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Research Article

MORPHOLOGICAL VARIABILITY IN THE COMMON SEDGE PLANTS IN INDIA

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Abstract- *Cyperus* is the second largest genus of the sedges or Cyperaceae family, the plants of which are identified as one of the most common agricultural weeds. A total of eighty two sedge plants were collected from twenty one different places covering seven states of India. The plant species and morphological variations among different species were determined based on overall plant growth characteristics. The samples were identified as belonging to seventeen different species of *Cyperus* and related genera on the basis of UPGMA cluster analysis using Jaccard and Simple Matching coefficients. The mantel test coefficient between these two similarity coefficients was 0.97169. Based on morphological variations, plant samples were identified to be belonging to twelve different species of *Cyperus*, three species from genus *Fimbristylis* and two species from genus *Kyllinga*. Several morphological traits were assessed for identification of plants up to species level, among those spikelet was found the best to be used for the identification of sedge species.

Keywords- Sedge, Cyperaceae, Morphological variation, Cluster analysis

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Introduction

Weed populations exhibit a vast range of biodiversity resulting from taxonomic diversity among them including diversity in particular weedy traits that influences their survival, mortality, and reproduction [1]. The ecological diversity of sedges is tremendous; with species occurring in almost all habitats. Sedges mostly prefer moist and sunny sites. Sedges are monocotyledonous flowering plants belonging to family Cyperaceae which is commonly known as sedge family. Sedge plants are mostly grass-like herbs, which are abundantly found in moist and damp areas throughout the world. *Cyperus* having about 650 species, is the second largest genus after *Carex* in the Cyperaceae family. Members of the Cyperaceae (sedge family) resemble the Gramineae (grass family) but are distinguished by three-ranked leaves with one-third phyllotaxy and leaves that have closed leaf sheaths, usually solid stems, absence of a ligule and each flower subtended by a single glume or scale [2]. The morphology of plants belonging to the genus *Cyperus* reported so far is relatively consistent with uniform embryo type. Morphologically all the *Cyperus* species have common characteristics of leaves that are shiny, light to dark green, three-ranked and corrugated in cross section. Leaf initiation terminates with the formation of seed bearing culm. The culm that grows through the center of the leaf fascicle is erect, simple, smooth and triangular in cross section. The culm supports a terminal inflorescence, which is a simple, or slightly compound loose umbel subtended by two or four leaf-like bracts [2].

The *Cyperus* species are herbaceous plants and mostly used as fodder. In particular, *C. rotundus* and *C. esculentus* are used as medicinal herb. They are also called as purple nut sedge and yellow nut sedge, respectively. They are commonly found as a perennial weed with slender, scaly creeping rhizomes, bulbous at the base which is about 1-3 cm. long. They are useful for bowel disorder and inflammatory diseases as well as uterine relaxation in both pregnant and non-pregnant women and relieving pain. *C. rotundus* is a traditional herbal medicine used widely as antimalarial, analgesic, sedative, and treating stomach disorder etc. Anti-bacterial effect is also found in rhizome extract of *C. rotundus* [3]. Antimalarial, anticancer, antimicrobial activities in essential oil from the aerial parts of *Cyperus kyllingia* has also been reported [4]. *Cyperus involucratus* is planted as an ornamental plant. *Cyperus iria* is used as fodder and its stem is woven into mats. Leaf and tuber parts of *C. iria* are used as Tonic, stimulant, stomachic and astringent [5]. *Kyllinga odorata* is known for diaphoretic and diuretic properties [6]. *Kyllinga brevifolia* is a Paraguayan folk medicine and used as sedative and tonic for nervous system [7]. *Fimbristylis miliacea* has been found of an important role in phytoremediation to absorb heavy metals and zinc in waste water treatment [8].

Identification of the plant species of a potential use is not always easy in the absence of knowledge of the most preferred morphological trait to look upon on site of collection. It is also not feasible to apply costly and sophisticated molecular techniques to identify plants, which are otherwise regarded as weeds only. Their correct identification not only helps to formulate effective control strategy but to explore their potential uses too. Morphological parameters are commonly used as tools for investigating genetic relatedness and diversity among plant populations. It is pertinent to study variations in morphological traits among species to determine how plant genotype and diverse environmental conditions could influence the plant morphology of sedges under uniform conditions. We are reporting in the present study, the qualitative genetic--variations in morphological and phonological traits in sedges and the identification of sedge plants of Cyperaceae family up to the species level in plant samples collected at several locations from seven states of India. This study was conducted to document morphological characteristics of most common sedge plant species of *Cyperus* and related genera from different localities in India.

Materials and Methods

A total of eighty two sedge plant samples were collected from several places

located in seven states of India namely Chhattisgarh (CG), Gujarat (GJ), Madhya Pradesh (MP), Rajasthan (RJ), Tamil Nadu (TN), Uttarakhand (UK) and Uttar Pradesh (UP) in the year 2015 [Table-1]. Plant samples were named according to their places of collection. The morphological observations were recorded at various stages of growth at the site of collection as well as from some of the collected plants grown in pots till flowering that occurs in rainy season in India (July-October). Observations were recorded for each plant sample on various morphological traits including root, rhizome, nut, stem or culm, leaf, inflorescence, spike, spikelet, floret, glume etc. For each trait, different observations were tabulated in Microsoft excel sheet and a qualitative data was generated by recording 0 and 1 for the absence and presence of the trait, respectively, in a particular plant sample. This data was subjected to Unweighted Pair Group Method with Arithmetic Averages (UPGMA) based cluster analysis and dendrogram was generated using NTSYSpc version 2.02e software program [9]. The data analysis was done using two different similarity coefficients, Jaccard [10] and Simple Matching [11]. Routine procedures of NTSYSpc program (like SIMQUAL, SAHN, TREE) in appropriate modules were followed to test the clustering analysis based on these two similarity coefficients. For the comparison of original matrices generated by implementing Jaccard (J) and Simple Matching (SM) similarity coefficients, Mantel test [12] was applied in the option of MXCOMP in NTSYSpc program. The plant samples clustered in a group were identified up to species level by comparing the recorded morphological traits with various documented texts such as 'Flora of Jabalpur' [13], 'Flora of British India' [14], 'Flora of India' [15], 'Flora of Gorakhpurensis' [16], 'Hand Book on Weed Identification' [17] including 'eFloras' [18].

