Indian Journal of Weed Science (2023) **55**(3): 319–323
http://dx.doi.org/10.5958/0974-8164.2023.00059.X

RESEARCH NOTE

Long term effect of soil nutrient management on composition and structure of weed community in a cashew plantation

Meera V. Menon, S. Jalaja, Menon, A.C. Asna, A.N. Naziya Beegum and Teresa Alex*

Received: 18 October 2022 | Revised: 22 August 2023 | Accepted: 25 August 2023

ABSTRACT

Shift from conventional (integrated) to organic system of nutrient management influences the weed spectrum and species richness. Weed communities in conventionally and organically managed cashew plots were studied to assess phytosociological parameters and community diversity indices. The weed spectrum was found to have widened considerably in both systems in comparison to weed species recorded thirty years back, and was dominated by broad-leaved and grass species. Species richness was slightly lower in the organically managed plots. In both systems, broad-leaved weeds dominated, accounting for more than 78% of the population. The major broad-leaved species were *Synedrella nodiflora*, *Borreria hispida* and *Pouzolzia zeylanica*, while the major grass species were *Oplismenus burmannii, Brachiaria* sp. and *Panicum* sp. Community diversity indices, *viz.* Simpson's diversity index and evenness index, did not vary greatly between the two systems, indicating the uniformity of distribution of species, and lack of any major dominant species due to introduction in any one system alone.

Keywords: Cashew plantations, Diversity indices, Soil composition, Weed density, Weed spectrum

The composition and distribution of weed species in a cropping system largely depends on climate soil and agricultural practices. Crop rotation increases the species diversity, while use of herbicides is known to reduce it. Pronounced changes in the ecosystem have been observed on transition from conventional to organic system of cultivation. A reduction in the incidence of problematic weeds and increased species richness has been noted in organic production systems as observed by Liebman and Davis (2000) in sweet corn and potato. In a perennial plantation crop like cashew which covers large areas with similar abiotic characteristics, management practices would largely be responsible for the variation in weed species composition. Cashew (*Anacardium occidentale*) is an important foreign exchange earning crop of India. Planted at a spacing of 7 to 10 m, the wide interspaces between the trees are covered by a dense undergrowth of weeds, if left uncontrolled. The humid tropical climate of Kerala in the southern-most state of India, is conducive for the luxuriant growth of a wide diversity of weed species. Although weeds may offer competition to young cashew plants for water and nutrients, later on their roots occupy different niches and competition for natural resources with cashew is unlikely. The cashew is a surface feeder with about 50% of the root activity being confined to the top 15 cm of the soil, and about 72% cent of the roots within a 200 cm radius from the tree trunk (Wahid *et al.* 1989). However, luxuriant weed growth poses problems in intercultural operations and harvesting, and serves as alternate hosts for several cashew pests. Vanitha *et al.* (2014) have reported that fourteen weed species belonging to eleven families serve as alternate hosts to the most serious cashew pest, the tea mosquito bug.

Conventional system of nutrient management in the Cashew Research Station, Madakkathara, under the Kerala Agricultural University involves both organic and inorganic sources of nutrients. Herbicides are not usually applied, and mechanical weeding using slasher-fitted tractors or brush cutters are the common methods adopted for reducing weed growth in the plantation. The current study focused on organic agriculture necessitates the replacement of the integrated nutrient supply with organic sources of nutrients. Such a shift to organic system is expected to affect the weed spectrum and richness. While several studies have been conducted in annual crops to assess the magnitude and type of change, such studies are lacking in perennial crops like cashew and an investigation was, therefore conducted to assess the effect of transition from conventional to organic system of nutrient management on weed species composition, abundance and density.

Cashew Research Station, Kerala Agricultural University, Thrissur, Kerala 680656, India

College of Agriculture, Kerala Agricultural University, Thrissur, Kerala 680656, India

