2021

Floristic Composition and Diversity of Weeds in Organic Rice Fields in Langkong, M'lang, Cotabato

Samuel Herbert T. Mamora

Abstract

This study investigated the floristic composition and diversity of weeds in organic rice fields in Langkong, Mlang, Cotabato covering an area of 2.5 hectares within which 100 quadrats were randomly assigned. Identification of weeds showed thirteen species belonging to six families eight of which are annuals and five perennials comprising five broadleaf, three grass, and five sedge types. All weed species had <50% uniformity which may imply less competitiveness against rice or effective control by weed management practices. Fimbristylis littoralis and Cyperus difformis have the highest frequencies and the highest field uniformities and highest mean field densities indicating that these weeds are the most difficult to control. The weed density of fields in which the species occurred increased compared to densities from all fields for all weed species that may mean that site-specific or management-specific factors contribute to the survival of those species. Relative abundance values showed that Fimbristylis littoralis and Cyperus difformis are the two most dominant weed species. Weed species diversity is medium and equivalent to 5 equally abundant species.

Keywords: organic rice, weeds, Lorenz curve, relative abundance, effective number of specie

Author information:

Samuel Herbert T. Mamora
samuelherbert.mamora@usep.edu.ph
https://orcid.org/0000-0003-2131-4327

Faculty, College of Arts and Sciences,
University of Southeastern Philippines,
Obrero, Davao City

Organic agriculture is an alternative system that started in 1924 through the advocacy of biodynamic agriculture by Rudolf Steiner that viewed the farm as a living organism and used methods that promoted the health of people, soil, and the ecosystem. The application of Steiner's concepts on organic rice agriculture relies on ecological processes to sustain a healthy environment and promote environmentally friendly food production by reducing the carbon footprint to address climate change and food security. One of the first to advocate and practice organic rice agriculture in the Philippines is Don Bosco Multipurpose Cooperative in M'lang, Cotabato.

Weeds are a serious problem to rice farmers in the Philippines and other rice-growing countries causing annual global yield loss of 9.5% (Rabbani et al., 2011) and 57-61% in the Philippines (Mukherjee et al., 2008). The negative influence of weeds on rice productivity may be attributed to competition for light, water, and nutrients (Mesquita et al., 2013)—which may be intensified by increasing temperatures associated with global warming as a consequence of climate change (Santra et al., 2014).

Weeds may also function as hosts to rice insect pests and viruses, bacteria, and nematodes that are deleterious to the rice plant. On the other hand, high weed diversity may support beneficial arthropod species such as crop pollinators (Marshall et al., 2003) and regulate soil microbial diversity (Yufeng Luo et al., 2014).

Rice yield losses caused by weeds depend on species composition, density, and duration of infestation including the associated environmental conditions such as pH and salinity that vary according to location. Thus, ecological knowledge on rice weed species could lead to a better understanding of the rice agroecosystem and improvement in weed management.

Several studies in the Philippines and other countries focused on weeds in conventional rice fields. However, there is little information on the weed flora in organic rice fields in M'lang, Cotabato.

Materials and Methods

Study site

The selection of the study site in Barangay Langkong, M'Lang, Cotabato was facilitated by the Don Bosco Multi-Purpose Cooperative—a pioneer in organic agriculture in the Philippines. The chosen area had been subject to organic rice farming for twenty-two years and was among the few farms that are certified by the European Union Certification of Environmental Standards (CERES) and U.S. Department of Agriculture (USDA). The farm lies at

6.92327 N, 124.897 E and is approximately 25000 m2. The shape of the farm as a whole is an irregular hexagon composed of 31 fields of unequal sizes.

