Chapter 3

Diversity of the Genus *Cyperus* L.

Abstract

The genus *Cyperus* L. is widely distributed in tropical and temperate regions of the world and flourishes in soils along the waterlogged areas or soils with reasonable moisture content. World over, 964 *Cyperus* species are reported and the genus has remarkable species richness in India with 92 taxa, of which 58 species are reported in south India. The infrageneric classification of the genus is controversial and several assumptions have been made by various taxonomists. The general morphological features of the genus, dominant *Cyperus* species of the world and a detailed view on the world's worst sedge *Cyperus rotundus* are discussed in this chapter.

Introduction

Cyperus L., the taxonomically complex genus included under the tribe Cypereae of the subfamily Cyperoideae, is distributed widely from tropical to temperate regions with a concentration of species and presumed origin in tropical Africa (Goetghebeur, 1998; Spalink *et al.*, 2016). Presence of both C3 and C4 species is a favourable factor for the genus to expand their diversity to tropical as well as temperate regions of the world. However, the genus is species rich in tropics where it exhibits remarkable species richness. Thegenus shows a wide range of distribution, while other genera are somewhat habitat specific. In terms of their wide distribution and occurrence, *Cyperus* species are generally characterised as weed. Bryson and Carter (2008) cited 147 species of *Cyperus* as weeds. The most important weeds of this genus in terms of their adverse effect on agriculture include *C. rotundus, C. esculentus, C. difformis* and *C. iria* ranking 1st, 16th, 32nd and 33rd respectively among the world's worst weeds (Bryson and Carter 2008; Holm *et al.*, 1977). *Cyperus* species are major natural constituents of wetlands and riverside vegetation and become the chief primary producers of grasslands and marshlands. Densely tangled rhizome of these species helps in erosion control and water purification. Some of them are serving as important indicators of environmental damages, especially to lowering of water table. In swampy areas sedges forms dense beds, which provides food and shelter for birds

and animals. Several species of *Cyperus* are cultivated as ornamentals including *C. involucratus* and *C. albostriatus*. The genus has considerable economic importance as well. Several species under the genus provides food, fodder, medicines, weaving materials and perfumery materials.The historically important paper making plant *C. papyrus* is also used in horticulture for planting along the waterways. *Cyperus pangorei*is exclusively used for making of mats and is highly stable and the peculiar arrangement of fibro vascular bundles in the culms is of great advantage contributing to the productivity of mat industry (Ravichandran *et al*., 2005).

Infra generic delimitation of *Cyperus* species

The status of infra generic divisions of this genus is still under confusion among the taxonomists due to the morphological diversity and the presence of several convergent evolutionary lines. Nees (1835) proposed the primary infra generic classification and divided the genus into eight sections. In line with Kunth (1837) and Steudel (1855), *Mariscus* and *Kyllinga* are segregated genera. Kükenthal (1936), Haines and Lye (1983) and other subsequent workers accepted *Cyperus sensulato* and treated *Kyllinga* Rottb. and *Pycreus* P. Beauv. as of infrageneric rank. Recent molecular studies reveal that the core genus *Cyperus* includes several segregate genera. Goetghebeur (1998) included *Kyllinga, Pycreus* and other related taxa at generic level and proposed *Cyperus sensustricto* encompassing two subgenera. Taxonomic complexity of the genera resulted in the accumulation of 79 subdivisional names within the taxa, of which 20 are not seems to be validly published and two are illegitimate (Wim Huygh *et al*., 2010). Recent molecular phylogenetic analysis, following the classification of Goetghebeur (1998) and Govaerts *et al*. (2007) revealed that the *Cyperus* clade is a monophyletic clade including the paraphyletic genus *Cyperus sensustricto* encompassing at least 12 segregate genera (Simpson *et al*., 2007; Muasya *et al*., 2009). Larridon *et al*. (2011, 2013) proposed two subgenera under the genus *viz*., *Cyperus* subgenus *Anosporum* with C3 photosynthesis and eucyperoid anatomy (paraphyletic but forming a clearly circumscribed natural group) and *Cyperus* subgenus *Cyperus* with C4 photosynthesis and chlorocyperoid anatomy (monophyletic). He also presented a new sectional classification for *Cyperus* subgenus *Anosporum* based on a well resolved phylogeny and a new classification of the genus

Cyperus and elucidated the phylogenetic relationships and generic delimitation in C4 *Cyperus,* combining the sedge genera like *Ascolepis, Kyllinga* and *Pycreus.*

