



Weed floristic composition and diversity in paddy fields of Mandakini valley, Uttarakhand, India

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Abstract

Weeds are one of the most challenging threats faced by agricultural lands and impart severe effect on crop yield thus impose a high cost to agriculture. The present study was made to characterize the weed communities associated with paddy fields of Mandakini valley, Uttarakhand. Field data was collected by quadrat method (size 1 m²) through field surveys in the year 2017-2018. A total of 57 weed species belonging to 45 genera and 19 families were recorded from the paddy fields. *Echinochloa colona*, *Cyperus iria* and *Ageratum conyzoides* are the most problematic weeds prevailing the paddy fields of the study area. The alpha diversity indices showed that Site 3 was the most diverse zone. High value of Sorenson index represented close similarity occurred in weed species in all the comparison between the sites. The Steinhaus coefficient demonstrated highest similarity intensity between Site 1 and Site 3.

Keywords: weed, paddy, agriculture, similarity indices, alpha diversity, sorenson index, steinhaus coefficient

1. Introduction

Agriculture is the human enterprise by which natural ecosystems are converted into field lands to meet the human needs for the production of food, fibre, timber and other natural products. The agricultural status of an area not only supports its rural economy but also enhances the status of the country. In agro-ecosystems, weeds are the major problem of concern for the low productivity and economic losses to the producers. Weeds are unwanted plants that compete with the crop plants for nutrients, water, space and light [4] and this competitive ability of weeds depends on various unrelated factors such as growth form of weeds, their density and time of weed emergence in relation to crop emergence [23]. The floristic diversity and distribution of weeds within the crop fields depends on the cultural practices within the agricultural fields, crop type, tillage systems, soil type, moisture availability, location and season [25]. They can harbour plant pathogens and pests, spread infection in crop plants and thus degrade their quality [24]. They are genetically labile and phenotypically plastic; such characters enable them to survive in adverse habitats. A sizeable quantity of crop harvests is lost each year, due to inadequate weed control systems [19]. Improvements in productivity of crops can be achieved by combating with problematic weeds associated with the agricultural fields. Phytosociological studies of weeds are widely used for understanding the relationship between crops and their weed flora [26]. It mainly focuses on analyzing the species composition and evaluating various quantitative characters of the community. To understand the dynamics of weeds infesting the crop fields, it is important to identify them, as all the weed species are not equally interfering with the crop [12]. The information on weed biology and floristic composition is crucial for agricultural sustainability, enables one to use required herbicides and to develop an effective management strategy for agro-ecosystems.

Weeds have speciously flourished all over the world imparting a tremendous cost on paddy production [11]. Paddy

(*Oryza sativa* L.) is consumed by more than 60% population of the world as a staple food. It also contributes in maintaining the economic, religious, cultural and social functions of people of the world. It provides feed for cattle thus reducing pressure on grazing fields. It is a source for various industrial products like puffed rice, rice starch, flaked rice, rice husk etc. Paddy is growing in an area of about 45 million hectares producing approximately 96 million tones contributing 45% to the total food grain production of India [17]. Weeds cause up to 33% of loss in the production of paddy in India and loss of about 10% in world [15, 17, 18]. Weed management is required to overcome the loss in production of paddy by weeds [6]. The present study is an attempt to investigate the weed communities infesting the paddy fields from the study area.

Materials and Methods

The present study was conducted in the Mandakini valley located in Uttarakhand state of Northern India. It is situated between 30.16°N to 30.49°N latitude and 78.49°E to 79.21°E longitude. It occupies an area of 2439 km² and elevation ranges from 800 m to 8000m. The Mandakini is the main river of the valley which originates from the Chorabari Glacier near Kedarnath. The valley is well known for its natural beauty, majestic glaciers, beautiful grasslands, lakes, alpine meadows and temples which attract many tourists and pilgrims. Geography of Mandakini valley mainly includes mountainous terrains. The climatic conditions vary with the altitude across the valley. The area is floristically quite rich and has diverse vegetation. During the last decade extensive roads expansion and construction occur in the area causing loss to biodiversity and triggering landslides.

