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Biology and management of *Rottboellia cochinchinensis*[1]

Biologia e manejo de ***Rottboellia cochinchinensis***

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Abstract - *Rottboellia cochinchinensis* (Lour.) Clayton, popularly known as itchgrass is the main weed of at least 18 crops grown in many countries. Therefore, it is proposed, in this review, to present biological and management aspects of this important weed species. It is an annual or perennial plant reproduced by seeds or from pieces of stems, reaching up to 4.0 m high. The seeds can remain dormant in the soil for up to four years and the light is not a limiting factor for germination. Although with the system clear/dark there is stimulating seed germination. The rapid development of the root system, with subsequent formation of the aerial part, favors the space occupation by plants. Furthermore, the decomposing plant waste of that species release to soil phytotoxic compounds which can inhibit germination and growth of adjacent or species, whether harmful or cultured. In rural workers, it cause skin irritation by contact, with rigid trichomes of leaf sheaths. There is little information in the literature on the chemical control of this species, especially for pre-emergence herbicides applied. This can be attributed to the difficulty of the product crossing the structure surrounding the seeds and thus reaching the embryo. In sugarcane, clomazone + imazapyr, clomazone + isoxaflutole and sulfomethuron + diuron + hexazinone, sprayed pre-emergence resulted in satisfactory controlling *R. cochinchinensis*.
Keywords: itchgrass; sugarcane; control; *Rottboellia exaltata*

Resumo - *Rottboellia cochinchinensis* (Lour.) Clayton, conhecida popularmente como capim-camalote, é a principal planta daninha de pelo menos 18 culturas cultivadas em diversos países. Por isso, propõem-se com essa revisão apresentar aspectos biológicos e de manejo dessa importante espécie de planta daninha. Trata-se de uma planta anual ou perene, reproduzida por sementes ou a partir de pedaços de caules, podendo atingir até 4,0 m de altura. As suas sementes podem ficar dormentes no solo por até quatro anos e a luz não é um fator limitante para a germinação. Embora com o regime claro/escuro há estímulo na germinação das sementes. O rápido desenvolvimento do sistema radicular, com posterior formação da parte aérea, favorece a ocupação do espaço pelas plantas. Além disso, os resíduos vegetais em decomposição dessa espécie liberam compostos fitotóxicos para o solo que podem inibir a germinação e, ou o crescimento de espécies adjacentes, sejam elas daninhas ou cultivadas. Nos trabalhadores rurais causa irritação na pele pelo contato dos tricomas rígidos das bainhas foliares. São poucas as informações na literatura sobre o controle químico dessa espécie, principalmente para herbicidas aplicados em pré-emergência. Isto pode ser atribuído à dificuldade do produto em atravessar a estrutura que envolve as sementes e, assim, atingir o embrião. Em cana-de-açúcar, clomazone + imazapyr, clomazone + isoxaflutole e sulfometuron + diuron + hexazinone, pulverizados em pré-emergência, resultaram em controle satisfatório de *R. cochinchinensis*.
Palavras-chaves: capim-camalote; cana-de-açúcar; controle; *Rottboellia exaltata*

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Introduction

The species *Rottboellia cochinchinensis* (Lour.) Clayton, synonymy *R. exaltata* L.f., popularly known in Brazil as capim-camalote and in English as Itchgrass, belongs to the Poaceae family, is an annual C_4 grass or perennial, depending on environmental conditions, and reproduced by seeds or from pieces of stems, which have gems in nodes (Kissmann, 1997). Plants are always large, reaching up to 4.0 m height; in Brazil, the size is usually between 1.0 and 2.5 m (Kissmann, 1997; Lorenzi, 2008).

Due to its high ecological adaptability, *R. cochinchinensis* occurs in various production environments (Figures 1 and 2) (Carvalho et al., 2005). This is the main weed of at least 18 cultures in Africa, Asia, Central America and South America, United States, Australia and Papua New Guinea (Anning and Yeboah-Gyan, 2007; Holm et al.. 1991; Kissmann, 1997). It is associated with significant losses in crop production, such as sugarcane (*Saccharum* sp.), soy (*Glycine max*), corn (*Zea mays*), cotton (*Gossypium hirsutum*), sorghum (*Sorghum bicolor*), rice (*Oryza sativa*), etc. (Lencse and Griffin, 1991; Holm et al., 1991; Lejeune et al., 1994; Strahan et al., 2000; Correia and Gomes, 2014).

