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Diversity of crop plants in Nile Delta, Egypt

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*T*his study aims to answer the following questions: 1- what are the crop diversity and distribution in Nile Delta and its outskirts?, 2- what are their annual cyclic distribution? and 3- what are the economic goods and environmental services which they offer?. One hundred field trips were conducted to many districts in Nile Delta including Greater Cairo and Alexandria during summer 2012 to spring 2014. One hundred and seventy three crop species belonging to 99 genera and 44 families were recorded. Poaceae was the most represented family, where *Cucumis* was the most represented genus. Herbaceous plants were the most represented, followed by trees and shrubs. The period from March to May was characterized by the highest flowering activity. Most of the species were propagated by seeds (86.9%), followed by cutting (13.2%). Twenty two groups of crops were resulted after the application of TWINSPAN and DCA: 6 groups occurred in only one district, 3 in 2 districts, and another 3 in > 10 districts. Group 10 that included 13 districts had the highest species richness (67.9 species region^{-1}), while G 11 that included 20 districts had the highest species turnover (3.7). Of the 173 crop species recognized in Nile Delta, 82.1 % had at least one potential or actual economic good. Food plants were the most common crops, while grazing plants were the least. In addition, 64.2 % of the crop species had at least one environmental service; cold-tolerant plants were the most represented, while the sand accumulators were the least. This study is the first attempt to evaluate the agro-diversity in Nile Delta and introduces for the scientific community a baseline data for evaluating the agro-biodiversity in Egypt as a whole.

***Key words*:** *Crop plants, agro-diversity, growth form, propagation method*.

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Introduction

Crop plants are defined according to US Department of Agriculture (USDA) as cultivated plants that are grown on a large scale commercially, such as cereals, fruits, vegetables, tree nuts, dried fruits, horticulture and nursery crops.

The Egyptian civilization dates back to the dawn of civilization and remnants exist in a continuous 6000 year-old record (Janik, 2002). Knowledge of crops of ancient Egypt comes from the desiccated remains of plants in Ancient Egyptian Agricultural Museum in Cairo, these include grain crops such as wheat (*Triticum turgidum*); and vegetable crops such as garlic (*Allium sativum*), onion (*Allium cepa*) and radish (*Raphanus sativum*). In addition to legumes such as cowpea (*Vigna sinensis*), chickpea (*Cicer arietinum*) and lentils (*Lens culinaris*); and various cucurbits such as cucumber (*Cucurbita sativa*), melons (*Cucumis melo*) and later watermelon (*Citrullus lanatus*) (Janik, 2002).

Land-use change will have the largest global impact on biodiversity by the year 2100 (Sala *et al*., 2000; Buckley & Roughgarden 2004). Biodiversity loss in agricultural landscapes affect not only the production of food, fuel and fiber, but also the ecological services supporting clean water supplies, habitat for wild species and human health (Jackson *et al*., 2005). Biological diversity has a vital importance for the health and wellbeing of all life (Heneidy & Marzouk, 2008). According to the Strategy of Botanic Gardens Conservation International (BGCI), there is an urgent need to identify the sectors of the greatest agro-biodiversity, especially that which is endangered (Heneidy & Marzouk, 2008).

Few studies were focused on the survey of crops in Egypt as a whole, and Nile Delta in particular. Clot Bey (1840), published the oldest and most important contribution "*Aperçu Général sur l'Egypte*" which enumerated the cultivated plants that grown at the time of both Mohamed Ali and Ibrahim Pasha. In another early study, Figari (1865) classified the cultivated plants in Egypt and Arabian Peninsula into six main groups: cereals, fodders, vegetables and salads, economic trees and ornamentals (Hamdy *et al*., 2007). Commercially Afifi *et al*. (1999) classified the crop plants into nine groups: sugar crops, cereals, fodder crops, fiber crops, oil crops, medicinal and aromatic crops, legumes, fruits and vegetables.

This study aims to determine the diversity of crop and their distribution in Nile Delta and its outskirts, to assess their annual cyclic distributions and

to evaluate the economic goods and environmental services which they offer.

Study area:

Nile Delta is a classic delta with a triangular shape; its length from south to north is 170 km, and its northern width from west to east is 220 km. The area of this region (about 22000 km^2) comprises about 63% of Egypt's productive land (Abu Al-Izz, 1971). Its agro-ecosystem is one of the most important successful in the world (Shaltout *et. al.*, 2010), Administratively, Nile Delta includes eight governorates: Menufia, Gharbia, Qalyubia, Dekahlia, Sharqiyah, Beheria, Kafr El-Sheikh and Damietta (**Fig. 1**). The ancient distributaries of River Nile disappeared due to intensive irrigation and constructions in the onshore Delta plain, and were eventually reduced to the two branches (Damietta at the east and Rosetta at the west). The construction of the Aswan High Dam in 1962 produced significant reduction of outflow and concurrent sedimentary load, resulting in severe erosion of the Delta shore with its consequent retreat of several meters per year (El-Sheikh, 1996).

Nile Delta is predominantly agricultural; half of its occupants are farmers who depend upon the waters of the Nile to irrigate their crops. Average farm size is about 8,000 square meters. Cultivated lands in Nile Delta are irrigated by River Nile through a net of irrigation canals and drained by a similar one of drainage canals (Al-Sodany, 1998). Most of these watercourses were dug in the last 200 years, but have been subjected to many alterations (Shaltout & El-Sheikh, 1993). In the north Nile Delta, drains have been constructed to minimize water logging and salinity hazards and hence the cultivation of some salt tolerant crops such as sugar beet and rice is abundant. This has contributed significantly to the restoration of the fertility of these saline lands (Shaltout *et al*., 1995).