General morphology of *Cyperus* species

Species under *Cyperus* are mostly annuals or perennials and growing in a tuft, which forms dense vegetation in the areas where they grow. The members are recognized by the presence of a rosette of linear leaves, formed as the result of the combination of short internodes with spirally alternate leaves, terminal inflorescence, distichously arranged glumes, bisexual flowers, trifid style and trigonous nuts. The inflorescence is compound, essentially a panicle of spikelets with the main axis called a culm (**Figure 1**). The ultimate branch is always a lateral spikelet, consisting of a rachilla and spirally to distichously placed glumes, each subtending a bisexual flower. Lateral spikelets are subtended by a bract and have a prophyll (Goetghebeur, 1998). Several species are highly variable and shows polymorphism even within the species, leading to ambiguity to distinguish them based on the morphological features, and the specific delimitations are done by minute floral features. As a result, there has been intermixing of taxa, which further result into species complexes.

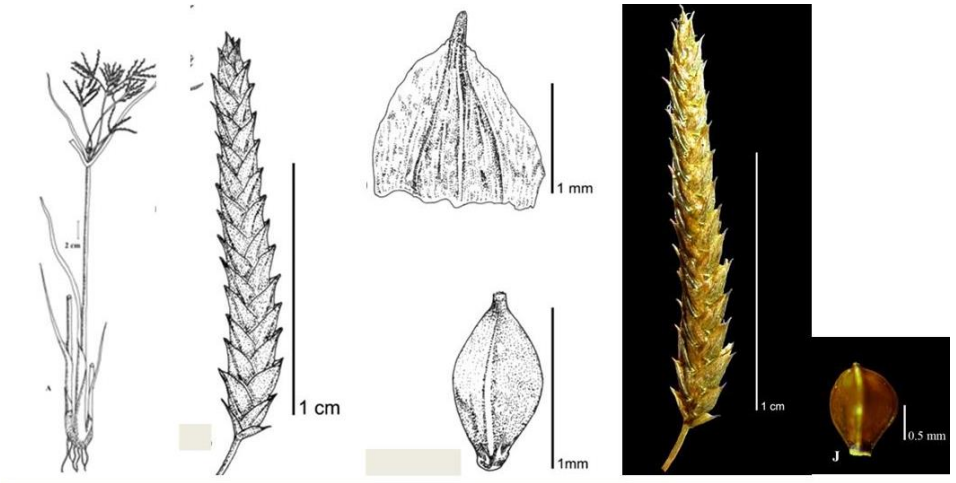

Figure 1. Habitat and floral organs of *Cyperus*

Distribution of *Cyperus* species

Studies proved that sedges flourish in soils with moderate to high moisture regimes as they have ability to adapt to such situations. The seeds are produced in large quantities and dispersed by means of wind, rain or slow water current along the nutrient rich muddy substrate. Species such as *C. haspan and C. pilosus* showed strong affinity towards alkaline rich soils while *C. iria, C. difformis* and *C. rotundus* showed affinity for acidic soils with rich organic matter content. Most of the *Cyperus* species are hygrophilous or moisture-loving and abundantly located in the water-logged areas such as ponds, canals, lakes, tanks, rivers and rice fields. Some are found in areas of low water availability or seasonally mesic or moderate growing conditions. Species such as *C. stoloniferous* and *C. arenarius* are arenophilous and confined to coastal areas. Some of the high altitude *Cyperus* species are petrophilous or cremnophilous. Species such as *C. diffuses* and *C. macrostachyos* are distributed in wet forest margin.

***Cyperus rotundus* L.**

Cyperus rotundus L. is one of the highly variable taxa of the genera *Cyperus,* forming species complexes, suggested having origin in Asia. The species belongs to the section rotundii andis a perennial herb, commonly known as 'puple nut sedge' due to its characteristic reddish-brown-purple spikelet. They have an unfavourable effect on natural ecosystems by displacing native plants or by reducing the availability of food or shelter for native animals. It can tolerate highest temperatures and grows in cultivated fields, waste areas, roadsides, pastures and natural areas. The rapid growing plant can quickly develop dense colonies due to its ability to produce an extensive system of rhizomes and tubers. The mass production of tubers is an efficient means of dispersal mechanism and reproduction and these characters along with the ineffectiveness of herbicides make this weed nearly indestructible.

Taxonomy of *Cyperus rotundus* L.

