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Observation of Weed Species, Frequency and Density in Common Barley (*Hordeum vulgare* L.) Fields of Diyarbakir, Turkey: A Case Study

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ABSTRACT
The weed species in the common barley (*Hordeum vulgare* L.) fields in the Diyarbakir were observed with this study. For this purpose, 50 quadrats of 1m by 1m (1 m^{-2}) were randomly placed and examined at each study site. In every set of the quadrat, frequency and density were observed throughout the cropping season of 2015-2016. During the course of field study 72 weed species belonging to 21 families, 13 grasses, 59 broadleaves were recorded. The common families were Asteraceae and Poaceae in the common barley fields. The encounter frequency of weeds was determined by observing 80% wild mustard (*Sinapis arvensis* L., 80%), animated oat (*Avena sterilis* L., 63%), common wild oat (*Avena fatua* L., 54%), corn buttercup (*Ranunculus arvensis* L., 54%), corn poppy (*Papaver rhoeas* L., 52%), creeping thistle (*Cirsium arvense* (L.) Scop., 51%), volunteer lentils (*Lens culinaris* Medik., 51%). Wild mustard, which had the highest frequency was also the densest weed species (5.18 plant m^{-2}), and other species such as animated oat (4.33 plant m^{-2}), creeping thistle (1.77 plant m^{-2}), common wild oat (1.72 plant m^{-2}), corn buttercup (1.47 plant m^{-2}), cleavers (1.38 plant m^{-2}), corn poppy (1.22 plant m^{-2}), volunteer lentils (1.07 plant m^{-2}) were important species at all the observed fields. It was observed that the great infestation was shown by broadleaf weeds due to the lack of effective weed control in the barley areas.

Keywords: Common barley (*Hordeum vulgare* L.); Weed species; Abundance; Distribution; Infestation

1. Introduction

The common barley (*Hordeum vulgare* L.) is an annual grass and long-day plant belonging to the Poaceae family and grown in the cool climate temperatures of spring and winter (Awika 2011; Koehler & Wieser 2013). It is a significant grain after common wheat (*Triticum aestivum* L.), rice (*Oryza sativa* L.) and corn (*Zea mays* L.) as global (IGC 2018). The worldwide common barley production has been between 130 and 150 million tons from year to year. Turkey's annual production has been between 7-8 million tons (FAOSTAT 2014). Southeastern Anatolia Region of Turkey, which has 16% of the production of barley due to animal husbandry and marketing opportunities. The Diyarbakir, which is the grain center of the region, grows 2% of the country's common barley production (TUIKSTAT 2015). The barley is the principal dryland crop, and general winter planted in the region, both two-rowed (Namely; Sahin-91, Sur-93, Samyeli, Baris and Hevsel) and six-rowed (Namely; Kral-97, Vamik Hoca-98, Akhisar, Kendal and Altikat) varieties are grown (TTSM 2018). The selection of two-rowed or six-rowed barley varieties by farmers depends on the current environment, climate and diversity. Both are used to make animal feeding, malting and food making (Coken & Akman 2016; AHDB 2018). There are many abiotic and biotic factors such as temperature**,** light**,** and soil (nutrients), bugs, fungi,

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bacteria and weeds that can cause yield loss in the common barley crop. The severity of yield loss depends on water capacity of the soil, drought, frost, barley varieties, planting norm and density of diseases, pests, and the weeds (Afentouli & Eleftherohorinos 1996; Samarah 2005; Jaggard et al 2010; Schumacher et al 2018).

