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Soil Characteristics and Weed Diversity in Paddy Fields of Hojai District, Assam, Northeast India

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ABSTRACT

Soil attributes play a crucial role in determining weed community structure, which affects the overall dynamics of agricultural ecosystems. This study explores the relationships between weed infestation and soil properties in paddy fields of Hojai district, Assam, Northeast India. Soil samples were collected during two crop growing seasons viz. *Rabi* and *Kharif*, to analyze important physico-chemical properties between the year 2021 and 2024 from the paddy fields of the study site. The findings of the study showed considerable variations in soil properties across different seasons. Weed species richness exhibited positive correlation with porosity, soil moisture content, soil organic carbon, total nitrogen content, available phosphorus and potassium in both seasons. This study offers valuable insights into how the physico-chemical properties of soil affect weed diversity in agricultural lands, providing a useful basis for developing effective management strategies.

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INTRODUCTION

Weeds are plants that grow in locations where they are not wanted; interfering with land use, crop production, and human welfare (Buchholtz 1967). Their presence not only decreases the quantity of crops but also affects their quality (Dangwal *et al.* 2010). Weeds are a formidable challenge to global crop production, aggressively competing with crops for essential resources such as light, water, and nutrients (Rao and Nagmoni 2010). Weeds threaten agricultural crops by releasing allelo-chemicals that significantly disrupt germination, growth, and survival rates of crops, leading to reduced yields (Onen *et al.* 2018). Additionally, the diversity and density of weed populations are strongly influenced by soil properties, such as moisture, pH and nutrient availability (Fried *et al.* 2008 ; Pinke *et al.* 2010; Ramirez *et al*. 2018). Understanding these interactions is crucial for effective weed management and sustainable farming practices.

Numerous studies have investigated the relationship between diversity of plant and the physico-chemical properties of soil in agricultural fields across various regions worldwide (Mishra *et al.* 2016; Al-Mutairi, 2017 ; Al-Robai *et al.* 2018 ; Gu *et al.* 2019 ; Gao *et al.* 2020; Hossain *et al.* 2020;

Wang *et al.* 2021; Ghimire *et al.* 2023; Chen *et al.* 2024). However, information on diversity of weeds in paddy fields of Assam is scarce (Satapathy *et al.* 2017, Sarmah 2019, Gogoi 2020, Biswas *et al.* 2023, Sakachep and Rai 2025). With this background, the present study was carried out to explore the relationship between soil variables and weed diversity in the paddy fields of Hojai district, Assam, India.

MATERIALS AND METHODS

For the present study, paddy fields of Hojai district, situated in central part of Assam was selected which covers a geographical area of 1685 km² and lies between 25° 58' 46. 92" to 26° 1'18.49" N latitude and 92° 50' 0.064" to 92° 52' 16.679" E longitude with an average elevation of 59 meters (Fig. 1). The average temperature ranged from 25ºC to 33ºC (https://hojai.assam.gov.in). The climate of district ranged from subtropical humid to tropical humid (https://hojai.assam.gov.in). The average annual rainfall ranged from 1000 mm to 2300 mm (https://hojai.assam.gov.in). *Rabi* and *Kharif* are the two main cropping seasons (Swamma 2022, https://hojai.assam.gov.in).

An extensive field survey was conducted in the paddy fields of selected study site between the year 2021 and 2024 in the two main crop growing seasons viz. *Rabi* and *Kharif*. Random sampling method was employed and 50 quadrats (based on species-area curve) of 1 m² were placed in the study site. Thus, a total of 100 quadrats were used for the study. Plant species in all quadrats were identified by referring to

