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Quantifying the effects of altitude and soil texture on weed species distribution in wheat fields of Tabriz, Iran

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Abstract

Correlations between weed species prsence with altitude and soil texture data were investigated in 42 wheat (*Triticum aestivum* L.) fields of Tabriz county (northwest of Iran) in spring 2014. Canonical correspondence analysis (CCA) was used to find relationships between presence and absence of weeds in wheat fields with altitude data received by GPS and soil texture (sand, silt, ans clay) data taken from soil analysis of each field. In this research, 97 weed species were observed. CCA showed that altitude and soil texture can effect on weeds distribution in wheat fields. The first two CCA axes explained 76.7% of the variation in weed species distribution. The first axis had positive correlation with altitude (0.97%) and secondary axis had positive correlation with sand content of the soils (0.84%). Silt and clay vectors were located in opposite of sand vector. Altitude of the fields had highest effect in weeds distribution. Maximum richness was observed in low altitudes. By increasing of field's altitude, species diversity was decreased. *Convolvulus arvensis*, *Acroptilon repens*, and *Chenopodium album* that were observed in the center of CCA biplot, as a dominant and noxious weeds with wide ecological needs were founded in wheat fields with different soil texture and altitude (1320 until 1960 m asl).

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Introduction

Yield losses from weeds and the effectiveness of control measures depend largely upon the weed species present (Kent *et al.* 2001). Weed species composition, species richness, and weed communities structuring and functioning may vary considerably among fields due to differences in environmental conditions and agricultural management (Le Coeur *et al.*, 2002; Marshall and Moonen, 2002; Hassannejad and Porheidar Ghfarbi, 2013). Co-evolution between weed communities and cropping systems, allowing them to adapt to highly disturbed environments (Martinez-Ghersa *et al.*, 2000; Poggio *et al.*, 2004).

Management factors which affect the composition of the weed flora include tillage, water control, soil fertility, crop rotations, sowing time and methods, and herbicide use (Moody 1996; Dieleman *et al.* 2000; Leeson *et al.* 2000; Hassannejad and Porheidar Ghafarbi 2013). Management methods between crops compare environmental parameters had little effect on weed community structure. For example, Suarez *et al.* (2001) have shown that management differences between maize (*Zea mays* L.) and soybean (*Glycine max* (L.) Merr.) had little effect on weed community structure. Investigations showed that environmental factors have an important affect on weed communities. According to Lososova *et al.* (2004), altitude and associated climatic factors are the most important variables. Management methods, soil fertility and some of environmental parameters may be changed during the time, however altitude and soil texture are constant. Assessment of weed species distribution with constant characteristics of the area helps us in finding the native species. Knowledge about noxious weed species ecological needs can help us to moderated these troublesome species. The purpose of this study was to determine the effect of altitude and soil texture on weed species distribution in wheat fields of Tabriz-Iran.

Materials and methods

Survey of area

The study site was located in northwest of Iran from 35°7´ latitude and 46°26´ longitude. The climate is cold and semi-aired, with annual average rainfall ranges 289mm, mean annual temperature is 12.5 ◦C, and annual sunshine hours 2794.3 (Hassannejad and Porheidar Ghafarbi, 2013).

Data sampling

We selected 42 wheat fields in 14 different districts of various aspects of Tabriz County in 2014. Time of sampling was started by beginning of stem elongation until the end of heading stages of wheat (Minbashi *et al.*, 2008). Longitude, latitude, and elevation information of each wheat field was recorded using the Global positioning system (GPS). Weed sampling method in each field was according to the methodology defined by Thomas (1985), so that 20 quadrates (0.25 m^2) were randomly placed along a "W" pattern (5 quadrates 0.5 m × 0.5 m were located in each line of this pattern). Density and cover percentage of all weed species in each quadrat were recorded for subsequent data entry and analysis. Soil samples were collected at 0 -20 cm depth. The collected weed specimens were catalogued, pressed, and identified with the help of flora Iranica (Rechinger, 1963-2007) and Turkey (Davis, 1965-85). Our object was to ordinate and compare of weed species distribution between fields, thus we used soil real data by soil sample analysis for each field. The geographical latitude, longitude, and altitude of the each field measured by a GPS receiver.

Multivariate analysis

Data of weed species presence in wheat fields at different districts of Tabriz county with altitude and soil texture of each field were collected and analyzed through canonical correspondence analysis (CCA) in order to find relationships between weeds distribution and environmental factors. CANOCO v. 4.5 (Plant Research International, Wageningen, The Netherlands) was used for CCA ordination.

