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Review Article

A COMPREHENSIVE EVALUATION OF *CYPERUS ROTUNDUS* LINN

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ABSTACT
Cyperus rotundus, a noxious weed all over the world falls in least concerned category in red list. It is used as food, fodder, medicine, insect repellant, molluscicide, etc. It exhibits lot of chromosomal and morphological variations. Recent studies highlight its allelopathic effect, pharmaceutical or therapeutic uses, insecticidal potential, bioethanol yield, etc. It can be cheaper substitute for endangered medicinal plant *Aconitum heterophyllum*. Its nanoparticles are helpful in reducing toxicity to the environment. This communication is an attempt to integrate all the information available on *C. rotundus* which may help academicians, agronomists, environmentalists, biological scientists and researchers to explore the potential of this commonly growing weed.

Keywords: *Cyperus Rotundus*

INTRODUCTION
Family Cyperaceae to which belong *Cyperus rotundus* is one of the largest and widely distributed families of the monocots represented throughout the world by about 4000 species (Santapau and Henry, 1973). *Cyperus* Linn. with 1468 species world over is the second largest genus after *Carex* Linn. It is represented by 104 species in India. *C. rotundus* is a global species found in tropical, subtropical and temperate regions of the world. It is native to India, but it has been introduced around the World (Holm *et al*., 1977). It is present in 92 countries. It is a perennial species flowering almost throughout the year. It is a C_4 plant. This species grows in variety of habitats and can tolerate habitat disturbances. It can grow in almost every soil type, altitude, humidity, soil moisture and pH. It is a serious weed of cultivated areas.

Taxonomy
C. rotundus belongs to Kingdom - Plantae, Division - Magnoliophyta, Class- Liliopsida, Subclass - Commelinidae, Order - Poales (Cyperales), Family- Cyperacae, Genus – *Cyperus*, Species - *rotundus* (Clark, 1893).

Common Names
C. rotundus is called Keyabon (Assamese); Nagarmotha (Bangali); Suo cao, Hsiang-fu (Chinese); Common nut sedge, Coco grass, Nutgrass, Purple nutsedge (English); Bara-nagar-motha, Korehi-jhar, Motha (Hindi); Abdahullu, koranari-gadde (Kannada); Nagaramothaya (Gujarati); Karimuttan, kora-kizanna, muttanna (Malayalam); Shembang kouthum (Manipuri); Barik motha, Bimbal (Marathi); Mothe (Nepalese); Mutha (Oriya); Dila (Punjabi); Abhrabheda, Ambhodhara, Ambuda, korai, Korai kilangu, Muthakasu , Musta, Varida, Mustaka, Khana, Kuruvinda (Sanksrit); Bhadra-tunga-muste, Bhadramuste, Chakranksha, Charukesara (Telugu); sad kufi, habu-ul-zillam, nagarmotha (Urdu).

Origin and Distribution
According to Holm *et al.*, (1977), *C. rotundus* is native to India, but it has been introduced around the world whereas others believe that the origin is more widespread, including northern and eastern Australia. It is a global species found in tropical, subtropical and temperate regions of the world.

Habitat and Ecology
According to Cook (1996) this species occurs in a wide variety of wetland habitats including seasonally wet grasslands, swamps, ditches, pond and lake margins, springs, and stream and river banks. It can tolerate habitat disturbances and often grows in waste places as well as damp habitats in cultivation. It can grow in almost every soil type, altitude, humidity, soil moisture and pH and is a serious weed of cultivated areas.

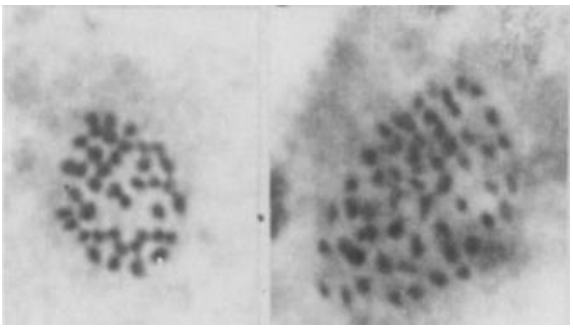
Morphological and Anatomical Features

It is a perrenial species flowering almost throughout the year and possesses small, erect herbaceous stem with nodosely thickened base. The base gets constricted into a wiry rhizome supporting brown, chestnut brown or green umbellate inflorescence comprised of spikelets. Flowers are bisexual. Fruit, although rarely produced, consists of a three-angled achene or nutlet (Clark, 1893).

It is a C_4 plant adapted to fix CO_2 at higher temperature and higher light intensities to be a successful plant in tropical and subtropical regions.

