Review Article

The Biology of Balochistani Weed: *Cyperus rotundus* Linnaeus. A Review.

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Abstract

Cyperus rotundus L. is considered one of the world's top 10 noxious weeds of agricultural fields of different economically important crops. Its rapid growth tendency and extensive underground rhizome/tuber system makes it extremely difficult to control. Although this weed also produces seeds but it mostly spreads by tubers. In this review, morphology, reproductive biology, economic importance, and different preventive measures of this weed are described in detail.

Keywords: *Cyperus rotundus* L.; Kullichk; tubers; phenolic compounds.

1. Name

Cyperus rotundus L. is commonly known as Coco-grass, Java grass, nut grass, purple nut sedge, red nut sedge. Other common names include: Khmerkravanh chruk. It belongs to monocotyledonous family of Cyperaceae, (commonly known as sedge family) and is native to Africa, southern and central Europe and southern Asia. The word *cyperus* is derived from the Greek *kyperos*, and *rotundus* is from Latin, meaning round. *C. rotundus* is vernacularly (Urdu/Hindi) called Nagarmotha. In Punjab area of Pakistan it is called Deela [1]. In Balochistan it is commonly known as Kullichk, Kab/Kabb (Balochi, Brahui).

2. Distribution

C. rotundus is a noxious weed of tropical and subtropical regions of the world. It is reported in 52 different crops in 92 countries

[2]. *C. rotundus* mostly grows in shores, wet meadows, ditches, turf, ornamental areas, agricultural fields, moist road sides, sandy soils, river bottoms and waste places. In Pakistan, it is mostly reported in summer (Kharif) crops of cotton, rice, sugarcane and maize grown in the Indus valley [2, 3]. In Balochistan it is mostly found in perennial canal based irrigated areas of Nasirabad Division, perennial and seasonal ravine tracts of Lasbela and Khuzdar districts and seasonal rain-fed agrarian areas of Nokbur (Kulanch area of Gwadar District).

3. Morphological description

Cyperus rotundus is a perennial, persistent and prolific weed of tropical, subtropical and temperate zones of the world. The plant has slender leaves and reaches the height of 20-60 cm and leaves are shorter than stem. Leaves are connected together with an

underground modified stem which is commonly known as rhizome. Besides rhizomes, *C. rotundus* also produces tubers, basal bulbs and fibrous roots below ground. In early stages of growth the rhizomes are white and fleshy with crusty leaves and later on become fibrous, woody and dark brown with numerous long-creeping stolons [4]. Inflorescence is terminal (umbel) and flowers are numerous but these flowers produce only few seeds, therefore seeds are considered not the main source of propagation in *C. rotundus* [5]. The

flowering period of *C. rotundus* is between April – October [6]. The underground modified parts e.g. rhizome, tubers and corms are the main sources of propagation of *C. rotundus* [5, 7].

The morphological resemblance of *C. rotundus* with yellow nutsedge (*C. esculentus* L.) often causes confusion in identification. *C. rotundus* has brownish flowers, and its stolons occur in chains while *C. esculentus* has yellowish-brown flowers, and its stolons occur at the end of rhizomes.

Figure 1. *Cyperus rotundus* (www.innerpath.com.au)

4. Economical importance

4.1 Detrimental

C. rotundus is a native species of India and Pakistan [8], mostly distributed in disturbed areas as well as in agricultural fields. *C. rotundus* is considered as the most serious weed of different parts of the world [5, 9,

10]. In Pakistan it is mostly reported in cultivated fields of rice [8], maize [11], sugarcane [12] and cotton [3, 13]. Similarly, Riaz *et al.* [14] and Iqbal *et al.* [15] also elaborated its deleterious negative impacts on different economically important crops of Pakistan. According to Lati *et al.*, *C.*

rotundus is a C₄ weed, which is characterized by high photosynthetic efficiency and makes it a troublesome weed compared with C₃ weeds [7].

C. rotundus has been quickly spreading in different agricultural fields due to modified underground storage vegetative parts i.e., tubers, which move from one area to another in soil with the help of agricultural equipment. It is reported that under favorable conditions, a single plant which arises from a single tuber can produce 100 or more tubers in about 100 days [5]. Similarly, about 80–95 percent of these tubers are to be found within the 6 inches of top soil and under constant moisture conditions these tubers remain viable for two years [5]. These tubers are light sensitive and once they are brought to the soil surface due to soil tillage than they lose the viability within a week. The polymorphism in tuber sizes is correlated with different levels of dormancy which is the most important adaptive factor that enables *C. rotundus* to cope with unfavorable environmental conditions. Therefore, dormancy plays an important role in survival of *C. rotundus* against herbicide applications or hand weeding.

