DIVERSITY OF WEED SPECIES COMPOSITION OF CYPERACEAE AND POACEAE IN PADDY RICE FIELD IN AN GIANG PROVINCE

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Abstract

This study was conducted to provide data on the weed species composition of the Cyperaceae and Poaceae in the rice fields in An Giang province. The study results show that the weed species composition of Cyperaceae and Poaceae families is very diverse with 38 species belonging to 25 genera, of which 27 are usable. The largest number of species is in crop 1 and in the fields inside the ring dike. Although the species composition is diverse, only a few species are very high frequencies, and most of the remaining species have very low frequencies. Chau Phu district has the highest weed density, averaging 28.42 trees/m^2. Weed density in crop 1 is highest in the 3 crops (15.79 trees/m^2). Fields outside the ring dike have a higher weed density than paddy fields inside the ring dike (15.37 trees/m^2). Although crop 1 has more species abundance than crop 3, the species diversity and the species equality in the weed community in crop 1 are lower than crop 3. Rice fields inside the ring dike have higher species abundance than those outside the ring dike, but the indicators H 'and 1 – λ are lower.

Keywords: *An Giang province, crop, Cyperaceae, dike, paddy rice, Poaceae, weed.*

ĐA DẠNG THÀNH PHẦN LOÀI CỎ DẠI THUỘC HỌ CÓI (CYPERACEAE) VÀ HỌ HÒA BẢN (POACEAE) TRONG CÁC RUỘNG LÚA Ở TỈNH AN GIANG

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Tóm tắt

Nghiên cứu này được thực hiện nhằm cung cấp dữ liệu về thành phần loài cỏ dại thuộc họ Cói và Hòa thảo trong các ruộng lúa ở tỉnh An Giang. Kết quả nghiên cứu cho thấy, thành phần loài cỏ dại thuộc hai họ Cói và Hòa thảo rất đa dạng với 38 loài thuộc 25 chi, trong đó có 27 loài có giá trị sử dụng. Số loài hiện diện nhiều nhất là ở vụ 1 và ở các ruộng phía trong đê bao. Tuy thành phần loài đa dạng nhưng chỉ có một số ít loài xuất hiện với tần suất rất cao, hầu hết các loài còn lại có tần suất xuất hiện rất thấp. Huyện Châu Phú có mật độ cỏ dại cao nhất, trung bình đạt 28,42 cây/m^2. Mật độ cỏ dại ở vụ 1 cao nhất trong 3 vụ (15,79 cây/m^2). Các ruộng ở phía ngoài đê bao có mật độ cỏ dại cao hơn các ruộng lúa phía trong đê bao (15,37 cây/m^2). Tuy vụ 1 có sự phong phú về loài hơn vụ 3, nhưng sự đa dạng loài và sự bình đẳng giữa các loài trong quần xã cỏ dại ở vụ 1 thấp hơn vụ 3. Các ruộng lúa ở phía trong đê bao có sự phong phú về loài cao hơn so với phía ngoài đê bao, nhưng các chỉ số H' và 1 – λ lại thấp hơn.

Từ khóa: *Cỏ dại, đê bao, họ Cói, họ Hòa thảo, ruộng lúa, tỉnh An Giang, vụ lúa.*

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1. Introduction

Weeds are considered to be one of the four most important groups of pests in rice fields along with bugs, diseases and rats (Kremer, 1997). The mean yield loss in rice due to weed competition is estimated to vary from 40% to 60% and can be as high as 94%-96% with uncontrolled weed growth (Chauhan and Johnson, 2011). According to statistics in Asian rice growing countries, weeds can reduce rice yields by up to 60%, of which the weeds of the Poaceae and Cyperaceae families account for over 50% of the damage (Nguyen Manh Chinh and Mai Thanh Phung, 1999). Of the 1,800 species reported as rice weeds in the world, those in the Cyperaceae and Poaceae families are dominant (Golmohammadi *et al.*, 2018). Weeds compete for light, nutrients and water with rice plants and they also store and spread a wide variety of pests, diseases and shelter for rats that damage rice (Phung Dang Chinh *et al*., 1978). Grass seeds mixed in rice after harvest reduce the quality and value of rice (Duong Van Chin and Ho Le Thi, 2014). Therefore, the damage caused by weeds to rice is serious, especially those of the Cyperaceae and Poaceae as they are often present in high frequencies and densities in rice fields (Golmohammadi *et al.*, 2018).

