RICE WEED COMMUNITY COMPOSITION AND RICHNESS IN NORTHERN IRAN: A TEMPERATE RAINY AREA

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Abstract. Knowledge about weed density and composition plays an important role in weed management decision making. Surveys were carried out to study the weed flora composition in rice fields of Guilan Province in Iran. 481 fields from 16 regions were selected for survey. Weed samples were taken with a W-shaped sampling pattern. Weed species were identified and the plant density, percentage frequency, uniformity, and abundance indices were determined. Biodiversity was calculated using Shannon-Weiner (H′) and Simpson (D) diversity indices. A total of 66 species, belonging to 43 genera and 29 families were identified. The highest number of weeds belonged to the two families Cyperaceae and Poaceae with 15 and 8 species, respectively. The most frequent weed species were *Echinochloa crus-galli* (89.8%), and *Paspalum distichum* (79.4%), *Echinochloa oryzoides* (60.3%), *Cyperus difformis* (56.5%), *Ecliptal prostrate* (49.5%), *Cyperus serotinus* (34.7%), *Azolla filiculoides* (34.5%), *Sagittaria trifolia* (31.6%), *Cyperus esculentus* (31.6%) and *Alisma plantago-aquatica* (28.7%). Relative abundance index indicated that the annual weed species were more dominant than the perennial ones. Based on Shannon-Weiner and Simpson's diversity indices Talesh area had the highest weed diversity (H′ = 2.85; D = 0.916) and Rudbar showed the lowest diversity values (H′ = 1.97; D = 0.749).
Keywords: *abundance index, density, dominance, rice fields, sustainable agriculture*

Introduction

Rice is the primary staple food for more than half of the world's population and provides 20% of the total calorie intake of people in the world (Dass et al., 2016). More than half of the world's rice is produced in Asia (Awan et al., 2015). In Iran also rice is the main staple food in most parts of the country. There are almost 600,000 hectares of rice plantation in Iran with a total production of 2,540,000 tons (FAO, 2016). More than 75% of the rice crop is grown in the Provinces of Mazandaran and Guilan, north of Iran. Weeds are considered as the most important challenge to rice production in Iran (Yaghoubi et al., 2010; Tshewang et al., 2016). The mean reduction in rice yield caused by weeds competition is 40-60%, which may reach 94-96% if weeds are not properly controlled (Chauhan et al., 2011). Rice yield reduction resulting from weed competition may vary depending on rice planting methods, type of weed, degree of importance of the weed, agricultural operations, and weather conditions (Jabran and Chauhan, 2015). Information regarding spatial variation of weeds plays an important role in increasing efficiencies of weed management methods. The four main pillars of management suitable for the location of interest are collection of information, its analysis, adoption

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of suitable decisions, and applying management practices based on obtained information (Mohammaddoust Chamanabad, 2011).

Weed community and its distribution in rice fields are determined by the planting method, moisture regime, land preparation, and crop management (Matloob et al., 2015). Weed succession and distribution patterns in rice fields are dynamic in nature, and weed flora composition may be region-dependent (Begum et al., 2008; Uddin et al., 2010). Information concerning presence or absence of weeds, their composition, abundance, importance, and rank depends on weed management strategies and mean rice yield (Begum et al., 2006). Poggio et al. (2004) believe that structures of weed communities and their diversity are determined by environmental and management factors and by interspecific competition between weeds and crop plants and intraspecific competition between plants of the same weed species. Rao et al. (2007) stated that there was a broader spectrum of variation and diversity in rice weeds in direct seeding areas compared to transplanted areas. Weed flora composition in agricultural systems results from seasonal changes, crop rotation, and long-term environmental changes such as soil erosion and climate change. Agricultural operations such as plowing, the crop plant species growth, weed control methods, and fertilizer application changes the natural distribution pattern and availability of resources and, hence, change the structure and composition of plant species (Ahmadvand, 2005; Kraehmer et al., 2016; Lal et al., 2014 Noroz zade et al., 2008). Accurate determination of weed distribution pattern and density at each location is of great importance. Therefore, before any action is taken, the necessary maps of weed distribution pattern and density must be prepared (Lass et al., 1993).

However, detailed information on the presence, composition, abundance, importance and ranking of weed species especially in Guilan province with around 230000 hectare rice fields is rare. Understanding the sociological structure of weeds in rice fields is a pre- requisite for its effective management. Weed management can be an effective step in increasing production and hence in preserving the actual potential yields of crop plants thus increasing production. The objective of this study is to investigate rice weed community richness and composition in the Guilan province, Iran during 2014 and 2016 and their relationships with management.

