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Original article

Cereal weeds variation in middle Egypt: Role of crop family in weed composition

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ABSTRACT

Cereals occupies a major part in the diet of humans globally, participating more to our daily protein and calorie intake than any other crop. The present study highlight the weed flora of cereal crops compared to other crops in middle Egypt and their distribution. Ninety-two weed species were recorded in the all studied crops, cereal and other crops; in the studied area belong to 67 genera and 20 families. Egyptian clover; showed the highest numbers of both weed species and genera followed by wheat, on contrast the lowest weed species and genera numbers were recorded associated with Solanaceous crops tomato and pepper. Wheat crops exhibited the highest number of weed species, among cereals, followed by maize crop, while the lowest weed species number was detected in barley crop. *Chenopodium murale*, *Cynodon dactylon, Convolvulus arvensis* and *Malva parviflora* were the most frequent species in winter cereals, while *Echinochloa colona*, *P. oleraceae* were the most frequent weeds in summer cereals. Chorological analysis of the recorded weed species showed that cosmopolitan elements showed the highest numbers in total weed flora Differences in weed species compositions were fundamentally influenced by seasonal priority. Based on TWINSPAN and Ward classifications, crop family showed slightly effect as a factor affecting weed composition.

1. Introduction

Weeds are defined as any plant that is objectionable or interferes with human activities (Vencill, 2002); they represent a major barrier for farmers in respect of the harvest losses. Weeds characterized by the high seed production, leading to high population numbers, rapid germination, early growth, long duration and life cycle, (Baker, 1974). It is, therefore, consider a strong competitor for crops for soil nutrients, soil moisture, light, carbon dioxide and able to compete quite well with crops in the less stressful field. Egyptian weeds were classified into three groups, winter, summer and all-year weeds (El hadidi et al., 1996). El Hadidi and Fayed (1994/1995) recorded 470 species constitute the weed assemblages in Egypt since two decades ago and stated that Egyptian farmlands have weed composition, somewhat limited for every crop. The level of competition can be diminished to some extent by specific crop cultural practices based on our awareness of weed ecology and biology. These methods include planting times, spacing, and herbicide placement. Previously it was recorded that cover crops perform a potentially significant biological management filter in order to compete with weeds for space, light, water and nutrients (Smith and Gross, 2007). Thus cover crops have the possibility to reduce the abundance of weed species (i.e., filter) that are competitively inferior. In fact, Cover crops are used to suppress weeds to avoid the disadvantage of herbicide use (Monaco et al., 2002; Snapp et al., 2005). Furthermore, according to the chemical characteristics of plant taxonomy and allelopathy theory, it will be needful to understand if specific cover-crop families differentially filter weeds through weed composition. This filtering could be viewed as directional if various cover-crop families result in weed communities with expected different weed species composition. Egypt is one of the oldest agricultural countries in the world, although its agricultural land accounts for only 4 percent of the total area and the rest of the country is desert (Al Sherif et al., 2018). Wheat, sorghum and barley were the most significant

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crops cultivated by the ancient Egyptian farmers since pre-historic time. Breasted (1905) recorded that wild wheat found in old Egypt and the Nile Valley were the origin of the wheat cultivated in many agricultural areas in the world. Because the study of weed composition can provide an objective basis for the development of environmentally and economically sustainable strategies for the management of these weeds (Navas, 1991). The current study differs from previous studies as it focuses on ten important major crops, of which five cereals. As well as knowing whether the crop families had an effect on weeds. The present study aims to identify cereal weed flora in the study area. Second, to answer the question: Do cover crop families differ in their effect on weed flora composition?

2. Material and methods

2.1. Study area

The study was conducted at Beni Suef Governorate in Middle Egypt. Geographically, it is located at 28° 36′ to 29° 26′ N lat. and 30° 36′ to 31° 21′ E long with 30 m a.s.l. (Fig. 1). A great part of its economy depends on agriculture and it considered one of the important agricultural lands in Egypt. The River Nile is the fundamental source of water used for irrigation. Meteorological data from Cairo station showed that the total annual rainfall is 8 mm with the rainy season from November to April. The mean monthly air temperature ranges between 12.4 °C (January) and 29.2 °C (July). Mean relative humidity varies between 36% (May) and 56% (December).

