه TWINSPAN على التركيب النوعى ل 130 موقع، تم تحديد 18 مجموعة نباتية. وجد أن أراضى البساتين لديها أعلى نسبة رمال (39.1 %)، والمادة العضوية (9.3%)، بينما أراضى المحاصيل الصيفية كانت الأعلى فى نسبة الملوحة، والفسفور (6.9 %). بالإضافة الى أراضى قنوات الرى وكانت الأكبر فى نسبة الطمى (28.4 %)، الطين (58.6 %)، الأس الهيدروجينى (8.1 %)، النيتروجين (0.22 %) وكربونات الكالسيوم (8.1 %)، بينما الأراضى المهملة كانت الأعلى فى نسبة البوتاسيوم (40.3 مجم/ لتر). تم تحديد أكثر عناصر التربة تأثيرا على المجموعات النباتية. تنتشر بذور نبات الرجلة البرى بواسطة الرياح، وتنتمى إلى البذور الخفيفة وتمتد فترة الإزهار من شهر فبراير إلى سبتمبر والإثمار من يونيو إلى سبتمبر، وتم دراسة مميزات البذرة و أيضاً الصفات الكمية لها. كانت نسبة إنبات البذور الأعلى فى الأراضي المهملة (74 %)، بينما كانت الأقل فى حقول الذرة (50 %).