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Research Article

The influence of crop rotation and climatic factors on weed flora dynamics in irrigated wheat *Triticum aestivum* fields

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Abstract: In this study, the relationship between crop rotation and climatic factors in the change of weed flora in 52 wheat fields in seven cities of Tehran province during 2005-2015 was investigated. The frequency, uniformity, density, and dominance index of weed species were investigated in relation to crop rotations and climatic factors. Redundancy analysis (RDA) and Canonical correlation analysis (CCA) showed four significant correlations; in RDA, the first and second components together explained more than 51.8% of the variance in the relationship between weed species and crop rotations. In CCA, the first and second components predicted more than 59.5% of the variance in the relationship between species and climatic factors. The areas with the highest consecutive wheat cultivation and wheat rotation with barley (*Hordeum vulgare* L.), high density of Flixweed (*Descurania Sophia* (L.) Webb and Berth), Prostrate knotweed (*Polygonum aviculare* L.), Rigid ryegrass (*Lolium rigidum* Gaud.), Wild barley (*Hordeum spontaneum* C. Koch) and winter wild oat (*Avena ludoviciana* Dur.) were observed. Continuous cultivation of wheat and its rotation with Rapeseed (*Brassica napus* L.) have a linear and negative correlation with the predominant weeds of African mustard (*Malcolmia africana* L.), Wild radish (*Raphanus raphanistrum* L.), and Wild mustard (*Sinapis arvensis* L.). The results showed that temperature and altitude had the greatest effect on weed distribution, while annual evaporation and total annual rainfall had the least effect. Rigid ryegrass (*L. rigidum* Gaud.), Common fumitory (*Fumaria vaillantii* Loisel) and Groundsel (*Senecio vulgaris* L.) had a positive correlation with annual surface evaporation.

Keywords: Density, Rainfall, Uniformity index, Weed composition

Introduction

Wheat is Iran's most important strategic crop and plays an irreplaceable role in the food system. According to statistics (2014-2015), the wheat-cultivated area in Iran was 5.848 million hectares, of which 35.3% was irrigated, and the rest was rainfed. Wheat production in that year was 14.300 million tons, two-thirds of which was obtained from irrigated cultivation and one-third from rainfed cultivation (Anonymous, 2016). Weeds have special characteristics such as abundant seed production, high germination ability and fast establishment, high growth rate, long dormancy period, preservation of vegetative power, adaptability for propagation

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and distribution, and vegetative reproduction organs. They are serious competitors of crops and an integral part of agricultural systems; despite significant investment in control, they still damage crops (Buhler, 1995). Weeds also use resources efficiently, show high species diversity, and remain dominant and stable against environmental, temporal, and spatial changes (Tarmi *et al*., 2009). Diversity in weed community structure indicates the success of weed management programs. The shift in weed populations toward several dominant species indicates that conditions have allowed these species to adapt to common agricultural operations (Dutoit *et al*., 2003).

According to some researchers, successive cereal cultivation for several years, Incorrect crop rotation, and the use of herbicides with the same mechanism of action can change the composition and structure of plant species (Blackshaw *et al*., 1994; Lemerle *et al*., 2001; Radosevich *et al*., 1997). Crop rotation is also one of the most important weed control methods, reducing weed presence in crops (Lososova *et al*., 2004; Lapinsh *et al*., 2008; Andreasen and Skovgaard, 2009). Weeds often imitate and adapt to the crop's growth period and pattern, climatic conditions, and soil characteristics (Anderson and Milberg, 1998; Andreasen and Skovgaard, 2009; Cimalová and Lososová, 2009; Tarmi *et al*., 2009). Crop rotations can affect weed populations through multiple processes. Continuous, systematic changes in the environment and agricultural activities alter the course and evolutionary trajectory of weed species (Poggio *et al*., 2004). Therefore, weed populations will vary significantly during multi-year rotations (Anderson *et al.*, 2007).

