Turkish Journal of Botany

http://journals.tubitak.gov.tr/botany/

Research Article

Turk J Bot
(2013) 37: 464-488

doi:10.3906/bot-1205-11

Weed flora in the reclaimed lands along the northern sector of the Nile Valley in Egypt

Monier ABD EL-GHANI[1], Ashraf SOLIMAN[1], Rim HAMDY[1,*], Ebtesam BENNOBA[2]
[1]Department of Botany, Faculty of Science, Cairo University, Giza, Egypt
[2]Department of Botany, Faculty of Science, 7th April University, Zawiya, Libya

Received: 09.05.2012 • **Accepted:** 23.12.2012 • **Published Online:** 15.05.2013 • **Printed:** 30.05.2013

Abstract: Deserts comprise about 95% of the total land surface of Egypt; therefore, their potential for production must be assessed. Weed communities are mainly affected by the environment, and studies may increase our knowledge of the relationship among the weed flora, soil properties, crop rotation, soil management, fertiliser usage, and weed control. The area under study is one of the most recently reclaimed lands. The recorded 150 species in the monitored 19 sites were distributed within 33 families. The species-rich families were: Poaceae (31), Asteraceae (23), Brassicaceae (13), Chenopodiaceae (12), and Fabaceae (12). Chorological analysis revealed that the widely distributed species belonging to cosmopolitan, palaeotropical, and pantropical chorotypes constituted about 39.3% of the recorded flora. Pure Mediterranean species were very poorly represented, while biregional and triregional Mediterranean chorotypes constituted 28%. Saharo-Arabian chorotypes, either pure or penetrated into other regions, constituted 32%. Ubiquitous species with wide amplitude were *Cynodon dactylon* (L.) Pers. and *Sonchus oleraceus* L. Species richness varied from one crop to another. The winter weeds represented the main bulk of the recorded species within each crop, desert perennials exhibited notable variations, and margin species were the lowest. Redundancy analysis demonstrated the effect of soil organic matter, coarse sand, fine sand, silt, and soil saturation point on the spatial distribution of weed communities. The species–environment correlations were higher for the 4 axes, explaining 64.1% of the cumulative variance. The variations in soil pH, bicarbonates, ammonia, silt, and sulphate contents classified the vegetation into 4 site (vegetation) groups. Application of cluster analysis of species in crop–orchard farmlands resulted in 4 floristic groups (A–D). The weed species of the 2 winter crops, Egyptian clover and wheat, separated in Group A, tomato (winter/summer crop) in Group B, maize as a summer crop in Group C, and weeds of olive orchards and vineyards in Group D. This demonstrated high significant correlations between the olive and vineyard orchards ($P < 0.01$), and between the 2 winter crops, wheat and clover.

Key words: Weed flora, Egypt, agroecology, cropping system, spatial distribution, winter crops, orchards, summer crops

1. Introduction

Deserts comprise about 95% of the total land surface of Egypt; therefore, their potential for production must be assessed. Except for the Delta and the Fayium Oasis, only a narrow strip along the Nile is cultivated, and the population is concentrated in these areas (Adriansen, 2009). Seen from this perspective, reclamation of the desert appears natural, almost inevitable, in light of the population growth and increased congestion in the so-called old lands in the Nile Valley and the Delta. Since the early 1960s, vast areas in the Egyptian deserts (Western, Eastern, and Sinai) were subjected to land reclamation, which were private and government schemes. Not surprisingly, 61% of the priority reclaimable land through the Nile waters is located on the fringes of the Delta region where soil, in parts of these areas, is loamy in nature; cultivation can be relatively successful (Biswas, 1993).

Man-made habitats, as in reclaimed desert lands, represent species-rich environments (Wittig, 2002) due to habitat heterogeneity, frequent and diverse disturbances creating mosaics of different successional stages, and immigration of alien species (Pyšek et al., 2002). This human interference causes the weedy species to replace the wild plant species in these reclaimed areas (Baessler & Klotz, 2006), which are considered to be transitional habitats between the old cultivated land and desert. In line with this, several authors have reported similar conclusions (Staniforth & Scott, 1991; Shaltout & El-Halawany, 1992; Bazzaz, 1996; Shaheen, 2002). The invasive species in the new agricultural lands cause serious problems that require attention to be paid to the negative impacts of plant invasions on ecosystems and gene pools (Hegazy et al., 1999). Arable land is not only disturbed with varying frequency, intensity, and predictability, but has been directly created by disturbance associated with agriculture since the Neolithic period (Holzner & Immonen, 1982). Disturbance can be described in terms of crop management, but is difficult to quantify as it

* Correspondence: rimhamdy@yahoo.com

may interact with environmental factors (Pyšek & Lepš, 1991; Dale et al., 1992; Salonen, 1993; Erviö et al., 1994; Andersson & Milberg, 1998; Hallgren et al., 1999).

Ecological and phytosociological studies of weeds are necessary for understanding the relationship between crops and their weed flora. Weed communities are affected by the environment and studies may increase our knowledge of the relationship among the weed flora, soil properties, crop rotation, soil management, fertiliser usage, and weed control. Analyses of spatial variation in multispecies weed communities, together with environmental factors, may be useful as a tool for developing a sustainable long-term weed control and soil management strategy (Kenkel et al., 2002). Some species thrive well at the same soil conditions (Ellenberg et al., 1992), and the probability of finding these species growing together might be great, even though other factors also influence their abundance, such as climatic conditions, competition ability, seed production capacity, and geographic distribution. By growing different crops in rotation, which usually have different weed floras, rapid propagation of some aggressive weeds, which are well adapted and competitive in specific crop types, can be avoided.

The earliest phytosociological study on weeds in Egypt may be that of Tadros and Atta (1958), who described the communities of rainfed barley fields in the western Mediterranean coastal region. After that, many studies have been carried out in the Nile region, but most of them are floristic (e.g., Boulos, 1966, 1967; El Hadidi & Ghabbour, 1968; El Hadidi & Kosinova, 1971; Imam & Kosinova, 1972; Boulos & El Hadidi, 1984). Wealth studies on desert vegetation in Egypt have been conducted (Kassas & Zahran, 1962; Shaltout et al., 1992), but studies on the vegetation of the reclaimed areas in Egypt are still limited. One of these studies was carried out by Shehata and El-Fahar (2000) and was concerned with the vegetation of the reclaimed areas north-east of the Nile Delta.

Weeds of Egyptian croplands differ from season to season because of their ecological requirements. The results of several earlier studies (Abd El-Ghani & Amer, 1990; Abd El-Ghani & El-Bakry, 1992) revealed that weeds can be grouped into 3 main categories according to their seasonal performance: winter weeds, which are more restricted to the cooler months of the year; summer weeds, which are more restricted to the warmer months of the year; and all-year weeds, which are present and biologically active throughout the year. The all-year weeds, however, can be differentiated into all-year weeds with winter affinity (fare better during winter, i.e. with more abundant populations and more vigorous growth in winter) and all-year weeds with summer affinity (fare better during summer).

Application of numerical methods, such as cluster and correlation analyses, and multivariate techniques such as canonical correspondence analysis, can be a useful tool to show relationships between weed species and crops (Streibig, 1979; Andreasen, et al., 1992; Salonen, 1993; Kenkel, et al., 2002). In Egypt, the application of multivariate analysis techniques in weed studies was also conducted: e.g., Shaltout and El-Fahar (1991), Shaltout and El-Sheikh (1993), Shaltout et al. (1994), and El-Demerdash et al. (1997) in the Nile Delta, and Abd El-Ghani (1998) in southern Sinai.

The aims of this work are: 1) to study the relationship between crops and their weed flora in the newly reclaimed lands along the northern sector of the Nile Valley, and 2) to assess the influence of some environmental factors on weed species' composition and distribution.

2. Materials and methods

2.1. Area of study

The area is located within the territories of 4 governorates: Cairo, Giza, Fayium, and Beni-suef. It comprises the reclaimed desert lands extending on both sides (eastern and western) of the Nile Valley between 29°04′44″N and 29°33′10″N and 31°03′33″E and 31°23′12″E (Figure 1). The eastern part of the study area represents a part of Helwan-Kuraymat and the Assiut eastern desert roads that cross the Eastern Desert parallel to the Nile Valley, and extends for about 80 km. This part will be referred to in this study as the eastern transect. The western part of the study area represents a part of Assiut western desert road crossing the Western Desert parallel to the Nile Valley, and extends for about 31 km. This part will be referred to in this study as the western transect.

Meteorological data from Cairo, Giza, and Fayium stations showed that maximal values of air temperature were recorded in summer months (May–October) ranging between 27 °C and 36.8 °C. On the other hand, mean minimal values were recorded in winter months (November–April). Records ranged between 5.9 °C and 15.8 °C. Rainfall is scanty, unpredicted, and variable in both space and time. Annual averages ranged among 7.2 mm in Fayium, 6.4 mm in Cairo, and 3.9 mm in Giza. It is seasonal and the main bulk of rain falls in winter and spring (October–April). Summer is practically rainless. Values of relative humidity were less in winter months than summer months.

2.2. Field sampling design and data collection

Field data on the floristic composition were gathered throughout intensive fieldwork between December 2008 and October 2010 along the eastern and western transects of the study area. A total of 19 permanently visited sites were surveyed, using a stratified sampling technique (Müller-Dombois & Ellenberg, 1974). To perform that technique, a number of sites were randomly selected within each transect, and in each site a variable number of

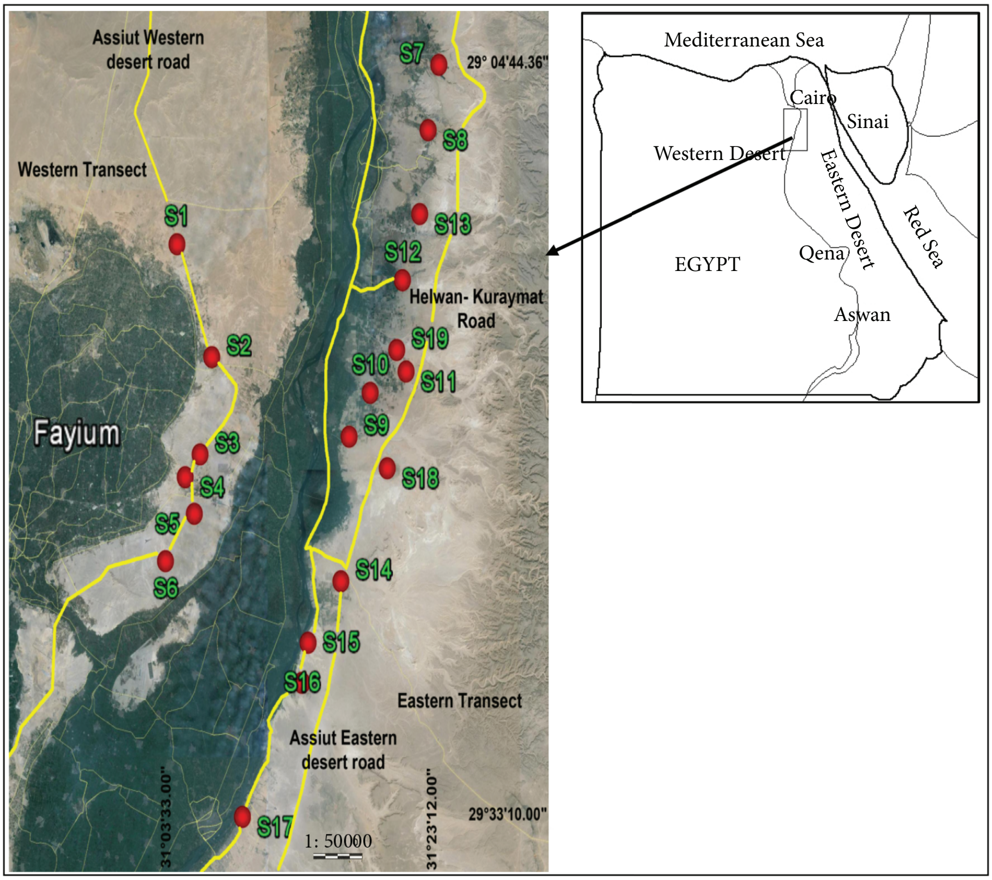

Figure 1. The location map of the 19 studied sites in the study area.

sampling plots were chosen. The number of sites in each transect varied according to its agricultural potentialities. Sites were visited seasonally, 4 times a year, to follow the differentiation in the seasonal aspects of the monitored species, to follow the variation in the floristic composition, and to record their frequencies. These sites included 13 in the eastern transect and 6 in the western (Figure 1). A total of 123 sampling stands were selected: 10 stands (5 stands in each of sites 7 and 14) were in the outskirts of the irrigated stands to compare the floristic composition of the natural vegetation with those in the cultivated fields. The other 113 stands represent the 2 recognised agroecosystems and are distributed as follows: 59 in the orchards and 54 in the croplands. In each of the 19 studied sites, presence or absence of plant species was recorded using a number of stands (fields) randomly positioned and representing as much as possible the variation in both agroecosystems. Frequency of occurrence (f%) of species was calculated as the number of stands where the species was recorded divided by the total number of stands in each site. The presence performance (P%) of each species was calculated as the number of stands where the species was recorded divided by the total number of stands for each crop. The size of the stand (field) varied from one site to another, depending on the total cultivated area, variability in both croplands, and habitats. The area of each stand (field) was around 20 × 100 m, which approximates the minimal area of weed associations in the study area. Such size of sampled stands has been applied in other related studies (Saavedra et al., 1989; Shaltout et al., 1992; Abd El-Ghani, 1998). The sampled stands may be regarded as fairly representative within each crop type. The stands were in conventional agricultural use (tilled and sprayed with pesticides), but were not sprayed with herbicides in the sampling years, such that the weeds had been affected by the respective crops throughout the growing season.