An Giang is a province in the Mekong Delta, located along the Tien and Hau rivers of the Mekong river system, so it has an abundant surface water source, and a considerable amount of alluvium from the river, suitable for rice cultivation. In order to increase the cultivated area and rice yield, and to control the harmful effects of yearly floods, An Giang has built a ring dike system in many rice growing areas to produce the third crop (Nguyen Xuan Thinh *et al.*, 2016). This created two rice growing areas with different crops: the area outside the dike can only grow 2 rice crops and the remaining time is flooded, while the area inside the dike can grow 3 rice crops. It is from intensive rice cultivation and the application of direct-seeding of rice (DSR) that has resulted in a change in the relative abundance of weeds in the rice crop, especially species belonging to the Cyperaceae and Poaceae families, which are widely adapted to the DSR conditions (Golmohammadi *et al.*, 2018). Although An Giang is one of the largest rice producing provinces in the country, studies of weeds in rice fields in An Giang are very rare. Previous studies only mentioned the diversity of plant species composition in a district farming system (Le Thanh Phong and Chau Hoang Hai, 2014), and diversity of plant species in different soil types (Nguyen Hai Ly and Nguyen Huu Chiem, 2017) or diversity of medicinal plant resources in some districts (Dang Minh Quan and Tran Ngoc Thuan, 2017), but there is no in-depth research on the weed composition of these two families in rice fields. Therefore, the objective of this study is to evaluate the diversity of species composition and distribution of weeds in the Cyperaceae and Poaceae families according to different crops and cultivating environments (inside and outside the ring dike) in An Giang province, providing a scientific basis for more effective management and weed control in rice fields in An Giang province.

2. Research methods

2.1. Time and location of the study

This study was conducted during three crops: Crop 1 from April 2019 to July 2019 (Summer-Autumn season), Crop 2 from August 2019 to November 2019 (Autumn – Winter season), and Crop 3 from December 2019 to March 2020 (Winter-Spring season). Samples were collected within 75-80 days after the rice was planted. This time is selected because after the rice is planted, most of plants in the rice field are already grown up, aiding the classification, collection, and analysis of data samples.

The study covered 6 districts of An Giang province, namely Cho Moi, Chau Phu, Tinh Bien, Tri Ton, Thoai Son, and Chau Doc. For each district, there were two fields to be examined: out dike (two crops per year) and in dike (three crops per year) (Figure 1, Table 1).

2.2. The investigation of studied sites and classification of plant samples

To survey the local farmers and agricultural managers in An Giang, the method of PRA (Nguyen Duy Can and Nico Vromant, 2009) was used. This method helps to generate data of rice-growing sites, crops, and plant composition within rice fields.

To investigate sampling sites and to design quadrats of the sampling, research methods of Nguyen Nghia Thin (2007) were applied. At each of the sampling sites (rice field) both inside and outside the ring dike, two quadrats were randomly placed and fixed in all three rice crops, with 100 m^2 (10 m x 10 m) per quadrat. Within each of the 100 m^2 quadrat were 5 sub-squares of sample collection, each of 1 m^2 at 4 corners and a meeting point of 2 diagonals of the quadrat. Plants were collected and identified before plant species and the number of each species was defined, followed by a calculation of the frequency and density of samples.

The scientific names of plant samples were identified by using morphology comparison, in combination with using references from published data of plant classification (Pham Hoang Ho, 2003; Suk *et al.*, 2000; Dương Van Chin *et al.*, 2003; Vo Van Chi, 2002, 2004; Tran Triet *et al.*, 2018). The use of these species was looked up in "List of plant species in Vietnam" (Nguyen Tien Ban, 2005).