Table-1 *Eighty two plant samples collected from different locations and their identification (All are annual to perennial herb, Status: Common, Least Concern in IUCN Red List)*

S.N.	Place and Sample ID	Latitude_Longitude	Collection date	Species Identified	Vernacular Name
1	Chabi-2-MP	"22.825720 N 80.700650 E"	27-Aug-2015	*Cyperus compressus* Linn.	Mothi
2	Chennai-2-TN	"12.990738 N 80.185958 E"	20-Nov-2015	*Cyperus compressus* Linn.	Mothi
3	Jabalpur-1-MP	"23.2203 N 79.9638 E"	15-July-2015	*Cyperus compressus* Linn.	Mothi
4	Jabalpur-2-MP	"23.2095 N 79.9533 E"	15-July-2015	*Cyperus compressus* Linn.	Mothi
5	Kundam-2-MP	"22.845746 N 81.075466 E"	26-Aug-2015	*Cyperus compressus* Linn.	Mothi
6	Mandla-1-MP	"22.611542 N 80.372824 E"	27-Aug-2015	*Cyperus compressus* Linn.	Mothi
7	Mandla-3-MP	"22.601269 N 80.378423 E"	27-Aug-2015	*Cyperus compressus* Linn.	Mothi
8	Niwas-2-MP	"23.035570 N 80.437791 E"	27-Aug-2015	*Cyperus compressus* Linn.	Mothi
9	Amarkantak-2-MP	"22.677726 N 81.758913 E"	27-Aug-2015	*Cyperus compressus* Linn.	Mothi
10	Amarkantak-4-MP	"22.682933 N 81.748302 E"	27-Aug-2015	*Cyperus compressus* Linn.	Mothi
11	Dindori-1-MP	"22.938539 N 81.080024 E"	27-Aug-2015	*Cyperus compressus* Linn.	Mothi
12	Kapildhara-1-MP	"22.700877 N 81.705569 E"	27-Aug-2015	*Cyperus compressus* Linn.	Mothi
13	Sagartola-1-MP	"22.941793 N 81.076845 E"	27-Aug-2015	*Cyperus compressus* Linn.	Mothi
14	Garjiya-1-UK	"29.462150 N 79.153404 E"	30-Sep-2015	*Cyperus cyperoides* Linn.	Flatsedge
15	Garjiya-3-UK	"29.468026 N 79.146967 E"	30-Sep-2015	*Cyperus cyperoides* Linn.	Flatsedge
16	Jabalpur-6-MP	"23.2095 N 79.9533 E"	15-July-2015	*Cyperus cyperoides* Linn.	Flatsedge
17	Jabalpur-13-MP	"23.2203 N 79.9638 E"	15-July-2015	*Cyperus cyperoides* Linn.	Flatsedge
18	Corbett National Park -3-UK	"29.5486 N 78.9353 E"	30-Sep-2015	*Cyperus cyperoides* Linn.	Flatsedge
19	Garjiya-2-UK	"29.466382 N 79.145765 E"	30-Sep-2015	*Cyperus cyperoides* Linn.	Flatsedge
20	Anand-2-GJ	"22.569384 N 72.931226 E"	15-Oct-2015	*Cyperus esculentus* Linn.	Yellow nut sedge, Chufa flatsedge
21	Anand-4-GJ	" 22.56451 N 72.92887 E"	15-Oct-2015	*Cyperus esculentus* Linn.	Yellow nut sedge, Chufa flatsedge
22	Jabalpur-3-MP	"23.2203 N 79.9638 E"	15-July-2015	*Cyperus esculentus* Linn.	Yellow nut sedge, Chufa flatsedge
23	Jabalpur-12-MP	"23.2095 N, 79.9533 E"	15-July-2015	*Cyperus esculentus* Linn.	Yellow nut sedge, Chufa flatsedge
24	Kapildhara-4-MP	"22.700877 N 81.705569 E"	27-Aug-2015	*Cyperus esculentus* Linn.	Yellow nut sedge, Chufa flatsedge
25	Jabalpur-23-MP	"23.2203 N 79.9638 E"	20-Nov-2015	*Cyperus involucratus* Roxb.	Umbrella plant
26	Jabalpur-5-MP	"23.2203 N 79.9638 E"	18-July-2015	*Cyperus iria* Linn.	Morphula, Umbrella sedge, Rice flat sedge
27	Jabalpur-11-MP	"23.2095 N 79.9533 E"	15-July-2015	*Cyperus iria* Linn.	Morphula, Umbrella sedge, Rice flat sedge
28	Jabalpur-14-MP	"23.2203 N 79.9638 E"	15-July-2015	*Cyperus iria* Linn.	Morphula, Umbrella sedge, Rice flat sedge
29	Jabalpur -21-MP	"23.233164 N 79.967455 E"	30-Aug-2015	*Cyperus iria* Linn.	Morphula, Umbrella sedge, Rice flat sedge
30	Jagdalpur-8-CG	"19.075409 N 82.012864 E"	10-Sep-2015	*Cyperus iria* Linn.	Morphula, Umbrella sedge, Rice flat sedge
31	Lucknow-2-UP	"26.8429 N 80.9544 E"	01-Jan-2014	*Cyperus iria* Linn.	Morphula, Umbrella sedge, Rice flat sedge
32	Niwas-4-MP	"23.035570 N 80.437791 E"	27-Aug-2015	*Cyperus iria* Linn.	Morphula, Umbrella sedge, Rice flat sedge
33	Amarkantak-3-MP	"22.677726 N 81.758913 E"	27-Aug-2015	*Cyperus iria* Linn.	Morphula, Umbrella sedge, Rice flat sedge
34	Dindori-2-MP	"22.938539 N 81.080024 E"	27-Aug-2015	*Cyperus iria* Linn.	Morphula, Umbrella sedge, Rice flat sedge
35	Jagdalpur-9-CG	"19.075409 N 82.012864 E"	10-Sep-2015	*Cyperus iria* Linn.	Morphula, Umbrella sedge, Rice flat sedge
36	Amarkantak-1-MP	"22.677726 N 81.758913 E"	27-Aug-2015	*Cyperus kyllingia* Endl.	Java grass, Red nut sedge
37	Jabalpur-16-MP	"23.2203 N 79.9638 E"	15-July-2015	*Cyperus kyllingia* Endl.	Java grass, Red nut sedge
38	Kapildhara-2-MP	"22.700877 N 81.705569 E"	27-Aug-2015	*Cyperus kyllingia* Endl.	Java grass, Red nut sedge
39	Pantnagar-1-UK	"29.025347 N 79.477147 E"	20-Sep-2015	*Cyperus kyllingia* Endl.	Java grass, Red nut sedge
40	Chabi-1-MP	"22.825720 N 80.700650 E"	27-Aug-2015	*Cyperus microiria* Steud.	Asian flat sedge
41	Jabalpur-4-MP	"23.2095 N 79.9533 E"	15-July-2015	*Cyperus microiria* Steud.	Asian flat sedge
42	Jabalpur-7-MP	"23.2203 N 79.9638 E"	15-July-2015	*Cyperus microiria* Steud.	Asian flat sedge
43	Jabalpur-8-MP	"23.2203 N 79.9638 E"	18-July-2015	*Cyperus microiria* Steud.	Asian flat sedge
44	Jabalpur-9-MP	"23.2095 N 79.9533 E"	18-July-2015	*Cyperus microiria* Steud.	Asian flat sedge
45	Jagdalpur-2-CG	"19.075409 N 82.012864 E"	10-Sep-2015	*Cyperus microiria* Steud.	Asian flat sedge
46	Jagdalpur-4-CG	"19.078032 N 82.004904 E"	10-Sep-2015	*Cyperus microiria* Steud.	Asian flat sedge
47	Jagdalpur-5-CG	"19.078722 N 82.006148 E"	10-Sep-2015	*Cyperus microiria* Steud.	Asian flat sedge
48	Kundam-1-MP	"22.845746 N 81.075466 E"	26-Aug-2015	*Cyperus microiria* Steud.	Asian flat sedge
49	Niwas-1-MP	"23.035570 N 80.437791 E"	27-Aug-2015	*Cyperus microiria* Steud.	Asian flat sedge
50	Niwas-3-MP	" 23.04752 N 80.44701 E"	27-Aug-2015	*Cyperus microiria* Steud.	Asian flat sedge

