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Correlation between weeds and crops

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Abstract

In order to survey the effects of some crops (allelopathic and non allelopathic) on weed population, an experiment was done with sowing of seven different crops in 2012 at field research of University of Tabriz. Treatments were corn (*Zea mays* L.), sunflower (*Helianthus annus* L.), common beans (*Phaseolus vulgaris* L. var 1 and *Phaseolus vulgaris* L. var 2), castor bean (*Ricinus communis* L.), chicken pea (*Cicer arientinum* L.), and Lallemantia (*Lallemantia iberica* L.). Sampling of weed density in each plot was done in four times. Canonical correspondence analysis (CCA) showed that crop species can effect on weed species density. So that, the first two CCA axes explained 93.2, 82.5, 88.5, and 81.3 % of the variation in weed species density in sampling times 1, 2, 3, and 4, respectively. For example in the first sampling, the first axis of CCA represents a gradient of *Cicer*, *Ricinus*, *Helianthus* and the second axis represents a gradient of *Ricinus*, *Cicer*, *Phaseolus* 2, *Phaseolus 1*, and *Lallemantia*. So that, *Lallemantia* and *Phaseolus 1*, also *Helianthus* and *Zea* vectors with minimum angle, showed that these crops had maximum correlation each other, but *Cicer* and *Zea* vectors with maximum angle, showed they had minimum correlation together. Lamb,s squarters (*Chenopodium album* L.) and prostrate knotweed (*Polygonum aviculare* L.) were dominant weed species observed in the beginning and ending of crops life cycle, respectively. In forth sampling, *Ricinus* plots were weed free, this is may be duo to interference (competition and allelopathy) presented with *Ricinus* and weeds.

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Introduction

Weeds are unwanted plants growing in the crop fields affecting them through competition for space, nutrients, sunlight, water and carbon dioxide. These unwanted plants can have a harmful effect on crop quality as well as quantity. Understanding the correlation between crops and weeds in agro ecosystems is very important. Presence, growth, and population density of weed species in each filed is strongly associated with agricultural practices. Investigations showed that a variety of factors can affect the existence of weed species (Dale *et al.* 1992; Salonen 1993; Andersson and Milberg 1998; Marshall *et al.* 2003). For example, the choice of crops, crop rotations, fertilizing, and weed management methods are the main factors that change weed community structure (Chancellor 1985; Froud-William 1987). Crop rotations can help to disrupt association between weeds and crops, duo to disturb mimicry behavior of weeds with life history of the crops. Certain crops with allelopathic effects can suppress the growth of neighboring plants. Sunflower, fall rye, alfalfa, and barley are some allelopathic crops that suppress growth of certain weeds (Bertholdsson, 2005).

The effects of environmental factors on weed communities, such as species shifts can be done by multivariate analysis of weed communities (Kenkel *et al.* 2002). Multivariate analyses allow the researcher to simultaneously analyze multiple measurements on each object under investigation (Kenkel *et al.*, 2002). Multivariate analyses like canonical correspondence analysis (CCA) can be applied to analyses of the occurrence and distribution of weed communities (Post 1988; Salonen 1993; Dieleman *et al.* 2000a, 2000b; Kenkel *et al.* 2002). CCA is a direct gradient analysis that is the most frequently used to describe weed communities as affected by environmental variables (Kenkel *et al.*, 2002), also CCA is a data analysis method that represents correspondences between two or more sets of measurements. By using this method, researchers have survey the floristic composition and relative abundance of weeds, the influence of some management methods like crop rotation, tillage, herbicide usage and fertilizer application on dynamics of weed populations (Thomas 1991; Pysek and Leps 1991; Hume *et al.* 1991; Ball 1992; Thomas and Frick 1993; Derksen *et al.* 1993, 1995; O'Donovan *et al.* 1997; Barberi *et al.* 1997; Andersson and Milberg 1998; Legere and Samson 1999; Dieleman *et al.* 2000a; Leeson *et al.* 1999, 2000). Thus, the main objective of this study was to survey relationships between kinds of crops and weed population density with canonical correspondence analysis.