Germplasm Evaluation

Variation in Chromosome Number



Meiosis in pollen mother cells n=40,56

The cytological reports show that meiosis in the species is perfectly normal resulting in fertile pollen. It has x=8,9,10,11 and 12 as the base numbers (Cheema *et al*., 1992).

Table 1: Chromosomal data for *C. rotundus* Linn

Chromosome number (2n)	Ploidy level	Chromosome number (2n)	Ploidy level	Chromosome number (2n)	Ploidy level
16	2X	100	10X	124	11X (aneu)
26	3X (aneu)	104	10X (aneu)	132	12 X
~86	9X (aneu)	108	8X	138	12X (aneu)
80	8X	110	11X	152	16X
84	8X (aneu)	112	11X (aneu)	160	16X
96	12X	116	11X (aneu)	~200	20X

Cytomorpho-variants/morphovariants

Phenotypic comparisons in 13 populations from Punjab (India) reveal marked differences in leaf lamina, length of epidermal cells, stomatal index, stomatal frequency, inflorescence size and colour, pollen size and colour. Three colours - green, brown and chestnut brown were noticed in the inflorescence. Cytomorpho-variants were reported for two cytotypes (2n=100, 132) where as morphovariants were recorded in six populations (2n=104, 110, 112). Occurrence of morphovariants reflects the ongoing process of evolutionary processes at microlevel (Cheema, 1991).

Polyploidy and Aneuploidy

Polyploidy is distinct feature of the family cyperaceae and that is also reflected in this species. The reported biotypes are high degree polyploids. Out of 18 chromosomal reports only one is diploid whereas 17 have polyploid numbers (Table 1). Among the polyploids 9 are euploid and 8 are aneuploid numbers (Cheema and Bir, 1994). Both euploidy and aneuploidy aided by vegetative propagation are responsible for the formation and survival of the cytotypes and biotypes.

Economic and Ethnobotanical Importance

According to checklist of cyperaceae with economic, ethnobotanical and horticultural importance compiled by Simpson and Inglis (2001), *C. rotundus* has been used as food, fodder, in perfumery, as

medicine, as insect repellant, molluscicide, etc. It binds the soil and provides protection against wind erosion but it is also troublesome weed. Leaves are used in weaving baskets and hats.

It is widely used in curing circulatory system disorders, digestive system disorders, diabetes, menstrual disorders, mental and nervous system disorders, nutritional disorders and respiratory system disorders. It is also useful in child birth, as analgesic and as antidote for snake poison. Decoction of whole plant is given to cure malarial fever. Dried rhizome powder is commercially marketed by companies as 'Musta root powder'. Rhizome are eaten as food in Ghana, India, Thailand and Australia. Culms are cooked as vegetable. Aerial parts as well as rhizomes are eaten by cattle and pigs. The culm bases are used as bait for rats, in perfumery and as face powder. Rhizomes are used in unspecified medicinal disorders in Europe, India, China, Malasia and Philippines. Due to presence of cyperone rhizomes are used as tonic, diaphoretic, diuretic, hypotensive and anti-inflammatory agent.

Chemical Characterization

Bioactivity

There are reports that aqueous extracts from *C. rotundus* tubers protected pulses stored post-harvest without infestation by *Callosobruchus maculatus* upto 6 months. The insecticidal effect of *C. rotundus* may be due to alkaloids, anthraquinones, coumarins, steroids, triterpenes, sesquiterpenoid, flavonoids, saponins, tannins and resins present in it. These compounds have an insecticidal effect. Saponins, tannins and alkaloids are generally toxic herbivores. *C. rotundus* extract is effective against wood, agricultural, hygiene, cereals, and domestic insect pests. Its sesquiterpenes are effective against domestic and agricultural insect pests (e.g., flies, cockroaches, mosquitoes, slugs, wolf moths, and rice weevils) and are used to make insect repellents which are non toxic and environment friendly (Barbosa, 2011).