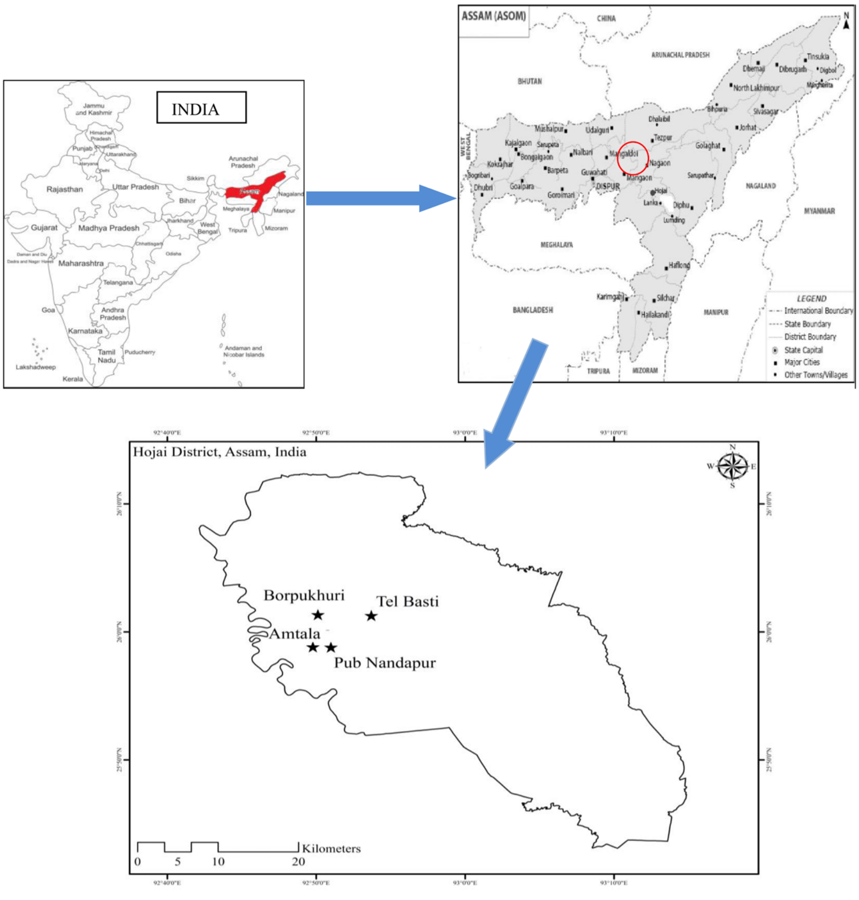

Fig. 1. Map showing study sites.

literature (Caton *et al.* 2010, Hazarika and Borthakur 2014, Zimdahl and Basinger 2024, Kumar *et al.* 2024) and authentic website (https://www.worldfloraonline.org; https://agritech.tnau.ac.in; https://www.isws.org.in).

The phytosociological attributes such as frequency, density, dominance, their relative values, Importance Value Index (IVI) were calculated using standard techniques (Curtis and McIntosh 1950; Misra 1968; Mueller-Dombois and Ellenberg 1974). Ecological indices such as Shannon-Weiner diversity index (Shannon and Weaver 1963), Simpson's dominance index (Simpson 1949), Margalef's species richness index (Margalef 1958), and Pielou's evenness index (Pielou 1966) were also calculated. Similarities in the weed species composition in different seasons were worked out and expressed through Sorenson's similarity index (Sorenson 1948).

Soil samples were randomly collected from 40 paddy fields at a depth of 0–15 cm (https://research.csiro.au, Yadav *et al.* 2021) and thoroughly mixed to obtain 12 composite samples for each season. Thus, total 24 composite soil samples were made for this study. These composite soil samples were taken to the laboratory in airtight polythene bags for further analysis. Fresh composite soil samples were used to determine Soil moisture content (SMC) by gravimetric technique (Allen *et al.* 1974) and pH of soil by using pH meter. Air-dried, crushed, sieved composite soil samples were used to determine Soil texture by Bouyoucos hydrometer and bulk density by gravimetric method (Allen *et al.* 1974). Soil porosity was calculated from bulk density and particle density values (Allen *et al.* 1974). The quantity of soil organic carbon (SOC) was determined using modified Walkley-black method (Walkley and Black 1934). Total nitrogen content (N) was determined by Kjeldahl method (Allen *et al*. 1974). Available phosphorus (P) was estimated by method of Bray and Kurtz P1 (Bray and Kurtz 1945). Available potassium in soil was estimated by flame photometer (Allen *et al.* 1974).

SPSS was used for statistical analysis of all obtained data. The means of soil properties between the two seasons were compared using an Independent sample t- test at $p \leq 0.05$. The relation between species richness and soil attributes was examined via regression analysis in Microsoft Excel.

