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Composition and diversity of weedy rice species in lowland irrigated rice field of Argao, Cebu, Philippines

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Abstract. *Lillo EP, Chavez MLM, Malaki AB, Alcazar SMT, Baoy RR, Margate MA, Abrigana M. 2022. Composition and diversity of weedy rice species in lowland irrigated rice field of Argao, Cebu, Philippines. Biodiversitas 23: 6275-6283.* Weeds serve as a severe challenge for rice growers, causing annual crop losses worldwide. The study aims to provide baseline information on the composition and diversity of weedy rice species in lowland irrigated rice fields of Argao, Cebu, Philippines, as a basis for farmers' weed management practices. Field surveys were done using the quadrate method. A quadrate measuring 1m x 1m was randomly placed in weed-infested rice plantation areas. Weedy rice species inside the quadrate were identified. The diversity of species was computed using Shannon diversity index. A total of 53 species were recorded and classified into 21 families and 40 genera. Dominant weedy rice species during the vegetative stage was *Sphenoclea zeylanica* Gaertn., and *Fimbristylis quinquangularis* (Vahl) Kunth. for both the reproductive and harvesting stage. The site has a computed diversity value of H'=3.36 with a relative value of high species diversity, indicating less input in terms of weed management practices. The cluster analysis reveals that the lowland rice fields of Argao were covered by seven weedy rice communities. This situation could create a negative impact on rice production output. The similarity in species composition among sampling sites signifies uniformity in the application of specific weed management practices.

Keywords: Growth stages, lowland rice field, rice farmers, rice production, weeds management practices

INTRODUCTION

Weeds are a serious problem in rice farms (Tshewang et al. 2016). According to Rabbani et al. (2011), weeds are also a severe challenge for rice growers, causing annual crop losses worldwide. In addition, Luo et al. (2014) reiterated that weeds also serve as hosts to rice insect pests and viruses, bacteria, and nematodes that are deleterious to the rice plant and regulate soil microbial diversity, like stem borers (Guo et al. 2013). Mesquita et al. (2013) also emphasized that the negative influence of weeds on rice productivity was attributed to the competition for light, water, and nutrients, as intensified by increasing temperatures associated with global warming, as well as the consequence of climate change (Santra et al. 2014; Sutomo et al. 2021).

The Philippines ranked eighth in world rice production in 2018 (FAO 2020). However, this rice production will decline sharply if weeds are not controlled effectively (Farooq et al. 2011; Zahan et al. 2021). Crops and weeds compete for diverse elements, such as light, space, water, and nutrition (Zimdahl 2013). It has been reported that weeds absorb more than 60% of applied fertilizers, resulting in poorer nutrient availability for crops (Hemalatha 2020). In weed-ridden areas, weeds can absorb up to nine times more nutrients than crops (Dhaliwal 2021). Weeds can germinate and grow, even after harvesting, causing weed management problems in the coming season (Rodenburg et al. 2011). As emphasized by Chauhan et al. (2015), the late-season weed, seed bank and weed seed bank cover the soil again and perpetuate the weed infestation. Moreover, weeds are more prevalent in aerobic field conditions due to the absence of water (Chauhan et al. 2015). Knowledge of appropriate weed identification is essential for weed management strategy selection and implementation (Donayre et al. 2018). Farmers will also be able to save money and maintain an environmentally friendly farm by using less herbicide if they effectively treat weeds (Donayre et al. 2018).

Weed management in organic production aims at maintaining the weed infestation at an acceptable level, balancing the detrimental effects against the beneficial aspects (Turner et al. 2007). In conventional agriculture, a systems approach to weed management can reduce the need for herbicides (Deytieux et al. 2012). A weed in one place may be a useful food, deed, or medicine in another (Chauhan et al. 2015). Thus, ecological knowledge of weedy rice species could lead to a better understanding of the rice agroecosystem and improvement in weed management (Caton et al. 2010). However, there is little information on the weed flora in different rice fields, particularly on Cebu Island. This study could be valuable to researchers and agriculture extension workers when improving rice farming systems, as well as in teaching rice stakeholders about new weed management practices.