The distribution patterns of the recorded species were organised into 5 main categories: I- Ubiquitous species, those recorded in 17–19 sites (89.5%–100% presence); II- Common species, those recorded in 11–16 sites (57.9%–84.2% presence); III- Frequent species, those recorded in 6–10 sites (31.6%–52.6% presence); IV- Occasional species, those recorded in 2–5 sites (10.5%–26.3% presence), and V- Restricted species, those recorded in 1 site (5.3% presence).

2.3. Multivariate analysis of the data

Both classification and ordination techniques were employed. Unicates of the total flora were eliminated from the data set to avoid noise and summarise redundancy (Gauch, 1982). A floristic presence/absence data matrix consisting of 19 sites and 150 species was classified by 2-way indicator species analysis (TWINSPAN) using the default settings of the computer program CAP for Windows. The sites were ordered first by divisive hierarchical clustering, and then the species were clustered based on the classification of sites. An ordered 2-way table that expresses succinctly the relationships of the samples and species within the data set was constructed (Hill, 1979; Økland, 1990). To assure the robustness of the resultant classification, we devised a second classification using a squared Euclidean distance dissimilarity matrix with minimum variance (also called Ward's method) as the agglomeration criterion (Orloci, 1978) of the Multivariate Statistical Package for Windows (MVSP), version 3.1 (Kovach, 1999). This produced nearly identical results to the TWINSPAN analysis, and a dendrogram was elaborated.

The basic goal of ordination is to summarise the community patterns, and to compare these with the environmental information. In this study, the default option of the computer program CANOCO, version 3.12 (ter Braak, 1987, 1990), was used for all ordinations. The indirect gradient analysis was undertaken using detrended correspondence analysis (Whittaker, 1967). Preliminary analyses were made by applying the default options of the DCA (Hill & Gauch, 1980) in the CANOCO program to check the magnitude of change in species composition along the first ordination axis (i.e. gradient length in standard deviation units). DCA estimated the compositional gradient in the vegetation data of the present study to be less than 4 standard deviation units for most subset analysis; thus, redundancy analysis (RDA) is the appropriate ordination method to perform direct gradient analysis (ter Braak & Prentice, 1988). The relationships between vegetation gradients and the studied environmental variables can be indicated on the ordination diagram produced by RDA biplot. A Monte Carlo permutation test (499 permutations; ter Braak, 1990) was used to test for significance of the eigenvalues of the first canonical axis. The use of canonical coefficients in determining the significance of environmental variables is undesirable because they can be unstable. Interset correlations from the RDAs were therefore used to assess the importance of the environmental variables. All data variables were assessed for normality (SPSS for Windows, version 10.0) prior to the RDA analysis, and appropriate transformations were performed when necessary to improve normality according to Zar (1984).

Soil samples were collected from each stand at 3 depths: 0–10, 10–25, and 25–50 cm. The samples were pooled together to form one composite sample, spread over sheets of paper, and left to dry in the air. Dried soils were passed through a 2-mm sieve to remove gravel and debris, and then packed in paper bags for physical and chemical analysis. Such a technique is adopted in comparable areas, for instance, see Abd El-Ghani et al. (2011). Seventeen environmental variables were included: soil reaction (pH), electric conductivity (EC), organic matter (OM), coarse sand (CS), fine sand (FS), silt, clay, bicarbonates (HCO_3^-), chlorides (Cl^-), sulphates (SO_4^{-2}), Ca, Mg, Na, K, NH_4, nitrates (NO_3^-) and saturation point Only 9 soil variables were included in the analysis, as 8 variables (electric conductivity, Silt, SO_4^{-2}, Cl^-, NO_3^-, Ca, K and Mg.) were excluded due to their high inflation values.

The TWINSPAN vegetation groups were subjected to one-way analysis of variance (ANOVA) based on soil variables to find out whether there were significant variations among groups. The similarities between the 6 studied orchards–croplands were estimated by using the linear correlation coefficients (*r*). Application of the cluster analysis to the presence performance percentages of species in each crop was elaborated and then was separated along the first 2 axes of the scatter plot of nonmetric multidimensional analysis based on the Gower similarity measure, which is one of the most popular measures of proximity for mixed data types.

2.4. Species diversity

Species richness (SR) within each separated TWINSPAN vegetation group was calculated as the average number of species per stand. The Shannon–Wiener diversity index was calculated from the formula $H' = -\Sigma_i^S P_i \log_e P_i$ (Pielou, 1975), where H′ is the Shannon–Wiener diversity index, S is the total number of species, and P is the frequency of the *i*th species.

2.5. Crop–weed relationships

Differences in the composition of weed assemblages were evaluated among different cultivations. These included 2 orchard crops, grape (*Vitis vinifera* L.) and olive (*Olea europaea* L.); 2 winter crops, Egyptian clover (*Trifolium alexandrinum* L.) and wheat (*Triticum aestivum* L.); 1 summer crop, maize (*Zea mays* L.); and tomato (*Lycopersicon esculentum* L.), which has 2 different cultivations (summer and winter). Permanent stands were visited seasonally to record the variation in the floristic composition. The 113 studied stands were distributed among the recognised agroecosystems as follows: 37 in the olive orchards, 22 in the vineyards, 18 in the Egyptian clover stands, 11 in the wheat stands, 10 in the tomato stands, and 15 in the maize stands. Five frequency classes were used to classify the species composition within each crop: Class I, P% > 80%–100%; Class II, P% > 60%–80%; Class III, P% > 40%–60%; Class IV, P% > 20%–40%; and Class V, P% > 0%–20%. Voucher specimens of each species were collected and identified in the herbarium of Cairo University (CAI), where they were deposited. Taxonomic nomenclature was according to Täckholm (1974), updated by Boulos (1999, 2000, 2002, 2005, 2009).

To express variations in growth form (species duration) traits, an arbitrary 7-category system was adopted: winter weeds (w), summer weeds (s), all-year weeds (a), desert annuals (da), desert perennials (dp), trees (t), and margin species (ms). The latter are those recorded at the transition zones separating different agricultural fields from each other or from other landscape elements. Plant species composition and species numbers may vary considerably due to differences in ecological conditions and agricultural management (Norderhaug et al., 1999; Le Coeur et al., 2002; Marshall & Moonen, 2002).

3. Results

3.1. Floristic composition

A total of 150 species of vascular plants belonging to 125 genera in 33 families were recorded (Table 1). The most species-rich families were Poaceae (31 species) and Asteraceae (23 species), followed by Brassicaceae (13 species), Chenopodiaceae (12 species), and Fabaceae (12 species). Other families were represented in different ways. Monospecific families (13 families) constituted less than 42% of the total recorded families. The main bulk (98) of the genera was represented by 1 species. Generally, the family size is small: 28 families have less than 10 species and only 5 families have more than 10 species. Obviously, the total number of genera within each family followed the same sequence for the total number of species. Genera with highest number of species included *Chenopodium* L., *Amaranthus* L., *Coronopus* Zinn, *Zygophyllum* L., and *Euphorbia* L. (3 species each). Another 12 genera were represented by 2 species, including, amongst others, *Rumex* L. and *Brassica* L.

Table 1. Number of species with their percentages, and the total number of genera included in each family.

Family	Number of genera	Number of species	% of the species
Poaceae	28	31	20.6
Asteraceae	21	23	15.3
Brassicaceae	10	13	8.6
Chenopodiaceae	9	12	8
Fabaceae	9	12	7.3
Zygophyllaceae	3	5	3.3
Boraginaceae	4	4	2.7
Caryophyllaceae	4	4	2.7
Euphorbiaceae	2	4	2.7
Lamiaceae	3	4	2.7
Polygonaceae	3	4	2.7
Amaranthaceae	1	3	2
Apocynaceae	3	3	2
Convolvulaceae	3	3	2
Capparaceae	2	2	1.3
Cyperaceae	1	2	1.3
Geraniaceae	2	2	1.3
Plantaginaceae	1	2	1.3
Tamaricaceae	1	2	1.3
Apiaceae	2	2	1.3
Families with 1 species	13	13	8.6
Total number	125	150	

Annuals constituted the main bulk of the total flora, where 100 species (about 67% of the total) were recorded, in addition to 33 perennials, 11 margin species, and 6 trees. The number of species varied between agroecosystems: 118 in the orchards and 129 in the croplands. Trees and shrubs included 29 species, mostly of desert habitats, such as *Anabasis setifera* Moq., *Calotropis procera* (Aiton) W.T.Aiton, and *Pergularia tomentosa* L. Certain halophytic shrubs that characterised the salt-affected soils were also recorded, such as *Suaeda vera* Forssk. ex J.F.Gmel, *Tamarix nilotica* (Ehrenb.) Bunge, and *Zygophyllum album* L.f.

As for weeds, 65 winter species 14 summer and 10 all-year weeds were recognised. The most common winter weeds were *Ammi majus* L. and *Anagallis arvensis* L. var. *caerulea* (L.) Gouan. Common summer weeds included *Amaranthus hybridus* L. and *A. viridis* L. Commonly recorded all-year weeds included *Convolvulus arvensis* L. and *Cynodon dactylon*.

3.2. Chorological affinities

Chorological analysis revealed that the widely distributed species belonging to cosmopolitan, palaeotropical, and pantropical chorotypes constituted 59 species, or 39.3% of the recorded flora (Table 2). Monoregional chorotypes were presented by 19 species, of which pure Mediterranean species were very poorly represented (3 species). On the other hand, bi- and triregional Mediterranean chorotypes constituted 42 species, while Saharo-Arabian chorotypes, either pure or penetrated into other regions, constituted 49 species of the total recorded flora. This may reflect the equal effect of both Mediterranean and Saharo-Arabian chorotypes in the flora of the study area.

The 3 major monoregional phytochoria represented in this study were Saharo-Arabia (SA), Sudano-Zambezian (SZ), and Mediterranean (MED). Apparently, the combinations of Saharo-Arabian + Sudano-Zambezian (SA+SZ) and Mediterranean + Irano-Turanian (MED+IT) were the most important, represented by 19 and 15 species, respectively. Those of Saharo-Arabian + Irano-Turanian (SA+IT) and Mediterranean + Saharo-Arabian (MED+SA) were moderately represented by 10 and 5 species, respectively.

Table 2. Summarised chorological analysis of the recorded flora. COSM = cosmopolitan, PAL = Palaeotropical, PAN = Pantropical, MED = Mediterranean, SZ = Sudano-Zambezian, SA = Saharo-Arabian, IT = Irano-Turanian, ES = Euro-Siberian.

Chorotypes	Total number of species
COSM	31
PAL	16
PAN	12
Subtotal	59
Monoregional	
SA	11
SZ	5
MED	3
Subtotal	19
Biregional	
MED+IT	15
MED+SA	5
MED+ES	1
SA+SZ	19
SA+IT	10
SZ+IT	1
Subtotal	51
Triregional	
MED+IT+ES	16
MED+IT+SA	3
MED+SA+SZ	1
MED+IT+SZ	1
Subtotal	21
Total	150

3.3. General distribution patterns of species

Appendix 1 displays the distribution patterns of the recorded species in the study area. Two ubiquitous (omnipresent) species, *Cynodon dactylon* and *Sonchus oleraceus*, had the widest ecological amplitudes recorded in all monitored sites. Common species included 10 winter weeds, 4 summer weeds, and 3 all-year weeds. Certain species exhibited variations in their frequency percentages (f%) in the eastern and western transects. Twenty-nine frequent species included 16 winter weeds and 3 species each for the all-year and summer weeds. A group of 6 desert species, such as *Zygophyllum coccineum* L. and *Z. simplex* L., showed high values of frequency percentages in site 8 of the eastern transect (f% ranged from 30% to 90%). Sixty-eight occasional species (occurred in 2 to 5 sites) were recorded. Obviously, winter weeds constituted the main bulk: 25 species or about 36.8% of the total number of species were in this category, followed by the desert plants (22 species or 32.3%). Wide variation in the distribution patterns and floristic structure can be noticed in the 31 restricted species. It is to be noticed that sites 7 and 14 (in the outskirts of the cultivated fields) had no restricted species.