* Corresponding author email: teresaalex93@gmail.com

MATERIALS AND METHODS

Weed sampling was conducted in August-September of 2022 in the Cashew Research Station, Madakkathara, Thrissur under the Kerala Agricultural University. The area comes under the midland laterite zone and is located geographically at a location between 10°15' and 40°35' N latitude and between 75°15' and 76°25' E longitude, and at an elevation of 30 m above MSL. Humid tropical climate prevails in the region and the annual rainfall received in the area is around 2900 mm. The soil type is laterite with acidic pH. The experiment was carried out in 13-year-old cashew trees, consisting of several high yielding varieties, planted at a spacing of 7 x 7 m. The farm followed the conventional system of cultivation, with nutrients applied in an integrated manner as per the package of practices of the Kerala Agricultural University (KAU 2016). An organic system of cultivation was initiated in 2009 and continued up to 2021 (for 12 years) in about 30 cents area (1214m^2) of the farm with solely organic nutrient sources including farmyard manure, vermicompost, cashew leaf litter and green leaf manure. An equal area (30 cents) under the conventional system was also marked out for the purpose of the study. Weed growth was restricted in both types of cultivation by operating tractors equipped with slashers twice a year. Quadrats of 0.5 x 0.5 m were placed randomly in fifteen locations each in both conventional and organic plots. The quadrats were placed approximately at the centre, equidistant from four cashew trees. All the weed species as well as their number in each quadrat were recorded. Phytosociological measures indicating weed abundance were worked out for each species as per the standard methods proposed by Odum (1971) and Raju (1977).

Analytical characters and community diversity indices of the surveyed areas were then calculated. All parameters were recorded separately for the conventional and organic plots. The analytical characters included frequency (F, number of individual species in an area in percentage), abundance (A, number of individuals of different species in the community per unit area of their occurrence), density (D, the numerical strength of a species per unit area), relative density (RD, the numerical strength of a species in relation to total number of individuals of all species in the quadrat), relative frequency (RF, the frequency of a species in terms of its dispersion relative to that of all the rest of the species), relative abundance (RA, the abundance of a species in terms of its occurrence relative to that of all the rest of the species), important value index (IVI, the sum of relative density, relative frequency and relative dominance, which is the area covered or occupied by different species in percentage), and summed dominance ratio (SDR, the ratio of the IVI of the given species to the number of parameters used to work out the IVI). The derived or synthetic characters, *viz*. species richness (R: total number of species in a given area), Shannon-Wiener diversity index (H'), Simpson's diversity index (C) and Evenness index (J) were worked out using following equations:

$$\text{Shannon's diversity index } H' = -\sum_{i=1}^{K} Pi \, lnPi$$

$$\text{Simpson's diversity index } (C) = \sum_{i=1}^{K} Pi^2$$

$$\text{Evenness index} = \text{H}'/\log \text{R}$$

Where, Pi is the proportion of number of individuals of species 'i' to the total number of individuals of all species in the quadrat (K).

The organic carbon content in the conventional plot was 0.40%, while in the organic plot it was 0.32%. Available N, P and K in the conventionally manured plots were 242, 18 and 90 kg/ha, while the corresponding figures in the organically manured plots were 232, 17 and 155 kg/ha, respectively. Soil pH was slightly higher in the organically manured plots (5.06) than in the conventionally manured plots (4.99).

Weed spectrum and occurrence

The weed species present in the Cashew Research Station, Madakkathara were compared with species documented almost 30 years ago by Salam *et al*. (1993). At that period of time, five grass species were identified, *viz*. *Pennisetum pedicellatum, P. polystachyon, Paspalum* sp., *Brachiaria* sp. and *Ischaemum indicum*. The fourteen major broad-leaved weeds recorded were *Chromolaena odorata, Mimosa pudica, Synedrella nodiflora, Elephantopus scaber, Desmodium triflorum, Glycosmis arborea, Hemidesmus indicus, Ichinocarpus frutescens, Passiflora foetida, Cyclea peltata, Tragia involucrata, Triumfetta rhomboidea, Ziziphus* sp. and *Naregamia alata.*

The list of weed species observed in the plantation after a period of thirty years revealed that the diversity had widened considerably (**Tables 1** and **2**). The current weed spectrum in the plantation was composed of broad-leaf weeds (BLWs) and grasses, with the former dominating. In the present study, under conventional nutrient management, nine grass species (22%) and 22 broad-leaved (78%) weed species were recorded. Of the grasses documented 30 years ago, only one species namely *Brachiaria* sp., persisted, while four new grasses were identified. Only *Synedrella nodiflora* and *Desmodium triflorum* of the original BLW population were identified, while many new species, particularly

Borreria hispida and *Pouzolzia zeylanica*, were abundant. Broad-leaved species were dominant in the weed community, with *Synedrella nodiflora*, *Borreria hispida*, and *Pouzolzia zeylanica* recording the highest density (**Figure 1a**), frequency, relative density and relative frequency. *Borreria hispida* and *Pouzolzia zeylanica* also recorded the highest abundance and relative abundance. These three weeds also recorded the highest importance value index and summed dominance ratio (**Table 1**). Among grasses, the dominant ones were *Brachiaria* sp., *Oplismenus burmannii* and *Panicum maximum* (**Figure 1b**). From the ecological point of view, the most important species was *Borreria hispida* (IVI of 43.15 and SDR of 11.38%), followed by *Pouzolzia zeylanica* (IVI of 29.10 and SDR of 9.71%) and *Synedrella nodiflora* (IVI of 28.70 and SDR of 9.57%). Among grasses, the major species was *Brachiaria* sp. (IVI of 18.4 and SDR of 6.15%).