Furthermore, the study aims to provide baseline information on the composition, diversity, and distribution of weedy rice species in relation to different growing stages (vegetative, reproduction, and harvesting) in lowland irrigated rice fields of Argao, Cebu, Philippines, as a basis for an improve weeds management practices.

MATERIALS AND METHODS

Study area

The study was conducted in the Municipality of Argao, Cebu, Philippines. The study site is located at a coordinate of 9º55' 57.29" N, 123º33'1.47"E (Figure 1). The Municipality of Argao was considered one of the 14 municipalities of Cebu Island as a major producer of rice based on the record of the Department of Agriculture (2020). The Argao municipality comprises 45 barangays, of which 9 (20%) of this has an intact rice field. Rice was also considered the staple food in the Municipality. In Fact, Argao Municipality Mountain barangays have developed a portion of its area into rice fields, cultivated into perfection like the Banaue rice terraces. The area was carved through time, supported by rock walls, and well-irrigated by natural springs coming underneath a leviathan *Ficus* sp., shaping mountain barangay agricultural and sloped terrains.

Methods in the collection of data

A purposive sampling technique was used in the study. Purposive sampling is an informant selection tool or also called judgment sampling. It is the deliberate choice of an informant due to the qualities the informant possesses (Tongco 2007; Chauhan 2013). Sampling sites were identified, and the rice field areas were infested by weedy rice species. Weeds are those plants that are out of place, unwanted, non-useful, often prolific and persistent, competitive, harmful, and even poisonous, which interfere with agricultural operation, increase labor, add to costs, reduce yields and detract from comforts of life (Rana and Rana 2019). A quadrate/ plot measuring 1m x 1m was randomly placed in identified sampling sites. A total of 135 plots were established in 9 identified sampling sites. All the weed species within the plots (1m x 1m) were identified and classified (Focht & Pillar 2003; Olorunmaiye et al. 2011). The unidentified weeds were collected and placed inside the zip lock bearing the local name and quadrate number. The identification of the weed species was based on morphological characteristics and was compared to a field guide on weeds developed by Donayre et al. (2018), Chauhan (2013), and Caton et al. (2010). Species not found in the guide were compared in the CO's Digital flora of the Philippines or in online published literature. The conservation status of the species was determined based on the DENR-DAO (DENR-DAO 2017) and IUCN (IUCN 2022) Red List of Threatened Species. An informal interview or focal group discussion (FGD) with the rice farmers within the sampling sites was conducted to know their weed management practices.