Although the common barley has a suffocating effect on various weeds through crop intervention (Lanning et al 1997), some weeds have the potential to reduce yield (Lyon & Young 2015). The weeds not only compete with the common barley for nutrients, water and light, but can also make crop harvesting more difficult, increase clamping, and promote insect infestation or mold growth in stored grain (Swanton et al 2015). The common barley crop that is contaminated with the weeds may not be able to reach malt species, and the taste can be reduced when used as animal feed, therefore the weeds reduce crop quality. In the common barley fields, the grass weeds such as common oat (*Avena fatua* L.), animated oat (*Avena sterilis* L.), rigid rye-grass (*Lolium rigidum* L.), and canarygrass (*Phalaris brachystachys* L.) are the most threatening to the barley production. The broadleaf weeds such as cornflower (*Centaurea cyanus* L.), knapweed (*Centaurea depressa* Bieb.), thistle [*Cirsium arvense* (L.) Scop.], field bindweed (*Convolvulus arvensis* L.), wild carrot (*Daucus carota* L.), cleavers (*Galium aparine* L.), prickly lettuce (*Lactuca serriola* L.), groundsel (*Senecio vulgaris* L.), wild mustard (*Sinapis arvensis* L.), and false carrot [*Turgenia latifolia* (L.) Hoffm.] are the most threatening species for the barley growth (Turk & Tawaha 2003; Kordali & Zengin 2011; Guncan 2014; Tepe 2014; Veisi & Moeini 2015).

Increased knowledge on how to identify and destruction of the weeds in the common barley produced areas reasonable a significant tactic for the weed control. The prevalence level and development of the abundance and dispersal of the weeds depend on weed control methods. Weed determination researches can supply valued data to growers and scientist on whether weed control is warranted, and if so, what are the favorable weed management strategies (Kumar & Jha 2017). The aim of this study is to contribute to the academic literature on weeds that have caused problems in the barley cultivated fields. In addition to the barley cultivation, the study raises awareness that weeds can pose a threat to long-term sustainable weed control. Therefore, this research was undertaken to detect the frequency and density of the weeds in the barley fields.

2. Material and Methods

2.1. Plant material and field trial

The current study deals with weed species found in the Diyarbakir common barley fields. The study was based on surveys of common barley covered area during the cropping seasons of 2015-2016. The sampling areas were selected to represent the area according to the size of the sowing area and the samples were calculated by the sectioned sampling method (Bora & Karaca 1970). Survey studies were carried out in all of the 17 districts where the common barley is grown in the Diyarbakir province. For these purposes, 180 fields of the common barley were observed across the Diyarbakir located in Southeastern Anatolia Region to find out more about weed species in the 2015-2016 cropping season (Figure 1).

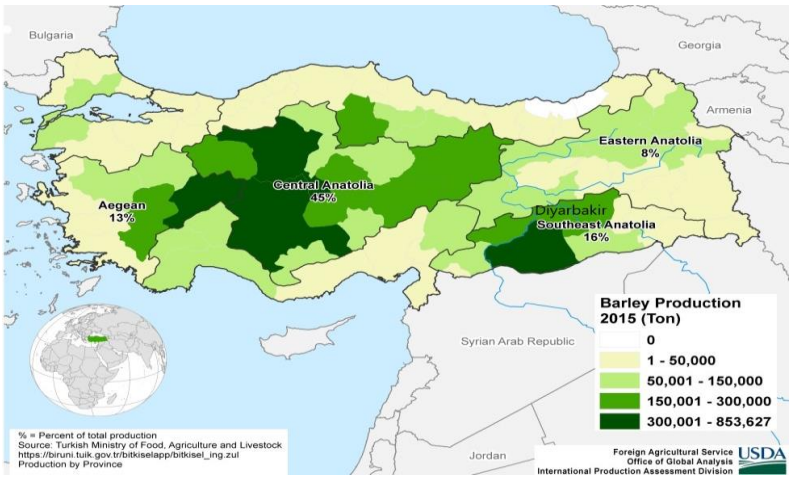

Figure 1- The location of the studied area Diyarbakir province in Turkey

As a result of this, a proportional distribution was made taking into account the maximum production areas (Table 1).

