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Weed Flora Composition in Upland Direct Seeded Rice in Brahmaputra River Ecotones and Edges in Majuli District, Assam

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ABSTRACT

Background: The River Brahmaputra is one of the largest braided rivers in the world, where the island and bars (“Chapories”) are formed almost annually by erosion and deposition, which are good agricultural lands, as most of the depositions are extremely fertile and possess ready water source in close proximity. With an aim to depict the weed vegetation pattern in upland direct seeded rice ecosystem in such an ecotone zone, Chapories of Majuli district were surveyed during 2021 and 2022.

Methods: One square meter quadrates were plotted in between 20 to 65 days after sowing (before flowering) of rice to study the weed status in the critical period of crop weed competition in four locations.

Result: Study recorded altogether 55 species of weedy nature in four locations with as many as 39 broadleaved species belonging to 25 families, 3 sedges and 13 grasses, which represented a great diversity with several unusual species unique to chapori areas. Isolation of location - 4 by water channel has contributed in increasing dissimilarity with respect to weed flora, though river water might have had great role in distribution of weeds especially the stubble borne perennial species. The cumulative IVI of grass species was also 30.4 per cent higher in this isolated location than the non-grass species, unlike the locations that had land connectivity with shore areas.

Key words: Brahmaputra, Ecotone, Majuli, Rice, Weeds.

INTRODUCTION

River beds and banks are typical ecotone zones between hydrological and terrestrial ecosystems, which are excellent for the development of agricultural land as along the river ecotone, the land is extremely fertile with water source in close proximity (Babu, 2016). The mighty river Brahmaputra is an extremely dynamic and one of the largest braided rivers in the world (Coleman, 1969; Gilfellon *et al.,* 2003), where both erosion-deposition and increased agricultural activity in lower reaches especially in post monsoon period are continuous processes (Saikia *et al*., 2019). The bank and beds of this river is sand and silt rich annual or sometimes short-lived perennial uplands (islands and sand-bars) enriched with annual deposition of humus by flood water converting to a fertile land for cultivation of crops. Depending on land suitability in such flood plain ecotones and edges, farmers of Assam used to cultivate variety of crops, where the crop cycle, productivity and crop management systems are very typical under the influence of riverine environment, unlike that of terrestrial ecosystems. Farmers nomenclature for such islands and bars of the Brahmaputra based ecotones and edges is “chapori” or “chor” in local language, where weed flora plays a major role in crop productivity under the naturally enriched fertile soil, extremely shallow water table and often treeless windy and sunny environment. As a major stable crop of this region, rice is widely cultivated in summer season and the semi perennial chapories are ideal for summer rice, followed by winter vegetables. With an aim to depict the weed vegetation pattern in upland direct seeded rice ecosystem in such an ecotone zone, Chapories of Majuli district was selected where farmers used to cultivate both dry seeded and transplanted rice.

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MATERIALS AND METHODS

Study site

Study area is the Brahmaputra river bed (“Chapori”) situated in the southern part of Majuli district of Assam. Data were collected from 4 distinct locations (Table 1) in and around greater “Dhodang Chapori” which covers a total geographical area of 361.98 hectares. Out of total four locations, location 1, 2 and 3 had land connectivity with the mainland of Golaghat district and location 4 was separated from the main land by river channel; soil pH of the area varied from 5.6 to 6.9. The climate that experienced by the island (Majuli district) is subtropical with warm humid summer and cool dry winter with average annual rainfall of 1900-2100 mm (Bhaskar, 2019 and Sarmah, 2019).

Data collection

Upland direct seeded (d. s.) rice fields were kept under observation since 2021 and farmers were interviewed for weed problem and management strategies. Weed data were collected for the present analysis both in 2021 and 2022 from the selected locations. For collection of data 1 m × 1 m square quadrates were used in between 20 to 65 days after sowing (before flowering) of rice to represent the weed status during the critical period of crop weed competition. Altogether 10 quadrates (5 quadrates in each year) were plotted in each location randomly distributed at an interval of 5-8 meter distance around the GPS point recorded for the location. Collected weeds were immediately sorted species-wise and their population count was recorded. Considering runners as propagating organ, rooted slips of perennial species were considered as separate individuals in the counting process. Basal diameter of each species were recorded at ground level or nearly so. Collected weeds were oven dried at around 65°C for recording the weed dry weight.