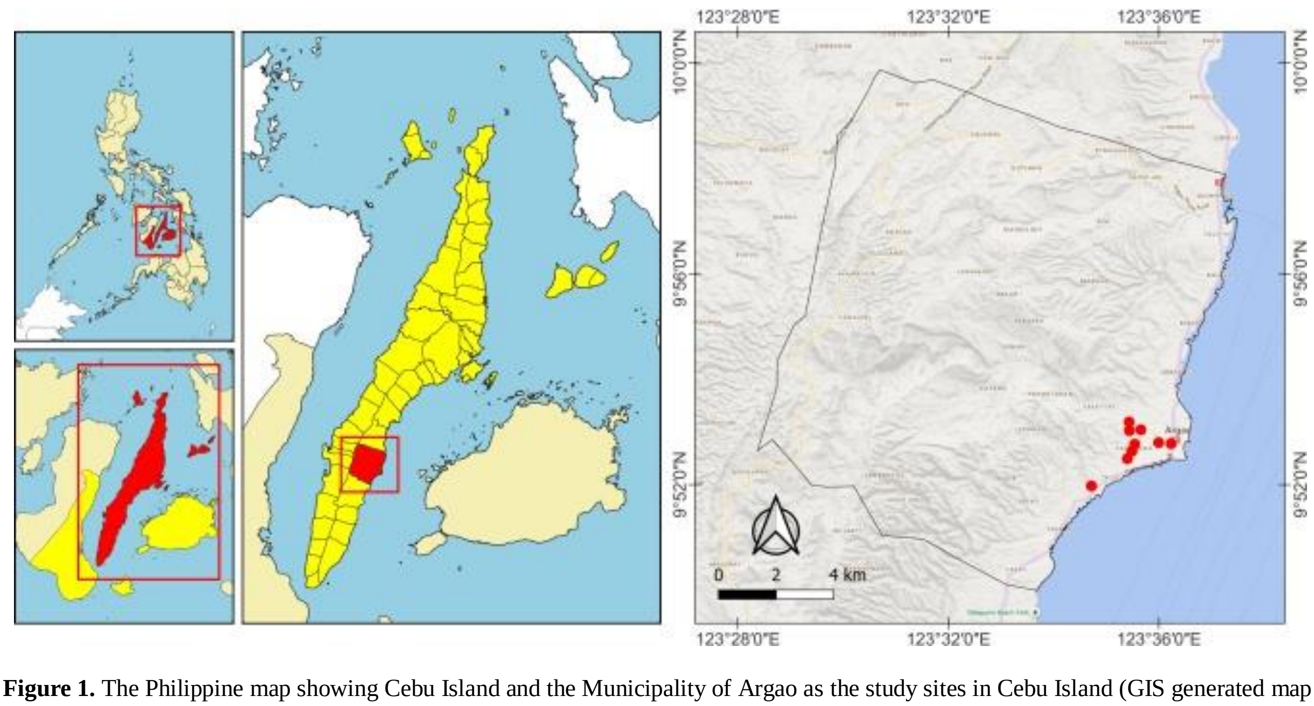

Figure 1. The Philippine map showing Cebu Island and the Municipality of Argao as the study sites in Cebu Island (GIS generated map: Landsat 8; www.earthexplorer.usgs.ph; NAMRIA; Philippines GIS Data)

Data analysis

The diversity of the species was computed and interpreted using the Shannon diversity index (H'), through the Multivariate Statistical Package (MVSP) software (Lillo et al. 2019). Using the software, the computation was easier, and an assurance of a high possibility of its accuracy. The clustering analysis (dendrogram) among sampling sites was determined based on similarity and dissimilarity of species (presence and absence of species) using the Jaccard and Sorensen index as a package in the MVSP software. There are more than 20 binary similarity measures now in the literature (Cheetam and Hazel 1969; Lillo et al. 2019). Two of the most often used similarity coefficients for binary data were Jaccard's index and Sorensen's index. Similarity and dissimilarity of species composition per sampling sites would give information on what type of weed management practices.

RESULTS AND DISCUSSION

Species composition and distribution

Based on the result of the study, the lowland irrigated rice field of Argao, Cebu, recorded a total of 53 weedy species, classified into 21 families and 40 genera. All the species, both from DENR-DAO (2017) and IUCN (2022) categories, were considered as Least Concerned or still abundant in the wild. The majority of the weedy species were recorded in Looc Poblacion sampling site (50 species), followed by the Lamacan sampling site (48 species), and Labangon sampling site (47 species) (Table 1). *Sphenoclea zeylanica* Gaertn. was the most dominant weed during the vegetative stage, while *Fimbristylis quinquangularis* (Vahl) Kunth ssp. *quinquangularis* was the most recorded species both in the reproductive and harvesting stage. The most represented family was Poaceae (Table 2). Gonzales (2017) emphasized that in La Union, Philippines the species of *Fimbristylis littoralis* Gaudich. was the most abundant weed in rice fields, which is similar in genus and characteristics with the abundant species in Argao which is *Fimbristylis quinquangularis* (Vahl) Kunth ssp. *quinquangularis*. The result also confirmed the study of Kraehmer (2016) in which globally, the key weed genera dominating the rice fields despite the decade-long use of well-performing herbicides Echinochloa, Cyperus, Scirpus, or Fimbristylis species. These weed species occur in all kinds of rice cropping.