Materials and methods

The study was conducted in Guilan province, Iran, which is situated in the north of Iran, South of the Caspian Sea and occupies about 14,044 km by area. Guilan Province is located between 36° 34' to 38° 27' latitudes and 48° 53' to 50° 34' longitudes *(Fig. 1)*.

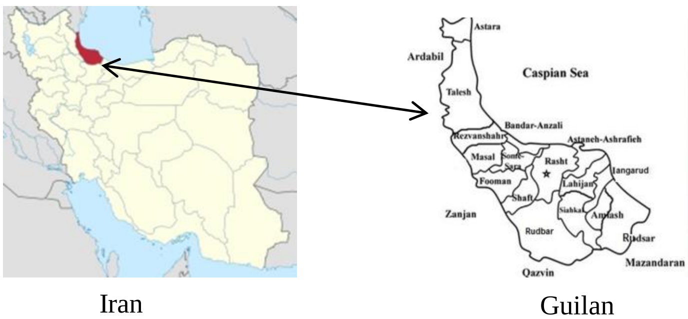

Figure 1. *Geographic map of Guilan province*

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Guilan province has the best type of weather and soil with moderate and humid climate typically known as the moderate Caspian climate. The annual average rainfall is 1356 mm, the annual average temperature is 16.1 °C. During the springs and summers of 2014, 2015 and 2016, when the current study was being done, temperature ranged from 16 to 29.4 °C, monthly average rainfall recorded 213 to 853 mm, average sunshine hours 3320, and relative humidity averaged 45-87%.

The chemical and physical attributes of the soil at the study sites are given in (*Table 1*).

Table 1. *Physico-chemical properties of soil in regions of Gilan province*

Region	Soil properties						
	Clay (%)	**PH**	**EC (ds/m^2)**	**Phosphorus (mg/kg)**	**Nitrogen (%)**	**Potassium (mg/kg)**	**OC%**
Astara	18	6.2	0.55	24.5	0.213	100	2.1
Astaneh-ye Ashrafiyeh	23	7	1	24.4	2.1	245	2.4
Amlash	23	5.6	0.91	39.1	0.16	270	1.85
Anzali	32	6.3	0.63	12.8	0.235	105	2.3
Talesh	21	6.6	0.6	12.2	0.221	106	2.4
Rasht	33	6.8	1.56	11.6	0.161	165	2
Rezvanshahr	24	6.8	0.68	14.1	0.252	100	2.6
Rudbar	30	7.2	0.89	7.9	0.071	190	1
Rudsar	26	6.1	0.9	26	0.167	141	2.4
Siahkal	35	6.9	0.86	7	0.3	175	1.4
Shaft	18	6.2	0.67	6.3	0.168	108	2.1
Sowme’eh Sara	23	6.4	1	18.6	0.222	106	2.3
Foman	26	6.1	0.85	21.7	0.176	116	2.1
Lahijan	29	6.5	1.16	15.5	0.204	178	2.35
Langarud	26	6	1.2	32.3	0.166	178	2.2
Masal	28	7	0.9	16.1	0.234	110	2

Based on the area under rice cultivation in each site of this province, 481 fields were selected from 5 days after transplantation to the end of panicle formation. Weeds in rice fields include annuals and perennials. In each growing season, seeds were sown in the seedling nursery and 21- day-old seedlings were transplanted with 2-3 seedlings per hill. Taking the area of each field into consideration, 0.25 m^2 quadrats were done to take samples using a W-shaped sampling pattern. The weeds in each quadrat were counted and their genera and species were identified. The frequency, field uniformity over all fields, density of the weeds in each field, the mean weed density of the visited fields, and relative abundance of the various species in each County were calculated using the following equations (Thomas, 1985):

Frequency (F) indicates the ratio of the number of fields having a specific weed species to the total number of the fields, and is expressed in terms of percentage. Frequency is concerned with the presence or absence of a species in a quadrat, a field, or a region, and does not refer to the number or quantity of the species (*Eq. 1*):

$$F_k = \sum (Y_i / n) \times 100 \tag{Eq.1}$$

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In above equation, F_k represents the frequency of the species, Yi the presence or absence of the species, and “n” the number of visited fields.

Uniformity (U) expresses the percentage infestation of the field by the species of interest and shows the surface area occupied by the weed (*Eq. 2*):

$$U_k = (\Sigma\Sigma X_{ij}/m_i) \quad \text{(Eq.2)}$$

In *Equation 2,* U_k is the uniformity of the field for the species k, X_{ij} the presence or absence of species k in quadrat “j” and in field “i”.

