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Weed management strategies for castor bean crops

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ABSTRACT. Castor bean crops are agriculturally relevant due to the quality and versatility of their oil, both for the chemical industry and for biodiesel production. Proper weed management is important for both the cultivation and the yield of castor bean crops; therefore, the intention of the present work is to review pertinent information regarding weed management, including the studies regarding weed interference periods, chemical controls for use in different crop production systems and herbicide selectivity, for castor bean crops. Weed science research for castor bean crops is scarce. One of the main weed management challenges for castor bean crops is the absence of herbicides registered with the Ministry of Agriculture, Livestock and Food Supply (MALFS). Research for viable herbicides for weed control in castor bean crops should be directed by research and/or rural extension institutions, associations and farmers cooperatives, as well as by manufactures, for the registration of these selective herbicides, which would be primarily used to control eudicotyledons in castor bean crops. New studies involving the integration of weed control methods in castor bean also may increase the efficiency of weed management, for both small farmers using traditional crop methods in the Brazilian Northeast region, as well as for areas with the potential for large scale production, using conservation tillage systems, such as the no-tillage crop production system.

Keywords: weed competition, herbicides, selectivity, *Ricinus communis*.

Estratégias de manejo de plantas daninhas na cultura da mamoneira

RESUMO. A cultura da mamoneira apresenta destacada relevância principalmente devido à qualidade e versatilidade de seu óleo tanto na indústria química como para produção de biodiesel. Considerando a importância do manejo de plantas daninhas para o cultivo e produtividade da mamoneira, o presente trabalho teve como objetivo abordar as principais informações disponíveis sobre o assunto, entre as quais foram destacados os estudos de períodos de interferência das plantas daninhas, controle químico em diferentes sistemas de produção e seletividade de herbicidas à cultura. Verificou-se que os resultados de pesquisa sobre o manejo da cultura da mamona são escassos, nos mais variados aspectos da ciência das plantas daninhas. Uma das principais dificuldades para o controle de plantas daninhas na cultura da mamona é a atual ausência de herbicidas registrados no MAPA. As informações existentes descrevem perspectivas viáveis que necessitam ser direcionadas por instituições de pesquisa e/ou extensão rural, associações e cooperativas de produtores rurais, assim como por empresas fabricantes, para o registro de herbicidas seletivos, principalmente para o controle de espécies eudicotiledôneas. Novos estudos envolvendo a integração de métodos de controle de plantas daninhas em mamoneira também podem aumentar a eficiência no manejo, tanto para pequenas propriedades da tradicional região do Nordeste brasileiro, assim como para áreas com potencial de produção em larga escala, sob sistemas conservacionistas, como é o caso da semeadura direta.

Palavras-chave: mato-competição, herbicidas, seletividade, *Ricinus communis.*

Introduction

Castor bean (*Ricinus communis* L.) is an oilseed crop of economic importance, the seeds are used to produce castor oil, which possesses excellent properties and is widely used as an industrial raw material. Castor oil is used in paint production, cosmetics, soaps, varnishes, oils with unique characteristics (related mainly to viscosity), dyes, plastics, adhesives, fungicides, insecticides, and even prostheses and implants. Additionally, during the industrial processing of castor oil, a sub-product is generated which has great applicability as a fertilizer (SANTOS et al., 2007).

As the National Program for the Production and Use of Biodiesel Fuel by the Brazilian Federal Government was created, castor bean production increased as one of the raw material sources for biodiesel fuel because the species not only has great yield and oil content (NASS et al., 2007) but also possesses great social relevance because it is commonly cultivated with the intensive use of family labor, mainly in the Brazilian Northeastern semi-arid region.

Brazil is the third largest producer of castor beans (FAO, 2011), having a production of 101 thousand tons of seeds (2009/10 cropping season), and the Northeast region is the primary production region for this crop. However, despite government incentives, over the past five cropping seasons, national production has remained between 93 and 104 thousand tons, with a cultivated area between 148 and 158 thousand ha and a yield between 587 and 703 kg ha^{-1} (CONAB, 2011). Castor bean crops have the potential to produce more than 4,000 kg ha^{-1} (SORATTO et al., 2011); therefore, Brazilian yields can be considered low. According to Vaz et al. (2010), because this crop is less profitable and competitive in relation to other oilseed crops, such as soybean, this has been one of the main reasons that castor bean crops are not more widely grown for biodiesel production.