In addition, according to Hakim (2010), the weedy rice species with the highest frequencies, field uniformities and mean field densities indicate that these weeds are the most difficult to control. The amount of infestation of weedy rice species variably reduces rice yield. Based on the study of Chauhan (2013), weedy rice species reduce rice yield by 50-60% under moderate infestation (15-20 weedy rice species per square meter), 70-80% under high infestation (21-30 weedy rice species per square meter), and total yield loss under heavy infestation (lodging in rice plants). Weedy rice species have greater nitrogen-use efficiency for biomass production as compared to cultivated rice, making them more competitive and aggressive (Chauhan 2013). Across in Asian continent, the annual loss of rice yield due to weeds is estimated to be 37% in India (Rao et al. 2015), and 47% in Nepal (Bhurer et al. 2014). On a global scale, 37% of the rice yield is considered to be lost due to weedy rice species infestations (Oerke 2006).

In this study, an average of 15 species of weedy rice were identified per square meter and categorized under moderate infestation with 50-60% yield loss (Chauhan 2013). *Sphenoclea zeylanica* Gaertn. (Dicot species) and *Fimbristylis quinquangularis* (Vahl) Kunth ssp. *quinquangularis* (Monocot species) weedy rice species dominated in different sampling sites. *Sphenoclea zeylanica* Gaertn originates from tropical Africa. The species is now distributed as a weed across the world in tropical and subtropical regions (Holm et al. 1977). The exudates of the species are toxic to rice root nematodes, *Hirschmanniella* spp. (Mohandas et al. 1981). Vongsaroj (1994) also reiterates that the young plants and the tender shoots of the species may be eaten. They are steamed as vegetables and eaten with rice in Thailand and Indonesia. While *Fimbristylis quinquangularis* (Vahl) Kunth ssp. *quinquangularis* is a native range to Tropical Africa, Iraq to Tropical & Subtropical Asia and N. Australia. The species is considered an annual or perennial and can grow primarily in the seasonally dry tropical biome (https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:308201-1). The species has higher in terms of nitrogen-use efficiency for biomass production (Chauhan 2013) as compared to cultivated rice, both during the vegetative and reproductive stages (Table 2), causing less production output for rice.

Table 1. Species composition, families and genera of weed species by study site

Sites	Species	Genera	Families
Canduran	36	26	14
Cancainap	30	25	16
Labangon	47	35	20
Proper, Canbanua	40	29	17
Lowac, Canbanua	39	31	17
Codrumo, Poblacion	44	31	18
Malinglingon	42	31	19
Looc, Poblacion	50	36	20
Lamacan	48	36	20
Total	53	40	21

Table 2. Dominant weed species and family per growth stages

Stages	Dominant species	Dominant family
Vegetative	*Sphenoclea zeylanica* Gaertn.	Poaceae
Reproductive	*Fimbristylis quinquangularis* (Vahl) Kunth ssp. *quinquangularis*	Poaceae
Harvesting	*Fimbristylis quinquangularis* (Vahl) Kunth ssp. *quinquangularis*	Poaceae

Distribution of species in the different study sites

Out of the 53 weedy rice species, 50 species (94%) were recorded in Looc, Poblacion sampling site. Then 48 weedy rice species (91%) were recorded in Barangay Lamacan sampling site, and 47 weedy rice species (89%) were recorded in Barangay Labangon sampling site. Less species were recorded in Barangay Cancainap sampling site, with 30 (57%) (Table 1 and 3). Of the 53 weedy rice species, 24 species were common in all the sampling sites, and no one was isolated to a certain sampling site (Table 3; Figures 2, 3, and 4). The recorded weedy rice species appear in a minimum of at least 4 sampling sites, to a maximum of occurring in all of the sites.

The result of the study implies that similarity in the ecological environment among sampling sites favored the occurrence of the species, and each species has favorable environmental requirements. As observed in the sampling sites, the dried soil surface is favorable to weeds. Less input on weed management practices also affects the occurrence of the species. Kraehmer et al. (2016) emphasize the fact that weeds in rice have to adapt to wet or aquatic conditions and reduce the biodiversity range in comparison to other arable crops. Water management has a considerable impact on weed diversity. Rice plantations with reduced irrigation may end up in higher weed infestations. Turner et al. (2007) added that weed management is the main factor in maintaining weed infestation in a rice field.