A. Floristic composition

In determining floristic composition of weed flora, following formulae were used as described by Githae *et al*. (2007) and Akwee *et al*. (2010):

(i) Basal area (BA) and relative dominance

Basal area of species in each quadrate

$$= \text{Average BA} \times \text{Number of individuals}$$
$$= (\pi d^2/4) \times \text{number of Individuals}$$

Where:
d= Average basal diameter of the weed.

Relative dominance (Rdom) (%) =

$$\frac{\Sigma \text{BA of each species}}{\Sigma \text{BA of all the species}} \times 100$$

(ii) Density, abundance and relative density

$$\text{Density (D)} = \frac{\text{Number of individuals of each species}}{\text{Total number of quadrates plotted}}$$

Abundance (A) =

$$\frac{\text{Number of individuals of each species}}{\text{Total number of quadrate where the species occurred}}$$

$$\text{Relative density (RD) (\%)} = \frac{\Sigma D_i}{\Sigma D_n} \times 100$$

(iii) Frequency and relative frequency

Frequency (%) =

$$\frac{\text{Total number of quadrates where species occurred}}{\text{Total number of quadrates plotted}} \times 100$$

$$\text{Relative frequency (RF) (\%)} = \frac{\Sigma F_i}{\Sigma F_n} \times 100$$

(iv) Importance value index (IVI)

The IVI was computed by considering population strength (RD), distribution pattern (RF) and ground space occupied (R.Dom) by each species.

$$\text{IVI} = \text{RD} + \text{RF} + \text{R.Dom}$$

B. Community relationship

For determination of diversity, similarity-dissimilarity, *etc*. amongst the weed communities of different locations, following formulae were used:

(v) Shannon and Weiner diversity index (H) (Shannon and Weaver, 1949)

$$H = -\Sigma Pi^*(LNPi)$$

Where:
Pi= Proportion of Individuals of the community.
LN= Natural logarithm.

(vi) Pielou's evenness index (I) (Pielou, 1977)

$$I = H/H_{max}$$

Where:
H= Number derived from shannon's diversity index.

$$H_{max} = (-)\Sigma 1/S^*LN(1/S)$$

S= Total number of species.

(vii) Species richness index (Dmg) (Margalef, 1951)

$$\text{Dmg} = \frac{(S-1)}{LN(N)}$$

Where:
S= Number of species.
N= Total number of individuals in the community.

(viii) Simpson's diversity index ('D') (Simpson, 1949)

$$D = 1 - \{\Sigma n^* (n-1)/N^* (N-1)\}$$

Where:
n= Total number of individuals of a particular species.
N= Total number of individuals of all species.

(ix) Simpson's modified similarity index (Sreejith, 2014)

$$\frac{[2C/(A+B) + (Ci/Di)]}{2}$$

Where:
A= Total number of species in first community.
B= Total number of species in second community.
C= Number of species common to both the communities.

$$Ci = \frac{Ai}{Bi}$$

Ai= Total IVI of common species found in first community.
Bi= Total IVI of common species found in second community.
Di= Total IVI of all species in both communities together (= nearly 600).

(x) Sorensen coefficient (Coefficient of community, CC) (Sorensen, 1948)

$$CC = \frac{2a}{(2a+b+c)}$$

Where:

a= Total number of species common to both community.

b= Number of species unique to first community.

c= Number of species unique to second community.

(xi) Bray-curtis dissimilarity (BC_{ij}) (Bray and Curtis, 1957)

$$BC_{ij} = 1- \{2C_{ij} / (S_i + S_j)\}$$

Where:

C_{ij}= Sum of lesser values for only those species in common between two communities.

S_i and S_j = Total number of individuals counted at both communities.