Results and discussion

The results of CCA showed relationships between 97 weed species observed with altitude and soil textures of 42 wheat fields surveyed. CCA ordination biplot was shown in Fig. 1. The first two CCA axes explained 76.7% of the variation in weed species distribution, so that the primary axis of CCA had positive correlation with altitude (0.97%), and the secondary axis had positive correlation with sand percentage of soil (0.84%) (Tab. 1 and Fig. 1). In contrast, the second axes had negative correlation with silt and clay content of Tabriz wheat field's soil (Tab. 1 and Fig. 1). Altitude ranged between 1320 and 1960 m asl. Altitude with longer vector than others had the highest effect on weed species distribution. So that, in wheat fields with minimum elevation, maximum weed species was observed. Species richness were lower in districts with high altitude (Tab. 3 and Fig. 1). In order to second axis, there seemed to be a close relationship between silt and clay. But according to third axis, these two factors were located in opposite of each other (Fig. 1 and Tab. 2).

Tabel 1. Variance extracted for first three axes of CCA from CANOCO version 4.5 programs.

	First axis	Second axis	Third axis
Eigenvalues	0.476	0.210	0.142
Species-environmental correlations	0.974	0.867	0.728
Cumulative percentage variance of species data	7.6	10.9	13.2
Cumulative percentage variance of species-environment relation	53.2	76.7	92.5

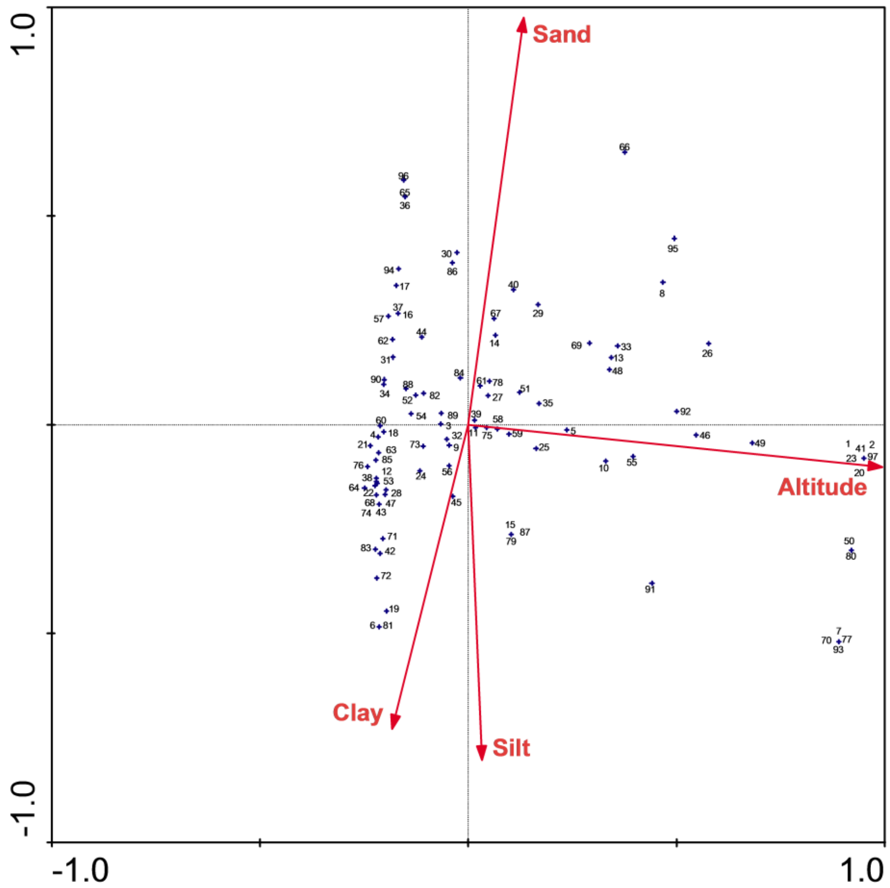

Fig. 1. CCA analysis biplot to show correlation between weed species distribution with wheat fields altitude and soil texture in Tabriz county.

Ordination of weed species with CCA showed that *Achilea bibersteimii*, *Achillea millifolium*, *Boissera squrrosa*, *Bupleurum rotundifolium*, *Cousunia calocephala*, and *Zygophyllum fabago with codes 1, 2, 20, 23, 41, and 97, respectively* are belonged to wheat fields located in high altitudes (in field 40 with 1960 m asl). Also species such as *Euphorbia chrirdenia*, *Eryngium billardiere*, and *Gypsophila leioclada* with codes 49, 46, and 55, respectively had correlation with altitude (Fig. 1 and Tab. 3).