The number of weed species was slightly lower in the plots applied with organic manures in which four grasses (21%) and 17 BLWs (79%) were identified. Highest densities were recorded of *Pouzolzia zeylanica*, *Synedrella nodiflora* and *Borreria hispida* (**Figure 2a**), the same as those in the conventionally manured plots. *Pouzolzia zeylanica* was the most dominant, recording an IVI of 45.88 and SDR of 15.29%, followed by *Synedrella nodiflora* (IVI of 39.21 and SDR of 13.07%) and *Borreria hispida* (IVI of 34.45 and SDR of 11.48%). The dominant grass weed was *Oplismenus burmannii* with an IVI of 30.33 and a SDR of 10.11%, *fb Panicum repens* (IVI of 14.67 and SDR of 4.89%) (**Table 2** and **Figure 2b**).

In arable systems, organic agricultural methods have been reported to increase the abundance of many weed species and organism groups compared with conventional methods. However, in some cases, reduction of species richness has been observed. Suppression of weeds by the addition of organic manures was reported by Jabran (2017) and was explained by the possible phytotoxic allelochemicals released after the addition of concentrated organic manures which effectively inhibited weed seed germination or caused weed seed mortality. Similar results were reported by Ghosh *et al.* (2022) in rice. However, in perennial plantations, such effects may not occur as frequent and regular soil disturbances are absent and more or less similar soil and weather conditions prevail throughout. Organic agriculture has been observed to have a stronger effect on biodiversity in arable systems (for example, in cereals) than in grassland systems (Tuck *et al.* 2014).

Composition, diversity and density of weeds are strongly influenced by the source, and dose of added nutrients like nitrogen (Ghosh *et al.* 2018). Availability of sunlight could also alter the species composition. Increased nitrogen availability in conventionally fertilized plots could have promoted the growth of

Table 1. Distribution of weed species in conventionally manured plots

Sl. no.	Weed species	Density (no./m^2)	Frequency (%)	Abundance (no./m^2)	RD (%)	RF (%)	RA (%)	IVI	SDR (%)
1.	*Ageratum conyzoides* L.	0.67	11.1	6.00	1.88	1.23	6.01	9.12	3.04
2.	*Oplismenus burmannii*	1.78	33.3	5.33	5.00	3.70	5.34	14.0	4.68
3.	*Alternanthera bettzickiana*	1.67	55.6	3.00	4.69	6.17	3.00	13.86	4.62
4.	*Asystasia gangetica*	1.22	33.3	3.67	3.44	3.70	3.67	10.8	3.60
5.	*Biophytum sensitivum*	0.89	33.3	2.67	2.50	3.70	2.67	8.87	2.96
6.	*Borreria hispida*	6.22	77.8	8.00	17.5	8.64	8.01	34.15	11.38
7.	*Brachiaria* sp.	2.67	44.4	6.00	7.50	4.94	6.01	18.4	6.15
8.	*Centrosema pubescens*	0.78	33.3	2.33	2.19	3.70	2.34	8.23	2.74
9.	*Cleome burmannii*	0.22	11.1	2.00	0.63	1.23	2.00	3.86	1.29
10.	*Commelina diffusa*	0.56	22.2	2.50	1.56	2.47	2.50	6.53	2.18
11.	*Dactyloctenium aegyptium*	0.11	11.1	1.00	0.31	1.23	1.00	2.55	0.85
12.	*Desmodium triflorum*	1.33	22.2	6.00	3.75	2.47	6.01	12.2	4.08
13.	*Digitaria sanguinalis*	0.56	11.1	5.00	1.56	1.23	5.01	7.80	2.60
14.	*Eleusine indica*	0.56	22.2	2.50	1.56	2.47	2.50	6.53	2.18
15.	*Hemidesmus indicus*	0.22	11.1	2.00	0.63	1.23	2.00	3.86	1.29
16.	*Ichnocarpus frutescens*	1.00	44.4	2.25	2.81	4.94	2.25	10.00	3.33
17.	*Ischaemum* sp.	0.22	11.1	2.00	0.63	1.23	2.00	3.86	1.29
18.	*Ludwigia parviflora*	0.33	11.1	3.00	0.94	1.23	3.00	5.18	1.73
19.	*Merremia* sp.	0.11	11.1	1.00	0.31	1.23	1.00	2.55	0.85
20.	*Merremia vitifolia*	0.44	33.3	1.33	1.25	3.70	1.33	6.29	2.10
21.	*Mikania micrantha*	0.22	11.1	2.00	0.63	1.23	2.00	3.86	1.29
22.	*Mimosa pudica*	0.56	22.2	2.50	1.56	2.47	2.50	6.53	2.18
23.	*Panicum maximum*	1.22	22.2	5.50	3.44	2.47	5.51	11.41	3.80
24.	*Paspalum conjugatum*	0.44	22.2	2.00	1.25	2.47	2.00	5.72	1.91
25.	*Phyllanthus niruri*	0.33	22.2	1.50	0.94	2.47	1.50	4.91	1.64
26.	*Pouzolzia zeylanica*	5.00	77.8	6.43	14.1	8.64	6.44	29.1	9.71
27.	*Rungia repens*	0.56	33.3	1.67	1.56	3.70	1.67	6.93	2.31
28.	*Sida rhombifolia*	0.22	11.1	2.00	0.63	1.23	2.00	3.86	1.29
29.	*Synedrella nodiflora*	4.78	88.9	5.38	13.4	9.88	5.38	28.70	9.57
30.	*Triumfetta rhomboidea*	0.44	33.3	1.33	1.25	3.70	1.33	6.29	2.10