Kamoshita et al. (2014) also emphasize that there are more than 1800 weedy rice species globally. Of the 1800 weedy rice species, more than 50 species have managed to dominate in very diverse environments. Therefore, Regional conditions and special selection pressure have led to local weed differentiations. However, *Leptochloa* and Fimbristylis species become major problems in Asia at the end of the last century and Europe because of their domination Kraehmer (2016), and even in this study (Table 3).

In this study, it was found that Barangay Cancainap has a better weed management strategy, resulting in higher rice production as compared to other sites. The sampling area with less rice production due to less weed management practices was Barangay Poblacion, Lamacan, and Labangon (Table 3). Based on the interview conducted with the rice field farmers, particularly to Cancainap sampling sites, with regards to their strategy or practices in controlling the impact of weedy rice species on the growth and production of their rice plantation. According to them, they have applied both hand weeding and herbicide. Those weedy rice species that can escape from herbicide application can be eradicated by hand weeding. Mukherjee and Karmakar (2015) reiterated that the integration of both herbicide application and hand weeding at 40-45 days after transplanting was considered the most effective treatment in controlling weeds and producing the highest grain yield. In addition, Chauhan et al. (2015) also emphasized that once the herbicide has no effect on certain weeds, hand weeding was very effective. In Japan, hand weeding is also recommended for small land-holding farmers to control *Echinochloa crus-galli* (L.) P.Beauv after controlling other weed species by chemical treatments (Shibayama 2008). Kolb and Gallandt (2012) elaborated that Organic production in the rice field relies both on indirect cultural control methods and direct means to control weeds. Melander et al. (2013) also emphasize that Primary tillage, by plowing the soil to a depth of 20-25 cm, is used to manage weeds, particularly perennial weed species.

Species diversity

Compilation of diversity values in all the sampling sites would provide valuable information on their production output, as well as their management practices. Based on the result, the average computed species diversity using the Shannon diversity index was H'= 3.36 (Table 4). The Simpson diversity index also signifies that the study sites have a relative value of very high species diversity (0.96). Almost 90% of the weedy rice species were common in all sampling sites. The result implies that the estimation of species diversity by the Shannon index signifies that species diversities are relatively high. Among the sampling sites with very high species diversity were Barangay Looc Poblacion (H'=3.62) and Barangay Lamacan (H'=3.53) (Table 4). The sampling site with lower species diversity was Barangay Cancainap (H'=2.93), with a relative value of moderate diversity. The rest of the sampling sites have high species diversity (Table 4). The high diversity of weedy rice in the sampling area was attributed to the important traits of the species, which is the early shattering of seed, ensuring that a portion of its seed drops on the soil surface before and during rice harvesting. Aside from that, the seed longevity of weedy rice is generally longer and more variable than that of cultivated rice (Chauhan 2013). In terms of biodiversity, areas with high species diversity signify a more stable and productive area (Lillo et al. 2019). However, in rice production, high weedy rice species diversity signifies fewer weed management practices resulting in lower production output for rice (Kolb and Gallandt 2012).

In this study. the result of the species diversity computation further proves that Barangay Lamacan and Looc Poblacion sampling sites have very high species diversity, also resulting in lower production output in terms of rice yield and indicating less input in weed management practices. Barangay Cancainap sampling site has lower in terms of species diversity (Table 4), but higher in rice production output. Based on the interviews, they have higher production output in terms of rice production as compared to other rice farmers in Argao, as a result of their better and proper weed management practices. Better weed management practices will limit the density of weedy rice species (Chauhan 2013). Pan et al. (2020) also emphasize that Fertilization treatments (NPK, NP, NK, and PK) reduce the number of weed species and as well as weedy rice species diversity. In addition, Fertilization strongly affects the species composition, density, diversity, nutrient uptake, and biomass of all weeds in farmland (Tang et al. 2013, 2014; Wan et al. 2012), favorable to rice crops.