RESULTS AND DISCUSSION

Total 52 plant species, belonging to 46 genera and 22 families were observed from the paddy fields of Hojai district during the study. Out of which, 46 weed species belonging to 42 genera and 22 families were recorded during *kharif* season and 36 species belonging to 33 genera and 17 families were reported during *Rabi* season (Table 1). A decreasing tendency in weed species number was observed during *Rabi* season in comparison to *Kharif* season, which could be due to adverse climatic condition and lack of seed germination (Travlos *et al.* 2020, Reddy *et al.* 2023). The finding of the study was comparable to rice fields of Tamil Nadu, India (56 species from 45 genera and 23 families) (Ramamoorthy and Nithya 2015), different crop ecosystems of Jorhat, Assam, India (56 species during *kharif* season and 61 from *Rabi* season) (Sarmah 2019), paddy fields of Mandakini valley, Uttarakhand, India (57 weed species from 45 genera and 19 families) (Tiwari *et al*. 2020) and rice fields of Imphal East, Manipur, India (52 weed species belonging 48 genera and 15 families) (Gupta and Haobijam 2021). However, the finding of the study was comparatively higher than that of weed composition observed in low land rice fields of Lakhimpur district, Assam, India (16 different species, from 12 families of weeds) (Phukan and Phukan 2008) and weed diversity found in wheat and rice fields of Goalpara district, Assam, India (25 species of weeds in wheat and 23 species in rice fields) (Nath

Table 1. Community characteristics of weeds during *Rabi* and *Kharif* seasons.

Parameters	Seasons	
	Kharif	*Rabi*
No. of species	46	36
No. of genera	42	33
No. of family	22	17
Shannon-wiener diversity index	3.71	3.12
Simpson's dominance index	0.03	0.05
Margalef's richness index	7.40	4.18
Pielou's evenness index	0.96	0.98
Sorensen's similarity index	64.61%	

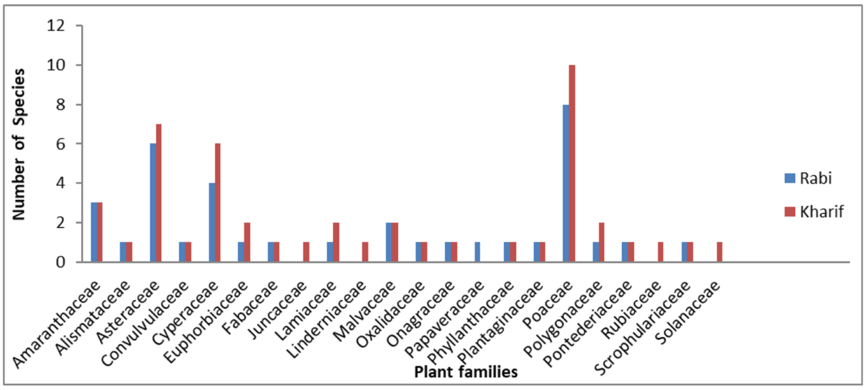

Fig. 2. Graph showing number of weed species belonging to different families during *Rabi* and *Kharif* season.

Table 2. Phytosociological attributes of weeds during *Rabi* and *Kharif* seasons. *F=Frequency, D=Density, IVI=Importance Value Index.

