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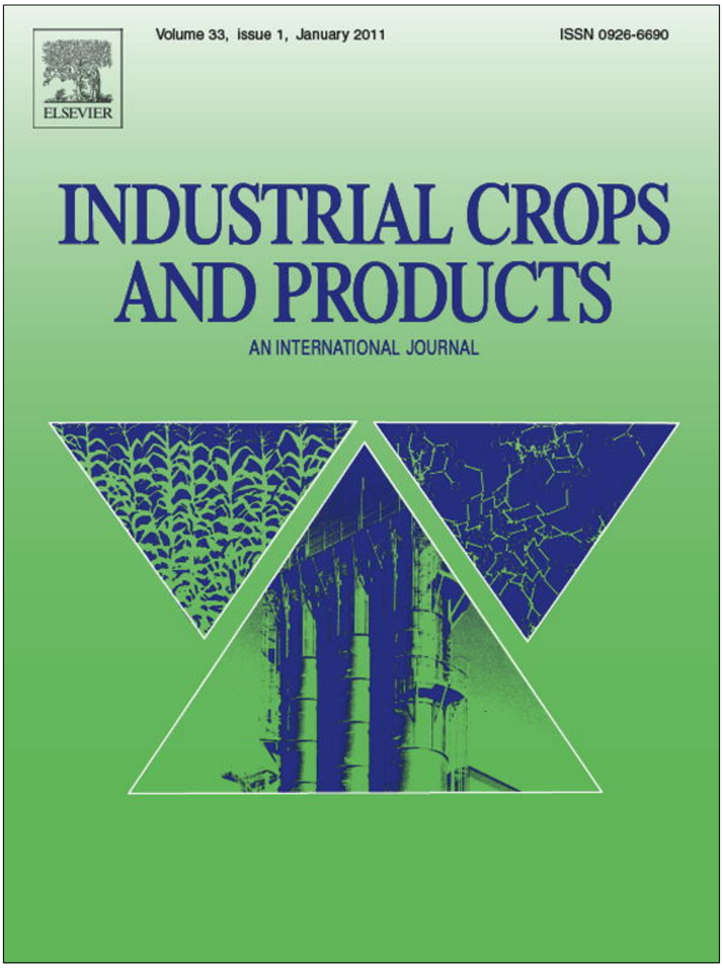

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Short communication

Pre and postemergence herbicides for weed control in castor crop

Valdinei Sofiatti[a], Liv S. Severino[a,b,*], Franklin M.O. Silva[c], Vivianny N.B. Silva[c], Giovani G. Brito[a]

[a] Embrapa Algodão, Rua Oswaldo Cruz, 1143, CEP 58428-095, Campina Grande, PB, Brazil
[b] Texas Tech University, Dep. Plant and Soil Science, Lubbock, TX 79409-2122, United States
[c] Universidade Estadual da Paraíba, Brazil

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ABSTRACT

Weed management is among the main factors limiting cultivation of castor (*Ricinus communis*) in extensive fields, particularly when labor is scarce or expensive. This experiment evaluated the efficiency of weed management programs using preemergence (clomazone, pendimethalin, and trifluralin) and a postemergence herbicide (chlorimuron-ethyl) applied at 20 days after emergence in castor plants cv. BRS Energia under rainfed conditions in Apodi, Brazil. No phytotoxicity was observed on the castor plants, and the postemergence herbicide significantly increased castor seed yield to 1466 kg ha^{-1} complementing the weed control of preemergence herbicides treatments in which seed yield was 1207 kg ha^{-1}. Seed yield on weedy and weed-free treatments was 760 and 1971 kg ha^{-1}, respectively. Weeds were kept under a satisfactory control up to 40 days after emergence. This program resulted in reasonable weed control because the preemergence herbicides controled monocotyledon weeds, while the postemergence herbicide controlled broad leafed species being selective to castor plants.

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1. Introduction

Castor plant (*Ricinus communis*) is very sensitive to competition with weedy plants. Weeds are able to grow quickly because castor plants grow slowly, and their large leaves are inefficient for intercepting the light (Silva, 2005). Herbicides are the best option for weed management in extensive castor fields when labor is unavailable or expensive, but this option is being limited by the lack of efficient herbicide programs.