In addition to the damage caused by competition for water, light, nutrients and space, the decaying plant debris of that species release phytotoxic compounds to the soil which can inhibit the germination and, or growth of adjacent species, whether weeds or cultivated (Kobayashi et al., 2008; Meksawat and Pornprom, 2010). Another damage originating from *R. cochinchinensis* is associated with its manual removal, which is very difficult and feared by rural workers, because of the presence of rigid trichomes (joçal) in leaf sheaths, which, in contact with skin, penetrate as glass needles, break up and cause irritation and inflammation (Kissmann, 1997; Lorenzi, 2008; Chauhan, 2013).

Given the great importance of *R. cochinchinensis* in the agricultural environment in different countries, ihis research proposed to present biological and management aspects in the culture of sugarcane, of that species.

Biology and Ecology of *Rottboellia cochinchinensis*

The inflorescences *R. cochinchinensis* are espiciforme racemes, cylindrical and slightly tapered at the end portion, in which seeds are formed with 6 to 7 mm in length. Each seed has two spikelets, one sessile and another one pedicel. At maturity, the branches release the seeds, which can be launched from a distance (Kissmann, 1997). Rain or irrigation, animals, farm machinery and implements, and crop seeds can also spread them quickly (Holm et al., 1991). A single plant is capable of outputting up to 100 tillers and produce 15,000 seeds that can be dormant in the soil for up to four years (Lorenzi, 2008). In Figures 1 and 2 photos of the adult plant and the seeds of that species are represented.

Bianco et al. (2004) found that plants of *R. cochinchinensis* have grown throughout the experimental period (133 days), resulting in higher dry matter accumulation at 133 days after emergence, located in greater quantity in stems and leaf sheaths of the plant. There was also growing accumulation of nutrients in plants, particularly of nitrogen and potassium. All these features show the great potential of *R. cochinchinensis* to compete with other plant species. Strahan et al. (2000) assessed the competitiveness of *R. cochinchinensis* with corn crop and obtained a reduction of 38% in the number of cobs in coexistence to the weed.

In addition to the competition for water, light, nutrients and space imposed on culture, plants of *R. cochinchinensis* also have allelopathic action. Farmers in Thailand grow *R. cochinchinensis* and use its mulch to control weeds in crop areas. Work done in this country with six vegetal species (*Bidens pilosa* L. *radiata* Sch. Biq., *Mimosa pudica* L., *Ageratum conyzoides* L., *Echinochloa crus-galli* L. P. Beauv., *Oryza sativa* L. var. RD 6 and *Lactuca sativa* L. var. OP) proved that vegetable waste of *R. cochinchinensis* inhibiting the growth of plants (Meksawat and Pornprom, 2010). Ground vegetable waste of root and aerial part of *R. cochinchinensis*, incorporated in the soil, were also toxic to radish plants after their degradation, and it was more severe by increasing the concentration of the ground powder (Kobayashi et al., 2008).

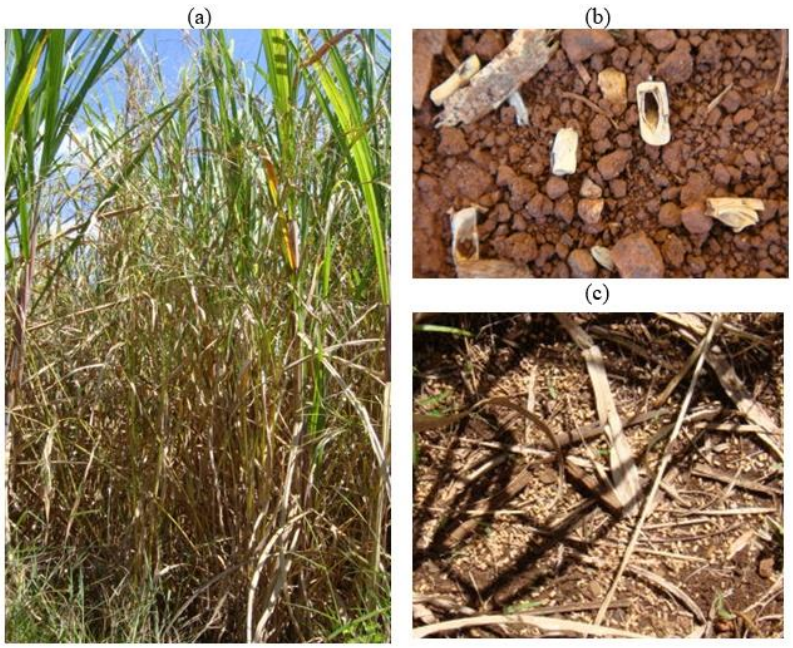

Figure 1. Adult plant of *Rottboellia cochinchinensis* (a), Seed detail (b) and seeds on the soil surface.