Table 1. The coordinates of sampling sites

District	Site	Latitude	Longitude	Note
Cho Moi	1	10°25'50.95"	105°28'15.89"	In dike
	2	10°27'3.72"	105°28'17.57"	
	3	10°26'22.76"	105°27'11.23"	Out dike
	4	10°25'34.53"	105°27'23.71"	
Chau Phu	5	10°33'59.70"	105°13'54.09"	In dike
	6	10°33'12.22"	105°13'8.41"	
	7	10°34'8.79"	105°12'41.69"	Out dike
	8	10°33'19.47"	105°12'0.65"	
Chau Doc	9	10°42'19.44"	105°6'28.56"	In dike
	10	10° 41'39.56"	105°5'27.86"	
	11	10°43'25.03"	105°6'13.96"	Out dike
	12	10°42'40.23"	105°5'39.89"	
Tinh Bien	13	10°34'34.01"	104°56'36.17"	In dike
	14	10°33'32.61"	104°56'1.48"	
	15	10°35'10.86"	104°55'35.88"	Out dike
	16	10° 34' 21.66"	104°55'3.76"	
Tri Ton	17	10°28'59.99"	104°53'0.53"	In dike
	18	10°27'50.89"	104°53'2.48"	
	19	10°28'43.18"	104°51'53.28"	Out dike
	29	10°27'49.70"	104°51'49.29"	
Thoai Son	21	10°19'42.51"	105°21'0.53"	In dike
	22	10°18'59.12"	105°20'4.77"	
	23	10°20'11.42"	105°19'55.62"	Out dike
	24	10°19'37.30"	105°19'10.81"	

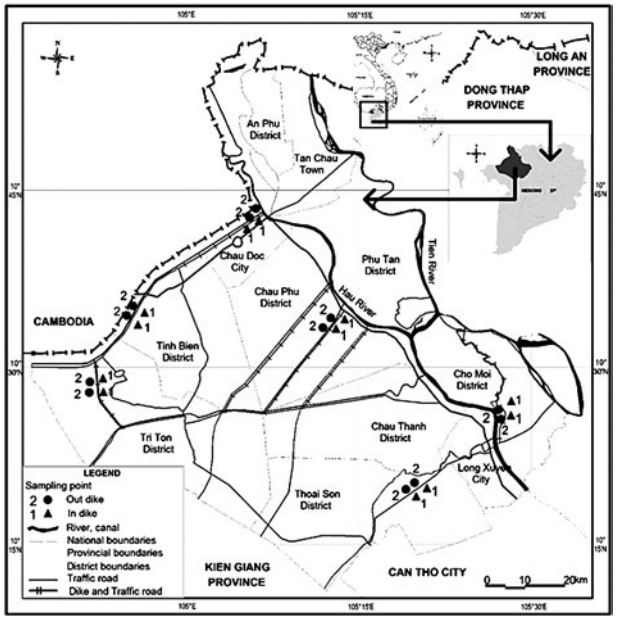

Figure 1. The illustration of sampling sites of rice crop in An Giang province

2.3. The identification of frequency and density

The frequency of plant species was calculated according to the formula F(%) = $\frac{pi}{P}$×100 (p_i: number of sample units in which the species occurs, P: total number of sample units studied). Based on F values, plants are arranged into 5 groups: group A with very low frequency (F=1-20%), group B with low frequency (F=21-40%), group C with moderate frequency (F=41-60%), group D with high frequency (F=61-80%) and group E with very high frequency (F=81-100%).

The density (individuals/m^2) was calculated according to Sharma's formula (2003):

$$\text{Density (D)} = \frac{\text{Total number of individuals}}{\text{Total number of quadrats studied}}$$

Biodiversity indexes such as Shannon-Weaver's diverse index $H' = -\sum_{i=1}^{n} p_i \log p_i$ (Shannon and Weaver, 1949), Simpson's dominant index $\lambda = \sum_{i=1}^{n}(p_i)^2$ (Simpson, 1949), Margalef's abundant index d = $\frac{S-1}{\ln N}$ (Margalef, 1958) ($p_i = \frac{ni}{N}$, n_i: the number of individuals of i^{th} species; S: the number of species; N: total number of individuals of all species in a research sample) were estimated by PRIMER v.6 (Clarke and Gorley, 2006).

