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Floristic Composition and Vegetation Analysis and Species Diversity of Some *Brassica* Species Associates in North of Nile Delta Region, Egypt

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ABSTRACT

The present study was carried out to provide insight on the floristic composition, vegetation analysis and species diversity of associated flora of three common *Brassica* spp (*Brassica rapa* L., *Brassica nigra* (L.) Koch and *Brassica tournefortii* Gouan) communities in the North of Nile Delta of Egypt. In 60 surveyed stands, a total of 150 species belonging to 122 genera and related to 34 taxonomic families were recorded. Annual/therophytes-biregional taxa were the predomninates. Vegetation classification distinguished four vegetation groups named after the first and second dominant species. Group A: *Cichorium endivia-Brassica nigra* and represents the vegetation type of old field crops cultivated with clover and wheat, while group B: *Polypogon monspeliensis- Rumex dentatus* and represents winter field crops in old cultivated lands, edges of cultivation (canal banks) and roadsides. Group C: *Brassica tournefortii- Cynodon dactylon* and was characteristic for newly reclaimed lands, while group D: *Echinops spinosus-Brassica tournefortii* was found in the roadsides and sand formations habitat along the Deltaic Mediterranean coast of Egypt. The highest species diversity was mainly in groups D and C from roadsides and sand formations habitat and in the newly reclaimed lands. Edaphic factors especially sulphates, bicarbonates, maximum water-holding capacity, total phosphorus, silt, magnesium, potassium, potassium adsorption ratio, sand fraction and chlorides affect the distribution and abundance of the characteristic weeds species.

Keywords: *Brassica* species, Edaphic factors, Flora, TWINSPAN, and Vegetation.

INTRODUCTION

Weeds have been defined as plants that are interfering with the activities or welfare of man (Weed Science Society of America, 1994). They are nuisance to agriculture because of their antagonistic impact on crop yields (Aldrich, 1984). Weeds are one of the important components in the agroecosystems. In Egypt, numerous studies were recommended that, weed vegetation constitute the majority of the flora in farmland (Shaltout and El Fahar, 1991; El-Demerdash *et al*., 1997). The occurrence of many weed species may be related to specific farming systems maintaining suitable habitat conditions including various environmental conditions as well as agro-technical treatments such as herbicides, soil tillage, fertilizers and irrigation (Tasseva, 2005). Likewise, weed diversity patterns are related to habitat type, climatic conditions and crop type (Hegazy *et al*., 2004).

Family Brassicaceae (Cruciferae or Mustard family) is one of the largest families among angiosperms of kingdom Plantae. It comprises about 365 genera and ca. 3250 species, of which about 104 species belonging to 45 genera are present in the flora of Egypt (Boulos, 1999 and 2009).

Brassica spp. (cruciferous vegetables or cabbage) includes approximately 100 species, of which five species are present in Egypt. These species are *Brassica rapa*, *B. nigra*, *B. tournefortii*, *B. deserti* and *B. juncea*. The first three species selected in the present study are widespread in Egypt while the last two species are rare (Boulos, 1999 and 2009).

Brassica is one of the most economically important genuses in family Brassicaceae (Gomez-Campo *et al*., 1980). Many crop species belonging to genus *Brassica*, have edible roots, leaves, stems, buds, flowers and seeds. Also, the benefits of *Brassica* spp. include oil seeds crop, forage crops, dietary fibers, sources of minerals and vitamins, and contain a large number of novel phytochemicals that act as anti-cancer (Steinmetz and Potter, 1996). Most *Brassica* species release chemical compounds that may be toxic to soil borne pathogens and pests, such as nematodes, fungi and some weeds (Balkcom *et al*., 2007). Members of *Brassica* spp. have been reported to be allelopathic. The allelopathic potential attributed to allelochemicals content such as glucosinolate (Bones and Rossiter, 1996). In a plant community, allelochemicals released from the dominant species can influence community structure and dynamics through their allelopathic potential (Djurdjevic *et al*., 2004). Allelochemicals may therefore play important roles in plant diversity and dominance in agroecosystems (Chou, 1999).

Three dominant and widespread *Brassica* species were selected in the present study, these species include *Brassica rapa* L., *Brassica nigra* (L.) Koch and *Brassica tournefortii* Gouan.