Density refers to the counted individuals of each species m^2 in the field of interest (*Eq. 3*):

$$D_{ki} = \left(\frac{\Sigma Z_j}{m_i}\right) \times 4 \quad \text{(Eq.3)}$$

In *Equation 3,* Dki stands for the density of species k in field i and Z_j the number of plants in quadrat j.

Mean density indicates the average number of plants belonging to each species m^2 of the visited fields (*Eq. 4*):

$$MD_{ki} = \left(\frac{\Sigma D_{ki}}{n}\right) \quad \text{(Eq.4)}$$

In the above relation, D_{ki} represents density in each field and “n” the total number of visited fields.

The coverage value indicates the coverage of plants m^{-2} for floating and submerged species averaged over fields sampled (*Eq. 5*):

$$MC_{ki} = \left(\frac{\Sigma C_{ki}}{n}\right) \quad \text{(Eq.5)}$$

In *Equation 5,* C_{ki} represents the coverage of plants m^{-2} for floating and submerged species and “n” the total number of visited fields.

Relative abundance (RA) was used to rank the weed species in the survey and it was assumed that the frequency, field uniformity, and mean field density measures were of equal importance in describing the relative importance of a weed species (*Eq. 9*). This value has no units but the value for one species in comparison to another indicates the relative abundance of the species (Hakim et al., 2013). The relative frequency (RF), relative field uniformity (RFU), and relative mean field density (RMFD) were calculated (*Eqs. 6-8*) by dividing the parameter by the sum of the values for the parameter for all species and multiplying by 100 (Nagaraju et al., 2014).

$$RFk = \frac{\text{Frequency value of species}}{\text{Sum of frequency values for all species}} \times 100 \quad \text{(Eq.6)}$$

$$RFUk = \frac{\text{Field uniformity value of species k}}{\text{Sum of field uniformity values for all species}} \times 100 \quad \text{(Eq.7)}$$

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$$RMFDk = \frac{\text{Mean field density value of species k}}{\text{Sum of mean field density values for all species}} \times 100 \quad \text{(Eq.8)}$$

$$RA_k = RFk + RFUk + RMFDk \quad \text{(Eq.9)}$$

One of the common methods for studying diversity of plant communities in the ecology of weeds and species uniformity and richness in agricultural ecosystems is to using the Simpson index and the Shannon-Wiener index. Species richness (S) was measured by the mean number of species per treatment (Magurran, 1988). The Simpson index (D) gives more importance to the common species, but the Shannon-Wiener index (H') puts greater importance on rare species and is calculated by *Equations 10* and *11* (Poggio et al., 2004).

$$H' = -\sum_{i=1}^{s} \left(Pi\ Ln(Pi)\right) \quad \text{(Eq.10)}$$

$$D = 1 - \sum_{i=1}^{s} (Pi)^2 \quad \text{(Eq.11)}$$

In these equations, Pi represents the relative abundance of a specific species (the ith species) that is calculated as –Pi = ni/N, and Ln is the natural logarithm. In the values obtained for the Shannon-Wiener index, the larger values indicate greater diversity in the weed communities (of the related County). After calculating the Shannon-Wiener index for every County, the Pielou index (E) has been used to determine the uniformity of the community (*Eq. 12*) (Booth et al., 2003).

$$E = \frac{H'}{ln\ S} \quad \text{(Eq.12)}$$

H´ represents the Shannon-Wiener index and S the number of weed species observed in each community (County), and logarithm of S is used in this relation (Magurran et al., 1988). As for the uniformity of the weed community in each County, the closer the obtained value gets to zero the more non-uniform the community is (one weed species is dominant in the community). However, the closer the obtained values are to 1, the more uniform the community will be (we witness the highest species diversity and lack of dominance of a specific weed species) (Mesdaghi et al., 2005; Tang et al., 2014).

After collecting the data and making the calculations required for determining the population indices, this information created the main layer in the project, and was then designed in the format of a databank.

Results

In the present research, a total of 66 species, belonging to 43 genera and 29 families were collected from the 16 representative sites (*Tables 2* and *3*). Thirty- four of the identified species were annuals and 22 perennial species. Moreover, 11 species were

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grass weeds, 17 sedges, 30 broad-leaved species, 4 ferns, 2 vascular gymnosperms, and 2 algae (*Tables 2* and *3*). With respect to life cycle, annual weeds with 34 species were the most diverse. Cyperaceae were the largest family representing with 15 species, followed by Poaceae with 7 species, Lythraceae with 5, Polygonaceae with 4, Asteraceae and Salviniaceae with 3 species and others families with 2 or 1 species (*Tables 2* and *3*). Weeds have non-uniformly distributed in various families including Cyperaceae, Poaceae, Lythraceae, Polygonaceae, Asteraceae, and Salviniaceae that accounted for 36 species (54.5%).