The deleterious effects of *C. rotundus* on yields of different economically important vegetables and crops are reported by different researchers. Working on different vegetables, Keeley reported that the interspecific completion between *C. rotundus* and different vegetables showed negative impacts on yields of these plants. For example, there was an 89% reduction in yield of onion, 62% in okra, 39-50% in carrot, 43% in cucumber and 35% in cabbage when they grow in fields infested with *C. rotundus* [16]. Similarly, Santos *et al.* reported that there was a 70% yield loss in radish when grown in completion with *C. rotundus* [17].

Results of different researches conducted in different parts of the world also revealed that tubers of *C. rotundus* produced different chemical substances which show negative impacts on germination of different crops. According to Javid *et al.* tuber extract (10 and 15% w/v concentration) of *C. rotundus* reduced the germination of three rice varieties, i.e. Pak Basmati, KS-282 and IRRI-8 [8]. Moreover, the water extracts of tubers also reduced the seed germination and seedling growth of rice, corn, cucumber, tomato, sorghum and onion [18, 19]. Similar results were obtained by Verma *et al.* when they germinated mustard and tomato seeds in aqueous extracts of *C. rotundus*, which showed negative effects on seed germination, seedling growth and biomass production [20]. Similarly Alsaadawi and Salih observed that the tuber residues of *C. rotundus* drastically decreased the root and shoot growth of tomato and cucumber plants [21]. The chemical analysis of aqueous residue obtained from tubers and different parts of *C. rotundus* revealed that its leaves and tubers have 19 phenolic compounds [22] and also contain different sesquiterpenes [23]. These phenolic substances from leaf and tuber extract of *C. rotundus* showed negative impacts on germination and growth of competing plants [22]. The molecular studies showed that these allelochemicals reduced the growth of susceptible plant species when grown in competition with *C. rotundus* by reducing the rate of mitosis [24].

4.2 Beneficial

C. rotundus is mostly treated as a noxious weed of different economically important crops of the world, however, in Asia particularly in India and China it is also considered as one of the most important medicinal plants which is traditionally in use for the cure of different ailments. The phytochemistry of *C. rotundus* tubers revealed the presence of polyphenol,

flavonol glycoside, alkaloid, saponins, sesquiterpenoids and essential oils [25]. In oriental traditional medicine *C. rotundus*, is used as an antioxidant and anti-inflammatory [26,27], anti-diabetic [28], anti-diarrheal [29], anti-malarial [30] and anti-pyretic and analgesic [31]. In Ayurveda and Chinese medicine plant extract of *C. rotundus* is used as a blood purifier in case of gynecological diseases which are caused by blood stagnation [32, 33]. The tubers of *C. rotundus* are used to treat dysmenorrhea and menstrual irregularities [34]. It has been suggested that *C. rotundus* may have potential for wide spectrum activity in biological systems and have inhibitory effects on platelet aggregation [35]. According to Seo *et al.*, the antiplatelet effects of *Cyperus rotundus* EtOH extract (CRE) was due to its active component (+)-nootkatone which helps in preventing platelet-associated cardiovascular diseases [36].

The leaves of *C. rotundus* are used by local folks of Middle East and Southeast Asia to flavor food where it is an important component in their daily diet [36]. The seeds are also used as a curries and pickling spices in India and Southeast Asia. Seeds have digestive properties and are used for cure of minor digestive problems, and for hemorrhoids and painful joints [37]. The foliage parts and seeds of *C. rotundus* are rich in oily substances which are useful for cure of different ailments of digestive system, as well as stimulating the appetite and mitigating irritation [37]. It has been suggested that the oil extracted from *C. rotundus* has fungicidal and bactericidal properties. Experiments conducted by Nima, *et al.* was revealed that oil extract from leaves and seeds of *C. rotundus* has significant activities against gram-positive bacteria (*Staphylococcus* and *Enterococcus*) compared with gram-negative bacteria (*Klebsiella pneumonia* and *Escherichia coli*)

where less antibacterial activity was found [37]. From these results it was concluded that the cell wall of gram-positive bacteria contain lipopolysaccharides which is sensitive to oily substances of *C. rotundus* [38].