Table 1- Barley cultivation areas and sampling numbers according to the districts of Diyarbakir province

Districts	*Barley fields (da)**	*Sample number*
Baglar	30.000	10
Bismil	105.885	36
Cermik	22.194	7
Cinar	68.540	23
Cüngüs	4.996	2
Dicle	4.977	2
Egil	17.956	6
Ergani	120.000	40
Hani	17.914	6
Hazro	5.500	2
Kayapinar	9.000	3
Kocakoy	3.500	1
Kulp	39.227	13
Lice	649	1
Silvan	10.000	3
Sur	70.000	24
Yenisehir	2.971	1
Total	533.309	180

*, data are taken from TUIK (2015)

The field studies were carried out during the peak weed growth season, which is from March to May when weeds could be easily identified. Field surveys were performed twice a week to each site to collect weed species. Care has been taken to ensure that there was a minimum distance of 3 km between each field in the fields where the sample was taken from. During this research, interviews were carried out with producer and agriculturists from each field concerning weed species which are characteristic of a particular season of the year and important notes on germination, 2-6 leaves, flowering and fruiting seasons of weeds. The counts have been started within at least 10 m of the fields to remove the edge effect. Quadrats 1 m by 1 m (1 m^2) were randomly laid down in the agricultural fields to quantify various weed species, and they were used 4 times for a decare chosen to represent the field in the fields studied (Odum 1971).

2.2. Computation and data analysis

The broadleaf weeds were evaluated as whole plants and the grasses were evaluated as stalks and were reported survey forms. The vegetation structure and composition in the agricultural areas have been compared with the plant frequency and density, which is the simplest and most popular measurement methods for measuring abundance and distribution of weed species (Nkoa et al 2015). Different phytosociological parameters such as plant frequency (%) and density (plant m^{-2}), were calculated by using the following equations (Guncan 2014):

% Frequency = (Number of sampling units in which the species occurs (*N*))/(Total number of sampling units employed for the study (*Q*))*100

$$F=(N/Q)*100 \quad (1)$$

Where; *F*, *f*requency; *N*, number of quadrats in which the species is present; *Q*, *t*otal number of quadrats studied.

Density = (Total number of individuals of the species in all the sampling unit (*S*))/(Total number of sampling units studied (*Q*))

$$D=(S/Q) \quad (2)$$

Where; *D*, density; *S*, total number of individuals; *Q*, total number of quadrats studied.

The weed species that could not be diagnosed in the field were appropriately collected, pressed, dried, preserved and identified according to Davis (1965-1989). The same grading method was used to score the predominant weed species. The weeds were recorded in the field when the density of weed species was less than 20% per square meter, from 20 to 40% in medium and when the density was more than 40%.

3. Results and Discussion

As a result of observations made in the common barley fields of the Diyarbakir, there were 72 weed species belonging to 21 families; including 13 monocotyledons, and 59 dicotyledons. The overall results of common barley weeds were presented in Table 2. The main biological groups were identified: monocots and dicots, annuals, biennials, and perennials, including rhizome plants. *A. fatua, A. sterilis, C. arvense*, *G. aparine, L. culinaris, P. rhoeas, P. bractystachys, R. arvensis, S. arvensis, T. latifolia* were determined as highly spread in the common barley field. According to the results of the survey, it can be concluded that the most common weed families in the common barley fields in the region were 13 species of the Asteraceae and Poaceae. In addition, other families such as Brassicaceae, Fabaceae, Caryophyllaceae, Apiaceae, Ranunculaceae, Geraniaceae, Papaveraceae etc. was recorded, but at low levels with less than 10 weed species. The weed families identified in the study (Figure 2).