specific weed species, as compared to organically manured plots where nutrients were only slowly available in smaller quantities from the manure and did not directly affect the weeds (Stevenson *et al.* 1997). Weed species dominating arable fields under conventional farming tended to be more nitrophilous than those species characteristic in organic farming (Rydberg and Milberg 2000). Efthimiadou *et al.* (2012) observed that N availability had a significant on weed density and biomass in sweet maize, with highest weed biomass recorded in fertilizer treatments and a similar effect was obtained with organic amendments only when double the dose was applied. The increased abundance of dicotyledonous weeds and some grasses in the present study could be related to increased N availability, tolerance to acidic soil conditions and tolerance to partial shade. Dominance of the same weeds in both systems of nutrient management could be related to the similar contents of major nutrients in the soil. Nitrogen fertilization was seen to increase growth and fresh and dry matter production of *Synedrella nodiflora* as compared to organic manure application (Suwignyo *et al.* 2020). However, in the present study, both systems had similar soil nitrogen contents leading to *S. nodiflora* being equally abundant. The high density and frequency of *Borreria hispida* in both conventionally and organically manured plots could be linked to the acidic nature of the soil as *B. hispida* is an acidophile (Rao 2000). Decreased light availability in older cashew plantations could be a factor favouring the growth of dicotyledonous weeds. Hence, cashew plantations with partial sunlight penetration are ecologically suited to *Pouzolzia zeylanica,* another dominant weed in both situations. This observation is supported by the findings of Shukla (2009), who reported that grasslands were dominated in partial or full shade by *Pouzolzia zeylanica* and *Oplismenus burmannii*, the latter grass also being an important constituent of the weed spectrum in the plantation. Shade tolerance of *Pouzolzia zeylanica* was also reported by Yang *et al.* (2019). The spread of *O. burmannii* due to partial weed slashing in shaded coffee plantations has been reported by Milberg (2003), while *Brachiaria* sp. and *Panicum* sp., which were also prominent grasses in both the systems, had been rated as medium tolerant to shade by Shelton *et al.* (1987).

Habitat analysis

Habitat analysis of the conventionally and organically manured plots revealed that all diversity indices were slightly higher in the former (**Table 3**). Higher species richness and biodiversity was recorded on integrated application of nutrients as compared to organic manures alone. It was seen that BLWs dominated in both conventionally manured and organically manured plots and hence the Simpson's diversity index was almost the same (0.91 and 0.86). Almost similar values of evenness index (0.82 and 0.79) indicated the uniformity of distribution of the species in the two systems, probably due to lack of significant variation in soil fertility. Thus, the species richness or evenness of the weed communities was not significantly affected by organic nutrient sources as compared to inorganic sources in the present study. This indicated that there was no major dominant species due to introduction, and the soil weed seed bank was not greatly influenced by organic amendments (Cordeau *et al.* 2021).