Brassica rapa L. (turnip) is an annual or biennial herb, 30-80 cm, with a swollen taproot. It is cultivated worldwide for its fleshy tuberous root. In Egypt, it is widespread in Nile region and Mediterrhanean strip. It escaped as a weed from cultivation (Boulos, 1999). In India, *B. rapa* is cultivated as an oilseeds crop (Raymer, 2002).

Brassica nigra (L.) Koch is an annual erect herb sparingly hispid with stiff hairs (Boulos, 1999). It is growing as a weed in winter field crops as well as roadsides of Mediterreanean region in Egypt (Hegazy *et al*., 2004). The vegetation of *Brassica nigra* in Beni-Suef Province in Egypt was studied by Gomaa *et al*. (2013). The allelopathic potential of *B. nigra* was cited in the study of Hassan (2011).

Brassica tournefortii Gouan is a winter annual, herbaceous and erect plant. It produces numerous seeds which buried in the soil and stay viable for several years

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(Abd El-Gawad, 2014). It is native to arid deserts of North Africa and the Middle East (Minnich and Sanders, 2000) as well as to the Mediterranean coast, where it survives on sand dunes (Thanos *et al*., 1991). It is considered as an invasive weed in Australia (Chauhan *et al*., 2009).

The knoweldge about the floristic composition and diversity of *Brassica* spp. communities is poor. Thus, this study aimed to characterize the associated flora, species diversity, vegetation analysis and habitat conditions of three selected *Brassica* spp. in the North of Nile Delta of Egypt.

MATERIALS AND METHODS

Study Area

The sampled stands are dispersed in four Provinces in the North of Egypt namely, Damietta (N 31° 07′, E 32° 35′), El-Dakahlia (N 31° 04′, E 31°42′), Kafr El-Sheikh (N 31° 12′, E 30° 96′) and El-Behira (N 31° 03′, E 30° 43′) (Figure 1). These Provinces were situated in the North of Nile Delta region of Egypt. According to Abu Al–Izz (1971), Nile Delta occupies an area ca. 22000 km^2 representing about two-third of the fertile lands in Egypt. Natural vegetation in Nile Delta includes weeds of field crops, urban habitats, and the Deltaic Mediterranean coastal vegetation (Shaltout *et al*., 2010). The Nile River is the main source of water in the study area. Nile Delta is included in arid region with hot summer and mild winter, the mean annual temperature ranges between 20-35 °C and the annual rainfall varies from 8.9 mm to 14.6 mm.

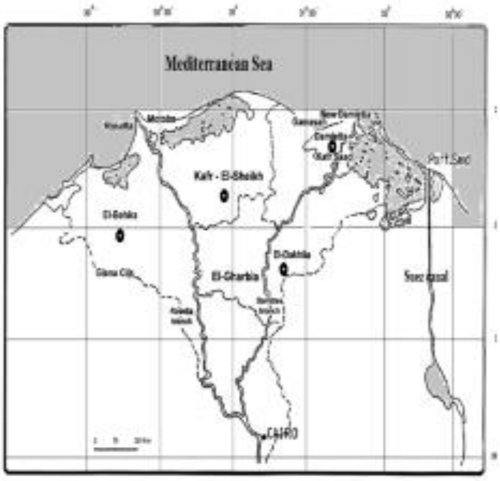

Figure (1): Map of Nile Delta of Egypt showing the location of sampling sites (●)

Vegetation and Data Analysis

Sixty stands (2x5 m each) representing the different habitats (old and newly reclaimed cultivated lands, roadsides and sand formations) were selected in the study area where the studied three *Brassica* spp. grow. Vegetation sampling was carried out in 2014. The values of relative density (Shukla and Chandel, 1989) and relative cover (Canfield, 1941) for each plant species within *Brassica* spp. stands were estimated and summed up to give an importance value (IV, out of 200). Plant species identification and nomenclature followed Boulos (1999–2005). Life-forms spectrum was described according to Raunkiaer (1934), while chorological affinities were recognized according to and Zohary (1966 and 1972) and Feinbrun-Dothan (1978 and 1986). Two patterns of multivariate analysis, classification and ordination were applied. TWINSPAN cluster analysis was used to classify the floristic data matrix of 60 stands and 150 species (Henderson and Seaby, 1999), Canonical Correspondence Analysis (CCA) was used to correlate the vegetation with the estimated soil variables (Ter Braak, 2003). Data of the soil variables of the vegetation groups yielded from TWINSPAN classification were compared by one way ANOVA. For measurement of species diversity within each separated vegetation group, species richness and Shannon-Wiener diversity index were applied (Pielou, 1975). Species richness was calculated as the average number of species per stand. The Shannon-Wiener index (H’) was calculated from the formula $H' = -\Sigma Pi (\ln Pi)$, where Pi is the importance value of the i^{th} species.

