

Diversity Analysis of Weed Flora in Spring Rice Fields of Saptari District, Nepal

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ABSTRACT

Grown in a variety of environments, including irrigated lowlands and uplands, rice is a major crop in Nepal. Drought, flooding, and weeds are just a few of the difficulties farmers confront that can drastically lower harvests. Although improved spring rice types are being used more frequently to address these problems, weeds are still a major issue. Using 22 quadrats per stage, this study examined weeds in spring rice fields in Saptari, Eastern Terai, at three crucial growth stages: tillering, milking, and maturity. The milking stage had the maximum weed abundance (2,492), followed by tillering (2,337) and maturity (753). *Cyperus difformis*, *Eclipta prostrata*, *Fimbristylis littoralis*, *Alternanthera sessilis*, and *Monochoria vaginalis* were the most prevalent species. Grasses were scarce, broad-leaved weeds predominated, and the most prevalent groups were Cyperaceae, Asteraceae, Poaceae, and Amaranthaceae. Diversity peaked at the maturity stage, indicating changes in the makeup of weeds as the crop grows. These results demonstrate that weed biology, rice development, and environmental factors all affect weed variety and abundance. By identifying these trends, farmers in the Eastern Terai can improve spring rice productivity by creating integrated weed management plans that are specific to the region.

Keywords: Spring rice, Weed species, Diversity, Quadrats

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INTRODUCTION

Rice, *Oryza sativa* L. has been cultivated belongs to family Poaceae in the Monocotyledonae class of angiosperm. There are three distinct stages of growth of rice i.e. vegetative, reproductive and ripening (Mohapatra and Sahu 2022).

In Nepal, rice is grown in a variety of ecosystems, including uplands, mid-deep lowlands, deep water, and irrigated lowlands (Niraula and Karki 2023). The most important main food crop in Nepal is rice, which also provides significant revenue for the farmers. The Terai produces about 73% of the rice, the hills produce 24%, and the high hills produce 4%. In addition to its 20% contribution to the Agricultural Gross Domestic Product and 7% GDP, rice is essential for employment, income for farmers, and food and nutrition security. The 67% of total cereal consumption and 23% of protein intake from rice (Joshi 2021).

Spring rice is typically sown from last week of February to first week of March, and 30 to 40-day-old seedlings are then transplanted. The reason the rice is called Chaite rice is because the month of transplanting coincides with the Nepali month of "Chaitra". It is found that the areas covered by spring rice in the Terai, hill, and mountain regions are 69.67%, 24.85% and 5.48% respectively. The main (Barkhe) season rice occupies 92% of the rice-growing area, while the spring (Chaite) season occupies only 7% of it (Regmi et al 2023). Twenty thousand two hundred and fourteen tons of spring rice is produced overall, with a productivity of 4.4 t ha⁻¹. Spring rice is more efficient in terms of lower quantity of loss percentage during production and is resistant to numerous diseases and pests. For the Terai, inner Terai, river basin areas, and other similar climatic regions, about 11 varieties of spring rice have already been released (Ajay et al 2020).

In addition to the issue of drought in Nepal, weeds and flooding are major problems in the rice production

system, which is why it has become popular to adapt improved spring rice varieties (Subedi et al 2018). Any undesired plant, native or non-native, in an unwanted location at an unwanted period is considered as weed. In addition to serving as a host for insects or parasites, weeds can spread illness (Irakiza et al 2021).

However, weed infestation is a major biotic barrier to rice production, particularly in developing nations with high rates of subsistence farming like Nepal. Weed competition has caused an annual loss of 15 million tons of crop output potential because of the dominance and quick growth of weeds (Niraula and Karki 2023). Agriculture is directly impacted economically by weeds, so understanding how they spread could help with pressing issues facing the sector. The populations of weeds are unstable. The composition of weed flora and the degree of infestation are influenced by multiple factors. Over the past 200 years, there have been significant changes in farming practices, which has led to a corresponding shift in weed populations. Certain weeds are commonly linked to specific crops, such as weeds in rice (Krahmer et al 2020).

Weeds cause around one-third of the crop loss because they compete with rice for nutrients, light, water, and space (Niraula and Karki 2023). Despite being produced in smaller quantities, spring rice in Nepal is more productive than summer rice. Removing weeds' ability to compete with crops can boost crop yields and biomass production (Bidhan and Sah 2023).