RESULTS AND DISCUSSION

Species composition

The study recorded 55 species of weedy nature in four locations of the upland d. s. rice in the chapori area of southern Majuli during 2021-2022. This enumeration included 39 broad leaved species belonging to 25 families, 3 sedges belonging to Cyperaceae family and 13 grasses belonging to Poaceae (12) and Typhaceae (1). It was interesting to note that, out of all these species, only few namely*, Centella asiatica, Cynodon dactylon, Echinochloa colona, Eleusine indica, Fimbristylis littoralis, Hydrocotyle sibthorpioides, Imperata cylindrica* and *Paspalum notatum* had common occurrence in all the four locations.

The area studied represented typical ecotone zone between the terrestrial agro-ecological vegetation of river bank areas and the hydrological vegetation of the river Brahmaputra, where the presence of *Ficus heterophylla, Imperata cylindrica, Paspalum notatum, Tamarix dioica* and *Typha latifolia* represented the peculiarity of the ecotone vegetation of the river ecosystem. Out of that, presence of many other species like *Galeopsis tetrahit, Ipomoea carnea*, *Ricinus communis, etc*. was found to be quite unusual, as compared to the weed flora in d. s. rice of nearby villages with typical upland situations. That might be due to the migration of seeds to the chapori areas through various means including run-off and flood water. In such a situation, weed growth was quite enormous and the weed dry matter recorded during 20 to 65 days after sowing of d. s. rice varied from 105±07 g/m^2 (Location-3) to 123±0 g/m^2 (Location-1) with an average value of 117±12 g/m^2 (Table 3).

Weed spectrum

The data presented in Table 2 revealed that *Marchantia polymorpha*, the colony forming Bryophyte, was the most dominant species in location-1 and location-3. However, the highest importance value index (IVI) in both the locations was due to higher values of basal area coverage, while the frequency (distribution) and density (population) were much lower and therefore, the species might be considered as falsely dominant one. Similarly, *Tamarix dioica* in location-4 was also a falsely dominant weed. In contrary, *Cynodon dactylon-Eleusine indica* complex was the most populated, widely distributed and highly dominant group in all the four locations as reflected by quite higher values of relative frequency, relative density and IVI respectively as shown in Table 2. *Imperata cylindrica* was found to be rather dominant than *Eleusine indica* in location-1, 2 and 3, while, *Paspalum distichum* and *Echinochloa colona* in location-4.

Grasses are always found to be dominant in many crops including upland d. s. rice in high rainfall, subtropical environment. That was reflected in the location 4 which was separated by river canal where the cumulative IVI of grasses was 30.4 percent higher than that of non-grass species. On the other hand, the cumulative IVI of grass species were of 109, 49 and 75 per cent higher than the grass species in the locations-1, 2 and 3, respectively, which had land connectivity with the main land. That might be due to easy migration of weeds seed of board leaved annual and sedges in those locations ('edges effect').

The area under the study represented only 3 species of sedges namely *Cyperus rotundus, Eleocharis congesta and Fimbristylis littoralis* complex. In the river-bed atmosphere, the growing up weed vegetation under the heavy competition in the rice ecosystem is represented by the more or less lower values of relative frequency of the weeds in the locations-1, 2 and 3, while in the location-4, the values of relative densities which is greatly varied from minimum of 1.32 per cent in *Digitaria setigera*, 6.58 per cent in *Echinocloa colona* and to maximum of 7.89 per cent in *Paspalum distichum* to 11.84 per cent in *Cynodon dactylon* reflecting the early maturity of weed vegetation.

In ecosystem functioning in addition to environmental drivers, abundance of species (*i.e*. relative number of individuals) and frequency (*i.e*. occurrences across landscapes) always play significant role (Poorter, *et al*., 2017; Sandoya *et al.,* 2021). Species density or abundance depends on the long-term population dynamics, *i.e*. the balance between mortality and recruitment (Lines *et al.,* 2010). Hall *et al.* (1992) opined that numerically abundant species can be assumed to have a higher capacity of mobilizing resources and assimilating energy. Relatively higher magnitude of abundance was shown by *Cynodon dactylon - Digitaria setigera - Eleusine indica* complex, often coupled with *Imperata cylindrica* in the study area in direct seeded rice ecosystem along the bars of the river

Table 1: List of locations under study.