Material and methods

Experimental site and procedure

This study was conducted in 2012 at the field research of Tabriz University, Iran ($38^{\circ}01'$ North latitude, $46^{\circ}25'$ East longitude, with altitude 1676 meters). The soil type was loam with 42.4% sand, 38% silt, 19.6% clay, 0.17% organic matter, PH 7.4 and Ec 0.93 ds/m. In order to determine the effects of different crops on weed species presence and their density, and understating relationship between crops planted in each plots and their weeds, an experiment was carried on the basis complete randomized block design with four replications. Corn (*Zea mays* L.), sunflower (*Helianthus annus* L.), common beans (*Phaseolus vulgaris* L. var 1 and *Phaseolus vulgaris* L. var 2), castor bean (*Ricinus communis* L.), chicken pea (*Cicer arientinum* L.), and Lallemantia (*Lallemantia iberica* L.) were planted as crop species. Seeds of these crops were sown in the same time, same distance (30 cm × 30 cm) and in the plots with same size (3 m × 4 m).

Measuring of treatments and Statistical analysis

Sampling of weeds was done within the quadrats 0.5 m × 0.5 m in each plot. Weed species in each quadrat were identified, counted, and recorded for subsequent data entry and analysis. After weed species density were determined in each plots, we arranged the samples into first matrix where weed species are represented by columns and plots by rows. Also, in second matrix, crop species are represented by columns and plots by rows. Data on weed species density and crops presence or absent in all plots were analyzed through with ordination methods like canonical correspondence analysis (CCA), also weeds and crops distribution and their correlation displayed in ordination diagrams. These ordination methods were done for weed species that were nearly observed in all replication of each treatment. For CCA, CANOCO software (Version 4.5) was used. The association between weed species composition and some main environmental factors were examined with CCA by other researches (Ter Braak, 1986, 1987). Ordination plots were produced for both sampling quadrats and weed species associated with crop species.

Results and discussion

The results of CCA clearly demonstrated the correlation between crops and weed species. CCA showed that crops can effect on weed species density. So that, the first two CCA axes explained 93.2, 82.5, 88.5, and 81.3 % of the variation in weed species density in sampling times 1, 2, 3, and 4, respectively (Table 1).

Table 1. Eigenvalues of the first two CCA axes that explained of the variation in weed species distribution affected by crop species. All four eigenvalues reported in this table are canonical and correspond to axes that are constrained by crop and weed species.

Axes	First sampling		Second sampling		Third sampling		Fourth sampling	
	1	2	1	2	1	2	1	2
Eigenvalues	0.078	0.025	0.09	0.024	0.121	0.032	0.124	0.055
Species-environment correlations	0.977	0.917	0.935	0.877	0.958	0.972	0.93	0.922
Cumulative percentage variance of species data	56.7	74.6	49.5	62.8	59.7	75.5	44.1	64.0
Cumulative percentage variance of species-environment relation	70.8	93.2	65.1	82.5	70.0	88.5	56.1	81.3

Table 2. Weighted correlation matrix (weight= sample total) between crop species with CCA axes output by CANOCO (Version 4.5)

	First Sampling		Second Sampling		Third Sampling		Fourth Sampling	
	axes 1	axes 2	axes 1	axes 2	axes 1	axes 2	axes 1	axes 2
Cic.	0.9251	0.293	-0.5357	0.4786	-0.548	0.0347	-0.3637	0.3147
Lal.	-0.1056	-0.239	0.3371	0.0667	0.1262	0.7758	0.1745	-0.3869
Rci.	-0.4100	0.6494	0.3704	-0.0586	0.5091	-0.4016		
Zea.	-0.1845	0.0829	0.1879	-0.1024	0.3135	0.2062	0.4787	-0.3977
Hel.	-0.2157	0.1259	0.3773	0.5143	0.4030	-0.3082	0.6524	0.6390
Pha.ch	0.0201	-0.5896	-0.5685	-0.2060	-0.4891	-0.4398	-0.2050	0.2602
Pha.	-0.0917	-0.2667	0.0768	-0.5799	0.0921	0.1122	0.0554	-0.2794