The competition for resources caused by the presence of weeds may affect yield and mechanization of an oil crop production system; such is the case with castor bean crops. The negative effects observed result from either direct environmental pressures (competition mainly for water, light, nutrients, physical space, allelopathy and harvest interference) or indirect pressures (hosting insects, diseases and nematodes) (PITELLI, 1985). Currently, research methodologies seek to elucidate the possible negative interactions between cultivated species and weeds, where competition over available resources exists (VIDAL et al., 2008; VIDAL; MEROTTO JÚNIOR, 2010).

Castor bean crops are considered highly sensitive to weed competition (FERREIRA et al., 2009a), and the employed technology in castor bean cultivation and weed management has been quite variable between the different Brazilian production regions (MACIEL, 2006). Yield reduction has occurred due to the absence of information on weed competition (AZEVEDO et al., 2007; MACIEL et al., 2008). According to Beltrão and Alves (2008) and Silva et al. (2010a), acquiring knowledge on weed control in castor bean crop is still limited, and new research into this area is necessary. Thus, research on weed management in castor bean crops is important for elucidating the cropping systems that would allow the expansion of castor bean crop production in Brazil, while also increasing yield and economic return for this crop.

The objective of this review was to compile the available information regarding weed management in castor bean crops for different crop production systems; the goal is to assist professionals interested in this important oilseed, through a technical-scientific approach.

Weed interference in castor bean crop

The degree of weed interference in a cultivated crop is influenced by factors relating to the infesting community (specific composition, density and distribution), and to the crop (species or genotype, spacing and planting density), as well as to the time and extent of the coexistence between the species. Moreover, weed interference may be changed by climatic and edaphic conditions and crop traits (PITELLI, 1985).

Castor bean is a species of C_3 photosynthetic plants with a metabolism characterized by a low photosynthetic efficiency, slow initial growth and a low ability to compete for resources with other species (AZEVEDO et al., 2007; BELTRÃO et al., 2006a); therefore, castor bean is very sensitive to weed interference. Castor bean yield decreases, due to weed competition, may reach 86%, according to a study by Azevedo et al. (2006).

Another factor that contributes to weed interference in castor bean crops is the seeding density commonly used, represented by wide plant spacing (3.0 x 1.0 m for cultivars with large sizes and 1.0 x 1.0 and 1.0 x 0.5 m for dwarf cultivars). This spacing results in a low efficiency for the interception of incident solar radiation, especially at the crop establishment stage, which leads to a low level of weed suppression (SILVA et al., 2005).

To determine when weed control in castor bean crops must be performed, studies regarding weed interference periods have been conducted for Brazilian growing conditions. Maciel et al. (2004) performed an experiment in Paraguaçu Paulista County, São Paulo State, using the AL Guarany 2002 cultivar (medium sized) with 1.0 x 1.0 m spacing, and found that the critical period to prevent interference (CPPI) from weeds occurred from 9 to 41 days after emergence (DAE) of the castor bean crop. Azevedo et al. (2006), using the medium sized 28 Sipeal cultivar spaced at 2.0 x 1.0 m, in the Cariris Velhos region, Paraiba State, found that the critical period for weed competition occurred from the 2nd to the 12th week after emergence.

According to Silva et al. (2005), reducing castor bean spacing may result in a reduction of weed interference. Additionally, Maciel et al. (2006a) using the Iris hybrid (dwarf sized), in the Middle Valley of Paranapanema, São Paulo State, observed that with a 0.5 x 1.0 m spacing CPPI occurred from 9 to 35 DAE but with a 0.5 x 0.5 m spacing CPPI was reduced to 3 to 25 DAE. More recently, Maciel et al. (2007a), using the Savana hybrid (dwarf sized) in no-tillage system in Garça County, São Paulo State, found with a 0.5 x 1.0 m spacing, based on vegetative development, that CPPI occurred from 6 to 40 DAE. Similar results were obtained in Cassilândia, Mato Grosso do Sul State, by Tropaldi et al. (2009) with the Lyra hybrid (dwarf sized), sown with 0.45 m spacing between lines and plants, obtaining a CPPI of 14 to 42 DAE.