Soil sampling and analysis

Three soil samples were collected per stand as a profile at a depth of 0-30 cm. the samples were pooled together, forming one composite sample for each stand. For soil particles size, sieves method was used to separate soil fractions (sand, silt and clay). Soil pore-space was estimated by using measuring flask. Maximum water-holding capacity was measured by Hilgard-Pan box. Oxidizable organic carbon was determined by Walkely-Black method. Sulphates were estimated using $BaCl_2$ solution. $CaCO_3$ was dissolved in HCl then determined using 1N NaOH. Total soluble nitrogen was estimated by Kjeldahl method. Soil water extracts of 1:5 were prepared and for the determination of soil salinity (EC) using conductivity meter (YSI Incorporated Model 33) and soil reaction (pH) using pH meter (Model Lutron pH 206). Chlorides were estimated by titration method against $AgNO_3$ solution using K_2CrO_4 indicator. Bicarbonates were determined by titration method using 0.1N HCl. Total soluble phosphorus was estimated by stannous chloride method. Na^+ and K^+ were determined using a Flame Photometer, while Ca^{++} and Mg^{++} were estimated using an Atomic Absorption Spectrometer. The sodium adsorption ratio (SAR) and potassium adsorption ratio (PAR) were calculated to express the combined effects of different ions in the soil. All these procedures following Piper (1947), Jackson (1962), Allen *et al*. (1974), McKell and Goodin (1984) and AOAC (1990).

RESULTS

Floristic composition

In totat, 150 plant species belonging to 122 genera and related to 34 taxonomic families were recorded in this study.These plant species included 100 annuals, 46 perennials and 4 biennials (Table 1). The largest families were Poaceae (29 species), followed by Asteraceae (26 species), then Chenopodiaceae (14 species) and Brassicaceae (13 species). The life-forms spectrum indicated that, 68.67% of the total number species were therophytes, 9.33% for each of chamaephytes and hemicryptophytes, 8.67% cryptophytes (including geophytes and helophytes), 3.33% nanophanerophytes and 0.67% for parasites (Figure 2). The floristic analysis elucidated that, Biregional taxa attained the highest contribution and represented by 30.67% of the total number of recorded species, followed by 29.33% Worldwide taxa, then 23.35% Pluriregional chorotypes and 16.67% Monoregional taxa (Figure 3).

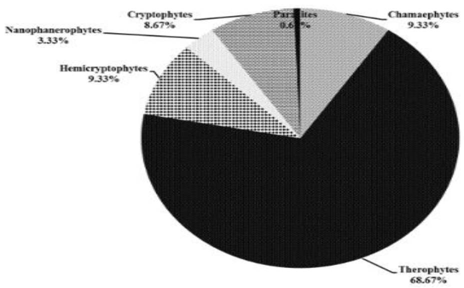

Figure (2): Life form spectrum of the plant species recorded in the present study.

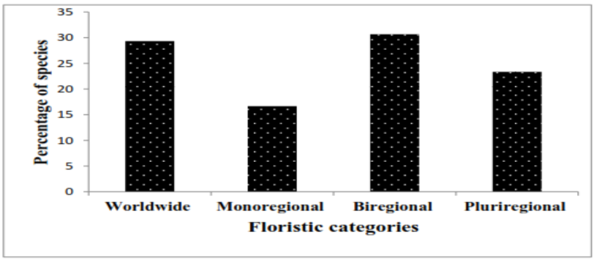

Figure (3): Floristic categories of the recorded plant species in the study area.