Weeds compete with crops for nutrients, moisture, light, and other elements in the agricultural ecosystem (Irakiza et al 2021). Identifying the undesirable vegetation accurately is the first step towards creating an effective weed control program. Not every weed reacts to every kind of treatment in the same way. Having a successful identification gives us the information we need to create a management plan that works (Lillo et al 2022).

Numerous investigations and studies have been conducted on weeds globally, covering various aspects such as floristic composition, diversity, management strategies, ethnobotanical aspects, and biodiversity. The majority of the literature is floristic, discussing crop-related control measures and their effects. There aren't many studies that examine the diversity of weeds in spring rice of Nepal. Saptari district represents the typical subtropical agro-ecosystem of eastern Nepal with intensive agriculture and diverse cropping systems that favor rich weed flora making it suitable for representative weed diversity assessment. Therefore, the objective of the study was to access and determine the diversity of weed flora in connection to various phenophase of spring rice in Saptari district.

MATERIALS AND METHODS

Study area

The district of Saptari is located in the Sagarmatha Zone of the Eastern Development Region of Nepal. Its coordinates are 26°35'46.32" North, 86°45'05.40" East. One of Nepal's seventy-seven districts, Saptari District is a part of Madhesh Province.

Study design

In order to identify potential study fields, a reconnaissance survey was conducted between March and April 2024. The sites suitable for sample collection for survey were overviewed during those periods of spring rice transplanted at the place. The quantitative data were collected randomly at three different growing stages of rice i.e. at tillering, milking and maturity stage. The plots chosen in the agricultural field were roughly comparable in size, location for quantifying the weeds. A quadrat size of 0.5m × 0.5m was positioned at the center of the field to represent the entire field. 22 fields were randomly selected and weed population were monitored under the same quadrat across all growth stages.

Data analysis

All the recorded data were arranged systematically based on each phenophase of rice. The obtained data was tabulated in Microsoft Office Excel and data were employed to find out the following parameters:

Frequency and relative frequency

The percentage of a specific species that exists in the studied quadrat relative to the total number of studied quadrats is known as its frequency (Travlos et al 2018).

$$\text{Frequency (\%)} = \frac{\text{Number of quadrats in which the species occurred} \times 100}{\text{Total number of quadrats studied}} \dots\dots\dots(\text{Eq. 1})$$

The percentage occurrence of a specific species in relation to the overall frequency of all the species present in the community is known as relative frequency. It is calculated by using following formula (Travlos et al 2018).

$$\text{Relative Frequency (\%)} = \frac{\text{Total frequency of particular species} \times 100}{\text{Total frequency of all species}} \dots\dots\dots(\text{Eq. 2})$$

Density and Relative density

The number of distinct species per unit area is known as density. It displays the species' relative abundance within the community (Travlos et al 2018).

$$\text{Density (Number/m}^2\text{)} = \frac{\text{Total number of individuals of a species}}{\text{Total number of quadrats studied} \times \text{Area of each quadrat}} \dots\dots\dots(\text{Eq.3})$$

The percentage occurrence of a specific species in relation to the total density of all the species present in the community is known as relative density.

$$\text{Relative Density (\%)} = \frac{\text{Total density of particular species}}{\text{Total density of all species}} \dots\dots\dots(\text{Eq. 4})$$

Important value Index (IVI)

Relative frequency and relative density add up to an important value index. It displays the interactions and relative contributions of the various species that make up the community (Travlos et al 2018).

$$\text{IVI} = \text{Relative frequency} + \text{Relative Density} \dots\dots\dots (\text{Eq. 5})$$

Summed Dominance Ratio (SDR)

Depending on the phenological stage of growth and crop development, the weed structure's summed dominance ratio (SDR) is heterogeneous and co-oscillatory for both the generation of the number of distinct species and their height dominance (Tsytisiura 2020).

$$\text{SDR} = \frac{\text{Relative Density} \times 100 \%}{\text{Relative Frequency}} \dots\dots\dots(\text{Eq. 6})$$

Shannon- Weiner Diversity Index

The Shannon- Weiner Diversity Index (Shannon and Weaver1963) H' is calculated by the following equation:

$$H' = - \sum_{i=1}^s P_i (\log P_i) \dots\dots\dots(\text{Eq. 7})$$

Where Pi is the proportion of individual belonging to the ith species and s is the total number of species. The values of this index ranges between 1.5 to 3.5 (Travlos et al 2018).

