Weed Population Dynamics and Composition in a Tropical Island Eggplant (*Solanum melongena L.*) Agroecosystem: Implications for Sustainable Weed Management[1]

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Abstract: Competition between crops and weeds is a huge challenge for eggplant (*Solanum melongena* L.) farmers in Fiji. The aim of this study was to identify and quantify weed species in major eggplant agroecosystems of Fiji, with a focus on their prevalence, distribution, and seasonal abundance to inform effective and sustainable weed management strategies. The weed population data were used to calculate frequency, abundance, density, relative values, importance value index per species per location, and similarity index of species against each location. In addition, principal component analysis was used to identify key factors influencing weed distribution and abundance. A total of 40 weed species from 18 families were identified across agroecosystems, comprising 24 annual species and 16 perennial species. Overall, weed species composition comprised 27.2% grasses, 25.4% sedges, and 47.4% broadleaves. The predominant weed species were found to be from the Poaceae family, specifically *Cynodon dactylon* L. Pers. (Couch grass), *Echinochloa colona* L. Link (Jungle rice), and *Eleusine indica* L. Gaertn. (Crows foot), while *Cyperus rotundus* L. (Purple nutsedge) was the major species from the Cyperaceae family. The first two principal components (dry zone PC1 and intermediate zone PC2) explain 55.8% of total variance, highlighting the dominance of sedges like *C. rotundus* in PC1 and the prevalence of grass species such as *E. indica* and *E. colona* in PC2.

Keywords: weed survey, weed diversity, importance value index, similarity index, Fiji

WEEDS pose a significant global challenge to agricultural production (Mengist et al. 2019, Madden et al. 2021). Their detrimental impacts manifest in substantial economic losses for individuals and nations alike (Marques et al. 2016). Weeds compete with cultivated food crops for essential resources such as light, moisture, nutrients, and space, culminating in reduced crop yields, inferior product quality, and diminished farm income (Jibat et al. 2019, Mengist et al. 2019, Sintayehu 2019). Moreover, weeds can act as alternative hosts for some pests and diseases, thereby exacerbating these issues (Oliveira et al. 2018). Unchecked weed proliferation can lead to significant losses in yield and quality, depending on the crop type and environmental conditions (Marques et al. 2017, Soltani et al. 2018, Unnikrishnan et al. 2024). To counter this threat, farmers often resort to

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repeated herbicide applications, resulting in herbicide-resistant weed populations (Amare 2023) as well as environmental and health risks (Das et al. 2024).

Understanding weed dynamics within specific cropping systems is crucial for developing effective management strategies (Derksen et al. 2002, Mengist et al. 2019). Crops exhibit varying degrees of susceptibility to weed competition, impacting the intensity of weed control required to safeguard yields (Madden et al. 2021). Furthermore, a multitude of factors, including cultural practices, cropping systems, soil type, location, and environmental conditions, influence the abundance and distribution of weed species in cultivated fields (Mohler 2001, Sit et al. 2007, Banjare et al. 2014). Consequently, identifying associated weed species and examining their distribution, density, frequency, dominance, and population fluctuations in response to agronomic practices and agroclimatic conditions is essential.

Fiji's tropical climate fosters a thriving environment for diverse vegetable and fruit production for domestic consumption and export. In recent years, eggplant cultivation has surged in Fiji (MOA 2023), transitioning from a minor crop to Fiji's primary horticultural export (FAO 2016). Production increased from 1,138.5 to 8,651.0 tonnes between 2016 and 2023, generating a revenue of approximately 15 million FJD from exports (MOA 2023). However, this export success is now threatened by pest outbreaks impacting eggplant fruit quality and market access (Jackson et al. 2021). Several studies have reported that weeds can harbor insect pests such as thrips, which now represent a significant constraint to the quality of eggplant production throughout the world (Silva et al. 2018, Elimem et al. 2022, Jangra et al. 2022, Matsuda and Ichihara 2022).

In addition to harboring pests, weeds can directly affect eggplant growth and yield, with reported yield reductions ranging from 49% to 96% (Banjare et al. 2014, Marques et al. 2016, 2017). Thus, understanding the diversity and effects of weed species in eggplant farms is critical for their effective management (Kaur and Kaur 2021). However, limited research has been conducted on weed species associated with eggplant in Fiji. This knowledge gap hampers the development of sustainable weed management practices.

To address these challenges, this study was designed to assess the prevalence, distribution, and seasonal abundance of dominant weed species in the major eggplant agroecosystems in Fiji. By understanding these factors, we seek to predict the invasive potential of weed biotypes and inform effective control strategies. This information will guide economically sound weed management decisions in Fijian eggplant agroecosystems.

MATERIALS AND METHODS

Description of Study Area

The study was conducted in the western provinces of Fiji, specifically in the major agricultural zones of Nadroga/Navosa and Ba, where eggplant is cultivated for export markets. These provinces contributed 93.8% of total eggplant production for the Western Division and had more than one-third of the national eggplant production in 2020 (36.7%) (MOA 2020). The study sites exhibited intermediate (Nadroga/Navosa) and dry (Ba) climatic conditions. The geographic coordinates of the surveyed area ranged from 17.3°S, 177.4°E to 18.0°S, 177.3°E (Figure 1). Table 1 presents average temperature, annual and seasonal rainfall, elevation, and soil types for the study area between September 2014 and March 2021.