Vegetation classification

The application of TWINSPAN cluster analysis on the importance values of 150 species recorded in the 60 sampled stands, led to the separation of four vegetation groups (A-D, Figure 4 and Table 2). Each vegetation assemblage comprises a set of stands which are similar in their floristic composition. Group A includes 9 stands dominated by *Cichorim endivia* (IV=38.10). The most common associated species in this group were *Brassica nigra* (IV=23.80), *Sonchus oleraceus* (IV=18.20), *Coronopus squamatus* (IV=18.70) and *Mentha longifolia* (IV=17.70). Group B comprises 3 stands, where *Polypogon monspeliensis* (IV=65.60) was the dominant species, while *Rumex dentatus* (IV=20.10) and *Brassica rapa* (IV=18.20) were the common associates. Twenty–two stands of group C was dominated by *Brassica tournefortii* (IV=24.60).

Table (2): Characteristics of the different vegetation cluster yielded from TWINSPAN classification.

Group	No. of stands	Total species	Habitat type	1st and 2nd dominant species	Other important species	Indicator species
A	9	20	Old cultivated lands	*Cichorim endivia* (IV=38.10) and *Brassica nigra* (IV=23.80)	*Sonchus oleraceus* (IV=18.20), *Coronopus squamatus* (IV=18.70) and *Mentha longifolia* (IV=17.70)	*Beta vulgaris* (IV=4.53)
B	3	26	Old cultivated lands, canal banks & roadsides	*Polypogon monspeliensis* (IV=65.60) and *Rumex dentatus* (IV=20.10)	*Brassica rapa* (IV=18.20), *Ranunculus sceleratus* (IV=13.89) and *Trifolium resupinatum*(IV=13.80)	No indicator species
C	22	59	Newly reclaimed lands	*Brassica tournefortii* (IV=24.60) and *Cynodon dactylon* (IV=14.30)	*Euphorbia peplus* (IV=12.04) and *Chenopodium murale* (IV=11.90)	*Aizoon canariense* (IV=1.52)
D	26	79	Roadsides & coastal sand formations	*Echinops spinosus* (IV=16.50) and *Brassica tournefortii* (IV=13.20)	*Rumex dentatus* (IV=13.10) and *Erodium laciniatum* (IV=9.42)	*Erodium laciniatum* (IV=9.42), *Chenopodium murale* (IV=8.51) and *Malva parviflora* (IV=2.21)

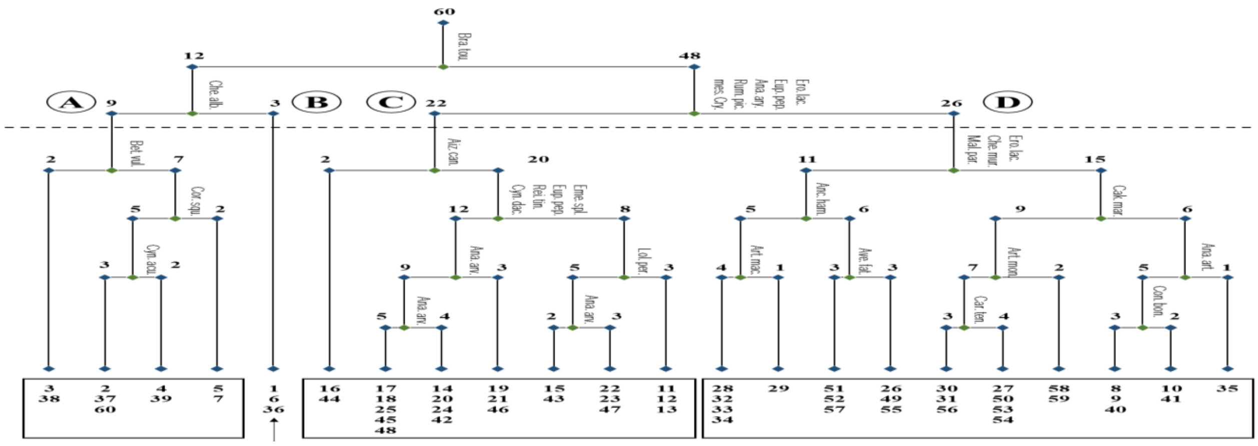

Figure (4): TWINSPAN dendrogram showing the four vegetation groups (A-D) at the 2nd level of classification resulting from the cluster analysis of the 60 sampled stands. Dashed line shows the level of classification. The indicator species are abbreviated by the first three letters of genus and species, respectively. For abbreviations, see Table (1).