In the first sampling time (two weeks after crops emergence), six weed species were observed in plots (Fig. 1 & 2). CCA axis 1 was positively correlated with Cicer and negatively correlated with *Ricinus* and *Helianthus* (Table 2 and Fig. 1). CCA axis 2 was positively correlated with *Ricinus* and *Cicer* and negatively correlated with *Phaseolus* 2, *Phaseolus* 1, and *Lallemantia* (Table 2 and Fig. 1). The first axis represents a gradient of *Cicer*, *Ricinus*, *Helianthus* and the second axis represents a gradient of

Ricinus, *Cicer*, *Phaseolus* 2, *Phaseolus* 1, and *Lallemantia* (Table 2 and Fig. 1). The closeness of weed species to a particular vector (crops vector) indicates that these weed species are likely to occur more often with increases this vector or weed species density increases when this crop is present. On the other hand, weed species are far from the particular vector (crops vector), by present this crops were decreased (Fig. 1).

Crops with minimum and maximum angle between their vectors, have maximum and minimum correlation each other in weed species observed in their plots (Fig. 1). For example, *Lallemantia* and *Phaseolus*, also *Helianthus* and *Zea* vectors with minimum angle, showed they had maximum correlation each other. *Cicer* and *Zea* vectors with maximum angle each other, showed they had minimum correlation together (Fig. 1). bindweed (*Convolvulus arvensis* L.) as a weed specie that preferring Cicer is located at the right side of the CCA diagram, this weed had maximum correlation with Cicier (Fig. 1). While green foxtail (*Setaria viridis* (L.) P. Beauv.*)* with maximum density was observed in *Helianthus* and *Zea* plots. Lamb,s squarters (*Chenopodium album* L.), red root amaranth (*Ammaranthus retroflexus* L.), and prostrate knotweed (*Polygonum aviculare* L.) are weeds that found in all crop plots, so that these weed species had highest correlation with all crops planted in this experiment (Fig. 1). *Cheopodium* had highest density in all plots (Fig. 2). This subject indicated that our field research is intensely infested by *Cheopodium*, and this is due to soil's type our research filed. *Setaria.* as only crass weed observed in plots, used from free spaces in Ricinus plots and was dominant in this plot in the first sampling time (Fig. 2). Because this crop was very weaker in positioning compare with *Setaria* in Tabriz climate. Surveys showed that in the first sampling time (two weeks after crops emergence), crops such as *Cicer*, *Phaseolus 2*, and *Ricinus* are weaker than others (Fig. 1). On the other hands, *Helianthus* and *Zea* are crops that have minimum weed density in the first sampling time, because these crops are powerful in beginning of their life cycle (Fig. 1). Observations showed that mergence of these two crops were sooner than other crops.

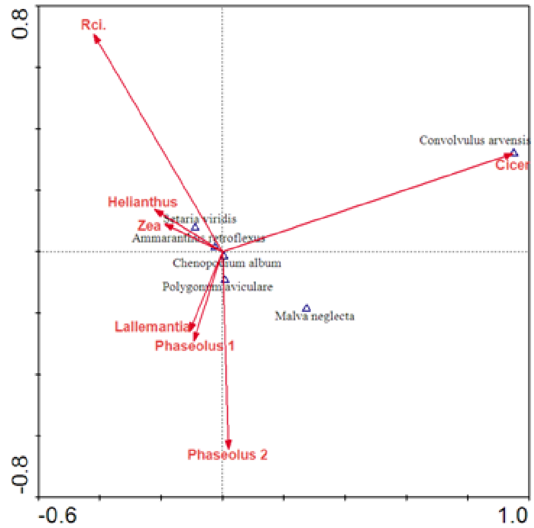

Fig. 1. Biplot from the first two canonical variates describing the relationship of weed species and crops in the first sampling time (two weeks after crops emergence).