Sl. No.	Plant name	Family	*Kharif* F (%)	*Kharif* D (Stem/ha)	*Kharif* IVI	*Rabi* F (%)	*Rabi* D (Stem/ha)	*Rabi* IVI
1	*Cyperus odoratus* L.	Cyperaceae	85	2.50	5.75	–	–	–
2	*Monochoria vaginalis* (Burm. f.) C. Pres.	Pontederiaceae	90	1.95	9.93	–	–	–
3	*Ludwigia erecta* (L.) H.Hara.	Onagraceae	70	0.90	4.36	20	0.20	8.08
4	*Cynodon dactylon* (L.) Pers.	Poaceae	85	3.15	5.75	30	0.30	10.29
5	*Parthenium hysterophorus* L.	Asteraceae	60	0.90	7.14	20	0.20	7.02
6	*Eclipta alba* L.	Asteraceae	80	1.70	6.45	35	0.35	13.98
7	*Alternanthera philoxeroides* (Mart.) Griseb.	Amaranthaceae	55	0.90	4.36	40	0.40	15.31
8	*Evolvulus nummularius* (L.) L.	Convulvulaceae	65	0.95	3.66	10	0.10	4.70
9	*Cyperus iria* L.	Cyperaceae	85	3.15	5.75	0	0	0
10	*Phyllanthus niruri* L.	Phyllanthaceae	70	1.6	5.05	10	0.10	4.70
11	*Leucas aspera*	Lamiaceae	50	0.6	4.36	55	0.55	19.28
12	*Scoparia dulcis* L.	Plantaginaceae	55	1.05	10.37	20	0.20	5.05
13	*Sonchus oleraceus* L.	Asteraceae	15	0.2	5.75	10	0.10	4.70
14	*Ageratum conyzoids* L.	Asteraceae	55	0.9	4.36	10	0.10	4.70
15	*Abutilon hirtum* (Lam.) Sweet	Malvaceae	65	0.95	3.66	10	0.10	4.70
16	*Casia tora* L.	Fabaceae	80	1.5	5.05	10	0.10	4.70
17	*Cyperus eragrostis* L.	Cyperaceae	90	3.15	5.75	–	–	–
18	*Setaria pumila* (Poir.) Roem.& Schult.	Poaceae	80	1.5	5.05	–	–	–
19	*Digitaria sanguinalis* (L.) Scop.	Poaceae	85	2.5	5.75	34	0.40	12.46
20	*Cyanthillium cinereum* (L.) H. Rob.	Asteraceae	65	0.95	3.66	–	–	–
21	*Croton bonplandianus* Baill.	Euphorbiaceae	65	0.95	3.66	–	–	–
22	*Fimbristylis dichotoma* (L.) Vahl.	Cyperaceae	95	3.2	11.78	65	0.70	22.95
23	*Cyperus compressus* L.	Cyperaceae	80	2.65	10.62	20	0.20	5.05
24	*Echinochloa colona* (L.) Link.	Poaceae	85	1.5	5.75	45	0.45	16.63
25	*Lindernia dubia* (L.) Pennell.	Linderneaceae	70	0.9	4.36	–	–	–
26	*Juncus tenuis* Willd.	Juncaceae	25	0.3	5.05	–	–	–
27	*Cyperus rotundus* L.	Cyperaceae	85	3	9.93	35	0.35	13.98

Table 2. Continued..

Sl. No.	Plant name	Family	*Kharif* F (%)	D (Stem/ha)	IVI	*Rabi* F (%)	D (Stem/ha)	IVI
28	*Sagittaria latifolia* L.	Alismataceae	60	1.45	4.36	10	0.10	4.70
29	*Centratherum punctatum* Cass.	Asteraceae	25	0.3	5.05	–	–	–
30	*Dentella repens* (L.) J. R Forst. & G. Forst.	Rubiaceae	30	0.35	5.75	–	–	–
31	*Polygonum aviculare* L.	Polygonaceae	65	0.95	3.66	20	0.20	7.02
32	*Polygonum lapathifolium* L.	Polygonaceae	50	0.6	4.36	–	–	–
33	*Paspalum distichum* L.	Poaceae	90	3.15	5.75	20	0.20	7.02
34	*Achyranthes aspera* L.	Amaranthaceae	50	0.60	4.36	10	0.10	4.70
35	*Carex digitata* L.	Cyperaceae	85	2.95	11.15	–	–	–
36	*Oxalis corniculata* L.	Oxalidaceae	75	2.10	9.23	10	0.10	4.69
37	*Sida cordifolia* L.	Malvaceae	70	0.90	4.36	10	0.10	4.70
38	*Hyptis brevipes* Poit.	Lamiaceae	70	0.90	4.36	–	–	–
39	*Poa annua* L.	Poaceae	–	–	–	20	0.20	5.05
40	*Mazus rugosus* (Burm. f.) *Steenis*	Scrophulariaceae	85	2.40	7.84	20	0.20	5.05
41	*Vernonia cinerea*	Asteraceae	70	0.90	4.36	20	0.20	5.05
42	*Euphorbia hirta* L.	Euphorbiaceae	60	1.45	4.38	20	0.20	5.05
43	*Mimosa pudica* L.	Mimosaceae	80	1.90	5.05	10	0.10	4.70
44	*Chenopodium album* L.	Amaranthaceae	45	0.70	11.34	10	0.10	4.30
45	*Cyperus difformis* L.	Cyperaceae	90	3.20	11.34	54	0.54	15.59
46	*Argemone mexicana* L.	Asteraceae		–	10	0.10	4.70	47
47	*Cyperus involucratus*	Cyperaceae	–	–	–	54.66	0.64	14.40
48	*Solanum nigram* L.	Solanaceae	15	0.20	5.75	–	–	–
49	*Amaranthus viridis* L.	Amaranthaceae	50	0.70	11.32	–	–	–
50	*Eleusine indica* (L.) Gaertn	Poaceae	–	–	–	68	0.84	15.60
51	*Axonopus compressus* (Sw.) *P. Beauv.*	Poaceae	–	–	–	10	0.10	4.70
52	*Chloris barbata* Sw.	Poaceae	65	1.35	13.12	10	0.10	4.70
	Total			70.55	300		9.02	300