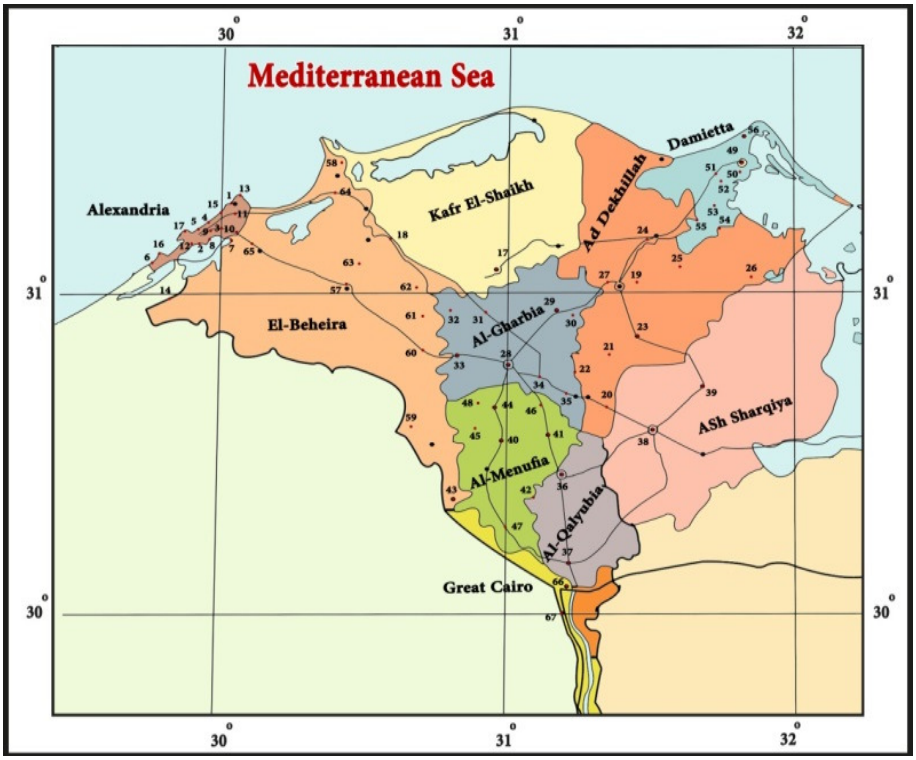


Fig. 1. Map showing the distribution of the 98 districts in the eight governorates of Nile Delta, in addition to Cairo and Alexandria, represented by numbers.

Soil of Nile Delta was mostly heavy in texture and rather compact at the surface, the human status of the soils is well. Thus, all soils with exception of the northern part were human-made and regarded as anthropic variants of the Gleysols and Fluvisols (El-Gabaly *et al.*, 1969a). The process of land growing in this Delta was rather peculiar and was related to the corresponding process of the northern coastal region. In the eastern and western parts of the Delta, where the deposits are not so heavy and sand bars are numerous, the desalinization of salt marshes leads to the Salic Gleysols and then Humic Gleysols. Conversely, in the Middle Delta, the soil is composed of very fine textured materials; Olonetzs form a stage of dissalinization after Solanchacks stage. Marshy Solanchacks, Humic Solanchacks and Humic Solonetzs, represent a typical soil association of the Northern Delta (El-Gabaly *et al.*, 1969b).

Climatologically, the northern part of Nile Delta belonged to the arid region, while the southern part belonged to the hyperarid region. Minimum air temperature ranged between 5.9 ^{o}C and 11.2, while maximum air temperature ranged between 29.7 ^{o}C and 35.4 ^{o}C. The relative humidity varied between 42% and 76%, but evaporation varied between 2.0 mm day^{-1}, and 17 mm day^{-1}. Annual rainfall ranged between 193.3 mm year^{-1} in the North and 23.9 mm year^{-1} in the South (Anonymous 1980).

Material and methods:

1. Data collection

One hundred field trips were conducted to 98 districts in Nile Delta including Greater Cairo and Alexandria during summer 2012 to spring 2014 (Fig. 1). In each district, specimens of the present crop species were collected from different sites. Floristic records were carried out based on the presence / absence of species, taking into consideration the flowering time of each species. Species were identified according to Diwan *et al*. (2004), Heneidy (2010) and Kew Garden plantlist website (http://www.theplantlist.org) and revised in Agricultural Museum Herbarium (CAIM). The herbarium sheets of the collected species were deposited in Tanta University Herbarium (TANE).

Six growth forms were identified according to Diwan *et al*. (2004): trees-shrubs, climbers-creepers, cacti-succulents, herbaceous plants, aquatic-semi aquatic plants, palms-palm likes. The propagation methods of the recorded species were gathered from the following studies: Bedevian (1935), Osman (1939), Abu Dahab *et al*. (1980), Graham & Toogood (2001), Bradley (2002), Bryant (2006), Kumar *et al*., (2010), Kumar (2011) and website (http://www.mastergardenproducts.com). Eleven propagation methods were recorded: seeds, air layering, division (offsets and stolons), separation (bulbils, corms and suckers), cutting, rhizomes, grafting, budding and tissue culture (**Table 1**). The global distribution of the crop plants (i.e., floristic regions) was assessed according to the Good system (1974), which divided the globe into six kingdoms, three subkingdoms and thirty-nine floristic regions.

Table 1. Asexual propagation methods which identified in crop species in Nile Delta (Kumar *et al*., 2010 and Kumar, 2011).