Procedure of Weed Survey

Eggplant farm selection was guided by Ministry of Agriculture Bilateral Quarantine Agreement locality officers with expertise in fresh export pathways, prioritizing farms with at least three to five years of eggplant production history, cultivation of export varieties, and diverse climatic conditions. Six farms were selected (three in each of the two provinces of Nadroga/Navosa and Ba). Four (quarterly) weed flora surveys were conducted on these six farms to identify prevalent weed species over a one-year period (January–December 2023), totaling 24 weed surveys.

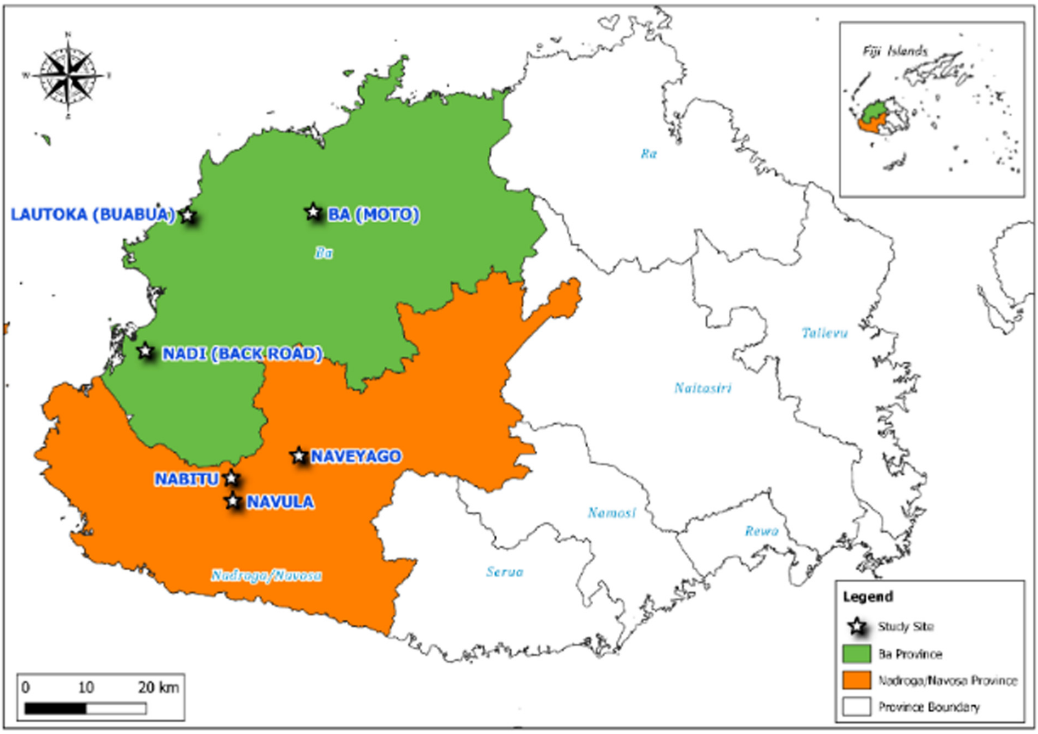

FIGURE 1. Map displaying the geographical locations of the study sites situated on the Western side of Viti Levu, encompassing the Nadroga/Navosa and Ba provinces in Fiji.

TABLE 1

Typical Climatic Conditions, Elevation, and Soil Type for Two Provinces Surveyed during September 2014–March 2021

	Parameters			
Surveyed Location	Elevation (m)	Rainfall Range (mm)	Temp. Monthly Mean (°C)	Soil Type[a]
Nadi	6–24	Annual average: 1,800–1,400	25	Nadi clay (31d)
		Dry season: 400–500		
		Wet season:1,400–1,800		
Lautoka	3–20	Annual average: 1,800–2,400	26	Lautoka clay (48a)
		Dry season: 400–500		
		Wet season: 1,400–1,800		
Ba	15–150	Annual average: 1,800–2,400	25.5	Ba gravelly clay (35d)
		Dry season: 400–500		
		Wet season: 1,400–1,800		
Sigatoka	5–15	Annual average: 2,000–3,200	25	Sigatoka sand and sandy loam (7a), Sigatoka clay (7b)
		Dry season: 600–800		
		Wet season: 1,400–2,000		

[a]Source: Leslie and Seru (1998).

The Quarter 1 weed survey was conducted shortly after the transplanting of eggplant seedlings, while Quarter 2 and Quarter 3 surveys corresponded to the flowering and fruiting stages, and Quarter 4 took place during the late fruiting stage.

Weed vegetation within selected sites was systematically recorded using a 1 m^2 quadrat. Within fields, quadrats were placed equidistantly in a "W" pattern such that nine quadrats were sampled per field, following the quantitative survey methodology outlined by Thomas (1985). Quadrat spacing was adjusted based on field size, shape, and potential obstructions such as rocks, uneven crop planting, or areas with dense crop growth limiting quadrat placement. All plant species within each quadrat were identified to species level using available plant identification guides and subsequently counted and recorded. Each species that was present was assigned an abundance score (1–6) based on percentage ground cover (6: plant species >60% ground cover; 5: 40%–60%; 4: 20%–40%; 3: 10%–20%; 2: 5%–10%; and 1: <5% (Silva et al. 2018)). For later verification (Smith 1985, Whistler 1994), sample weed specimens were collected, tagged, and pressed in the field. Collected weed samples were preserved at the National Insect & Weeds Museum at Plant Protection Section, Koronivia Research Station Ministry of Agriculture, and the South Pacific Regional Herbarium of The University of the South Pacific (USP), Fiji, with assigned accession numbers for future reference.