The important associated species in this group include *Cynodon dactylon* (IV=14.30), *Euphorbia peplus* (IV=12.04) and *Chenopodium murale* (IV=11.90). Group D includes 26 stands dominated by *Echinops spinosus* (IV=16.50). The most common associates were *Brassica tournefortii* (IV=13.20) and *Rumex dentatus* (IV=13.10).

Species diversity

Four TWINSPAN vegetation groups proved differences in species richness and Shannon diversity index (Figure 5). The highest species richness of value 7 was attained in group B, while decreased to 3.27 in group D, followed by slight decrease to value of 2.91 in group C, then decreased to minimum value of 2.11 in group A. The Shannon diversity index (H') of the four vegetation groups showed almost invers trend to that obtained in case of species richness. The highest H' value of 3.72 was recorded in group D, then the value decreased to 3.56 and 2.54 in groups C and A, while the minimum value of 2.40 was attained in group B.

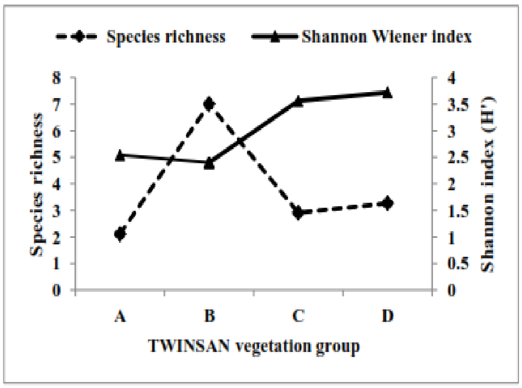

Figure (5): Species diversity of the different vegetation groups (A-D).

Vegetation- soil relationship

The soil variables of the four groups derived from TWINSPAN classification indicated a considerable variation (Table 3). Out of the measured soil parameters, calcium carbonates, electrical conductivity, sulphates, total nitrogen, total soluble phosphorus, sodium, potassium and calcium showed significant differences among vegetation groups. Soils of group A attained the highest values of maximum water-holding capacity (50.24%), pH (8.30), dissolved phosphorus (10.98 mg g^{-1} dry soil) and magnesium (13.67 mg g^{-1} dry soil), while soils of group B showed the highest percentages of silt (8%), soil porosity (43.63%) and organic carbon (1.76%). The maximum values of sand fraction (94.27%), electrical conductivity (0.6 mmhos cm^{-1}), chlorides (0.17%), total nitrogen (100.59 mg g^{-1} dry soil), sodium (72.27 mg g^{-1} dry soil) and sodium adsorption ratio (17.74) were recorded in the soils of *Brassica tournefortii* (group C). On the other hand, the highest values of clay (0.83%), $CaCO_3$ (10.27%), SO_4^{--} (0.31%), HCO_3 (0.14%), K^+ (8.22 mg g^{-1} dry soil), Ca^{++} (20.04 mg g^{-1} dry soil) and potassium adsorption ratio (2.86) were estimated in group D.

The correlation between the soil variables and the characteristic species with the highest importance values in the present survey was indicated in the ordination diagram produced by CCA-biplot (Figure 7). Obviously, sulphates, bicarbonates, maximum water-holding capacity, total phosphorus, silt, magnesium, potassium, potassium adsorption ratio, sand fraction and chlorides were the most effective soil variables.Sulphates and bicarbonates were positively correloated with axis 1, while that correlated negatively were magnesium and total dissolved phosphorus. Axis 2 has positive correlation with maximum water-holding capacity and soil porosity, but negatively correlated with electrical conductivity and clay fraction.

Table (3): Mean values and standard errors of the soil variables representing the four vegetation groups obtained by TWINSPAN technique. The F-value and its probability (P) were indicated. *P < 0.05, **P < 0.01, ***P < 0.001.