The study was carried out in the paddy fields of the Mandakini valley which is divided into three study sites i.e. S1, S2 and S3 (Table 1) on the basis of altitude. Quadrats of 1m × 1m were laid down randomly for evaluating weed composition in the paddy fields of each study site. The plant specimens were collected with field notes at the

reproductive stages and identified with the help of available literature (Naithani, 1984-1985^[8]; Gaur, 1999^[16]) and herbarium (GUH). The phytosociological parameters i.e. abundance, density, frequency and Importance Value Index (IVI) were calculated following Curtis and McIntosh, (1950)^[5]; Misra, (1968)^[13]; Mueller-Dombois and Ellenberger, (1974)^[14]. Alpha diversity indices (Shannon-Weiner, Simpson and Equitability) and similarity index of Sorensen (SS) and the Steinhaus coefficient (SST) were calculated following Booth *et al.*, (2003)^[2].

Results and Discussions

A total of 57 weed species belonging to 45 genera and 19 families were recorded from the paddy fields of the valley. They were distributed in different life forms i.e. broadleaved (35 species), grasses (12), sedges (09) and fern (01). Poaceae (12) and Cyperaceae (09) contain highest number of weed species among the recorded families from the study sites. S3 and S2 were most diversified with 50 weed species under 18 families, 40 genera and 16 families, 41 genera respectively. S1 represented 48 weed species from 16 families and 37 genera (Table 2).

The analysis of IVI represented that 26 weed species are the dominant weeds in the paddy fields of the region. The major weeds infesting paddy fields are *Echinochloa colona*, *Cyperus iria*, *Ageratum conyzoides*, *Cyperus difformis*, *Fimbristylis miliacea*, *Lindernia ciliata*, *Commelina benghalensis*, *Digitaria ciliaris*, *Dactyloctenium aegyptium*, *Murdannia spirata*, *Eriocaulon cinereum*, *Ammannia baccifera*, *Lindernia crustacea*, *Cyperus rotundus*, *Galinsoga parviflora*, *Cynadon dactylon*, *Eragrostis cilianensis*, *Eragrostis unioides*, *Eleocharis atropurpurea*, *Mazus pumilus*, *Eclipta prostrata*, *Drymaria cordata*, *Echinochloa crus-galli*, *Eleusine indica*, *Ischaemum rugosum* and *Lindernia nummulariifolia* (Table 3).

In S1, *Cyperus iria* show maximum infestation with an IVI of 17.97 and density of 4.02/m² followed by *Ageratum conyzoides*, *Echinochloa colona* and *Lindernia ciliata* having IVI of 17.56, 17.49 and 15.91 respectively. In S2 and S3, *Echinochloa colona* is the most dominating weed having an IVI of 17.99 and 18.83 respectively (Table 3).

The diversity within weed community in the study sites was analyzed by alpha diversity indices such as Shannon-Weiner (H), Simpson and Equitability (E) index. The S3 site revealed as most diverse zone. According to Shannon-Weiner, S3 site represented comparatively highest species diversity, with value 3.563 followed by S2 with 3.557 and S1 with 3.470. The high value of Equitability index i.e. 0.910 was also observed in S3 suggesting high species diversity in that zone. The lowest value of Simpson dominance index in S3 (0.033) was showing S3 area is more diverse (Table 4).

The similarity indices i.e. Sorensen index and Steinhaus coefficient are used to compare the areas for composition of weed communities. High value of Sorensen index indicated close similarity occurred in weed species in all the comparison between the sites. The highest similarity of 0.9 was observed between S2-S3 and S1-S3 (Table 5). The Steinhaus coefficient describe the similarity between

communities by considering the differences in the abundances of species. The Steinhaus coefficient for the present study showed similarity in all of the comparison between the sites as the value obtained were above 0.5 in all the cases. The similarity was higher in comparison between S1 and S3 showing high quantity of common species with similar levels of abundance.