The plant usually grows 20-50cm tall, and occasionally taller under favourable conditions. Culms usually erect, solitary, smooth and trigonous with terminal inflorescence. Leaves are dark to bright green, glossy, slightly serrated, and generally shorter than the culm. There

are up to 22 leaves per plant, emerging in three vertical rows near ground level. Inflorescences simple to compound corymb, loose and variable in size, consisting of 3-9 rays of different length. Spikes densely to sub-loosely bearing 3-12 spikelets with glabrous rachis (**Figure 2**). Spikelet is spicately arranged, suberect to spreading, compressed, linear and 10-14 flowered. The nuts are trigonous, oblong-obovoid and brownish. Nutgrass may be distinguished from other common *Cyperus* species by the darker green leaves, the umbrella shape rather than a dense or bottlebrush-style, and reddish brown or purplishbrown flower heads. Sub-globose shaped tubers will help the plant to easily distinguish from closely allied species.The species exhibits plasticity and are morphologically different under different conditions and this led to description of ecotypes.

Figure 2. *Cyperus rotundus*-Habit, spikelet and nut

Synonyms for *Cyperus rotundus* L.

Chlorocyperus rotundus (L.) Palla
Cyperus olivaris Targioni Tozzetti
Cyperus purpurovariegatus Boeckeler
Cyperus stoloniferumpallidus Boeckeler
Cyperus tetrastachyos Desf.
Cyperus tuberosus Roxb
Pycreus rotundus (L.) Hayek

Common names for *Cyperus rotundus* L.

Arabic: Sa'ed
Burmese:Vomonniu
Chinese: Suo cao, Xiang fu zi

English: Coco grass, Ground almond, Java grass, Nut sedge, Nut grass, Purple nutsedge, Purple nutgrass, Red nut sedge
French: Souchet rond
German: Knolliges Zypergras
Indian: Motha, Mutha, Musta,
Italian: Zigoloinfestante
Japanese: Hamasuge
Korean: Hyangbuja
Malayan: Mushkezamin
Persian: Mushkzenezamin
Portuguese: Alho-bravo, Capimalho, Capimdandá, Tiririca, Tiririca-vermelha
Spanish: Castañuela, Cipero, Coquito, Juncia real
Swedish: Nötag
Urdu: Saad kufi

Distribution of *Cyperus rotundus*

Though India is considered as the centre of origin of purple nutsedge, it is yet to be ascertained (Holm *et al*., 1977; Molin *et al*., 2019). This species occasionally occurs in more temperate regions but widely distributed throughout the warmer regions of the world. It is estimated to be distributed in more than 92 countries in;

Africa: Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Chad, Cote D'Ivoire, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Ghana, Guinea, Kenya, Libya, Malawi, Mali, Mauritania, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, Tanzania, Togo, Tunisia, Uganda, Western Sahara, Zaire, Zambia, Zimbabwe

Asia: Afghanistan, Armenia, Azerbaijan, China, India, India, Indonesia, Iran, Iraq, Japan, Kazakhstan, Korea, Kyrgyzstan, Lebanon, Malaysia, Myanmar, Nepal, Pakistan, Palestine, Philippines, Russia, Saudi Arabia, Sri Lanka, Syria, Taiwan, Thailand, Turkey, Turkmenistan, Uzbekistan, Vietnam, Yemen

Europe: Albania, Austria, Bulgaria, Croatia, France, Greece, Marshall Islands, Micronesia, Northern Mariana Islands, Portugal, Romania, Serbia, Slovenia, Spain, Switzerland

North America: USA and Mexico

South America: Argentina, Bolivia, Brazil, Colombia, Ecuador and Peru

A recent investigation of the genetic diversity among geographically separated *C. rotundus* accessions based on RAPD markers and morphological characteristics revealed that the

global population of purple nutsedge consisted of two clades. Accessions from USA, Taiwan, Western Samoa, New Zealand, Malaysia, Japan, El Salvador, Columbia, Australia, Thailand and West Indies formed one cluster, while the second cluster included accessions from Sudan, Greece, Iran, Brazil, Argentina, Mauritius, Philippines, Indonesia and Tanzania. The lack of genetic diversity among accessions supported the hypothesis that the spread and propagation into new environments were largely by tubers which preserved genetic identity. The lack of diversity particularly among New World and USA accessions may also reflect a relatively recent introduction of the species into the Americas and a low level of outcrossing (Molin *et al*., 2019).

Seasonality, soil types and climate preference of *Cyperus rotundus*

Nutgrass is a perennial sedge species that favours tropical and subtropical climates and shows abundant growth in low-lying areas where water accumulates, and the plant is distributed in more than 92 countries. The species infests at least 52 different crops worldwide, and hence got the notorious designation as "world's worst" weed (Holm *et al*., 1977). Below 20°C, plant growth is slow and tuber sprouting is inhibited. In temperate areas, new seedlings will commence in spring, once temperatures start to increase. In more arid conditions, an increase in soil moisture appears to be more stimulant for its growth. Flowering more commonly occurs during summer, and under favourable conditions, flowering may occur in 3-6 weeks after emergence. Plant growth can be restricted by shade as well as by lower temperatures and saline soils. The plant appears to be susceptible to extended dry conditions. When tubers are dried out until their water content reaches 15%, the tubers will not survive. Plant growth rate is high in hot weather, high light and high temperatures. During drought or flooding, tubers that are commonly found several centimeters underground, can remain dormant and viable for future regrowth once conditions suit.Normally the plant prefers moderate to high fertility soils, and moderate moisture levels. However, around the world it has been observed that it can tolerate almost every soil type, moisture level and soil pH.