Data Analysis

Quantitative and qualitative analyses were conducted using appropriate equations, derived from previous studies (Booth et al. 2003, Bonham 2013, Mishra 2013, Terfa 2018, Kumar et al. 2020, Bekele and Azerefegne 2022, Salaudeen et al. 2022), as shown below:

$$\text{Frequency } (F) = \frac{\text{Total no. of quadrats in which the species occurs}}{\text{Total number of quadrats used}} \times 100 \tag{1}$$

$$\text{Density } (D) = \frac{\text{Total no. of individuals of species in all the quadrats}}{\text{Total number of quadrats studies}} \tag{2}$$

$$\text{Abundance } (A) = \frac{\text{Total no. of individuals of a species in all the quadrats}}{\text{Total number of quadrats in which the species occured}} \tag{3}$$

$$\text{Relative frequency (RF)} = \frac{\text{Frequency of individuals of a species}}{\text{Total frequency of all species}} \times 100 \tag{4}$$

$$\text{Relative density (RD)} = \frac{\text{Density of individuals of a species}}{\text{Total density of all species}} \times 100 \tag{5}$$

$$\text{Relative abundance (RA)} = \frac{\text{Abundance of individuals of a species}}{\text{Total abundance of the species}} \times 100 \tag{6}$$

$$\text{Importance value index (IVI)} = \text{Relative frequency} + \text{Relative density} + \text{Relative abundance} \quad (7)$$

$$\text{Similarity index (SI)} = \frac{\text{Number of species found in both locations}}{\text{Species both location} + \text{Species only location I} + \text{Species only location II}} \times 100 \quad (8)$$

Frequency (F) represents the distribution of a weed species across sampling units, indicating its presence and distribution within a community (Bonham 2013). Density (D) measures the number of individuals of a species per unit area, while abundance (A) reflects population density. Relative frequency (RF) shows the species' dispersion compared to others, and relative density (RD) represents the proportion of individuals relative to the total population. Relative abundance (RA) indicates the evenness of species distribution. The importance value index (IVI), combining RA, RD, and RF, assesses a species' ecological significance, while the similarity index (SI) measures species diversity and helps monitor biodiversity threats (Rahman et al. 2018). To reduce the dimensionality of the dataset and identify the key variables contributing to the variance in the data, a principal component analysis (PCA) was performed. PCA was conducted using the R software (Version 4.3.3), with scaling applied to standardize the variables. The dataset comprised environmental parameters and abundance of different weed species.

RESULTS

Common Weed Species in Eggplant Agroecosystems

The survey showed that the most common weeds associated with eggplant cultivation in the six study locations were broadleaved species (47.4%), grasses (27.2%), and sedges (25.4%; Table 2). Forty different plant species from 18 families were identified, with the Poaceae and Asteraceae being defined as highly diverse (6 species each). Of these 40 weed species, 29 were Dicotyledonae (15 families), while the rest were Monocotyledoneae

TABLE 2

Common Weed Species Found in and around Eggplant Fields Growing Areas in the Provinces of Nadroga/Navosa and Ba Fiji in 2023

Class	Family	Scientific/Botanical Name	Common Name	Average Abundance Score	Percent Weed Flora
		Eleusine indica (L.) Gaertn.	Crows foot (A)	2	8.9
		Echinochloa colona (L.) Link	Jungle rice (A)	2	8.9
Grasses	Poaceae	*Cynodon dactylon* L. Pers.	Couch grass (P)	2	8.1
		Axonopus affinis Chase	Carpet grass (P)	1	0.3
		Digitaria setigera Roth ex R. & S.	Digitaria (A)	1	0.7
		Dactyloctenium aegyptium (L.)	Beach wire grass (A)	1	0.3
		Cyperus rotundus L.	Purple nutsedge (P)	4	25.0
Sedges	Cyperaceae	*Kyllinga polyphylla* Willd. ex Kunth	Navua sedge (P)	1	0.1
		Fimbristylis miliacea (L.) Vahl	Codamu (A)	1	0.4

(table continues)

TABLE 2 (*Continued*)