Propagation method	Definition
1- Air Layering	Used to propagate some indoor plants with thick stems, or to rejuvenate them when they become leggy. Slit the stem just below a node. Pry the slit open with a toothpick. Surround the wound with wet unmilled sphagnum moss. Wrap plastic or foil around the sphagnum moss and tie in place. When roots pervade the moss, cut the plant off below the root ball.
2- Division	Considered a modification of layering, as the new plants form before they are detached from their parent plants. Division Plants with more than one rooted crown may be divided and the crowns planted separately. If the stems are not joined, gently pull the plants apart. If the crowns are united by horizontal stems, cut the stems and roots with a sharp knife to minimize injury. Divisions of some outdoor plants should be dusted with a fungicide before they are replanted.
2.1. Offsets	The term "offset" refers to plant structures that develop by the side of mother plants or Plants with a rosetted stem often reproduce by forming new shoots at their base or in leaf axils. Sever the new shoots from the parent plant after they have developed their own root system. Unrooted offsets of some species may be removed and placed in a rooting medium.
2.2. Stolon	Is a horizontal, often fleshy stem that can root, then produce new shoots where it touches the medium. Plants that produce stolons are propagated by severing the new plants from their parent stems.
3- **Separation**	Separation is a term applied to a form of propagation by which plants that produce bulbs or corms multiply.
3.1. Bulbs	New bulbs form beside the originally planted bulb. Separate these bulb clumps every 3 to 5 years for largest blooms and to increase bulb population. Dig up the clump after the leaves have withered. Gently pull the bulbs apart and replant them immediately so their roots can begin to develop. Small, new bulbs may not flower for 2 or 3 years, but large ones should bloom the first year.
3.2. Bulbils	Plants produce tiny aerial bulbs called bulbils at leaves joining the stem (leaf axils). Bulbils can be used to produce new plants after separating and planting. They take two or three years to reach flowering size.
3.3. Corms	A large new corm forms on top of the old corm, and tiny cormels form around the large corm. After the leaves wither, dig up the corms and allow them to dry in indirect light for 2 or 3 weeks. Remove the cormels, then gently separate the new corm from the old corm. Dust all new corms with a fungicide and store in a cool place until planting time.
3.4. Suckers	Plants produce adventitious shoots known as suckers that originate from roots. Propagate suckers by digging, separating from the mother plant, and growing as individual plants.
4- Cutting	A vegetative plant part which is severed from the parent plant in order to regenerate itself, thereby forming a whole new plant.
5- Rhizome	Is the union of one bud and a small piece of bark from the scion with a rootstock. It is especially useful when scion material is limited. It is also faster and forms a stronger union than grafting.
6- Grafting	Is accomplished by inserting a piece of stem containing 3 to 4 vegetative buds onto the stem of the plant that will serve as the root system for the unified plant.

Goods and services are the potential and actual economic environmental benefits of the recorded species that assessed on three bases; field observations, information collected from local inhabitants and herbalists, and literature review (e.g. Bedevian, 1935, Osman, 1939, Abu Dahab *et al.,* 1980 and Simpson & Ogorzaly, 1995). Economic goods were classified into six major categories: decoration, medicine, food, timber, grazing and others (e.g. industry, fuel, paintings and timber). In addition, the environmental services were classified into 10 categories: shade source, drought tolerant, salinity tolerant, wind breaker, humidity tolerant, sand accumulator, resistant against insects and pests, cold and heat tolerant plants and nitrogen fixers.

2. Data analysis

TWINSPAN classification and DCA ordination (Hill, 1979a, b) were applied to the crop composition of the 98 districts in the study area. Species richness (alpha-diversity) for each group of districts was calculated as the average number of species per district, while the species turnover (beta-diversity) was calculated as the total number of species in each group divided by its species richness (Magurran, 1988).

Results and discussion:

One hundred and seventy three crop species belonged to 99 genera and 44 families were recorded in the study area. Poaceae (Gramineae) had the highest contribution (22 species = 12.7 % of the total species), followed by Fabaceae (Leguminosae) (21 species = 12.1 %), Cucurbitaceae (20 = 11.6 %), Apiaceae (Umbelliferae) and Rosaceae (each of 12 = 6.9%). On the other hand, the genus *Cucumis* had the highest contribution (8 species = 4.6 % of the total species), followed by *Citrus* and *Brassica* (each of 7 species = 4.0 %), and *Hordeum*, *Sorghum* and *Allium* (each of 6 species = 3.5 %) (**Fig. 2**). According to Box (1987), the term growth form is generally understood to refer to basic structural forms of whole organisms (e.g., trees, shrubs, aquatic, semi aquatic, palms, palm-like, cacti-succulents and graminoids), without reference to supposed environmental relationships. In the present study, the most represented growth form was the herbaceous plants (101 species = 71.1%), followed by trees-shrub (34 species = 23.9%) (**Fig.3**).

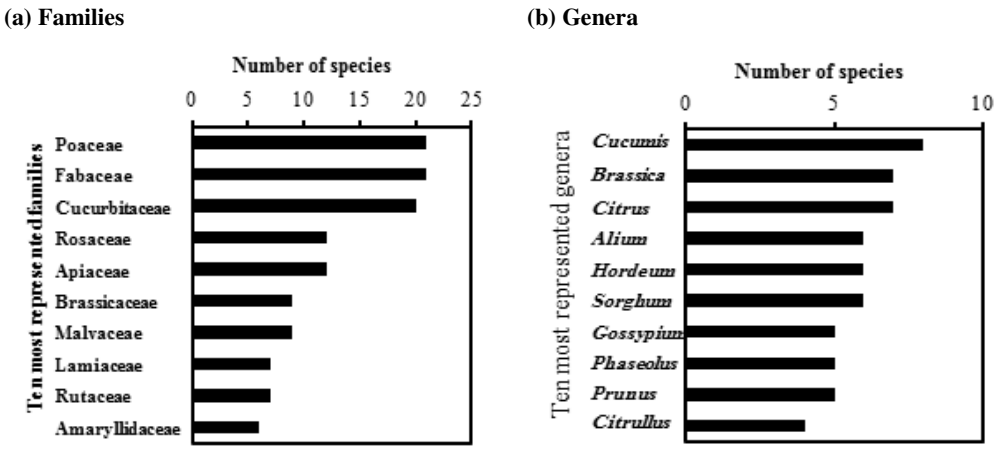


Fig. 2. The ten most represented families (a) and genera (b) of the recorded crop species in Nile Delta.