Table 3. Distribution of weed species by study sites

Family name	Scientific name *)	Distribution of weed species by study site								
		Canduran	Cancainap	Labangon	Proper, Canbanua	Lowac	Codrumo	Malinglingon	Looc	Proper, Lamacan
Acanthaceae	*Ruellia tuberosa* L.	X	X	X	X	X	X	X	X	X
Amaranthaceae	*Alternanthera sessilis* (L.) DC.		X	X	X				X	
	Amaranthus spinosus L.			X	X	X	X	X	X	X
	Amaranthus viridis L.			X	X				X	X
Apiaceae	*Centella asiatica* (L.) Urb.				X				X	
Asteraceae	*Bidens pilosa* L.	X	X	X		X	X	X	X	X
	Eclipta prostrata (L.) L.	X	X	X	X	X	X	X	X	X
	Eclipta angustata Umemoto & H.Koyama	X		X		X	X	X	X	X
	Sphagneticola trilobata (L.) Pruski	X			X	X	X	X	X	X
	Synedrella nodiflora (L.) Gaertn.				X	X		X	X	X
	Tridax procumbens L.	X		X	X	X	X	X	X	X
	Vernonia elmeri Merr.	X	X	X	X	X	X	X	X	X
Cleomaceae	*Arivela viscosa* (L.) Raf.								X	X
	Sieruela rutidosperma (DC.) Roalson	X	X	X	X	X	X		X	X
Commelinaceae	*Commelina benghalensis* L.	X		X	X		X	X	X	X
	Commelina diffusa Burm.f.	X		X	X	X	X	X	X	X
Convolvulaceae	*Ipomea aquatica* Forssk.	X	X	X	X	X	X	X	X	X
	Merremia emarginata (Burm.f.) Hallier f.	X	X	X	X		X	X	X	X
Cyperaceae	*Cyperus brevifolius* (Rottb.) Endl.	X	X	X	X	X	X	X	X	X
	Cyperus difformis L.	X	X	X		X	X	X	X	X
	Cyperus digitatus Roxb.		X	X			X		X	
	Cyperus rotundus L.	X		X	X		X	X	X	X
	Fimbristylis dichotoma (L.) Vahl	X	X	X	X	X	X	X	X	X
	Fimbristylis quinquangularis (Vahl) Kunth	X	X	X	X	X	X	X	X	X
Euphorbiaceae	*Euphorbia hirta* L.	X	X	X	X	X	X	X	X	X
Fabaceae	*Aeschynomene indica* L.		X	X	X	X	X		X	X
	Centrosema molle Mart. ex Benth.	X	X	X	X	X	X	X	X	X
Heliotropiaceae	*Heliotropium indicum* L.			X				X		X
Lamiaceae	*Hyptis capitata* Jacq.			X			X	X	X	
	Basilicum polystachyon (L.) Moench			X		X		X	X	X
Mimosaceae	*Mimosa pudica* L.	X	X	X	X	X	X	X	X	X
Onagraceae	*Ludwigia octovalvis* (Jacq.) P.H.Raven	X	X	X	X	X	X	X	X	X
	Ludwigia perennis L.	X	X	X	X	X	X	X	X	X
Phyllanthaceae	*Phyllanthus debilis* Klein ex Willd.	X	X	X	X	X	X	X	X	X
	Phyllanthus urinaria L.	X	X	X	X	X	X	X	X	X