51	Shahpura-1-MP	"23.185804 N 80.703249 E"	26-Aug-2015	*Cyperus microiria* Steud.	Asian flat sedge
52	Lucknow-1-UP	"26.8429 N 80.9544 E"	01-Jan-2015	*Cyperus microiria* Steud.	Asian flat sedge
53	Kapildhara-3-MP	"22.700877 N 81.705569 E"	27-Aug-2015	*Cyperus nutans* Vahl.	-
54	Kundam-3-MP	"22.845746 N 81.075466 E"	26-Aug-2015	*Cyperus nutans* Vahl.	-
55	Chennai-3-TN	"12.990738 N 80.185958 E"	20-Sep-2015	*Cyperus odoratus* Linn.	Fragrant flatsedge, Rusty flatsedge
56	Kausani-1-UK	"29.846996 N 79.604959 E"	30-Sep-2015	*Cyperus odoratus* Linn.	Fragrant flatsedge, Rusty flatsedge
57	Rewa-1-MP	"24.536571 N 81.272274 E"	20-July-2015	*Cyperus retrorsus* Chapman.	Pine barren flatsedge
58	Amarkantak-5-MP	"22.681982 N 81.753827 E"	27-Aug-2015	*Cyperus rotundus* Linn.	Motha, Nagramotha, Purple nut sedge
59	Anand-1-GJ	"22.569384 N 72.931226 E"	15-Oct-2015	*Cyperus rotundus* Linn.	Motha, Nagramotha, Purple nut sedge
60	Dindori-3-MP	"22.938539 N 81.080024 E"	27-Aug-2015	*Cyperus rotundus* Linn.	Motha, Nagramotha, Purple nut sedge
61	Jabalpur-10-MP	"23.2203 N 79.9638 E"	15-July-2015	*Cyperus rotundus* Linn.	Motha, Nagramotha, Purple nut sedge
62	Jabalpur-19-MP	"23.208857 N 79.955460 E"	18-Aug-2015	*Cyperus rotundus* Linn.	Motha, Nagramotha, Purple nut sedge
63	Jabalpur -20-MP	"23.233164 N 79.967455 E"	30-Aug-2015	*Cyperus rotundus* Linn.	Motha, Nagramotha, Purple nut sedge
64	Jagdalpur-1-CG	"19.075409 N 82.012864 E"	10-Sep-2015	*Cyperus rotundus* Linn.	Motha, Nagramotha, Purple nut sedge
65	Jagdalpur-6-CG	"19.078032 N 82.004904 E"	10-Sep-2015	*Cyperus rotundus* Linn.	Motha, Nagramotha, Purple nut sedge
66	Corbett National Park-1-UK	"29.5486 N 78.9353 E"	30-Sep-2015	*Cyperus rotundus* Linn.	Motha, Nagramotha, Purple nut sedge
67	Corbett National Park-2-UK	" 29.52744 N 78.77467 E"	30-Sep-2015	*Cyperus rotundus* Linn.	Motha, Nagramotha, Purple nut sedge
68	Pantnagar-3-UK	"29.025347 N 79.477147 E"	20-Sep-2015	*Cyperus rotundus* Linn.	Motha, Nagramotha, Purple nut sedge
69	Anand-3-GJ	"22.569384 N 72.931226 E"	15-Oct-2015	*Cyperus rotundus* Linn.	Motha, Nagramotha, Purple nut sedge
70	Chennai-1-TN	"12.990738 N 80.185958 E"	20-Nov-2015	*Cyperus rotundus* Linn.	Motha, Nagramotha, Purple nut sedge
71	Jaipur-1-RJ	"26.9000 N 75.8000 E"	30-Oct-2015	*Cyperus rotundus* Linn.	Motha, Nagramotha, Purple nut sedge
72	Jabalpur-18-MP	"23.208857 N 79.955460 E"	18-Aug-2015	*Cyperus rotundus* Linn.	Motha, Nagramotha, Purple nut sedge
73	Jabalpur-22-MP	"23.233164 N 79.967455 E"	30-Aug-2015	*Cyperus tenuispica* Linn.	Slender spiked sedge
74	Mandla-4-MP	"22.601269 N 80.378423 E"	27-Aug-2015	*Cyperus iria* Linn.	Morphula, Umbrella sedge, Rice flat sedge
75	Mandla-2-MP	"22.611542 N 80.372824 E"	27-Aug-2015	*Cyperus iria* Linn.	Morphula, Umbrella sedge, Rice flat sedge
76	Pantnagar-2-UK	"29.025347 N 79.477147 E"	20-Sep-2015	*Fimbristylis autumnalis* (L.) Vahl.	Slender fimbry
77	Jagdalpur-7-CG	"19.075409 N 82.012864 E"	10-Sep-2015	*Fimbristylis autumnalis* (L.) Y. Vahl.	Slender fimbry
78	Jabalpur-17-MP	"23.2203 N 79.9638 E"	15-July-2015	*Fimbristylis littoralis* Gaud.	Lesser frimbristylis
79	Jabalpur-15-MP	"23.2203 N 79.9638 E"	15-July-2015	*Fimbristylis milliacea* (L.) Vahl.	Grass like fimbry Slender fimbry
80	Karanjia-1-MP	"22.710416 N 81.639093 E"	27-Aug-2015	*Kyllinga odorata* Vahl.	Fragrant Spikesedge; Whitehead Sedge
81	Karanjia-2-MP	"22.710550 N 81.638962 E"	27-Aug-2015	*Kyllinga odorata* Vahl.	Fragrant Spikesedge; Whitehead Sedge
82	Jagdalpur-3-CG	"19.075409 N 82.012864 E"	10-Sep-2015	*Kyllinga brevifolia* Rottb.	Green Kyllinga