Generally, studies on weed interference periods show a reduction of interference periods with greater plant densities per area. While the largest spacing of plants being used for cultivation conditions occurs in the Brazilian Northeastern semi-arid production region, in the Southeast and Midwest production regions, the minimal spacing of plants is preferred. However, there exists no research data regarding other factors that contribute to the degree of weed interference in castor bean crops under Brazilian growing conditions. Specifically, there is an absence of studies on the intercropping system, which is the predominant growing condition for the largest producing region (Northeast, semi-arid).

Castor bean crops show interference with other plants. Carvalho et al. (2007) observed that extracts produced by isolated rhizobacteria from castor beans promoted deformity and reduced seed germination in lettuce, with greater effects than extracts from ten other plant species tested. Hongyun et al. (2008), assessing the allelopathic potential from plant extracts, found that those from castor bean produced the largest reduction in germination and growth of *Echinochloa crus-galli, Bidens tripartita*, *Pycreus sanguinolentus* and *Oriza sativa* weed species, when compared to other plant extracts.

Control methods

Crop, mechanical and chemical methods have all been considered as approaches for weed control in castor beans (DEUBER, 1997; SAVY FILHO, 2005; BELTRÃO et al, 2006a; BELTRÃO et al, 2006b; AZEVEDO et al., 2007). However, the usual methods employed must consider the agricultural practices of integration that provide control strategies adapted to the local infrastructure, taking into account the labor availability and the implementation costs.

a) Crop Management Control

The main types of weed control in castor bean include the system of soil preparation, crop rotation, intercropping cultivation and plant population (AZEVEDO et al., 2007).

Severino et al. (2006a) consider the choice of plant population a crop practice, which is extremely simple and can have a great impact on weed control and plant yield. Bizinoto et al. (2010) report that dwarf sized castor bean cultivars allow for a reduction in seeding density, and these dwarf plants are advantageous for weed control; therefore, the development of new genotypes with this dwarf characteristic is important.

As discussed earlier, Maciel et al. (2006a) observed a reduction in CPPI when there was a reduction in sowing density of the castor bean hybrid 'Iris'. However, Ferreira et al. (2009b) found that plant density did not interfere in the development and yield of medium-sized castor bean cultivars (BRS 188 Paraguaçu and BRS 149 Nordestina) along with dwarf sized plants (Savana and Lyra hybrids). Carvalho et al. (2010) reported that increasing levels of sowing density to 12.5 thousand plants ha^{-1} resulted in a higher yield for the cultivars BRS 188 Paraguaçu and BRS 149 Nordestina. Souza-Schlick (2010) described distinct behavioral differences between season crops and off-season seeding for dwarf-sized cultivars (FCA-PB and IAC-2018) of castor bean. Soratto et al. (2011) described the largest grain yield and oil content for the FCA-PB cultivar, when sowing initial populations from 55 to 70 thousand plants ha^{-1}, with row spacing from 0.45 to 0.75 m.

According to Maciel (2006), the adoption of a direct seeding system for castor bean crops would allow greater flexibility in the sowing period; this would allow the crop to be sown immediately after burning a field or several days after field management of the previous vegetative cover. According to the author, there are many options for succession crops, such as maize, millet, sorghum, sugar cane, wheat, black oats and brachiaria grass, with crop residues having a high C/N ratio and physio-chemical properties favorable as mulch in different Brazilian regions. The results from the work developed under field conditions, by Ferrari Neto et al. (2011), of burning down the straw residues of *Cajanus cajan* and millet (*Pennisetum glaucum*) species in both single and intercropping cultivations suggest that there is no hindrance to castor bean development. Novo et al. (2007) found that the addition of sugar cane straw to the soil surface did not change the emergence of castor beans, but interfered with the initial development of specific castor bean genotypes (IAC Guarani, Iris and IAC-2028). The authors also verified that vinasse application (150 m^3 ha^{-1}) reduced castor bean emergence; however, there was no damage subsequent to seedling development that occurred from the presence of this residue. This positive interference of vinasse over the Iris and IAC-2028 genotypes, mainly related to plant vigor, was also reported by Ramos et al. (2008).