Growth, development and impact of *Cyperus rotundus*

Cyperus rotundus is perennial and producing short rhizomes and emitting long, slender stolons clothed with brownish scales. Rhizomes are white and fleshy with scale leaves

during their production and as they mature, become ligneous or wiry. Later the rhizomes grow upwards and reach the surface, swell to form a basal bulb, or corm that grows into a new plant producing shoots, roots and rhizomes (Wills, 1987). Rhizomes that do not grow towards the surface may produce chains of tubers, each of which may separate from the parent plant and lie dormant for years before growing into a new plant (Hauser, 1962; Holm *et al*., 1977). They are prolific in disturbed soil due to their tuber production which can remain as dormant for several months. Production from rhizomes and tubers is the most common method adapted to increasing numbers and quantity. Rochecouste (1956) reported that *C. rotundus* produces 6 and 14 times more tubers in humid conditions (1250 to 2500 mm of annual rainfall) than in sub-humid (less than 1250 mm of rain) and super-humid (greater than 2500 mm of rain) conditions. He also observed that in humid regions the abundant growth of this sedge severely restricts water availability to sugarcane and other crops. These tubers are resilient and can survive extreme conditions of flooding, drought, heat and lack of aeration (Holm *et al*., 1977).

The organic substances released from the decay of dead subterranean tissues of *Cyperus rotundus* may be allelopathic and reduce crop production. Under experimental conditions, barley yield was reduced by 15 to 25% by *C. rotundus* residues in the soil (Horowitz and Friedman, 1971). Rhizomes and tubers are produced extensively and most tubers are found growing in 15 to 20 cm of soil, a few penetrate more than 40 below the soil. Rao (1968) reported that under favourable conditions, a single tuber could produce 99 tubers in 90 days. They produce flowers abundantly but rarely produce viable seeds. Tubers and basal bulbs help in vegetative propagation. *Cyperus rotundus* is C4 plant, which is an adaptation to assimilating CO_2 at higher temperatures and higher light intensities compared to C3 pathway plants. Wills (1987) suggest that the leaf anatomy is Krantz-type and sheaths of cells that form around the vascular bundles serve to compartmentalize the photosynthetic events.

Cyperus rotundus is considered as the world's worst weed and they are known to produce allelochemicals that hinder the crop growth. It is one of the most significant weed species and competes vigorously with most crops for soil moisture, nutrients and light, and the competition is remarkable with crops that do not form dense canopy. Rhizomes and tubers

from nutgrass plants may also interfere with harvesting operations for root crops and it can also increase postharvest processing costs.

Being a notorious weed, the possibility of producing huge quantity of *C. rotundus* tubers in various geoclimatic conditions across the globe is high. During active growing periods, 2-3 million tubers/ha/week can be produced yielding 30-40 million tubers/ha (Horowtz, 1972). *Cyperus rotundus* produces up to 40,000 kilograms of subterranean plant material per hectare in a year. In addition, tuber has 16 months half-life and 42 months predicted longevity (Neeser *et al*., 1997). The rich biomass is yet to be exploited to its full potential.

***Cyperus esculentus* L.**

Cyperus esculentus L**.,** commonly known as 'yellow nut sedge, is a potential perennial weed with a worldwide distribution. Holm *et al.* (1977) regarded it as the world's 16th worst weed. Although yellow nutsedge produces viable seeds, the weed usually spreads by means of the small tubers produced on the rhizomes, and hence a population in a single field may be the progeny of one or only a few genotypes (Horak and Holt 1986). Its centre of origin is undetermined, but it is believed to be originated from the Mediterranean and Southwest Asia. The first study of the infraspecific taxonomy of *Cyperus esculentus* was done by Boeckeler (1870) and he recognized a cultivated taxon, *C. esculentus* var. *sativus,* known as earth almond, tiger nuts, or chufa, which is distinguished by its large edible tubers. *Cyperus esculentus* is perennial with usually long fleshy rhizomes producing new shoots or with one persistent tuber at the end. Leaves are linear, clustered, pale green with triangular culms. Spikes compound, with secondary peduncles branched, with 30-50 compressed spikelets. Tigernut is used as a source of food, medicine and perfumes and it can be eaten raw, roasted, dried, baked or made into a refreshing beverage called 'Horchata De Chufas' or tigernut milk which is very nutritive (De Vries, 1991). The tubers are very nutritious, containing proteins, fats, starch, glucose, fibre, vitamins, enzymes and minerals (Burden, 2003). The nuts have medicinal values and are reported to be aphrodisiac, carminative, diuretic, stimulant and tonic which can be used in the treatment of constipation, high blood pressure and diarrhoea (Oladele and Aina, 2007).