Location	Geo positioning	Name of the village
1	26°48′09″N 94°02′25″E	Neul gaon
2	26°47′47″N 94°01′11″E	Kolia missing gaon
3	26°49′02″N 94°01′3″E	Bahir kolia gaon
4	26°50′25″N 92°02′22″E	Pohumora vakeli chapori

Table 2: Dominance spectrum of weeds of upland direct seeded rice in different chapori areas of river Brahmaputra in Majuli district, Assam during 2020-2021.

	RF	RD	R_{dom}	IVI
Name		**Location-1**		
Marchantia polymorpha L.	2.80	5.24	54.72	62.76
Cynodon dactylon (L.) Pers	3.74	22.44	1.63	27.81
Imperata cylindrica (L.) Raeusch.	3.74	8.73	5.70	18.17
Eleusine indica (L.) Gaertn.	3.74	5.24	6.08	15.06
Galeopsis tetrahit L.	1.87	2.00	9.27	13.13
Digitaria setigera Roth	2.80	8.73	0.63	12.17
Oxalis debilis (DC.) Lour.	2.80	1.00	7.24	11.04
Paspalum notatum Flugge	3.74	3.99	2.61	10.33
Other minor broad-leaves (*Amaranthus viridis, Centalla asiatica, Commelina benghalensis, Euphorbia hirta, Hydrocotyle javanica, H. sibthorpioides, Justicia simplex, Leonurus sibiricus, Leucus linifolia, Lindernia diffusa, Lygodium microphyllum*, *Mimosa pudica, Oldenlandia diffusa, Oxalis corniculata, Potentila indica, Solanum aculeatissimum*)	59.8	31.7	9.68	101.2
Other grasses (*Echinochloa colona, Pennisetum glaucum*)	6.54	5.98	0.97	13.5
Sedges (*Cyperus rotundus, Fimbristylis littoralis*)	8.41	4.98	1.45	14.84
Name		**Location-2**		
Imperata cylindrica (L.) Raeusch.	4.46	14.46	14.65	33.57
Cynodon dactylon (L.) Pers	3.57	21.69	2.44	27.70
Eleusine indica (L.) Gaertn.	4.46	6.51	11.72	22.69
Oxalis debilis (DC.) Lour.	4.46	1.45	16.28	22.19
Diplazium esculentum (Retz.) Sw.	1.79	1.20	16.41	19.40
Galeopsis tetrahit L.	3.57	1.45	10.42	15.44
Other minor broad-leaves: (*Amaranthus viridis, Centalla asiatica, Commelina benghalensis, Ficus hetrophylla, Justicia simplex, Hydrocotyle javanica, H. sibthorpioides, Leonurus sibiricus*, *Lindernia diffusa, Lygodium microphyllum, Mimosa pudica, Oldenlandia diffusa, Oxalis corniculata, Potentila indica, Solanum aculeatissimum*)	53.55	31.83	15.73	101.12
Other grasses (*Chrysopogon aciculatus, Echinochloa colona Pennisetum glaucum, Paspalum notatum*)	12.5	14.22	4.86	31.57
Sedges (*Cyperus rotundus, Fimbristylis littoralis*)	8.03	4.1	1.85	13.98
Name		**Location-3**		
Marchantia polymorpha L.	2.48	2.07	24.04	28.59
Oxalis debilis (DC.) Lour.	3.31	2.30	18.55	24.16
Imperata cylindrica (L.) Raeusch.	4.13	10.37	7.51	22.01
Galeopsis tetrahit L.	3.31	3.00	15.43	21.73
Eleusine indica (L.) Gaertn.	4.13	7.60	9.79	21.53
Cynodon dactylon (L.) Pers	3.31	13.82	1.11	18.24
Fimbristylis littoralis Gaudisch	3.31	6.91	2.23	12.44
Digitaria setigera Roth	3.31	6.91	0.56	10.77
Echinochloa colona (L.) Link	4.13	4.61	1.48	10.22
Other minor broad-leaves: (*Ageratum houstonianum, Amaranthus viridis, Centalla asiatica, Commelina benghalensis, Euphorbia hirta, Ficus hetrophylla, Hydrocotyle sibthorpioides, Justicia simplex*, *Leucus linifolia, Leonurus sibiricus, Lindernia diffusa, Lygodium microphyllum, Mimosa pudica, Oxalis corniculata, Oldenlandia diffusa, Solanum aculeatissimum*)	54.55	30.37	15.92	100.87
Other grasses (*Paspalum notatum, Pennisetum glaucum, Chrysopogon aciculatus*)	9.92	10.61	2.94	23.45
Sedges (*Cyperus rotundus*)	4.13	1.38	0.45	5.96