Results and Discussion

Cluster analysis based on recorded morphological traits in all the eighty two sedge plant samples resulted in to grouping of plant samples in to a total of 17 groups in case of both the clustering methods based on Jaccard and Simple Matching similarity coefficients. The dendrogram generated for both the similarity coefficients has been presented in [Fig-1A & B]. The plant samples in the 17 groups were identical in the groups made by both the methods. Both the methods had shown the plant samples Jagdalpur-3-CG, Jabalpur-15-MP, Jabalpur-17-MP, Jabalpur-22-MP, Jabalpur-23-MP and Rewa-1-MP as groups with single individuals. However, the differences were observed in the major clusters containing various groups of plants. As first major cluster (from top of the dendrogram [Fig-1A & B] made from J coefficient showed only two individual sample groups of Jagdalpur-3-CG and Jabalpur-23-MP while the first major cluster made from SM coefficient showed individual sample groups of Jabalpur-15-MP, Jabalpur-17-MP, Rewa-1-MP and Jagdalpur-3-CG. However, some difference in both the clustering methods is not unexpected as the Jaccard coefficient provides different results compared to the simple matching coefficients, because these do not consider the negative co-occurrences [19].

The Mantel test correlation coefficient value 0.97169 between the two similarity coefficients J and SM was found to be significant at $p < 0.05$, shown in graph [Fig-2] which suggests that the dendrograms constructed from J and SM coefficients are highly correlated. The observed correlation between similarity matrix and phenetic trees indicates the goodness of fit of cluster analysis in accordance with the similarity matrix [20].

The sedge plant samples of each group in different clusters were identified to the species level under family Cyperaceae on the basis of comparing and matching the recorded morphological trait observations with the documented flora texts [13-18]. They were identified as belonging to 17 different species [Table-1] among which twelve species were from genus *Cyperus* namely *C. compressus, C. cyperoides, C. esculentus, C. involucratus, C. iria, C. kyllingia, C. microiria, C. nutans, C. odoratus, C. retrorsus, C. rotundus and C. tenuispica.* Three species were belonging to genus *Fimbristylis* namely *F. autumnalis, F. littoralis and F. milliacea* and two were from genus *Kyllinga* of species *K. brevifolia and K. odoratus* [Plate-1]. Comparisons of different morphological structures of the sedge plant species from the genus *Cyperus, kyllinga* and *Fimbristylis* species from different locations around India are presented in [Table-2]. While the collected sedge plant samples varied from 83-100% [Fig-1], the visible appearances of plant samples of a particular species did not vary in different locations throughout India, indicating that all possessed several traits common within the species. This result is in agreement with the observations of Wills [2] wherein variations occurred in the flower parts including the spike lets in purple nuts edge plant samples collected from 13 states in United States of America and 21 other locations around the world. Cluster analysis using morphological characteristics among purple nutsedge collected from 21 countries and 14 states in the United States showed variations providing evidence for divergent groups of purple nuts edge [21]. However, our results show no location specific morphological variations within a species in India. Wills [2] also found greater variation among plants from different locations around the world than from within the continental United States. Morpho-phenological evaluations conducted among three populations of Redroot Pigweed (*Amaranthus retroflexus* L.) from Jordon also indicated that populations had similar phenological and morphological traits [22]. This is due to the fact that more variations is found in quantitative traits than qualitative traits in plants like yellow nuts edge, where vegetative propagation is the major means of reproduction and maintenance of populations [23].

In order to find out which morphological traits were actually responsible for grouping of individual plant samples in to separate clusters, we divided out the species specific data set in to three parts; vegetative traits (including observations on plant colour, root, rhizome, nut, stem/culm and leaves), inflorescence (including observations on inflorescence, spike and spikelets) and floral traits (including observations on- -glume colour, glume shape, keel, bracts and rachilla); and constructed dendrogram using J and SM coefficients. The vegetative traits grouped all the 17 species individually in case of both the coefficients used [Fig-3]. Similar results were observed in case of inflorescence [Fig-4]. Different species have shown the different pattern of inflorescence, but the floral traits failed to differentiate between the species *C. compressus* and *F. autumnalis* [Fig-5].