Sorensen's formula is to analyze the similarity of species composition between two crops or two studied areas: S = $\frac{2c}{a+b}$ (Nguyen Nghia Thin, 2007), with S the Sorensen index, taking the value from 0 to 1; a the number of species of studied area A; b the number of species of studied area B; c the number of similar species of 2 studied areas A and B. According to this formula: If S = 1 when the two study areas have identical species; If S = 0 when the two study areas do not have the same species; If S reaches the value closer to 1, corresponding to the closer the relationship between the two areas, while S has a value near 0, indicating that the two studied areas have a very distant relationship.

3. Research results

3.1. Diversity of species composition and the use of species

Research results on the composition of weeds belonging to the Cyperaceae and Poaceae in 12 rice growing located in 6 districts and cities of An Giang province, have collected 152 tree samples. These samples are currently being kept at the Plant Laboratory of Can Tho University. Based on the analysis of field samples and photos, 38 species of these two families have been identified. Cyperaceae has 14 species of 6 genera and Poaceae has 24 species of 19 genera (Table 2). The genus with the most species of Cyperaceae is Cyperus with 8 species accounting for 57.14% of the total species of this family. The genus with the most species of Poaceae is *Paspalum* with 5 species accounting for 20.83% of their total species. Compared with the research results of Duong Van Chin *et al.* (2003) on the weed species composition of these two families in wet rice fields in Vietnam (including 23 species belonging to 10 genera) and the list of weeds in rice fields in Vietnam by Caton *et al.* (2010) (including 20 species of 15 genera), the weed species composition of these

2 families in rice fields in An Giang is more diverse. This may be due to the intensification of rice and the application of direct-seeding of rice (DSR) in recent years, resulting in a change in the relative abundance of weeds in rice crops, especially those of the Cyperaceae and Poaceae families widely adaptable to DSR conditions (Golmohammadi *et al.*, 2018).

Table 2. Weed species composition in rice paddy fields in An Giang province

No	Scientific name	Crop	Farming environment	Local (District)	Frequency occurence	Density (tree/m^2)	Uses
	Cyperaceae						
1	*Cyperus babakan* Steud.	1, 3	In, Out	M, S	A	0.017	
2	*Cyperus difformis* L.	2, 3	In, Out	B, T	A	0.020	Fo
3	*Cyperus digitatus* Roxb.	1, 2, 3	In, Out	M, B, T, S	B	0.250	
4	*Cyperus elatus* L.	1, 2, 3	In, Out	P, D, T, S	A	0.023	Fo, Cm
5	*Cyperus halpan* L.	1, 2, 3	In, Out	P, B, T	A	0.030	As
6	*Cyperus imbricatus* Retz.	1, 2, 3	In, Out	M, P, B, T	B	0.053	Fo, Cm
7	*Cyperus iri*a L.	1, 2, 3	In, Out	M, P, D, B, T, S	B	0.233	Me, Fo, Cm
8	Cypeus rotundus L.	1, 2, 3	In, Out	M, P, D, B	A	0.027	Eo, Me, Fo
9	*Eleocharis dulcis* (Burm. f.) Hensch	1, 2, 3	In, Out	T	A	0.047	Fo, As
10	*Fimbristylis aestivalis* (Retz.) Vahl	1	Out	D	A	0.003	Fo
11	*Fimbristylis miliacea* (L.) Vahl.	1, 2, 3	In, Out	M, P, D, B, T, S	D	3.600	Fo, Pa
12	*Kyllinga brevifolia* Rottb.	1	In	D	A	0.007	Fo, Me
13	*Mariscus compactus* (Retz.) Druce	1, 2, 3	In, Out	M, B, T	A	0.023	Cm, Or
14	*Scirpus grossus* L. f.	1, 2	In	M, T	A	0.010	Cm, Ou
	Poaceae						
15	*Chloris barbata* (L.) Sw.	1, 2	In, Out	M, D, B	A	0.020	
16	*Cynodon dactylon* (L.) Pers.	1, 2, 3	In, Out	M, D, B, T, S	C	0.440	Fo, Me, Ou
17	*Dactyloctenium aegyptium* (L.) Beauv.	1, 3	In, Out	D, T	A	0.010	
18	*Digitaria ciliaris* (Retz.) Kohler	1, 3	In, Out	M, D, B, T	A	0.057	
19	*Echinochloa colona* (L.) Link.	1, 2, 3	In, Out	M, P, D, B, T, S	D	1.083	
20	*Echinochloa crus-galli* (L.) Beauv.	1, 2, 3	In, Out	M, P, D, B, T, S	D	0.737	Fo
21	*Eleusine indica* (L.) Gaertn.	1, 2, 3	In, Out	P, D, T, S	C	0.277	Me, Fo
22	*Eragrostis tenella* (L.) Beauv. ex Roem. & Schult.	1, 3	In, Out	B, T	A	0.020	Me, Fo