Table 2: Continue...

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Name	Location-4			
Tamarix dioica Roxb. ex Roth	2.27	3.95	47.72	53.94
Cynodon dactylon (L.) Pers	34.30	11.84	1.06	47.21
Typha latifolia L.	0.55	2.63	29.89	33.06
Paspalum distichum L.	17.29	7.89	2.15	27.33
Echinochloa colona (L.) Link	9.28	6.58	2.59	18.45
Eleusine indica (L.) Gaertn.	9.10	2.63	4.52	16.25
Adiantum caudatum L.	4.46	6.58	0.55	11.59
Other minor broad-leaves: (*Acmella ciliata, Ageratum houstonianum, Alternanthera philoxeroides, A. sessilis, Centalla asiatica, Chromolaena odorata, Desmodium gangeticum, Diplazium esculentum, Eclipta prostrata, Elephantopus scaber, Ficus hetrophylla, Hydrocotyle sibthorpioides, Ipomoea carnea, Ludwigia hyssopifolia, Mikania micrantha, Mollugo pentaphylla, Phyla nodiflora, Polygonum plebeium, Ricinus communis, Vicia sativa*)	13.44	44.79	9.5	67.71
Other grasses (*Imperata cylindrica, Digitaria setigera, Eragrostis japonica, Isachne himalaica, Paspalum notatum, Setaria pumila*)	6.19	10.54	0.56	17.27
Sedges (*Eleocharis congesta, Fimbristylis littoralis*)	3.09	2.64	1.46	7.17

(Species with individual IVI below 10 are shown in groups).

RF= Relative frequency; RD= Relative density; R_{dom}= Relative dominance; IVI= Importance value index.

Table 3: Weed dry matter, the Shanon-weiner diversity index (‘H’), Pielou’s evenness index (‘E’), Simpson’s diversity index (‘D’) and Margalef’s species richness (‘Dmg’) amongst the weed vegetations of different locations of upland d.s. rice of chapori areas of Majuli district during 2020-21.

	Weed dry matter (g/m^2)	‘H’	‘E’	‘D’	‘Dmg’
Location- 1	123±10	2.89	0.87	0.93	6.16
Location- 2	117±12	2.86	0.86	0.92	6.11
Location- 3	105±07	3.04	0.90	0.95	6.11
Location- 4	122±08	2.36	0.66	0.86	7.08

Brahmaputra (Fig 1). The number of species with abundance value of more than 4 was found to be higher in location-4 with altogether 18 species, out of which 12 species were perennial in habit. In contrary, high magnitude of species abundance (above 4) was recorded for 8 species in location 3 and 6 species each in location 1 and 2.

Species diversity

Amongst species diversity measures, the Shannon-Weiner Index or Simpson’s Diversity Index was the mostly used parameters (Yeom and Kim, 2011), where the number of individuals of the species is given equal weightage to the taxonomic variation in the rank of species. Giavelli *et al.* (1986) observed that all the indices were independent of the type of community considered, while for both absolute and comparative estimates, the Simpon’s Index was the most reliable. The data computed from the study of both the years revealed the highest Shannon-Weinner Diversity Index (‘H’) in location 3 (3.04) followed by location-1 (2.89), location 2 (2.86) and location 4 (2.36). Almost similar trend was depicted by Simpson Diversity Indices, which were 0.95, 0.93 and 0.86 in locations 3, 1, 2 and 4, respectively.