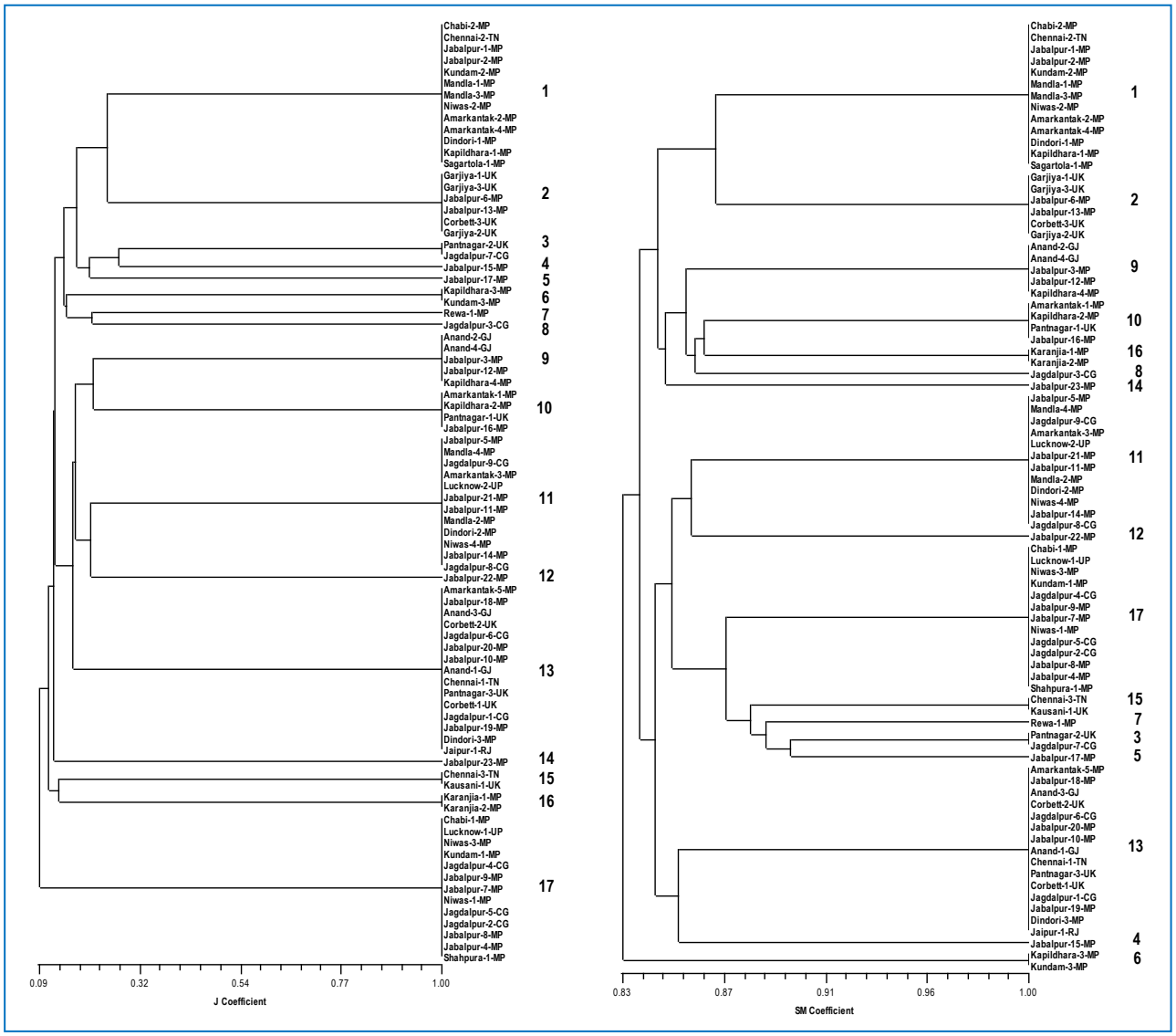

Fig-1 UPGMA clustering based on Jaccard (A) and Simple Matching (B) similarity coefficients of morphological data profiles between the 82 individuals of Cyperaceae family. Individual sedge plants are specified by their places of collection. Each cluster group represents a species: 1. *Cyperus compressus,* 2. *Cyperus cyperoides*, 3. *Fimbristylis autumnalis* , 4. *Fimbristylis milliacea*, 5. *Fimbristylis littoralis*, 6. *Cyperus nutans*, 7. *Cyperus retrorsus*, 8. *Kyllinga brevifolia*, 9. *Cyperus esculentus*, 10. *Cyperus kyllingia*, 11. *Cyperus iria*, 12. *Cyperus tenuispica*, 13. *Cyperus rotundus*, 14. *Cyperus involucratus*, 15. *Cyperus odoratus*, 16. *Kyllinga odorata*, 17. *Cyperus microiria*

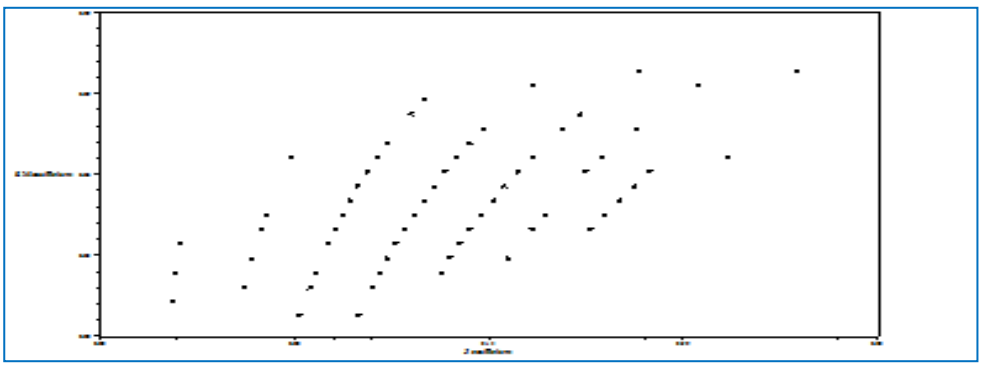

Fig-2 Mantel test graph showing correlation between the two similarity coefficients J & SM