Class	Family	Scientific/Botanical Name	Common Name	Average Abundance Score	Percent Weed Flora
	Commelinaceae	*Commelina diffusa* Burm.f.	Spreading dayflower (P)	2	8.4
		Commelina benghalensis L.	Wandering jew (P)	1	0.1
	Rubiaceae	*Hedyotis corymbosa* L.	Diamond flower (P)	2	6.8
		Spermacoce latifolia Aubl.	False buttonweed (P)	1	1.6
	Euphorbiaceae	*Phyllanthus amarus* Sch. & Thon.	Gale of wind (A)	1	0.6
		Euphorbia heterophylla L. var.	Milk weed (A)	1	1.9
		Euphorbia hirta L.	Garden spurge (A)	1	1.4
		Euphorbia hypericifolia L.	Graceful spurge (P)	1	0.1
	Amaranthaceae	*Gomphrena serrata* L.	Cocksbur (A)	1	0.5
		Amaranthus viridis L.	Slender amaranth (A)	1	1.8
		Amaranthus spinosus L.	Spiny amaranth (A)	1	2.5
Broad-leaves	Asteraceae	*Emilia sonchifolia* (L.) DC.	Emilia (A)	1	1.3
		Cyanthillium cinereum (L.) H. Rob.	Iron weed (P)	1	1.2
		Ageratum conyzoides L.	Goat weed (A)	1	1.0
		Synedrella nodiflora (L.) Gaertn.	Synedrella (A)	1	0.7
		Mikania micrantha HBK.	Mile a minute (P)	1	0.1
		Crassocephalum crepidioides (Benth.)	Thickhead (A)	1	0.1
	Fabaceae	*Mimosa pudica* L.	Sensitive grass (A)	1	1.9
		Cassia tora L.	Peanut weed (A)	1	1.0
		Desmodium triflorum (L.) DC	Desmodium (P)	1	2.8
	Lythraceae	*Cuphea carthaginensis* (Jacq.) J.F. Macbr.	Tarweed(A)	1	0.1
	Portulacaceae	*Portulaca oleracea* L.	Pigweed (A)	1	0.7
	Onagraceae	*Ludwigia octovalvis* (Jacq.) Raven	Willow primrose (P)	1	2.3
	Solanaceae	*Physalis angulate* L.	Wildcape gooseberry (A)	1	0.7
	Convolvulaceae	*Ipomoea carica* (L.) Lam.	Ipmoea (P)	1	2.7
	Plantaginaceae	*Bacopa procumbens* (Mill.)	Bacopa (A)	1	1.4
	Malvaceae	*Sida rhombofolia* L.	Arrowleaf sida (P)	1	1.0
		Sida acuta Burman f.	Broom weed (P)	1	1.0
	Lamiaceae	*Leucas lavandulifolia* Rees	Leucas (A)	1	0.6
	Cleomaceae	*Cleome viscosa* L.	Yellow cleome (A)	1	0.9
	Cucurbitaceae	*Momordica charantia* L.	Wild bittergourd (A)	1	0.1

Note: A = Annual; P = Perennial, weed flora Abundance score (1–6) based on percentage ground cover (6: plant species >60% ground cover; 5: 40–60%; 4: 20–40%; 3: 10–20%; 2: 5–10%; and 1: <5% (Silva et al. 2018).

(three families). The Monocotyledoneae families constituted 61.1% of the different weed species. The higher proportion of monocots compared to dicots in this study can be attributed to the dominance of families such as Poaceae, Cyperaceae, and Commelinaceae. More annual weed species (24) were recorded than perennial species (16). Among the 40 weed species recorded, the highest percentages of ground cover were observed for *Cyperus rotundus* (24.9%), *Eleusine indica* (8.9%), *Echinochloa colona* (8.9%), *Cynodon dactylon* L. Pers. (8.1%), *Commelina diffusa* (8.4%), and *Hedyotis corymbosa* (6.8%).

Weed Species Frequency, Density, and Abundance

Weed frequency analysis revealed a wide range from 1% to 86%, indicating varied levels of weed presence of the 40 species across the study fields (Table 3). There were two weed species recorded with >80% frequency: *E. indica* (grass 80%) and *C. rotundus* (a sedge 86%). In terms of the density of each weed species, values from 0.0 to 7.3 plants/m^2 were recorded. The sedge *C. rotundus* exhibited the highest density (7.3 plants/m^2), followed by the grasses *E. indica* and *E. colona*, both with densities of 2.6 plants/m^2. Among the broadleaf species, *C. diffusa* had the highest density at 2.4 plants/m^2. Of the three sedges, *C. rotundus* also recorded the highest abundance (8.4), while *C. dactylon* (6.0) and *H. corymbosa* (8.9) were most abundant for grasses and broadleaves, respectively. Furthermore, the results of the seasonal abundance analysis indicate that various weed species, each exhibiting different percentage counts, were identified across the six study sites (Figure 2). The data revealed distinct patterns in weed species distribution, with certain species being more dominant in specific seasons. Each study site demonstrated a unique composition of weed species, with percentage counts varying significantly between sites, highlighting localized ecological differences. Figure 2 provides a detailed breakdown of these variations, showing the weed species present, their seasonal prevalence, and the relative abundance percentages for each site.

IVI of the different weed species

The IVI analysis of the weed species (Figures 3–5) indicated that *C. rotundus* recorded the highest IVI (43.2%), followed by *E. indica* (20.7%), *C. dactylon* (20.1%), and *E. colona* (19.9%). Figure 3 shows the IVI scores for different grass species found within the study area. Of the six grasses recorded in the study area belonging to the Poaceae family, *E. indica*, *E. colona*, and *C. dactylon* emerged as the most widespread and densely populated species, highlighting the highest IVI scores of 20.7%, 19.9%, and 18.8%, respectively. The most common and densely populated sedge weed species was *C. rotundus* with a highest IVI of 43.2%, followed by *F. miliacea* (2.7%) and then *K. polyphylla* (1.8%) (Figure 4). Among the 31 broadleaves, *H. corymbosa* scored the highest with an IVI of 19.1%, followed by *C. diffusa* (19.0%) and then *D. triflorum* (11.0%) (Figure 5).