Simpson Index

The Simpson index was introduced by Simpson in 1949 in order to measure the degree of dominance of individuals weed species, according to the following equation:

$$d = \sum_{i=1}^s p_i^2 \dots\dots\dots(\text{Eq. 8})$$

Where Pi is the proportion of individuals to the ith species and S is the total number of species (Travlos et al 2018).

RESULTS AND DISCUSSION

Weed population

In this study altogether 2337, 2492 and 753 weed population were enumerated during tillering, milking and maturity stages of rice respectively. Out of all 25 weed species were identified during each of tillering and milking stages of rice and 20 species were identified during maturity stage. *Cyperus difformis* counted highest number of weed population with 1177 during tillering stage whereas *Linnea borealis* and *Ageratum conyzoides*

counted least with 1 weed population. Similarly, during milking stage of rice *Eclipta prostrata* (752) represented highest number of weed population and *Commelinadiffusa* (1) represented the lowest. Likewise, in this study *Alternanthera sessilis* (195) counted highest during maturity stage whereas *Limnophilageoffrayi*(1) counted lowest. The highest weed populations were counted in five major five weed species namely *Cyperus difformis* (1643), *Ecliptaprostrata* (1059), *Fimbristylis littoralis* (673), *Alternanthera sessilis* (390), *Monochoria vaginalis* (243) respectively. The other studies carried on rice field of Nepal had recorded 61 species of weed in the lowland and upland condition of rice in western part of Nepal (Bhatt, Tewari, and Singh 1970). Similarly (Joshi 2021) identified 53 species of weeds in the spring rice fields from 42 genera and 22 families in Chitwan.

Rice plant enters the reproductive phase during the early grain filing stage, commonly referred to as milking stge. The fast growth of rice plants during this period gives weeds plenty of cover. In the milking stage, rice is established and grow rapidly, but its canopy may not be dense enough to totally shade the ground, allowing weeds to develop. Weeds can more easily establish (Thapa and Kc 2023) themselves in the field at this point since rice plants may be concentrating their efforts on reproduction rather than vegetative growth. Since fertilizers are frequently administered to enable optimal rice production, the milking stage is also a time when the soil is rich in nutrients. Of the nutrients, particularly nitrogen, can promote the growth of weeds. Therefore, the interaction of favorable environmental circumstances, weed biology, and crop growth patterns results in ideal conditions for weed growth at the precise moment that the rice crop is entering its reproductive phase, which explains the high weed population during the milking period.

Altogether 13 weed families were identified during tillering stage, 15 and 11 milking and maturity stage of rice respectively of which family Cyperaceae counted highest during tillering and milking stage whereas Amaranthaceae counted highest during maturity stage. The rice fields were dominated by major weed families Cyperaceae, Asteraceae, Poaceae and Amaranthaceae respectively during all three stages of rice i.e at tillering, milking and maturity (Figure14). The rice field observed in Pokhara (Thapa and KC 2023) were dominated by families Poaceae (four), Cyperaceae (three), Commelimeaceae (one), and Asteraceae (two). Similarly, Bhatt, Adhikari and Kunwar (2021) found dominance of family Poaceae and Asteraceae (12%) over Alismataceae and Typhaceae (1%) in the field of rice.

Broad leaved weeds comprised highest weed population whereas grasses comprised lowest population in all three stages of rice which coincides with (Bhatt et al 2021) where population of broad leaved species were found highest over sedges and grasses. Because they can adapt to the often nutrient-rich and soggy conditions found in rice production, broad-leaved weeds predominate in rice fields. They can outcompete other weeds for sunshine, nutrients, and space because of their strong root systems, bigger leaves, and competitive growth habit. Their capacity to spread quickly is further enhanced by their high germination rates and copious seed output. Additionally, their growth is facilitated by conventional farming methods including transplanting and sporadic floods. But (Dangol et al 2020) recorded highest density of sedges followed by broad leaves and grasses in his rice field.

Diversity of weeds

Different species were found in the quantitative examination of weed diversity among several rice fields with varying crop management practices. Based on IVI, *Cyperus difformis*, *Alternanthera sessilis*, *Cynodondactylon* were the most dominant weed species during tillering stage. Similarly, *Cyperus difformis*, *Ecliptaprostrata*, *Echinocholacolonom* were dominant during milking stage of rice and *Fimbristylis littoralis*, *Ecliptaprostrata*, *Echinocholacolonom* were dominant during maturity stage. Overall looking at the IVI of rice field at Saptari *Cyperus difformis* (1643), *Eclipta prostrata* (1059), *Fimbristylis littoralis* (673), *Althernanthera sessilis* (390), *Monochoria vaginalis* (243) were dominant over other weed species.