3.4. Crop–weed relationships

Appendix 2 summarises the presence performance of each species within the studied 6 crops. The total number of species varied among crops: the highest was 105 species in olive, and the lowest was 56 in wheat.

Twenty-three species were recorded in all 6 crops (category 1: widest sociological ranges of species). Performance (P%) seems to differ. While *Cynodon dactylon* performed better in orchards; olive and vineyards, at 82% and 73%, respectively, *Sonchus oleraceus*, *Chenopodium murale* L., and *Malva parviflora* L. performed better in winter crops clover and wheat, ranging between 89% and 55%. All had the same performance in the summer crop, maize (P% = 60%). Certain species exhibited higher performance in 1 (or more) crop than others, e.g., *Cichorium endivia* L. in clover (P% = 89%), where its records in other crops ranged between 3% and 45%. *Tamarix nilotica* and the desert perennials *Zygophyllum coccineum* and *Alhagi graecorum* Boiss. fared well or at least commonly in tomato farmlands with performances of 80%, 60%, and 50%, respectively, while their records were 9% in wheat farmlands. *Anagallis arvensis* var. *caerulea*, *Melilotus indicus* (L.) All., *Polypogon monspeliensis* (L.) Desf., and *Euphorbia peplus* L. were among the species that performed better in winter crops than others. On the contrary, *Amaranthus graecizans* L. performed better (P% = 33%) in the summer crop than in the winter ones, at 6% and 9% in clover and wheat farmlands, respectively. Eighteen species were recorded in both categories II and III (species present in 5 or 4 crops, respectively). Naturally, winter weeds seem to be more common in winter crops. The performance differed from one type of cultivation to another. The desert species *Calotropis procera*, *Cotula cinerea*, and *Zygophyllum simplex* were absent in the records of winter crops. The winter weeds *Hordeum murinum* L. subsp. *leporinum* (Link.) Arcang. and *Ammi majus* were absent in the records of orchards. Category IV (species present in 3 crops) included 20 species. In this category, *Stipagrostis plumosa* (L.) Munro ex T.Anderson was common (P% = 60%) in tomato fields; *Ochradenus baccatus* Delile and *Pseudognaphalium luteoalbum* (L.) Hilliard & B.L.Burtt were less common (P% = 30% each), but these were absent or ranged between 11% and 24% in other cultivations. Thirty-six species were included in category V (species present in 2 assemblages). Three species, *Ifloga spicata* (Forssk.) Sch.Bip., *Diplachne fusca* (L.) P.Beauv. ex Roem. & Schult. subsp. *fusca*, and *Heliotropium bacciferum* Forssk. showed certain consistency in the orchards with very low performances ranging between 3% and 11%. Four species were confined to the winter crops: *Lamium amplexicaule* L., *Mentha longifolia* (L.) Huds., *Sorghum bicolor* (L.) Moench. subsp. *verticilliflorum* (Steud.) de Wet ex Wiersema & J.Dahlb., and *Tamarix tetragyna* Ehrenb., with performances ranging between 6% and 44%. Surprisingly, 11 out of the 13 of this category recorded in both olive orchards and tomato farmlands were desert species. However, *Trichodesma* and *Haloxylon* were more common in tomato farmlands (P% = 40% and 30%, respectively) than in olive orchards (14% and 11%, respectively).

Thirty-five species were confined to only 1 assemblage (narrowest sociological range), distributed as follows: 12 species in olive orchards, 7 species in vineyards, 11 species in clover farmlands, 2 species in wheat farmlands, 2 species in maize, and 1 species in tomato farmlands. All species of this category showed low or very low performances, except for *Brassica nigra* (L.) W.D.J.Koch, *Trigonella stellata* Forssk., and *Rumex dentatus* L. subsp. *dentatus*, recorded at 36% in wheat, 32% in vineyards, and 28% in clover cultivations, respectively. It is obvious that desert species of this category were confined to 1 of the orchards (8 species), except *Echinops spinosus* L., which was recorded in maize farmlands.

Table 3 displays the linear correlation coefficients (*r*) between the studied crops and orchards. It showed high significance between the weed flora of olive orchards and vineyards (P < 0.01), and between the 2 winter crops (wheat and clover). While significant high correlations occurred between weeds in maize (summer crop), olive, and vineyard orchards, insignificant correlations were found between it and the 3 other crops. Application of nonmetric multidimensional scaling analysis based on the Gower similarity measure of the presence percentages of species in the 6 crops (Figure 2) resulted in 4 floristic

Table 3. Linear correlation coefficient (*r*) between the 6 crops, *P < 0.01

Crops	Olive	Vineyard	Clover	Wheat	Tomato
Olive					
Vineyard	0.75*				
Clover	0.39	0.49			
Wheat	0.30	0.30	0.77*		
Tomato	0.71*	0.45	0.28	0.26	
Maize	0.65*	0.63*	0.26	0.51	0.45

groups (A–D). Group A included species of clover and wheat (winter crops), Group B included species of tomato (winter/summer crop), Group C included species of maize (summer crop), and Group D included species of olive and vineyard orchards.

3.5. Classification of vegetation

The TWINSPAN classification of the frequency percentages of the recorded 150 species in 19 studied sites resulted in 4 site groups (Figure 3). The first TWINSPAN dichotomy differentiated the 19 sites into 2 main splits according to soil pH ($P = 0.008$), bicarbonates ($P = 0.002$), and ammonia ($P = 0.03$). At the second hierarchical level, the first split was separated into 2 distinct groups (A and B), and the second split was separated into 2 groups (C and D) related to silt contents ($P = 0.02$) and sulphates ($P = 0.04$). Each site group will be referred to as a vegetation group and named after the dominants with the highest frequency percentages (f%). Group A: *Cynanchum acutum–Launaea nudicaulis* (70 species), characterised by the dominance of *Cynanchum acutum* (76.7%) and *Launaea nudicaulis* (75%) in sites 5, 6, and 8; Group B: *Launaea nudicaulis–Cynodon dactylon* (74 species), included in sites 7, 15, 16, and 18 along the eastern transect; Group C: *Cynodon dactylon–Sonchus oleraceus–Chenopodium murale* (102 species) from sites 1, 2, 3, and 4 along the western transect and sites 11, 12, 13, and 14 along the eastern transect; and Group D: *Sonchus oleraceus–Cichorium endivia* (88 species) from sites 9, 10, 17, and 19 along the eastern transect. Twenty-seven species were recorded in all 4 separated groups, whereas 9 species showed consistency to Group A, 17 to Group B, 12 to Group C, and 8 to Group D.

3.6. Soil characteristics of the vegetation groups

Data in Table 4 demonstrate that organic matter, coarse sand, silts, and soil saturation point were of significant variations ($P < 0.05$). Sites of Group A had the highest amounts of fine sand (60.9 ± 3.1) with the highest levels of electric conductivity (39.7 ± 8.4) and ions of Cl (460.2 ± 104.0), Na (457.4 ± 102.5), Ca (66.0 ± 18.0), K (4.9 ± 1.1), NH_4 (50.3 ± 12.7), and NO_3 (98.3 ± 26.4). The mean total number of species per site (species richness) reached its maximum in this group (41.7 ± 7.3), as did the Shannon diversity index (3.5 ± 0.1), as well. Sites of Group B had the lowest soil content of electric conductivity (7.3 ± 1.9) and ions of Cl (66.3 ± 22.1), SO_4^- (19.3 ± 4.0), Na (67.1 ± 21.5), and K (1.4 ± 0.5). Its species diversity measurements also showed the lowest among the other recognised groups (Table 4). Soil of Group C was characterised by the highest contents of SO_4^- (88.8 ± 51.4) and magnesium (22.6 ± 13.0) ions. Sites of Group D were rich in their organic matter, silt (22.6 ± 4.2), and clay (13.8 ± 2.3) contents, and had the lowest contents of coarse sand, fine sand, bicarbonates, magnesium, ammonia, and nitrate ions.

3.7. Ordination of sites

Figure 4 shows the ordination results of the DCA of the floristic data set. The 19 site scores were plotted along axis 1 (eigenvalue = 0.414) and axis 2 (eigenvalue = 0.252) and tended to cluster into 4 vegetation groups (A–D) that resulted from the TWINSPAN analysis described above. The sites were spread out at 3 standard deviation units along the first axis, expressing the high floristic variations among vegetation groups. The 4 DCA axes explained 30.8% of the total variation in species data. This low percentage of variance explained by the axes was attributed to the many zero-values in the vegetation data set. The ordination diagram graphically displayed that sites of Groups A and B were separated toward the positive end of axis 1. On the other hand, sites of Group D were separated toward the negative end. Sites of Group C occupied an intermediate position of the ordination plot between the other groups, i.e. transitional in their composition.

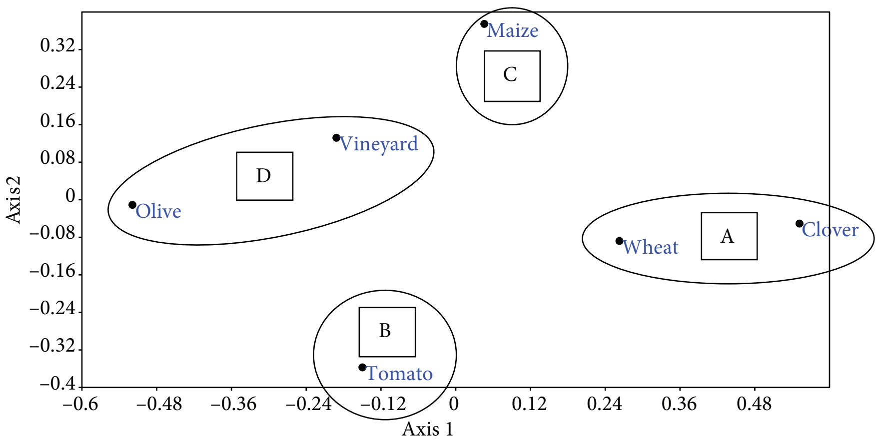

Figure 2. Scatter plot of nonmetric multidimensional scaling analysis based on Gower similarity measure of the species in the 6 crops. A–D are the vegetation groups that resulted from cluster analysis.

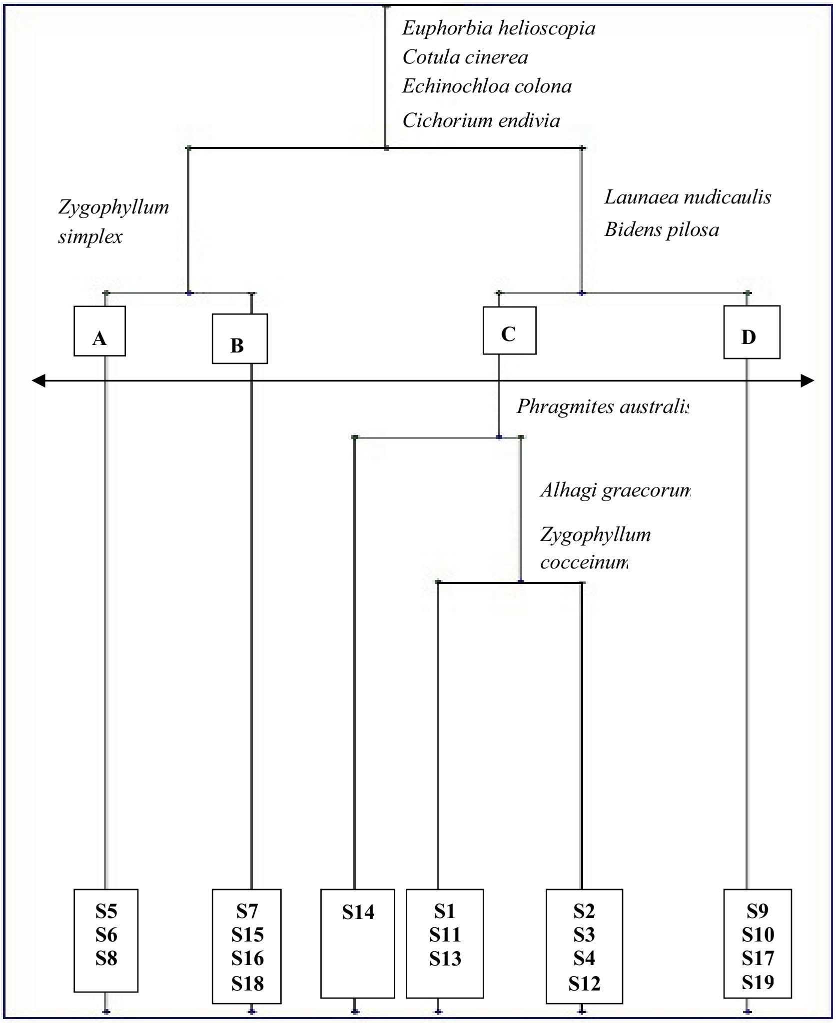

Figure 3. TWINSPAN dendrogram of the 19 studied sites based on their species frequency values. A–D are the 4 separated TWINSPAN vegetation groups.