In Botucatu county, São Paulo State, a reduction of 87.6% in weed populations and 60% in weed biomass with the production system 'season – off season' with castor bean cultivated after rice, was observed when compared to 'season- fallow' cultivation (CASTRO et al., 2011). This may indicate that crop succession and rotation may contribute to weed management for castor bean crops.

Although recently there has been an increase in research regarding crop practices for castor bean, such as the intercropping system (CORRÊA et al., 2006), seeding periods (ZUCHI et al., 2010), plant populations (CARVALHO et al., 2010; BIZINOTO et al., 2010; SOUZA-SCHLICK, 2010; SORATTO et al., 2011), cover crops, and straw management for no tillage systems (FERRARI NETO et al., 2011), there are few studies that evaluate these practices in relationship to their effect as a method for weed control.

b) Mechanical Control

Mechanical control, as accomplished through manual hoeing with hoes and/or through mechanical cultivations with animal traction equipment or with tractors, has been the most widespread method for weed control in castor bean crops, mainly on small properties (WEISS, 1983; DEUBER, 1997; SAVY FILHO, 2005; BELTRÃO et al, 2006a; BELTRÃO et al, 2006b; AZEVEDO et al., 2007). Despite there being scarce research on this type of weed control method for castor bean crops, large-sized cultivars needing more space typically require hoeing up to three times during the growing cycle to control weed infestations. Hoeing with hoes and/or cultivators, in rows and between rows, results in total area control at the initial stages of crop development, while avoiding this practice when soils are too damp or on hot, dry days (SILVA et al., 2007; CONSTANTIN, 2011). During these operations, damage to superficial roots may occur. Avoiding root damage requires great care from producers so that the cutting depth does not exceed 3.0 cm (YAROSLAVSKAYA, 1986; MELHORANÇA; STAUT, 2005; AZEVEDO et al., 2007).

Paulo et al. (1997), using the IAC-80 cultivar (large size) sown with a spacing of 3.0 x 1.0 m, observed that hoeing areas over the crop line must not have a width of less than 1.0 m to ensure no reduction in yields. Savy Filho (2005) reports that the adoption of hoeing in bands of 1.0 m over the crop line is associated with the maintenance of weeds between lines through clipping at 0.3 m tall. Besides saving labor and time, this also contributes to soil conservation, protecting the soil against possible problems from laminar and/or wind erosion. According to Araújo et al. (2010), the cost for controlling weeds with a cultivator and hoe in the traditional agricultural system of the Brazilian Northeast represents 28% of production costs. In addition, the field labor has become scarce, making it difficult to perform the mechanical control of weeds.

It is estimated that 15 men day^{-1} are needed for weeding 1 hectare of a castor bean crop, with weeds in their initial development stage. For weed cultivation between the lines, using animal traction, it takes two days man^{-1} per hectare; however, the use of tractor traction, with a speed of 7 km h^{-1} and a work band of 2.0 m wide, will require only 1 hour ha^{-1} (AZEVEDO et al., 2007).

c) Chemical Control

Despite their success, herbicide applications on castor bean crops are not the most widespread control method used among producers, but it may be the most practical and cost-effective control method for weed management (MACIEL, 2006). The introduction of new castor bean genotypes with a dwarf size has made it possible to reduce the spacing between plants, and consequently, chemical control has become an important tool for weed management in castor bean crops with the increase in plant populations, mechanical control becomes problematic.

Large-scale cultivation of most agricultural species is possible only with the availability of selective herbicides because other techniques for weed control are extremely costly, requiring large amounts of labor inputs (SILVA et al., 2010a). Albuquerque et al. (2008) reports a lack of knowledge about herbicide selectivity in castor bean crops, which has hampered crop expansion into larger production areas. Vitorino et al. (2012) states that many herbicides are used for controlling castor beans in other crops, implying that limitations may exist in finding products to control eudicotyledonous weeds while simultaneously being selective to castor beans. This has led to research on chemical controls, which has been mainly directed to selectivity studies to find herbicides that, while showing a wide spectrum of weed species control, do not interfere with castor bean development.