Poaceae	*Cynodon dactylon* (L.) Pers.	X	X	X	X	X	X	X	X	X
	Dactyloctenium aegyptium (L.) Willd.					X	X		X	X
	Echinocloa colonum (L.) Link	X	X	X	X	X	X	X	X	X
	Echinochloa crus-galli (L.) P.Beauv.	X		X	X	X	X		X	X
	Eleusine indica (L) Gaertn.	X	X	X	X	X	X	X	X	X
	Leptochloa chinensis L.	X		X	X	X	X		X	X
	Panicum repens L.	X	X	X		X	X	X		X
	Paspalum conjugatum P.J.Bergius			X	X	X	X	X	X	X
	Paspalum distichum L.	X	X	X	X	X	X	X	X	X
	Paspalum scrobiculatum L.	X			X	X	X		X	X
	Rottboellia cochinchinensis (Lour.) Clayton	X		X	X	X	X	X	X	X
Portulacaceae	*Portulaca oleracea* L.		X	X		X	X	X	X	X
Rubiaceae	*Spermacoce ocymoides* Burm.			X	X			X	X	X
	Oldenlandia corymbose L.			X			X	X		
Sparmanniaceae	*Corchorus aestuans* L.	X	X	X	X		X	X	X	X
	Corchorus olitorius L.	X		X	X	X	X	X	X	X
Sphenocleaceae	*Sphenoclea zeylanica* Gaertn	X	X	X	X	X	X	X	X	X
Verbenaceae	*Stachytarpheta jamaicensis* (L.) Vahl.		X	X				X	X	X
Total species		**36**	**30**	**47**	**40**	**39**	**44**	**42**	**50**	**48**

Note: *) Pelser et al. (2011 onwards). Co's Digital Flora of the Philippines. www.philippineplants.org

Table 4. The diversity of weeds species in Lowland Barangay in Argao, Cebu, Philippines

Study site	Shannon-Weiner	Relative value	Evenness index	Simpson	Relative value
Canduran	3.22	High	0.90	0.95	Very high
Cancainap	2.93	Moderate	0.86	0.93	Very high
Labangon	3.45	Very high	0.897	0.96	Very high
Proper, Canbanua	3.42	Very high	0.93	0.96	Very high
Lowac	3.29	High	0.90	0.957	Very high
Codrumo	3.38	High	0.89	0.959	Very high
Malinglingon	3.37	High	0.90	0.96	Very high
Looc	3.62	Very high	0.93	0.97	Very high
Proper, Lamacan	3.53	Very high	0.91	0.965	Very high
Average	3.36	High	0.90	0.96	Very high

Clustering of weedy rice species community (Jaccard's, Simpson's, and Sorensen Similarity/dissimilarity Matrix)

Clustering analysis of weedy rice species community both by Jaccard's and Sorensen coefficient similarity/dissimilarity matrix shows that all the sampling sites sampled from Argao Lowland irrigated rice fields forming into seven clusters/ groups correspondingly, based on species compositions and locations (Table 3; Figure 2 and 4). The nine (9) sampling sites proved to have distinctive weedy rice species association, hence grouping them together into seven (7) distinct clusters in terms of their species composition different from other sampling sites, but those sampling sites having found similar in terms of species composition were grouped together as one subgroup (Figures 2, 3, and 4; Table 3). Based on Figures 2 and 4; Table 3) Cancainap sampling site formed as one subgroup, Proper Canbanua sampling site formed as one subgroup, Malinglingon sampling site also formed as another subgroup, Lamacan and Looc Poblacion sampling sites formed together as one cluster/subgroup, Labangon sampling site also forming as another group, Lowac sampling site also formed as another subgroup, Condrumo and Canduran sampling sites also grouped together and formed as another subgroup/cluster.

The Simpson's similarity/dissimilarity matrix shows different results from both Jaccards and Sorensen's coefficient. Based on Figure 3 and Table 3, the nine (9) sampling sites proved to have distinctive weedy rice species association, hence grouping them together into five (5) distinct clusters/subgroups. The Malinglingon sampling site formed as one subgroup, Labangon and Cancainap sampling sites grouped together and formed as one subgroup, while Jaccard's and Sorensen coefficient consider these two sampling sites as a different subgroup. In here also, Looc Poblacion and Canbanua sampling sites formed together as one subgroup, while Jaccard's and Sorensen coefficient consider these two sampling sites as separate subgroup. The Lamacan and Lowac sampling sites also formed together as one subgroup, but Jaccard's and Sorensen coefficient consider these two sampling sites formed as a separate subgroup. However, for Condrumo and Canduran sampling sites, both the Jaccard's, Sorensen and Simpson coefficient agreed together that these two sites grouped together and formed as one subgroup/cluster.