Table 2. *Frequency, uniformity, mean field density, abundance indices and relative frequency, relative uniformity, relative density and relative abundance of weed species in rice fields*

Item	Scientific name	Family name	Frequency	Uniformity	Density (plant m^{-2})	Relative frequency	Relative uniformity	Relative density	Relative abundance
1	*Sagittaria trifolia* L.	Alismataceae	31.60	9.08	0.527	3.96	3.32	0.509	7.79
2	*Alisma plantago-aquatica* L.	Alismataceae	28.69	8.01	0.557	3.6	2.93	0.538	7.07
3	*Alternanthera sessilis* L.	Amaranthaceae	10.19	2.99	0.530	1.28	1.09	0.512	2.88
4	*Eclipta prostrate* L.	Asteraceae	49.48	14.49	2.275	6.21	5.3	2.196	13.7
5	*Bidens tripartita*	Asteraceae	15.38	3.24	0.170	1.93	1.18	0.164	3.28
6	*Xanthium strumarium*	Asteraceae	10.60	2.88	0.268	1.33	1.05	0.259	2.64
7	*Butomus umbellatus*	Butomaceae	6.24	1.82	0.172	0.78	0.67	0.166	1.62
8	*Cyperus difformis*	Cyperaceae	56.55	22.79	9.459	7.09	8.33	9.13	24.56
9	*Cyperus serotinus*	Cyperaceae	34.72	9.62	1.192	4.36	3.51	1.151	9.02
10	*Cyperus esculentus*	Cyperaceae	31.60	11.86	5.127	3.96	4.34	4.949	13.25
11	*Scirpus maritimus*	Cyperaceae	9.77	5.41	1.915	1.23	1.98	1.848	5.05
12	*Cyperus fuscus*	Cyperaceae	9.15	2.56	0.375	1.14	0.94	0.362	2.44
13	*Cyperus rotundus*	Cyperaceae	3.53	0.71	0.067	0.44	0.26	0.065	0.77
14	*Cyperus longus*	Cyperaceae	3.33	0.61	0.038	0.42	0.22	0.037	0.68
15	*Scirpus mucronatus*	Cyperaceae	3.12	0.75	0.037	0.39	0.27	0.036	0.7
16	*Cyperus strigosus*	Cyperaceae	2.49	0.53	0.043	0.31	0.19	0.042	0.55
17	*Pycreus flavescense*	Cyperaceae	1.46	0.28	0.028	0.18	0.1	0.027	0.31
18	*Cyperus odoratus*	Cyperaceae	1.04	0.36	0.024	0.13	0.13	0.023	0.28
19	*Pycreus lanceolatus*	Cyperaceae	0.83	0.25	0.014	0.1	0.09	0.014	0.21
20	*Fimbristylis miliacea*	Cyperaceae	0.62	0.14	0.009	0.08	0.05	0.009	0.14
21	*Cyperus glomeratus*	Cyperaceae	0.42	0.07	0.003	0.05	0.03	0.003	0.08
22	*Cyperus iria*	Cyperaceae	0.42	0.11	0.028	0.05	0.04	0.027	0.12
23	*Bergia capensis*	Elatinaceae	1.66	0.68	0.204	0.21	0.25	0.197	0.65
24	*Equisetum palustre*	Equistmaceae	2.29	0.57	0.060	0.29	0.21	0.058	0.55
25	*Equisetum arvense*	Equistmaceae	0.21	0.04	0.001	0.03	0.02	0.001	0.04
26	*Echinochloa crus-galli*	Poaceae	89.81	34.79	7.452	11.27	12.72	7.193	31.18
27	*Paspalum distichum*	Poaceae	79.42	30.24	8.556	9.96	11.06	8.259	29.28
28	*Echinochloa oryzoides*	Poaceae	60.29	13.57	0.779	7.56	4.96	0.752	13.28
29	*Echinochloa colona*	Poaceae	6.65	1.57	0.083	0.83	0.57	0.08	1.49
30	*Eleocharis palustris*	Poaceae	0.21	0.04	0.001	0.03	0.01	0.001	0.042
31	*Coix lacrima-jobi*	Poaceae	0.21	0.04	0.001	0.03	0.01	0.001	0.042
32	*Digitaria sanguinalis*	Poaceae	0.21	0.04	0.001	0.03	0.01	0.001	0.042
33	*Schoenoplectus juncoides*	Juncaceae	11.02	3.13	0.363	1.38	1.14	0.35	2.88