The present study revealed that the most destructive weeds belong to family Poaceae and Cyperaceae and this result coincide with earlier reported findings by Thapa and Jha, (2002)^[17]; Ramirez *et al.*, (2015)^[20] and Nithya and Ramamoorthy, (2015)^[27]. *Echinochloa colona* is the most important weed in paddy fields has been reported by various workers (Rao *et al.*, 2007^[10]; Kaur and Singh, 2014^[17]; Ramirez *et al.*, 2015^[20] and Nithya and Ramamoorthy, 2015^[21]). *Fimbristylis miliacea*, *Echinochloa crus-galli*, *Echinochloa colona*, *Cyperus iria*, *Lindernia crustacea* and *Ageratum conyzoides* were recorded as the most dominant weeds by Gupta, (2008)^[9] in paddy fields of doon valley, Uttarakhand. Ramirez *et al.*, (2015)^[20] reported the importance of *Echinochloa colona*, *Digitaria ciliaris*, *Cyperus iria*, *Ischaemum rugosum* and *Murdannia nudiflora* in paddy fields of Tolima, Columbia by using phytosociological attributes. *Echinochloa crus-galli*, *Cyperus difformis* *Echinochloa colona*, *Cyperus rotundus*, *Cyperus iria*, *Leptochloa chinensis*, *Paspalum distichum*, *Dactyloctenium aegyptium*, *Cynadon dactylon*, *Eleusine indica* and *Fimbristylis miliacea* are the major weeds of paddy in India (Rao, 2010^[21]). In the upland system, *Ageratum conyzoides*, *Galinsoga parviflora*, *Fagopyrum dibotrys* and *Persicaria runcinata* are also among the most dominant weeds of rice in Bhutan (Tshewang *et al.* 2016^[28]). The present study verified that weeds species mentioned in the results were dominant in the paddy fields of Mandakini valley, Uttarakhand.

The zones where crops are grown in continuous manner or with rotation over long period of time show dissimilarity in species composition^[3]. The sampled sites in Mandakini valley have been cultivated with paddy every year with crop rotation so high values of Sorensen index were obtained for all the comparison between the sites. Begum *et al.*, (2005)^[1] demonstrated homogeneity in weed communities as the range of Sorensen index valued between 0.82 to 0.95 for rice crops. Erasmo *et al.*, (2004)^[7] reported values between 0.22 and 0.75 in rotated rice crops: the low value was observed when the area of irrigated rice crop without rotation and area with rice-watermelon rotation were compared while 0.75 value was obtained when the area without rotation was compared with rice-soy rotation. High value of Steinhaus coefficient i.e. 0.8 was recorded between Centro and Norte zones of Tolima, Columbia by Ramirez *et al.*, (2015)^[20] due to similarity in temperature of these zones.

Table 1: Different study sites selected in Mandakini valley

Study Site	Altitude	Villages
Study Site 1 (S1)	800-900 m	Kalapad, Sumari, Tilwara and Silli
Study Site 2 (S2)	1000-1100 m	Bhiri, Temriya, Semi and Sansari
Study Site 3 (S3)	1200-1500 m	Nala, Masta, Chunni and Ukhimath