The ancient Egyptians first recognized the importance of this plant in culinary and medicinal purposes (Negbi, 1992). Nowadays the species has been widely cultivated in

Spain, Africa, Australia, South and North America. The annual value of *Cyperus esculentus* production in Spain is around 3.3 million Euros (Zhang *et al*., 2022). The species has strong allelopathic effect on many crops such as corn and soybean and found that the tuber residues reduced the dry weight of corn and soybean, and as the concentration increased, the growth decreased, affecting soybean more than corn (Zhang *et al*., 2022).

Cyperus esculentus is closely related to *C. rotundus* and their separation is based on distinction between vegetative characters (**Figure 3**). Both the species are variable in nature; the propagation is almost vegetatively by means of tubers. For their proper identification, the underground parts are necessary, and also the species can be identified by the colour of the inflorescence. *C. rotundus* having purple to red-brown flowers and ellipsoid tubers are borne in chains along the rhizomes. The culm arises from the nodule of the rhizome; rest of the portion is slender and wiry. The nodule or the tubers are much starchy. *C. esculentus* is golden-yellow flowered and tubers borne singly at the tip of rhizomes, which are globose in shape and covered by a grey tomentum and the stolons are very slender.

Figure 3. *Cyperus rotundus* and *Cyperus esculentus*

***Cyperus difformis* L.**

Cyperus difformis L., is an annual sedge species, commonly known as 'variable flat sedge' or 'small flower umbrella-sedge'. This plant is native to southern Europe and naturalized throughout the world (Holm *et al*., 1991). It is a prolific seed producer with short life span and complete the vegetative and reproductive cycle within a month. The species grows well in flooded or moist fertile soils and common in lowland. They can thrive well in

poorer sandy or clay soils in fallow lands but cannot tolerate deep flooding. It is frequently found in water logged areas such as pools, along rivers, canals, streams and in open wet places and in grassy swamps. Jacometti (1912) reported that one plant could produce 50,000 seeds, with about 60% germination. Like rice, *C. difformis* has the C3 photosynthetic pathway, which favours its growth in submerged soils. According to Holm *et al.* (1977), *C. difformis* is a serious weed of rice in various countries in the world and resistant to rice field herbicides.

C. difformis varies in height from 5 to 60 cm. The culms are smooth, triangular, and slightly winged with numerous, fibrous and reddish roots. The leaves are smooth flat, linear or sometimes reduced to green to reddish-brown tubular sheaths.The inflorescence consists of dense, globose, umbellate heads, simple or compound with stellately spreading spikelets and subtended by 1-4 leaf like bracts (**Figure 4**). Spikelets are linear to oblong-linear, compressed but slightly swollen with 6-30 flowers. Glumes obovate, pale-yellowish to dark reddish-brown with yellow or white margins and a green midrib ending in a short mucro. Stamens 1-2, achenes triangular, obovate-elliptic, yellowish-brown or pale-brown with minutely papillose.

Figure 4.*Cyperus difformis*- Inflorescence and nut

***Cyperus haspan* L. and *Cyperus tenuispica* Steud.**

Cyperus haspan L. is common weedy species distributed in tropics and subtropics in Africa, through Asia to Australia.The plant grows abundantly in wet open places, swamps, pastures, rice fields, wet grassland, as well as on thin wet soil over rock and in ditches and serves as the indicator of water. *Cyperus haspan* is an annual to perennial sedge with soft,

almost succulent growth. The roots are fibrous when the plant is an annual, with slender, horizontal, short or elongated rhizomes being produced when the plant perennates. Culms are slender, compressed triquetrous, and smooth with shorter leaves, sometimes sheathed only and bladeless; sheath pale green, base purplish brown to reddish purple. Inflorescence simple, compound, or decompound anthela with digitately arranged, linear to narrowly linear-ovoid, 6-28flowered spikelets in wingless rachilla. It is an economically useful plant species, and often used as food and fodder species by the people of Tropical and East Africa. Culm of this plant is used to make baskets and mats. Milliken (1997) has reported the medicinal use for *C. haspan,* particularly rhizome, used with other febrifuge plants by Wayapi, the indigenous peoplein French Guiana.

