Indian Journal of Weed Science (2025) **57**(1): 150–154
http://dx.doi.org/10.5958/0974-8164.2025.00025.X

RESEARCH NOTE

Temporal variability and ecological status of weeds in the home garden agroforestry system: A case study

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Received: 16 March 2024 | Revised: 3 March 2025 | Accepted: 7 March 2025

ABSTRACT

This paper presents a comprehensive analysis of weed status within the home garden agroforestry system at ICAR-Central Agroforestry Research Institute (CAFRI), Jhansi, Uttar Pradesh. The study was conducted to investigate the diversity and distribution of weeds in the agroforestry system during 2022-2023. A total of 21 weed species belonging to 14 families and 17 genera were identified, with notable representation from families such as Amaranthaceae and Poaceae. The findings highlight the seasonal fluctuations in weed species composition and abundance, shedding light on the dynamic nature of weed communities in the agroforestry context. The research findings contribute to the understanding of weed ecology in agroforestry settings, offering valuable information on sustainable agricultural practices and ecosystem management.

Keywords: Agroforestry system, Home garden, Sustainable agriculture, Weed ecology

Home garden agroforestry systems represent intricate arrangements of trees, crops, and other vegetation, interwoven within household landscapes to fulfil diverse socio-economic and ecological functions. These systems, prevalent in many parts of the world, play a pivotal role in sustaining rural livelihoods, enhancing food security, and conserving biodiversity. Located in Jhansi, Uttar Pradesh, India, the ICAR-Central Agroforestry Research Institute (CAFRI) Campus serves as a microcosm of such agroforestry systems, where traditional knowledge intertwines with modern agricultural practices (Dev *et al.* 2015). Weeds constitute a ubiquitous and often overlooked component of agroecosystems, exerting profound impacts on ecosystem dynamics, agricultural productivity, and resource allocation. Despite their ecological significance, weeds remain a persistent challenge for farmers, especially in agroforestry systems where multiple plant species coexist.

There exist approximately 2,50,000 plant species worldwide, among which around 8,000 species, accounting for roughly 3%, are classified as weeds. These weeds pose multifaceted challenges, primarily by engaging in intense competition for vital resources such as space, water, soil nutrients, and light. Furthermore, they produce chemicals through allelopathy, some of which are toxic to humans, animals, and cultivated plants (Kumari 2016, Sah *et al*. 2020). The proliferation of weeds also exacerbates other biotic stressors, fostering pest and disease problems by providing alternate hosts for harmful insects and pathogens, thereby amplifying production costs and diminishing crop yields and market value (Gharde *et al*. 2018, Kubiak *et al*. 2022). The economic repercussions of weed infestation are substantial, particularly in grain, pulse, and oilseed crops, causing an annual economic loss of more than Rs. 50,000 crores in India (Sah *et al*. 2020). Recognizing the imperative of understanding weed dynamics within cropping systems, a comprehensive study on the distribution of diverse weed species is fundamental to formulating effective weed management strategies for farmers (Derksen *et al*. 2002, Sah *et al*. 2020). It is recognized that the indigenous flora of India has been subject to invasion by several exotic (non-native) species, introduced either inadvertently through imported ornamental or commercial plants, leading to the widespread dissemination of noxious weed seeds (Mallick *et al*. 2019, Joshi *et al*. 2024a). Surprisingly, current estimates indicate that approximately 18% of India's flora comprises foreign or non-native species (Joshi *et al*. 2024b).

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This work presents a study conducted within the confines of the CAFRI Campus, focusing on the intricate interplay between weeds and the agroforestry system. By examining the temporal and spatial variations in weed species composition, abundance, and distribution, this research aims to elucidate the underlying drivers shaping weed dynamics in the context of home garden agroforestry. This study seeks to inform stakeholders, policymakers, and practitioners about the importance of integrating weed management into agroforestry strategies, thereby promoting the long-term sustainability of agricultural landscapes.