Soil variables	Vegetation groups				F-value
	A	B	C	D	
Sand (%)	91.7±1.36	91.67±0.83	94.27±0.56	93.38±1.06	0.95
Silt (%)	7.83±1.26	8.00±1.0	5.32±0.56	5.79±0.87	1.32
Clay (%)	0.47±0.17	0.33±0.17	0.41±0.11	0.83±0.23	1.09
Porosity (%)	40.44±1.87	43.63±2.48	40.89±0.81	37.39±0.86	3.79
Maximum water-holding capacity (%)	50.24±2.97	42.12±4.65	42.45±2.25	41.32±2.14	1.70
$CaCO_3$ (%)	8.28±1.93	6.00±2.65	7.16±0.52	10.27±1.53	1.32**
Organic carbon (%)	1.33±0.17	1.76±0.16	1.39±0.17	1.43±0.15	0.27
pH	8.30±0.20	8.00±0.41	7.77±0.08	7.98±0.07	1.34
Electrical conductivity (mmhos cm^{-1})	0.43±0.08	0.22±0.01	0.68±0.10	0.55±0.11	1.23**
Cl^- (%)	0.03±0.01	0.01±0.0	0.17±0.05	0.08±0.02	2.37
SO_4^{--} (%)	0.06±0.01	0.05±0.01	0.19±0.04	0.31±0.08	1.8***
HCO_3^- (%)	0.10±0.03	0.08±0.03	0.12±0.01	0.14±0.01	1.88
Total nitrogen (mg g^{-1} dry soil)	57.88±6.49	71.17±5.41	100.59±12.83	56.71±5.73	2.66*
Dissolved phosphorus (mg g^{-1} dry soil)	10.98±2.40	0.21±0.05	4.73±1.05	5.54±1.70	0.39**
Na^+ (mg g^{-1} dry soil)	47.07±5.89	12.88±3.16	72.27±6.26	32.46±2.47	1.24*
K^+ (mg g^{-1} dry soil)	2.59±0.88	1.17±0.11	2.76±0.58	8.22±1.79	3.85***
Ca^{++} (mg g^{-1} dry soil)	14.62±3.08	10.38±2.44	19.6±2.04	20.04±3.73	0.53**
Mg^{++} (mg g^{-1} dry soil)	13.67±2.90	8.24±1.80	8.29±0.89	8.44±1.14	1.08
Sodium adsorption ratio	14.00±2.79	4.30±1.09	17.74±2.91	7.88±2.16	1.55
Potassium adsorption ratio	0.81±0.26	0.39±0.07	0.81±0.20	2.86±0.59	4.86

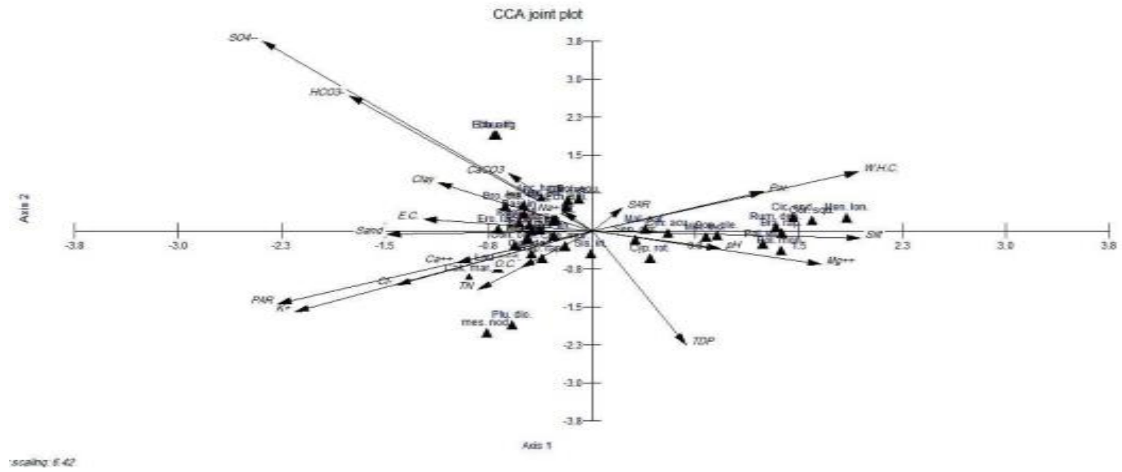

Figure (6): CCA ordination biplot of plant species and soil variables in the present study.

DISCUSSION

The basic goal of ecologist for over a century, to determine the relationship between environmental factors and plant species distribution as well as variation in vegetation composition (Motzkin *et al*., 2002).