Castor bean has selectivity to the herbicide trifluralin, which is used for weed control of the *Poaceae* family (monocotyledons), when the herbicide is incorporated as a pre-planting application (IPP) (MACIEL et al., 2007b) and as a pre-emergence (PRE) application (RAMOS et al., 2006; ALBUQUERQUE et al., 2008, MASCARENHAS et al., 2010; SOFIATTI et al., 2012). Trifluralin is the only herbicide that was registered at MALFS for this purpose (RODRIGUES; ALMEIDA, 1995; SOFIATTI et al., 2008). However, Maciel et al. (2012) reported that trifluralin application significantly increased the yield of the AL Guarany 2002 castor bean cultivar, when sowing seeds 5.0 cm deep, while the Iris and Savana hybrids both suffered yield reductions. Currently there is no herbicide registered for weed control in castor bean crops in Brazil (MALFS, 2011; RODRIGUES; ALMEIDA, 2011).

Among the herbicide options studied, most are products used for pre-emergence (BELTRÃO et al., 2006b; AZEVEDO et al., 2007) that predominantly control monocotyledon species and some eudicotyledons. However, for the herbicides that have been studied, the results of selectivity studies have varied, most likely due to differences in factors, such as: dosage, application mode, soil type, and plant genotype, among others.

In studies with the herbicide alachlor it was observed that it caused phytointoxication symptoms, or interference in germination, growth and/or initial development, when applied as a pre planting (IPP) (DAMASCENO et al., 2008) or a pre emergence (PRE) (RAMOS et al., 2006; SANTOS et al., 2008). Conversely, Moraes et al. (2008) did not find a reduction in castor bean germination when alachlor was applied as a PRE. As mentioned, these divergent results most likely occurred because of differences among soil classes between experiments, which may influence the adsorption of the chemical onto soil minerals and organic colloids. Due to the occurrence of phytointoxication reported by most authors, alachlor does not provide satisfactory castor bean selectivity.

In a study conducted over two consecutive crop seasons, evaluating castor bean yield, Beltrão et al. (2004) did not report phytointoxication symptoms in castor beans from either diuron or pendimethalin herbicides applied as a PRE in a clay soil. More recently, the harmful effects of diuron on the germination and initial growth of the castor bean crop were reported (SEVERINO et al., 2006b; MORAES et al., 2008). It is important to understand that in the study conducted by Beltrão et al. (2004) the soil was characterized by a high clay and organic matter content, which leads to a high adsorption capacity of the soil for diuron, on the contrary studies in soil with a lower percentage of clay show that the herbicide is not selective for castor beans.

Pendimethalin herbicide, belonging to the dinitroaniline chemical group, has been evaluated in castor bean crop initial stages of growth and development in studies conducted under greenhouse conditions. It has been published as selective when applied as a PRE (CARDOSO et al., 2006; SEVERINO et al., 2006c). Additionally, in some cases, pendimethalin may be phytotoxic as an IPP (SEVERINO et al., 2006c) or PRE (RAMOS et al., 2006). Studies conducted under field conditions indicated that the herbicide was selective for castor bean crops when applied as an IPP (MACIEL et al., 2007b) and as a PRE (SOFIATTI et al., 2012; MACIEL et al., 2012). With regards to herbicide efficacy, Manickan et al. (2009) reported that the PRE application of metolachlor or pendimethalin resulted in the satisfactory initial control of weeds and led to increases in castor bean yield. Additionally, Mascarenhas et al. (2010) observed selectivity for s-metolachlor as a PRE.

Research conducted with the herbicide clomazone showed phytotoxicity for both IPP and PRE applications on initial crop growth in castor beans (SEVERINO et al. 2006d; MASCARENHAS et al., 2010). Others have reported that there were no observed deleterious effects for this oilseed crop when PRE application was used (CARDOSO et al., 2006; THEISEN et al., 2006). Maciel et al. (2007b) reported selectivity for clomazone applied alone or as a clomazone + trifluralin tank mixture in field conditions with a sandy soil. Recently, Silva (2011) found that in French-sandy textured soils and in sandy soils low herbicide dosages were sufficient to cause a reduction in the root system growth and crop growth of castor beans. In this work, it was reported that the herbicide clomazone was selective for castor beans in dosages commonly recommended for weed control because the soil could be characterized by a high content of organic matter and/or a high argillaceous texture.