et al. 2009). The higher number of weeds recorded in the present study may be attributed to the favorable agro-climatic condition and monoculture of study site, which support diverse weed flora throughout the both growing seasons (Gao *et al.* 2022, Sharma *et al.* 2023, Ripoche *et al.* 2024). The study observed a higher number of dicots (58.33–58.69%) than monocots (41.30–41.66%) during both the seasons. This may be due to the faster seed germination of dicots, which gives them an early advantage in colonizing paddy fields (Ramamoorthy and Nithya 2015). Study revealed Poaceae (grasses) were the most dominant weed groups followed by Cyperaceae (sedges) in paddy fields of Hojai district during both the growing seasons (Fig. 2). The consistent dominance of Poaceae and Cyperaceae across both the seasons may be attributed to their ecological plasticity being extremely hydrophilic and alkaline tolerance nature and propagate through underground tubers which help them to grow throughout the both cropping seasons (Mukherjee *et al.* 2008, Ganie *et al.* 2015, Sarmah *et al*. 2016, Sharma and Singh 2014, Ameena *et al.* 2024). Fimbristylis dichotoma was found to be most dominant weed having the highest IVI during both the seasons (Table 2), which may be attributed to its adaptability, rapid growth, and effective seed dispersal (Ameena *et al*. 2024). Its tolerance to varying conditions enables it to thrive year-round, making it prominent weed in paddy field (Ameena *et al.* 2024). It is also reported as most harmful weed found in paddy fields of different parts of the country (Sarmah 2019, Ameena *et al.* 2024).

The weed diversity analysis revealed, that Shan-

Table 3. Physico-chemical properties of soil during *Rabi* and *Kharif* seasons.

Season	Soil parameters Porosity (%)	Moisture content (%)	pH	Soil organic carbon (%)	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)
Rabi	54.32±0.23*	47.65±0.16*	5.84±0.07*	1.45±0.03*	304.19±0.98*	2.84±0.01*	387.70±0.36^{NS}
Kharif	57.11±0.08*	57.06±0.14*	5.60±0.06*	2.01±0.08*	243.56±1.06*	3.28±0.02*	362.86±0.26^{NS}

Different letters after values in the column represent significant differences at p<0.05. *Values are significant at p≤0.05; ^{NS} values are not significant.