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34	*Mentha aquatic*	Labiatae	0.83	0.14	0.009	0.1	0.05	0.009	0.16
35	*Ammannia multiflora*	Lythraceae	16.84	5.31	0.688	2.11	1.94	0.664	4.72
36	*Ammannia baccifera*	Lythraceae	10.60	3.10	0.436	1.33	1.13	0.421	2.88
37	*Rotala indica*	Lythraceae	4.16	1.39	0.204	0.52	0.51	0.197	1.23
38	*Ammannia senegalensis*	Lythraceae	3.95	0.96	0.113	0.49	0.35	0.11	0.96
39	*Ammannia gracilis*	Lythraceae	0.83	0.21	0.019	0.1	0.07	0.018	0.19
40	*Ludwigia epilobioides*	Onagraceae	8.52	3.06	0.423	1.07	1.12	0.41	2.6
41	*Polygonum persicaria*	Polygonaceae	15.38	3.63	0.225	1.93	1.33	0.217	3.47
42	*Polygonum hydropiper*	Polygonaceae	6.44	1.57	0.091	0.81	0.57	0.088	1.47
43	*Polygonum hydropiperoides*	Polygonaceae	1.04	0.36	0.019	0.13	0.13	0.018	0.28
44	*Rumex crispus*	Polygonaceae	0.42	0.07	0.003	0.05	0.02	0.003	0.08
45	*Monochoria vaginalis*	Potederiaceae	16.63	8.19	2.969	2.09	2.99	2.866	7.95
46	*Samolus valerandi*	Primulaceae	0.21	0.07	0.003	0.02	0.03	0.003	0.05
47	*Galium aparine*	Rubiaceae	0.21	0.04	0.003	0.02	0.01	0.003	0.044
48	*Veronica anagalis-aquatica*	Scrophulariaceae	2.08	0.43	0.019	0.26	0.16	0.018	0.44
49	*Typha minima*	Typhaceae	1.46	0.25	0.010	0.18	0.09	0.01	0.28
50	*Berula angustifolia*	Umbelliferae	0.83	0.21	0.017	0.1	0.08	0.016	0.197

Table 3. *Frequency, uniformity, relative frequency, relative uniformity and relative weed cover related to the various weed species floating and submerged in rice fields of Guilan Province*

Item	Scientific name	Family name	Frequency	Uniformity	Relative frequency	Relative uniformity	Coverage %(m^2)
1	*Chara vulgaris*	Characeae	0.42	0.21	0.053	0.077	0.023
2	*Nasturtium officinale*	Cruciferae	10.40	2.46	1.305	0.91	0.229
3	*Algue blue-green*	Cyanophyceae	17.26	7.51	2.166	2.746	6.936
4	*Lemna minor*	Lemnaceae	28.27	12.50	3.547	4.571	6.030
5	*Najas marina*	Hydrocharitaceae	12.06	5.59	1.513	2.044	4.798
6	*Najas minor*	Hydrocharitaceae	2.70	1.18	0.339	0.431	0.645
7	*Marsilea quadrifolia*	Marsileaceae	6.24	1.75	0.783	0.64	0.242
8	*Ludwigia palustris*	Onagraceae	2.91	0.78	0.365	0.285	0.125
9	*Potamogeton crispus*	Potamogetonaceae	0.21	0.07	0.026	0.026	0.007
10	*Potamogeton nodosus Poir.*	Potamogetonaceae	19.33	6.87	2.426	2.512	1.383
11	*Ranunculus aquatilis*	Rananculaceae	3.12	0.89	0.392	0.325	0.373
12	*Riccia glauca*	Ricciaceae	2.49	0.93	0.312	0.34	0.147
13	*Azolla filiculoides*	Salviniaceae	34.51	18.69	4.331	6.834	24.316
14	*Azolla pinnata*	Salviniaceae	1.66	1.10	0.208	0.402	1.876
15	*Salvinia natans*	Salviniaceae	0.83	0.36	0.104	0.132	0.016
16	*Hydrocotyle ranunculoides*	Umbelliferae	0.83	0.32	0.104	0.117	0.046

Species with higher abundances had greater uniformity. Among the grass weeds, the most frequent weed species is *E. crus-galli* (89.8%) (*Table 2*), followed by *P. distichum*, *E. oryzoides* with frequency higher than 50%. *Echinochloa spp* are of the weeds that appear immediately after rice sowing or transplanting (Yaghoubi and