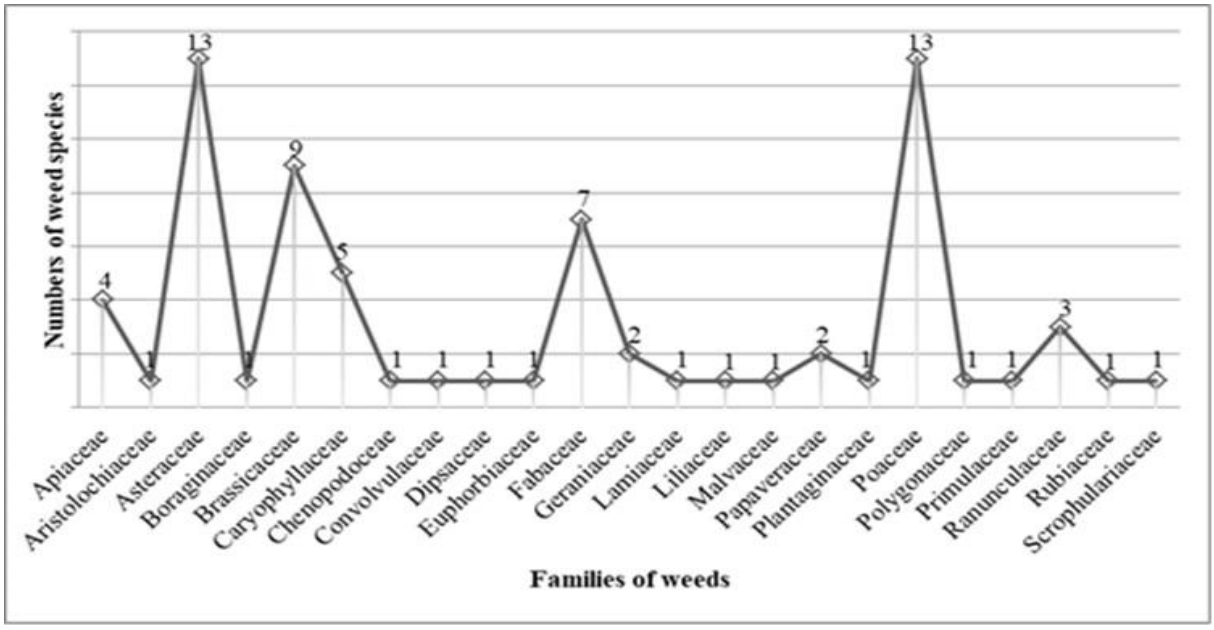

Figure 2- Families of weed species in barley cultivated areas of Diyarbakir province and the number of weed species owned by these families

The results of the surveys conducted in the Diyarbakir common barley fields showed that the frequency of the occurrence of more than 50% was *Sinapis arvensis* L. (80%), *Avena sterilis* L. (63%), *Avena fatua* L. (54%), *Ranunculus arvensis* L. (54%), *Papaver rhoeas* L. (52%), *Cirsium arvense* (L.) Scop. (51%), *Lens culinaris* Medik (51%). When evaluated according to the density of weeds; *Sinapis arvensis* L. (5.18 plant m^{-2}), *Avena sterilis* L. (4.33 plant m^{-2}), *Cirsium arvense* (L.) Scop. (1.77 plant m^{-2}), *Avena fatua* L. (1.72 plant m^{-2}), *Ranunculus arvensis* L. (1.47 plant m^{-2}), *Galium aparine* L. (1.38 plant m^{-2}), *Papaver rhoeas* L. 1.22 plant m^{-2}), *Lens culinaris* Medik (1.07 plant m^{-2}) species were found to be more than one in square meters (Table 2). It was seen that the densest and frequent species were *S. arvensis* and *A. sterilis*. However, there were some parallels in the frequency and density of weeds. For example, both the frequency and intensity of *Ranunculus arvensis* had been detected in the unit area.