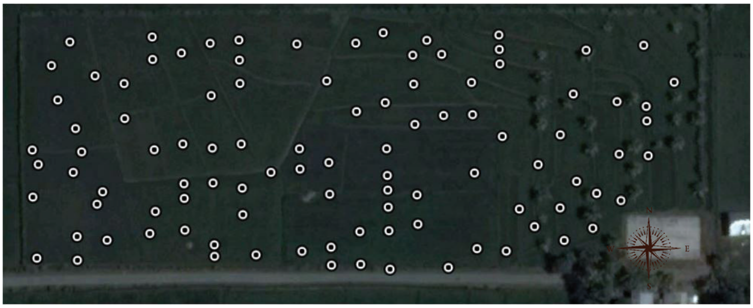

Figure 1. Fe's Organic rice farm in Langkong, Mlang, Cotabato showing locations of sampling units.

Sampling Procedure

Random selection of one hundred sampling units (0.25 m2 quadrat) was possible by the use of R. The allocation of sampling units to each field was proportionate to the relative field area (Figure 1).

Data collection and analyses

The sampling units were located in the field using Gramin eTrex GPS receiver. The quadrats had dimensions of 0.5 x 0.5 meters (Focht & Pillar, 2003; Olorunmaiye et al., 2011) that was improvised using PVC tubes with 1.9 cm diameter. All weeds inside the quadrats were collected and placed inside a plastic bag bearing the field name and quadrat number. Voucher specimens for the herbarium had sticky note labels attached (scientific name, field name and plot number) before they were placed in a standard 12" x 18" wooden plant press. The identification of weed species involved examination of diagnostic characteristics and comparison to photographs in the related literature.

Data analysis used the following quantitative measures:

Frequency (F) is the percentage of the total number of fields surveyed in which a species occurred in at least one quadrat.

Frequency = $$Fk = \frac{\sum_1^n Y_i}{n} \times 100$$

Where:

Yi = presence (1) or absence (0) of species k in field i

n = number of fields surveyed

Field uniformity (FU) is the percentage of the total number of quadrats sampled in which a species occurred.

Field Uniformity = $$FUk = \frac{\sum_1^n \sum_1^q Xij}{qn} \times 100$$

Where:

FUk = field uniformity value for species k

Xij = presence (1) or absence (0) of species k in quadrat j in field i

n = number of fields surveyed.

Field density (*D*) of each species in a field is the sum of the number of a species in all quadrats and divided by the area of quadrats in a field.

Field Density = $$Dki = \frac{\sum_1^q Zi}{Ai} \times 100$$

Where:

Dki = density (in numbers m^2) value of species k in field i

Zi = number of plants of a species in quadrat j (a quadrate is 0.25 m).

Ai = area in m^2 of quadrats in field i.

Mean field density (*MFD*) is the mean number of plants m^2 for each species averaged over all fields sampled.

Mean Field Density = $$MFDk = \frac{\sum_1^n Dki}{n}$$

Where:

MFDk = mean field density of species k

Dki = density (in numbers m^2) of species k in field i

n = number of fields surveyed.

The mean occurrence field density (MOFD) value is the mean number of plants m^2 for a weed species averaged over only the fields in which the species occurred.

Mean Occurrence Field Density = $MOFDk = \frac{\sum_1^n Dki}{n-a}$

Where:

MOFDk = Mean occurrence density of species k

Dki = Density (in number m[2]) of species k in field i

n = No. of field surveyed

a = No. of field from which species k is absent

The combination of the three measures below summarized the abundance of a species into a single value called the relative abundance.

1. Relative frequency for species k *(RF*k)

$$\text{RFk} = \frac{\text{Frequency value of species}}{\text{Sum of frequency values for all species}} \times 100$$

2. Relative field uniformity for species k *(RFU*k)

$$\text{RFUk} = \frac{\text{Field uniformity value of species k}}{\text{Sum of field uniformity values for all species}} \times 100$$

3. Relative mean field density for species k *(RMFD*k)

$$\text{RMFDk} = \frac{\text{Mean field density value of species k}}{\text{Sum of mean field density values for all species}} \times 100$$

The relative abundance of species k (*RA*k) is the sum of relative frequency, relative field uniformity, and relative mean field density for that species:

$$RAk = RFk + RFUk + RMFDk$$

Each of the three components in this synthetic index has equal weights. The total relative abundance of all species is 300. Thus, the relative abundance of a species is a convenient way of ranking species and of comparing the proportional contribution of each species or groups of species to the total abundance. For example, if species 1 had a relative abundance value of 180, then the proportional contribution of this species to the total relative abundance would be 180 divided by 300 or 0.6.