Proper crop rotation prevents weed population buildup and helps keep the population below the economic loss threshold. Crop rotation can reduce weed density, preserve species diversity, and, as a result, prevent the dominance of several weed species (Dorado *et al*., 1999; Cousens and Croft, 2000). Teasdale *et al*. (2004) showed that a suitable wheat-corn-soybean rotation controls broadleaf weeds and the composition of the soil seed bank. In the long-term experiments of crop rotation after successive cultivation of wheat, downy brome (*Bromus tectorum* L.) appeared as the dominant weed species in the field. However, after implementing wheat rotation with rapeseed, this weed was easily managed, and its damage remained below the economic threshold (Blackshaw, 1994). Chhokar and Sharma (2008) stated that crop rotations with different life cycles and the use of agricultural operations effectively reduce problematic weeds such as little seed canary grass (*Phalaris minor* Retz.). A study also found that a clover-barley-wheat-rice rotation controlled little seed canary grass (Chhokar and Malik, 2002).

Climate is the most important factor influencing the development of agricultural systems, so its change can greatly affect food production and, of course, transform human societies. Climate change can challenge weed distribution, competitive traits, and management in agricultural ecosystems (Abdolahipour and Bagherani, 2016). Studies by Thomas and Dale (1991a,b) also show that weed community structure depends heavily on climatic conditions and that spring and summer temperature and rainfall play an important role in shaping it. However, weed community dispersion in response to environmental conditions is independent of each other. Temperature and rainfall are the first factors affecting the regional distribution of weeds as well as the selection of species and cultivars of agricultural plants for cultivation. Lower latitudes, by contrast, limit the spread of cold-climate species (Woodward, 1992).

Multivariate statistical methods are powerful and sophisticated tools for descriptive and predictive modeling of complex data structures in weed science. The two main goals of descriptive multivariate models are summarization of data structure and prediction, which generally includes statistical hypothesis testing (Jeffers, 1988). Redundancy Analysis (RDA) is a canonical form or restricted form of Principal Component Analysis (PCA). The goal of RDA is to maximize the prediction of linear combinations for a set of dependent variables Y (living data), given a set of factor variables X (non-living data) (Legendre

and Legendre, 1998). Canonical Correspondence Analysis (CCA) is similar to RDA and is widely used in plant ecology to model relationships between plant floristic composition and environmental variables. Because the method is based on Correspondence Analysis (CA), it is very suitable for canonical analyses of non-linear live data sets (ter Braak, 1995). The purpose of this study is to evaluate the impact of crop rotation and climatic factors on the weed population of irrigated Wheat fields in Tehran province. This evaluation will play an important role in applying a management strategy based on future changes in climatic factors.

Materials and Methods

Site description and procedure

To investigate the changes in the flora of the weed communities of irrigated wheat fields in Tehran province based on Minbashi Moeini *et al*.'s (2008) method, a total of 52 fields in the cities of Rey, Damavand, Firouzkoh, Robat Karim, Shahriar, Islamshahr, and Varamin were investigated and re-evaluated in 2014. Geographical coordinates (longitude, latitude, and sea-level altitude) were entered into the Global Positioning System (GPS) in 2004, and the previous fields were evaluated based on these coordinates. A small number of fields in past years had crops other than irrigated wheat in their crop rotation, and wheat fields were selected within a 500-meter radius; sampling was done in each city based on the number of selected fields and each city's cultivation area (Table 1).

Sampling was conducted from mid-April to early June 2014, coinciding with mid-tillering through the beginning of spike. Within each field, we sampled at every point using a W-shaped quadrat measuring 0.5 by 0.5 meters (0.25 square meters) (Thomas, 1991, 1985; Uddin *et al*., 2009). We identified and counted weeds in each quadrat by gender and species (Uddin *et al*., 2009). For perennial weeds, density was defined as the number of stems, and for grasses, as the number of blades (Thomas *et al*., 1994).

Table 1 The number of selected fields according to the area under cultivation in the irrigated wheat fields of Tehran province.

The area under c rop cultivation in each city	The number of selected fields for sampling
Less than 500 ha	2 fields
500-1000 ha	3 fields
1000-5000 ha	4 fields
5000-10000 ha	6 fields
10000-15000 ha	8 fields
15000-30000 ha	11 fields
30000-60000 ha	15 fields
Over 60000 ha	For every 10,000 ha, one field is added to the number 15

The fields were divided into three categories by area: type A (1 to 5 hectares; 5 samples), type B (6 to 15 hectares; 9 samples), and type C (16 hectares and above; 13 samples). Using the following equations, we calculated frequency (1), uniformity (2), density (3), and average density (4) in each city.