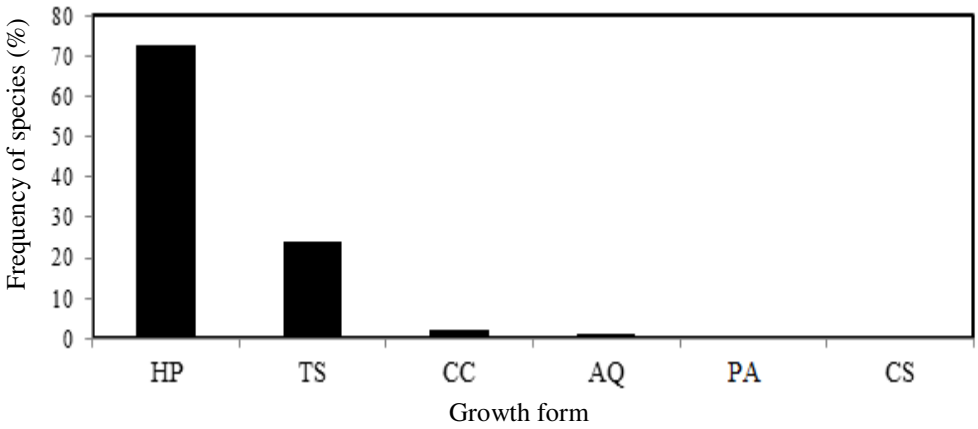


Fig. 3. Growth form of the recorded crop species in Nile Delta. HP: herbaceous plants, TS: trees-shrubs, CC: climbers-creepers, AQ: aquatic-semi aquatic plants, PA: palms-palm likes and CS: cacti-succulents.

In the Nile Delta, there is a gradual increase in the frequency of flowering time fromMarch to May, while the period from June to November is characterized by the lowest (Shaltout *et al*., 2010). In the present study, there is a gradual increase in the frequency of the flowered species from 24.8 % in December until reaching the maximum percentage 44.6 % in May (**Fig. 4**). This could be interpreted in the view that most species are growing in winter

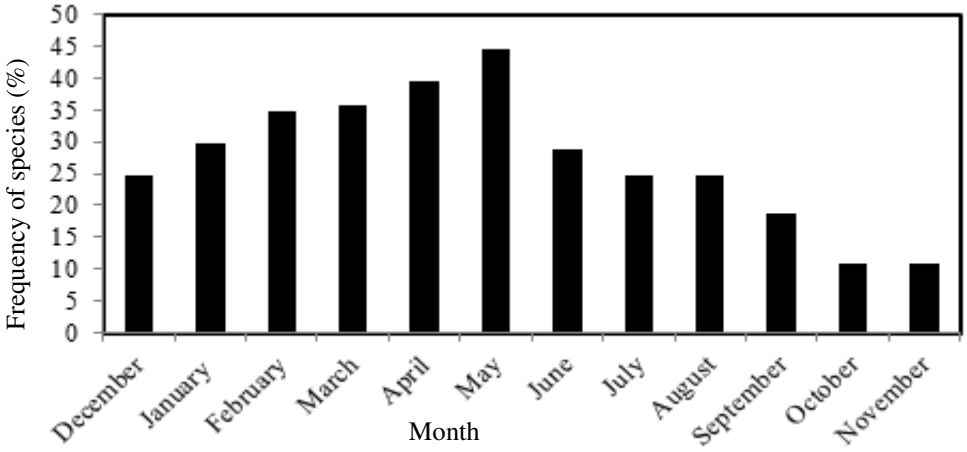


Fig. 4. Frequency of the recorded crop species in Nile Delta in relation to their time of flowering.

(68 %), followed by the summer (18 %) (Fig. 5). The plants start their growth activity reaching the flowering and fruiting stage during March to May (Bedevian, 1935; Abu Dahab *et al.*, 1980).

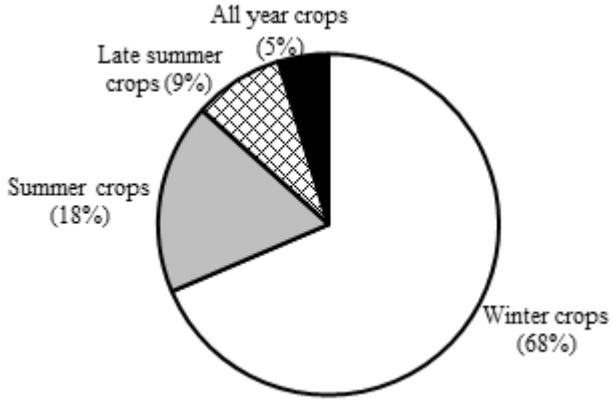


Fig. 5. Frequency of the crop species in relation to their annual duration.

Most flowering plants are propagated sexually by seeds; while some crops are propagated by at least one asexual method, in addition to seeds (Said 1994). The major methods of asexual propagation were cuttings, layering, division, and budding or grafting. In the present study, the species propagated by seeds 86.3 % of the total species (e.g. *Anethum graveolens* L. and *Phaseolus vulgaris* L.), followed by cutting (14.5 % as in *Strelitzia reginae* Aiton and *Eriobotrya japonica* (Thunb.) Lindl.), offsets (8.9 % as *Allium cepa* L. and *Musa x paradisiaca* L.), rhizomes and grafting (each of 5 %; of rhizomes are *Cymbopogon citratus* (DC. ex Nees) Stapf. and *Zingiber officinalis* Roscoe. and for grafting are *Annona cherimola* Mill. and *Pyrus malus* L.), bulbs and suckers (each of 4.8 %; of bulbs are *Allium cepa* L. and *Allium ampeloprasum* var. *kurrat* Schweinf. ex Krause and for suckers are *Fragaria chilensis* var. *tincta* Duchesne ex Ser. and *Musa x paradisiaca* L.), bulbils (3.2 % as *Allium sativum* L. and *Allium schoenoprasum* L.), air-layering and corms (each of 2.4 %; of air-layering are *Ficus carica* L., *Jasminum grandiflorum* L. and *Olea europea* L. and for corms are *Colocasia esculenta* (L.) Schott. *Convolvulus batatas* L. and *Gladiolus grandavensis* Van Houtte.) and stolon (1.6 % *Mentha longifolia* (L.) Huds. and *Mentha incana* Willd) (**Fig. 6**).