Biodiversity

Species richness and evenness are two concepts that relate to biodiversity. Species richness is the number of different species present and is a simple count. Evenness is the relative apportionment of abundances among species and a Lorenz curve or Lorenz dominance order for abundance arrays is the perfect representation for evenness ranking (Taillie, 1979; Gosselin, 2001). In a Lorenz curve, the ranking of relative abundances is from low to high. The highest evenness occurs in a diagonal line corresponding to perfect evenness. The Gini evenness index ranges from zero to one and is the ratio of the area between the diagonal and Lorenz curve divided by the total area under the diagonal. It is a measure of inequality. A Gini index of zero means perfect evenness and high biodiversity. The greater the Gini index the less evenness or the lower biodiversity. A Gini index of one indicates the presence of only one species. The Lorenz curve plots the cumulative proportion of species as a function of the cumulative proportion of abundance and is a graphical representation of biodiversity. The Gini index is a quantitative representation of the Lorenz curve.

Shannon-Weiner Diversity Index also involves species richness and evenness and is equal to the sum of the log transformed relative proportions weighted by its corresponding proportion multiplied by negative 1. Species diversity is high when the value is >three, medium when the value is between one and three, and low when the value is <one (Samharinto et al, 2012). The effective number of species is the antilog of Shannon-Weiner Diversity Index and provides an actual measure of biodiversity in terms of the number of equally abundant species (Jost, 2006).

Results and Discussion

The examination of 453 collected weed specimens showed 13 species, 11 genera, and 6 families. Cyperaceae (5 species), Poaceae (3 species), Onagraceae (2 species), and Lythraceae (1 species), Convolvulaceae (1 species) and Sphenocleaceae (1 species) comprising 8 annual species and 5 perennial species (Table 1). Hakim et al., (2010) in coastal rice fields in Malaysia, Al-Gohary (2008) in 11 wadis in Egypt, and Gonzales (2017) in rice fields in the Philippines observed the prevalence of annual species over perennial species. According to Kim et al. (1983), local biological and environmental factors influence the composition of weed communities.

Table 1. Distribution of weed species based on family, scientific name, local names, and life cycle.

Family name	Scientific name	Local name	Life cycle	("Invasive Species Compendium", 2020)
Campanulaceae	Sphenoclea zeylanica Gaertner	San Pablo	Annual	No
Convulvulaceae	Ipomoea aquatica Forssk	Tangkong	Perennial	No
Cyperaceae	Fimbristylis miliaceae (L.) Vahl	Bungot-bungot	Perennial	No
	Cyperus iria L.	Payong-payong	Perennial	No
	Cyperus difformis L.		Annual	No
	Fuirena ciliaris (L.) Roxb		Annual	No
	Schoenoplectus juncoides (Roxb.) Palla		Annual	No
Lythraceae	Ammannia coccinea Rottb.		Perennial	No
Onagraceae	Ludwigia octovalvis (Jacq.) P.H. Raven		Annual	No
	Ludwigia adscendens (L.) Hara	Maranhig	Annual	No
Poaceae	Echinochloa crusgalli (L.) P. Beauv	Duwa-duwa	Annual	No
	Oryza sativa f. spontanea		Perennial	No
	Cynodon dactylon Pers.	Bermuda	Annual	No

Table 2. Frequency (F), Field Uniformity (FU), Mean Field Density (MFD), and Mean Occurrence Field Density (MOFD) of weeds.