5. Population Dynamics

The purple nutsedge produces only few viable seeds which are generally responsible for the introduction of *C. rotundus* to a new area, however, tubers and rhizomes are the main sources of a local infestation. There is paucity of relevant scientific literatures on seeds behavior and germination of purple nutsedge and most of the researchers emphasized on the structure and behavior of tubers and rhizomes. Therefore it is imperative that seed behavior should be considered for future research which will be helpful in understanding of population dynamics of *C. rotundus*.

The morphological characteristics of *C. rotundus* make it relatively poor competitor, Iqbal *et al.* found *C. rotundus* to be more susceptible to interspecific competition than to intraspecific competition [15]. In early stages, growth of *C. rotundus* is slow but in later stages it is found fastest particularly 30 to 45 Days after seeding. During this period *C. rotundus* shows high competitiveness for different crops. Juraimi and Begum observed that the sowing timing of Tef (*Eragrostis tef* (Zucc.) Trotter) played an important role in competitiveness of this crop when grown in *C. rotundus* infested field and delayed sowing of crop very critical with respect to the *C. rotundus* interference [39]. It was suggested that the delay of 7 and 15 days of sowing reduced plant height between 6.97-11.53%, panicle length between 8.21-12.32% and grain yield up to 16%.

The competitive ability of *C. rotundus* is due to its widespread tuber system. Research conducted by Iqbal *et al.*, on the effect of number of tubers on morphological behavior

of *C. rotundus* when different densities of tubers (5, 10, 15 and 20 tubers) were planted in pots revealed that shoot density was significantly increased (78–151%) by increasing tubers numbers per pot compared with lower number of tubers [15]. Similarly shoot length, shoot biomass, underground biomass; number of tubers per pot and tubers weight was considerably increased with increasing the number of tubers up to 15 tubers per pot. However, 20 tubers per pot drastically reduced the vegetative structure of this plant. It is mainly because of intraspecific competition among the individual *C. rotundus* plants. Therefore the competitiveness of *C. rotundus* is depending upon the number of tubers to a certain limit and eventually increased with increasing in numbers of tubers.

6. Response to Herbicides

Inconsistency in dormancy of tubers is one of the reasons which make *C. rotundus* a noxious weed which reduce the effectiveness of different herbicides. Therefore it is important that herbicides applied should be absorbed through the shoot system and translocation of the chemical to the extensive tuber system. In early stages of growth it is relatively easy to control it; however, in later stages of growth it is rather difficult to eradicate the older plants because of extensive root and tubers system which developed after the damage of shoots. When tubers of *C. rotundus* treated with the combination of glyphosate and 2,4-D (2,4-Dichlorophenoxyacetic acid), there was a 91% destruction of tubers after 30 days of spray. However, after 45 days of spray there was an increase in germination of tubers [40]. From these results it was concluded that effectiveness of auxinic herbicides (glyphosate and 2,4-D) may be temporary and *C. rotundus* rapidly recovered from the damages caused by these herbicide due to dormant stocks of tubers which sprouted in later stages when the

effectiveness of herbicides diluted in the soil. As a non-selective herbicide, the timing of application of glyphosate to eradicate *C. rotundus* is important. For maximum control of *C. rotundus* for instance, glyphosate should be applied at flowering stages because translocation throughout the plant is limited before emergence of flowers. When applied at early stages of growth glyphosate only eradicate the aerial parts of plant and underground tubers and root systems escape the deleterious effect of herbicide. Best results with glyphosate only achieve 2-3 months after the initial emergence of *C. rotundus* which make this herbicide not suitable for agricultural purpose; however it can be used in lawn and other recreation centre where it used to eradicate this weed locally. In general, 2,4-D (3 kg /ha can kill 80 to 90 % nutsedge) in combination of dicamba (1 kg) and glyphosate applied as a post emergence herbicides for the control of *C. rotundus*. Similarly repeated application of Glyphosate showed positive results against *C. rotundus*. A list of different selective and non-selective herbicides for the control of *C. rotundus* in different crops is listed on table 1.

7. Cultural control methods

Most effective and common method of eradicating *C. rotundus* is hand weeding. However, this method is laborious and time consuming as well as is useless against *C. rotundus* because it removes only foliage parts and leaving tubers in the ground from which new plants appear rapidly. Therefore, it important the tuber of sprouting plant must be removed to control this weed. Similarly the traditional ploughing techniques are also useless because new plants can still grow from the damaged tubers. Extensive dormancy of tubers also prevents the effectiveness of ploughing and leads to rapid regrowth because it helps tubers to break their dormancy once they reached to the top soil.