2.2. Field selection and sample collection

The present study was based on an intensive fieldwork; a total of 200 crop and fodder fields belong to cereals and other three different families were surveyed. Five cereals were selected as follows: two winter crops (wheat and barley), two summer crops (maize and sorghum) and one perennial fodder (Elephant grass). The non-cereal crops were two summer crops belong to the Solanaceae (green pepper and tomato), two winter crops belong to Liliaceae (onion and garlic) and one winter fodder belong to Leguminoseae (Egyptian clover). Fields were relatively homogeneous as far as herbicide treatment, management practice and soil type are concerned (Table 1). The studied fields were selected in old cultivated lands because it contains many different agricultural crops and for its similar chemical and physical properties. The selected area, was distributed in five regions, with 40 fields each. Samples were taken from the fields from January 2017 to December 2018, where the average distance between the two sample fields was 100 m (range 50–250). Weed samples were gathered something like 5 m from any field edge, hence; all samples were gathered inside the focal point of the field to evade field edge impacts (Marshall and Arnold, 1995). Weeds were identified and named according to the local standard floras (Boulos, 1995; Täckholm, 1974). Chorological units were determined according to Zohary (1973). Weed species frequency was calculated by following formula:

Frequency of occurrence (%) = n/m × 100, n: Number of fields where species is in, m: Total number of fields that measured.

2.3. Soil samples and analyses

Five soil samples were collected from zero to 10 cm depth for each crop. Soil texture was estimated via the Bouyoucos hydrometer method. Soil water extracts of 1:2.5 were prepared for detecting of soil pH using a pH meter Model HI 8519, and electrical conductivity (soil: water ratio, 1:1) was estimated by a CMD 830 WPA conductivity meter. Soluble chlorides, bicarbonates and sulfates (soil:water ratio, 1:5) were determined by to Jackson (1962). Soil water extracts of 1:5 were prepared for estimation of potassium and sodium cations by using a flame photometer (Allen et al., 1986). According to Jackson (1962), soil water extracts of 1:5 were prepared for magnesium and calcium cations detection using EDTA (0.01 N).

2.4. Statistical analyses

Two classification methods were performed to test if crop family acts as a biological filter for weed composition. A hierarchical classification analysis based on presence/absence data with Wards' (minimum variance) method and Euclidean distances as a dissimilarity measure (Ward, 1963), two-way indicator species analysis (TWINSPAN) was also used to classify the studied crops and fodder into groups (Hill, 1979) with similar species frequencies patterns were performed by PC-ORD 5.10 (McCune and Mefford, 2006). Sorensen's similarity index was applied to evaluate similarity among weed flora for each crop (Castro and Jaksic, 2008; Magurran

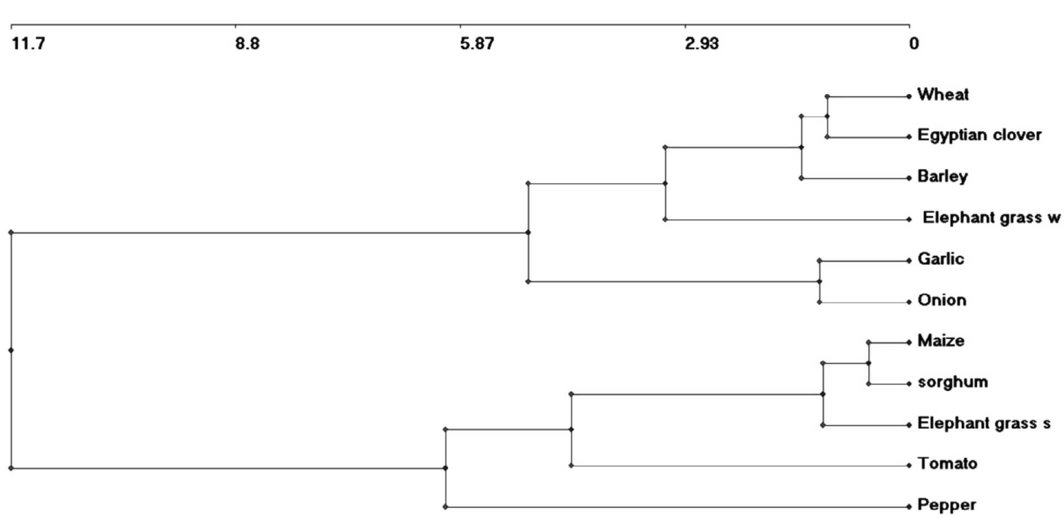

Fig. 1. Hierarchical classification of the studied crops based on their weed composition (incidence data), obtained using Ward's method and Euclidean distances as measures of Linkage Distance.

Table 1
Soil parameters registered along the studied crops. Results are the means of five replicates, ±: Standard deviations.