non wiener diversity index was higher during *Kharif* season (3.27) than *Rabi* season (3.16) (Table 1). The probable cause of higher value during *kharif* may be due to seasonal changes of soil moisture and nutrients that facilitate the growth of weeds (Sinha and Banerjee 2016), which may be attributed to favorable agro climatic conditions and traditional weed management practices that allow coexistence of wide range of weed species (Gao *et al.* 2022, Paul *et al.* 2025). The finding of this study was slightly higher than the finding of Hailakandi district, Assam (2.91 for herbs and 2.27 for shrubs) (Rai and Sakachep 2021). Simpson's dominance index was better in *Kharif* season (0.03) than *Rabi* season (0.04) (Table 1). The result was slightly lower than the finding in rice fields of Assam, India (0.07 for herbs) (Rai and Sakachep 2021), which may be attributed to the dominance of a few highly competitive weed species that are better adapted to the prevailing agro climatic conditions (Gao *et al.* 2022). Margalef's species richness was higher during *kharif* season (4.18) and lower during *Rabi* season (3.77) (Table 1). Higher value of species richness at study site during *Kharif* season compared to *Rabi* can be attributed to several factors. Monsoon rains provide ample moisture, triggering seed germination and increasing nutrient availability, which support wider range of plant species (Fried *et al.* 2008). The observed values were slightly lower than the findings of rice fields of Assam (4.82 herbs and 3.34 for shrubs) (Rai and Sakachep 2021). Pielou's species evenness index was higher during *Rabi* (0.98) and lower during *Kharif* (0.96) (Table 1). Lower value for evenness index during *Kharif* season showed that species clumped together within their habitats and not evenly spaced (Sinha and Banerjee 2016). Sorenson's similarity index between *Rabi* season and *Kharif* season was 64.61% (Table 1). This may be due to similar topography and climatic conditions (Javier *et al.* 2015, Yumnam and Ronald 2022).

The soil analysis showed that, soil porosity, SMC, SOC and P of soil were higher in *kharif* season (57.11±0.08%, 57.06±0.14%, 2.01±0.08% and 3.28±0.02 kg/ha respectively) than *Rabi* season (54.32±0.23%, 47.65±0.16%, 1.45±0.03% and 2.84±0.01 kg/ha, respectively) (Table 3). From the statistical analysis it was revealed that they (soil porosity, SMC, SOC and P), were significantly different among the seasons (P≤ 0.05). The variation of porosity, SMC and SOC may be attributed to seasonal fluctuations of rainfall and temperature which may affect the pore spaces, moisture level and organic matter inputs (Parama 2017, Fukumasu *et al.* 2024, Murthy and Raut 2024). Similar findings were reported by previous works (Chenu *et al.* 2000, King *et al.* 2019, Mar *et al.* 2020, Fukumasu *et al.* 2024, Murthy and Raut 2024). However, the seasonal variation of P may be due to nutrient uptake patterns, organic matter content and soil moisture during *kharif* season (Yung *et al.* 2020). Flooding during *kharif* season, increases phosphorus availability by reducing soil pH and enhancing solubility, higher organic matter and carbon content ultimately contributing to P availability (Yung *et al.* 2020). Similar finding was also obtained by previous workers (Yung *et al.* 2020; Supriyadi *et al.* 2021).

Soil pH, N and K were higher in *rabi* season (5.84±0.07, 304.19±0.98 kg/ha and 387.70±0.36 kg/ha respectively) than *kharif* season (5.60±0.06, 243.56±1.06 kg/ha and 362.86±0.26 kg/ha, respectively) (Table 3). From the statistical analysis it was revealed that soil pH and N were significantly different among the seasons (p≤ 0.05). The variation