Table 2: Weed species present in paddy fields at Mandakini valley, Uttarakhand

S.No.	Botanical Name	Family	Site 1	Site 2	Site 3
1.	<i>Alternanthera sessilis</i> (L.) DC.	Amaranthaceae	+	+	+
2.	<i>Gomphrena celosioides</i> Martius	Amaranthaceae	+	+	-
3.	<i>Ageratum conyzoides</i> L.	Asteraceae	+	+	+
4.	<i>Bidens pilosa</i> L.	Asteraceae	+	+	+
5.	<i>Eclipta prostrata</i> (L.) L.	Asteraceae	+	+	+
6.	<i>Galinsoga parviflora</i> Cav.	Asteraceae	+	+	+
7.	<i>Drymaria cordata</i> (L.) Willd. ex. Roemer & Schultes	Caryophyllaceae	+	+	+
8.	<i>Commelina benghalensis</i> L.	Commelinaceae	+	+	+
9.	<i>Cyanotis vaga</i> (Lour.) J.A. & J.H. Schultes	Commelinaceae	+	+	+
10.	<i>Murdannia spirata</i> (L.) Bruckn.	Commelinaceae	+	+	+
11.	<i>Ipomoea pes-tigridis</i> L.	Convolvulaceae	+	-	+
12.	<i>Cyperus alulatus</i> Kern	Cyperaceae	+	-	+
13.	<i>Cyperus difformis</i> L.	Cyperaceae	+	+	+
14.	<i>Cyperus iria</i> L.	Cyperaceae	+	+	+
15.	<i>Cyperus niveus</i> Retz.	Cyperaceae	+	-	+
16.	<i>Cyperus rotundus</i> L.	Cyperaceae	+	+	+
17.	<i>Cyperus compressus</i> L.	Cyperaceae	+	+	+
18.	<i>Eleocharis atropurpurea</i> (Retz.) C. Presl.	Cyperaceae	+	+	+
19.	<i>Fimbristylis miliacea</i> (L.) Vahl.	Cyperaceae	+	+	+
20.	<i>Kyllinga nemoralis</i> (J.R. Forst & G. Forst) Dandy ex Hutch. & Dalziel	Cyperaceae	+	+	+
21.	<i>Euphorbia hirta</i> L.	Euphorbiaceae	+	+	+
22.	<i>Euphorbia hypericifolia</i> L.	Euphorbiaceae	-	+	-
23.	<i>Euphorbia prostrata</i> L.	Euphorbiaceae	+	+	+
24.	<i>Phyllanthus niruri</i> L.	Euphorbiaceae	+	+	+
25.	<i>Eriocaulon cinereum</i> R.Br.	Eriocaulaceae	+	+	+
26.	<i>Equisetum arvense</i> L.	Equisetaceae	-	-	+
27.	<i>Aeschynomene indica</i> L.	Fabaceae	-	+	+
28.	<i>Cassia pumila</i> Lam.	Fabaceae	-	+	+