An important property of an herbicide is the selectivity to control weeds without being toxic to the crop. Some postemergence herbicides (POST) without selectivity for castor (e.g. glyphosate, paraquat, bentazon, and 2,4-D) can be applied using hoods (Maciel et al., 2008); however, this method is inefficient because only weeds growing between rows can be reached, and there is a risk of injury to the crop.

The finding of chlorimuron-ethyl as an herbicide selective to castor plants when applied in postemergence (Sofiatti et al., 2008) made possible the development of efficient weed management programs for this oilseed crop combining POST and PRE herbicides. The PRE herbicides selective to castor (alachlor, trifluralin, pendimethalin, and clomazone) (Maciel et al., 2007) are efficient against monocotyledon species, but they have lower efficiency against broad leafed plants.

Chlorimuron-ethyl is an ALS inhibiting herbicide used primarily in soybean crop (*Glycine max*) (Gonzini et al., 1999; Culpepper et al., 2000; Brighenti et al., 2002). It had an efficient weed control when tested in peanut (*Arachys hypogea*) (Price et al., 2007) and sorghum (*Sorghum bicolor*) (Reddy et al., 2007) but not on kenaf (*Hibiscus cannabinus*) (Kurtz, 1996). The selectivity of chlorimuron-ethyl in soybean plants occurs due to a rapid metabolism of the herbicide (Brown and Neighbors, 1987), and the selectivity of PRE herbicides to castor occurs due to the depth of sowing (Maciel et al., 2007).

Our objective was to evaluate the efficacy of weed management programs in castor crop based on PRE herbicides (clomazone, trifluralin, and pendimethalin) followed by the POST herbicide chlorimuron-ethyl.

2. Materials and methods

An experiment was run in Apodi, State of Rio Grande do Norte (5°37′S, 37°49′W, 120 m a.s.l.). The genotype BRS Energia (short stature, indehiscent fruits) was planted in rainfed conditions at 11,111 plants ha^{-1} (1.0 m × 0.9 m). Fertilization was made according to Severino et al. (2006): 30 kg ha^{-1} of N, 60 kg ha^{-1} of P_2O_5, and 60 kg ha^{-1} of K_2O at planting, and a dressing with 30 kg ha^{-1} of N at 30 days after emergence.

Ten treatments were adopted from a 4 × 2 + 2 factorial combination. Factors were four PRE herbicides and use or not of POST herbicide; a positive and negative control were non-weeded

* Corresponding author at: Embrapa Algodão, Rua Oswaldo Cruz, 1143, CEP 58428-095, Campina Grande, PB, Brazil. Tel.: +55 83 3182 4300.
E-mail address: liv@cnpa.embrapa.br (L.S. Severino).

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Table 1
Weed control (%) at 20, 40, and 60 days after sowing (DAS) of herbicides applied in preemergence and postemergence (POST) on castor crop.

Herbicide applied in preemergence	Weed control at 20 DAS	Weed control at 40 DAS		Weed control at 60 DAS		Control of *Cenchrus echinatus* at 60 DAS		Control of *Waltheria indica* at 60 DAS	
		Without POST	With POST	Without POST	With POST	Without POST	With POST	Without POST	With POST
Clomazone	82 a	75 aB	91 aA	54 aA	66 aA	97 aA	96 aA	98 aA	100 aA
Clomazone + trifluralin	82 a	78 aB	88 aA	58 aA	65 aA	87 aA	88 aA	90 aA	90 aA
Pendimethalin	75 a	77 aA	81 aA	62 aA	58 aA	86 aA	90 aA	89 aA	98 aA
Trifluralin	58 b	58 bB	83 aA	48 aB	62 aA	90 aA	96 aA	13 bB	88 aA
Average	74	72 B	86 A	55 B	63 A	90 A	93 A	73 B	94 A

Means are not different by Tukey test (5%) if followed by the same small letter in the column or the same capital letter in the row.

Table 2
Plant height, yield components, and seed yield of castor (*Ricinus communis*) under weed management combining preemergence (PRE) and postemergence (POST) herbicides.