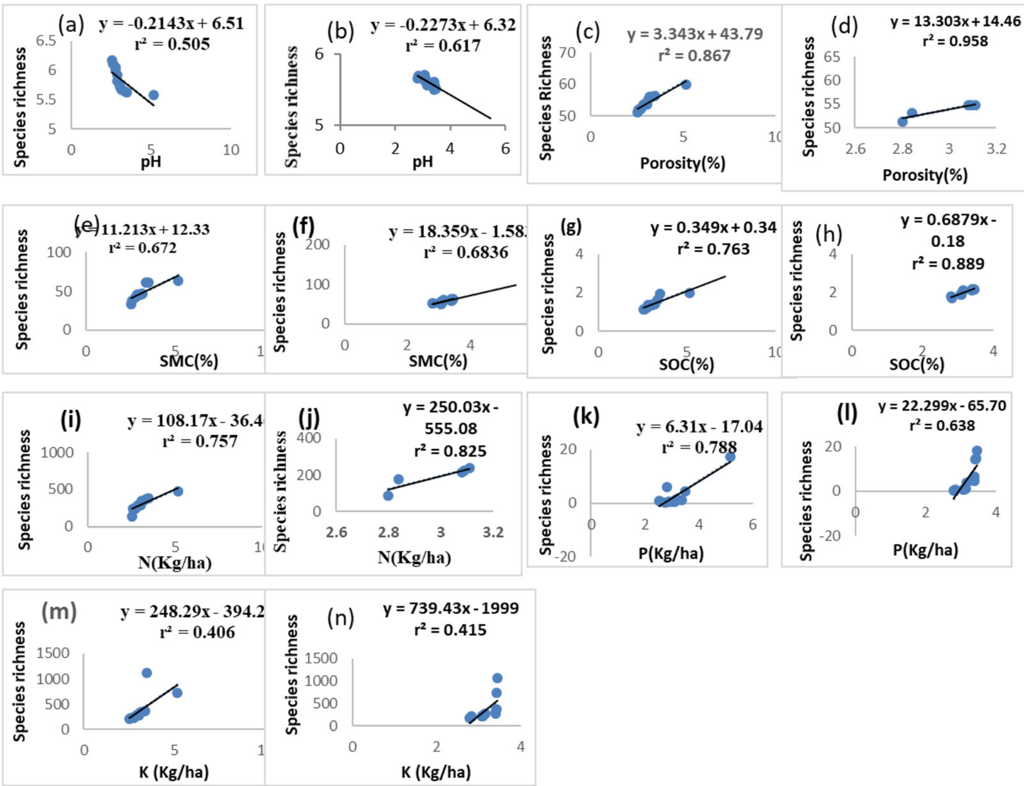

Fig. 3. Regression analysis between weed species richness and soil properties during *Rabi* season (a. porosity, c. SMC, e. pH, g. SOC, i. nitrogen, k. phosphorus and m. potassium) and *Kharif* season (b. Porosity, d. SMC, f. pH, h. SOC, j. nitrogen, l. phosphorus and n. potassium).

may be attributed to fluctuations in temperature and rainfall which influence chemical reactions in the soil affecting the pH level (Murthy and Raut 2024) and leaching losses of N, and denitrification resulting to reducing nitrogen availability of soil in *kharif* season (Wang *et al.* 2024). Similar findings were reported by previous studies (Parama 2017; Murthy and Raut, 2024; Murthy and Raut 2024; Stehlíková *et al.* 2024). However, K showed no significant variation among seasons ($p \leq 0.05$) (Table 3). The lack of significant seasonal variation may be due to consistent use of organic manure, which releases nutrient slowly, maintaining relatively stable potassium levels in the soil (Murthy and Raut 2024). The similar findings were reported by previous studies (Murthy and Raut 2024; Stehlíková *et al.* 2024).

The regression analysis revealed that during *rabi* season, weed species richness exhibited a strong positive correlation with porosity, SOC, N and P (r^2 = 0.86, 0.76, 0.75 and 0.78 respectively), a moderate strong positive correlation with SMC and K (r^2 = 0.67 and 0.40 respectively) and a moderate negative correlation observed for pH (r^2 = 0.50) (Fig. 3). Similar trend was followed in *kharif* season, weed species richness exhibited a very strong positive correlation observed with porosity, SOC and N (r^2 = 0.95, 0.88 and 0.82, respectively), a moderate positive correlation with SMC, P and K (r^2 =0.68, 0.63 and 0.41 respectively) and a moderate negative correlation with pH (r^2 = 0.61) (Fig. 3). Such findings were also reported by previous workers (Patzold *et al.* 2020).

CONCLUSION

The results from phyto-sociological study revealed that *kharif* season had higher weed diversity compared to *Rabi* season this may be due to *Kharif* season having more favorable conditions for weed growth, such as better soil physico-chemical properties that can support a wider variety of weed species. Regression analysis indicated that weed species richness in rice field was highly influence by both physical and chemical properties of soil. Factors like porosity, SMC, SOC, N, P and K influence weed species richness, while pH has a limiting effect. The above findings indicate that nutrient rich soil not only support crop productivity but also facilitate the proliferation of diverse weed flora, thereby intensifying crop-weed competition. Thus, soil properties play a decisive role in shaping seasonal patterns of weed diversity. Integrating soil management with weed control practices is essential for achieving sustainable crop production.

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