No	Scientific name	Crop	Farming environment	Local (District)	Frequency occurence	Density (tree/m^2)	Uses
23	*Erianthus arundinaceus* (Retz.) Jeswiel. ex Heyne	1, 2, 3	In, Out	M, B	A	0.083	Fo, Pa
24	*Eriochloa procera* (Retz.) Hubb	1, 2, 3	In, Out	M, P, B, T	A	0.077	
25	*Hymenachne acutigluma* (Steud.) Gillilland	1, 3	In, Out	M	A	0.023	
26	*Leptochloa chinensis* (L.) Nees	1, 2, 3	In, Out	M, P, D, B, T, S	E	2.667	
27	*Oryza sativa* L. (wild rice)	1, 2, 3	In, Out	M, P, D, B, T, S	D	3.660	
28	*Panicum repens* L.	1, 2, 3	In, Out	M, B, T, S	B	0.113	Me
29	*Paspalum conjugatum* Berg.	1, 3	In, Out	M, P, B	A	0.013	Ou
30	*Paspalum distichum* L.	1	In	D, B, T	A	0.020	Ou
31	*Paspalum longifolium* Roxb.	1, 3	In, Out	M, B	A	0.010	Fo
32	*Paspalum notatum* Flugge	1, 2, 3	In, Out	M, D, T	A	0.017	Fo, Ou
33	*Paspalum scrobiculatum* L.	3	In	T	A	0.007	Me, Fo
34	*Pennisetum purpureum* Schum.	1, 2	In	M, D	A	0.010	Fo
35	*Phragmites karka* (Retz.) Trin. ex Steud.	3	In	S	A	0.010	Me
36	*Pseudoraphis brunoniana* Griff.	1, 3	In, Out	M, B, T	A	0.093	
37	*Saccharum spontaneum* L.	1, 3	In	M, P, S	A	0.017	Fo, Pa, Ou
38	*Urochloa mutica* (Forssk.) T.Q. Nguyen	1, 2, 3	In, Out	M, P, D, B, T, S	D	0.717	Fo

Note (Some abbreviation in Table 2): 1 (crop 1), 2 (crop 2), 3 (crop 3); In (inside dike), out (outside dike); M (Cho Moi), P (Chau Phu), D (Chau Doc), B (Tinh Bien), T (Tri Ton), S (Thoai Son); A (F = 1-20%), B (F=21-40%), C (F=41-60%), D (F=61-80%), E (F=61-80%); As (Acidic soil indicator plants), Cm (Carpet and mat plants), Eo (Plants for essential oils), Fo (Forage plants), Me (Medicinal plants), Or (Ornamental plants), Pa (Paper material), Ou (Plants have other uses: keeping soil from eroding, roofing, grass cover...).

This study also identified 27 species of usable weeds, accounting for 71.05% of the species surveyed and they are classified into 8 functional groups. Each group of species can have one or more different uses. The number of species used for animal feed is the largest with 20 species accounting for 52.63% of the total species. There are 10 species used to make folk medicine, approximately 26.32% of the species and the most common species are Cypeus rotundus L., Eleusine indica (L.) Gaertn., Cynodon dactylon (L.) Pers... Ornamental and essential oils have the least number of species, only one species per each species (Table 3).