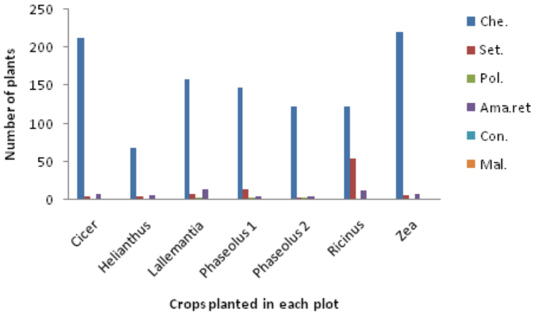

Fig. 2. Weed species observed in each crop plots and their density in the first sampling time. Che (*Chenopodium album* L.), Set. (*Seraria viridis* (L.), P. Beauv.), Pol. (*Polygonum aviculare* L.), Ama.ret (*Ammaranthus retroflexus* L.), Con. (*Convolvulus arvensis* L.), and Mal. (*Malva neglecta* Wallr.).

In the second sampling time (four weeks after crops emergence), seven weed species were observed in all plots (Fig. 3 & 4). CCA axis 1 was positively correlated with *Helianthus*, *Ricinus*., and *Lallemantia* and negatively correlated with *Phaseolus 2* and *Cicer* (Table 2 and Fig. 3). CCA axis 2 was positively correlated with *Helianthus* and *Cicer*, and negatively correlated with *Phaseolus* 1(Table 2 and Fig. 3). Weed species density were reduced in this time compare with first sampling, but *Chenopodium* had highest density in all plots (Fig. 4). *Malva* had highest correlation with *Phaseolus 2*, also prostrate amaranth (*Ammaranthus blitoides* S. Watson) and *Polygonum* observed with highest density in *Phaseolus 2* plots (Fig. 3 & 4).

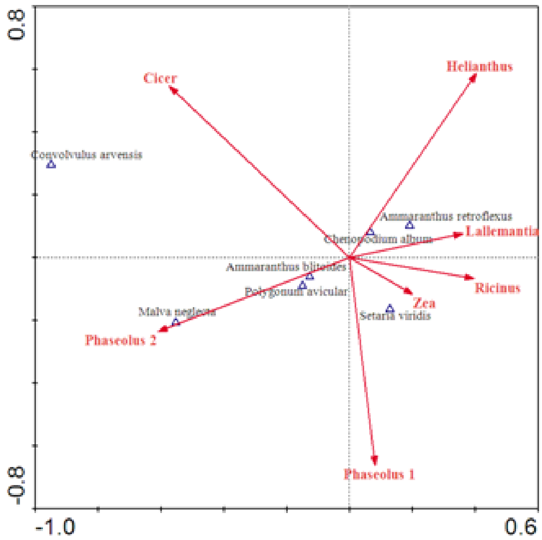

Fig. 3. Biplot from the first two canonical variates describing the relationship between weeds and crops, in the second sampling time (one month after crops emergence).

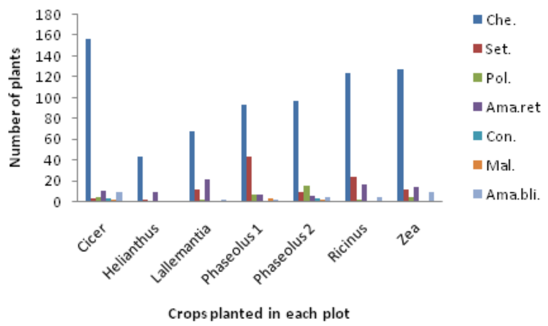

Fig. 4. Weed species observed in each crop plots and their density in the second sampling time (one month after crops emergence). Che (*Chenopodium album* L.), Set. (*Seraria viridis* (L.), P. Beauv.), Pol. (*Polygonum aviculare* L.), Ama.ret (*Ammaranthus retroflexus* L.), Con. (*Convolvulus arvensis* L.), Mal. (*Malva neglecta* Wallr.), and Ama.bli (*Ammaranthus blitoides* S. Watson).