SI

The SI of all weed species across all locations was calculated and presented in Table 4. The highest SI was between the farms in Lautoka and Nadi (84.5%), while the lowest SI was between the farms in Nabitu and Navula (65.4%). Between the two provinces, the farms in the Ba province had a SI ranging from 69.5% to 84.5%, while those farms from the Nadroga/Navosa province had the SI from 65.4% to 73.3%.

PCA

The data shows a clear pattern where certain weed species are more dominant in specific zones, contributing to the variability captured by the PCA. PCA extracted six principal components, with the first two principal components (PC1 and PC2) explaining most of the variance in the weed data (PC1: 33.3%, PC2: 22.5%, cumulative: 55.8%). PC1 is significantly correlated with the dominance and abundance of grasses, *E. indica* and *E. colona*; sedges, *C. rotundus* and *F. miliacea*; and broadleaved weeds, *C. difusa*, *H. corymbose*, *S. nodiflora*, and *S. rhombofolia*. Broadleaved weeds *C. tora* and *S. acuta* were significantly negatively correlated to PC2. PC2 appears to be influenced by the variation in the same dominant grass species, such as *E. indica* and *E. colona*. Of the environmental variables, rainfall was the most significant contributor to the principal components PC1 and PC2. The biplot (Figure 6) suggests an association between climatic zones, which are demarcated

TABLE 3

Phytosociological Attributes of the Common Weed Species Found Associated with Eggplant in Eggplant-Growing Areas in the Two Western Provinces (Nadroga/Navosa and Ba) of Fiji

Scientific Name	TQ	TOI	TNI	F	D	A	RF	RD	RA	IVI
E. indica	216	173	560	80	2.6	3.2	8.2	8.9	3.6	20.7
E. colona	216	136	559	63	2.6	4.1	6.4	8.9	4.6	19.9
C. dactylon	216	85	508	39	2.4	6.0	4.0	8.1	6.7	18.8
A. affinis	216	22	16	10	0.1	0.7	1.0	0.3	0.8	2.1
D. setigera	216	22	47	10	0.2	2.1	1.0	0.7	2.4	4.2
D. aegyptium	216	14	21	6	0.1	1.5	0.7	0.3	1.7	2.7
C. rotundus	216	186	1570	86	7.3	8.4	8.8	25.0	9.5	43.2
K. polyphylla	216	5	7	2	0.0	1.3	0.2	0.1	1.5	1.8
F. miliacea	216	18	24	8	0.1	1.3	0.8	0.4	1.5	2.7
C. diffusa	216	109	527	50	2.4	4.8	5.1	8.4	5.4	19.0
C. benghalensis	216	7	8	3	0.0	1.1	0.3	0.1	1.3	1.7
H. corymbosa	216	48	427	22	2.0	8.9	2.3	6.8	10.0	19.1
S. latifolia	216	60	100	28	0.5	1.7	2.8	1.6	1.9	6.3
P. amarus	216	53	38	25	0.2	0.7	2.5	0.6	0.8	3.9
E. heterophylla	216	50	117	23	0.5	2.3	2.4	1.9	2.6	6.9
E. hirta	216	80	86	37	0.4	1.1	3.8	1.4	1.2	6.3
E. hypericifolia	216	9	8	4	0.0	0.9	0.4	0.1	1.0	1.6
G. serrata	216	20	32	9	0.1	1.6	0.9	0.5	1.8	3.3
A. viridis	216	74	115	34	0.5	1.6	3.5	1.8	1.7	7.1
A. spinosus	216	95	157	44	0.7	1.7	4.5	2.5	1.9	8.8
E. sonchifolia	216	61	83	28	0.4	1.4	2.9	1.3	1.5	5.7
C. cinereum	216	66	78	31	0.4	1.2	3.1	1.2	1.3	5.7
A. conyzoides	216	44	61	20	0.3	1.4	2.1	1.0	1.6	4.6
S. nodiflora	216	38	47	18	0.2	1.2	1.8	0.7	1.4	3.9
M. micrantha	216	18	6	8	0.0	0.3	0.8	0.1	0.4	1.3
C. crepidioides	216	3	5	1	0.0	1.7	0.1	0.1	1.9	2.1
M. pudica	216	77	122	36	0.6	1.6	3.6	1.9	1.8	7.4
C. tora	216	48	60	22	0.3	1.3	2.3	1.0	1.4	4.6
D. triflorum	216	29	177	13	0.8	6.1	1.4	2.8	6.9	11.0
C. carthaginensis	216	2	4	1	0.0	2.0	0.1	0.1	2.3	2.4
P. oleracea	216	26	43	12	0.2	1.7	1.2	0.7	1.9	3.8
L. octovalvis	216	58	147	27	0.7	2.5	2.7	2.3	2.9	7.9
P. angulate	216	41	44	19	0.2	1.1	1.9	0.7	1.2	3.8
I. carica	216	103	169	48	0.8	1.6	4.9	2.7	1.8	9.4
B. procumbens	216	26	91	12	0.4	3.5	1.2	1.4	3.9	6.6
S. rhombofolia	216	72	62	33	0.3	0.9	3.4	1.0	1.0	5.4
S. acuta	216	50	66	23	0.3	1.3	2.4	1.0	1.5	4.9
L. lavandulifolia	216	28	40	13	0.2	1.4	1.3	0.6	1.6	3.6
C. viscosa	216	39	55	18	0.3	1.4	1.8	0.9	1.6	4.3
M. charantia	216	24	6	11	0.0	0.3	1.1	0.1	0.3	1.5