		Wheat	Barely	Elephant grass	Maize	Sorghum	Egyptian clover	Onion	Garlic	Tomato	Pepper	L.S.D. ($P < 0.05$)
Sand	(%)	24.7 ± 1.20	23.5 ± 1.3	24.1 ± 1.8	24.6 ± 1.7	25.1 ± 1.10	24.8 ± 1.3	24.7 ± 1.60	25 ± 1.80	24.6 ± 1.5	24.1 ± 0.90	2.10
Silt		18.1 ± 0.70	18.5 ± 0.80	18.7 ± 0.90	18.1 ± 1.20	18.1 ± 1.10	18.2 ± 1.80	18.6 ± 0.70	19 ± 1.30	18.2 ± 0.80	19.1 ± 0.70	3.50
Clay		57.2 ± 1.80	58 ± 3.80	57.2 ± 4.20	57.3 ± 2.80	56.8 ± 1.40	57 ± 2.80	56.7 ± 3.90	66 ± 3.80	57.2 ± 2.70	56.8 ± 2.90	5.60
pH		7.13 ± 0.10	7.22 ± 0.30	7.14 ± 0.10	7.25 ± 0.20	7.11 ± 0.50	7.14 ± 0.40	7.12 ± 0.30	7.13 ± 0.30	7.15 ± 0.40	7.11 ± 0.20	0.80
E.C.	(mS/cm)	0.43 ± 0.01	0.48 ± 0.020	0.41 ± 0.02	0.48 ± 0.03	0.21 ± 0.03	0.49 ± 0.04	0.51 ± 0.01	0.49 ± 0.20	0.46 ± 0.04	0.44 ± 0.03	0.09
Ca^{++}	(mg/100 gm)	17.4 ± 1.05	16.95 ± 1.60	20.6 ± 1.40	25.65 ± 1.30	31.6 ± 1.77	18.25 ± 1.35	27.1 ± 0.95	23.6 ± 0.90	32.65 ± 1.20	35.60 ± 1.45	3.75
Mg^{++}		71.1 ± 15.75	70.60 ± 10.75	69.3 ± 11.80	66.35 ± 10.05	70.8 ± 16.05	77.15 ± 12.85	90.70 ± 15.60	79.3 ± 11.80	74.25 ± 13.55	81.15 ± 14.75	18.25
Na^{+}		33.5 ± 1.40	35.5 ± 1.70	34.75 ± 2.05	34.95 ± 3.05	33.8 ± 1.7	87.9 ± 1.72	90.70 ± 2.80	39.15 ± 3.35	34.2 ± 2.15	37.30 ± 1.55	6.25
K^{+}		110 ± 5.10	109.5 ± 5.75	125 ± 11.7	130 ± 15.27	121.5 ± 16.30	115.4 ± 14.35	127.65 ± 15.40	216.5 ± 15.75	128 ± 16.75	120.5 ± 17.80	27.80
HCO_3^-		23.5 ± 1.05	23 ± 0.90	26.5 ± 0.45	32.6 ± 0.55	36.6 ± 1.05	39.25 ± 0.70	4.15 ± 0.90	27.1 ± 0.60	30.60 ± 0.55	28.40 ± 1.05	03.25
SO_4^{--}		231.2 ± 3.92	222 ± 20.65	231 ± 19.8	243.5 ± 17.85	199.3 ± 21.9	200.5 ± 20.9	215.5 ± 19.35	236.15 ± 18.20	233 ± 1.85	231 ± 0.19	05.25
Cl^-		231.25 ± 12.55	255.5 ± 15.22	256.5 ± 20.75	240 ± 22.05	226 ± 15.30	234 ± 25.6	255 ± 22.60	228 ± 21.6	235 ± 22.90	260.65 ± 12.80	30.25

2004). The analysis was performed with the Statistica statistical software package ver. 8 (StatSoft, Inc., Tulsa, OK, USA). In addition, Pearson's correlation coefficient of different crops, according to weed species frequencies were calculated. For soil analysis, the least significant differences (One-Way ANOVA) among the mean values were calculated as recommended by Bailey (1994), terms were considered significant at P = 0.05.

3. Results

Ninety-two weed species were recorded in the all studied crops, cereal and other crops; in the studied area belong to 67 genera and 20 families (Appendix). The major weed families were Poaceae (33.6%) followed by Asteraceae (13%) and Leguminosae (10.8%), while nine families were represented by only one species (Appendix). In general, the leguminous fodder; Egyptian clover; showed the highest numbers of both weed species and genera followed by wheat, in contrast the lowest weed species and genera numbers were recorded associated with Solanaceous crops tomato and green pepper, respectively (Table 2).