C. haspan L. and *C. tenuispica* Steud. belonging to the section *Haspani*, are morphologically similar in appearance (**Figure 5**). *C. haspan* forms creeping rhizome and the culms are tufted or scattered, whereas the culms of *C. tenuispica*are always tufted (Goetghebeur, 1998). For *C. haspan*, the leaves are very short, often reduced to mere short appendages of the sheaths and the involucral bracts are short and less in number.

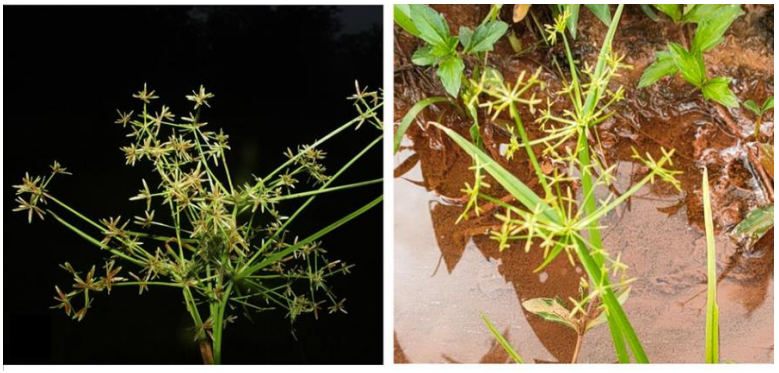

Figure 5.*Cyperus tenuispica* and *Cyperus haspan*

***Cyperus pilosus* Vahl., *Cyperus iria* L. and *Cyperus distans* L.f.**

Species like *C. pilosus*, *C. iria* and *C. distans* are highly variable in nature (**Figure 6**). *C. pilosus* is centred in Southeast Asia, from where itextends to other regions of the world, and is a common rice weed. This species is more frequent in the habitats of South India especially in Kerala, and can be easily identified by the nature of the inflorescence with the

hairy rachilla of the spikelet. Culms usually triquetrous and having antrose prickle hairs on wings edges.

Cyperus iria, commonly known as 'rice flatsedge,'is a tufted annual or perennial herb with short yellowish-red fibrous roots. Culms sharply 3-angled, smooth, yellowish red with linear to lanceolate leaves. Involucral bracts are leafy with spicate inflorescence. Spikelets are erect and spreading. It reproduces by means of seeds which may be dormant but can germinate about 80 days after shedding. One plant may produce more than 3000 seeds.

Cyperus distans, also known as 'slender cyperus', is distributed throughout the pantropical and subtropical regions of the world. It is an annual herb, found commonly in damp locations along rivers, roadside ditches, coastal and midland areas. The leaves are long and narrow, with scabrous margin. The stem is trigonous and carries a diffuse, compound inflorescence subtended by leafy bracts. Terminals peduncle carries cylindrical and elongated linear, reddish-brown spikelets which are spread out more or less at right angles.

Figure 6.*Cyperus pilosus, Cyperus iria* and C*yperus distans*

***Cyperus compressus* L. and *Cyperus sphacelatus* Rottb.**

Cyperus compressus and *C. sphacelatus* are morphologically alike and are difficult to discern (**Figure 7**). *C. compressus*is pantropical in its distribution and are common in grasslands, waste places and cultivated areas. Rhizome of this species is used as vegetable and also fodder for animals. Rhizomeshave characteristic *Cyperus* odour and are used for scenting oil. In India, roasted tubers of *C. compressus* is made into a paste and mixed with coconut oil and is used for killing lice (Deokule and Magdum, 1992; Simpson and Inglis, 2001).

Figure 7. *Cyperus compressus* and *Cyperus sphacelatus*

C. sphacelatus is assumed to be originated in Tropical Africa and Tropical America, from where the species was introduced to elsewhere. It is a common weed in cultivated lands and waste places, and consumed by grazing animals. Both the species are annuals with fibrous roots and very similar in external features. However, *C. sphacelatus* is unique in having a purplish spot on one or both sides of the glumes which gives an impression of a purplish stripe along the centre of the spikelet.

***Cyperus paniceus* (Rottb.) Boeckeler, *Cyperus cyperoides* (L.) Kuntze and *Cyperus cyperinus* (Retz.) Sur.**

Cyperus paniceus is morphologically similar to *C. cyperoides* and *C. cyperinus*, and often difficult to distinguish between (Prasad and Singh 2002). Among the three species, *C. paniceus* has a narrower distribution from Indian subcontinent to Indo-China region, and are widely distributed across Asia and Oceania. They are usually found in open, wet to seasonally wet areas and slightly shaded areas. These species can be easily separated from each other by the nature of spikelets and number of nuts per spikelet (**Figure 8**). *C. paniceus* always bears only one nut per spikelet and the plant emits slender stolons.