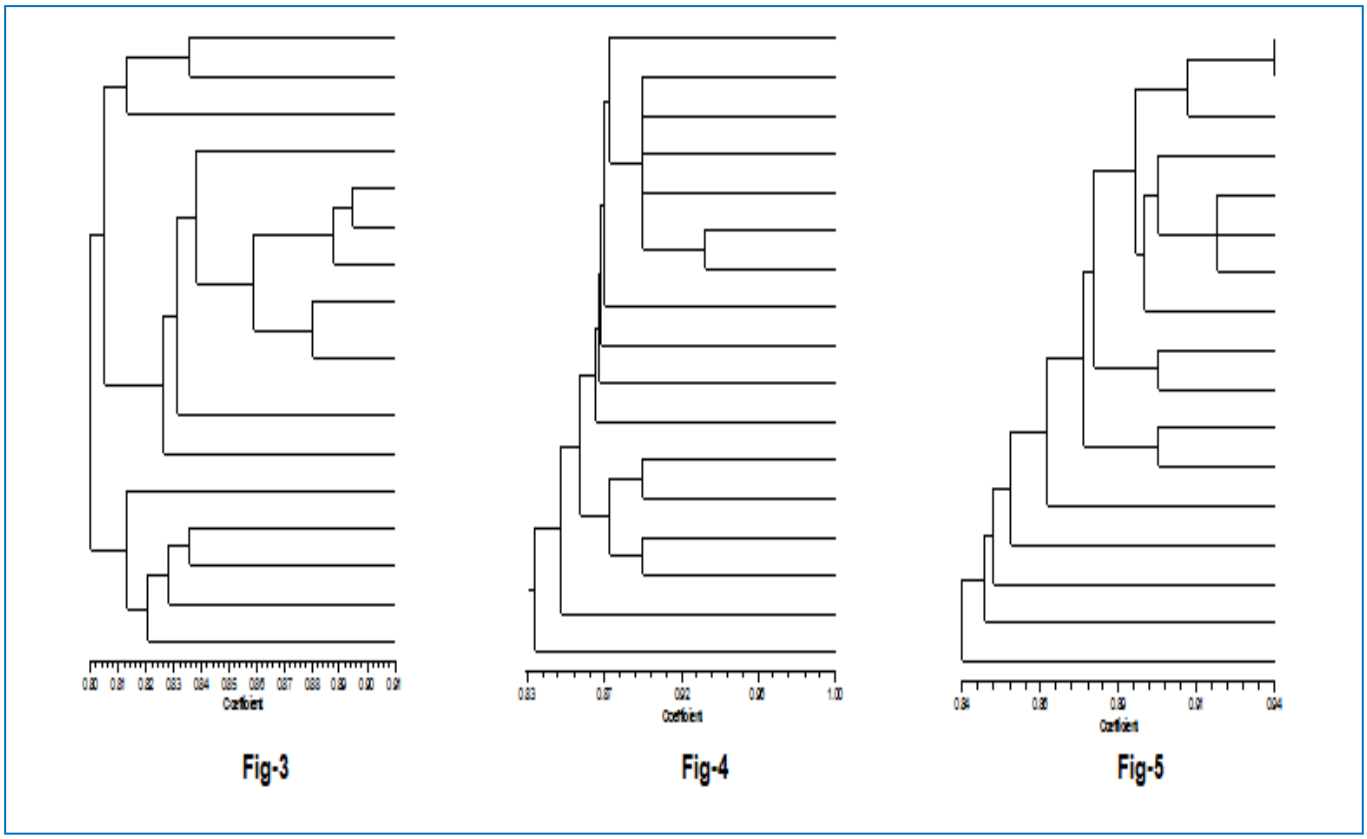

Fig-3 Fig-4 Fig-5

Fig-3-5 Dendrogram showing clustering of different species based on vegetative traits [Fig-3], inflorescence [Fig-4] and floral traits [Fig-5].

Further, we tried to find out a single morphological trait that could be observed for the identification and clustering of the sedge plants. We constructed dendrograms based on most variable morphological traits among the plants of 17 identified species which are Glume (glume colour, glume shape) and spikelet (colour and shape). The clustering based on glume did not identify the species *C. odoratus*, *C. retrorsus* and *F. autumnalis* separately but into a single cluster only [Fig-6]. Spikelet was found to be the best for identifying a sedge plant to its species since the dendrogram constructed [Fig-7] based on the observations on spikelet color and shape grouped all the 17 species individually in case of both the J and SM coefficients

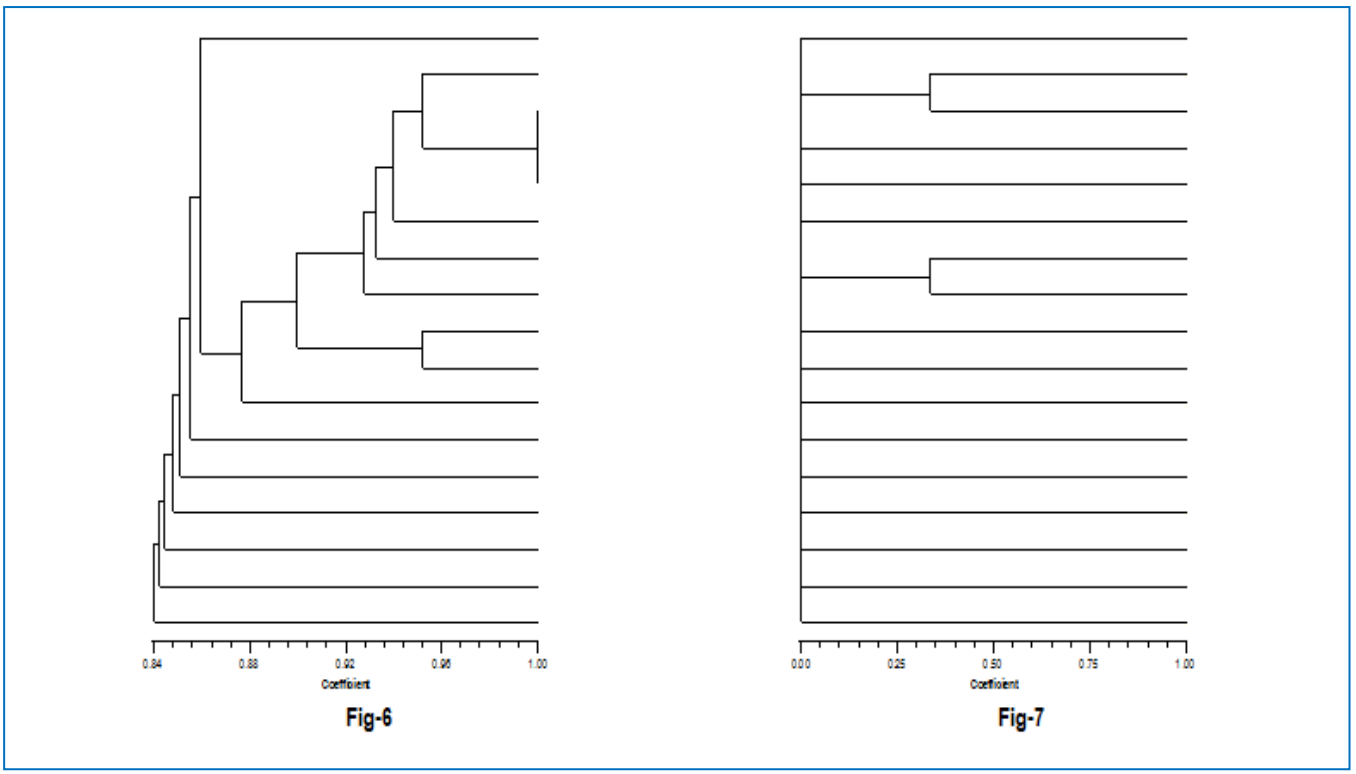

Fig-6 Fig-7

Fig-6-7 Dendrogram showing clustering of different species based on Glume [Fig-6] and Spikelet [Fig-7].