$$1): F_k = \frac{\sum Yi}{n} \times 100$$

Fk: K species frequency (Thomas, 1991)
Yi: Presence (1) or absence (0) of K species in field number i
n: The number of fields visited

$$2): U_k = \frac{\sum_{1}^{n}\sum_{1}^{m} X_{ij}}{\sum_{1}^{m} m} \times 100$$

Uk: Uniformity of K species (Thomas, 1991)
Xij: Presence (1) and absence (0) of species K in quadrate number i in field number j
m: Number of quadrates

$$3): D_{ki} = \frac{\sum_{1}^{m} Z_j}{m} \times 4$$

Density Dki: Number of plants per square meter K species in the field (Thomas, 1991)
Zj: Number of K species in the quadrat (0.25 square meters)

$$4): MFD_{ki} = \frac{\sum_{1}^{n} D_{ki}}{n}$$

MFDk: Mean density (number of plants per square meter) K species in the field (Thomas, 1991)
DKi: The density of K species in field number i.

Statistical analysis

To determine the relationship between weed species, crop rotation, and climatic factors, we calculated indicators of frequency, uniformity, density, and dominance, and obtained management information from the last ten years (crop rotation applied) from farmers through questionnaires (Fig. 1). Climatic information (altitude above sea level, annual precipitation, annual evaporation rate, minimum, average, and maximum temperature) from the Meteorological Organization from 1995 to 2005 in limited form (only two stations of Imam Khomeini Airport and Firouzkoh city) and from 2005 to 2015 as Comprehensive was obtained in each city separately and analyzed according to the method of Veisi *et al*. (2016).

The analyzed data were entered into Excel 2007 as separate matrices. In the first matrix, rows included the sampling locations (fields of each city), and columns showed the density of the identified dominant species (Table 2) at the sampling locations (Hassannejad and Porheidar Ghafarbi, 2013; Veisi *et al*., 2014). In the second matrix, sampling locations are in the rows and the crop rotation factor is in the columns (Table 3). In the third matrix, climatic information (height above sea level, minimum, average, and maximum temperature, annual precipitation, and annual evaporation) was placed in columns and rows, along with sampling locations (fields in each city).CANOCO software ver. 4.5 was used for the analysis. First, to decide whether to use linear or unimodal grading methods, Detrended Correspondence Analysis (DCA) was performed. Because the slope was low, we performed RDA between the first and second matrices to determine the relationship between the province's 32 dominant weed species and the seven conventional crop rotations among fields. Because the relationship between the weed species and the 6 climatic indicators was non-linear, we used CCA between the first and third matrices. We used the Monte Carlo test to determine significance ($P \leq 0.05$) in the relationships among species, management factor (crop rotation), and climate factors, and we drew biplot diagrams (Leps and Smilauer, 2003).

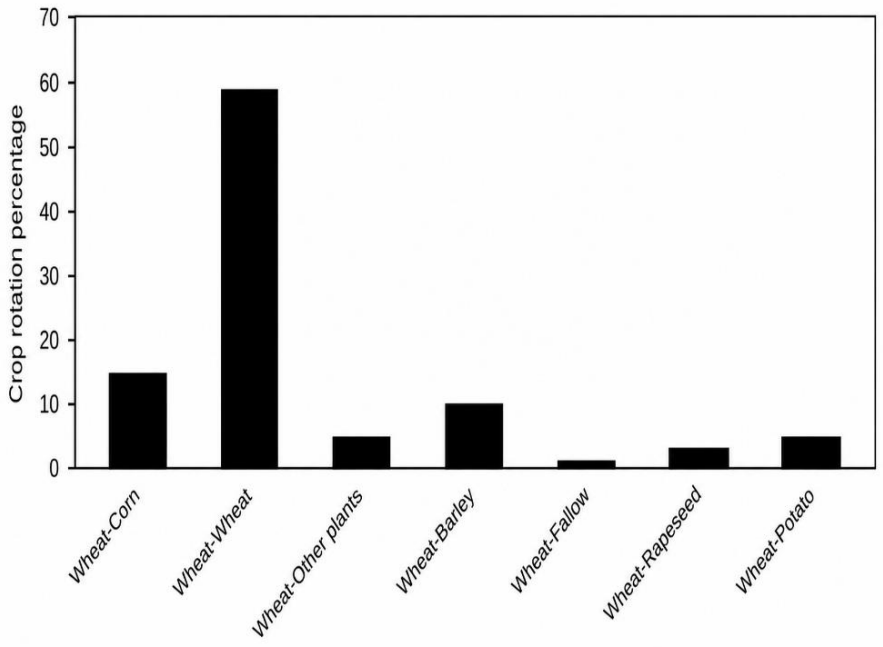


Figure 1 The percentage of crop rotation implemented in Tehran province during 2005- 2015.