Table 1. Weed population, species richness, species diversity: H', d and ENS, Saptari, in 2024

Variables	Tillering stage	Milking stage	Maturity stage
Weed population	2337	2492	753
Species richness	25	25	20
Family	13	15	11
ENS	6.4	9.2	10.25
Diversity Index			
H'	1.85	2.22	2.32
d	3.5	6.11	7.48

Where, weed population= H', Species richness= d, species diversity= ENS

Also *Ageratum conyzoides*, *Cynodondactylon*, *Echinochloacrusgalli*, *Cyperus rotundus*, *Cyperus difformis*, *Echinochloa colonum* were the most common weed species found by (Thapa and KC 2023) based on IVI value.

Likewise, (Sinha 2017) found that *Echinochloa colonum*, *Cyperus iria*, and *Cynodon dactylon* were the most common species in rice fields.

In the current study Shannon diversity index showed that weeds during maturity stage (2.32) were more diverse than at tillering (1.85) and milking (2.22) stages of rice. Likewise, Lillo et al (2022) computed diversity value of $H' = 3.36$ where the location had less input in the form of weed management techniques.

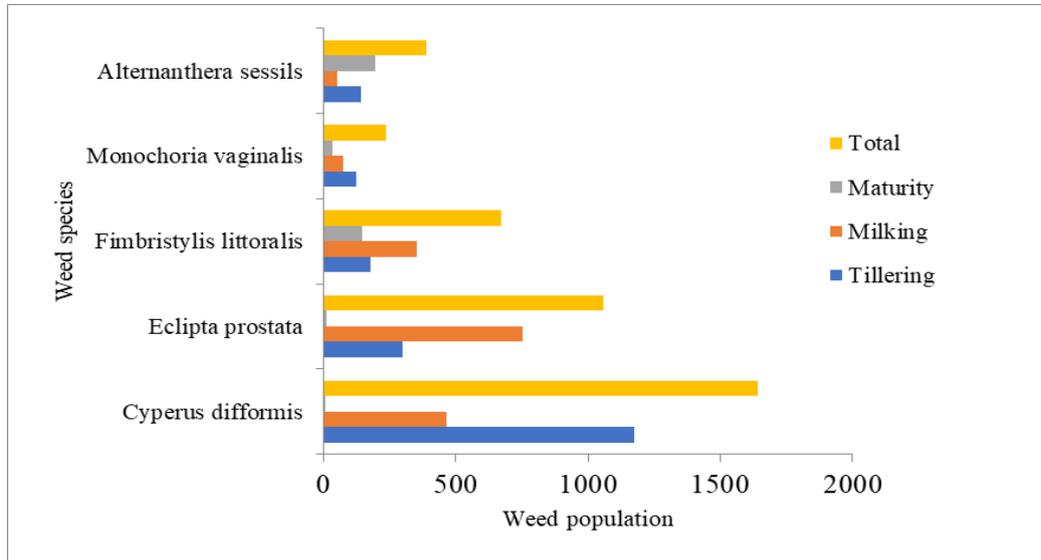


Figure 1. Major weed species at different stages of rice

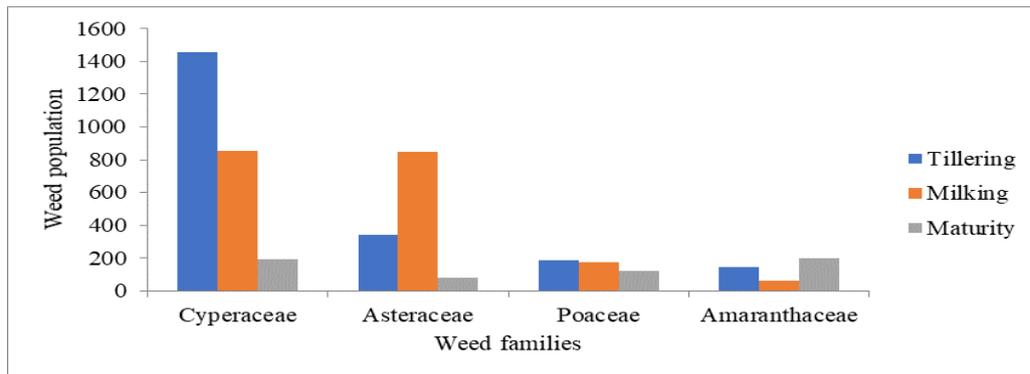


Figure 2. Major weed families at different stages of rice

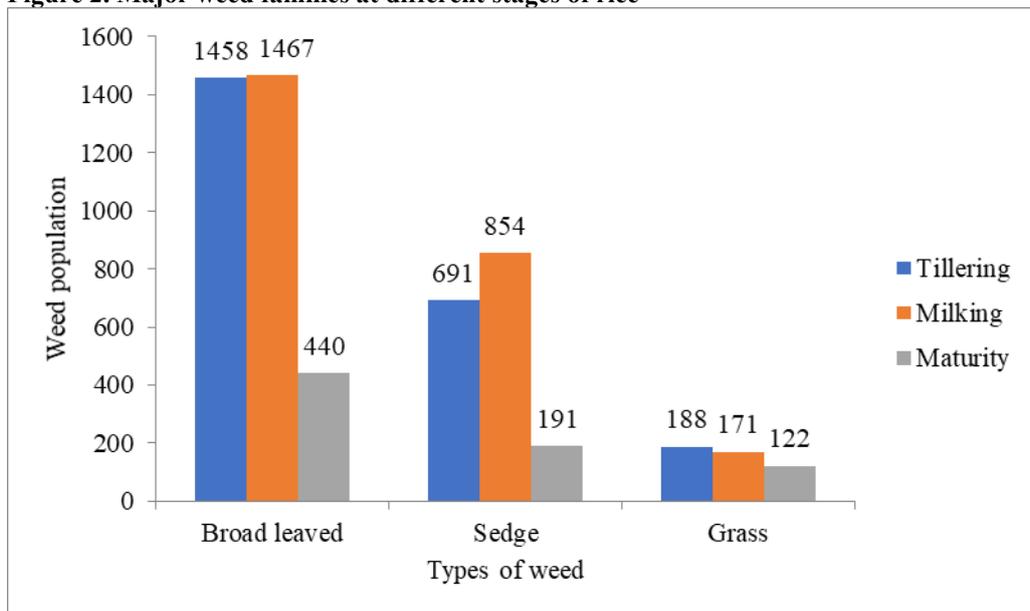


Figure 3. Types of weed at different stages of rice

CONCLUSIONS

The present study investigated the floristic composition and diversity of weed flora in rice fields of Eastern Nepal, Saptari. A total of 2,337, 2,492, and 753 individual weeds were enumerated under 22 quadrats during the tillering, milking, and maturity stages of rice growth, respectively. Twenty-five weed species were identified during both the tillering and milking stages, while 20 species were recorded during the maturity stage. The study observed the highest weed population among