Study area: The study on agroforestry home gardening was conducted at the Research Farm within the home garden of the ICAR-Central Agroforestry Research Institute (CAFRI), Jhansi, Uttar Pradesh, India (25.514°N latitude and 78.547°E longitude, with an elevation of 285 m above mean sea level) during the period from April 2022 to March 2023. The home garden with a total area of 29.9 x 16.3 m was segmented into three distinct categories: partially shaded, fully shaded, and open areas. Experimental plots (each of 1 x 1 m) were randomly allocated across 30 quadrants, ensuring representative sampling. The climatic conditions of the study area are characterized by an average annual rainfall of 837 mm, with evaporation rates and moisture levels reaching their maximum. The temperature ranges recorded in the previous year varied between 40.35°C and 3.75°C, reflecting the region's climatic variability and seasonal fluctuations. These environmental parameters provide the backdrop for understanding the dynamics of weed populations within the agroforestry system and their interactions with prevailing climatic conditions.

Data collection: Random quadrat method was employed to investigate the phytosociological attributes of weeds. A total 10 quadrats (each of 1 x 1 m) were randomly placed throughout the home garden, with a total of 10 quadrats per site. These investigations were carried out both during and after the rainy season to capture seasonal variations. The significance of each weed species was evaluated through parameters such as the Importance Value Index (IVI), frequency, and density, following the methodologies outlined by Mishra (1968) and Curtis and McIntosh (1950). Weed specimens from each quadrat were meticulously collected, and their vegetative and reproductive characteristics were thoroughly examined. Initial identification of the collected specimens was done, following "The Handbook on Weed Identification" (Naidu 2012: ICAR-Directorate of Weed Science Research, Jabalpur, Madhya Pradesh, India) as well as other relevant state, regional, and local floras.

Data analysis: Vegetation composition was evaluated by analyzing the frequency, density, and Importance Value Index (IVI) according to Mishra (1968). The density and IVI of species was calculated as:

$$\text{Density} = \frac{\text{Total number of individuals of a single species in all quadrats}}{\text{Total number of quadrats studied}}$$

Importance Value Index (IVI)= Relative density + Relative frequency + Relative dominance

The field data were also analysed for various species diversity as Shannon diversity (H') (Shannon and Wiener 1963)

$$H' = -\sum_{i=1}^{s} \left(\frac{N_i}{N}\right) log_2 \left(\frac{N_i}{N}\right)$$

Where, H` = Shannon's diversity index, Ni = number of individuals of species belonging to the i^{th} species and N = total number of individuals in the sample.

Temporal variation in weed species

The study revealed significant temporal variation in weed species composition across the study area. Analysis of monthly data demonstrated a dynamic pattern, with the highest diversity observed during the rainy season and reduced species richness during the cooler winter months. Specifically, the maximum number of weed species (21) was recorded during the rainy season, indicative of favourable environmental conditions for weed growth and proliferation. Conversely, the lowest number of weed species was recorded during the cool winter season, highlighting the seasonal fluctuations in weed community dynamics. Further examination of monthly data pinpointed specific periods of heightened weed diversity, with the months of August, September, and October, exhibiting the highest number of weed species (21). Data in the winter months (December-February) exhibited substantially reduced weed species richness, aligning with unfavourable climatic conditions for weed growth and development (**Figure 1, Table 1**). Distribution of weed species across the year followed a distinct polygonal curve, with peak species richness coinciding with the rainy months. This temporal distribution pattern underscores the influence of seasonal variations in precipitation, temperature, and other environmental factors on weed community dynamics.