Table 2 Frequency and plant code.

Scientific name	Plant code	Frequency (%)	Scientific name	Plant code	Frequency (%)
Descurania sophia (L.) Webb and Berth	Deso	74.34	*Acroptilon repens* (L.) DC.	Acre	10.93
Polygonum aviculare L.	Poav	61.65	*Thlaspi arvensis* L.	Thar	10.00
Avena ludoviciana Dur.	Avlu	59.97	*Malcolmia africana* (L.)	Maaf	8.54
Convolvulus arvensis L.	Coar	53.20	*Vicia villosa* Roth.	Vivi	9.40
Hordeum spontaneum C. Koch	Hosp	20.83	*Adonis aestivalis* L.	Adae	9.47
Fumaria vaillantii Loisel.	Fuva	30.42	*Lactuca serriola* L.	Lase	9.54
Cardaria draba (L.) Desv.	Cadr	25.28	*Carthamus oxycantha* M.B.	Caox	9.05
Galium aparine L.	Gaap	25.98	*Rumex crispus* L.	Recr	8.75
Goldbachia laevigata (M.Bieb.)	Gola	21.02	*Capsella bursa-pastoris* (L.)Medik	Cabu	6.88
Lolium rigidum Gaud.	Lori	7.01	*Sisymbrium irio* L.	Siir	7.22
Chenopodium album L.	Chal	19.65	*Senecio vulgaris* L.	Sevu	7.29
Sinapis arvensis L.	Siar	19.38	*Papaver dubium* L.	Padu	7.29
Cirsium arvense (L.) Scop.	Ciar	18.26	*Conringia orientalis* (Gay) Schrod	Coor	6.88
Lepyrodiclis holosteoides Fenzl.	Leho	14.05	*Veronica persica* Poir.	Vepe	6.76
Raphanus raphanistrum L.	Rara	11.87	*Consolida orientalis* (Willk) Losa and Rivas	Coor	6.25
Secale cereal L.	Sece	10.17	*Centaurea depressa* M.B.	Cede	6.90
Malva neglecta Wallr.	Mane	10.41			

Results

Relationship between weed species and rotation

In 2015, 67 weed species belonging to 24 plant families were identified: 56 dicotyledonous and the rest monocotyledonous. In 2015, 12 species observed in 2005 were removed from the field flora, and 16 new species belonging to 11 plant genera were identified. Brassicaceae, Poaceae, and Asteraceae were among the dominant families in the fields. The RDA analysis and biplot showed correlations among these factors; weed species distribution in wheat fields differs by crop rotation (Fig. 2).

Species density and frequency. The results showed that the first component can describe more than 28.6% of the total variance. Table 4 describes the contribution of each component in correlation and cumulative variance. The Monte Carlo test showed that, at the 0.04 level, the first component and, at the 0.008 level, the percentage of all focal components are significant (Table 5). The first component positively correlates with crop rotations of wheat with potatoes, fallow, corn, and other crops (fodder plants and legumes). It negatively correlates with wheat-wheat, barley, and rapeseed rotations (Fig. 2). Hasannejad and Pourhaider Ghafarbi (2013) found that the smallest and largest angles showed the strongest and weakest correlations, respectively. In Tehran province, wheat-wheat rotation had the highest level among other treatments (Fig. 2) and is considered the most important rotation in the spread of dominant weeds. After that, wheat is alternated with corn and barley. Weeds of Prostrate knotweed, Flixweed, Common bedstraw, Rigid ryegrass, Wild barley, and winter wild oats had the highest correlation with continuous cultivation of wheat and rotation of wheat with barley (Fig. 2).

Table 3 The percentage of common crop rotations in irrigated wheat fields in Tehran province between 2005-2015.