Table 2- Frequency and density of weeds detected in barley fields of Diyarbakir

Scientific names of weeds	*Common names of weeds*	*Family*	*F**	*D***
Adonis aestivalis L.	Summer pheasant's eye	Ranunculaceae	5	0.27
Agrostemma githago L.	Common corncockle	Caryophyllaceae	5	0.10
Allium sp.	Onion	Liliaceae	2	0.05
Alopecurus myosuroides Huds.	Meadow foxtail	Poaceae	15	0.46
Anagallis arvensis L.	Scarlet pimpernel	Primulaceae	7	0.15
Anchusa azurea Miller.	Italian bugloss	Boraginaceae	2	0.04
Anthemis arvensis L.	Mayweed	Asteraceae	20	0.35
Aristolochia maurorum L.	Birthwort	Aristolochiaceae	8	0.15
Avena fatua L.	Common wild oat	Poaceae	54	1.72
Avena sterilis L.	Animated oat	Poaceae	63	4.33
Bifora radians Bieb.	Wild bishop	Apiaceae	25	0.45
Boreava orientalis Jaub and Spach.	Yellow weed	Brassicaceae	14	0.35
Bromus tectorum L.	Cheatgrass	Poaceae	25	0.68
Capsella bursa-pastoris (L.) Medik.	Shepherd's purse	Brassicaceae	21	0.67
Cardaria draba (L.) Desv.	Whitetop hoary cress	Brassicaceae	9	0.16
Carduus pycnocephalus L.	Italian thistle	Asteraceae	3	0.09
Caucalis platycarpos L.	Bur-parsley	Apiaceae	1	0.01
Centaurea depressa Bieb.	Cornflower	Asteraceae	16	0.46
Centaurea solstitialis L.	Yellow star-thistle	Asteraceae	13	0.34
Cephalaria syriaca (L.) Schrad.	Syrian cephalaria	Dipsaceae	6	0.15
Cerastium dichotomum L.	Mouse-ear chickweed	Caryophyllaceae	5	0.09
Chondrilla juncea L.	Rush skeletonweed	Asteraceae	14	0.35
Cichorium intybus L.	Common chicory	Asteraceae	14	0.17
Cirsium arvense (L.) Scop.	Canada thistle	Asteraceae	51	1.77
Consolida orientalis (Gay) Schrid.	Larkspur	Ranunculaceae	6	0.13
Convolvulus arvensis L.	Field bindweed	Convolvulaceae	25	0.89
Daucus carota L.	Wild carrot	Apiaceae	21	0.56
Descurainia sophia (L.) Webb	Flixweed	Brassicaceae	2	0.03
Erodium hoefftianum C.A.Mey	Redstem filaree	Geraniaceae	9	0.19
Euphorbia helioscopia L.	Sun spurge	Euphorbiaceae	3	0.07
Fumaria officinalis L.	Common fumitory	Papaveraceae	22	0.66
Galium aparine L.	Cleavers	Rubiaceae	45	1.38
Geranium dissectum L.	Cut-leaved crane's-bill	Geraniaceae	23	0.92
Hordeum murinum L.	Mouse barley	Poaceae	9	0.03
Lactuca serriola L.	Prickly lettuce	Asteraceae	22	0.65
Lamium amplexicaule L.	Henbit dead-nettle	Lamiaceae	12	0.25
Lathyrus sp.	Chickling pea	Fabaceae	4	0.08
Lens culinaris Medik	Volunteer lentil	Fabaceae	51	1.07
Lolium temulentum L. Lam.	Darnel ryegrass	Poaceae	11	0.18
Lolium rigidum L.	Wimmera ryegrass	Poaceae	27	0.38

Table 2 (Continue)- Frequency and density of weeds detected in barley fields of Diyarbakir