One hundred and fifty species were recorded as associates in communities of *Brassica rapa, B. nigra* and *B. tournefortii* in the North of Nile Delta of Egypt. Theses associated plant species were grouped into four vegetation groups using TWINSPAN cluster analysis. These groups were named after the 1st and 2nd dominant species in each group. Group A: *Cichorium endivia-Brassica nigra*, group B: *Polypogon monspeliensis-Rumex dentatus*, group C: *Brassica tournefortii-Cynodon dactylon* and group D: *Echinops spinosus-Brassica tournefortii*. The identified weed associations in the present study might be coincide with numerous previous studies in various regions of Egypt viz Shaltout *et al*.(1992); El-Demerdash *et al*. (1997); Hegazy *et al*.(2004); El-Halawany *et al*. (2010); Mashally *et al* (2012); Gomaa *et al*. (2013) and Mashaly *et al*. (2014 and 2015 a&b).

Group A may represent the vegetation types of the old field crops cultivated with clover and wheat, while group B may represent the vegetation types of winter field crops in the old cultivated lands, edges of cultivation (canal banks) and roadsides.Vegetation of group C was characteristic for the newly reclaimed lands. Stands and plant species of group D may represent the roadsides and sand formations habitats along the Deltaic Mediterranean coast of Egypt.

Cichorium endivia was the dominant species in group A. Hegazy *et al.* (2004) attributed the domination of this plant species in clover fields due to its discoid stem that enables it to survive even after several cuttings of the crop. *Brassica nigra* is the 2nd dominant species in group A. The ability of *B. nigra* to dominate weed communities may be attributed to long lived buried seeds, hard and sticky seed coat and its allelopathic potential (Gomaa *et al*., 2013). *Polypogon monspeliensis* as the first dominant species in group B, has the ability to survive and produce huge number of seeds under low level of salinity (Callawy and Zedler, 1998) as well as absence of mechanical and chemical management of it may help in its establishment in wheat crop. The single harvest for wheat crop enabling *P. monspeliensis* to remains alive for long time (Gomaa *et al*., 2013). *Rumex dentatus* is the 2nd dominant species in group B and as one of the common associates in group D. Dominance of this weed species may be related to its allelopathic effect (Hussain *et al*., 1997). *Brassica tournefortii* as the dominant species in group C and as codominant species in group D is characterized by numerous long-lived buried seeds, high competition, quick growth, drought-tolerant and have allelopathic activity (Minnich and Sanders, 2000). *Cynodon dactylon* was found to be codominant species in group C, it is one of the early invaders of the cultivated lands (El-Hadidi and Kosinova, 1971) and characterized by its wide ecological amplitude as a result of phenotypic plasticity (Shaltout and Sharaf El-Din, 1988). *Echinops spinosus* was the dominant species in group D. The abundance of this speices may be attributed to highly seed production as well as fine pappi in its fruit that enables it to disperse easily by air.

Groups D and C exhibited relatively high species diversity as compared with the other two groups. This can be explained as follows, group D represents the sand formations and roadsides along the Deltaic Mediterranean coast, while group C may represent the newly reclaimed lands. Sand formations and roadsides are characterized by low human interefernce as compared with other ruderal habitats (groups A and B) On the other hand, the newly reclaimed cultivated lands are generally characterized by continuous addition of manures which contaminated by numerous weed seeds as well as the continuous irrigation may enables more weeds to grow (Hegazy *et al*., 2008).

The present study showed that, soil factors especially sulphates, bicarbonates, maximum water-holding capacity, total phosphorus, silt, magnesium, potassium, potassium adsorption ratio, sand fraction and chlorides affect the distribution and abundance of the surveyed weed species. These results are in agreement with other many previous studies on weed vegetation of many researchers as Hegazy *et al*. (2004 and 2008), El-Halawany *et al*. (2010), Mashaly *et al*. (2011, 2012, 2013, 2014& 2015 a & b) and Gomaa *et al*. (2013).

In conclusion, the present study attempt to provide a checklist for associated flora within *Brassica rapa, Brassica nigra* and *Brassica tournefortii* communities in the study area and to determine the soil factors control the distribution and abundance of the surveyed weed species.

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