In the third sampling time (six weeks after crops emergence), eight weed species were observed in all plots (Fig. 5 & 6). CCA axis 1 was positively correlated with *Ricinus*, *Helianthus*, and *Zea* and negatively correlated with *Cicer* and *Phaseolus 2* (Table 2 and Fig. 5). CCA axis 2 was positively correlated with *Lallemantia* and negatively correlated with *Phaseolus 2*, *Ricinus*, and *Helianthus* (Table 2 and Fig. 5). Weed species density were reduced in this time compare with first and second sampling. *Polygonum*, *Ammaranthus retroflexus* and *Setaria* like *Chenopodium* were dominant weeds in all treatments, without any antattention to kind of crops (Fig. 6). *Ammaranthus blitoides* and *Malva* not founded in *Ricinus*, and *Helianthus* plots, so these weeds are located in opposite of *Ricinus*, and *Helianthus* vectors (Fig. 5 & 6). Russian thistle (*Salsola kali* L.) and bindweed (*Convolvulus arvensis* L.) were founded in *Phaseolus 2* and *Cicer* plots, so that these weed species were located between *Phaseolus 2* and *Cicer* vectors (Fig. 5 & 6). *Ricinus* and *Helianthus* are crops that had highest correlation with weed species observed in their plots, because these crops vectors had minimum angle together (Fig. 5).

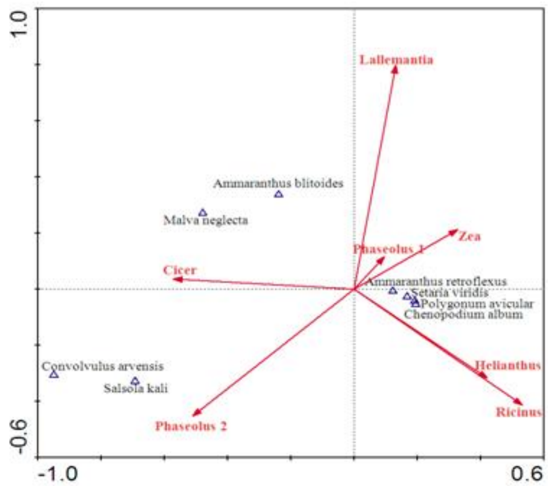

Fig. 5. Biplot from the first two canonical variates describing the relationship between weeds and crops, in the third sampling time (six weeks after crops emergence).

In the fourth sampling time (10 weeks after crops emergence), eight weed species were observed in all plots (Fig. 7 & 8). CCA axis 1 was positively correlated with *Helianthus* and *Zea*, and negatively correlated with *Cicer* and *Phaseolus 2* (Table 2 and Fig. 7). CCA axis 2 was positively correlated with

Helianthus, *Cicer* and *Phaseolus 2*, but this axis negatively correlated with *Lallemantia*, *Zea*, and *Phaseolus 1* (Table 2 and Fig. 7). In this sampling, *Ricius* plots were weed free, so that in CCA biplot, Ricinus vector was not observed (Fig. 7 & 8). In *Helianthus* plots only Set. and *Chenopodium* were found. *Polygonum* was dominant weed species in *Phaseolus 2*, *Phaseolus 1*, *Cicer* and *Lallemantia* plots, while this weed was not found in Ricinus, *Zea* and *Helianthus* plots, therefore this weed was located between *Phaseolus 2*, *Phaseolus 1*, *Cicer* and *Lallemantia* vectors in CCA biplot (Fig. 7 & 8). *Malva* as like as *Polygonum* was not observed in *Ricinus*, *Zea* and *Helianthus* plots (Fig. 7 & 8).

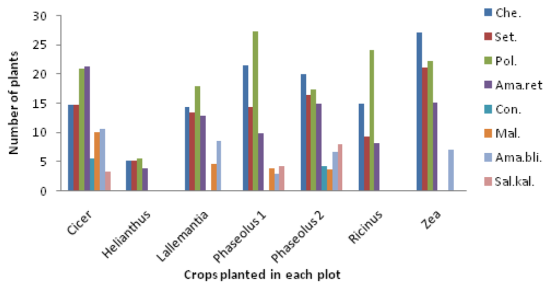

Fig. 6. Weed species observed in each crop plots and their density in the third sampling time (six weeks after crops emergence). Che (*Chenopodium album* L.), Set. (*Seraria viridis* (L.), P. Beauv.), Pol. (*Polygonum aviculare* L.), Ama.ret (*Ammaranthus retroflexus* L.), Con. (*Convolvulus arvensis* L.), Mal. (*Malva neglecta* Wallr.), Ama.bli (*Ammaranthus blitoides* S. Watson), and Sal.kal. (*Salsola kali* L.).