For the post-emergence control (POST) of monocotyledon species, ACCase-inhibitor herbicides show selectivity to castor bean crops and may be used when the application of pre-emergence herbicides fail. Mascarenhas et al. (2010) found no toxic effects to initial growth with fenoxaprop-p-ethyl, fluazifop-p-butil, sethoxydim and tepraloxydim. For tepraloxydim, Maciel et al. (2011) reported toxicity under field conditions; however, in the same study, fluazifop-p-butyl and sethoxydim, haloxyfop-methyl, quizalofop-p-ethyl, clethodim, propaquizafop and butroxydim did not cause either injury or decreased yield. Grichar et al. (2012) also found high selectivity for clethodim and fluazifop-p-butyl in the state of Texas (USA) during two seasons.

For eudicotyledon species control, Maciel et al. (2006b) noted selectivity of the herbicide chlorimuron-ethyl (ALS inhibitor) applied as a POST when plants had 4 to 5 and/or 7 to 8 leaves for the following castor bean genotypes: Lira, Iris, Savana and AL Guarany 2002. These results supported those of Sofiatti et al. (2008) with chlorimuron-ethyl as the only option for a selective latifolicide for application as a POST in castor bean crops. However, chlorimuron-ethyl may also be absorbed by castor bean root systems and cause phytointoxication, mainly in sandy soils that have low organic matter content (SILVA, 2010). Sofiatti et al. (2012) showed that weed management as a PRE with trifluralin, pendimethalin or clomazone, or weed management with the POST application of chlorimuron-ethyl, promoted satisfactory weed control without causing phytotoxic effects to the castor bean crop. POST application increased castor bean seed yields up to 21% when a complementing weed control as a PRE was used.

Even for POST applications, Silva et al. (2010c) found that the herbicide halosulfuron (ALS inhibitors) showed selectivity for castor bean crops in initial growth stages and is thus a good choice for *Cyperus rotundus* control. Other possibilities would be mixtures of nonselective herbicides, such as paraquat + bentazon and paraquat + diquat, applied as a directed spraying only between crop lines. This approach may also be used as an alternative to controlling weeds for POST emergence in castor bean crops (MACIEL et al., 2008). Vitorino et al. (2012) observed efficient weed control through the application of directed spraying using the herbicide saflufenacil singly or in a tank mixture with glyphosate.

Conversely, it has also been shown that various herbicides, which are nonselective for the crop, could assist in controlling castor bean volunteer plants, which eventually would infest succession crops. Among the herbicides that would control castor bean infestations in the successions crop are those used for pre-emergence: atrazine singly or in a mixture with simazine or metolachlor (CARDOSO et al., 2006; THEISEN et al., 2006), diclosulan and 2,4-D (ALBUQUERQUE et al., 2008), flumetsulan and imazaquin (RAMOS et al., 2006; ALBUQUERQUE et al., 2008), imazapic (CARDOSO et al., 2006; ALBUQUERQUE et al., 2008), imazapyr (ALBUQUERQUE et al., 2008), sulfentrazone (THEISEN et al., 2006; RAMOS et al., 2006) and isoxaflutole (RAMOS et al., 2006; ALBUQUERQUE et al., 2008; MASCARENHAS et al., 2010; MACIEL et al., 2011); as well as dicotyledon herbicides used for application as a post-emergence: pyrithiobac-sodium, lactofen, fomesafen (SOFIATTI et al., 2008), trifloxysulfuron-sodium (FERREIRA et al., 2009a) and saflufenacil (MONQUERO et al., 2011).

With regards to castor bean cultivation in no-tillage systems, the quality of weed control is directly related to management care prior to crop establishment, i.e., during the burning down operation, which is important for infestation suppression due to the mulch formed on the soil surface (MACIEL, 2006). Accordingly, Maciel et al. (2006c) reported the viability of different tank mixtures of glyphosate with chlorimuron-ethyl, carfentrazone and 2,4-D, for both weed control effectiveness in burning down and/or sowing time reduction for planting a castor bean crop. However, it was also observed that glyphosate+flumioxazin and paraquat+diuron mixtures caused crop phytointoxication. In this work, all treatments were seeded eight days after burning down and subjected to a clethodim + fenoxaprop-p-ethyl application at 25 DAE followed by a chlorimuron-ethyl application at 30 DAE, the goal was to control the new flows of weed emergence. Maciel et al. (2006d) evaluated burning down efficiency and the residual effects of glyphosate alone and glyphosate + 2.4-D on seed sowing. The authors identified the ideal sowing period for castor bean crops as being from 6 days after burning down, for tank mixtures with 2.4-D, indicating the possibility of castor bean cultivation in a system very close to an 'Apply and Plant' system.