3.8. Soil–vegetation relationships

The relationship between the vegetation and soil variables was studied using RDA. Figure 5 shows the RDA ordination biplot with vegetation Groups A–D and the examined soil variables. Preliminary analysis revealed high inflation factors for 8 soil variables, which should be excluded from the analysis. Consequently, this analysis is based on only 9 soil parameters: coarse sand, fine sand, clay, pH, saturation point, bicarbonates, sodium, organic matter, and ammonia. It can be noted that sites of Group A were highly correlated with fine sand, sodium and ammonia; Group B was correlated with coarse sand, while sites of Group D were affected by the organic matter, clay, and soil saturation. Apparently, sites of Group C were not affected by any soil variables.

The species–environment correlations were higher for the 4 axes, explaining 64.1% of the cumulative variance. These results suggested an association between vegetation and the measured soil parameters presented in the biplot. RDA axis 1 was highly positively correlated with saturation point and highly negatively correlated with Naions. This axis can thus be interpreted as the saturation point–sodium gradient. RDA axis 2 was highly positively correlated with organic matter and highly negatively correlated with ammonia. Thus, this axis can be interpreted as the organic matter–ammonia gradient. A test for significance with an unrestricted Monte Carlo permutation test (499 permutations) for the eigenvalue of axis 1 was found to be significant ($P = 0.05$), indicating that the observed patterns did not arise by chance.

4. Discussion

RDA of the present data set demonstrated the effect of some soil variables on the spatial distribution of weed

Table 4. Mean values ± standard errors of the soil variables in the sites representing the vegetation groups (A–D) obtained by TWINSPAN. CS = Coarse sand, FS = fine sand, EC = electric conductivity, OM = organic matter, SP = saturation point, SR = species richness, H' = Shannon's index. *P < 0.05.

Soil variables		TWINSPAN vegetation groups				F-ratio	P
		A	B	C	D		
Total number of sites		3	4	8	4		
pH		7.6 ± 0.1	7.7 ± 0.03	7.7 ± 0.03	7.7 ± 0.04	2.02	0.15
EC (mmhos/cm)		39.7 ± 8.4	7.3 ± 1.9	23.1 ± 10.0	12.9 ± 11.2	1.37	0.29
OM	(%)	0.15 ± 0.04	0.3 ± 0.1	0.22 ± 0.1	0.92 ± 0.4	3.38	0.05*
CS	(%)	20.7 ± 0.8	22.9 ± 1.5	21.5 ± 0.6	13.3 ± 3.0	7.47	0.003*
FS	(%)	60.9 ± 3.1	54.8 ± 1.6	56.8 ± 1.8	50.6 ± 4.4	1.96	0.16
Silts	(%)	10.0 ± 0.9	12.4 ± 1.4	10.7 ± 0.8	22.6 ± 4.2	7.92	0.002*
Clay	(%)	8.2 ± 2.5	10.0 ± 1.1	10.2 ± 1.2	13.8 ± 2.3	1.48	0.26
HCO_3^-	mEq/L	1.6 ± 0.2	1.6 ± 0.3	1.6 ± 0.2	1.5 ± 0.3	0.98	0.96
Cl	mEq/L	460.2 ± 104.0	66.3 ± 22.1	208 ± 86.5	153.1 ± 142.0	1.93	0.17
SO_4^-	mEq/L	86.0 ± 11.6	19.3 ± 4.0	88.8 ± 51.4	21.0 ± 17.2	0.69	0.57
Ca	mEq/L	66.0 ± 18.0	12.8 ± 3.3	57.4 ± 29.9	15.1 ± 12.1	0.91	0.46
Mg	mEq/L	19.6 ± 4.3	5.9 ± 1.8	22.6 ± 13.0	4.0 ± 3.0	0.69	0.57
Na	mEq/L	457.4 ± 102.5	67.1 ± 21.5	215.2 ± 92.1	154.9 ± 142.4	1.76	0.20
K	mEq/L	4.9 ± 1.1	1.4 ± 0.5	3.2 ± 0.9	1.7 ± 1.4	1.64	0.22
NH_4	mEq/L	50.3 ± 12.7	49.7 ± 7.1	45.9 ± 3.4	45.3 ± 1.8	0.18	0.90
NO_3	mEq/L	98.3 ± 26.4	70.3 ± 15.4	85.8 ± 34.7	69.5 ± 39.2	0.11	0.95
SP		23.0 ± 1.0	23.3 ± 1.1	22.9 ± 0.8	35.8 ± 5.5	6.1	0.006*
SR		41.7 ± 7.3	33.5 ± 6.4	41.4 ± 3.9	38.7 ± 8.3	0.37	0.77
H'		3.5 ± 0.1	3.3 ± 0.2	3.5 ± 0.1	3.4 ± 0.2	0.30	0.82

communities in the reclaimed lands of the study area; it has certain characteristics and floristic features. The land reclamation processes entail an almost complete change of the environmental factors. Thus, weeds find the new conditions favourable for their growth. Close to the boundaries of the desert and within the agroecosystem in this study, xerophytic species naturally grow among the weeds of the cultivation. This indicated that these species are native to the natural desert vegetation and can remain after the reclamation process. The analysis of the vegetation components of the agroecosystem of the reclaimed lands consisted mainly of the weed species growing in the crops of the old cultivated lands, in addition to some desert plant species. This suggests that land reclamation in the study area entails weed species replacing natural plant communities. Therefore, the reclaimed areas of this study can be considered as a transitional phase of the succession process between the habitat of the old cultivated lands and that of the desert. The availability or vicinity of water in newly reclaimed land because of the irrigation provides habitat for rich populations of several desert plants that were sparse elsewhere. The low number of perennials, marginal species, and trees might be related to the intensive management used in the plantations, which could affect vegetative growth structures, as well as the life cycles of the perennial weeds. The weed species vary in their sociological range, ecological aggressiveness, and seasonal preference. Sociological range and ecological performance seem to be linked; most of the species in the first category (present in all assemblages) are also the species with higher performance values. Species with narrow sociological range present in a few assemblages often have low scores of performance values. Differences in number and type of the weed species were clearly observed among different crop farmlands and mainly affected by type of crop, seasonal preference, and ecological factors. Moreover, highly significant correlations were recorded between the weed flora of the olive and vineyard orchards, and between those of the 2 winter crops (wheat and clover). Weeds recorded in tomato cultivations might stand alone due to the fact that many tomato fields were cultivated all year round (winter and summer cultivations), i.e. behaved as a perennial crop.

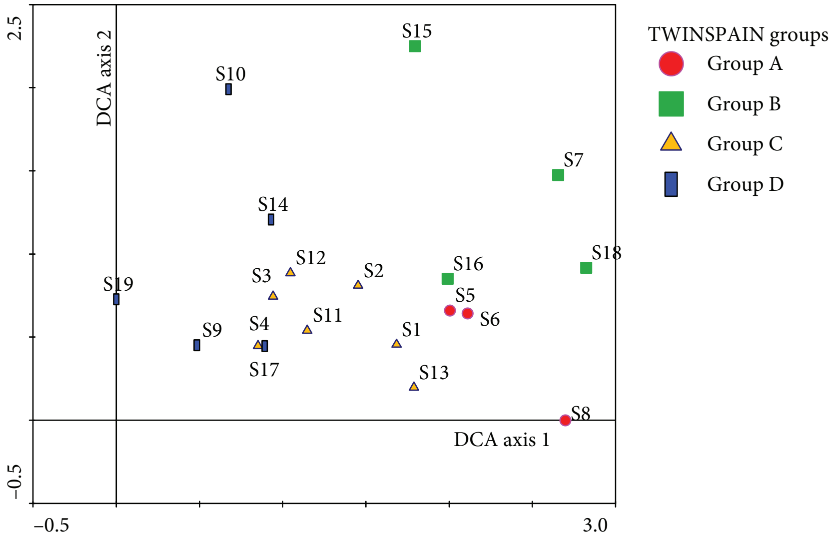

Figure 4. DCA ordination diagram for the 19 sites on the first 2 axes with the TWINSPAN vegetation groups (A–D) superimposed.

The 150 recorded species were distributed within 33 families. The 5 major families based on the number of species were Poaceae, Asteraceae, Chenopodiaceae, Fabaceae, and Brassicaceae. They accounted for 60.7% of the total flora of the study area. The former 4 families were reported to be the most frequent in the reclaimed areas in other parts of Egypt (Shehata & El-Fahar, 2000, in the reclaimed areas of Salhiya area; Shaheen, 2002, in the newly farmed lands along the southern border of Egypt; Abd El-Ghani & Fawzy, 2006, in the agroecosystems of the Oases). Moreover, Poaceae, Asteraceae, and Fabaceae were found to be the most frequent families containing many weed species in other studies in the tropics (Åfors, 1994; Becker et al., 1998; Tamado & Milberg, 2000). These families represent the most common in the Mediterranean North African flora (Quézel, 1978), and also the most important in small-scale farming in highland Peru, central Mexico, and northern Zambia (Åfors, 1994; Becker et al., 1998; Vibrans, 1998). These families are very rich in species, and so it is not unusual that they contain many weeds.

Annuals (therophytes) constituted the main bulk of the total flora, where 100 species (approximately 67% of the total) were recorded. The short life cycle of annuals, as well as the prevailing climatic conditions and water availability, lead to their frequent occurrence (Shaltout & El-Fahar, 1991). The dominance of annuals could be related to their high reproductive capacity and ecological, morphological, and genetic plasticity under high levels of disturbance (Grime, 1979). The low number of perennials (33 species), marginal species (11 species), and trees (6 species) might be related to the intensive management used in the plantations, such as ploughing, subsoiling, harrowing, levelling, and furrowing operations, which could affect vegetative growth structures, as well as the life cycles of the perennial weeds.

Chorological analysis revealed that the widely distributed species belonging to cosmopolitan, palaeotropical, and pantropical chorotypes constituted 59 species, or 39.3% of the recorded flora. This indicates that the floristic structure of the study area is relatively simple as compared with other areas of Egypt, being more affected by human disturbances (Shaltout & El-Fahar, 1991; Abd El-Ghani et al., 2011). Mediterranean species were very poorly represented and constituted 28%, while the Saharo-Arabian chorotype constituted 32.7% of the total recorded flora. This may reflect the equal effect of both Mediterranean and Saharo-Arabian chorotypes in the flora of the study area. Trees and shrubs were best represented by the Saharo-Arabian chorotype, as they are known to be a good indicator for desert environmental conditions, while Mediterranean species stand for more mesic environs. Similar results were reported in other reclaimed areas all over the country, e.g., Abd El-Ghani (1992) in Qara Oasis, Abd El-Ghani and Fahmy (1998) in Feiran Oasis, Shaheen (2002) in Upper Egypt, and Abd El-Ghani and Fawzy (2006) in the Egyptian Oases.