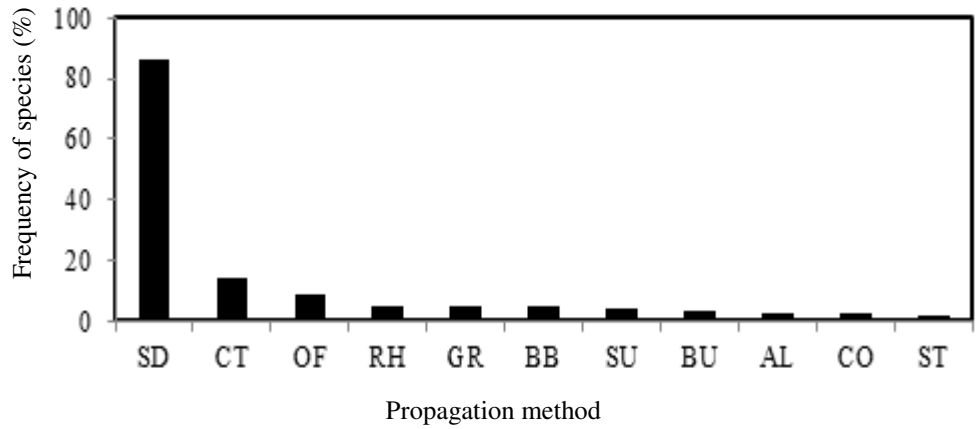


Fig. 6. Frequency of the recorded crop species in Nile Delta in relation to their propagation method. SD: seeds, CT: cutting, OF: offsets, RH: rhizomes, GR: grafting, BB: bulbs, SU: suckers, BU: bulbils, Al: air-layering, CO: corms, and ST: stolons.

The chorological analysis indicated the predominance of the taxa of Boreal Kingdom (59.5 % of the total species), followed by those of Palaeotropical Kingdom (53.4 %) and Neotropical Kingdom (17.6 %) (**Fig. 7**). This means that most of these crops were originated from the old world (Africa, Asia and Europe), while less number belong to the Australian Kingdom (Le Floch *et al*., 1990). The species belonged to one kingdom were represented by 65.6 % of the total species, followed by those of 2 and 3 kingdoms (27.5 % and 2.3 %, respectively).

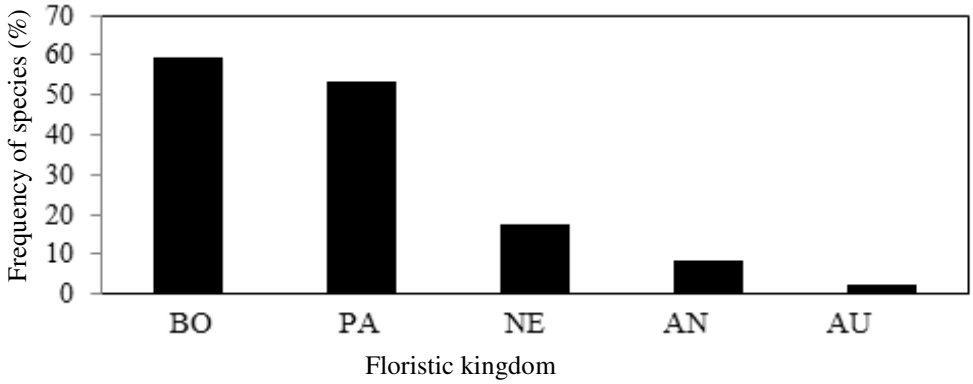
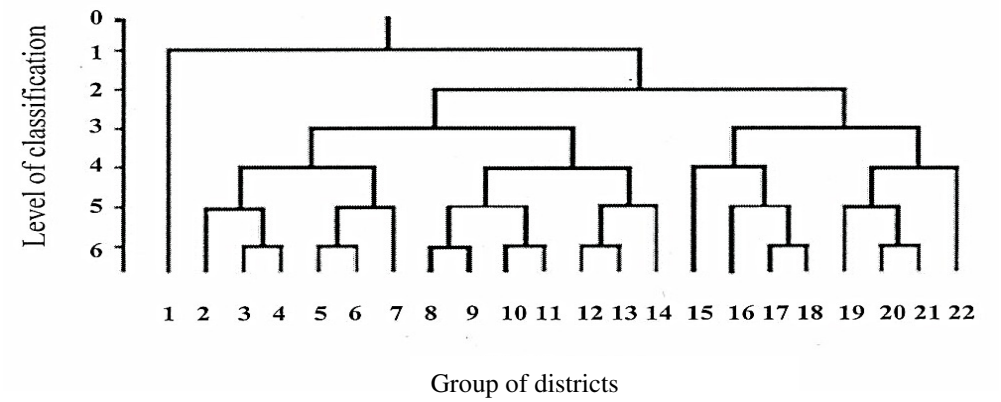


Fig. 7. Descending arrangement of the floristic kingdoms of the recorded crops. BO: Boreal Kingdom, PA: Palaeotropical Kingdom, NE: Neotropical Kingdom, AN: Antarctic Kingdom and AU: Australian Kingdom.