Species Richness and Species Evenness are two measurements that help to estimate the biological diversity of a particular ecosystem. Species richness describes the number of species in a particular geographical area and in contrast, species evenness describes how evenly the species are distributed in a particular area (Lakna, 2022). Pielou’s Evenness Index (‘I’), which has used the number derived from Shannon-Weiner’s Diversity Index, was as high as 0.90 in location 3 and the least value (0.66) was recorded in location 4. In contrary, Margalef’s Species Richness Index was the highest in location 4, followed by location 1, 2 and then 3 (Table 3).

Data in Table 2 has revealed that the taxonomic diversity was also the highest in location 4, with as many as 38 weed species. That might be due to the migration of planting materials including seeds of the weeds through flood water, animals and human beings, as well as contaminants of crop seeds. As the site was separated from the shore area by river canal that annually inundated by rising river water at least during peak monsoon period, there existed least possibility of having a rich soil seed bank, compared to the other three sites which had land connectivity with shore areas.

Community dissimilarity

The result revealed that the Sorreson‘s Co-efficient was the highest (0.91) between the weed communities of locations 1 and 3. It was above 0.8 between location 1 and 2, as well as location 2 and 3, whereas, that was shared by 0.30 to 0.34 by the weed community of location 4 with other three locations (Table 4).

To measure the differences between plant communities, the taxonomic distances between them might not be enough, since simply sharing of any taxa (Species or Genus) without their population abundance or distribution pattern could not reflect the exquisite specificity of the site in certain space and time. Sorrenson's dissimilarity Index or Coefficient of Communities, was one of the widely used parameters in depicting similarity or dissimilarity between communities, is based on species incidence (*i.e*. presence- absence) data, the number of species shared by two communities and number of species unique to each. The magnitude of dissimilarity between two communities is relatively of low significance, because of its focus on species incidence alone.

On the other hand, Bray and Curtis (1957) dissimilarity Index between the communities was based on the compositional differences between two sides. It is bounded between '0'(extreme similar composition) and '1' (total dissimilar composition), where the number of individuals counted at both communities is taken into account. Bray-Curtis dissimilarity Index amongst the weed communities of upland direct seeded rice of Brahmaputra chapories of Majuli District was as high as 0.92 between location 1 and location 2 and as minimum as 0.76 between locations 1 and 4 and locations 2 and 4 (Table 5).

Similarly, Simpson's similarity Index is also a commonly used measure of the degree, which gives greater weightage to species common to the communities, than to those found in only one location. Sreejit (2014) modified Simpson's Similarity Index by adding equal weightage to the Importance Value Indices with the species incidence data. The results revealed the highest magnitude