Note: TQ = Total no. of quadrats; TOI = Total no. of quadrats in which the individual species occurred; TNI = Total no. of individual species in all quadrats in which the species occur; % = Percent; F = Frequency (%); D = Density (plants/m^2); A = Abundance, RF = Relative frequency (%); RD = Relative density (%); RA = Relative abundance (%); IVI = Importance value index (%).

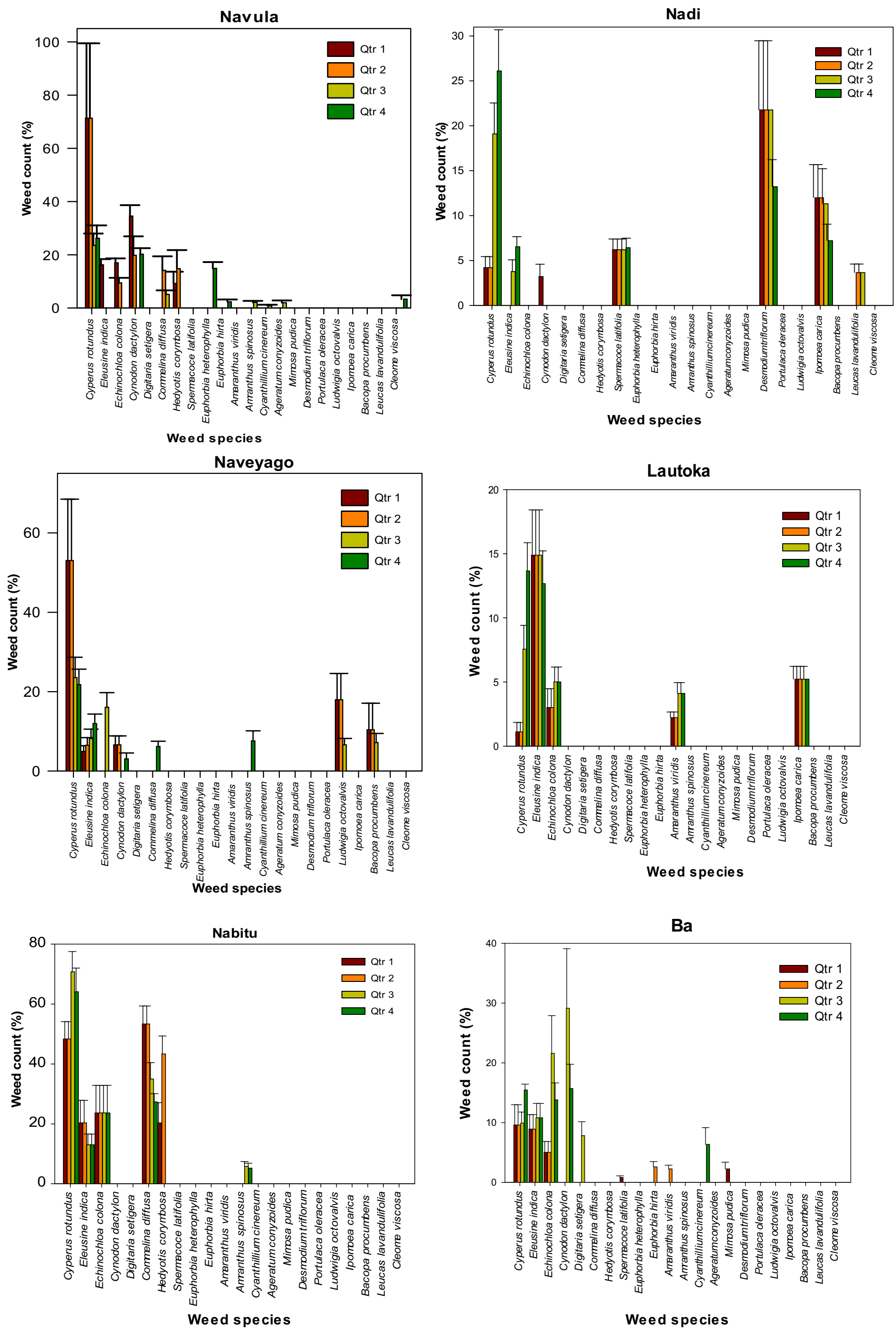

FIGURE 2. Seasonal abundance of common weeds in the six eggplant farms from the six study sites in the two Western provinces (Nadroga/Navosa and Ba) of Fiji.