Scientific names of weeds	*Common names of weeds*	*Family*	*F**	*D***
Malva neglecta Wallr.	Dwarf mallow	Malvaceae	6	0.12
Matricaria chamomilla L.	Chamomile	Asteraceae	7	0.17
Medicago sativa L.	Alfalfa	Fabaceae	5	0.25
Myagrum perfoliatum L.	Musk weed	Brassicaceae	8	0.11
Neslia paniculata (L.) Devs.	Ball mustard	Brassicaceae	8	0.24
Papaver rhoeas L.	Common poppy	Papaveraceae	52	1.22
Phalaris brachystachys Link.	Short-spiked canarygrass	Poaceae	42	0.48
Phalaris canariensis L.	Canarygrass	Poaceae	25	0.29
Phragmites communis Trin.	Common reed	Poaceae	5	0.20
Pisum sativum L.	Garden pea	Fabaceae	8	0.17
Plantago lanceolata L.	Ribwort plantain	Plantaginaceae	3	0.06
Poa annua L.	Bluegrass	Poaceae	2	0.01
Poa trivialis L.	Rough bluegrass	Poaceae	26	0.42
Ranunculus arvensis L.	Corn buttercup	Ranunculaceae	54	1.47
Rumex crispus L.	Curly dock	Polygonaceae	1	0.02
Salsola kali L.	Russian thistle	Chenopodoceae	6	0.12
Secale cereale L.	Cereal rye	Poaceae	6	0.10
Senecio vulgaris L.	Groundsel	Asteraceae	5	0.08
Silene conoidea L.	Large sand catchfly	Caryophyllaceae	6	0.14
Silene vulgaris (Moench) Garcke.	Bladder campion	Caryophyllaceae	4	0.18
Silybum marianum (L.) Gaertner	Milk thistle	Asteraceae	17	0.35
Sinapis arvensis L.	Wild mustard	Brassicaceae	80	5.18
Sisymbrium officinale (L.) Scop.	Hedge mustard	Brassicaceae	9	0.24
Sonchus asper (L.) Hill.	Spiny sowthistle	Asteraceae	3	0.06
Sonchus oleraceus L.	Common sowthistle	Asteraceae	4	0.35
Thlaspi arvense L.	Field pennycress	Brassicaceae	15	0.89
Trifolium sp.	Clover	Fabaceae	4	0.13
Turgenia latifolia (L.) Hoffm.	Broadleaf false carrot	Apiaceae	41	0.96
Vaccaria pyramidata Medik	Cowherb	Caryophyllaceae	17	0.52
Veronica hederifolia L.	Ivy-leaved speedwell	Scrophulariaceae	21	0.30
Vicia faba L.	Broad bean	Fabaceae	1	0.02
Vicia sativa L.	Common vetch	Fabaceae	8	0.44

* F, frequency (%); ** D, density (plant m^{-2})

As a result of exploratory realized to detect the frequency and density of weed species seen in the common barley fields of the Diyarbakir, the numbers of species of Asteraceae and Poaceae were found to be higher in a number of species. It is a natural result that most of the weed species have emerged from these two families because the plant families are two of the families with the highest species in our city cereal fields (Pala & Mennan 2017). Previous surveys had shown that these two families are among the most species-bearing families (Kordali & Zengin 2011).

As a result of the surveys carried out, it was observed that winter weed species (*S. arvensis, A. sterilis, C. arvense, R. arvensis, G. aparine*) were problematic. It is anticipated that these species, which have been well adapted to these ecological conditions because of the cold and rainy winters and hot and dry summers in the Diyarbakir, are expected to be a problem in grain fields (Zel 1974; Uludağ 1997; Sizer & Tepe 2016; Pala & Mennan 2017). This work is very important because it contains data that will form the basis of weed control work to be done in the common barley.

Climate, agricultural activities, and especially applied the weed control methods can change the weed composition in agricultural areas. Ergani, Bismil, Sur and Cinar districts of the Diyarbakir province were found to be heavily weeded in monoculture farming areas where dry farming was done. Crop rotation decreased weed species (Pala et al 2018), but it wasn't enough alone. Hence there was no obvious effect on the weed flora these districts.