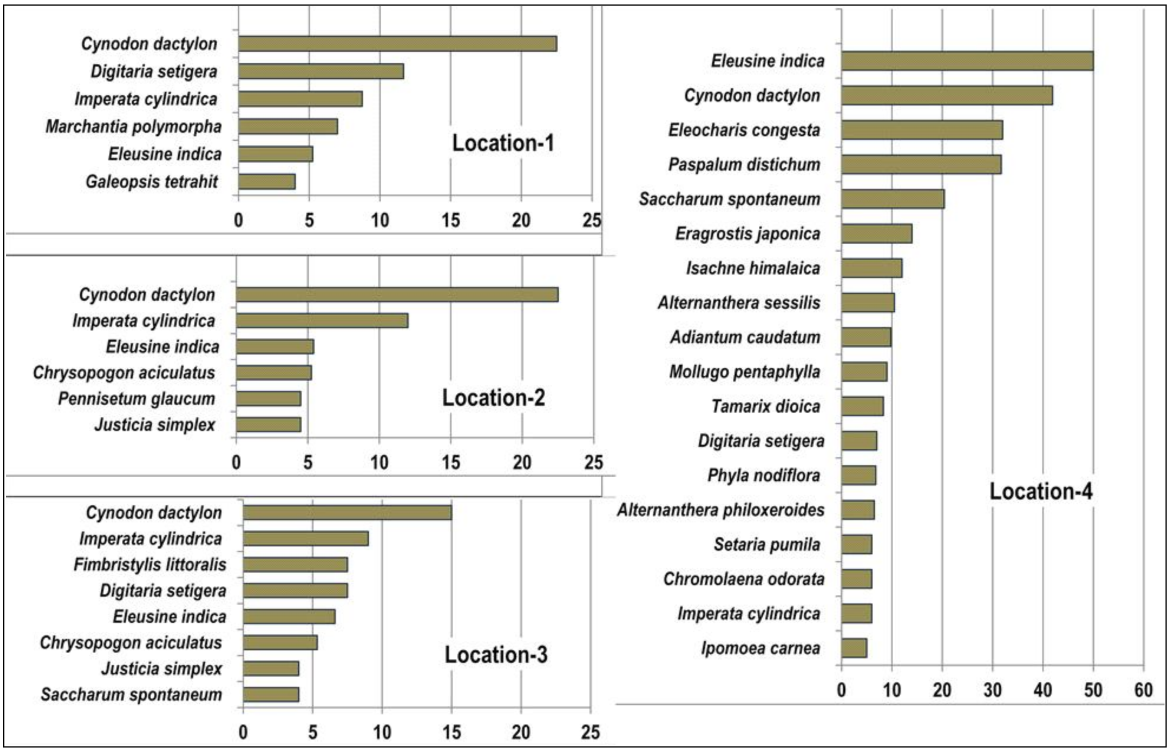

Fig 1: Most abundant weed species in the direct seeded rice in four locations of chapori areas of Majuli district during 2020-21.

Table 4: Simpson's similarity index (Modified) and sorensen's coefficient of the weed vegetations of different locations of upland d.s. rice of chapori areas of Majuli district during 2020-21.

	Location-1	Location-2	Location-3	Location-4
		Simpson's similarity index (Modified)		
Location- 1	-	0.81	0.93	0.30
Location- 2	0.86	-	0.87	0.38
Location- 3	0.91	0.88	-	0.35
Location- 4	0.30	0.34	0.33	-
		Sorensen's coefficient of communities.		

Table 5: Bray-curtis dissimilarity index of the weed vegetations of different locations of upland d.s. rice of chapori areas of Majuli district during 2020-21.

	Location-2	Location-3	Location-4
Location-1	0.08	0.10	0.24
Location-2	-	0.10	0.24
Location-3	-	-	0.22

of similarity according to Simpson's Modified Similarity Index between locations 1 and 3 (0.93) followed by locations 2 and 3 (0.87) and locations 1 and 2 (0.81). Weed community of location 4 shared 0.3, 0.35 and 0.38 similarity indices with locations 1, 3 and 2 respectively.

Isolation from mainland might be one of the major factors for developing uniqueness in composition of weed community in location 4. In addition, the presence of *Ficus heterophylla, Phyla nodiflora, Tamarix dioica* and *Typha latifolia* in this location with as much as 53.94, 33.06, 8.02 and 2.44 IVI have reflected the typical ecotone characteristic of this location along the bars of the river Brahmaputra, than the other locations. It is also seen that quite a good number of weeds present in the chapori areas were stubble borne which might be carried easily by river water during flood period. The most prominent stubble borne weeds dispersed by river water were *Acmella ciliata, Ageratum houstorianum, Alternanthera philoxeroides, Chromolaena odorata, Ipomea carnea, Mikania micrantha* and grasses belonging to the genera *Imperata, Paspalum, Typha*, *etc*.

All these findings could give an effective clue for adoption of management strategy of weeds as the developing or lag-phase is always been considered as the best phase for weed management (Deka and Barua, 2023).

CONCLUSION

Weed flora in upland direct seeded rice of ecotones and edges of river Brahmaputra in Majuli district represented a great diversity with several unusual species unique to chapori areas. Isolation (location-4) by water channel was observed to contribute towards increasing dissimilarity with respect to weed flora, though river water might have great role in distribution of weeds especially the stubble borne perennial species. The cumulative IVI of grass species was also 30.4 per cent higher than the non-grass species in location 4, unlike the locations that had land connectivity with shore areas.

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Conflict of interest

All authors declared that there is no conflict of interest.

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