Table 3. Uses of weeds in rice paddy fields in An Giang province

TT	Uses	Abbreviation	Number of species	Percent (%)
1	Forage plants	Fo	20	52.63
2	Medicinal plants	Me	10	26.32
3	Carpet and mat plants	Cm	5	13.16
4	Ornamental plants	Or	1	2.63
5	Paper material	Pa	4	10.53
6	Plants for essential oils	Eo	1	2.63
7	Acidic soil indicator plants	As	2	5.26
8	Plants have other uses (keeping soil from eroding, roofing, grass cover...)	Ou	6	15.79

3.2. Distribution of weed species composition

Crop 1 has the most diverse rice grass species composition with 35 species consisting of 92.11% of the total species surveyed. Because crops 1 (Summer-Autumn season) has hot and rainy weather, it is a suitable condition for the development of light-loving rice grass species of Cyperaceae and Poaceae. Next is crop 3 with 32 species and the least number of species is in crop 2 with 24 species. Up to 20 species are present in all 3 crops with popular ones of *Fimbristylis miliacea* (L.) *Vahl., Leptochloa chinensis* (L.) Nees, *Oryza sativa* L. (wild rice); 13 species found in 2 out of 3 crops; 5 species only in 1 out of 3 crops.

The composition of rice grass in the rice fields inside the dike is 37 species making up 97.37% of the total species and more diverse than in the rice fields outside the dike of 31 species. This is because the rice fields located in the dike is little affected by the floods, condition stable living environment for a long time than to facilitate the growth of weeds.

Cho Moi and Tri Ton districts have the most diverse weed species composition in rice fields, with 26 species accounting for 68.42% of the total species. The weed species composition is at least in the rice fields of Chau Phu and Thoai Son districts, with only 15 species making up less than 40% of the total species. Tinh Bien district has 24 species and Chau Doc city has 19 species.

The weed species composition similarity between rice crops, between rice fields inside and outside the ring dike and between districts was also determined by the Sorenson index. The results show that there is a very high similarity in the weed species composition in all 3 rice crops and in the rice fields inside and outside the ring dike when the S index between rice crops and between the inner fields and the outside of the ring dike are both greater than 0.7, which means they are similar across 70% of species. Because the seeds of the weeds belonging to the two families Cyperaceae and Poaceae are usually small, light and abundant, they easily disperse along rivers and canals from one rice field to another. The number of similar species between crops is from 0.7321 to 0.7797, between fields inside and outside the ring dike reaches 0.8823. The highest species composition similarity is found between crop 1 in rice fields both inside and outside the ring dike (Table 4).

Table 4. The similarity index (Sorenson index) of weed species composition between crops and two sides of the dike system in the paddy field

Category	Crop 1	Crop 2	Crop 3	Inside dike	Outside dike
Crop 1	1.0				
Crop 2	0.7797	1.0			
Crop 3	0.7761	0.7321	1.0		
Inside dike	0.9444	0.7869	0.8955	1.0	
Outside dike	0.9090	0.800	0.8889	0.8823	1.0

The weed species composition similarity index in rice fields between districts is all above 0.5. Especially, between Cho Moi district and Tinh Bien district, there is a similar number of species up to 0.8, meaning that there are 80% of species similarity (Table 5).

Seven species are only found in rice fields inside the dike and one species only found in rice fields outside the dike is *Fimbristylis aestivalis* (Retz.) Vahl.