Table 1. Herbicides for control of *C. rotundus* in different types of crops.

Product	Active ingredient	Crop type	Application rate	Reference
Certainty	Sulfosulfuron	Bermuda grass	1.25 oz per acre	Brosnan and DeFrank, 2008 [5].
Primextra 500 FW	atrazine + metolachlor	Summer crops	1.8 kg a.i. ha ⁻¹	Mahmood and Cheema, 2004 [43].
Stomp 330EC		Onion	3 ml m ⁻²	Gul, et al., 2013 [44].
Iso-proturon 50% SC		Onion	1 kg/ha	Ghosheh, 2004 [45].
	Pendimethalin + Prometryn	Maize	1400 g a.i. ha ⁻¹	Tahir, et al., 2009 [11].
	Dalapon	Cotton	6.76 kg a.i. ha ⁻¹	Cheema, et al., 1988 [13].
Gramoxone	Paraquat	Cotton	600 g a.i. ha ⁻¹	Cheema, et al., 1988 [13].
	S. metolachlor	Cotton	2.15 kg a.i. ha ⁻¹	Iqbal and Cheema, 2008 [3].
Buctril super 60 EC	Bromoxynil +MCPA	Wheat	0.45 kg a.i. ha ⁻¹	Usman, et al., 2013 [46]
Topik 15 WP	Clodinafop/propargyl	Wheat	0.09 kg a.i. ha ⁻¹	Usman, et al., 2013 [46].
Round up 490GL	Glyphosate	Summer crop	-----	Iqbal et al., 2012 [15].
Round up 490GL	Glyphosate	-----	2.0 kg ai ha ⁻¹	Ameena and George, 2004 [40]
	2,4-D Na salt	-----	1.75 kg ai ha ⁻¹	Ameena and George, 2004 [40].
Macete 60 EC	Butachlor	Rice	1.178 kg ha ⁻¹	Raza, et al. (2011[1])
Xinchlor 50 EC	Acetachlor	Rice	0.125 kg ha ⁻¹	Raza, et al., 2011 [1].
Sunstar	Ethoxy sulfuron	Rice	0.2 kg ha ⁻¹	Raza, et al., [1]
Puma Super 6.9% EW	Fenoxaprop-p-Ethyl	Rice	625-750 mL ha ⁻¹	Raza, et al., 2011 [1].

Application of plastic sheet mulch for *C. rotundus* control is not effective because the piercing shoot tip of plant can simply penetrate it. Experiments conducted by Bangarwa et al. on application of different cultural methods on density of tubers of *C. rotundus* in bell pepper organic farming systems [41]. In their experiments they used green polyethylene film, clear polyethylene film, turnip followed by green polyethylene film, turnip followed by clear polyethylene film, tillage every 3 wk, and fallow. The results of this experiment indicated that regular tillage and use of a polyethylene film resulted in a lower density of large tubers. In case of hand-weeded plots most of tubers were small in size ranging from 25 to 194 viable tubers m⁻². However frequent tillage or use of a translucent polyethylene film

showed no effectiveness in eradicating *C. rotundus* over two growing seasons. From these results it was concluded that for proper controlling of *C. rotundus* season-long management is essential.

8. Biological Control

The inadequate effectiveness of chemical herbicide against *C. rotundus* tubers and other modified underground parts opened the way for the search of alternative preventive measures. Similarly chemical herbicides also affect non target plant species as well as public concern regarding environmental problems associated with chemical pesticide usage. Unfortunately the application of biological control agents is a lengthy process and users cannot get the desirable results in a short period, therefore it did attract the farmers who are used to

indulging in quick results. During the last decade of previous century there were several promising bio-herbicide were discovered which were claimed to be alternative sources of chemical herbicides for the control of different weeds. However, when these bio-herbicides applied in the agricultural fields they did not provide adequate results therefore these bio-herbicides lost the public attention rapidly. Although working on different fungal pathogens as bio-herbicides against noxious weeds we came with better understanding about the biology of these weeds and their relations with these natural enemies. Trials conducted in greenhouse, on the impacts of *Dactylaria higginsii* fungal pathogen, on *C. rotundus*, Kadir and Charudattan concluded that this pathogen have potential to be used as a bio-herbicide agent against this weed [42]. Under greenhouse trails inoculation with conidial suspensions of *D. higginsii* showed significant reductions in shoot numbers (72%), shoot dry weight (73%), and tuber dry weight (67%) of *C. rotundus* 45 days after inoculation.

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