The wide distribution of some weeds in this investigation may be interpreted as ubiquitous species. Species with wide amplitude (e.g., *Cynodon dactylon* and *Sonchus oleraceus*) are often caused by phenotypic plasticity and heterogeneity (Shaltout & Sharaf El-Din, 1988). The restricted distribution of some weeds, such as *Cressa cretica* L. in salinised or waste lands and *Phyla nodiflora*

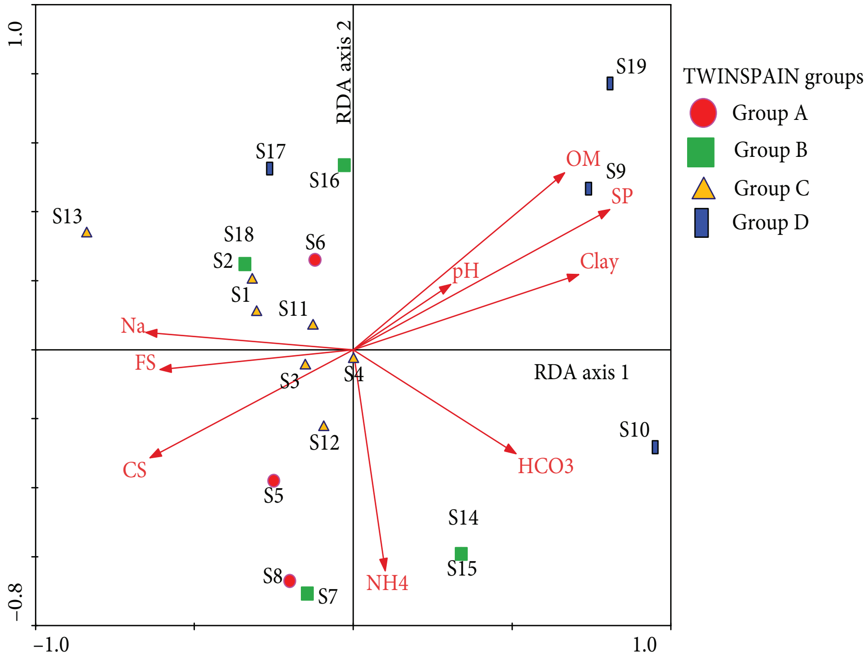

Figure 5. RDA biplot of axes 1 and 2 showing the distribution of the 19 sites with their TWINSPAN vegetation groups (A–D) and soil variables. Abbreviations: CS = coarse sand, FS = fine sand, OM = organic matter, SP = saturation point.

(L.) Greene and *Eclipta prostrata* (L.) L. along canal banks, can be attributed to the habitat preference phenomenon. In line with this, Abd El-Ghani and Fawzy (2006) discussed this phenomenon in the farmlands of the Egyptian Oases. They concluded that each of the 5 distinguished habitats (farmlands, canal banks, reclaimed lands, waste lands, and water bodies) has its own preferential species.

Type of crop is the second most important gradient in weed species composition. This is contradictory to the concept of phytosociological classifications from the central and northern European point of view (Šilc et al., 2008). However, crop is a more important factor in southern Europe than in central and northern Europe, as weed species in southern Europe are in their optimal climatic conditions (Holzner, 1978). Fried et al. (2008) also confirmed that type of crop has the most significant impact on species composition in western Europe, with Atlantic and Mediterranean climates. In Egypt, 2 crops are usually grown in a seasonal sequence: a winter crop and a summer crop. It follows that a crop rotation is accompanied by a weed–flora rotation (El Hadidi & Kosinova, 1971). The agroecosystem of the reclaimed lands in this study can be differentiated into orchards and croplands. Species richness varied from one crop to another. The winter weeds represent the main bulk of the recorded species within each crop, while desert perennials exhibited notable variations. The higher number of desert perennials in olive orchards compared to other crops may be attributed to the ploughing scarcity of this crop. The decline of desert perennials in other crops in the reclaimed lands may confirm a decrease of xerophytic species, which replaced by mesophytic and canal bank species. The were large number of weeds in olive orchards can be attributed to a long growth cycle, wider spacing between trees rows, and constant moist conditions due to irrigation, which might have created conducive conditions for the growth of weeds. Similar conclusions were reported by Firehun and Tamado (2006) in sugarcane plantations in Ethiopia. Moreover, the environment of olive orchards exhibited 2 different microhabitats according to light conditions: the shaded microhabitat below the crowns of olive trees, and the sunny microhabitat between trees. The environmental microheterogeneity causes the weed species to form isolated patches. Shade-loving species such as *Oxalis corniculata* L., *Bidens pilosa* L., and *Sisymbrium irio* L. dominated the shaded areas, whereas the sunny areas support the growth of other species in other croplands. Moreover, the shade effect produced by the olive orchards keeps the soils moist for a longer time than in the open sites. Therefore, it allows for the growth of certain species characteristic to canal banks and moist areas such as *Cyperus laevigatus* L., *C. rotundus*, *Imperata cylindrica* (L.) P.Beauv., and *Phragmites australis* (Cav.) Trin ex Steud.

Application of cluster analysis to the presence percentages of species in different crops resulted in 4 floristic groups (A–D). This demonstrated high significant correlations between the olive and vineyard orchards ($P < 0.01$), and between the 2 winter crops (wheat and clover). Differences were also observed between crop types in the weed flora composition. In this study, 35 species were confined to only 1 weed assemblage (narrowest sociological range). Weed communities are limited by their duration, or at least by their optimum life, to 1 agroecophase. Therefore, their classification into abstract community types according to the Zürich–Montpellier school has always been difficult. Shaltout et al. (1992) pointed out that these difficulties could be related to the complex environmental/anthropogenic factors, seasonal variation among weed communities, and aggressive colonisation of ruderals that tend to form monodominant stands that cover large areas. Accordingly, such communities are difficult to integrate into the phytosociological system (Holzner, 1978). The 4 site (vegetation) groups that were clearly separated along the first 2 axes of DCA were affected greatly by their soil pH and bicarbonate, ammonia, silt, and sulphate contents. A clear pattern in the distribution of site groups was evident, suggesting that the floristic variation in the data set was mainly related to environmental differences in the reclaimed lands. In line with that, Korkmaz and Özçelik (2013) stated that some plant species can be indicators of the environment where they exist or the soil where they grow. Fakhireh et al. (2012) also concluded that soil properties were major determinants in the establishment and distribution of *Demostachye* bipinnata. However, the application of both classification and ordination methods have resulted in a clear segregation of the different vegetation groups associated with the reclaimed lands in the study area in quantitative terms, and in recognising more weed groups than have been identified in other similar studies (Abd El-Ghani, 1994; Abd El-Ghani, 1998; El-Fahar & Sheded, 2002; Abd El-Ghani & El-Sawaf, 2004). The application of DCA indicated that the vegetation groups yielded by the classification technique of the studied sites were generally interconnected.

RDA of the present data set demonstrated the effect of soil organic matter, coarse sand, fine sand, silt, and soil saturation point on the spatial distribution of weed communities in the reclaimed lands of the study area. The species–environment correlations were higher for the 4 axes, explaining 64.1% of the cumulative variance. A test for significance with an unrestricted Monte Carlo permutation test indicated a strong relationship between the species and soil type/site variables considered in the study. RDA axis 1 is interpreted as the saturation point–sodium gradient. RDA axis 2 is interpreted as the organic matter–ammonia gradient. Sites of Groups A and B were highly correlated with coarse sand and ammonia, sites of Group D were affected by the organic matter and soil saturation, and sites of Group C were not affected by any soil variables. *Cynanchum acutum* and *Launaea nudicaulis*, which characterise the sites of Group A and are associated with *Cynodon dactylon* and *Imperata cylindrica*, demonstrated high correlation with soil with high percentages of coarse sand and ammonia (due to fertiliser application). The latter 2 soil parameters also affected the spatial distribution of sites of Group B, characterised by the dominance of *Launaea nudicaulis* and *Cynodon dactylon*, with *Medicago ciliaris* (L.) All. and *Solanum nigrum* L. as associated weed species. Karar et al. (2005) reported the influence of irrigation and fertiliser application on flora composition in the Gezira Scheme (Sudan). In line with this, different authors reported that fertiliser application affects the seed production potential, germination rate, and growth of weeds, which in turn affects the frequency and density of weed flora (Jrnsgard et al., 1996; Andersson & Milberg, 1998). Similarly, Ampong-Nyarko and De Datta (1993) reported an increased seed production and growth rate of the weed flora with an increased rate of nitrogen fertilisation. On the other hand, *Sonchus oleraceus* and *Cichorium endivia* dominated vegetation group D and exhibited the highest performance of several weeds, such as *Amaranthus viridis*, *Brassica tournerfortii* Gouan, *Euphorbia peplus*, *Melilotus indicus*, and *Phalaris minor* Retz. This group was affected by the organic matter and soil saturation. This result agrees with the view that weed flora are often structured by the soil types (Dale et al., 1992; Tamado & Milberg, 2000). However, the ecological reason for the association of these species with the specific soil types is difficult to explain within the scope of this study.

References

Abd El-Ghani MM (1992). Flora and vegetation of Qara Oasis, Egypt. *Phytocoenologia* 21: 1–14.

Abd El-Ghani MM (1994). Weed plant communities of orchards in Siwa Oasis–Egypt. *Feddes Repertorium* 105: 387–398.

Abd El-Ghani MM (1998). Weed communities of date-palm orchards in the Feiran Oasis (south Sinai, Egypt). *Fragmenta Floristica et Geobotanica* 43: 257–271.

Abd El-Ghani MM, Abo El-Kheir M, Abdel-Dayem M & Abd El-Hamid M (2011). Vegetation analysis and soil characteristics of five common desert climbing plants in Egypt. *Turkish Journal of Botany* 35: 561–580.

Abd El-Ghani MM & Amer AM (1990). Studies on weed assemblages in croplands, Egypt. I. Broad bean fields. *Egyptian Journal of Botany* 33: 15–30.

Abd El-Ghani MM, Bornkamm R, El-Sawaf N & Turky H (2011). Plant species distribution and spatial habitat heterogeneity in the landscape of urbanizing desert ecosystem of Egypt. *Urban Ecosystems* 14: 585–616.

Abd El-Ghani MM & El-Bakry AA (1992). Studies on weed assemblages in croplands, Egypt. II. Egyptian clover fields. *Bulletin of Faculty of Agriculture Cairo University* 43: 1221–1252.

Abd El-Ghani MM & El-Sawaf N (2004). Diversity and distribution of plant species in the agro-ecosystem of Egypt. *Systematics and Geography of Plants* 74: 319–336.

Abd El-Ghani MM & Fahmy AG (1998). Composition of and changes in the spontaneous flora of Feiran Oasis, S. Sinai, Egypt, in the last 60 years. *Willdenowia* 28: 123–134.

Abd El-Ghani MM & Fawzy AM (2006). Plant diversity around springs and wells in five oases of the Western Desert, Egypt. *International Journal of Agriculture and Biology* 8: 249–255.

Adriansen HK (2009). Land reclamation in Egypt: a study of life in the new land. *Geoforum* 40: 664–674.

Åfors M (1994). Weeds and weed management in small-scale cropping systems in northern Zambia. Valsätra-Ultuna, Sweden: Crop Production Science, Swedish University of Agricultural Science.

Ampong-Nyarko K & De Datta SK (1993). Effect of nitrogen on growth, nitrogen use efficiency, and rice-weed interactions. *Weed Research* 33: 269–276.

Andersson TN & Milberg P (1998). Weed flora and the relative importance of site, crop, crop rotation, and nitrogen. *Weed Science* 46: 30–38.

Andreasen C, Jensen JE & Haas H (1992). *Setária viridis* and *Echinochloa*: new grass weed species in Denmark. 9th Danish Plant Protection Conference / Weeds. Statens Planteavlsforsøg, beretn. S 2178: 49–60.

Baessler C & Klotz S (2006). Effects of changes in agricultural land-use on landscape structure and arable weed vegetation over the last 50 years. *Agriculture, Ecosystems & Environment* 115: 43–50.

Bazzaz FA (1996). *Plants in Changing Environments*. Cambridge: Cambridge University Press.

Becker B, Terrones F & Horchler P (1998). Weed communities in Andean cropping systems of northern Peru. *Angewandte Botanik* 72: 113–130.

Biswas AK (1993). Land resources for sustainable agricultural development in Egypt. *Ambio* 22: 556–560.

Boulos L (1966). Flora of the Nile region in the Egyptian Nubia. *Feddes Repertorium* 73: 184–215.

Boulos L (1967). On the weed flora of Aswan, Egypt. *Botaniska Notiser* 120: 368–372.

Boulos L (1999). *Flora of Egypt, Vol. 1*: *Azollaceae-Oxalidaceae*. Cairo: Al Hadara Publishing.

Boulos L (2000). *Flora of Egypt, Vol. 2*: *Geraniaceae-Boraginaceae*. Cairo: Al Hadara Publishing.

Boulos L (2002). *Flora of Egypt, Vol. 3*: *Verbenaceae-Compositae*. Cairo: Al Hadara Publishing.

Boulos L (2005). *Flora of Egypt, Vol. 4*: *Alismataceae-Orchidaceae*. Cairo: Al Hadara Publishing.

Boulos L (2009). *Flora of Egypt Checklist: Revised Annotated Edition*. Cairo: Al Hadara Publishing.

Boulos L & El-Hadidi MN (1984). *The Weed Flora of Egypt*. Cairo: The American University Cairo Press.