City	Field no	Wheat-Corn (Wh-Co)	Wheat-Wheat (Wh-Wh)	Wheat-Other plants (Wh-Ot)	Wheat-Barley (Wh-Ba)	Wheat-Fallow (Wh-Fa)	Wheat-Rapseed (Wh-Ra)	Wheat-Potato (Wh-Po)
Shahriar	1	30	50	0	20	0	0	0
	2	20	70	0	10	0	0	0
	3	20	60	10	10	0	0	0
	4	40	40	0	20	0	0	0
Islamshahr	5	30	60	0	10	0	0	0
	6	30	70	0	0	0	0	0
	7	20	60	10	20	0	0	0
	8	30	50	10	10	0	0	0
	9	10	60	0	20	0	10	0
	10	10	60	10	20	0	0	0
	11	40	60	0	0	0	0	0
	12	0	90	0	0	0	10	0
	13	30	50	0	10	10	0	0
	14	40	40	10	10	0	0	0
Robat Karim	15	10	60	0	20	0	10	0
	16	0	70	0	30	0	0	0
	17	0	80	0	20	0	0	0
Rey	18	20	60	0	20	10	0	0
	19	30	60	0	0	0	10	0
	20	0	50	10	40	0	0	0
	21	0	70	10	20	0	0	0
	22	0	50	20	20	0	10	0
	23	0	80	0	10	0	10	0
Varamin	24	30	60	0	10	0	0	0
	25	40	60	0	0	0	0	0
	26	10	60	10	20	0	0	0
	27	10	60	10	0	10	10	0
	28	0	80	0	0	0	20	0
	29	30	70	0	0	0	0	0
	30	50	50	0	0	0	0	0
	31	20	50	0	30	0	0	0
	32	20	50	0	30	0	0	0
Pakdashat	33	30	50	0	20	0	0	0
	34	0	50	0	20	20	10	0
	35	10	60	0	30	0	0	0
	36	10	60	0	0	0	30	0
	37	0	70	0	0	10	0	10
	38	30	60	0	0	10	0	0
	39	0	60	10	20	0	10	0
	40	20	70	0	0	0	0	0
	41	20	60	20	0	0	0	0
	42	30	40	10	20	0	0	0
	43	20	80	0	0	0	0	0
Damavand	44	0	50	20	10	0	0	20
	45	0	60	20	0	0	0	20
	46	0	50	10	0	0	10	30
	47	0	60	10	0	0	0	30
Firouzkouh	48	0	50	20	0	0	0	30
	49	0	40	20	20	0	0	20
	50	0	50	20	10	0	0	20
	51	0	60	10	0	0	10	20
	52	0	50	20	10	0	0	20

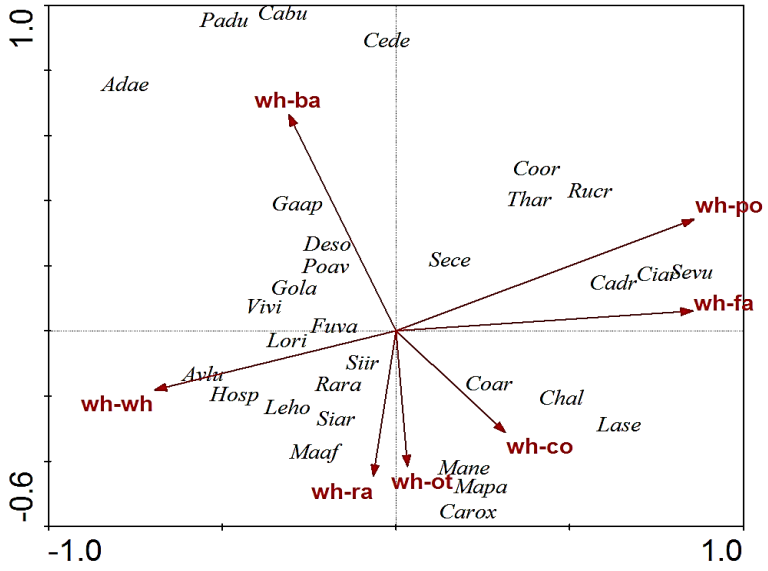


Figure 2 Biplot from the first two canonical variates describing the relationship of weed species fields and crop rotations ($p \leq 0.004$) over 2005-2015 in Tehran province.