Total weed species recorded in cereals were 87 species and the species richness differed from one cereal to another. Fifteen weed species were recorded in cereals and not recorded in other crops, while five species were recorded in Egyptian clover and not recorded in cereals. The weed species number associated with wheat (Triticum spp.) was more than those of barley by 15%. Wheat crops exhibited the highest number of weed species, among cereals, followed by maize crop, while the lowest weed species number was detected in the barley crop (Table 2). Weed species associated with winter cereals were higher than those associated with summer cereals by 11%. In contrast, weed species associated with Elephant grass in summer season were significantly higher than those associated with the same fodder in winter season by 45% (Table 2).

Generally, *Chenopodium murale* L. and *Cynodon dactylon* (L.) Pers. were the most dominant weed species in all crops, cereals and the other crops; recorded in 90% of the studied crops; followed by *Malva parviflora* L., which was recorded in 81% of the studied crops. While, *Convolvulus arvensis* L., *Phragmites australis* (Cav.) Trin. ex Steud. and *Anagallis arvensis* L. were recorded in 72% of the studied fields. Ten weed species were recorded in only one crop; the majority of which grew in Egyptian clover (4 species). While two species were recorded in wheat crop and were not recorded in the other crops. The weeds that were recorded in barley contained one species that was not recorded in other crops, as well as sorghum and summer elephant grass. *Chenopodium murale*, *Cynodon dactylon, Convolvulus arvensis* and *Malva parviflora* were the most frequent species in winter cereals (Table 3), while *Echinochloa colona (L.) Link*, *Portulaca oleracea* L. were the most frequent weeds in summer cereals. *Phramites australis*, *Beta vulgaris* L. and

Table 2
Weed species, genera and families recorded in the studied crops.

	Species	Genera	Families
Wheat	58	42	16
Barley	27	27	14
Elephant grass W	24	22	11
Clover	73	56	19
Onion	24	24	12
Garlic	27	23	13
Maize	43	38	17
Sorghum	48	38	17
Elephant grass S	33	28	13
Tomato	8	7	5
Green pepper	12	11	7

Table 3
Frequencies (%) of the top 10 weeds recorded in the studied cereals.

	Wheat	Barley	Elephant grass (winter)	Maiz	Sorghum	Elephant grass (summer)
C. dactylon	85	50	100	65	69	86
C. arvensis	65	25	50	78	69	57
B. vulgaris	45	75	50	22	8	0
C. murale	50	75	50	26	38	71
M. parviflora	55	75	50	35	8	14
M. indicus	30	75	50	0	0	0
E. colona	10	0	0	91	92	100
P. oleracea	0	0	0	65	69	71
H. trionum	0	0	50	61	46	43
A. viridis	15	0	0	48	15	71

Table 4
Phytogeographical groups of the recorded weed species as percentage of the total number along different crops.

	Cosmopolitan	Mediterranean	Sudano- Zambezian	Irano -Turanian	Paleotropic	Pantropic	Biregional	Pluriregional
Clover	29	8	5	1	14	12	16	15
Wheat	26	9	5	2	12	7	20	19
Barely	30	7	4	0	11	7	19	22
Elephant grass (winter)	46	8	0	0	17	0	13	16
Garlic	31	8	4	0	12	8	15	22
Onion	35	4	4	0	4	13	18	22
Maize	24	4	11	2	15	20	9	15
Elephant grass (summer)	30	6	6	0	21	21	10	6
Sorghum	25	4	8	0	19	21	10	13
Green pepper	50	0	8	0	9	33	0	0
Tomato	38	13	0	0	12	37	0	0

Anagallis arvensis were recorded in more than 80% of cereals, while 21 species were observed in only one cereal. The dominant weed species in non-cereal crops were *Portulaca oleracea* green pepper), *Malva parviflora* and *Cichorium endivia* L. in the tomato crop, *Anagallis arvensis* L. in onion crop, *Convovulus arvensis* L. in garlic and *Cichorium endivia* L. in Egyptian clover.