Dale MRT, Thomas AG & John EA (1992). Environmental factors including management practices as correlates of weed community composition in spring seeded crops. *Canadian Journal of Botany* 70: 1931–1939.

El-Demerdash MA, Hosni HA & Al-Ashri N (1997). Distribution of the weed communities in the North East Nile Delta, Egypt. *Feddes Repertorium* 108: 219–232.

El-Fahar RA & Sheded MG (2002). Weed flora in plantation of recent established tourist resorts in the Western Mediterranean coast of Egypt. *Egyptian Journal of Biotechnology* 11: 330–343.

El Hadidi MN & Ghabbour SI (1968). Floristic study of the Nile valley at Aswan. *Revue Zoologique et Botanique Africaine* 78: 394–407.

El Hadidi MN & Kosinová J (1971). Studies on the weed flora of cultivated land in Egypt. 1. Preliminary survey. *Mitteilungen der Botanischen Staatssammlung München* 10: 354–367.

Ellenberg H, Weber HE, Düll R, Wirth W, Werner W & Paulien D (1992). Zeigerwerte von Pflanzen in Mitteleuropa. *Scripta Geobotanica* 18: 1–258.

Erviö R, Hyvärinen S, Erviö LR & Salonen J (1994). Soil properties affecting weed distribution in spring cereal and vegetable fields. *Journal of Agricultural Science in Finland* 3: 497–504.

Fakhireh A, Ajorlo M, Shahryari A, Mansouri S, Nouri S & Pahlavanravi A (2012). The autecological characteristics of *Desmostachya bipinnata* in hyper-arid regions. *Turkish Journal of Botany* 36: 390–396.

Firehun Y & Tamado T (2006). Weed flora in the Rift Valley sugarcane plantations of Ethiopia as influenced by soil types and agronomic practices. *Weed Biology and Management* 6: 139–150.

Fried G, Norton RL & Reboud X (2008). Environmental and management factors determining weed species composition and diversity in France. *Agriculture, Ecosystems and Environment* 128: 68–76.

Gauch HG (1982). *Multivariate Analysis in Community Ecology*. Cambridge: Cambridge University Press.

Grime JP (1979). *Plant Strategies and Vegetation Processes*. John Wiley & Sons: New York.

Hallgren E, Palmer WM & Milberg P (1999). Data diving with cross-validation: an investigation of broad-scale gradients in Swedish weed communities. *Journal of Ecology* 87: 1037–1051.

Hegazy AK, Diekmann M & Ayyad G (1999). Impact of plant invasions on ecosystems and native gene pools. In: Hegazy AK (ed.) *Environment 2000 and Beyond*, pp. 275–310. Cairo: Horus for Computing and Printing.

Holzner W (1978). Weed species and weed communities. *Vegetatio* 38: 13–20.

Holzner W & Immonen R (1982). Europe: an overview. In: Holzner W & Numata M (eds.) *Biology and Ecology of Weeds*, pp. 203–226. The Hague: Dr. W. Junk.

Hill MO (1979). TWINSPAN-A FORTRAN Program for Arranging Multivariate Data in an Ordered Two-Way Table of Classification of Individuals and Attributes. Ithaca: Cornell University.

Hill MO & Gauch HG (1980). Detrended correspondence analysis: an improved ordination technique. *Vegetatio* 42: 47–58.

Imam M & Kosinova J (1972). Studies on the weed flora of cultivated land in Egypt. 2. Weeds of rice fields. *Botanische Jahrbücher für Systematik* 92: 90–107.

Jrnsgard B, Rasmussen K & Hill J (1996). Influence of nitrogen on competition between cereals and their natural weed populations. *Weed Research* 36: 461–470.

Karar RO, Mohamed BF & Marrs RH (2005). Factors influencing the weed flora in the Gezira Scheme. *Weed Research* 45: 121–129.

Kassas M & Zahran MA (1962). Studies on the ecology of the Red Sea coastal land. I. The district Gebel Ataqa and El-Galala El-Bahariya. *Bulletin de la Société de Géographie d'Egypte* 35: 129–175.

Kenkel NC, Derksen DA, Thomas AG & Watson PR (2002). Multivariate analysis in weed science research. *Weed Science* 50: 281–292.

Korkmaz M & Özçelik H (2013) Soil–plant relations in the annual *Gypsophila* L. (Caryopyhllaceae) taxa of Turkey. *Turkish Journal of Botany* 37: 85–98.

Kovach WL (1999). MVSP - A Multivariate Statistical Package for Windows, Version 3.1. Pentraeth, UK: Kovach Computing Services.

Le Coeur D, Bandry J, Burel F & Thenail C (2002). Why and how we should study field boundary biodiversity in an agrarian landscape context. *Agriculture, Ecosystem and Environment* 89: 23–40.

Marshall EJP & Moonen AC (2002). Field margins in northern Europe: their functions and interactions with agriculture. *Agriculture, Ecosystem and Environment* 89: 5–21.

Müller-Dombois D & Ellenberg H (1974). Aims and Methods of Vegetation Analysis. New York: John Wiley & Sons.

Norderhaug A, Austad I, Hauge L & Kvamme M (1999). Skjøtselsboka for kulturlandskap og gamle norske kulturmarker. Oslo: Landbruksforlaget.

Økland RH (1990). Vegetation ecology: theory, methods and applications with reference to Fennoscandia. *Sommerfettia Supplement* 1: 1–216.

Orloci L (1978). *Multivariate Analysis in Vegetation Research.* The Hague: W. Junk Publishers.

Pyšek P, Jarošík V & Kučera T (2002). Patterns of invasion in temperate nature reserves. *Biological Conservation* 104: 13–24.

Pyšek P & Lepš J (1991). Response of a weed community to nitrogen fertilization: a multivariate analysis. *Journal of Vegetation Science* 2: 237–244.

Quézel P (1978). Analysis of the flora of Mediterranean and Saharan Africa. *Annals of the Missouri Botanical Garden* 65: 479–534.

Saavedra M, Garcia-Torres L, Hernandez-Bermjo E & Hidalgo B (1989). Weed flora of the Middle Valley of the Guadalquivir, Spain. *Weed Research* 29: 167–179.

Salonen J (1993). Weed infestation and factors affecting weed incidence in spring cereals in Finland – a multivariate approach. *Agricultural Science in Finland* 2: 525–536.

Shaheen AM (2002). Weed diversity of newly farmed land on the southern border of Egypt (Eastern and Western shores of Lake Nasser). *Pakistan Journal of Biological Sciences* 5: 602–608.

Shaltout KH & El-Fahar R (1991). Diversity and phenology of weed communities in the Nile Delta region. *Journal of Vegetation Science* 2: 385–390.

Shaltout KH & El-Halawany EF (1992). Weed communities of date palm in eastern Arabia. Q*atar University Science Journal* 12: 105–111.

Shaltout KH & El-Sheik MA (1993). Vegetation–environment relations along water courses in the Nile Delta region. *Journal of Vegetation Science* 4: 567–570.

Shaltout KH & Sharaf El-Din A (1988). Habitat types and plant communities along transect in the Nile Delta region. *Feddes Repertorium* 99: 153–162.

Shaltout KH, Sharaf El-Din A & El-Fahar RA (1992). Weed communities of the common crops in Nile Delta region. *Flora* 187: 329–339.

Shaltout KH, Sharaf El-Din A & El-Sheikh MA (1994). Species richness and phenology of vegetation along irrigation canals and drains in the Nile Delta, Egypt. *Vegetatio* 112: 35–43.

Shehata MN & El-Fahar RA (2000). The vegetation of reclaimed areas in Salhiya region. *Proceedings of the 1st International Conference on Biological Science (ICBS)*, Faculty of Science, Tanta University 1: 315–332.

Šilc U, Vrbničanin S, Božić D, Čarni A & Dajić Stevanović Z (2008). Classification of weed vegetation in the north western Balkans. *Phytocoenologia* 38: 241–254.

Staniforth RJ & Scott PA (1991). Dynamics of weed populations in a northern subarctic community. *Canadian Journal of Botany* 69: 814–821.

Streibig JC (1979). Numerical methods illustrating the phytosociology of crops in relation to weed flora. *Journal of Applied Ecology* 16: 577–587.

Täckholm V (1974). *Students' Flora of Egypt*, 2nd ed. Cairo: Cairo University Press.

Tadros TM & Atta A (1958). The plant communities of barley fields and uncultivated desert areas of Mareotis (Egypt). *Vegetatio* 8: 161–175.

Tamado T & Milberg P (2000). Weed flora in arable fields of eastern Ethiopia with emphasis on the occurrence of *Parthenium hysterophorus*. *Weed Research* 40: 507–521.

ter Braak CJF (1987). CANOCO-A FORTRAN Program for Canonical Community Ordination by Partial Detrended Canonical Correspondence Analysis, Principal Community Analysis and Redundancy Analysis, Version 2.1. Wageningen: Agricultural Mathematics Group .

ter Braak CJF (1990). Update Notes: CANOCO Version 3.1. Wageningen: Agricultural Mathematics Group.

ter Braak CJF & Prentice LC (1988). A theory of gradient analysis. *Advances in Ecological Researches* 18:271–317.

Vibrans H (1998). Native maize field weed communities in south-central Mexico. *Weed Research* 38: 153–166.

Whittaker RH (1967). Gradient analysis of vegetation. *Biological Reviews* 42: 207–264.

Wittig R (2002). *Siedlungsvegetation*. Stuttgart: Eugen Ulmer (in German).

Zar JH (1984). *Biostatistical Analysis*, 2nd ed. Englewood Cliffs, NJ, USA: Prentice Hall.

Appendix 1. The general distribution patterns of the recorded species in the surveyed 19 sites within the area. Sites are shown in Figure 1. Values are the average frequency percentage (f%) of each species in the site.

Transect	Western									Eastern									
Site number	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**
Number of stands	**9**	**8**	**6**	**6**	**5**	**4**	**5**	**10**	**13**	**4**	**9**	**9**	**3**	**5**	**5**	**10**	**4**	**5**	**3**
I- Ubiquitous species (19 sites)																			
Cynodon dactylon (L.) Pers.	44.4	100	83.3	66.7	80	75	20	50	30.8	75	44.4	88.9	100	100	100	40	100	100	33.3
Sonchus oleraceus L.	77.8	87.5	50	66.7	60	25	80	50	61.5	25	66.7	66.7	100	40	80	20	100	60	100
II- Common species (11–16 sites)																			
All-year weeds																			
Cynanchum acutum L.	55.6	62.5	50	16.7	80	100		50		75	22.2	77.8	33.3	60	40	40		100	
Phragmites australis (Cav.) Trin. ex Steud.	55.6	25	16.7	33.3	20	25	60	50			11.1	11.1	66.7				50	60	33.3
Convolvulus arvensis L.	22.2	25	33.3	66.7		25	20	40	76.9		22.2	33.3		60			50	20	
Desert species																			
Launaea nudicaulis (L.) Hook.f.	77.8	100	50	16.7	60	75	60	90	7.7		22.2	33.3	100		40	80		100	
Bassia indica (Wight) A.J.Scott	77.8	62.5	50	33.3	60	100	40	20			11.1	33.3	100			20	100	80	
Summer weeds																			
Echinochloa colona (L.) Link	22.2	37.5	33.3	50		25			23.1	25	33.3	44.4	33.3	40					66.7
Dactyloctenium aegyptium (L.) Willd.		50	33.3	33.3		25			7.7	75	33.3	22.2	33.3	40	20			60	
Cenchrus biflorus Roxb.	11.1			16.7		25		20			11.1	11.1	66.7	20	80	40	25	60	
Amaranthus viridis L.	11.1			16.7	40				46.1	100	33.3	66.7		20	40	20			66.7
Winter weeds																			
Chenopodium murale L.	66.7	50	33.3	100	60	25	40		30.8		77.8	88.9	66.7	60	60		75	20	66.7
Malva parviflora L.	55.6	50	16.7	66.7	40			20	38.5		100	66.7	33.3	20		20	75	40	33.3
Polypogon monspeliensis (L.) Desf.	33.3		16.7	16.7	40		40	10	30.8		22.2	22.2	66.7	20	20	60	75		
Senecio glaucus L. subsp. *coronopifolius* (Maire) C.Alexander	44.4	37.5	16.7	50	60	50					77.8	11.1	100		20	80	25	60	
Anagallis arvensis L. var. *caerulea* (L.) Gouan	22.2	12.5	50	66.7		25			46.1		44.4	22.2	66.7			20	25	40	100
Erigeron bonariensis L.	55.6	62.5	66.7	66.7	40	75	20		30.8		44.4				60	60	50	60	
Melilotus indicus (L.) All.	11.1	12.5		50	40	25			30.8		55.6	33.3	33.3	40		40	100		33.3
Euphorbia peplus L.		37.5	16.7	16.7		25			30.8	75	11.1		33.3	60		10	50		66.7

Appendix 1. (continued).