Integrated weed management in castor bean

In general, for many agricultural crops, integrated weed management has contributed to more effective and sustainable weed control (ACCIARESI et al., 2003; MACHADO et al, 2006; GALON et al., 2007; RONCHI et al., 2008; PACHECO et al., 2009; FERREIRA et al., 2010; THEISEN; BIANCHI, 2010). This integration uses several control techniques to minimize weed interference in crops, keeping weed populations at levels below those that cause economic damage, while also mitigating negative effects on the environment (RONCHI et al., 2010). In castor bean crops, integrated weed management has occurred primarily as a result of other crop practices. This brings to light aspects which relate to the scarce information available for weed management in castor beans.

The use of an intercropping system, as a control method, has been shown to be effective in the suppression and reduction of infesting communities for several crops (MARTINS, 1994; MUELLER et al., 2001; SEVERINO et al., 2006e; MOTA et al. (2010); MACHADO et al., 2011). Castor beans have been intercropped predominantly with common beans, cowpea beans and maize (AZEVEDO et al., 2001), and this practice may assist in the management and reduction of infesting communities and, consequently, reduce the hoeing necessary between lines (mechanical control) of castor beans. However, there are no reports that confirm these and other benefits resulting from the association of cropping method versus the mechanical method for weed management in castor bean crops. According to technical recommendations, the distance of a secondary crop in intercropping, in relation to the sowing line for castor beans, must be at least 1 m, and weed control may occur in the total area for up to 60 days after emergence, which also would cover the critical period of competition for common beans (BELTRÃO et al., 2002). Therefore, the ideal hoeing area along castor bean lines, determined by Paulo et al. (1997), would correspond to the resultant area of recommended distance between intercropping crops, thus avoiding the interference of the secondary crop with the castor beans.

Manickam et al. (2009), in a study conducted with castor beans and peanuts intercropped in India, showed that the pre-emergent application of the herbicide metolachlor combined with weed control with a hoe and cultivator at 40 days after sowing (DAS), produced greater initial control of weeds when compared to mechanical control exclusively (at 20 and 40 DAS), with an increase in grain yield for both of the oilseed crops. However, when adapted for the no tillage crop system, the vegetation cover residues that are present on the soil surface may delay and/or reduce the emergence of some weed species in castor bean crops, both extending the available period for mechanical infestation control and requiring less herbicide application (MACIEL, 2006).

In addition to the previously discussed crop control practices, (sowing periods, plant populations, intercropping and mulching), crop rotation, especially in areas where the extent of the hydric system allows greater flexibility of the sowing period, may also be used as a weed control strategy when combined with mechanical and/or chemical practices. This may also be a viable strategy for weed control when the castor bean crop is grown with irrigation. 'Off-season' castor bean cultivation in the Brazil Central-South region shows high growth potential and could facilitate such crop practices. Additionally, in recent years, new castor bean hybrids and cultivars, which have a dwarf size, have been developed and adapted to mechanized production systems and no tillage systems (FERRARI NETO et al., 2011), thus allowing for increased planting.

Conclusion

Research in weed science for castor bean crop management is scarce. The majority of available data are related to chemical controls, primarily herbicide selectivity, followed closely by research on the weed interference periods for castor bean crops.

One of the main difficulties for weed control in castor bean crops is the current absence of registered herbicides at MALFS. For the viable herbicide prospects reported in this review to become registered, it would be necessary to direct the efforts of research institutions and/or rural extensions, associations and farmers cooperatives, combined with those of manufacturing companies, to register these selective herbicides (primarily latifolicides used to control eudicotyledons in castor bean crops). A joint effort of this magnitude could replace or even complement mechanical control practices for weed control and contribute to the expansion of oilseed production areas in Brazil.

New studies involving the development of integrated weed control methods in castor bean crops may also increase management efficiency, whether for the traditional production systems in the Northeast semi-arid region of Brazil, or for areas with the potential for large-scale production (preferably under no-tillage systems).

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