Table 4 Eigenvalues of RDA axes that explained the variation in weed species distribution affected by rotation in wheat fields (2015).

	Weed species–Crop rotation components			
Entries	λ1	λ2	λ3	λ4
Eigenvalues	0.26	0.21	0.18	0.10
Species- rotation correlations	0.85	0.76	0.77	0.61
Cumulative percentage variance of species data	5.4	9.8	13.5	15.6
Cumulative percentage variance of species rotation	28.6	51.8	71.6	82.8

Table 5 Monte Carlo test ($p \leq 0.05$) of significance of the relationship of weed species rotation (2015).

	Rotation	
Test	F-ratio	P-value
Eigenvalues: test of significance of first canonical axis	2.507	0.04
Test of significance of all canonical axes	1.459	0.008

RDA analysis identified four significant correlations (four components) between linear combinations of weed.

The evaluation of wheat fields in Tehran province in 2015 based on the drawn bi-plot (Fig. 2) showed that Wild barley is close to the wheat-wheat rotation and it is located between the rotation of wheat and rapeseed and the continuous cultivation of wheat (wheat-wheat and wheat-rapeseed vectors) that It is a confirmation of this claim. In addition, the negative correlation of winter wild oat with rotations of wheat with corn, fallow, and potatoes shows reduced weed pressure in these rotations. Fallowing, high corn height, and a long growing season make weed control difficult and promote the spread of weeds with deep root systems. The continuous cultivation of wheat and its alternation with rapeseed had a linear and negative correlation with the dominant weeds, wild radish, wild mustard, London rocket (*Sisymbrium irio* L.), and False jagged-ckickweed (*Consolida orientalis* (Willk.) Losa and Rivas), so that False jagged-

ckickweed was one of the dominant weeds in Shahriar, Islamshahr, and Robat Karim cities and was observed with considerable frequency (Minbashi Moeini *et al*., 2008). The observation of curly dock (*Rumex crispus* L.) and field pennycress (*Thlaspi arvense* L.) had a positive correlation with wheat-potato rotation, and rye was observed between wheat-barley and wheat-potato vectors, which is one of the predominant rotations in Firouzkouh and Damavand cities (Fig. 2). The questionnaire showed that, because barley is used as livestock fodder, weed control has not been carried out well, and the distribution of Rye seeds causes this weed to dominate in subsequent cycles.

The relationship between weed species and climatic factors

The 2015 evaluation showed that the behavior of the identified weed species differs under the influence of climatic factors (average between 2005 and 2015) (Fig. 3). CCA identified four significant correlations (four components) between combinations of climatic factors and weed species density. The results of the analysis (CCA) showed that the first and second components predict more than 59.5% of the variance of the relationship between species and climatic factors (Table 6). The Monte Carlo test also showed that, at the 0.01 level, the first component and all central components are significant at the 0.001 level (Table 7).

The first component positively correlates with height, total precipitation, and evaporation, and negatively with minimum, average, and maximum temperature (Fig. 3). Across the 4 parts of the bi-plot, the evaluation showed that temperature and altitude above sea level have the greatest effect on weed distribution. In contrast, annual evaporation and total annual precipitation have the least effect. Low evaporation and precipitation can be linked to wheat wetness, which may reduce the need for precipitation by adjusting the irrigation cycle.

The biplot diagram shows that as temperature decreases in different parts of the province, narrow-leaf weed density decreases (except for Rigid ryegrass and rye) and wild mustard. Most dominant narrow-leaved weeds, except rye, are located at the opposite end of the height vector above sea level and show a negative correlation; they are more abundant in low-altitude areas of the province, whereas rye shows a positive correlation with total annual precipitation (Fig. 3).