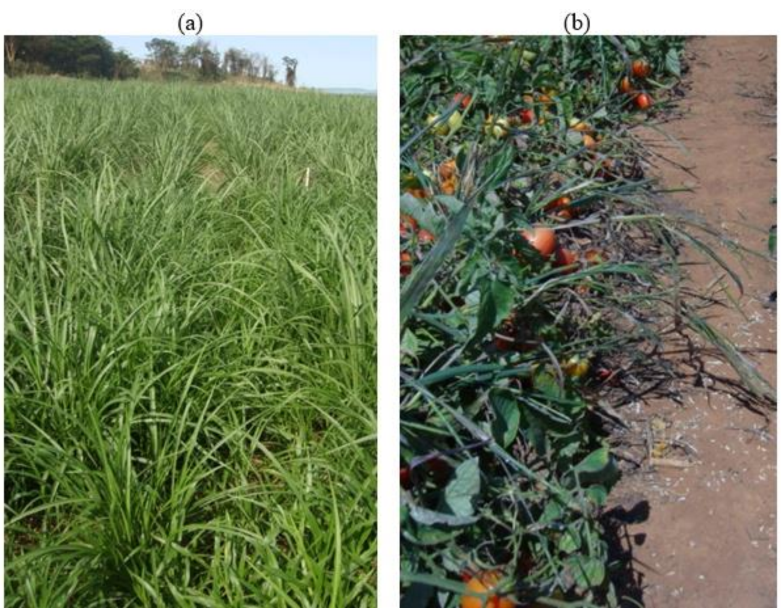

Figure 2. Occurrence of *Rottboellia cochinchinensis* in cane field in São Paulo state (a) and pivot with bush tomato in Goiás with the deposition of seeds on the soil surface (b).

The presence of mulch on the ground, moreover, may affect the emergence of that species. When studying the amounts 1, 2, 4 and 6 t ha^{-1} of rice plant residues on the soil surface, Bolfrey-Arku et al. (2011) reported that there has been lower emergency *R. cochinchinensis* in larger amounts. Oliveira and Freitas (2008) observed the same situation with 16 t ha^{-1} of cane straw on the soil. Therefore, the emergence of *R. cochinchinensis* in sugar cane plant area is larger than the areas of ratoon cane (Oliveira and Freitas, 2008).

The cropping systems (conventional tillage, minimum tillage and no-till) of rice cultivation did not affect the emergence of this species (Chauhan and Johnson, 2009). The soil tillage, which resulted in the seed distribution in the soil profile, or the complete absence of movement, with accumulation of the seeds on the surface, did not influence the emergence dynamic of the plants and, consequently, its level of infestation.

In assessing the sowing depth (0, 2.5, 5, 7.5 and 10 cm) and the presence of sugarcane straw (0, 5, 10 and 15 t ha^{-1}) in emergence of *R. cochinchinensis*, Correia et al. (2013) mentioned that there was less emergence and mass accumulation by plants with the soil cover (Figure 3), especially in larger straw levels associated with greater sowing depths. However, without straw on the surface, seeding depth did not affect the weed dynamics. Consequently, there will be the emergence possibility of seedlings from seeds placed within 10 cm of the soil profile in a bare soil condition (Correia et al., 2013).

The blanching of *R. cochinchinensis* derived from seeds deposited at 10 cm depth with the maintenance of 15 t ha^{-1} of cane straw on the surface can be seen in Figure 4.

In another study, the emergence of *R. cochinchinensis* was higher when the seeds were sown on the surface and diminished with increasing depth of planting the soil, in the absence of plants emerged from seeds deposited at 10 cm (Bolfrey-Arku et al., 2011). These results are justified, at least in part, by the ability of seeds of that species to germinate both in the light and in the dark (Thomas and Allison, 1975). However, while the light is not a requirement for seed germination, with the light/dark regime there is stimulating the germination of *R. cochinchinensis* (Bolfrey-Arku et al., 2011). Silva et al. (2009) also found that the seeds hardly presented numbness and the light was not a limiting factor for germination of that species.