29.	<i>Desmodium microphyllum</i> (Thunb.) DC.	Fabaceae	-	+	-
30.	<i>Clinopodium umbrosum</i> (M. Bieb.) C. Koch	Lamiaceae	-	+	-
31.	<i>Ammannia baccifera</i> L.	Lythraceae	+	+	+
32.	<i>Rotala indica</i> (Willd.) Koehne	Lythraceae	+	-	-
33.	<i>Oxalis corniculata</i> L.	Oxalidaceae	+	+	+
34.	<i>Persicaria nepalensis</i> (Meisn.) H. Gross	Polygonaceae	+	+	+
35.	<i>Polygonum plebeium</i> R.Br.	Polygonaceae	+	+	+
36.	<i>Polygonum barbatum</i> L.	Polygonaceae	+	-	-
37.	<i>Cynodon dactylon</i> (L.) Persoon	Poaceae	+	+	+
38.	<i>Dactyloctenium aegypticum</i> (L.) P. Beauv.	Poaceae	+	+	+
39.	<i>Digitaria ciliaris</i> (Retz.) Koeler	Poaceae	+	+	+
40.	<i>Echinochloa colona</i> (L.) Link.	Poaceae	+	+	+
41.	<i>Echinochloa crus-galli</i> (L.) P. Beauv.	Poaceae	+	+	+
42.	<i>Eleusine indica</i> (L.) Gaertner	Poaceae	+	+	+
43.	<i>Eragrostis cilianensis</i> (All.) Vign. ex Janchen	Poaceae	+	+	+
44.	<i>Eragrostis unioides</i> (Retz.) Nees ex Steudel	Poaceae	+	+	+
45.	<i>Ischaemum rugosum</i> Salisbury	Poaceae	+	+	+
46.	<i>Panicum psilopodium</i> Trinius	Poaceae	+	+	+
47.	<i>Paspalum distichum</i> L.	Poaceae	+	+	+
48.	<i>Setaria pumila</i> (Poir.) Roemer & Schultes	Poaceae	+	+	+
49.	<i>Hedyotis corymbosa</i> (L.) Lam.	Rubiaceae	+	+	+
50.	<i>Oldenlandia diffusa</i> (Willd.) Roxb.	Rubiaceae	-	+	+
51.	<i>Lindernia ciliata</i> (Colsmann) Pennell	Scrophulariaceae	+	+	+
52.	<i>Lindernia crustacea</i> (L.) F.V. Mueller	Scrophulariaceae	+	+	+
53.	<i>Lindernia nummulariifolia</i> (D. Don) Wettstein	Scrophulariaceae	-	+	+
54.	<i>Mazus pumilus</i> (Burm. f.) Steenis	Scrophulariaceae	+	+	+
55.	<i>Torenia cordifolia</i> Roxb.	Scrophulariaceae	-	+	-
56.	<i>Physalis minima</i> L.	Solanaceae	+	+	+
57.	<i>Pouzolzia zeylanica</i> (L.) J. Bennett & Brown	Urticaceae	+	-	+