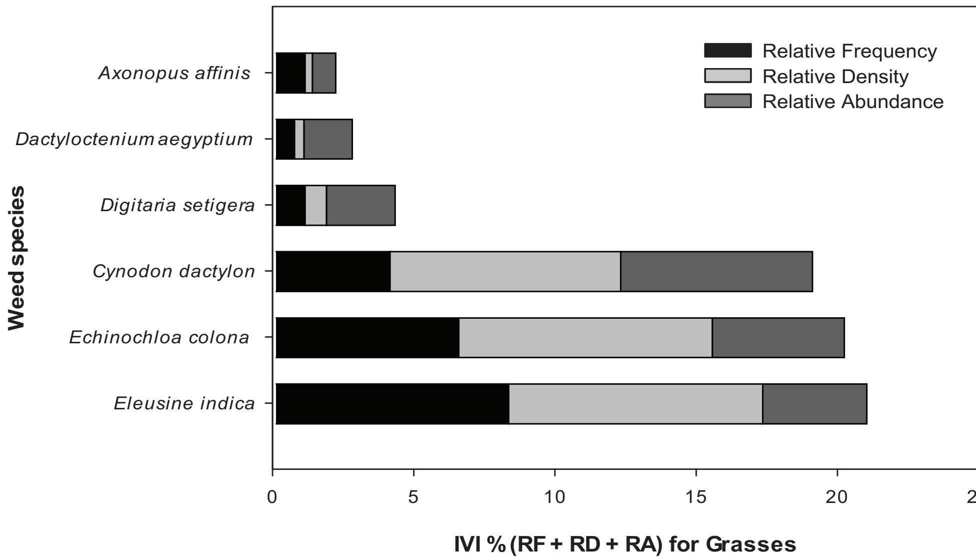

FIGURE 3. IVI of grasses in the six eggplant farms from the study sites in the two Western provinces (Nadroga/Navosa and Ba) of Fiji in year 2023.

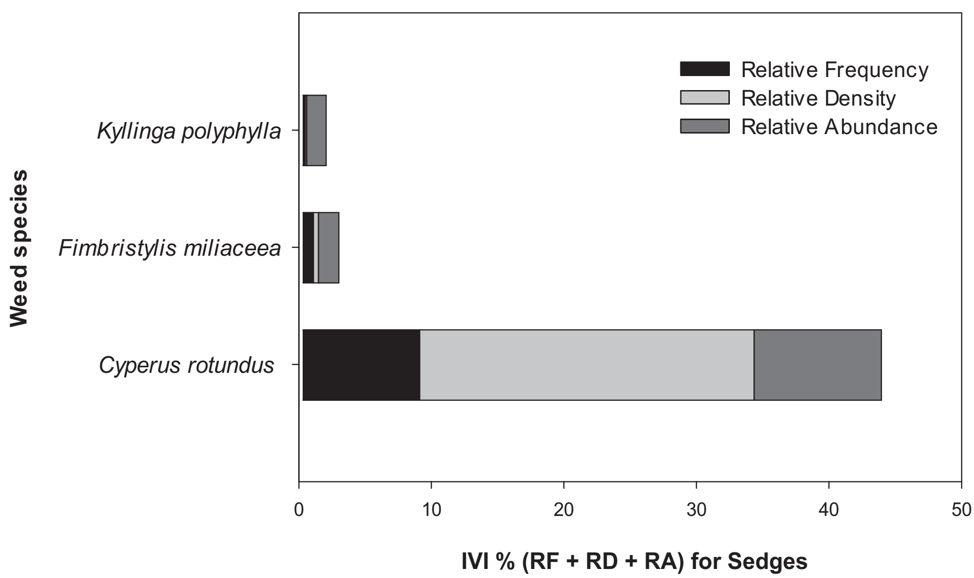

FIGURE 4. IVI of sedges in the six eggplant farms from the study sites in the two Western provinces (Nadroga/Navosa and Ba) of Fiji in year 2023.

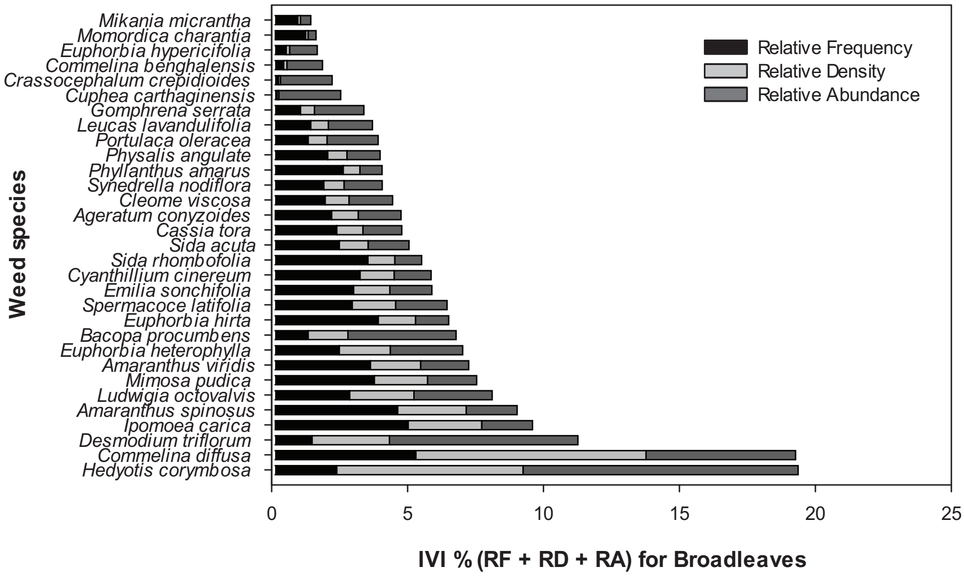

FIGURE 5. IVI of broadleaves in the six eggplant farms from the study sites in the two Western provinces (Nadroga/Navosa and Ba) of Fiji in year 2023.