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Farahpour, 2013). And may compete heavily with the rice for nutrients, space, light and water. The most frequent observed species among the sedges were *C. difformis* with 56.5%, *C. serotinus* and *C. esculentus* with frequency of 34.5 and 31.6%, respectively. Among broad-leaved weeds *E. prostrata*, *S. trifolia*, and *A. plantago-aquatica* respectively with 49.5, 31.6, and 28.7%, frequency, were the most abundant weeds (*Table 2*). Among the floating and submerged species, *A. filiculoides*, *L. minor*, and *P. nodosus* with frequently of 34.1, 28.3, and 19.33%, respectively, were the most frequent observed species (*Table 3*).

C. difformis and *P. distichum* were the most abundant species with 9 and 8 plants m^{-2}, respectively. *E. crus-galli* and *C. esculentus* with a density of 5 plants m^{-2}. *E. prostrate* and *Monochoria vaginalis* were the other weed species with more than 2 plant m^{-2}. While other weed species varied from 0.003 to 1.91 plants m^{-2}. Weeds density was very variable for different species (*Table 2*) and it is an important factor for adoption any decision for weed control. Uniformity refers to quantitative measurement of weed distribution in fields and relative abundance values quantify the predominance of a given weed species in a environment by calculating the frequency, field uniformity, and density of a particular weed species relative to all over species observed. *E. crus-gall*, *P. distichum, C. difformis, A. filiculoides, E. prostrata, E. oryzoides, L. minor, C. esculentus, C. serotinus, S. trifolia, M. vaginalis*, respectively, had the highest uniformity in rice fields of Guilan (*Tables 2* and *3*). Among the grass weeds, uniformity and relative abundance for *E. crus-galli* were 34.7% and 31.18, *C. difformis* with 22.8% and 24.56, respectively, had the highest uniformity and relative abundance among the sedges (*Table 2*), and *A. filiculoides* was present with the highest uniformity and relative plant coverage of 18.5 and 24.3%, respectively, among the floating and submerged weeds (*Table 3*). The most important weeds with high RA value in rice fields were *E. crus-galli* (31.18), *P. distichum* (29.28), *C. difformis* (25.56), *E. prostrate* (13.7), *E. oryzoides* (13.28), and, *C. esculentus* (13.25) (*Fig. 2*).

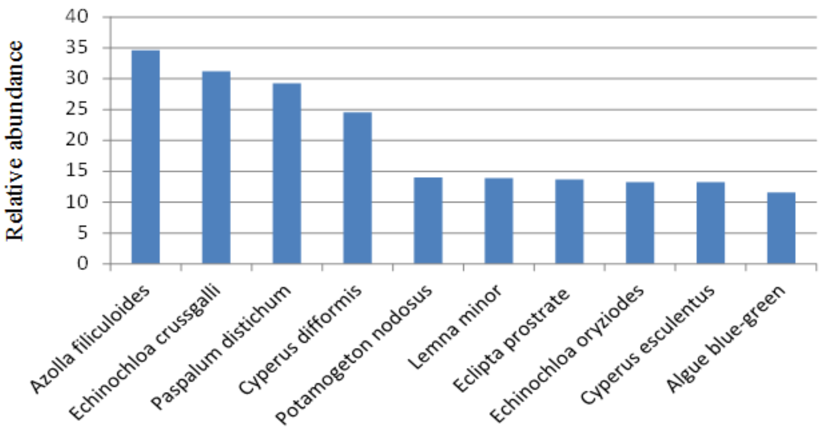

Figure 2. *Top 10 important weed species in rice fields of Guilan Province, Iran*

Rudsar and Langarud regions were the most dominant site registering a total of 47 weed species followed by Rasht and Lahijan (46 sp.), Astaneh-ye Ashrafiyeh (42 sp.), Amlash (37 sp.), Talesh (36 sp.), Foman and Siahkal (34 sp.), Rudbar (32 sp.), Rezvanshahr and Sowme’eh Sara (30 sp.), Masal (28 sp.), Astara (27 sp.) and Shaft and Anzali (25 sp.). The Simpson and the Shannon-Wiener distribution indices had the

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highest values in Talesh and the lowest in Rudbar regions (*Table 4*). It shows that weed diversity was the highest and the lowest in these regions. The Shannon-Wiener index gives greater importance to rare species, and the smaller the value of this index for the relative abundance of a species the rarer the species will be *E. arvense*, *G. aparine*, *S. valerandi*, and *Ch. vulgaris* were among the most rarely found species.