Phytochemistry

Studies have shown that the major chemical components of this herb are alkaloids, flavonoids, tannins, starch, glycosides, furochromones, monoterpenes, sesquiterpenes, sitosterol, fatty oil containing a neutral waxy substance, glycerol, linolenic, myristic and stearic acids (Harborne *et al.,* 1982; SriRanjani and Prince, 2012). The major compounds isolated from essential oil and the extracts of *C. rotundus* rhizome are α-cyperone, α -rotunol, β-cyperone, β-pinene, β-rotunol, β-selinene, calcium, camphene, copaene, cyperene, cyperenone, cyperol, cyperolone cyperotundone D- copadiene, D-epoxyguaiene, D-fructose, D-glucose, flavonoids, γ-cymene, isocyperol, isokobusone, kobusone, limonene, linoleic-acid, linolenic acid, magnesium, manganese, C-rotunduskone, myristic acid, oleanolic acid, oleanolic-acid-3-o-neohesperidoside, oleic acid, P-cymol, patchoulenone, pectin, polyphenols, rotundene, rotundenol, rotundone, selinatriene, sitosterol, stearic acid, sugeonol and sugetriol (Khan *et al.,* 2011; Lawal and Oyedeji, 2009; Sonwa and König, 2001; Jeong *et al.,* 2000; Immam *et al.,* 2014). Ferulic acid acid and catechuic acid has also been reported (Li, 2014). A new flavanone 7, 8-dihydroxy-5,6-methylenedioxyflavone was established and five compounds - quercetin, kaempferol, luteolin, ginkgetin and isoginkgetin were isolated from the rhizomes (Zhou and Fu, 2013**).**

The characteristic aroma and spicy taste of the herb is due to an essential oil which contains sesquiterpene hydrocarbons, epoxides, ketones, monoterpenes and aliphatic alcohols. Sesquiterpenes include selinene, isocurcumenol, nootkatone, aristolone, isorotundene, cypera-2,4(15)-diene and norrotundene as well as the sesquiterpene alkaloids rotundines A-C.

Other constituents include the ketone - cyperadione and the monoterpenes - cineole, camphene, pinene and limonene. *C. rotundus* also contains triterpenes including oleanolic acid, sitosterol, flavonoids, sugars and minerals (Sonwa and König, 2001; Jeong *et al.,* 2000).

Therapeutic Potential

The rhizome is used in ayurvedic medicine, usually called musta, mustak, or mustaka and is mentioned in the ancient ***Charaka Samhita*** (ca. 100 A.D.). Its uses in modern ayurvedic medicine are primarily for treating fevers and digestive system disorders. It is also known as an emenagogue and an analgesic useful for dysmenorrhea. It is considered a diuretic. It is classified as being bitter and astringent, light and dry, cold, pungent (aromatic) and pacifying kapha and pitta (Nadkarni, 1976; Williamson, 2002). It is an ingredient in popular ayurvedic formulas such as the herbal honey, chyawanprash, the women's blood

tonic and uterine regulating formula ashokarishta. It is an important ingredient of anti-aging ayurvedic neutraceutical chyavanprash in India (Sharma and Gupta, 2007). Various studies have proved it as analgesic, antibacterial, anticancer, anticonvulsant, anti-diarrheal, anti-emetic, antihyperglycemic, anti inflammatory, antimalarial, antimicrobial, antimutagenic, anti-obesity, antioxidant, antipyretic, gastroprotective, hepatoprotective, hypolipidaemic, hypotensive, tranquillizer and wound healer (Cheema, 2014).

Nanoparticle Synthesis

Silver nanoparticles play important role in Chemistry and biology applications. These have been reported to be used in sanitizing air, water and hazardous wastes. Silver nanoparticles have been synthesized from *C. rotundus* plant extract as reductant and capping agent. The reduction of silver ions and stabilization of Ag nanoparticles may be due to tannins and flavonoids present in *C. rotundus*. This biosynthesis may help in reducing toxicity to environment (Siva *et al.*, 2014).

Noxious Weed

C. rotundus has been called the "world's worst" weed. The species known from about 92 countries infests at least 52 different crops worldwide (Holm *et al.*, 1977). It grows in all types of soils and can survive the highest temperatures known in agriculture. The spread of the plant is accomplished through rhizomes, which may extend upward, downward or horizontally. *C. rotundus* cultivated in field can produce 10 to 30 million tubers per hectare in a season. It is a troublesome C_4 weed, characterized by high photosynthetic efficiency. Although relatively small in stature, *C. rotundus* provides ample resource competition for crop plants and ornamentals.

This rapid growing plant can quickly form dense colonies due to its ability to produce an extensive system of rhizomes and tubers. Many studies document reduced yields in sugar cane, corn, cotton, rice, vegetables and numerous other crops. The abundantly produced tubers present an efficient means of dispersal and reproduction. These features together with the ineffectiveness of herbicides make this weed nearly indestructible.

Allelopathy

Many researchers have shown that *C. rotundus* tubers produce allelopathic substances which inhibit the growth of other plants. Aqueous extract of *C. rotundus* are known to reduce the germination and growth of vegetables, rice, wheat, maize, banana and weeds. The potential allelopathic compounds in various parts of *C. rotundus* are ferulic, caffeic, hydroxyl benzoic, syringic, chlorogenic, vanelic, cinnamic and p-coumaric acids (Iqbal *et al.*, 2012). The tubers and leaves mixed in soil inhibited the weeds *Echinochloa crus-galli* and *Chorchorus olitorius* commonly growing in soyabean crop (El-Rokiek *et al.*, 2010).