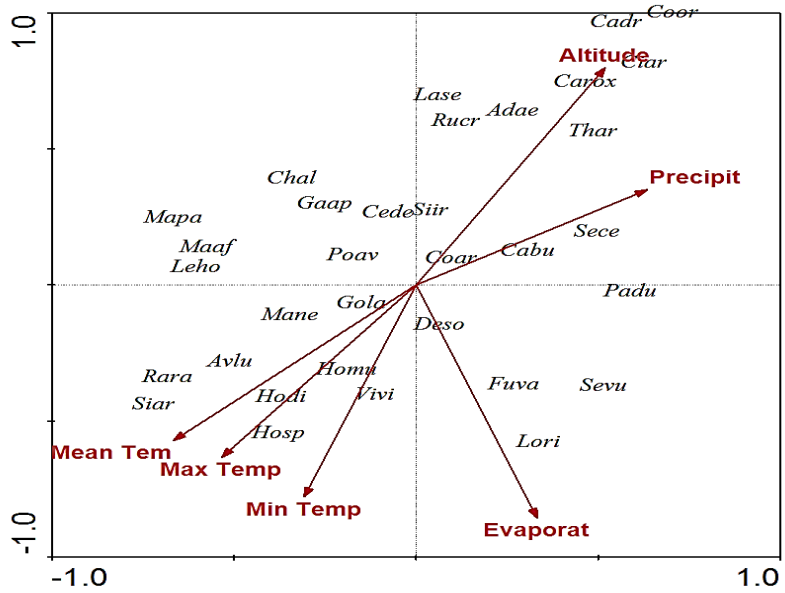


Figure 3 Biplot from the first two canonical variates describing the relationship of weed species fields and environmental factors ($p \leq 0.004$) over 2005-2015 in Tehran province.

Table 6 Eigenvalues of CCA axes that explained of the variation in weed species distribution affected by climatic factors in irrigated wheat fields (2015).

	Climatic factors and weed species components			
Entries	λ1	λ2	λ3	λ4
Eigenvalues	0.288	0.149	0.127	0.072
Species- climate correlations	0.859	0.70	0.622	0.655
Cumulative percentage variance of species data	5.8	8.8	11.4	12.8
Cumulative percentage variance of species- climate	39.2	59.5	76.8	86.6

Table 7 Monte Carlo test ($p \leq 0.05$) of significance of the relationship of weed species and Climatic factors (2015).

	Weed species and climatic factors	
Test	F-ratio	P-value
Eigenvalues: test of significance of first canonical axis	2.755	0.001
Test of significance of all canonical axes	1.951	0.01

Weeds such as hare's ear mustard (*Conringia orientalis* L.), hoary cress (*Cardaria draba* L.), and common name field pennycress have a positive correlation with high altitude, and these weeds were more frequently observed in Damavand and Firouzkoh cities. Other weeds, such as common knotgrass (*Polygonum aviculare* L.), catchweed bedstraw (*Galium aparine* L.), false jagged-cockle (*Lepyrodiclis holosteoides* Fenzl), and common mallow (*Malva neglecta* Wallr.), which were not related to any of the climatic factors, are distributed throughout the country, compatible with all climates. Their frequency and density seem to be less affected. It is one of the climatic factors; other factors, such as soil characteristics or human management practices like the use of agricultural inputs, may also influence the distribution and adaptation of these weeds.

Discussion

According to Hassannejad and Porheidar Ghafarbi(2013) and Veisi *et al*. (2014), the closer the weeds are to a vector, the greater the increase in the density of that weed when this management factor is considered; the farther the distance between the weeds and the vector is, the lower the effect of this factor on the increase in weed density. In an experiment in Fars province, successive cultivation of wheat and wheat with rapeseed had the highest seedling density in alternate years (Jamali and Joukar, 2010). An evaluation of the weed flora of Kermanshah province in 2012 showed that sugar beet-corn rotations best reduced weed density in the province's wheat fields (Veisi *et al*., 2014). According to Parpinchi *et al*.'s (2011) report in Golestan province, winter wild oat density was high in wheat-wheat rotation and rapeseed-wheat rotation in the treatment without wheat weed control. It should be mentioned that shortspike canarygrass (*Phalaris brachystachys* L.) showed the highest density in the pea-wheat rotation. In wheat-corn and wheat-fallow rotations in the fields of the province, weeds such as field bindweed (*Convolvulus arvensis* L.), Lamb'squarter (*Chenopodium album* L.), prickly lettuce (*Lactuca serriola* L.), hoary cress (*Cardaria draba* L.), Canada thistle (*Cirsium arvense* L.), and groundsel are closely related to these rotations, and in wheat cultivation they appear dominant.