Table 4. *Quantitative indices of weed distribution in various regions of Guilan Province*

Item	Area	Shannon-Wiener index	Simpson index	Pielou index	Species richness
1	Talesh	2.850	0.916	0.795	36
2	Rezvanshahr	2.740	0.909	0.806	30
3	Foman	2.590	0.896	0.734	34
4	Rudsar	2.640	0.892	0.686	47
5	Siahkal	2.530	0.885	0.717	34
6	Langarud	2.450	0.877	0.640	47
7	Astaneh-ye Ashrafiyeh	2.580	0.874	0.690	42
8	Amlash	2.360	0.865	0.654	37
9	Astara	2.230	0.863	0.677	27
10	Rasht	2.420	0.858	0.632	46
11	Lahijan	2.420	0.843	0.632	46
12	Sowme’eh Sara	2.340	0.834	0.688	30
13	Masal	2.645	0.904	0.792	28
14	Shaft	2.050	0.815	0.637	25
15	Anzali	1.990	0.787	0.618	25
16	Rudbar	1.970	0.749	0.568	32

In the present research, *Echinochloa spp* was the most common weed in rice fields of Guilan province, and Langarud and Rudsar Counties each with 47 species and Anzali and Shaft with 25 species (with 71.2 and 37.9%, respectively) had the highest and lowest species diversities. Rezvanshahr city was 0.806 and Rudbar city with 0.568 highest and lowest levels of Pielou index (*Table 4*). As for the Simpson index, any species that is more dominant has a greater relative abundance. This index gives greater importance to the more common species.

Discussion

During the last century, more than 1,800 species were identified in rice fields (Kamoshita et al., 2014). Tshewang et al. (2016) reported weeds in fields in Bhutan included 27 species (13 annual and 14 perennial species) belonging to 10 families. In a study conducted in rice fields of Egypt, 71 weed species were identified, and it was reported that the largest percentages belonged to the Poaceae, Asteraceae and Cyperaceae families with 28, 9, and 7%, respectively. It founded that various factors including the environment, soil, and biological factors such as soil structure, pH, nutrients, and moisture, type of crop, and history of grown crops influenced weed diversity (Hakim et al., 2010; Turki et al., 2002). *E. colona* constituted about 60% of the weed population 60 days after transplantation. In the research by Matloob et al. (2015),

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D. aegypticum, E. colona, and *E. crus-galli* were more common than other grass weeds. In our study, the most common grass weeds were *E. crus-galli, P. distichum* and *E. oryzoides. C. serotinus,* which has also been reported from some Asian countries and from Italy, is apparently confined to transplanted rice. Yakup (2007) reported 70 weed species from rice fields in western Java, with the broad-leaved, Cyperaceae, and grass weeds having the largest number of species. Dominance and relative population of broad-leaved weeds increased by about 62% more than grass weeds and sedges 30 days after rice was transplanted (Singh et al., 2008). In Malaysia, grass weeds formed more than 80% of weed communities in direct seeding of rice. Broad-leaved weeds are more dominant than grass weeds and sedges in direct rice-sowing (Matloob et al., 2015). Scirpus species play an important role among weeds in rice fields (Schaedler et al., 2015), and Begum et al. (2006) reported that *F. miliacea* and *Scirpus grossus* were the most common weeds among the sedges emerged by the change from transplanting to direct rice-sowing in some regions of Malaysia. Singh et al. (2008) observed that most common weeds in rice fields were of annual types that were able to survive even under unfavorable conditions and complete their life cycle from seed to seed during one growing season. All weed species are not identically present in crop plants. *Echinochloa spp* and weedy rice are the most common weeds in rice fields of the world (Kraehmer et al., 2016). In the present study, *E. crus-galli* and *E. oryzoides* were the most dominant weeds. It seems that weedy rice cannot survive in transplanted rice mainly because of handweeding. Kraehmer et al (2016) stated that *C. rotundus, C. iria, and C. difformis* were the most frequent observed Cyperus species in rice fields. In another report submitted by Kraehmer et al. (2016), it was stated that the genera Alisma, Heteranthera, Monochoria, and Sagittaria constituted the most frequent found broad-leaved weeds in rice fields. In our study, the weeds of *E. crus-galli, P. distichum, E. oryzoides, C. difformis, A. filiculoides, A. plantago-aquatica, E. prostrate, C. esculentus, C. serotinus, Xanthium strumarium, Lemna minor* were dominant species. Nithya and Ramamoorthy (2015) identified 23 weed families in rice fields among which nut-grass (*C. rotundus*) was the most dominant because of its biological and physiological characteristics. Despite presence many sedges in our study, *C. rotundus* is not listed here probably because of not being able to survive in flooded rice. Rabbani et al. (2011) collected 20 weed species from five locations in the Punjab region of India and noticed that *C. difformis, E. colona, Euphyllia glabrescens, Cynodon dactylon*, and *P. paspaloides* had the highest abundances in at least 60% of the fields. The following weeds are economically important in India: *E. crus-galli, E. colon, Cyperus spp., Alternanthera spp., C. rotundus, Commelina benghalensis, Caesulia axillaris, Ammania spp., Dnebra spp., E. prostrata, F. miliacea,* and *Dactyloctenium aegypticum* (Rao et al., 2015). Begum et al. (2006) reported that *Oryza sativa* L. (weedy rice), *E. crus-galli, Leptochloa chinensis, L. hyssopifolia*, and *F. miliacea* were the most frequent found species with abundances higher than 30%. *Wolffia globosa* was the most abundant weed in rice fields of North Costal Andhra Pradesh (Nagaraju et al., 2014). Wicks et al. (2003) reported that mean densities of weeds were less than 9 plants m^{-2}, but some species had a higher mean density than the average. Uddin et al. (2009) stated that densities of most species were higher compared to the total weed density. Uddin et al. (2009) stated that *C. compressus* and *C. aromaticus* with 16.7 and 43.6%, respectively, had the highest uniformity. Most of the weeds that had the highest frequencies, uniformity, and mean density in the field are hard to control (Hakim et al., 2013). This is confirmed by the problematic weeds in terms of relative abundance in the rice agro-