Table-2 *Morphological characters observed in sedge plant samples of different species*

S.N.	Species and its Morphological Characters
1	***Cyperus compressus*** **Linn.** Annual, Erect herb with numerous, fine tufted root, plant greenish or grayish-green, 5-10 cm high, Stem 3-gonous, Leaves basal, as long as or longer than the stem, Inflorescence umbellate, Spikelets condensed linear or oblong, grey-green or straw-color, Anthela simple, lax, glumes ovate, mucronate, strongly keeled, Glumes green on the sides winged, Stamens 3, shortly apiculate, dark brown to blackish, Nuts broadly triquetrous, dark brown [13, 15].
2	***Cyperus cyperoides*** **Linn.** A slender grass like sedge, 30-75 cm high. Stems several on a short creeping rhizome covered with the remains of old leaf-sheath. Leaves often as long as or exceeding stem. Spikletes closely spirally arranged in cylindric pedunculate spikes in simple terminal umbel. Fruiting spikelet after falling consists of 2 sub-equal glumes, outer lanceolate oblong, muticous many nerved, inner cymbiform with curved keel. Nuts brown, curved oblong, triquetrous [16].
3	***Cyperus esculentus*** **Linn.** Stem at base erect, stolons lateral long very slender bearing tubers, leaves and bracts long, spikletets yellow or yellow-brown, glumes over nearly their whole breadth plicate striate (otherwise as *C. rotundus*) [14].
4	***Cyperus involucratus*** **Roxb.** Perennial plant of height about 2 m with fibrous root, hard rhizomes, triangular stem with leaf sheaths at stem base. Large umbrella-like Inflorescence with 12-25 leaf-like bracts beneath 15 to 27stalked spikelet clusters (rays). A ray has 8-20 shiny brown clusters of tiny flowers (spikelets). Fruit small dark brown triangular achene [24].
5	***Cyperus iria*** **Linn.** Erect, glabrous annual variable in size and form. Stems striate, 3-quetrous. Leaves basal, blade linear, with papery sheaths and blades scabrid towards apex, sheath brown. Spikelets brown-yellow. Rachilla glabrous, wingless. Glumes obovate. Nuts obovate-elliptic, exceeding the glumes when mature [13].
6	***Cyperus kyllingia*** **Endl.** An erect, glabrous sedge upto 30cm tall, with well-developed rhizomes. Stem slender, covered with leaves linear, acuminate, rough on midrib and margin bracts 3 to 4, unequal. Spikes splitary, sub-globose white; spikelets obliquely lanceolate, elliptic, containing on flower. The lowest glume hyaline, second glume narrower; third glume boat-shaped with 3 well marked nerves on each side of the prominent winged keel; fourth glume slightly narrower; stamen 2-3. Nut elliptic-ovoid flattened [16].
7	***Cyperus microiria*** **Stud.** It resembles the rice-field flatsedge (*C. iria*), but has smaller achenes and spikelets. The inflorescence is at the tip of the plant and branched. Inflorescence a compound or decompound anthela; rays 5-9, mostly to 13 cm, unequal in length. Spikes ovoid, broadly ovoid, with many spikelets. Spreading spikelets linear to ovoid shape bearing 8-24 flowers; straight or hyaline white winged rachilla, straw-colored to pale glumes on rachilla, Glumes broadly obovate, rounded apex, keel abaxially extended into a mucro beyond apex [18].
8	***Cyperus nutans*** **Vahl.** Large size, spikletes recemose (i.e. loosely spicate) ripe suberect, glumes somewhat remote often minutely mucronate. Usually 2-3.5 feet. Umbel primary rays often 8-12 inch spikes bowing on the ultimate rays. Spikletes in ripe fruit collapsing in a tassel [14].
9	***Cyperus odoratus*** **Linn.** Annual, herb, culms trigonous, spikelets cylindric to subcylindric, corky rachilla disarticulated at base of scale. Segmented mature spikelet consisting of a scale and an internode of the rachilla, achene clasped into corky wings of rachilla [18].
10	***Cyperus retrorsus*** **Chapm.** Herbs, perennial, shortly rhizomatous. Culms trigonous, glabrous. Inflorescence: spike 1, densely oblong-ovoid often with small basal branches, rachilla deciduous, wings persistent, Spikelets 40–120, oblong-lanceoloid, subterete, distal spikelet spreading or ascending; floral scales persistent [18].
11	***Cyperus rotundus*** **Linn.** Erect, perennial herb with a woody, stoloniferous rhizome, which is clothed with fibrous. Stems nodose at base leaves radical, shorter than the stem, linear. Inflorescence a compound umbel of short spikes. Spikelets pale yellow or brown often with reddish tinge, glume ovate, straw-colored. Nuts broadly obovoid, greyish-black [13].
12	***Cyperus tenuispica*** **Steud.** Erect, annual, glabrous sedge. Stems tufted, 15-20 cm tall. Leaves shorter or longer than the stem, linear acute. Umbels compound or decompounds. Spikelets 3-6 mm linear lanceolate. Glumes 0.8 mm long, brown, oblong, rounded. Stamen one. Nuts globosely obovoid [16].
13	***Fimbristylis autumnalis*** **(L.) Y. Vahl.** Tiny sedge grows in clusters, 5-8 cm tall plants with thread-like leaves, larger leaves are wider than 1.0 mm. Small egg-shaped spikes (3-7 mm long) borne in clusters on top of the flat stems. anthelae compound and mostly diffuse, filiform to linear scapes, usually single bract, blade exceeded by anthela. Mostly narrowly lanceoloid to narrowly ellipsoid brown or red-brown spikelets, fertile keeled lanceolate scales [18].
14	***Fimbristylis littoralis*** **Gandich.** A glabrous, leafy annual. Stems 15-60 cm long, slender, obtusely angled below and triquetrous above. Leaves shorter than the stem, tapering to a firm point and with nearly smooth margins. Umbels decompounds rays unequal, suberect or spreading, filiform bearing may scattered very small pedicellate spikeletes. Spikletes sub-globose or sub-cylindric, obtuse, brown; rachilla stout, pitted, not winged. Glumes closely imbricate, ovate, stamens 1-3. Nuts obovoid, obtusely trigonous [16].
15	***Fimbristylis miliacea*** **(Linn.) Vahl.** An erect, tufted, annual sedge. Stems angular. Leaves basal, longer or shorter than the stems scabrid on the margins and midrib beneath. Spikletes very numerous, small, ellipsoid or oblong lanceolate, Spikletes brown, Inflorescence decompound umbels. Glumes ovate; keel 3-nerved, slightly excurrent. Nuts globosely obovoid, pale brown or whitish, minutely tuberculate [13, 16].
16	***Kyllinga brevifolia*** **Rottb.** A glabrous, 8-20 cm high, slender sedge with horizontally running rhizomes. Stems covered towards the base with usually brown leaf sheath. Leaves few erect, 2-8 cm long, sometimes exceeding the stems, bracts very similar to the leaves. Spikes green oblong cylindrical; Spikelets lanceolate or ovate-lanceolate, containing one flower. The lowest glumes empty and sub-equal; third glume boat-shaped, acuminate, 2 nerves on either side of the keel; fourth glume slightly larger; stamen 2. Nuts obovate ellipsoid, strongly compressed laterally; styles with two filiform arms [16].
17	***Kyllinga odorata*****Vahl.** Erect, tufted, rhizomatous perennial; culms 12-29 cm tall, triquetrous. Leaves few, linear, acute, scabrid on upper margins; sheaths, pale brown. Inflorescence a head with 1-3 spikes, whitish-green; central spike cylindrical; lateral spikes globose, much shorter than the central spike; leafy bracts 3-5. Spikelets elliptic, flattened. Glumes 4, braodly ovate, folded with green, smooth keel. Nuts brown to black oblong, apiculate, biconvex.