Table 5. The similarity index of weed species composition in the paddy fields between districts/city in An Giang province

District/City	Cho Moi	Chau Phu	Chau Doc	Tinh Bien	Tri Ton	Thoai Son
Cho Moi	1.0					
Chau Phu	0.5854	1,0				
Chau Doc	0.7556	0.5882	1.0			
Tinh Bien	0.800	0.6159	0.5581	1.0		
Tri Ton	0.68	0.6857	0.6222	0.760	1.0	
Thoai Son	0.5366	0.7333	0.647	0.5128	0.5854	1.0

3.3. The occurrence frequency and density of weeds

Survey results in all 3 rice crops, rice fields inside and outside the ring dike and the entire study area show that weeds have very low frequency (Group A, F <20%), accounting for the highest percentage, over 50% of the total species. The species with high frequency (Group D) and very high occurrence (Goup E) all account for a low percentage, less than 17% of the total species (Figure 2). This shows that, although the weed composition of Cyperaceae and Poaceae families surveyed in rice growing areas in An Giang is very diverse, only a few species appear regularly at the time of the study.

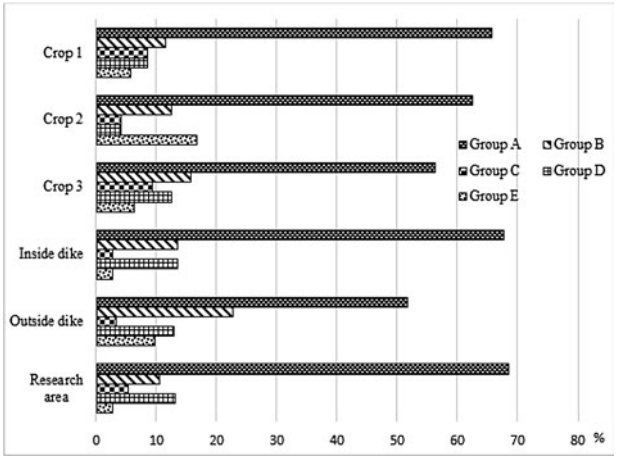

Figure 2. Frequency of weed groups

Crop 2 has a high number of species, with very high frequency (Group E), making up 16.67%, higher than crop 1 (5.71%) and crop 3 (6.25%). The rice fields outside the ring dike have a very high number of species (Group E), approximately 9.68%, higher than the rice fields inside the ring dike (5.71%) (Figure 2).

There are 5 species with very high frequency from 83.30% to 100% (Group E) in all 3 rice crops, inside and outside the ring dike and the entire study area. Among them, *Leptochloa chinensis* (L.) Nees has the highest frequency (F = 100%), occurs in all study sites in all 3 rice crops and in rice fields inside and outside the dike. Species *Fimbristylis miliace*a (L.) Vahl. has a very high frequency in crop 2 and in rice fields outside the ring dike. *Species Echinochloa colona* (L.) Link. occurs with very high frequency in crop 2 and 3. Urochloa mutica (Forssk.) T. Q. occurs with very high frequency in crop 1 and rice fields outside the ring dike. *Oryza sativa* L. appears with very high frequency in crop 2.

The weed density of the two families is highest in crop 1 (Summer - Autumn) with an average of 15.79 trees/m^2. Next is crop 2 (Autumn - Winter) with an average of 12.32 trees/m^2 and the lowest is crop 3 (Winter - Spring) with an average of 11.61 trees/m^2. Because crop 1 has favorable weather conditions for the development of the light-loving weeds of Cyperaceae and Poaceae,

weed density of these two families is higher than that of crop 2 and 3. This result is completely consistent with the study of Duong Van Chin and Ho Le Thu (2014); in some provinces in the Mekong Delta, the Summer - Autumn season often has a higher weed density than other crops of the year. The fields outside the dike have an average weed density of these two families at 15.37 trees/m^2, higher than the fields inside the ring dike with a density of 13.96 trees/m^2.

The district with the highest weed density of Cyperaceae and Poaceae is Chau Phu district with an average of 28.42 trees/m^2. Three with nearly equal weed densities are Cho Moi district (16.36 trees/m^2), Tinh Bien district (average 15.96 trees/m^2), and Tri Ton district (15.44 trees/m2). The lowest weed density is found in Chau Doc city (average 6.56 trees/m^2) and Thoai Son district (average 4.40 trees/m^2). The average weed density of these two species in the entire study area is 14.52 trees/m^2. Five species with high species densities of 1-6 trees/m^2 in the rice crops and rice fields inside and outside the ring dike are shown in Table 6.