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ecosystems. Kandibane et al. (2007) identified 17 weed species in rice fields with *E. colona*, *C. rotundus*, *C. iria*, *C. difformis*, *Panicum repens*, and *Brachiaria mutica* the more dominant ones. Considering the dominance of several weed species in rice fields of Guilan Province and the low values of the index, we can consider unsuitable management of weeds and consecutive rice growing one of the reasons why these species have become dominant. Rezvanshahr and Rudbar had the lowest values of the Pielou index (E = 0.806 and E = 0.568, respectively) (*Table 4*). In Kashmir, the Bandipora and Anantang districts had the highest and the lowest values of the Shannon-Wiener index (H' = 3.755 and H' = 3.271), respectively (Bahaar and Baht, 2012). A study in the greenhouse conducted, floristic diversity was greater *ex situ* (H'= 2.66) than *in situ* (H'=2.53). The high number of weed species found *ex situ* contributed to the great floristic diversity in this area (Mesquita et al., 2013).

The Simpson index had the values of 7.82, 6.82, 6.56, and 6.12 in Kiliyanur, Thailapuram, Thensiruvallur, Aadhanapattu, and Konthamur, respectively, whereas the highest value of the Shannon index (2.46) was that of Kiliyanur. Of the 56 identified species belonging to 23 plant families, 37 species were present in Kiliyanur, 45 in Thensiruvallur, 30 in Thailapuram, 28 in Konthamur, and 32 in Aadhanapattu. Nithya and Ramamoorthy (2015) stated that the Simpson index allowed better comparison between various areas compared to the Shannon-Wiener index. In the present study, *C. difformis*, *P. distichum*, *E. crus-galli*, *A. filiculoides* and *C. esculentus* had the highest values of the Simpson index among the 66 weed species identified in the rice fields.

Conclusion

Weed flora composition in rice fields of 16 counties in Guilan Province includes 66 species belonging to 29 families. Eleven species, three grass (narrowleaf) species (*E. crus-galli*, *P. distichum*, and *E. oryzoides*), three sedge species (*C. difformis*, *C. serotinus*, and *C. esculentus*), four broad-leaved species (*E. prostrata*, *S. trifolia*, *A. plantago-aquatica*, and *P. nodosus*), and one fern species (*A. filiculoides*) were the most widespread and of the highest abundances. Depending on weed management, weed growth in transplanted rice begins around 5 days after pulling or transplanting. Perennial weeds such as *P. distichum*, *P. nodosus*, *A. filiculoides*, and *B. umbellatus* new species with high density and tolerance to flooding the main tool for weed control in transplanting rice cause numerous problems like using more herbicides and repeating the handweeding in rice fields Every year, due to lack of awareness of the identification and effective factors on weed control of farms, their population is increasing. Therefore, the study of the role of management in the restructuring of communities and species diversity of weeds can be useful in developing strategies and management of weeds.

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