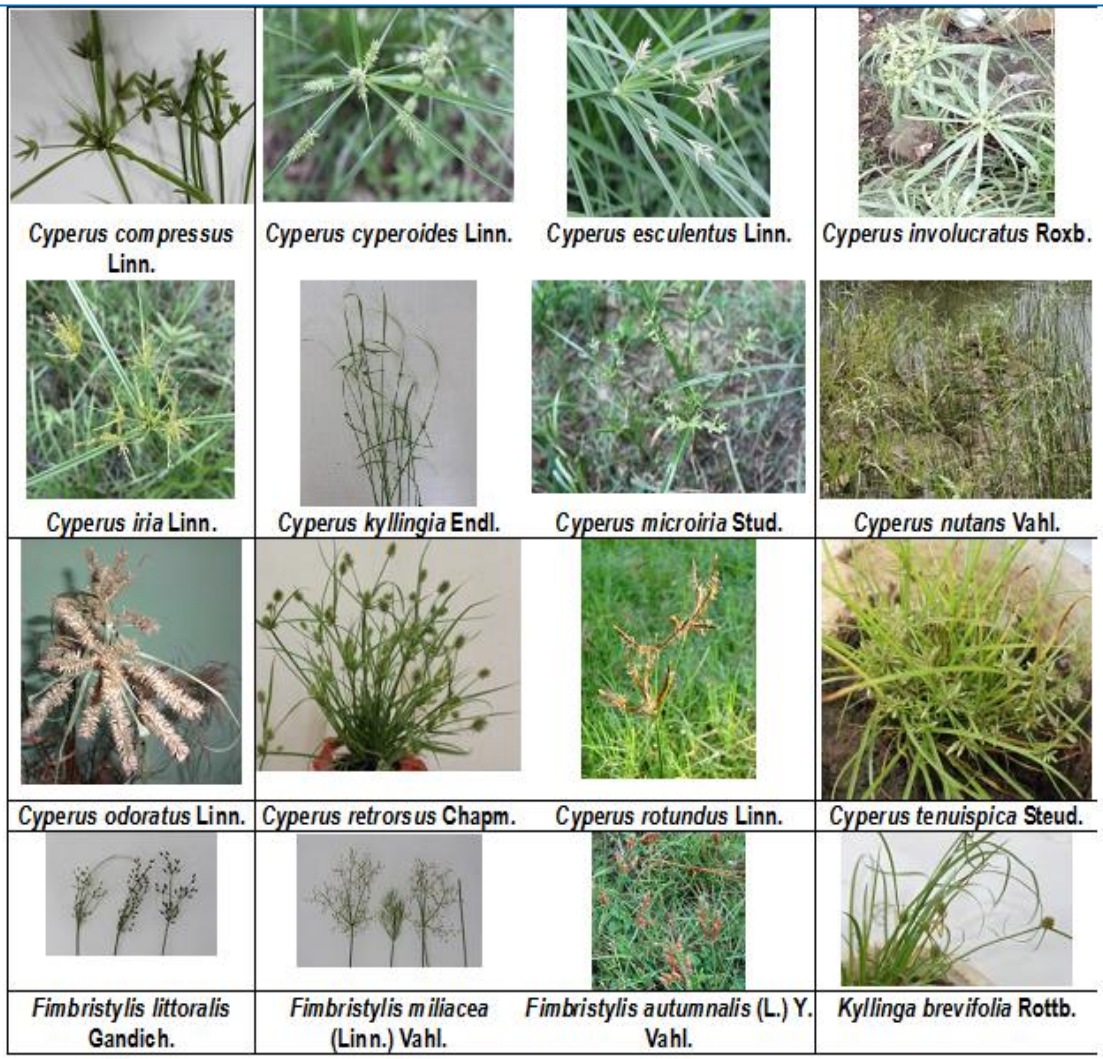

Plate-1 Photo of sedge plant samples from different species

Conclusion

Morphological variations among weed populations play an important role in their competitiveness in actual field situation where they have to compete with agricultural crops for their survival. These variations may also influence their response to chemical or other control strategies. *Cyperus* spp. have shown drastic change in their growth according to climatic conditions for their better adoption and growth. Although morphological descriptions of Cyperaceous have been widely reported [13-16], results of this study shows that to identify a sedge plant spikelet or inflorescence is the best morphological trait to be observed at first. Morphological observations analyzed for cluster analysis can serve as easy and cheapest method of identification in sedge plants. We conclude that sedge plants commonly prevalent in India are mostly belonging to three genera *Cyperus, Fimbristylis,* and *Kyllinga* with significantly distinctive morphological characters. Morphological variations analyzed among seventeen different sedge species of India also indicates that several different ecotypes of sedge species can be passively identified in many different geographical locations not only in India but in around the world

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