The application of TWINSPAN on the matrix of 173 species versus 98 districts resulted in 22 groups at the level six. These groups were segregated along the ordination plane of the second and third axes of DCA (**Fig. 8**). Six groups include only one district (Scattered fields, Police Agricultural Management in Cairo, Mahmoudia in Beheria, Bilbas, Salheyia and Abu Kebeer in Sharqiyah) and 3 in two districts (Rahamnah and Hagagah in Damietta, Shohada and Ashmun in Menufia and Abu Hamadan and Fakoos in Sharqiyah), and another 3 groups in > 10 districts (**Table 2**). Group 10 (G10) that included 13 districts had the highest species richness (67.9 species district^{-1}), while G3 that included two districts had the lowest (12.5 species district^{-1}). On the other hand, G11 that included 20 districts had the highest species turnover (3.7).

a- Twinspan classification



b – DCA ordination

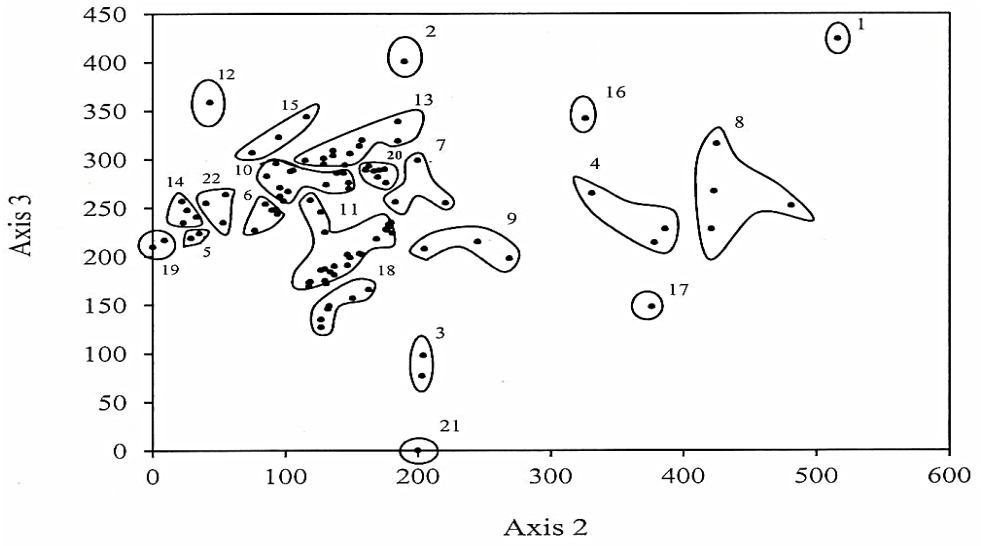


Fig. 8. TWNISPAN classification (a) and DECORANA ordination (b) of the 98 district of crops in the Nile Delta based on their crop composition. The districts that support each of the 22 groups are encircled together (1-22).

Table 2. Characteristics of the 22 district groups of the recorded crop species in Nile Delta. Ac: actual number of species and Re: relative number of species. The maximum and minimum values are underlined

Group number	No. of district	Total species		Species richness	Species turnover	Winter crops	Summer crops	All year crops
		Ac	Re					
1	1	22	12.7	22.0	1.0	*Triticum turgidum* L.	-	*Citrus reticulata* × *sinensis*
2	1	14	08.1	14.0	1.0	-	-	*Citrus sinensis* (L.) Osbeck
3	2	13	07.5	12.5	1.0	-	-	*Psidium guajava* L.
4	3	17	09.8	21.5	0.8	-	-	*Punica granatum* L.
5	2	33	19.1	28.5	1.2	*Triticum aestivum* L.	*Zea mays* L.	*Vitis vinifera* L.
6	5	30	17.3	43.2	0.7	*Triticum aestivum* L.	*Zea mays* L.	*Citrus sinensis* (L.) Osbeck
7	3	44	25.4	26.0	1.7	*Sorghum saccharatum* (L.) Moench	*Saccharum officinarum* L.	*Mangifera indica* L.
8	4	24	13.9	20.0	1.2	*Triticum aestivum* L.	*Gossypium herbaceum* L.	*Citrus sinensis* (L.) Osbeck
9	3	37	21.4	24.7	1.5	*Triticum aestivum* L.	*Solanum lycopersicum* L.	*Citrus reticulata* Blanco
10	13	71	41.0	67.9	1.0	*Triticum aestivum* L.	*Oryza sativa* L.	*Phoenix dactylifera* L.
11	20	88	50.9	24.0	3.7	*Triticum aestivum* L.	*Gossypium herbaceum* L.	*Citrus sinensis* (L.) Osbeck
12	1	65	37.6	65.0	1.0	*Vicia faba* L.	*Cucurbita moschata* Duchesne ex Poir.	*Prunus persica* (L.) Botsch.
13	11	88	50.9	38.1	2.3	*Triticum aestivum* L.	*Zea mays* L.	*Psidium guajava* L.
14	3	53	30.6	34.3	1.5	*Brassica oleracea* var. *captata* L.	*Gossypium herbaceum* L.	*Mangifera indica* L.
15	4	53	30.6	30.0	1.8	*Brassica oleracea* var. *captata* L.	*Zea mays* L.	*Mangifera indica* L.
16	1	51	29.5	51.0	1.0	*Triticum aestivum* L.	*Zea mays* L.	*Prunus domastica* L.
17	1	43	24.9	43.0	1.0	*Spinacia oleracea* L.	*Zea mays* L.	*Citrus x paradisi* Macfad.
18	6	49	28.4	35.7	1.4	*Triticum aestivum* L.	*Gossypium herbaceum* L.	*Phoenix dactylifera* L.
19	2	41	23.7	35.0	1.2	*Capsicum frutescens* L.	*Cucurbita pepo* L.	*Citrus sinensis* (L.) Osbeck
20	8	41	23.7	32.1	1.3	*Phaseolus vulgaris* L.	*Gossypium herbaceum* L.	*Citrus sinensis* (L.) Osbeck
21	1	35	20.2	35.0	1.0	*Spinacia oleracea* L.	*Saccharum officinarum* L.	*Citrus x paradisi* Macfad.
22	3	80	46.2	50.0	1.6	*Triticum aestivum* L.	*Zea mays* L.	*Musa paradisiaca* L. var. *sapientum*
Total	98	173		39.6	2.5			