five major species: *Cyperus difformis* (1,643), *Eclipta prostrata* (1,059), *Fimbristylis littoralis* (673), *Alternanthera sessilis* (390), and *Monochoria vaginalis* (243). The major weed families Cyperaceae, Asteraceae, Poaceae, and Amaranthaceae accounted for the highest weed populations across all three stages of rice growth. Broad-leaved weeds were the most abundant, whereas grasses had the lowest population. The Shannon-Wiener Diversity Index revealed that the milking stage exhibited lower diversity of weed species compared to the maturity stage but higher diversity than the tillering stage. Overall, the tillering stage showed the least weed species diversity among the three stages.

Strong competition for nutrients, water, and light is indicated by high weed diversity, which, if improperly managed, can drastically lower rice productivity. Farmers can use integrated weed management strategies that combine mechanical, chemical, and cultural techniques by having a thorough understanding of the nature of weed communities. These results encourage more productive spring rice farming and site-specific, sustainable weed control.

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AUTHORS' CONTRIBUTION

Conceptualization and methodology were developed by Alisha Bhujel under the supervision of Abhishek Shrestha and Umesh Timilsina. Field sampling and weed flora documentation were conducted by Alisha Bhujel and Manila Tiwari. Data curation and diversity indices analysis were performed by all the authors. Manuscript writing was done by Alisha Bhujel. Manuscript revision and supervision were provided by Abhishek Shrestha and Umesh Timilsina. All authors approved the final manuscript.

CONFLICTS OF INTEREST

The authors have no any conflict of interest to disclose.

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