Scientific name	F(%)	FU(%)	MFD(m^2)	MOFD(m^2)
Fimbristylis littoralis	45.16	21.78	9.13	20.21
Cyperus difformis	45.16	19.80	9.05	20.04
Ammannia coccinea	29.03	10.89	0.89	3.06
Sphenoclea zeylanica	25.81	10.89	1.15	4.44
Ludwigia octovalvis	22.58	7.92	1.22	5.38
Cynodon dactylon	22.58	6.93	0.77	3.41
Cyperus iria	16.13	4.95	0.41	2.52
Ludwigia adscendens	12.90	3.96	0.78	6.03
Oryza sativa f. spontanea	12.90	3.96	1.11	8.60
Echinochloa crusgalli	9.68	2.97	0.65	6.71
Fuirena ciliaris	9.68	2.97	0.59	6.04
Ipomoea aquatica	3.23	0.99	0.09	2.67
Schoenoplectus juncoides	3.23	0.99	0.13	4.00

The most common and frequent weed species are Fimbristylis littoralis and Cyperus difformis and the least are Ipomoea aquatica and Schoenoplectus juncoides (Table 2). The remaining nine weed species had frequency values between the highest and lowest frequencies. All weed species had <50% uniformity which imply less competitiveness against rice or effective control by weed management practices (Hakim, 2010).

Fimbristylis littoralis and Cyperus difformis are the most abundant weeds with mean densities of 9.127 and 9.049 plants m2 (Table 2). Ipomoea aquatica and Schoenoplectus juncoides are the least abundant weeds with mean densities of 0.086 and 0.129 plants m2. The other weed species had mean densities ranging from 1.1215 to 0.406 plants m2. Gonzales (2017) in La Union, Philippines and Hakim (2010) reported Fimbristylis littoralis as the most abundant weed in rice fields. According to Hakim (2010), the weed density of fields in which the species occurred increased compared to densities from all fields for all weed species that may mean that site-specific or management-specific factors contribute to the survival of those species.

Frequency and field uniformity contribute to the differences between MOFD and MFD (Table 2). Fimbristylis littoralis and Cyperus difformis have the highest frequencies and also the highest field uniformities and highest mean field densities indicating that these weeds are the most difficult to control (Hakim, 2010). However, weeds that have frequencies less than 40%, field uniformities less than 10, and mean field densities less than 0.0645 m2 may be less competitive with rice (Hakim, 2010). Donayre et al. (2016) said that farmers consider Cyperaceae as a limiting factor in rice production causing 44-96% reduction in rice yield. Vincent (2016) obtained 100% frequency for Cyperus difformis in Nairobi rice paddies.

Relative abundance measures the overall weed problem posed by a species (Table 3). Fimbristylis littoralis and Cyperus difformis have the highest RA values of 74.69% and 72.39%. Ipomoea aquatica and Schoenoplectus juncoides had the lowest RA values of 2.747% and 2.582%. The other weed species had RA values ranging from 25.67% to 9.005%. It is probable that Fimbristylis littoralis and Cyperus difformis are the more serious weed species in the study site. Using the RA values to indicate dominance ranking among weeds (Thomas, 1985), Fimbristylis littoralis and Cyperus difformis are the two most dominant weed species. Rabbani et al. (2011) in Pakistan and Vincent (2016) in Nairobi mentioned Cyperus difformis as one of the most abundant and dominant weeds in rice fields.

Table 3. Relative Frequency (RF), Relative Field Uniformity (RFU), Relative Mean Field Density (RMFD), and Relative Abundance (RA) of grasses, sedges, and broadleaf weeds.