Table 3: Phytosociological attributes of major weeds in paddy fields of Mandakini valley, Uttarakhand

Botanical name	Family	Site 1			Site 2			Site 3		
		Freq.	Den.	IVI	Freq.	Den.	IVI	Freq.	Den.	IVI
<i>Ageratum conyzoides</i> L.	Asteraceae	100	3.35	17.56	100	3.12	15.97	100	2.97	15.19
<i>Eclipta prostrata</i> (L.) L.	Asteraceae	68.33	2.12	11.36	48.33	1.18	6.55	51.67	1.63	8.20
<i>Galinsoga parviflora</i> Cav.	Asteraceae	48.33	1.58	8.35	51.67	1.68	8.52	45	1.43	7.18
<i>Drymaria cordata</i> (L.) Willd. ex. Roemer & Schultes	Caryophyllaceae	56.67	1.90	8.98	45	1.35	6.32	60	2.02	8.96
<i>Commelina benghalensis</i> L.	Commelinaceae	63.33	2.05	10.85	56.67	1.97	9.78	46.67	1.52	7.56
<i>Murdannia spirata</i> (L.) Bruckn.	Commelinaceae	43.33	1.47	7.66	48.33	1.55	7.88	41.67	1.20	6.20
<i>Cyperus difformis</i> L.	Cyperaceae	81.67	2.82	13.19	73.33	2.45	11.08	78.33	2.63	11.70
<i>Cyperus iria</i> L.	Cyperaceae	100	4.02	17.97	100	3.20	14.67	100	3.52	15.41
<i>Cyperus rotundus</i> L.	Cyperaceae	53.33	1.77	8.38	60	2.08	9.31	56.67	1.87	8.35
<i>Eleocharis atropurpurea</i> (Retz.) C. Presl.	Cyperaceae	51.67	1.62	7.81	48.33	1.43	6.74	70	2.20	9.99
<i>Fimbristylis miliacea</i> (L.) Vahl.	Cyperaceae	73.33	2.53	11.86	85	2.97	13.24	81.67	2.72	12.11
<i>Eriocaulon cinereum</i> R.Br.	Eriocaulaceae	55	1.85	8.73	51.67	1.77	7.93	48.33	1.53	6.94
<i>Ammannia baccifera</i> L.	Lythraceae	51.67	1.57	8.46	63.33	2.20	10.93	60	2.05	10.07
<i>Cynadon dactylon</i> (L.) Persoon	Poaceae	58.33	1.95	9.22	63.33	2.15	9.67	55	1.78	8.02
<i>Dactyloctenium aegyptium</i> (L.) P. Beauv.	Poaceae	61.67	2.02	9.61	65	2.32	10.27	58.33	1.98	8.78
<i>Digitaria ciliaris</i> (Retz.) Koeler	Poaceae	76.67	2.73	12.67	95	3.30	14.74	70	2.40	10.60
<i>Echinochloa colona</i> (L.) Link.	Poaceae	100	3.87	17.49	100	4.27	17.99	100	4.63	18.83
<i>Echinochloa crus-galli</i> (L.) P. Beauv.	Poaceae	46.67	1.42	6.92	45	1.32	6.22	43.33	1.23	5.79
<i>Eleusine indica</i> (L.) Gaertner	Poaceae	40	1.22	5.94	26.67	0.57	3.02	46.67	1.48	6.71
<i>Eragrostis cilianensis</i> (All.) Vign. ex Janchen	Poaceae	45	1.25	6.30	56.67	1.60	7.65	61.67	1.72	8.12
<i>Eragrostis unioloides</i> (Retz.) Nees ex Steudel	Poaceae	51.67	1.48	7.39	46.67	1.37	6.45	45	1.30	6.07
<i>Ischaemum rugosum</i> Salisbury	Poaceae	60	1.98	9.41	63.33	2.17	9.73	68.33	2.32	10.27
<i>Lindernia ciliata</i> (Colsmann) Pennell	Scrophulariaceae	88.33	3.07	15.91	81.67	2.70	13.60	85	2.90	14.25
<i>Lindernia crustacea</i> (L.) F.V. Mueller	Scrophulariaceae	53.33	1.65	8.86	50	1.53	7.89	56.67	1.75	8.85
<i>Lindernia nummulariifolia</i> (D.Don) Wettstein	Scrophulariaceae	-	-	-	36.67	0.78	4.55	43.33	1.12	5.98
<i>Mazus pumilus</i> (Burm. f.) Steenis	Scrophulariaceae	48.33	1.43	7.80	45	1.23	6.57	55	1.68	8.54