Identification of weed distribution can be a significant point in the weed control in the common barley production. Monitoring weeds in the studied areas will help to define the implementation of appropriate management preventions (Moeini et al 2008). Veisi & Moeini (2015) found that *C. arvense* and *C. depressa* species, also *Avena*, *Galium*, and *Vicia*, a genus which is the prominent weeds in Kermanshah common barley areas, observed in the Diyarbakir too, this indicates that these weeds can be a trouble in different ecosystems. The very limited study had been done on weeds which are a problem in the common barley fields, both in Turkey and the world. Therefore, there are limited studies to compare weed species in Diyarbakir barley fields with weeds in other barley cultivation areas. The weed species found by Kordali & Zengin (2011) in the common barley fields of Bayburt differ significantly in terms of species and density compared to the weeds we have identified in our study. This explains the frequency and density of the weed species, density, and coverage areas vary in different regions and years. Various factors such as early planting, densely sown and appropriately fertilized can apply to enhance crop yield in common barley in small agricultural systems of semi-arid regions and reduce weed populations (Elwis & Young 2000; Poggio 2005). Santin-Montanya et al (2013) reported that the application of new farming techniques led to constant changes in the weed population, while some strains of some weeds lost some of the previously no problematic species. On the other hand, Schumacher et al (2018) note that the loss of weed biodiversity in agricultural fields is a global issue that should be avoided to protect the supported ecosystem services and food networks. The weed flora of the product varies from field to field depending on the environment terms, irrigation systems, fertilization, soil structure and weed management (Anderson & Beck 2017). Inadequate weed management in the Diyarbakir common barley fields and incomplete and faulty applications are increasing the weed problem in these areas. It was observed that chemicals were used to control *Avena spp.* and *Sinapis arvensis*, but these weeds could be partially controlled. The results showed that preventive and cultural methods such as certified seed use, development of tolerant variety, deep tillage with the pre-sowing disc, frequent sowing, late sowing should be developed because the current weed control methods are not sufficient. On the other hand, attention should be paid to the avoidance of early and late applications in the fertilization of common barley with the herbicide, the spraying of a well-calibrated sprayer in the appropriate climatic and soil conditions during the 2-6 leaf period of the weeds. In recent years, due to increased resistance to herbicides in the weeds of cereals in the Diyarbakir (Sizer & Tepe 2016), the rotation of the herbicide is an important consideration to be taken to reduce the weed populations. Awareness activities of the common barley producers need to be done on the weeds.

4. Conclusions

The Diyarbakir is one of the common barley gene and production center in Turkey. Several researchers have tried to explore of the weeds, but the studies on species diversity of weeds in the common barley are still unscreened. Hence, in the present study attempts were made to screen out the structure of weed communities associated with the common barley crop. This study provides preliminary data of the different categories of weeds in the common barley crop fields. According to the results of the survey, it can be concluded that the common barley plants in the region are affected by a series of the weeds. It was found that the broadleaf weeds were significant, especially *Sinapis arvensis* and *Ranunculus arvensis* were dense in the common barley which is known to have highly competitive with weeds. Consequently, the weeds were a serious concern in the common barley fields, in particular, the winter weeds were a serious problem in the common barley fields, hence it ought to seek new solutions for controls. The study is helpful to farmers, agronomists, and researchers related to this

field for identification of weeds and to understand the distribution and growth patterns of weeds associated with the common barley fields. During the study, it became obvious that farmers should be trained in suitable common barley crop management practices and need to make better access to advanced weed management practices. New varieties that are tolerant to the climatic factors and herbicides, resistant to diseases and insects and that have strong weed competition, meet production and consumer's needs should continue to grow. Weed identification and control should be taken critically. It is obvious that the frequency and density of the weed species in the common barley fields will decrease losses of the common barley crop yield. Proper control of the weeds will increase the yield of common barley cultivation and total grain production. In this context, field observations to make necessary and collect information about the frequency and density of the weeds, to evaluate the economic losses caused by the weeds and to improve the new weed management tactics for the common barley production. In addition, it is concluded that weed needs to be investigated for the weed bank dynamics to a better estimate of the weed populations.

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