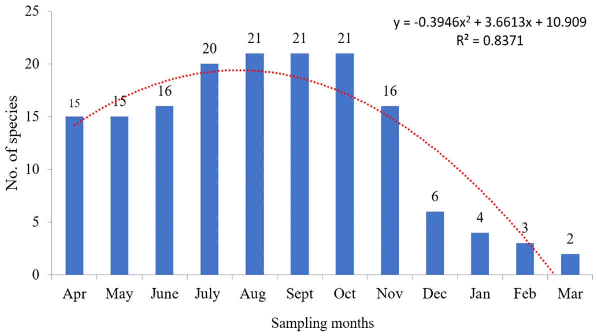

Figure 1. Temporal variation in the weed species across the study site

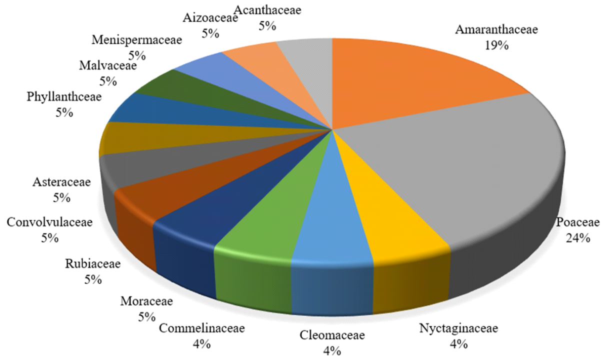

Figure 2. Family-wise distribution of weed species in the home garden agroforestry system of ICAR-CAFRI

Table 1. Monthly variation in species distribution in the home garden during 2022-23

Species	Family	Place of nativity	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Achyranthes aspera	Amaranthaceae	SE Asia and Africa	+	+	+	+	+	+	+	+	+	+	+	+
Atriplex prostrata	Chenopodiaceae	Africa and Europe	+	+	+	+	+	+	+	-	-	-	-	-
Boerhavia erecta	Nyctaginaceae	America	+	+	+	+	+	+	+	+	+	+	-	-
Brachypodium retusum	Poaceae	Africa, America	-	-	-	+	+	+	+	-	-	-	-	-
Celosia argentea	Amaranthaceae	India	-	-	-	-	+	+	+	+	-	-	-	-
Chenopodium album	Amaranthaceae	Asia, North America,	+	+	+	+	+	-	-	-	-	-	-	-
Chloris virgata	Poaceae	America	-	-	-	+	+	+	+	+	-	-	-	-
Cleome gynandra	Cleomaceae	Tropical Africa to Asia	+	+	+	+	+	+	+	+	-	-	-	-
Commelina communis	Commelinaceae	Europe to Japan and Indo-China	+	+	+	+	+	+	+	+	-	-	-	-
Ficus spp.	Moraceae	SE Asia and Australia	+	+	+	+	+	+	+	+	-	-	-	-
Gallium aparine	Rubiaceae	Europe, North Africa	-	-	-	+	+	+	+	+	-	-	-	-
Grass spp.	Poaceae	-	+	+	+	+	+	+	+	+	+	+	+	-
Ipomoea alba	Convolvulaceae	South-eastern USA	+	+	+	+	+	+	+	+	+	-	-	-
Lactuca serriola	Asteraceae	Europe to SW	+	+	+	+	+	+	+	+	-	-	-	-
Panicum sp.	Poaceae	Central America	-	-	+	+	+	+	+	+	-	-	-	-
Paspalum dilatatum	Poaceae	Central America	-	-	-	+	+	+	+	-	-	-	-	-
Phyllanthus nirurii	Phyllanthceae	Tropical & Subtro pical America	+	+	+	+	+	+	+	+	-	-	-	-
Ruellia geminiflora	Acanthaceae	Argentina and Brazil	+	+	+	+	+	+	+	+	-	-	-	-
Sida acuta	Malvaceae	Central America	+	+	+	+	+	+	+	+	+	+	+	+
Tinospora cordifolia	Menispermaceae	Indian subcontinent and China	+	+	+	+	+	+	+	+	+	-	-	-
Trianthema portulacastrum	Aizoaceae	Africa, North and South America	+	+	+	+	+	+	+	+	-	-	-	-

+ showed presence of species and – showed absence of species

In the present study highest diversity was recorded during the rainy season, characterized by favourable environmental conditions conducive to weed growth and proliferation (Anwar *et al.* 2021). In contrast, species richness decreased during the cooler winter months, aligning with reduced moisture availability and suboptimal temperatures for weed development (Mhlanga *et al.* 2022). The monthly analysis highlighted specific periods of heightened weed diversity, with peak richness occurring during the months of August, September, and October, corresponding to the peak of the rainy season. This temporal distribution pattern, characterized by a distinct polygonal curve, reflects the strong association between moisture availability and weed proliferation (Fanfarillo *et al.* 2020).