Bioethanol Production

Bioethanol is a biofuel which is blended with petrol in fixed proportion and used as alternative fuel. It was found that sufficient amount of ethanol can be produced by enzymatic hydrolysis from weed plant *C. rotundus* which is rich in fat and carbohydrates. Total 22 % of biomass was converted into simple monomeric carbohydrate. and 40 % of it was converted into bioethanol (Kumar *et al.*, 2013).

Biopesticide

Barbosa *et al.*, (2011) observed that extract of *C. rotundus* leaves has a toxic effect on pest *Diabrotica speciosa*. It can be a good biopesticide for pest control in agroecologic systems.

Substitute for Endangered Species

Ayurveda supports the substitution of medicinal plant with the functionally similar drug containing plant, it is termed as Abhava Pratinidhi Dravya (drug substitution). 'Ativisha–Musta' is one such pair of plants where a weedy *C. rotundus* is a recommended substitute for the endangered Himalayan species *Aconitum heterophyllum* Wall. ex Royle (Ranunculaceae). Both of these plants have similar biological functions in treating diarrhoea, curing fevers, liver, spleen, skin, urinary tract diseases and diabetic conditions (Seethapathy *et al.*, 2014).

Management

C. rotundus reproduce primarily by underground tubers. Its management is focused on depleting tuber reserves and suppressing tuber multiplication.

Manual or Mechanical Control

C. rotundus tubers are confined to the top 12 cm of soil, making shallow tillage an effective tool in reducing its density. Tillage causes a breakup of tubers bringing them close to the soil surface where they are subjected to carbohydrate starvation, desiccation and cold injury.

Physical Control

Solarization during summer months controls *C. rotundus* by producing lethal temperatures near the soil surface. Thermal infrared film is more effective than low-density polyethylene film. Mulches like straw, hay, etc. can be used in between the rows to suppress the weed growth.

Biological Control

Some scientists have investigated native pathogens *Puccinia romagnoliana*, *P. canaliculata* and *Dactylaria higginsii* as potential mycoherbicides for *C. rotundus*. In India, native soil endomycorrhizal fungi were found to colonize *C. rotundus*, but failed to form the mutually beneficial arbuscular structures in the plant's roots, and significantly reduced nutsedge growth rates (Muthukumar *et al.,* 1997).

As reported in Bangarwa *et al.*, (2008), Brassicaceae species contain a variety of glucosinolates which exhibit allelopathic weed suppression and reduce shoot density and biomass in *C. rotundus* and yellow nutsedge. Iqbal and Cheema (2008) showed that intercropping of field crops in cotton could be implemented as an effective option for an integrated management of *C. rotundus*. Four foliar applications of a water extract of sorghum (containing water soluble allelochemicals) significantly reduced growth of a weed flora dominated by *C. rotundus* (Cheema *et al*., 2004).

Chemical Control

According to Webster *et al.,* (2008), glyphosate is the most widely used herbicide for the control of *C. rotundus*. It is economical and minimises tuber production and is suitable to manage weed. Corn growers use post-emergence herbicide halosulfuron which provides soil and foliar control of *C. rotundus*. Pre-emergence application of alachlor at 2.0 to 2.5 kg/ha is also effective. Bangarwa and Norsworthy (2014) investigated allyl isothiocyanate as a methyl bromide alternative for *C. rotundus* control under polyethylene-mulch.

Cultural Control

As mentioned in *C. rotundus* (Purple Nutsedge) management Information (2008) that in Panama pigs are raised with crops to control *C. rotundus*. Geese and chicken are effective control agents for weed. In India, pigs are sometimes used to remove *C. rotundus* from rice fields before planting the next crop.

Red List Category

This is a very widespread and common species with no major threats, hence listed as Least Concern category in red list in 2009.

CONCLUSION

Reports indicate that *C. rotundus* can be used as food, fodder, beverage material, medicinal source and has many other uses. Several chemical compounds have been isolated from world's worst weed and some of these chemicals possess medicinal properties and are used worldwide. Decoctions of the plant in Brazil are used for their anti-infective and anti-inflammatory properties. Various preparations of *C. rotundus* have been used for centuries in perfumes, spices and traditional medicines in India, China, Arab and Africa. It is an important ingredient of anti-aging Ayurvedic neutraceutical Chyavanprash. It is also reported to be used as a soil stabilizer. The objective of the review is urge the scientific community to unravel further potentialities of this plant.

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