Symphyotrichum subulatum var. *squamatum* (Spreng.) S.D.Sundb.			16.7		20	25	20	10	23.1	25					20	20	50	40	
Reichardia tingitana (L.) Roth	11.1	12.5		16.7	40	25		10				11.1	33.3	20		40		20	
Trees																			
Tamarix nilotica (Ehrenb.) Bunge	66.7	25	16.7	16.7	40	50		100	7.7				100			40	50	80	
III- Frequent species (6–10 sites)																			
All-year weeds																			
Imperata cylindrica (L.) P.Beauv.	11.1	25		33.3	60	100		30			11.1			20	40	60			
Solanum nigrum L.	33.3			16.7			20				22.2	22.2	33.3	40		40		40	33.3
Cyperus rotundus L.	11.1		16.7					20	7.7	50	33.3	11.1				20			33.3
Desert species																			
Zygophyllum coccineum L.	55.6	37.5				50	40	90	7.7		22.2		66.7			40			
Cotula cinerea Delile					20	25	20	40					33.3			20		40	
Alhagi graecorum Boiss.		87.5	50	33.3		50		60								40	100		
Zygophyllum simplex L.	11.1				20	25		30		25	22.2								
Launaea mucronata (Forssk.) Muschl. subsp. *cassiniana* (Jaub. & Spach) N.Kilian	44.4				40	25		40					33.3					20	
Stipagrostis plumosa (L.) Munro ex T.Anderson	11.1						40	90	7.7		11.1							100	
Summer weeds																			
Portulaca oleracea L.	33.3			16.7	40	25		20	38.5		11.1	55.6							33.3
Amaranthus graecizans L.	22.2	25		33.3				40			22.2	33.3			20				
Setaria verticillata (L.) P.Beauv.	11.1		16.7	33.3						25	11.1	22.2	33.3						
Winter weeds																			
Cichorium endivia L.	11.1	25	33.3	66.7					76.9	25	22.2	11.1					100		66.7
Lolium perenne L.	11.1		50	50	20				15.4		22.2	11.1	33.3	20			25		
Rumex vesicarius L.	22.2			16.7		25		10	23.1		11.1		66.7				25	40	33.3
Euphorbia helioscopia L.			16.7	16.7					30.8	25	11.1	11.1	33.3				50		66.7
Brassica tournefortii Gouan		12.5		33.3		25	20		23.1					20		20	50		
Digitaria sanguinalis (L.) Scop.			16.7	16.7		25		20	7.7	50	33.3		66.7						
Hordeum murinum L. subsp. *leporinum* (Link.) Arcang.	11.1	25	16.7	16.7					15.4		11.1						25		33.3

Appendix 1. (continued).

Avena fatua L.			33.3	66.7				40	46.1		11.1	11.1					50		
Bidens pilosa L.				16.7					7.7	75					20	60	75		33.3
Emex spinosa (L.) Campd.	11.1	12.5	50	16.7					30.8		11.1						25		
Medicago ciliaris (L.) All.	11.1		16.7	33.3							11.1					20	25	80	
Chenopodium album L.			16.7	50					15.4		11.1	22.2					25		33.3
Phalaris minor Retz.			66.7	33.3				30	7.7	50							50		
Eruca sativa Mill.	11.1			16.7				10	38.5	25								60	
Lamium amplexicaule L.	11.1		16.7						15.4		22.2						50		33.3
Beta vulgaris L.	11.1	12.5	16.7	33.3					7.7		22.2								
Trees																			
Calotropis procera (Aiton) W.T.Aiton					20			40			11.1		100		20			100	
IV- Occasional species (2–5 sites)																			
All-year weeds																			
Pluchea dioscoridis (L.) DC.	11.1	12.5														20	50	40	
Spergularia marina (L.) Griseb.	22.2		16.7	33.3													50		
Citrullus colocynthis (L.) Schrad.					20	25		30			11.1								
Mentha longifolia (L.) Huds.				16.7					7.7								50		66.7
Pennisetum divisum (Forssk. ex J.F.Gmel.) Henrard								20								20		20	
Cyperus laevigatus L.		12.5		16.7												20			
Diplachne fusca (L.) P.Beauv. ex Roem. & Schult. subsp. *fusca*												22.2	33.3	20					
Polygonum bellardii All.		25							46.1										
Iphiona mucronata (Forssk.) Asch. & Schweinf.																20		40	
Sorghum bicolor (L.) Moench subsp. *verticilliflorum* (Steud.) de Wet ex Wiersema & J.Dahlb.	11.1																75		
Geranium dissectum L.								10										40	
Paspalidium geminatum (Forssk.) Stapf.				33.3							11.1								
Salsola vermiculata L. var. *villosa* (Schult.) Eig	22.2												33.3						
Desert species																			

Appendix 1. (continued).

Neurada procumbens L.	11.1				20	25		40										40	
Ifloga spicata (Forssk.) Sch.Bip.					20	25	20	10								20			
Matthiola longipetala (Vent.) DC. subsp. *livida* (Delile) Maire					20			40				11.1					25		
Trichodesma africanum (L.) R.Br.								70	7.7		11.1								
Schismus barbatus (L.) Thell.							20										25	40	
Cleome amblyocarpa Barratte & Murb.								20								20			
Ochradenus baccatus Delile	11.1				20	25		80										80	
Fagonia arabica L.				16.7	20			50										40	
Pulicaria undulata (L.) C.A.Mey. subsp. *undulate*					20	25		50			11.1								
Polycarpaea repens (Forssk.) Asch.	11.1						20											40	
Stachys aegyptiaca Pers.																20		40	
Heliotropium bacciferum Forssk.																20		20	
Monsonia nivea (Decne)Webb.	11.1																	40	
Capparis aegyptia Lam.								10	7.7										
Suaeda vera Forssk. ex J.F.Gmel.						25		10											
Summer weeds																			
Amaranthus hybridus L.				16.7					15.4		22.2	11.1		20					33.3
Setaria verticillata (L.) P.Beauv.	33.3	12.5									11.1					20			33.3
Corchorus olitorius L.			16.7						23.1			11.1							
Eragrostis pilosa (L.) P.Beauv.	11.1					25													33.3
Echinochloa crussgalli (L.) P.Beauv.				16.7								11.1							
Winter weeds																			
Plantago lagopus L.								40	30.8		33.3		33.3						
Melilotus messanensis (L.) All.	11.1								23.1								25		66.7
Poa annua L.									30.8		11.1				20		25		
Cuscuta pedicellata Ledeb.	11.1	12.5	16.7														25		
Lathyrus sativus L.								10	7.7			11.1					25		
Rumex dentatus L. subsp. *dentatus*			16.7						23.1			11.1		40					
Sisymbrium irio L.	11.1		33.3							50				20					
Oxalis corniculata L.									30.8	100								40	

Appendix 1. (continued).

Ammi majus L.			33.3							11.1						50		
Phalaris paradoxa L.								7.7		22.2		33.3						
Trigonella stellata Forssk.						40			75					80				
Pseudognaphalium luteoalbum (L.) Hilliard & B.L.Burtt							10	46.1										
Raphanus sativus L.			33.3					23.1										
Urtica urens L.			16.7						100									
Vicia sativa L.																75	40	
Brassica nigra (L.) W.D.J.Koch			16.7					23.1										
Lotus tenuis Waldst.								23.1								25		
Anchusa humilis (Desf.) I.M.Johnst.							20			11.1								
Medicago polymorpha L.			16.7													25		
Plantago major L.								7.7										33.3
Trifolium resupinatum L.										11.1						25		
Trees																		
Phoenix dactylifera L.					25		50										20	
Sesbania sesban (L.) Merr. subsp. *sesban* var. *sesban*												66.7				25		
Tamarix tetragyna Ehrenb.	12.5										11.1							
V- Restricted species																		
All-year weeds																		
Seriphidium herba-alba (Asso) Soják														100				
Cressa cretica L.															20			
Atriplex lindleyi Moq. subsp. *inflata* (F.Muell.) P.G.Wilson					25													
Phyla nodiflora (L.) Greene																		33.3
Sporobolus spicatus (Vahl) Kunth																	20	
Desert species																		
Bassia muricata (L.) Asch.						40								60				
Savignya parviflora (Delile) Webb							30											
Haloxylon salicornicum (Moq.) Bunge ex Boiss.						40	70											
Panicum turgidum Forssk.						60											60	
Achillea fragrantissima (Forssk.) Sch.Bip.						20	20											
Anabasis setifera Moq.						40	20											
Deverra tortuosa (Desf.) DC.						20											40	
Farsetia aegyptia Turra						40											40	

Appendix 1. (continued).

Heliotropium digynum (Forssk.) Asch. ex C.Chr.																		60	
Gymnocarpos decandrus Forssk.																		40	
Pergularia tomentosa L.																		40	
Pulicaria inuloides (Poir.) DC.								20											
Zilla spinosa L.								20											
Zygophyllum album L.f.								20											
Cornulaca monacantha Delile	11.1																		
Echinops spinosus L.									7.7										
Summer weeds																			
Euphorbia prostrata Aiton								20											
Tribulus terrestris L.															20				
Winter weeds																			
Urospermum picroides (L.) Scop. ex F.W.Schmidt														20				60	
Coronopus niloticus (Delile) Spreng.														20					66.7
Capsella bursa-pastoris (L.) Medik.														20			25		
Lepidium coronopus (L.) Al-Shehbaz														20			25		
Parapholis incurva (L.) C.E.Hubb.																30			
Lactuca serriola L.		25																	
Mentha sativa L.									15.4										
Rostraria cristata (L.) Tzvelev			33.3																
Silene rubella L.									15.4										
Brachiaria reptans (L.) Stapf.						25													
Bromus catharticus Vahl											11.1								
Chenopodium ambrosoides L.													33.3						
Chloris virgata Sw.																		20	
Lepidium didymium L.									7.7										
Eclipta prostrata (L.) L.																			33.3
Galinsoga parviflora Cav.				16.7															
Orobanche ramosa L. var. *ramosa*				16.7															
Trigonella hamosa L.						25													
Trees																			
Ricinus communis L.																		100	
Total number of species	52	34	39	56	30	40	26	55	57	21	54	36	34	26	21	37	48	50	29

Appendix 2. Sociological range of species recorded in the studied orchards and crops. P% = presence performance. Values are number of fields where species was recorded. GF = growth form, w = winter weeds, s = summer weeds, a = all-year weeds, da = desert annuals, dp = desert perennials, t = trees, ms = margin species.