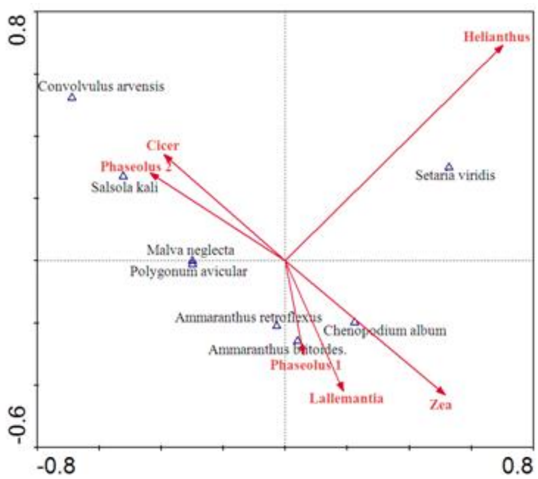

Fig. 7. Biplot from the first two canonical variates describing the relationship between weeds and crops, in the fourth sampling time (10 weeks after crops emergence). Weed species observed in this sampling are same with third sampling time.

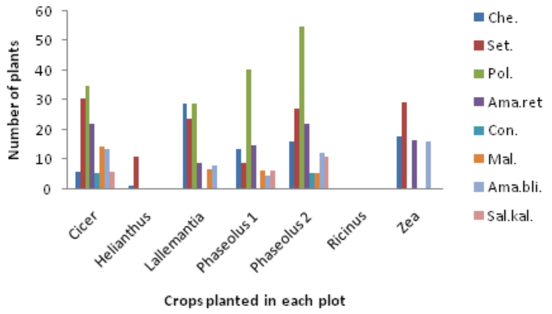

Fig. 8. Weed species observed in each crop plots and their density in the fourth sampling time (10 weeks after crops emergence). Che (*Chenopodium album* L.), Set. (*Seraria viridis* (L.), P. Beauv.), Pol. (*Polygonum aviculare* L.), Ama.ret (*Ammaranthus retroflexus* L.), Con. (*Convolvulus arvensis* L.), Mal. (*Malva neglecta* Wallr.), Ama.bli (*Ammaranthus blitoides* S. Watson), and Sal.kal. (*Salsola kali* L.).

Conclusion

In this research we found that weed species presence in each plot can duo to kind of crops planted in plots. Although presence or absent of each weed in each plot can duo to weed seed bank. Result of this survey showed that some weeds with extensivly ecological need can growth in different niches and microclimates under and between crop rows. Chancellor (1985) and Froud-William (1987) in their researches showed that selecting of crops can change weed population structure. Also, results showed that some weed species such as *Chenopodium* is aggressively occupied plots in beginning of crop life cycle, while it's density will reduced by increasing crop canopy and presence of other weed species. Weeds often mimic the life history of the crops, so crop rotations can help to disturb correlation between crop and weeds. Some crops can interference with weeds by competition and allelopathy. In this experiment, we found that *Helianthus* and *Zea* can compete with weeds and suppress their growth, because fast germination and emergence. On the other hands, investigations showed that these two crops have allelopathic effects on weeds (Patrick and Koch, 1958; Guenzi and McCalla 1962; Bertholdsson, 2005). Allelopathic effects of shoot and root extracts on the seed germination and early seedling growth have been frequently reported (Tanveer *et al.*, 2008). Perception the response of weeds to allelopathic plants in weed control methods is very important, because we have a complex agro-ecosystems that allelopathy plays an important role in their (Hassannejad et al., 2013 a, b). Understanding harmful or useful interactions between crop-weed communities plays an important role in integrated weed managements (IWM) systems.

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