Herbicide treatment	Plant height (m)	Racemes per plant	Seed weight (mg)	Seeds per raceme	Seed yield (kg ha^{-1})
Clomazone (PRE)	1.59 a	7.0 a	279 a	96 a	1390 a
Clomazone + trifluralin (PRE)	1.57 a	6.5 a	310 a	81 a	1345 a
Pendimethalin (PRE)	1.55 a	7.5 a	308 a	81 a	1334 a
Trifluralin (PRE)	1.60 a	6.8 a	298 a	84 a	1277 a
Without chlorimuron-ethyl (POST)	1.60 a	6.5 a	297 a	82 a	1207 a
With chlorimuron-ethyl (POST)	1.56 a	7.5 a	301 a	89 a	1466 b
Weedy	1.34 a	5.7 a	302 a	57 a	760 a
Hoeing	1.59 b	6.2 a	318 a	111 b	1971 b

Means followed by the same letter are not significantly different according to the *F* test of the analysis of variance (5%).

(weedy) and hand-hoeing treatments. PRE herbicide treatments were clomazone (750 g a.i. ha^{-1}), clomazone + trifluralin (500 + 1200 g a.i. ha^{-1}), pendimethalin (1500 g a.i. ha^{-1}), and trifluralin (1800 g a.i. ha^{-1}). The POST herbicide was chlorimuron-ethyl (15 g a.i. ha^{-1}). In the weed-free treatment hand-hoeing was performed three times up to 60 days after sowing (DAS). The experimental design was completely randomized blocks with five replications. Each plot had six rows 7 m long, and data was collected on the four central rows.

PRE herbicides were applied immediately after sowing. The POST herbicide was sprayed covering the whole plot at 20 DAS, when broad leafed weeds had between 2 and 6 leaves. Herbicides were applied using a compressed CO_2 backpack sprayer delivering 200 L ha^{-1}, at 2.0 kgf cm^{-2} of pressure, spraying at 40 cm from the canopy.

Visual evaluation of herbicide's phytotoxicity on castor plants was done at 20, 40, and 60 DAS using the scale proposed by the EWRC (1964), which consist in scores varying from 1 (no injury) to 9 (plant's death). The efficiency of weed control was visually estimated, taking the treatment managed by hand-hoeing as reference of 100% of control, and the weedy treatment as 0% of control (Gazziero et al., 1995). At 20 DAS, phytotoxicity was estimated prior to application of POST herbicides. At 60 DAS, the efficiency for controlling the two predominating weed species (*Cenchrus echinatus* and *Waltheria indica*) was estimated through the same method.

Data on plant height and number of racemes per plant in two central rows was taken just before harvesting. The number of seeds per raceme and seed weight was measured in one plant per plot, and seed yield was measured on the whole plot. Data was submitted to analysis of variance Tukey test (5%) for comparison of means.

3. Results and discussion

No phytotoxicity was observed in castor plants due to the PRE and POST herbicides. At 20 DAS, weed control of trifluralin (58%) was smaller than the other three PRE herbicides (75–82%) (Table 1). At 40 DAS, chlorimuron-ethyl (applied 20 days before) was effective to complement and increase the weed control of clomazone (from 75 to 91%), clomazone + trifluralin (from 78 to 88%), and trifluralin (from 58 to 83%). At 60 DAS, the weed control on average had been significantly increased by the POST herbicide from 55 to 63% (Table 1).

The weed *C. echinatus* was not controlled by chlorimuron-ethyl because this herbicide has low toxicity against monocotyledons; nevertheless, this weed was satisfactorily controlled by clomazone and pendimethalin. In an opposite way, the weed *W. indica* was not controlled by trifluralin (PRE) but by chlorimuron-ethyl (13 compared to 88%) (Table 1).

Plant height and yield components were not influenced by any PRE or POST herbicide treatment (Table 2). Plant height and number of seeds per raceme were reduced in the weedy treatment compared to the hand-hoeing treatment. Seed yield was equal in all PRE herbicide treatments, but the use of the POST herbicide significantly increased seed yield from 1207 to 1466 kg ha^{-1}. In the weedy treatment seed yield was 760 kg ha^{-1}, and on hoeing treatment it was 1971 kg ha^{-1} (Table 2). Because the highest yield of herbicide treatments was only 74% of the hoeing treatment, it is likely that more efficient weed management programs can be developed.