Relationships of weed species such as *Alium ampeloprasum*, *Aegilops cylidrica*, *Koelpinia linearis*, *Rapistrum rugosum*, and *Alium atreviolaceum* 10, 5, 59, 58, 75, and 11, respectively that located near the altitude axis, but also close to the center of CCA biplot was gradually reduced (Fig. 1 and Tab. 3). In contrast, some species likes *Adonis aestivalis*, *Chorispora iberica*, *Lithospermum arvensis*, *Trifolium repens* with codes 4, 34, 60, and 90, respectively were founded in wheat fields with minimum altitude (1320 to 1354 m asl) (Tab. 3 and 4, Fig.1). *Aeluropus lithoralis*, *Sclerochloa woronowii*, and *Bellevalia pycantha* with codes 6, 81, and 19 respectively, had maximum correlation with clay, so that these weeds were founded in the fields with maximum clay in soil texture. *Ammi visnaga*, *Stipa pennata*, and *Salvia nemerosa* had correlated with silty soils (Fig. 1 and Tab. 3). Also, CCA biplot shown in Fig. 1 explain that which weed species has the highest correlation with sandy soils and which ones has relationship with all factors (Fig. 1 and Tab. 3).

Weed species such as *Convolvulus arvensis*, *Alium atreviolaceum*, *Koelpinia linearis*, *Rapistrum rugosum*, *Acroptilon repens*, *Chenopodium album*, *Tragopogon graminifolius*, and *Alhagi persarum* with codes 39, 11, 58, 75, 3, 32, 89, and 9 that are observed in the center of CCA biplot, had correlated with all factors (Fig. 1 and Tab. 3). These weeds with wide ecological amplitude were founded in the most wheat fields of Tabriz county. *Acroptilon repens*, *Convolvulus arvensis*, and *Chenopodium album* with codes 3, 39, and 32, respectively are dominant weeds that were founded in wheat fields with minimum to maximum altitude (1320 to 1960 m asl) and in the soils with different texture. These 3 weeds were observed in 90.48, 76.19, and 71.43 percentages of surveyed fields, respectively (Fig. 1 and Tab. 3).

Table 2. Correlation of CCA axes with altitude, soil texture (silt, clay, and sand percentage) and weed species distributions of wheat fields of Tabriz county.

Environmental factors	First axis	Second axis	Third axis
Altitude	0.97	-0.09	-0.012
Clay	- 0.18	-0.63	0.48
Sand	0.13	0.84	-0.13
Silt	0.03	-0.70	-0.37

Table 3. Weed code (used for CCA analysis) and scientific name of weed species observed in wheat fields of Tabriz county.

Weed code	Scientific name	Weed code	Scientific name
1	*Achilea bibersteimii* Afar.	50	*Euphorbia helioscopia* L.
2	*Achillea millifolium*	51	*Euphorbia hetradena* Jaup. Spach.
3	*Acroptilon repens* (L.) DC.	52	*Fumria vaillantii* L oise.
4	*Adonis aestivalis* L.	53	*Gallium tricornutum* Dandy.
5	*Aegilops cylidrica Hos.*	54	*Goldbachia laevigata* (M. B.) DC.
6	*Aeluropus lithoralis* (Gouan.) Parl.	55	*Gypsophila leioclada* Rech.
7	*Agropyrum intermedium* (Host.) P. Beauv.	56	*Hordeum murinum* L.
8	*Agropyrum repens* (L.) P. Beauv.	57	*Hordeum vulgaris* L.
9	*Alhagi persarum*	58	*Koelpinia linearis* Pall.
10	*Alium ampeloprasum* L.	59	*Lactuca serriola* L.
11	*Alium atreviolaceum* Boiss.	60	*Lithospermum arvensis* L.
12	*Allopecurus myosuroides* Hudson.	61	*Malcolmia africana* (L.) R. Br.
13	*Alyssum linhfolium* Steph.et Willd var. *linifolium*	62	*Malva neglecta* (Wallr.)
14	*Amaranthus retroflexus* L.	63	*Medicago sativa* L.
15	*Ammi visnaga* (L.)Lam.	64	*Melilotus officinalis* (L.) Desr.
16	*Anchusa azurea* Mill.	65	*Nonnea pulla* (L.) DC.