In the present study, 142 crop species had at least one aspect of the potential or actual economic use. Goods were arranged descendingly as follows: food (110 species = 77. 5 % of the total species), decoration (54 species = 38 %), medicinal (49 species =34.5 %), other uses (e.g. oil industries, paintings and timber: 44 species = 31. 6 %) and grazing (4 species = 2.8 %) (**Fig. 9**). Fifty-one species had only one use, 54 species had two uses, 23 had three uses and 14 had four uses. Because different kinds of plants were available in different parts of the world, various peoples built up their own inventories of useful plants. It has been estimated that about 3000 species of plants have been used as human food throughout history and that about 200 have been domesticated as food crops (Simpson & Ogorzaly, 1995). In addition to the most common food crops (*Oryza sativa* L., *Triticum aestivum* L., *Phaseolus vulgaris*, *Pisum sativum* L., *Vicia faba* L. and *Zea mays* L.), fresh leaves and young shoots of *Malva parviflora* L.(Khubbayza) are cooked as vegetable dish, fresh leaves and stems of *Beta vulgaris* L. (Salq) are eaten cooked as stew or as a soup mixed with lentil, and the soft fresh pods of *Vicia sativa* L. (Beselet eblees) are also eaten raw (Al-Eiswi & Takruri 1989). Certain fruit trees especially as ornamental decorative plants in Nile Delta, such as *Morus alba* L., *Vitis vinifera* L. and *Citrus aurantium* L., *Dianthus sinensis* L. and *Rosa pendulina* L. var. *hybrid tea roses* are used for the ornamental purposes (Soliman & Amer, 2002 and Heneidy, 2010).

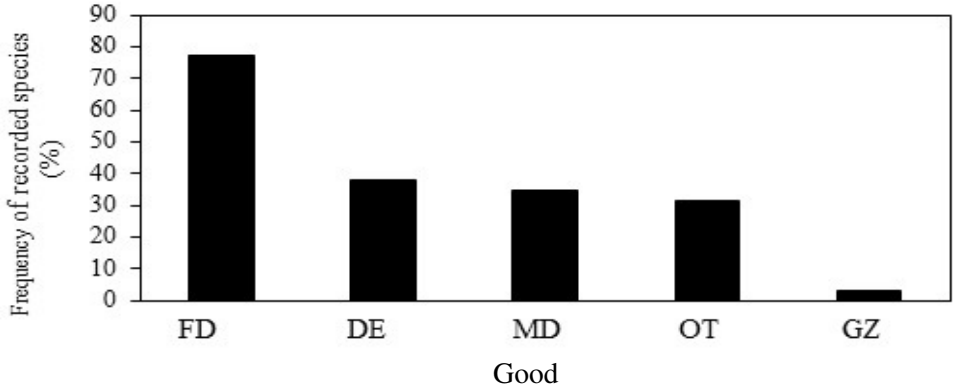


Fig. 9. Descending arrangement of the goods that offered by the recorded crop plants in Nile Delta. FD: food, DE: decoration, MD: medicine, OT: other uses (e.g. Oil industries, paintings and timber) and GZ: grazing.

Medicinal crops such as lemon grass *Cymbopogon citratus* (DC. Ex Nees) Stapf. give aromatic strong smell used in folk medicine, while lime *Citrus aurantifolia* (Christm.) Swingle is used as a source of volatile oils (limonene and linalool). In addition, citric acid gives testy for food and is medicinal purposes in folk medicine (Heneidy, 2010). In many traditional systems of medicine, *Zingiber officinale* Roscoe had been used since centuries for its versatile medicinal actions like antiemetic, stomachic, expectorant, anti-inflammatory, and aphrodisiac. It is also useful for the treatment of various gastrointestinal, pulmonary, cardiovascular and sexual disorders (Imtiyaz *et al*. 2013). Fourteen species could be considered as multipurpose species that have many uses (**Table 3**).

Table 3. Multipurpose crop plants which have 4 goods (human food, decoration, medicine and other uses such as oil industries, paintings and timber.

Latin name	English name	Arabic name
Caricaceae		
Carica papaya L.	Papaya	باباظ
Rutaceae		
Citrus aurantifolia (Christm.) Swingle	Key lime	ليمون
Citrus reticulata Blanco	Mandarin orange	يوسفى
Poaceae		
Cymbopogon citratus (DC. Ex Nees) Stapf.	Lemon grass	حشيشة الليمون
Myrtaceae		
Eugenia jambolana Lam.	Black plam	بامبوزيا
Fabaceae		
Glycine max (L.) Merr.	Soya bean	فول صويا
Malvaceae		
Gossypium herbaceum L.	Cotton	قطن
Lamiaceae		
Mentha piperita L.	Peppermint	نعناع سعودى
Ocimum basilicum L.	Common basil	ريحان
Origanum majorana L.	Origanum	بردقوش
Rosmarinus officinalis L.	Common Rosemary	حصا لبان
Moraceae		
Morus alba L.	White mulberry	توت
Rosaceae		
Rosa pendulina L. var. *hybrid tea roses*	Rosa	ورد بلدى
Vitaceae		
Vitis vinifera L.	Grape vine	عنب

One hundred and eleven crop species had at least one aspect of the potential or actual environmental uses. The environmental services were arranged descendingly as follow: cold tolerant (76 species = 68.5 % of the total species), humidity tolerant (75 = 68 %), shade source (33 = 30 %), drought tolerant (28 = 25 %), heat tolerant (21 = 20 %), nitrogen fixers (17 = 15 %), resistant against insects and pests (10 = 9 %), salinity tolerant (6 = 5 %), wind break (2 = 2 %) and sand accumulator (1 = 0.9 %) (**Fig 10**). Thirteen species had one environmental service (12 %), 53 species had two environmental service, (48 %), 39 species had three (35 %), five had four (5%) and one species had five services (0.9%). Olive *Olea europaea* L. can avoid freezing damage by preventing extracellular ice formation below the equilibrium freezing temperature (Arias *et al*., 2015). An important characteristic of most Fabaceae members is their propensity to form root associations with various bacteria (e.g. *Rhizobium* spp.). Plants with nodulating bacteria have overcome the problem of obtaining usable nitrogen through converting the atmospheric nitrogen into ammonia (Simpson & Ogorzaly, 1995).