4. Conclusions

The weed management of castor crop was satisfactory with a program combining PRE herbicides (clomazone, pendimethalin, or trifluralin) and a POST herbicide (chlorimuron-ethyl) applied at 20 days after emergence.

No phytotoxicity was observed on castor plants, and the POST herbicide significantly increased castor seed yield complementing the weed control of PRE herbicides. Weeds were kept under a satisfactory control up to 40 days after emergence. The efficiency of this herbicide program was adequate because the PRE herbicides were effective against monocotyledons and the POST herbicide was effective against broad leafed weeds.

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References

Brighenti, A.M., Adegas, F.S., Bortoluzi, E.S., Almeida, L.A., Voll, E., 2002. Soybean genotype tolerance to trifluralin and imazaquin. Planta Daninha 20, 63–69, doi:10.1590/S0100-83582002000100009.

Brown, H.M., Neighbors, S.M., 1987. Soybean metabolism of chlorimuron ethyl: physiological basis for soybean selectivity. Pestic. Biochem. Physiol. 29, 112–120.

Culpepper, A.S., York, A.C., Batts, R.B., Jennings, K.M., 2000. Weed management in glufosinate- and glyphosate-resitant soybean (*Glycine max*). Weed Technol. 14, 77–88.

EWRC – European Weed Research Council, 1964. Committee of Methods in Weed Research, 4, 88.

Gazziero, D.L.P., Velini, E.D., Osipe, R., 1995. Procedimentos para instalação, avaliação e análise de experimentos com herbicidas. Sociedade Brasileira da Ciência de Plantas Daninhas, Londrina.

Gonzini, L.C., Hart, S.E., Wax, L.M., 1999. Herbicide combinations for weed management in glyphosate-resistant soybean (*Glycine max*). Weed Technol. 13, 354–360.

Kurtz, M.E., 1996. The influence of preemergence applied herbicides on kenaf stand, height, and yield. Ind. Crops Prod. 5, 265–271.

Maciel, C.D.G., Poletine, J.P., Velini, E.D., Amaral, J.G.C., Zani, L.P., Santos, R.F., Rodrigues, M., Raimondi, M.A., Ribeiro, R.B., 2008. Possibility of applying total action herbicide tank mixture using direct sprayer on dwarf internode castor bean. Planta Daninha 26, 457–464, doi:10.1590/S0100-83582008000200023.

Maciel, C.D.G., Poletine, J.P., Velini, E.D., Zanotto, M.D., Amaral, J.G.C., Santos, H.R., Artioli, J.C., Silva, R.R.M., Ferreira, R.V., Lolli, J., Raimondi, M.A., 2007. Herbicide selectivity in castor bean cultivars. Rev. Bras. Oleaginosas Fibrosas 11, 47–54.

Price, A.J., Reeves, D.W., Patterson, M.G., Gamble, B.E., Balkcom, K.S., Arriaga, F.J., Monks, C.D., 2007. Weed control in peanut grown in a high-residue conservation-tillage system. Peanut Sci. 34, 59–64.

Reddy, K.N., Bryson, C.T., Burke, I.C., 2007. Ragweed partheniun (*Partheniun hysterophorus*) control with preemergence and postemergence herbicides. Weed Technol. 21, 982–986, doi:10.1614/WT-07-053.1.

Severino, L.S., Ferreira, G.B., Moraes, C.R.A., Gondim, T.M.S., Freire, W.S.A., Castro, D.A., Cardoso, G.D., Beltrão, N.E.M., 2006. Growth and yield of castor bean fertilized with macronutrients and micronutrients. Pesqui. Agropecuária Bras. 41, 563–568.

Silva, S.D.A., 2005. A cultura da mamona na região de clima temperado: informações preliminares. Embrapa Clima Temperado, Pelotas.

Sofiatti, V., Silva, D.M.A., Severino, L.S., Silva, F.M.O., Cardoso, G.D., Freire, M.A.O., Sampaio, L.R., 2008. Seletividade de herbicidas pós-emergentes à cultura da mamoneira. Congresso Brasileiro de Mamona, 3rd., Embrapa Algodão, Campina Grande (available at: www.cnpa.embrapa.br/produtos/mamona/publicacoes/cbm3/trabalhos/manejo%20cultural/mc%2025.pdf).