Scientific name	RF(%)	RFU(%)	RMFD(%)	RA(%)	Type of weed
Fimbristylis littoralis	17.50	22.00	35.19	74.69	Sedge
Cyperus difformis	17.50	20.00	34.89	72.39	Sedge
Ammannia coccinea	11.25	11.00	3.42	25.67	Broadleaf
Sphenoclea zeylanica	10.00	11.00	4.42	25.42	Broadleaf
Ludwigia octovalvis	8.75	8.00	4.68	21.43	Broadleaf
Cynodon dactylon	8.75	7.00	2.97	18.72	Grass
Oryza sativa f. spontanea	5.00	4.00	4.28	13.28	Grass
Cyperus iria	6.25	5.00	1.57	12.82	Sedge
Ludwigia adscendens	5.00	4.00	3.00	12.00	Broadleaf
Echinochloa crusgalli	3.75	3.00	2.50	9.25	Grass
Fuirena ciliaris	3.75	3.00	2.26	9.01	Sedge
Schoenoplectus juncoides	1.25	1.00	0.50	2.75	Sedge
Ipomoea aquatica	1.25	1.00	0.33	2.58	Broadleaf

The Lorenz curve (Figure 2) shows the dominance of Fimbristylis littoralis and Cyperus difformis. Both species contributed a combined proportion of 0.49 or 49% of the total abundance. In contrast, the four least dominant species contributed a combined proportion of 0.079 or 7.9% to the total abundance. This pattern of dominance reflects the distance of the curve from the diagonal. The Gini index (0.472) and Shannon –Weiner Diversity Index (1.6) indicate that weed species diversity is medium. The effective number of species shows that the weed species diversity is equivalent to five equally abundant species. Nithya and Ranamoorthy (2015) in rice fields of India reported a Shannon – Weiner Diversity Index ranging from 2.11 to 2.46 that would be equivalent to 8 to 12 equally abundant species.

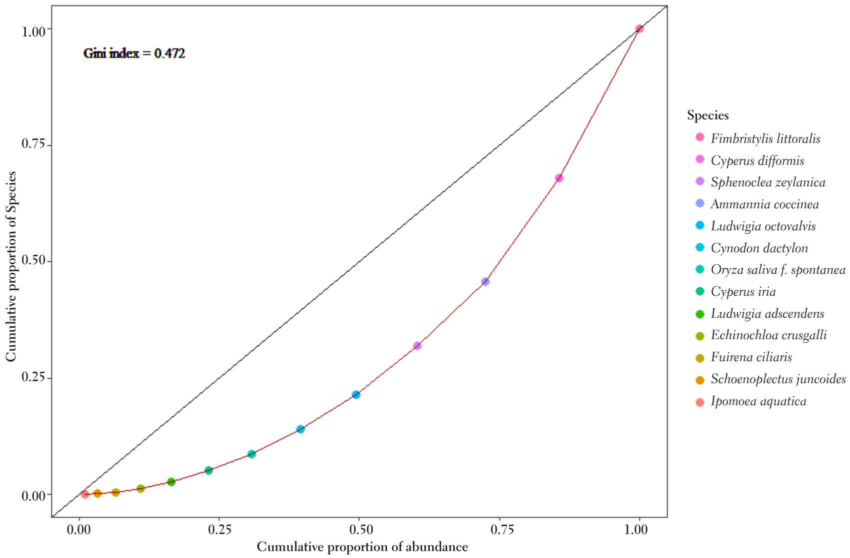

Figure 2. Lorenz curve for evenness of the relative abundance of weed species.

Conclusions and Recommendations

This ecological study presents quantitative information on weeds in organic rice fields. Observations show thirteen weed species five of which are broad leafs (Ammannia coccinea, Ipomoea aquatica, Ludwigia adscendens, Ludwigia octovalvis, Sphenoclea zeylanica), three grasses (Cynodon dactylon, Oryza sativa f. spontanea, Echinochloa crusgalli), and five sedges (Fimbristylis littoralis, Cyperus difformis, Cyperus iria, Fuirena ciliaris, Schoenoplectus juncoides) in Langkong, Mlang, Cotabato. Similar studies in different environments may provide additional information and insights on weed ecology in organic rice fields with implications on weed control practices.

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