Chorological analysis of the recorded weed species showed that cosmopolitan elements showed the highest numbers in total weed flora, 27.9%, (Table 4). Weed flora recorded in wheat were more complex, comprising 58 species, belonging to many phytogeographical elements (Table 4), while the weed assemblage of maize (Zea mays) does not exceed 43 species and includes pan- and palaeotropical species (Table 4). The bioregional elements (Mediterranean + Irano-Turanian) constituted 16%, while the Plurirgional elements were represented by 17.2%. The uniregional elements, Mediterranean and Sudano- Zambezian were represented by only six species for each. Both palaeotropical and Pantropical elements exhibited 11.8% and the Irano-Turanian was represented by only one species. Sudano- Zambezian, pantropical and palaeotropical elements represented in summer cereals by higher percentages than winter cereals. In contrast, Mediterranean and Plurirgional elements in winter cereals were represented by higher percentages than summer cereals.

Based on weed composition, Dendrograms obtained from Ward classification (Fig. 1) differentiated the studied crops into two main groups. The first group included all winter crops, which were divided into two subgroups: one included onion and garlic (Liliaceae) and the other subgroup contained the cereal crops with Egyptian clover. The second main group included all summer crops, which was subdivided into two subgroups, green pepper crop in one group while tomato with the cereal crops in the other subgroup. Additionally, the dendrograms showed that summer cereal crops were relatively more homogeneous floristically than the tomato crop.

Sorenson similarities (Table 5) were exhibited the highest values between sorghum and maize, followed by those obtained between Egyptian clover and wheat. Similarityvalue between garlic and onion was higher than those among onion or garlic with other crops. In addition, weed flora of tomatoes showed highest similarity with weeds of green pepper compared to other crops

Table 5
Sorensen similarities between crops according to weed composition.

	Wheat	Barley	Elephant grass (winter)	Egyptian clover	Garlic	Onion	Maize	sorghum	Elephant grass (summer)	Pepper	Tomato
Wheat	1										
Barley	0.37	1									
Elephant grass (winter)	0.32	0.42	1								
Egyptian clover	0.63	0.33	0.29	1							
Garlic	0.34	0.26	0.24	0.3	1						
Onion	0.34	0.19	0.26	0.28	0.46	1					
Maize	0.38	0.28	0.17	0.42	0.26	0.17	1				
sorghum	0.34	0.25	0.16	0.42	0.23	0.18	0.71	1			
Elephant grass (summer)	0.28	0.15	0.12	0.34	0.25	0.16	0.49	0.5	1		
Green pepper	0.11	0.15	0.09	0.13	0.11	0.13	0.23	0.22	0.29	1	
Tomato	0.06	0.06	0.07	0.11	0.13	0.1	0.15	0.17	0.21	0.18	1

Table 6
Pearson correlation coefficients between crops according to weed composition.

	Wheat	Barley	Elephant grass w	Egyptian clover	Garlic	Onion	Maize	sorghum	Elephant grass s	Pepper	Tomato
Wheat	1.00	0.60	0.41	0.68	0.23	0.17	0.19	0.16	0.16	0.06	0.11
Barley	0.60	1.00	0.50	0.66	0.14	0.06	0.14	0.11	0.12	0.13	0.09
Elephant grass w	0.41	0.50	1.00	0.46	0.11	0.21	0.10	0.09	0.09	−0.02	0.06
Egyptian clover	0.68	0.66	0.46	1.00	0.33	0.28	0.25	0.16	0.18	0.18	0.16
Garlic	0.23	0.14	0.11	0.33	1.00	0.63	0.04	0.03	0.08	0.06	0.04
Onion	0.17	0.06	0.21	0.28	0.63	1.00	−0.08	−0.09	−0.01	0.01	−0.03
Maize	0.19	0.14	0.10	0.25	0.04	−0.08	1.00	0.85	0.72	0.48	0.51
sorghum	0.16	0.11	0.09	0.16	0.03	−0.09	0.85	1.00	0.79	0.58	0.45
Elephant grass s	0.16	0.12	0.09	0.18	0.08	−0.01	0.72	0.79	1.00	0.57	0.41
Green pepper	0.06	0.13	−0.02	0.18	0.06	0.01	0.48	0.58	0.57	1.00	0.23
Tomato	0.11	0.09	0.06	0.16	0.04	−0.03	0.51	0.45	0.41	0.23	1.00

except that exhibited with summer elephant grass. The lowest similarity value was exhibited between tomatoes and barely. Pearson correlation coefficient (Table 6) confirmed Sorenson similarities results.

4. Discussion

Because the fields studied are homogeneously chosen in relation to management practices and soil characteristics, the noticeable difference in weed diversity is the result of the difference in cover crop (Drinkwater et al., 2000; Doucet et al., 1999).