Figure 8.*Cyperus cyperoids* and *Cyperus cyperinus*

In *Cyperus cyperoides*, the spikelets are at right angles to the rachis, and the appearance of spikelet is exactly cylindrical. But in *Cyperus cyperinus*, the spikelets are obliquely erect and the spikes are attenuate at the base and are almost sessile. Among the three species, *C. cyperoides* is used for medicinal purpose. The plant ash is used to heal wounds in Nepal (Manandhar, 1989; Simpson and Inglis, 2001). In Philippines, the infusions of nutlets are used for toothache (Siri von Reis Altschul, 1973; Simpson and Inglis, 2001).

Conclusions

Though most of the *Cyperus* species are serious agricultural weeds, they also have considerable economic, ecological and ethnobotanical importance. Inspite of the wide distribution, utilities and ecological importance, the plant group is considered as a taxonomically complex genus and the status of infra generic divisions are still under confusion among the taxonomists. Taxonomic complexity of the genera resulted in the accumulation of several subdivisional names of which many are illegitimate. Further, there is no systematic study performed till date to evaluate the phytogeographical variation and genetic differences of *Cypeus* species, especially in India. An intense and in-depth study of this group with proper taxonomic clarity may lead to better understanding of conservation and utilization prospects.

References

1. Altschul SVR. **1973**. Drugs and Foods from Little-Known Plants: Notes in Harvard University Herbaria.
2. Böckeler O. **1870**. Die Cyperaceen des Königlichen Herbariums zu Berlin. *Linnaea*, 36, 691-768.
3. Bryson CT and Carter R. **2008**. The significance of Cyperaceae as weeds. In Naczi RF and Ford BA. (eds). Sedges: uses, diversity, and systematics of the Cyperaceae. Missouri Botanical Garden Press.
4. Burden D.**2003**. Meadowfoam. Agricultural Marketing Resource Center. Retrieved 2011-10-24.
5. De Vries FT.**1991**. Chufa (*Cyperus esculentus*, Cyperaceae). *Econ. Bot.*, 45, 27-37.

6. Deokule SS, and Magdum DK. **1992**. Enumeration of medicinal plants from Baramati area, district Pune, Maharashtra state. *J. Econ. Taxon. Bot. Addit. Ser.*, 10, 289-299.
7. Goetghebeur P.**1998**. Cyperaceae. Flowering Plants· Monocotyledons: Alismatanae and Commelinanae (except Gramineae).The families and genera of vascular plants, 141-190.
8. Govaerts R, Simpson DA, Goetghebeur P, Wilson KL, Egorova T and Bruhl J. **2007**. World Checklist of Cyperaceae- Sedges. Kew Publishing, Kew.
9. Haines RW and Lye KA. **1983**. The sedges and rushes of east Africa. East African Natural History Society, Nairobi. 404.
10. Hauser EW. **1962**. Establishment of nutsedge from space-planted tubers. *Weeds*, 10(3), 209-212.
11. Holm LG, Pancho JK, Herberger JP and Plunkett PL. **1991**. A geographical atlas of world weeds Krieger Malabar.
12. Holm LG, Plucknett DL, Pancho JV and Herberger JP. **1977**. The world's worst weeds, distribution and biology. East-West Center, University Press of Hawaii, Honolulu.
13. Horak MJ and Holt JS. **1986**. Isozyme variability and breeding systems in populations of yellow nutsedge (*Cyperus esculentus*). *Weed Sci.*, 34(4), 538-543.
14. Horowitz M. 1972. Growth, tuber formation and spread of *Cyperus rotundus* from single tubers. *Weed Res.*, 12, 348-363.
15. Huygh W, Larridon I, Reynders M, Muasya AM, Govaerts R, Simpson DA andGoetghebeur P. **2010**. Nomenclature and typification of names of genera and subdivisions of genera in Cypereae (Cyperaceae): 1. Names of genera in the Cyperus clade. *Taxon.*, 59(6), 1883-1890.
16. Jacometti G. **1912**. Le erbecheinfestano le risaieitaliane. Congresso Risicolo Internazionale, *Vercelli*., 4, 57–91.
17. Kukenthal G. **1936**. En: Engler (ed.), Das Pflanzenreich, *Regni vegetabilis conspectus*. 20(101), 116-121
18. KunthCS.**1837**. Enumeratio Plantarum (Cyperaceae) II.
19. Larridon I, Bauters K, Reynders M, Huygh W, Muasya AM, Simpson DA and Goetghebeur P. **2013**. Towards a new classification of the giant paraphyletic genus *Cyperus* (Cyperaceae): phylogenetic relationships and generic delimitation in C4 *Cyperus. Bot. J. Linn.*, 172(1), 106-126.