The cluster analysis using Jaccard's and Sorensen indices reveals that the lowland rice field of Argao was covered by seven-weedy rice species communities with high species diversity. The result implies that this seven-weedy rice species community with high species diversity existing in Argao rice plantation could affect or be harmful to the rice production output of the area. The similarity in species composition among sampling sites implies similarity in weed management practices. The results of the similarity comparison in weedy rice species also indicated that although the aboveground weed community differed among the different cropping patterns, the weed species composition in the soil seed bank was still similar (Yun-he et al. 2019).

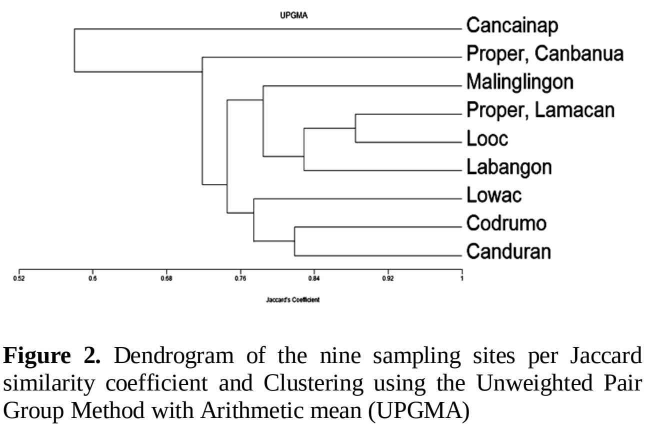

Figure 2. Dendrogram of the nine sampling sites per Jaccard similarity coefficient and Clustering using the Unweighted Pair Group Method with Arithmetic mean (UPGMA)

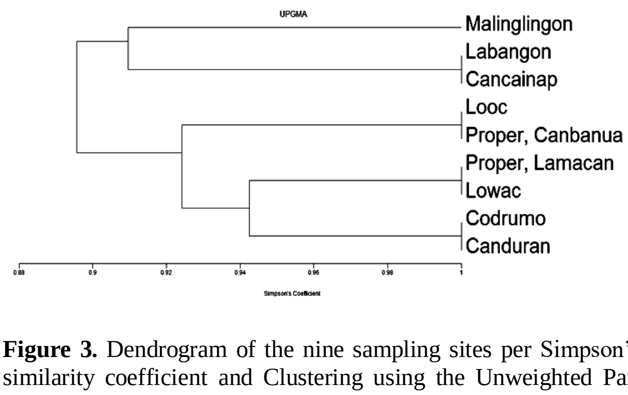

Figure 3. Dendrogram of the nine sampling sites per Simpson's similarity coefficient and Clustering using the Unweighted Pair Group Method with Arithmetic mean (UPGMA)

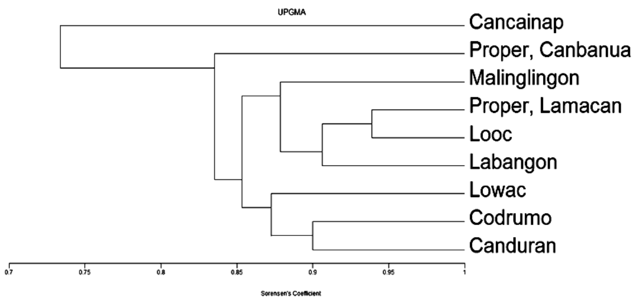

Figure 4. Dendrogram of the nine sampling sites per Sorensen's similarity coefficient and Clustering using the Unweighted Pair Group Method with Arithmetic mean (UPGMA)

In conclusion, based on the result of the study, it was found that the lowland rice field of Argao recorded a total of 53 weedy rice species, classified into 21 families and 40 genera. The site has an average computed diversity index of H'=3.36 with a relative value of high species diversity. Identification of high species diversity in terms of weedy rice is a manifestation that the rice farmers of the Municipality of Argao employed only less input in terms of weed management practices, resulting in less rice production output. The cluster analysis reveals that the lowland rice field of Argao was covered by seven weedy rice communities from nine sampling sites. This situation could create a negative impact on rice production output. However, the similarity in species composition among sampling sites signifies an application of a similar strategy in controlling weedy rice species.

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