TABLE 4

SI (%) of Weeds Species on Six Eggplant Farms in the Two Nadroga/Navosa and Ba Provinces, Fiji

Locations	Navula	Naveyago	Nabitu	Nadi	Lautoka	Ba
Navula	100	73.3	65.4	74.8	78.5	74.1
Naveyago		100	68.2	78.4	82.5	77.6
Nabitu			100	69.5	72.7	68.9
Nadi				100	84.5	79.4
Lautoka					100	83.5
Ba						100

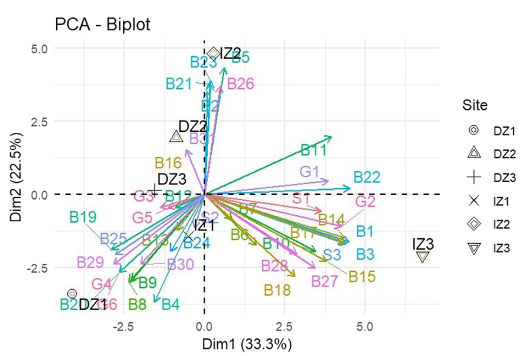

FIGURE 6. PCA biplot of weed species abundance in different climatic zones in the Western provinces (Nadroga/Navosa and Ba) of Fiji. DZ = dry zone; IZ = intermediate zone.

largely by rainfall variability in Fiji, and specific weed populations.

DISCUSSION

This study has provided a comprehensive examination of the weed diversity in the eggplant cultivated areas of western Viti Levu, Fiji. Ecological analysis of the weed data showed that *C. rotundus*, *E. indica*, *E. colona*, *C. dactylon*, *C. diffusa*, *H. corymbosa*, and *D. triflorum* were the major weed species associated with the eggplant fields. Overall, grasses and sedges occurred more frequently than broadleaves in the eggplant fields. *C. rotundus* showed a significant occurrence across all six farms, with the most dominance in the drier regions. This is indicative that the species is highly adaptable and competitive across varying environmental conditions, a characteristic that has also been reported by other researchers (Peerzada 2017, Henry et al. 2021, Rojas-Sandoval and Acevedo-Rodríguez 2022). Preferring warm temperatures and adequate moisture levels (Hefler 2010), this weed is able to rapidly establish itself in the eggplant-growing conditions of tropical and subtropical regions. In addition, it is difficult to control due to its hardy and extensive system of underground tubers and herbicide tolerance, leading to high abundance in agroecosystems (Rojas-Sandoval and Acevedo-Rodríguez 2022, Salaudeen et al. 2022).

Grasses tend to grow best in areas exposed to sunlight, allowing for optimum growth, reproduction, and spread. This could explain why a high number of grass species, such as *E. indica*, *E. colona*, and *C. dactylon*, were dominant across the sampled sites, which receive relatively high levels of sunshine throughout the year. Similarly, the considerable impact of these weeds has also been reported by Marques et al. (2016) within the eggplant agroecosystems of Brazil, reflecting its adaptability and competitive strength in the eggplant cultivation environment. Several other researchers have reported the occurrence of *C. rotundus*, *E. indica*, *E. colona*, and *C. dactylon* as major weeds of other crops as well (Bükün and Uygur 2003, Motlagh and Javadzadeh 2011, Kumar et al. 2020, Rahmawati and Rosleine 2023). Out of these, *C. rotundus* is considered the most important cyperaceous weed in terms of its adverse effect on agriculture, ranking first among the world's worst weeds (Bryson and Carter 2008).

Although our study found broadleaf weeds to be less frequent than grassy weeds, it is important to consider that they are more competitive than grass weeds. This is due to its leaves with wider area coverage and ability to create dense canopies that overshadow low-growing crops (Bailey et al. 2014), like eggplant. In addition, broadleaf weeds develop extensive and aggressive root systems that extract nutrients and moisture from the soil, frequently depleting these resources before the crop can access them (Schenk 2006). These differences not only affect the strategies required for their management but also their interaction with the crops they infest (Sangakkara and Stamp 2006). While nearly all eggplants in Fiji are transplanted, a practice that initially provides some competitive advantage against weeds, the slow initial growth of eggplants and their wide planting spacings make them highly susceptible to weed competition as the season progresses.

The competitive dominance of several weed species in the major eggplant agroecosystems of Fiji could be thriving due to the lack of effective control measures. Therefore, these findings emphasize the necessity for species-targeted and location-specific weed management strategies to mitigate their impact on eggplant production. Strategies such as crop rotation, intercropping, mulching, mechanical weeding, and selective herbicide use should be employed in combination to address the unique challenges posed by dominant weeds in tropical agroecosystems. Future research into the analysis and impact of agricultural practices as well as the ecological behavior of these species will be crucial for developing sustainable weed management practices in Fiji.

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