GF	Number of visited fields	Olive		Vineyard		Clover		Wheat		Tomato		Maize		Total	
		37	%	22	%	18	%	11	%	10	%	15	%	113	P%
	I- Species present in all crops														
a	*Cynodon dactylon* L.	27	73	18	82	11	61	5	45	4	40	9	60	74	65
a	*Sonchus oleraceus* L.	23	62	11	50	14	78	8	73	5	50	9	60	70	62
w	*Chenopodium murale* L.	12	32	7	32	16	89	7	64	1	10	9	60	52	46
w	*Malva parviflora* L.	12	32	5	23	12	67	6	55	3	30	9	60	47	42
w	*Erigeron bonariensis* L.	18	49	7	32	6	33	1	9	2	20	11	73	45	40
da	*Bassia indica* L.	23	62	5	23	3	17	2	18	3	30	7	47	43	38
w	*Senecio glaucus* L. subsp. *coronopifolius* (Maire) Alexander	21	57	7	32	4	22	2	18	1	10	5	33	40	35
t	*Tamarix nilotica* L.	20	54	4	18	2	11	1	9	8	80	3	20	38	34
a	*Convolvulus arvensis* L.	8	22	1	5	7	39	5	45	4	40	8	53	33	29
w	*Anagallis arvensis* L. var. *caerulea* (L.) Gouan	8	22	2	9	10	56	6	55	1	10	6	40	33	29
w	*Melilotus indicus* (L.) All.	7	19	3	14	10	56	6	55	1	10	3	20	30	27
w	*Cichorium endivia* L.	1	3	1	5	16	89	5	45	1	10	5	33	29	26
dp	*Alhagi graecorum* L.	10	27	6	27	4	22	1	9	5	50	2	13	28	25
dp	*Zygophyllum coccineum* L.	15	41	4	18	1	6	1	9	6	60	1	7	28	25
w	*Polypogon monspeliensis* (L.) Desf.	9	24	5	23	7	39	4	36	2	20	1	7	28	25
ms	*Phragmites australis* (Cav.) Trin. ex Steud.	15	41	2	9	4	22	2	18	2	20	2	13	27	24
s	*Echinochloa colona* (L.) Link	5	14	3	14	8	44	1	9	2	20	6	40	25	22
ms	*Imperata cylindrica* (L.) P.Beauv.	13	35	7	32	1	6	1	9	1	10	1	7	24	21
s	*Dactyloctenium aegyptium* (L.) Willd.	6	16	6	27	3	17	2	18	2	20	4	27	23	20
w	*Euphorbia peplus* L.	4	11	3	14	6	33	4	36	2	20	1	7	20	18
a	*Solanum nigrum* L.	6	16	4	18	1	6	1	9	1	10	3	20	16	14
s	*Amaranthus graecizans* L.	4	11	2	9	1	6	1	9	3	30	5	33	16	14
w	*Phalaris minor* L.	4	11	2	9	3	17	3	27	1	10	1	7	14	12
	II- Species present in 5 crops														
dp	*Launaea nudicaulis* (L) Hook.f.	30	81	13	59	3	17			8	80	4	27	58	51
a	*Cynanchum acutum* L.	23	62	15	68	4	22			3	30	6	40	51	45
s	*Amaranthus viridis* L.	5	14	10	45	6	33			1	10	7	47	29	26
s	*Cenchrus biflorus* Roxb.	9	24	6	27	1	6			1	10	4	27	21	19
s	*Portulaca oleracea* L.	6	16	3	14	3	17			3	30	6	40	21	19
w	*Avena fatua* L.	3	8			7	39	4	36	3	30	3	20	20	18
w	*Bidens pilosa* L.	3	8	7	32	3	17	2	18			1	7	16	14
w	*Rumex vesicarius* L.	4	11			4	22	2	18	1	10	4	27	15	13
w	*Symphyotrichum subulatum* (Michx.) G.L.Nesom var. *squamatum* (Spreng.) S.D.Sundb.	6	16	3	14	1	6	1	9			4	27	15	13

Appendix 2. (continued).

a	*Cyperus rotundus* L.	4	11	4	18	3	17			1	10	2	13	14	12
w	*Euphorbia helioscopia* L.	2	5	1	5	5	28	5	45	1	10			14	12
w	*Reichardia tingitana* (L.) Roth	8	22	3	14	1	6			1	10	1	7	14	12
w	*Digitaria sanguinalis* (L.) Scop.	7	19	2	9	1	6			1	10	2	13	13	12
w	*Eruca sativa* Mill.	2	5	1	5	1	6			3	30	5	33	12	11
w	*Medicago ciliaris* (L.) All.	4	11	1	5	2	11	2	18			3	20	12	11
w	*Plantago lagopus* L.	4	11			2	11	2	18	2	20	2	13	12	11
w	*Brassica tournefortii* Gouan	2	5	1	5	3	17	3	27	2	20			11	10
ms	*Pluchea dioscoridis* (L.) DC.	2	5	1	5	3	17	1	9			1	7	8	7
	III- Species present in 4 crops														
t	*Calotropis procera* (Aiton) W.T.Aiton	10	27	1	5					2	20	2	13	15	13
w	*Lolium perenne* L.	3	8			5	28	3	27			4	27	15	13
w	*Emex spinosa* (L.) Campd.	3	8			5	28	3	27			1	7	12	11
da	*Cotula cinerea* Delile	8	22	1	5					1	10	1	7	11	10
w	*Chenopodium album* L.			1	5	3	17	4	36			3	20	11	10
w	*Hordeum murinum* L. subsp. *leporinum* (Link) Arcang.					1	6	7	64	1	10	1	7	10	9
w	*Oxalis corniculata* L.	1	3	4	18			2	18			3	20	10	9
da	*Zygophyllum simplex* L.	6	16	1	5					1	10	1	7	9	8
dp	*Fagonia arabica* L.	5	14			1	6			2	20	1	7	9	8
s	*Setaria verticillata* (L.) P.Beauv.	3	8	2	9	1	6					3	20	9	8
s	*Setaria italica* (L.) P.Beauv.	4	11	1	5	2	11					1	7	8	7
ms	*Spergularia marina* (L.) Griseb.	3	8			1	6	2	18	1	10			7	6
da	*Matthiola longipetala* (Vent.) DC. subsp. *livida* (Delile) Maire	3	8			1	6	1	9	2	20			7	6
s	*Amaranthus hybridus* L.			1	5	2	11	1	9			3	20	7	6
w	*Poa annua* L.			1	5	3	17	2	18	1	10			7	6
s	*Corchorus olitorius* L.	1	3	1	5					1	10	2	13	5	4
w	*Ammi majus* L.					2	11	1	9	1	10	1	7	5	4
w	*Vicia sativa* L.	1	3			2	11	1	9			1	7	5	4
	IV- Species present in 3 crops														
dp	*Stipagrostis plumosa* (L.) Munro ex T.Anderson	8	22							6	60	3	20	17	15
dp	*Ochradenus baccatus* Delile	9	24							3	30	3	20	15	13
da	*Neurada procumbens* L.	6	16							1	10	2	13	9	8
ms	*Polygonum bellardii* All.					4	22			1	10	3	20	8	7
w	*Beta vulgaris* L.					4	22	3	27	1	10			8	7
w	*Melilotus messanensis* (L.) All.					4	22	1	9			2	13	7	6
w	*Pseudognaphalium luteoalbum* (L.) Hilliard & B.L.Burtt					2	11	2	18	3	30			7	6
ms	*Pennisetum divisum* (Forssk. ex J.F.Gmel.) Henrard	3	8	1	5					1	10			5	4
w	*Raphanus sativus* L.					2	11	2	18	1	10			5	4
w	*Sisymbrium irio* L.	1	3	2	9	2	11							5	4
ms	*Cyperus laevigatus* L.	1	3	1	5	2	11							4	4
dp	*Iphiona mucronata* (Forssk.) Asch. & Schweinf.	2	5	1	5							1	7	4	4

Appendix 2. (continued).

da	*Cleome amblyocarpa* Barratte & Murb.	2	5	1	5					1	10			4	4
dp	*Stachys aegyptiaca* Pers.	2	5	1	5							1	7	4	4
w	*Lathyrus sativus* L.					2	11	1	9	1	10			4	4
w	*Phalaris paradoxa* L.	1	3			1	6	2	18					4	4
a	*Geranium dissectum* L.	1	3							1	10	1	7	3	3
ms	*Paspalidium geminatum* (Forssk.) Stapf					1	6	1	9			1	7	3	3
da	*Schismus barbatus* L.	1	3			1	6					1	7	3	3
s	*Eragrostis pilosa* (L.) P.Beauv.	1	3			1	6					1	7	3	3
	V- Species present in 2 crops														
dp	*Launaea mucronata* (Forssk.) Muschl. subsp. *cassiniana* (Jaub. & Spach) N.Kili	12	32							1	10			13	12
da	*Trichodesma africanum* (L.) R.Br.	5	14							4	40			9	8
w	*Lamium amplexicaule* L.					8	44	1	9					9	8
dp	*Pulicaria undulata* (L.) C.A.Mey. subsp. *undulata*	6	16							2	20			8	7
dp	*Haloxylon salicornicum* (Moq.) Bunge ex Boiss.	4	11							3	30			7	6
t	*Phoenix dactylifera* L.	5	14							2	20			7	6
dp	*Citrullus colocynthis* (L.) Schrad.	5	14							1	10			6	5
ms	*Mentha longifolia* (L.) Huds					5	28	1	9					6	5
da	*Ifloga spicata* (Forssk.) Sch.Bip.	4	11	1	5									5	4
t	*Ricinus communis* L.	3	8									2	13	5	4
w	*Urtica urens* L.			4	18	1	6							5	4
a	*Sorghum bicolor* (L.) Moench subsp. *verticilliforum* (Steud.) de Wet ex Wiersema & J.Dahlb.					3	17	1	9					4	4
a	*Diplachne fusca* (L.) P.Beauv. ex Roem & Schult. subsp. *fusca*	1	3	2	9									3	3
da	*Savignya parviflora* (Delile) Webb	2	5							1	10			3	3
dp	*Heliotropium bacciferum* Forssk.	2	5	1	5									3	3
dp	*Heliotropium digynum* (Forssk.) Asch. ex C.Chr.	2	5									1	7	3	3
dp	*Monsonia nivea* (Decne) Webb	1	3									2	13	3	3
dp	*Polycarpaea repens* (Forssk.) Asch.	1	3									2	13	3	3
T	*Sesbania sesban* (L.) Merr. subsp. *sesban* var. *sesban*	2	5			1	6							3	3
W	*Anchusa humilis* (Desf.) I.M.Johnst.	2	5							1	10			3	3
dp	*Achillea fragrantissima* (Forssk.) Sch. Bip.	1	3							1	10			2	2
dp	*Anabasis setifera* Moq.	1	3							1	10			2	2
dp	*Capparis aegyptia* Lam.					1	6			1	10			2	2
dp	*Deverra tortuosa* (Desf.) DC.	1	3									1	7	2	2
dp	*Farsetia aegyptia* Turra	1	3									1	7	2	2
dp	*Gymnocarpos decandrus* Forssk.	1	3									1	7	2	2
dp	*Pergularia tomentosa* L.	1	3									1	7	2	2
dp	*Pulicaria inuloides* (Poir.) DC.	1	3							1	10			2	2
dp	*Zilla spinosa* L.	1	3							1	10			2	2
dp	*Zygophyllum album* L.	1	3							1	10			2	2

Appendix 2. (continued).

S	*Echinochloa crussgalli* (L.) P.Beauv.			1	5							1	7	2	2
T	*Tamarix tetragyna* Ehrenb.					1	6	1	9					2	2
W	*Medicago polymorpha* L.					1	6					1	7	2	2
W	*Mentha sativa* L.					1	6					1	7	2	2
W	*Plantago major* L.					1	6					1	7	2	2
w	*Rostraria cristata* (L.) Tzvelev	1	3			1	6							2	2
	VI- Species present in 1 crop														
ms	*Atriplex lindleyi* Moq. subsp. *inflata* (F.Muell.) P.G.Wilson	1	3											1	1
dp	*Sporobolus spicatus* (Vahl) Kunth	1	3											1	1
dp	*Cornulaca monacantha* Delile	1	3											1	1
w	*Urochloa reptans* (L.) Stapf.	1	3											1	1
w	*Chenopodium ambrosoides* L.	1	3											1	1
w	*Chloris virgata* Sw.	1	3											1	1
w	*Trigonella hamosa* L.	1	3											1	1
dp	*Suaeda vera* Forssk. ex J.F.Gmel.	2	5											2	2
s	*Euphorbia prostrata* L.	2	5											2	2
dp	*Salsola vermiculata* L. var. villosa (Schult.) Eig	3	8											3	3
dp	*Panicum turgidum* Forssk.	3	8											3	3
w	*Urospermum picroides* (L.) Scop. ex F.W.Schmidt	3	8											3	3
s	*Tribulus terrestris* L.			1	5									1	1
ms	*Cressa cretica* L.			2	9									2	2
w	*Lactuca serriola* L.			2	9									2	2
da	*Bassia muricata* (L.) Asch.			3	14									3	3
w	*Parapholis incurva* (L.) C.E.Hubb.			3	14									3	3
dp	*Seriphidium herba-alba* (Asso) Soják			5	23									5	4
w	*Trigonella stellata* Forssk.			7	32									7	6
a	*Phyla nodiflora* (L.) Greene					1	6							1	1
w	*Bromus catharticus* Vahl					1	6							1	1
w	*Capsella bursa-pastoris* (L.) Medik.					1	6							1	1
w	*Lepidium didymus* L.					1	6							1	1
w	*Lepidium coronopus* (L.) Al-Shebaz					1	6							1	1
w	*Coronopus niloticus* (Delile) Spreng.					2	11							2	2
w	*Silene rubella* L.					2	11							2	2
w	*Trifolium resupinatum* L.					2	11							2	2
w	*Cuscuta pedicellata* Ledeb.					4	22							4	4
w	*Lotus tenuis* Waldst.					4	22							4	4
w	*Rumex dentatus* L. subsp. *dentatus*					5	28							5	4
w	*Eclipta prostrata* (L.) L.							1	9					1	1
w	*Brassica nigra* (L.) W.D.J.Koch.							4	36					4	4
w	*Orobanche ramosa* L. var. *ramosa*									1	10			1	1
dp	*Echinops spinosus* L.											1	7	1	1
w	*Galinsoga parviflora* Cav.											1	7	1	1
	Total number of species	105		66		88		56		73		79			