Table 4: Alpha diversity indices for the study sites in the Mandakini valley, Uttarakhand.

Study Site	Shannon-Weiner	Simpson Dominance Index	Equitability
S1	3.470	0.036	0.896
S2	3.557	0.034	0.909
S3	3.563	0.033	0.910

Table 5: Similarity indices of the sampled study areas in the Mandakini valley, Uttarakhand.

Index	S1-S2	S2-S3	S1-S3
Sorensen	0.857	0.900	0.900
Steinhaus	0.885	0.895	0.900

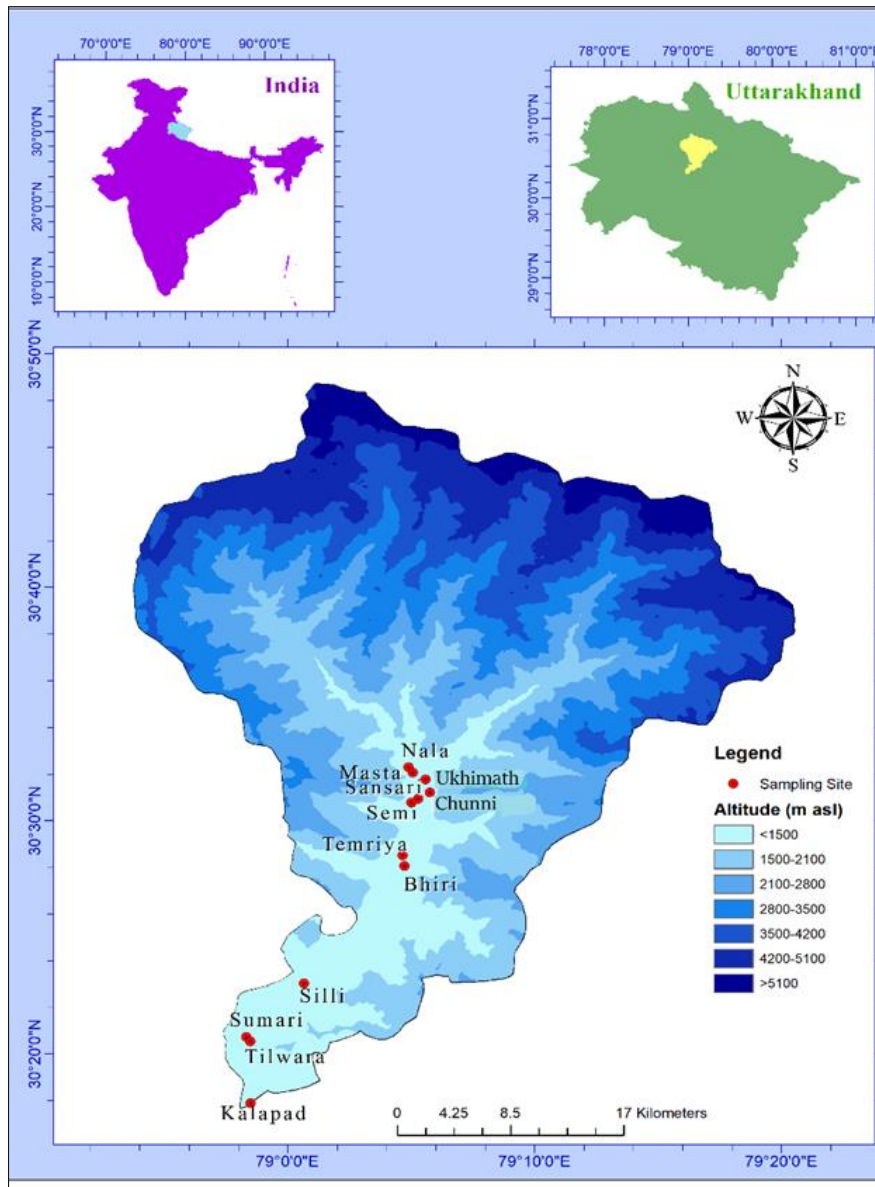


Fig. 1: Location map of the study area



Fig 2: A, B and C. Paddy fields in the study area, D. Weed eradication by hand pulling method