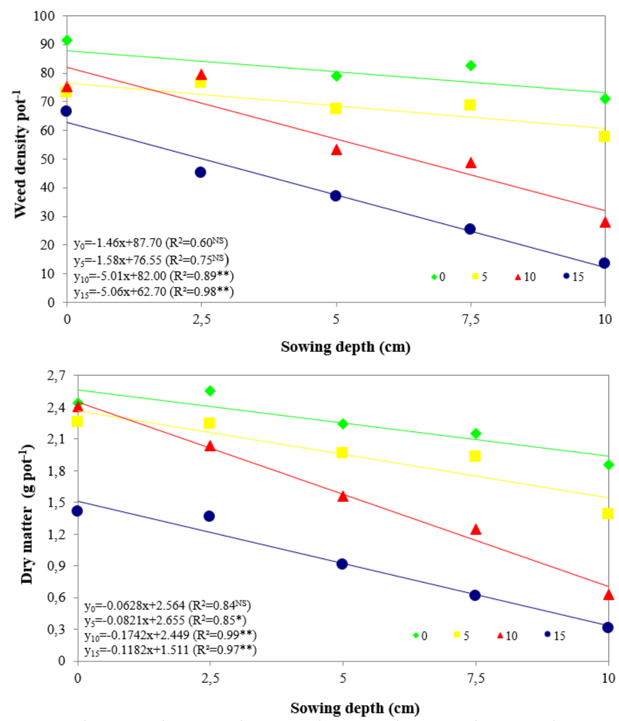

Figure 3. Density and aerial dry matter of *Rottboellia cochinchinensis* at 35 days after sowing, due to the increase of sowing depth (0; 2.5, 5, 7.5 and 10 cm) in soil associated to the amounts 0, 5, 10 and 15 t ha^{-1} sugarcane straw on the surface. Source: Correia et al. (2013).

Water is a resource essential for plants, interfering in their vegetative and reproductive development. Therefore, Chauhan (2013) mentioned that water stress affects the production of seeds of *R. cochinchinensis*, either by increasing the drought period or by reducing the amount of water available in the soil (field capacity). However, plants produce seeds in a considerable number. Few weed seeds is enough to cause infestation and consequently damage to succeeding crops. Therefore, the seed production capacity in any soil moisture condition contributes to survival of *R. cochinchinensis* in unpredictable environments (Chauhan, 2013).

Figure 4. Plant blanching of *Rottboellia cochinchinensis*, derived from seeds deposited at 10 cm depth with the maintenance of 15 t ha^{-1} of cane straw on the surface.

Another aspect to be mentioned refers to the genetic variability of weed populations, which is affected by numerous evolutionary factors, such as the production system, the interaction between culture and weed (gene flow through pollen and seed dispersal), geographical distribution and natural selection (Huangfu et al., 2009). In this sense, when identifying and characterizing *R. cochinchinensis* six accesses (Aramina, Campinas, Dumont, Igarapava, Jaboticabal and Ribeirão Preto), Alves et al. (2003) observed that seeds from Ribeirão Preto have longer and narrow coat, and higher germination (72%), contrary to the ones from Campinas with lower germination (34%) and other accesses, with intermediate germination (Aramina, 54%; Dumont, 56%; Igarapava, 48% and Jaboticabal, 52%). The access also differ in plant height, leaves number and insertion angle on the stem and beginning of flowering. These differences may reflect the ecological adaptation of accesses in the environment and even in their response to a certain management strategy, such as the use of herbicides.

A better understanding of the biology and ecology of weeds is critical for the establishment of strategies that make it possible to increase the competitive capacity of crops on weeds. As demonstrated by Awan et al. (2014), which, by increasing the population of rice plants, the aerial biomass (stems, leaves and inflorescence) and root of the plant *R. cochinchinensis* decreased. The culture major competition for light and nutrients, nitrogen management, along with other control practices are essential to the successful management of this species (Awan et al., 2014).

Rottboellia cochinchinensis Management in Sugarcane

R. cochinchinensis has occurred with certain frequency in Brazilian sugarcane fields, especially in Rio de Janeiro (Oliveira and Freitas, 2008), São Paulo, Paraná and Mato Grosso do Sul. There are reports of its occurrence also in the North and other states in the Midwest of Brazil (Kissmann, 1997).

In the survey of weeds in sugar cane fields conducted in Campo dos Goytacazes, RJ, Oliveira and Freitas (2008) found that *R. cochinchinensis* was the second weed species with higher importance value index, second only to *Cyperus rotundus* L. This infestation was attributed to the vigor and plant survivability, easily spreading. In a similar study, Firehun and Tamado (2006) found in areas of sugarcane in the Rift Valley in Ethiopia that *R. cochinchinensis* was one of the main weed species in the evaluated sites. Furthermore, the three most common species of weeds in Ashanti region, Ghana, among the 43 species identified, were: *Chromolaena odorata* (12.71%), *Centrosema pubescens* (10.42 %) and *R. cochinchinensis* (6.39 %) (Anning and Yeboah-Gyan, 2007).