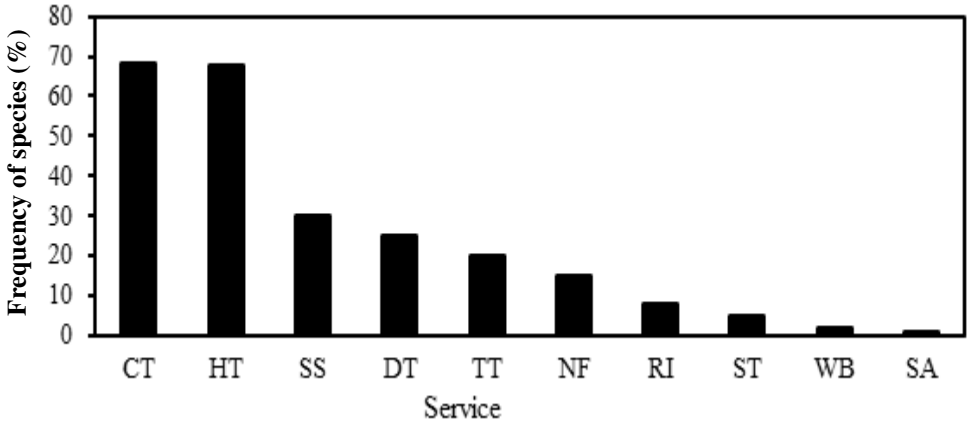


Fig. 10. Descending arrangement of the environmental services that offered by the recorded crop species in Nile Delta. CT: cold tolerant, HT: humidity tolerant, SS: shade source, DT: drought tolerant, TT: heat tolerant, NF: nitrogen fixers, RI: resistant against insects and pests, ST: salinity tolerant, WB: Wind break and SA: sand accumulator.

In the present study, ten species were resistant to insects and pests (e.g. *Brassica chinensis* L., *Brassica juncea* (L.) Vassiliĭ Matveievitch Czernajew, *Brassica oleracea* var. *botryti*s L., *Brassica oleracea* var. *captata* L., *Brassica napus* L., *Brassica nigra* L., *Brassica rapa* L., *Eruca sativa* Mill., *Raphanus sativus* L. and *Ricinus communis* L.). The food crops of Brassicaceae, including quantities of mustard oils which are toxic to insects and other pests (Simpson & Ogorzaly, 1995). Sand controllers, such as sand accumulation and windbreak, are the species which deal effectively with drift sand (Simpson, 1932). Sand controllers that make efficient windbreaks include *Ricinus communis* and *Phoenix dactylifera* (Shaltout & Ahmed, 2012).

In winter, the most important common crops species in Nile Delta were *Triticum aestivum* L., *Trifolium alexandrinum* L. and *Pisum sativum* L., while in summer were *Oryza sativa* L., *Zea mays* L. and *Solanum lycopersicum* L. (**Table 4**). The common all year crops orchards were *Psidium guajava* L., *Fragaria chilensis* var. *tincta* Duchesne ex Ser. and *Pyrus malus* L. *Triticum aestivum* is grown in extensive areas compared with any other food crop, as it is one of the most important sources of calories and protein for humans in many parts of the world (A Global Agricultural Research Partnership Website, (http://www.cgiar.org) and Singh *et al*. (2015). In conclusion, this study is the first attempt to evaluate the agro-biodiversity in Nile Delta, and it introduces for the scientific community a baseline data for evaluating the agro-biodiversity in Egypt as a whole. The authors recommend carrying out further studies on the gardens flora in order to fill the gaps in our agricultural biodiversity.

Table 4. Common crop species in Nile Delta in relation to their duration in Nile Delta.

Latin name	**Family**	**Arabic name**	**English name**
Winter crops			
Triticum aestivum L.	Poaceae	قمح	Wheat
Trifolium alexandrinum L.	Fabaceae	برسيم	Egyptian clover
Pisum sativum L.	Fabaceae	بسلة	Green Pea
Brassica oleracea L. *var. captata*	Brassicaceae	كرنب	Cabbage
Daucus carota L. *var. sativa*	Apiaceae	جزر	Carrot
Hordeum vulgare L.	Poaceae	شعير	Barley
Vicia faba L.	Fabaceae	فول	Horse bean
Beta vulgaris L. *var. rapa*	Chenopodiaceae	بنجرالسكر	Sugar beet
Spinacia oleracea L.	Chenopodiaceae	سبانخ	Spinach
Phaseolus vulgaris L.	Fabaceae	فاصوليا	Tepary bean

Table 4. Cont. 1

Latin name	Family	Arabic name	English name
Summer and late summer crops			
Zea mays L.	Poaceae	ذرة شامية	Maize
Oryza sativa L.	Poaceae	أرز	Rice
Gossypium vitifolium	Malvaceae	قطن	Cotton
Cucumis sativus L.	Cucurbitaceae	خيار	Cucumber
Solanum lycopersicum L.	Solanaceae	طماطم	Tomato
Solanum tuberosum L.	Solanaceae	بطاطس	Potato
Cucumis sativus L.	Cucurbitaceae	خيار	Cucumber
Cucurbita pepo L.	Cucurbitaceae	كوسة	Squash
Cucurbita citrullus L.	Cucurbitaceae	بطيخ	Watermelon
Cucumis melo L. *var. flexuosus*	Cucurbitaceae	قثاء	Armenian
All the year			
Psidium guajava L.	Myrtaceae	جوافة	Guava tree
Fragaria chilensis var. tincta Duchesne	Rosaceae	فراولة	Strawberry
Pyrus malus L.	Rosaceae	تفاح	Apple
Morus alba L.	Moraceae	توت	White mulberry
Citrus sinensis (L.) Osbeck.	Rutaceae	برتقال	Sweet orange
Citrus aurantium L.	Rutaceae	نارنج	Bitter orange
Punica granatum L.	Punicaceae	رمان	Pomegranate
Musa paradisiaca L. *var. sapientum*	Musaceae	موز بلدى	Banana
Phoenix dactylifera	Arecaceae	بلح	Date
Prunus persica (L.) Botsch.	Rosaceae	خوخ	Peach

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