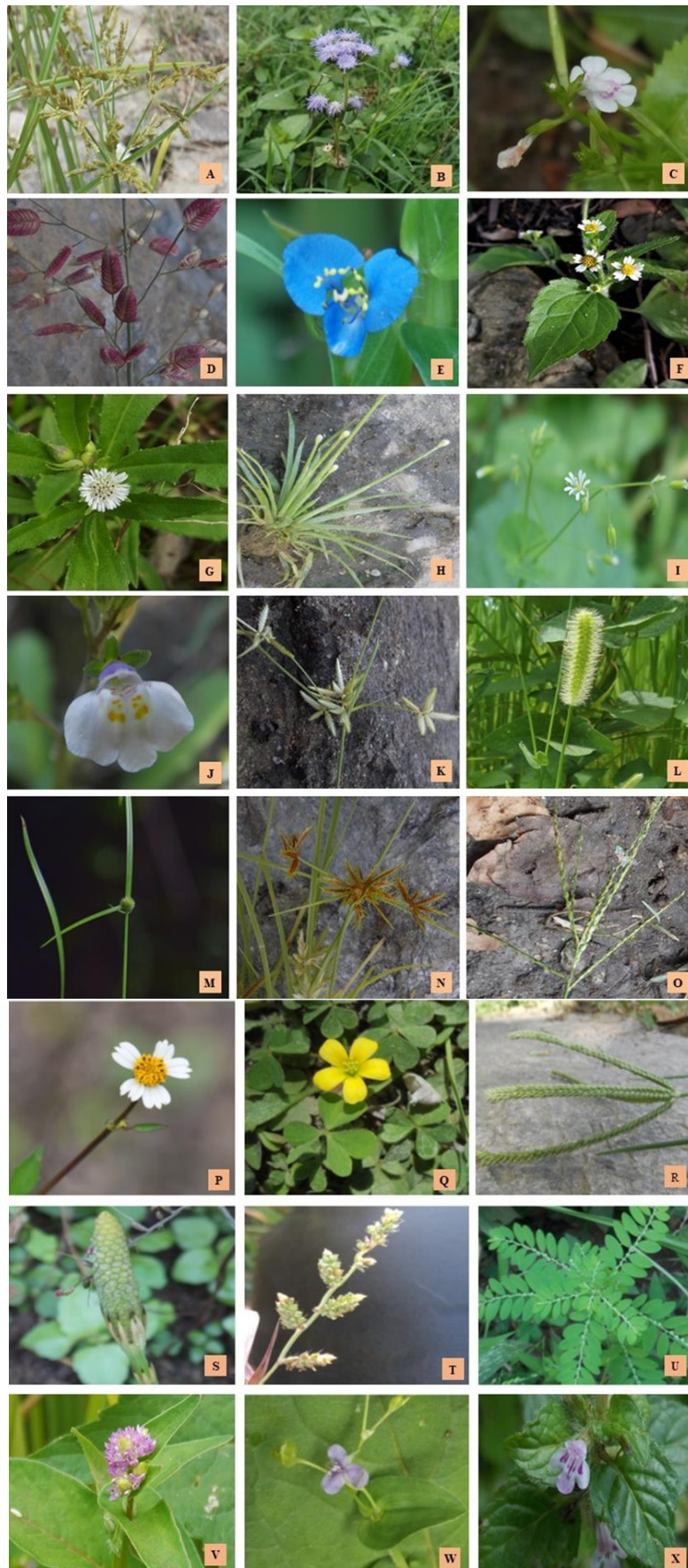


Fig 3: Weeds in Paddy fields: (A) *Cyperus iria*; (B) *Ageratum conyzoides*; (C) *Lindernia ciliata*; (D) *Eragrostis uniolooides*; (E) *Commelina benghalensis*; (F) *Galinsoga parviflora*; (G) *Eclipta prostrata*; (H) *Eleocharis atropurpurea*; (I) *Drymaria cordata*; (J) *Mazus pumilus*; (K) *Cyperus niveus*; (L) *Setaria pumila*; (M) *Kyllinga nemoralis*; (N) *Cyperus difformis*; (O) *Digitaria ciliaris*; (P) *Bidens pilosa*; (Q) *Oxalis corniculata*; (R) *Eleusine indica*; (S) *Equisetum arvense*; (T) *Echinochloa colona*; (U) *Phyllanthus niruri*; (V) *Persicaria nepalensis*; (W) *Murdannia spirata*; (X) *Clinopodium umbrosum*

Conclusion

It is concluded from the obtained results that the dominant weeds present in the paddy fields of the Mandakini valley, Uttarakhand are *Echinochloa colona*, *Cyperus iria*, *Ageratum conyzoides*, *Cyperus difformis*, *Fimbristylis miliacea*, *Lindernia ciliata*, *Commelina benghalensis*, *Digitaria ciliaris*, *Dactyloctenium aegypticum*, *Murdannia spirata*, *Eriocaulon cinereum*, *Ammannia baccifera*, *Lindernia crustacea*, *Cyperus rotundus*, *Galinsoga parviflora*, *Cynadon dactylon*, *Eragrostis cilianensis*, *Eragrostis unioides*, *Eleocharis atropurpurea*, *Mazus pumilus*, *Eclipta prostrata*, *Drymaria cordata*, *Echinochloa crus-galli*, *Eleusine indica*, *Ischaemum rugosum* and *Lindernia nummulariifolia*. The weed community of S3 was more diverse followed by S2 and S1. There was close similarity in the composition of weed community between S2-S3 and S1-S3 according to similarity index of Sorenson while S1-S3 show similarity in high quantity of in-common species with similar levels of abundance according to Steinhaus coefficient. Site specific knowledge on nature and extent of infestation of weed is crucial for proper weed control planning. The survey on composition and structure of weed communities will be helpful to the agriculturist to overcome the problem faced by them in fields due to the severe weed effects.

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