This species performs photosynthesis through C4 cycle, contributing to the presence of the species in sugarcane production areas and in competition with other weeds (Carvalho et al., 2005). The favorable moisture conditions, lots of fertilizer, increased row spacing and long sugarcane cycle, favor the germination and growth of this species. The rapid development of the root system, with subsequent formation of the aerial part, favors the use of space where the plant grows (Firehun and Tamado, 2006).

There is little information in the literature on chemical control of *R. cochinchinensis* in the culture of sugarcane, especially with pre-emergence herbicides applied. However, it is known that management is costly due to the need to use up to six applications of herbicides during the growing season (Oliveira e Freitas, 2009). The minor weed control with herbicides sprayed in pre-emergence can be attributed to the difficulty of the product to pass through the structure surrounding the seeds and thus reach the embryo (Correia and Gomes, 2014).

In post-emergence, the herbicide trifloxysulfuron-sodium + ametryn (37 + 1465 g ha^{-1}), MSMA + diuron (2880+1120 g ha^{-1}) and diuron + paraquat (300 + 600 g ha^{-1}) were effective in controlling *R. cochinchinensis*, when sprayed on plants having from six to eight leaves (Freitas et al., 2004). For the pre-emergence control, the herbicide indaziflam is promising, adjusting the dosage to the soil texture (sandy, loamy and sandy-clay) (Amim et al., 2014). The clomazone and imazapyr herbicides were also effective in controlling *R. cochinchinensis*, regardless the straw level (5, 10 and 15 t ha^{-1}) maintained on the ground. The same happened to flumioxazin, but only on the condition without straw (Correia et al., 2013).

Under field conditions, however, the application of clomazone alone was not as effective in controlling *R. cochinchinensis* (Figure 5) (Correia and Gomes, 2014). According to the authors, this result can be explained by the most appropriate conditions of soil moisture in the pot experiment compared to field experiments. Additionally, the effect of herbicides by only 35 days and in the field up to 140 days after application was evaluated in greenhouse. In this environment, treatments clomazone + imazapyr, clomazone + isoxaflutole and sulfomethuron + diuron + hexazinone, applied pre-emergence, promoted better control, reflected in the seed bank of this species in soil and production of cane stalks (Correia e Gomes, 2014).

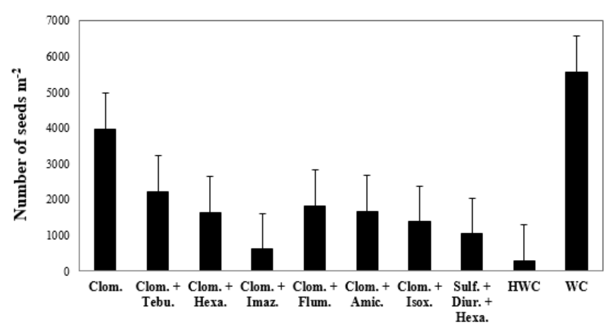

Figure 5. Estimated number of seeds (per m^2) of *Rottboellia cochinchinensis* in the soil of the plots sprayed with herbicides (clomazone isolated, clomazone + tebuthiuron, clomazone + hexazinone, clomazone + ametryn, clomazone + flumioxazin, clomazone + amicarbazone, clomazone + isoxaflutole, sulfometuron-methyl + diuron + hexazinone) and unsprayed hand-weeded control (HWC) and weedy control (WC) plots, at 249 days after herbicide application. Source: CORREIA and GOMES (2014).

Before mechanical harvesting without burning of sugarcane and straw maintenance on the soil surface, the dynamics of infestation of *R. cochinchinensis* in the cane fields may be affected. In this harvesting system drastic reduction in the occurrence of weeds, especially grasses are observed (Velini and Negrisoli, 2000). Oliveira and Freitas (2009) found that high levels of cane straw were effective in controlling *R. cochinchinensis*. However, the reduction in emergence of *R. cochinchinensis* with increasing levels of straw was not enough to achieve adequate control levels (Correia et al., 2013).

Final Remarks

Although *R. cochinchinensis* has a wide distribution throughout the world and in many important crops, reports on herbicidal resistance are rather unexpressive, only two: one in the US, to ACCase inhibitors in 1997; and the other in Venezuela to ALS inhibitors, 2004 (Heap, 2015). Still, it is necessary to adopt other strategies such as direct planting, crop rotation, proper fertilization, more competitive cultivars, spacing and adequate arrangements, etc. that added to the chemical control, will lead to weed management. After all, management encompasses the adoption of various control practices, seeking to work in an integrated manner, and the sustainability in agriculture.

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