Ecological status of weed species

A total of 21 distinct weed species belonging to 14 families and 17 genera were identified, reflecting the rich ecological tapestry present within the study area. Notably, the Amaranthaceae and Poaceae families emerged as predominant contributors, with 5 and 4 species, respectively, followed by representatives from diverse botanical families such as Nyctanginaceae, Clemaceae, Moraceae, and Rubiaceae, among others. The species diversity was maximum as recorded at Site-II (3.42) followed by

Table 2. Ecological status of recorded weed species during 2022-23

Species	Site-I		Site-II		Site-III	
	Density (no./m^2)	IVI	Density (no./m^2)	IVI	Density (no./m^2)	IVI
Achyranthes aspera	3.3	32.16	4.3	31.45	1.8	17.29
Atriplex prostrata	-	-	-	-	2.8	23.36
Boerhavia erecta	-	-	2.9	23.79	2.4	21.19
Brachypodium retusum	1	14.82	1	12.45	1	11.89
Celosia argentea	1.2	16.25	1.3	14.05	1.8	18.48
Ipomoea alba	-	-	-	-	2.1	19.58
Chenopodium album	1.5	18.82	1.9	18.02	-	-
Chloris virgata	-	-	1.4	14.83	1.8	17.24
Cleome gynandra	-	-	1.3	14.05	1.6	16.42
Commelina communis	2.2	24.12	-	-	2.7	22.67
Ficus sp.	1.3	17.49	-	-	-	-
Gallium sp.	2.8	28.55	2.9	23.79	1.8	18.47
Grass sp.	2.8	28.39	4	30.72	-	-
Lactuca serriola	1.4	17.97	1.5	15.38	-	-
Panicum sp.	2.9	29.27	2.9	23.79	2.7	23.13
Paspalum dilatatum	-	-	-	-	0.9	11.07
Phyllanthus niruri	2.7	27.8	2.7	22.65	2.1	19.2
Ruellia geminiflora	-	-	2.2	19.8	2.6	22.13
Sida acuta	-	-	-	-	2.4	22.59
Tinospora cordifolia	1.5	18.76	1.2	13.68	-	-
Trianthema portulacastrum	2.4	25.59	2.5	21.55	1.5	15.29
Total	27	299.99	34	300	32	300

Site-II (3.02) and minimum at Site-I (2.83). The study revealed variations in species richness, and density. The species density was maximum at Site-II (34/m^2), followed by Site-III (32/m^2) and minimum (27/m^2) at Site-I. Detailed analysis of quadrat-level data unveiled specific trends in weed density across the study area. The *Achyranthes aspera* emerged as the dominant species, at Site I and Site-II, exhibiting a maximum density of plants (3.3 and 4.3/m^2, respectively), However *Atriplex prostrata* was the dominant weed at Site-III (**Table 2**).

The study provided valuable insights into the diversity and distribution of weed species within the study area. A total of 21 distinct weed species spanning multiple families and genera were identified, showcasing the rich ecological tapestry present in the home garden agroforestry system. The dominance of families such as Amaranthaceae and Poaceae, along with contributions from diverse botanical families, underscores the heterogeneous nature of weed communities within the agroforestry context. Furthermore, the quadrat-based assessments revealed spatial variations in weed species richness, with differences observed across randomly selected quadrats. These variations highlight the heterogeneous distribution of weeds within the study area and emphasize the need for targeted management interventions tailored to specific locations (Joshi *et al.* 2024c) Detailed analysis of quadrat-level data further elucidated patterns of weed density and species composition, providing valuable insights into the dominant species and their spatial distribution within the home garden agroforestry system. These findings enhance our understanding of weed ecology in agroforestry and inform sustainable land management strategies.

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