The current study showed that cereal crops include weed flora more than other crops that is mean cereal crops more vulnerable to weeds than other crops. Some weed species showed wide ecological amplitudes, while others were limited to a particular type of crop with very narrow amplitude; indicating that the ecological amplitudes of the recorded weed species were differed from each other. The current finding is consistent with previous studies in Egypt (Mahgoub, 2019a; Shaheen, 2002; Shaltout and Sharaf El-Din1988) who cited that these herbs were ubiquitous in large capacity, often caused by phenotypic plasticity And heterogeneity. Hâkansson (1982) and Holm et al. (1977) stated that *Cynodon dactylon* considered one of the world's worst weeds, and invades most subtropical and temperate agroecosystems; occurs on almost all soil types and can be a serious weed, rapidly invading cultivated land, and it is difficult to eradicate. *Chenopodium murale*, one of the dominant recorded weeds, characterized by high growth rate, wider environmental flexibility, higher reproductive potential, best resource utilization and phytotoxicity (Holm et al., 1977). *Convolvulus arvensis* was recorded previously as one of the world's superior injurious weeds and grow in many different crops in more than 50 countries (Holm et al., 1991). Therefore, the current study highlights these species and their dangers to agricultural crops and the need to find solutions to eliminate them in the study area before the problem arises.

Egyptian clover has the highest number of weeds, possibly because leguminous plants have been shown to contribute to substantial over-yielding in other species through their impacts on soil nitrogen availability (Zahran, 1999). Conversely, barley had the lowest number of weeds and this could be explained by its allelopathic effect (Bertholdsson, 2004, 2005; Kremer and Ben-Hammouda, 2009). The Dendrograms obtained the Ward classification of weed composition showed that differences in weed species compositions were mainly affected by seasonal priority. The current results confirmed previous studies, which concluded that the crop season is the most significant factor in the floristic composition of Egyptian weed species (El-Hadidi and Kosinová, 1971, Mahgoub, 2019b), and in central Europe (Lososová, et al., 2004).

Crop family showed slightly effect as a factor affecting weed composition, which was consistent with many previous studies (Andersson and Milberg, 1998; Fried et al., 2008). This effect may be due to the chemical properties of each plant family. It is well known that all members of the same plant family have common chemical properties, and the roots of plants release chemicals in the soil. In turn, these substances affect weeds, either negatively or positively, Allelopathy theory, (Rice, 1974).

Wingler et al. (2015) recorded that the effect of crop plant, however, was less pronounced than the effects of altitude, season or year. The present study is consistent with Mucina (1993) and Ries (1992) for Austria, who accepted similar results, which put a less affirmation on the discrimination of weed vegetation due to the crop. In addition to its compatibility with the studies of Jarolímek et al. (1997) for Slovakia, and Haveman et al. (1998) for the Netherlands.

Similarities between onion and garlic weeds as well as similarity between pepper weeds and tomato weeds could be attributed to their taxonomic relations that may lead to their common allelopathic effect. In addition, these similarities could be attributed to the novel weapons, speculation hypothesizes that plant species belonging to the same genus and exposed to the equivalent ecological conditions, will in general have comparable characteristics, mainly concerning their defense mechanisms, which incorporate the production of inhibitory secondary metabolic compounds (Inderjit et al., 2008).

Although, competition theory proposes that plant species with similar morphological and functional traits relevant to resource utilization and earning, like phenology, rooting morphology, water usage, nutrient requirements and leaf architecture, should compete more robustly than species with various traits (Johansson and Keddy,1991; MacArthur and Levins, 1967). The current findings are incompatible with this theory; Poacea recorded the highest weed number of cereal crops. This may be explained by the allelopathy effect of cereal crops on weeds belong to other families is greater than the effect of competition with similar morphological and functional traits. For instance, it was documented that wheat has allelopathic effects on the growth of a number of agricultural weeds (Steinsiek et al., 1980; Shilling et al., 1985; Wu et al., 2000). It was stated that crop characters that have been shown to be most significant in helping crops to compete with weeds include rapid germination and root development, early aboveground growth and vigor, rapid establishment of leaf area and canopy, development and leaf area, and greater height (Callaway, 1992).

5. Conclusion

The current study highlighted the cereal weeds in the studied area and compared it with weeds of other crops. The results showed that wheat crops exhibited the highest number of weed species, among cereals. *Chenopodium murale*, *Cynodon dactylon, Convolvulus arvensis* and *Malva parviflora* were the dominant species, which required attention to these species and the search for ways to eliminate them. Results showed slightly effect of crop family in weed composition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sjbs.2020.07.001.

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