20. Larridon I, Reynders M, Huygh W, Bauters K, Vrijdaghs A, Leroux O andGoetghebeur P. **2011**. Taxonomic changes in C3 Cyperus (Cyperaceae) supported by molecular data, morphology, embryography, ontogeny, and anatomy. *Plant Ecol. Evol.*, 144(3), 327-356.
21. Manandhar NP. **1989**. Medicinal plants used by Chepang tribes of Makawanpur District, Nepal. *Fitoterapia*, 60(1), 61-68.
22. Milliken W.**1997**. Plants for malaria, plants for fever. Medicinal species in Latin America-a bibliographic survey. The Trustees, Royal Botanical Gardens, Kew.
23. Molin WT, Kronfol RR, Ray JD, Scheffler BE and Bryson CT. **2019**. Genetic diversity among geographically separated *Cyperus rotundus* accessions based on RAPD markers and morphological characteristics. *Am. J. Plant Sci.*, 10(11), 2034.
24. Muasya AM, Simpson DA, Verboom GA, Goetghebeur P, Naczi RF, ChaseMW and Smets E. **2009**. Phylogeny of Cyperaceae based on DNA sequence data: current progress and future prospects. *Bot. Rev.*, 75, 2-21.
25. Nees Von Esenbeck. **1835**. Ubersicht der CyperaceenGattungen. *Linnaea.*, 9, 273-308.
26. Neeser C, Aguero R and Swanton CJ. **1997**. Incident photosynthetically active radiation as a basis for integrated management of purple nutsedge (*Cyperus rotundus*). *Weed Science* 45, 777-783.
27. Negbi M. **1992**. A sweetmeat plant, a perfume plant and their weedy relatives: A chapter in the history of *Cyperus esculentus* L. and *C. rotundus* L. *Econ. Bot.*, 46 (1), 64-71.
28. Oladele AK and Aina JO. **2007**. Chemical composition and functional properties of flour produced from two varieties of tiger nut (*Cyperus esculentus*). *Afr. J. Biotechnol.*, 6(21).
29. Prasad VP and Singh NP. **2002**. Sedges of Karnataka (FamilyCyperaceae). Scientific Publishers, Jodhpur, India.
30. Rao J. **1968**. Studies on the development of tubers in nutgrass and their starch content at different soil depths. *Madras Agric. J.*, 55 (1), 19-23.
31. Ravichandran P, Mathithumilan B, Benazir JF and Manimekalai V.**2005**. Anatomy and vascular bundle diversity in mat sedges. *Phytomorphol.*, 55, 75-83.
32. Rochecouste E.**1956**. Observations on nutgrass (*Cyperus rotundus*) and its control by chemical methods in Mauritius. In *Proceedings of Ninth Congress of the International Society of Sugar Cane Technologist*, 1-11.

33. Simpson DA and Inglis CA. **2001**. Cyperaceae of economic, ethnobotanical and horticultural importance: a checklist. *Kew Bull.*, 56 (2), 257-360.
34. Simpson DA, Muasya AM, Alves M, Bruhl JJ, Dhooge S, Chase M, Furness CA, Ghamkhar K, Goetghebeur, Hodkinson TR, Marchant AD, Nieuborg R, Reznicek AA, Roalson EH,Smets E, Starr JR, Thomas WW, Wilson KL and ZhangX. **2007.** Phylogeny of Cyperaceae based on DNA sequence data- a new rbcL analysis. In: Columbus JT, Friar EA, Porter JM, Prince LM, and Simpson MG. (eds.) Monocots: Comparative biology and evolution. Claremont, Rancho Santa Ana Botanic Garden. Aliso.
35. Spalink D, Drew BT, Pace MC, Zaborsky JG, Starr JR, Cameron KM and Sytsma KJ. **2016**. Biogeography of the cosmopolitan sedges (Cyperaceae) and the area richness correlation in plants. *J. Biogeogr.*, 43(10), 1893-1904.
36. Steudel EG. **1855**. *Synopsis plantarum glumacearum*. JB Metzler.
37. Wills GD. **1987**. Description of purple and yellow nutsedge (*Cyperus rotundus* and *C. esculentus*). *Weed Technol.*, 1(1), 2-9.
38. Zhang S, Li P, Wei Z, Cheng Y, Liu J, Yang Y and Mu Z. **2022**. *Cyperus* (*Cyperus esculentus* L.): a review of its compositions, medical efficacy, antibacterial activity and allelopathic potentials. *Plants*, 11(9), 1127.