Table 2. Distribution of weed species in organically manured plots

Sl. no.	Weed species	Density (no./m^2)	Frequency (%)	Abundance (no./m^2)	RD (%)	RF (%)	RA (%)	IVI	SDR (%)
1.	*Achyranthes aspera*	0.83	33.3	2.5	3.03	4.26	4.33	11.62	3.87
2.	*Alternanthera bettzickiana*	0.67	16.7	4.0	2.42	2.13	6.93	11.48	3.83
3.	*Asystasia gangetica*	1.00	33.3	3.0	3.64	4.26	5.20	13.09	4.36
4.	*Borreria hispida*	4.17	83.3	5.0	15.15	10.64	8.66	34.45	11.48
5.	*Brachiaria* sp.	0.83	16.7	5.0	3.03	2.13	8.66	13.82	4.61
6.	*Cyclea peltata*	0.17	16.7	1.0	0.61	2.13	1.73	4.47	1.49
7.	*Elephantopus scaber*	0.17	16.7	1.0	0.61	2.13	1.73	4.47	1.49
8.	*Euphorbia geniculata*	0.33	16.7	2.0	1.21	2.13	3.46	6.80	2.27
9.	*Ficus hispida*	0.33	16.7	2.0	1.21	2.13	3.46	6.80	2.27
10.	*Ichnocarpus frutescens*	0.33	33.3	1.0	1.21	4.26	1.73	7.20	2.40
11.	*Macaranga peltata*	0.33	16.7	2.0	1.21	2.13	3.46	6.80	2.27
12.	*Merremia* sp.	0.83	66.7	1.3	3.03	8.51	2.17	13.71	4.57
13.	*Panicum maximum*	0.33	16.7	2.0	1.21	2.13	3.46	6.80	2.27
14.	*Panicum* sp.	1.17	50.0	2.3	4.24	6.38	4.04	14.67	4.89
15.	*Phyllanthus niruri*	0.17	16.7	1.0	0.61	2.13	1.73	4.47	1.49
16.	*Pouzolzia zeylanica*	6.17	83.3	7.4	22.42	10.64	12.82	45.88	15.29
17.	*Oplismenus burmannii*	3.50	66.7	5.3	12.73	8.51	9.09	30.33	10.11
18.	*Sida rhombifolia*	0.33	16.7	2.0	1.21	2.13	3.46	6.80	2.27
19.	*Synedrella nodiflora*	5.00	83.3	6.0	18.18	10.64	10.39	39.21	13.07
20.	*Triumfetta rhomboidea*	0.17	16.7	1.0	0.61	2.13	1.73	4.47	1.49
21.	*Urena lobata*	0.67	66.7	1.0	2.42	8.51	1.73	12.67	4.22

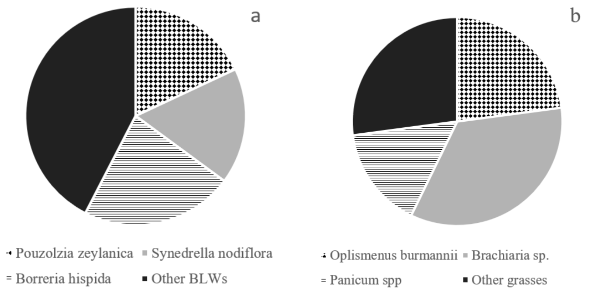

Figure 1. Major broad-leaved (a) and grass weeds (b) in conventionally manured cashew plots

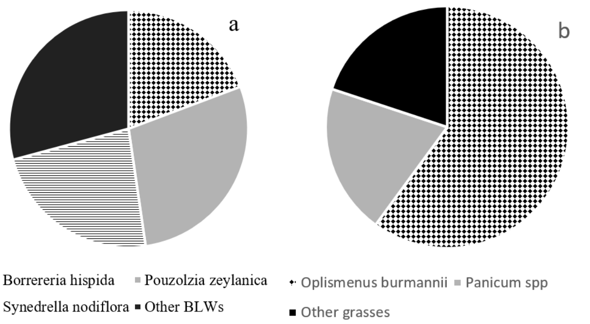

Figure 2. Major broad-leaved (a) and grass weeds (b) in organically manured cashew plots

Table 3. Diversity indices of conventionally and organically managed cashew plots

Diversity indices	Conventional management	Organic management
Species richness	31	21
Shannon-Wiener diversity index (H’)	2.84	2.37
Simpson’s diversity index (C)	0.91	0.86
Evenness index (J’)	0.82	0.79

Conclusion

The weed community in a cashew plantation underwent a significant change in composition, species richness and abundance over a thirty-year period. A few broad-leaved species, namely *Pouzolzia zeylanica, Synedrella nodiflora* and *Borreria hispida,* dominated in the weed community. Conventional plots recorded more number of weed species than the organically managed plots. However, the evenness of the weed communities in organically and inorganically manured plots did not vary greatly, probably due to similar environmental parameters. As the quantity of N supplied was the same in both treatments, domination of specialist nitrophilic species did not occur. Ecologically safe weed management strategies through nutrient management could be developed based on these results.

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