17	*Anchusa italica* Retz.	66	*Onopordon leptoleptoepis* DC. Rech.
18	*Asperugo procombens* L.	67	*Papaver rhoeas* L.
19	*Bellevalia pycantha* (C.Koch) A. Los.	68	*Phragmites australis* (Cav.) Trin. exSteud
20	*Boissera squrrosa* Banks. Soland.	69	*Picnomon acarna* (L.) Cass.
21	*Bormus danthoniae* var. lanuginosus (Trin.)	70	*Plantago atrata* Hoppe.
22	*Bromus japonicum* (Thunb.)	71	*Poa bulbosa* L.
23	*Bupleurum rotundifolium*	72	*Poa timoleontis* Helder.& Boiss.
24	*Cardaria draba* (L.) Desv.	73	*Polygonum aviculare* L.
25	*Carthamus oxyacantha* M. B.	74	*Ranunculus arvensis* L.
26	*Cenaturea virgata* (Lam.)	75	*Rapistrum rugosum* (L.) All.
27	*Cenaturea depressa* M.B.	76	*Rumex abtusifolium* L.
28	*Centaura iberica* Terv.	77	*Rumex crispus* L.
29	*Ceratocarpus arenarius* L.	78	*Salsola kali* L.
30	*Ceratocephalus falcalus* (L.)Pers.	79	*Salvia nemerosa* L.
31	*Cerpis foetida* L.	80	*Scariola oriantalis*
32	*Chenopodium album* L.	81	*Sclerochloa woronowii* (Hack.)Tzvel.
33	*Chondrilla juncea* L.	82	*Scorzonera calyculata* Boiss.
34	*Chorispora iberica* (M.B)DC.	83	*Setaria viridis* (L.) P. Beauv
35	*Cirsium arvense* (L.) Scop.	84	*Silene conoidea* L.
36	*Cnicus benedictus* L.	85	*Sorghum halepense* (L.) Pers.
37	*Conringia oriantalis* (L.) Andraz	86	*Stellaria pallida* (Dumort.)Pire.
38	*Consolida orientalis* (Gay.) Schrod.	87	*Stipa pennata* L.
39	*Convolvulus arvensis* L.	88	*Taraxacum syriacum* Boiss
40	*Cornulaca aucheri*	89	*Tragopogon graminifolius* DC.
41	*Cousunia calocephala* Jub. Spach.	90	*Trifolium repens* L.
42	*Cynodon dactylon* (L.) pers.	91	*Turgenia latifolia* (L.) Hoffm.
43	*Daucus carota* L.	92	*Vaccaria pyramidata* Medi.
44	*Descurainia Sophia* (L.) Schur	93	*Verbascum thapsus*
45	*Ermopyrum bonaepatis* (Spreng.)	94	*Veronica persica* Poir.
46	*Eryngium billardiere* F.Delaroche.	95	*Xanthium spinosum* L.
47	*Euclidium syriacum* (L.) R. Br.	96	*Xanthium strumarium* L.
48	*Euphorbia boissieriana* (Woronow) Prokh.	97	*Zygophyllum fabago* L.
49	*Euphorbia chrirdenia* Boiss& Hohen.		

Table 4. The number and altitude of wheat fields surveyed in Tabriz county for CCA analysis.

Field number	Altitude	Field number	Altitude	Field number	Altitude	Field number	Altitude	Field number	Altitude
40	1960	41	1521	24	1354	11	1340	26	1333
39	1960	30	1517	23	1352	17	1339	8	1332
36	1700	32	1505	19	1352	12	1339	27	1331
35	1695	31	1505	16	1352	7	1339	6	1328
28	1668	37	1476	22	1351	2	1339	14	1326
29	1667	38	1471	9	1344	21	1338	3	1323
34	1540	20	1366	15	1343	10	1336	5	1322
33	1537	18	1358	13	1342	1	1336	4	1320
42	1529	25	1354						

Results of this study showed that CCA has been able to interpret weed species distribution with altitude and soil texture to the best way in wheat fields of Tabriz county.

In this research we found strong evidence of altitude controlling on weed species distribution. So that altitude increases significantly reduced weed species diversity, so that maximum richness was observed in lower altitude. Whereas Begon *et al.* (1990) and Pysek *et al.* (2002) in their investigations showed that species richness was increased by increasing in altitude. But how can this paradox are explained? Perhaps lower fertility of wheat fields located in higher elevation and minimum management practices implemented in these fields reduced weed species diversity. Researchers believe that differences in vegetation community from place to place over time are dependent upon soil factors and altitude of the site and the regional climatic conditions (Andreasen and Skovgaard 2009; Pinke *et al.* 2012; Gomaa 2012; Hassannejad and Porheidar Ghafarbi 2013). Sperry and Hacke (2002) in their research showed that soil texture may affect soil productivity via influence on the soil water holding capacity, infiltration rate, moisture availability for plants and consequently plant nutrition.

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