Table 6. Five species with the highest densities in rice paddy fields were surveyed in An Giang province

Category	*Oryza sativa*	*Fimbristylis miliacea*	*Leptochloa chinensis*	*Echinochloa colona*	*Urochloa mutica*
Crop 1	5.15±0.26^a	3.75±0.17^b	1.93±0.43^b	1.20±0.06^a	1.27±0.08^a
Crop 2	2.62±0.38^b	2.83±0.60^b	3.18±0.24^a	1.35±0.12^a	-
Crop 3	1.44±0.11^b	2.33±0.12^b	3.15±0.09^a	-	-
In dike	5.13±0.14^a	3.02±0.30^b	2.02±0.14^b	-	-
Out dike	1.46±0.08^b	4.47±0.16^a	3.64±0.32^a	1.59±0.09^a	1.07±0.07^a

Note: Values followed by dissimilar letters (a, b) under the same column are significantly different at $p<0.05$ by Duncan's test.

Table 6 shows that 3 species of *Leptochloa chinensis* (L.) Nees, *Fimbristylis miliacea* (L.) Vahl. and Oryza sativa L. hold high density in all 3 crops and in paddy fields inside and outside the ring dike. These three species are also common weed constituents in wet rice fields in Vietnam (Duong Van Chin *et al.*, 2003).

3.4. Evaluation through biodiversity indicators

Indicators such as Margalef's abundant index (d), Shannon-Weaver's diverse index (H') and Simpson's dominant index (1 - λ') of weeds identified in all three rice crops, in the fields inside and outside the ring dike and in the districts/cities are shown in Table 7.

Margalef index (d) is highest in crop 1, followed by crop 3 and lowest in crop 2, meaning that crop 1 has the highest species abundance, and crop 2 has the lowest species richness. Shannon-Weaver (H ') and Simpson (1 - λ) indices in crop 3 are highest, followed by crop 1 and lowest in crop 2. This shows that although crop 1 has more species richness the species diversity and the equality between species in the weed community are lower in crop 1 than in crop 3.

The rice fields inside the ring dike have a higher species abundance (d = 4,598) than those outside the ring dike (d = 3,990), but the indicators H 'and 1 - λ' are lower, because species type and species equality in the weed community is lower in the ring dike.

The two districts with the highest species richness index are Tri Ton district (d = 3,760) and Cho Moi district (d = 3.728). However, the highest indexes H 'and 1 - λ' are Tri Ton districts (H '= 2.168, 1 - λ = 0.824) and Thoai Son (H' = 2.163, 1 - λ = 0.860). Chau Phu district has the lowest d and H' indexes among the 6 surveyed districts.

Table 7. Biodiversity indexes of weeds collected from study sites

Category	S	N	d	H'(loge)	1 - λ'
Crop 1	35	1895	4.505	2.043	0.807
Crop 2	24	1069	3.298	1.811	0.771
Crop 3	32	1393	4.282	2.303	0.852
Inside dike	37	2513	4.598	2.041	0.789
Outside dike	31	1844	3.990	2.156	0.830
Cho Moi district	26	818	3.728	1.864	0.734
Chau Phu district	15	1421	1.929	1.569	0.740
Chau Doc city	19	328	3.107	1.988	0.816
Tinh Bien district	24	798	3.442	2.063	0.787
Tri Ton district	26	772	3.760	2.168	0.824
Thoai Son district	15	220	2.596	2.163	0.860

4. Conclusion

The weed species composition of the two families Cyperaceae and Poaceae in rice fields in An Giang is very various with 38 species belonging to 25 genera. The largest number of species is in crop 1 and in the fields inside the ring dike. Most of the remaining species appear very low (Group A, F ≤ 20%) and only a few species appear with very high frequency (Group E, F> 80%). The highest weed density is found in Chau Phu district, in crop 1, and fields outside the ring dike. Crop 1 holds the highest species abundance, but the species diversity and the species equality in the weed community at crop 3 are the highest. The rice fields inside the ring dike have higher species abundance than those outside the ring dike, but the H 'and 1 – λ indexes are lower.

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