The emergence of weed species with a family resemblance or a life cycle compatible with crops leads to more of these weeds in crops (Rashed Mohassel *et al*., 2005). Seyedi Vafaei *et al*. (2011) believe that rapeseed is not a strong competitor with weeds in the early stages of growth because of its slow growth and delayed coverage of the soil surface. Safahani Langerodi *et al*. (2008) state that wild mustard is one of the most common weeds in rapeseed fields in Golestan province, and no effective, economically justified method exists to control it

in rapeseed; in subsequent rotations, it appears as a dominant weed.

In Chhokar and Sharma (2008) in India, they found that cultivating vegetables such as beans and potatoes in crop rotation reduces weed populations in wheat fields. Scursoni *et al*. (2014) believe that using crop rotation in weed management prevents uniformity and homogenization of agricultural ecosystems for one or more specific weed species. Some studies indicate that crop rotation, compared with plowing, has a greater effect on weed flora and frequency (Dorado et al., 1999). Rashed Mohassel *et al*. (2005), in investigating the effects of different rotations, concluded that implementing different rotations reduces weed density.

Glemnitz *et al*. (2006) believe that irrigation in wheat fields reduces the effectiveness of annual rainfall. Mottaghi et al. (2012) reported that height above sea level, annual rainfall, and average annual temperature affect the density of rye and wild oat weeds. Mottaghi *et al*. (2012) state that height above sea level and total annual rainfall are the most influential factors in rye distribution. In the 2015 assessment, rye was observed only in Damavand and Firouzkoh cities, which had higher rainfall and higher altitude. Rigid ryegrass, Common fumitory, and groundsel showed a positive correlation with annual surface evaporation. It was observed mostly in the warmer regions of the province with higher annual evaporation, such as Robat Karim, Rey, and Varamin cities. An assessment of 2012 weed flora changes in Kermanshah province showed that rye density positively correlated with the annual evaporation rate (Veisi *et al*., 2016). Khademol-Hoseini *et al*. (2007) believe that increased elevation above sea level affects plant communities directly by reducing temperature and indirectly by affecting soil formation.

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Disclosure statement

The authors declare no conflicts of interest.

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تأثیر تناوب زراعی و عوامل اقلیمی در تغییرات فلور علف‌های هرز مزارع گندم آبی *Triticum aestivum*

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چکیده: در این مطالعه ارتباط تناوب زراعی و عوامل اقلیمی در تغییر فلور علف‌های هرز ۵۲ مزرعه گندم آبی در هفت شهرستان استان تهران طی یک دهه (۱۳۸٤ تا ۱۳۹٤) مورد بررسی قرار گرفت. فراوانی، یکنواختی، تراکم و شاخص غالبیت گونه‌های هرز محاسبه شد و رابطه آن‌ها با تناوب‌های اعمال شده و عوامل اقلیمی مورد تجزیه‌وتحلیل قرار گرفت. تجزیه چندمتغیره کاهشی (RDA) و کانونی (CCA)، حاکی از چهار هم‌بستگي معني‌دار بود به‌طوری‌که در تجزیه کاهشی مجموع دو مؤلفه اول و دوم بیش از ۵۱/۸ درصد واریانس ارتباط بین حضور گونه‌های علف هرز و تناوب‌هاي زراعي و هم‌چنین در تجزیه کانونی دو مؤلفه اول و دوم بیش از ۵۹/۵ درصد واریانس ارتباط بین گونه‌ها و عوامل اقلیمی را پیش‌بیني نمود. در مناطقي که بیش‌ترین کشت متوالی گندم و تناوب گندم با جو را داشتند، تراکم بالایي از علف‌هاي هرز خاکشیر معمولی، هفت بند، چچم، جودره و یولاف وحشی زمستانه مشاهده شد. کشت‌وکار مداوم گندم و تناوب آن با کلزا هم‌بستگي خطي و منفی با علف‌هاي هرز غالب درشتوک، تربچه وحشی و خردل وحشی داشت. نتایج نشان داد که دمای محیط و ارتفاع از سطح دریا بیش‌ترین تأثیر را بر روی پراکنش علف‌های هرز داشت و کم‌ترین تأثیر متعلق به تبخیر سالیانه و مجموع بارش سالیانه بود. علف‌های هرز چچم، شاتره و پیرگیاه، هم‌بستگی مثبت و معنی‌داری با تبخیر سطحی سالیانه داشتند.

واژگان کلیدی: تراکم، بارش باران، شاخص یکنواختی، ترکیب علف‌های هرز