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Can pre- and/or post-emergent herbicide application affect soybean seed quality?

Aplicações de herbicidas em pré e/ou pós-emergência da soja podem afetar a qualidade de sementes?

Jamile M. Ceretta[1], Alfredo J. P. Albrecht[2], Leandro P. Albrecht[2], André F. M. Silva[3]*, Andressa Sa. Yokoyama[2]

[1]Department of Agronomic Sciences, Universidade Estadual de Maringá, Umuarama, PR, Brazil. [2]Department of Agronomic Sciences, Universidade Federal do Paraná, Palotina, PR, Brazil. [3]Crop Pesquisa, Maripá, PR, Brazil.

ABSTRACT - Soybean cultivation requires herbicide application in the off-season, before emergence for weed desiccation, and after emergence. It is believed that the use of pre- and post-emergent herbicides combined with preharvest application may negatively affect the quality of soybean seeds. As such, the present study aimed to assess the effect of pre- and post-emergent herbicides on soybean seed quality. Five field experiments were conducted during the 2018/2019 and 2019/2020 growing seasons to investigate the effects of synthetic auxins and pre-emergents, acetyl-CoA carboxylase (ACCase) inhibitors, broadleaf herbicides, and s-metolachlor or clomazone on the quality of soybean seeds. Dicamba application combined with the pre-emergent herbicides imazethapyr/flumioxazin before soybean planting reduced seed vigor and germination. ACCase inhibitors in association with broadleaf herbicides before planting had no effect on seed quality. Applying s-metolachlor (up to 2,880 g of active ingredient [ai] ha^{-1}) or clomazone (up to 1,800 g ai ha^{-1}) was safe for seed germination, even when used after soybean emergence.

Keywords: *Glycine max.* Synthetic auxins. Acetyl-CoA carboxylase. S-metolachlor. Clomazone.

RESUMO - No cultivo da soja, faz-se necessário a aplicação de herbicidas na entressafra, com a associação de herbicidas para a dessecação das plantas-daninhas com pré-emergentes, bem como com aplicações em pós-emergência da soja. Acredita-se que herbicidas aplicados na dessecação pré-semeadura soja, em associação com herbicidas pré-emergentes, bem como herbicidas pré -emergentes aplicados em pós-emergência da soja, possam afetar negativamente a qualidade de sementes da cultura. Assim, objetivou-se com este estudo avaliar o efeito de herbicidas, aplicados em pré ou pós-emergência da soja, na qualidade de sementes produzidas. Foram conduzidos cinco experimentos no campo, durante as safras 2018/2019 e 2019/2020. Foram investigados os efeitos de auxinas sintéticas e pré-emergentes, inibidores da ACCase e latifolicidas, e s-metolachlor ou clomazone sobre a qualidade de sementes produzidas. A aplicação de dicamba em associações com os herbicidas pré-emergentes imazethapyr/flumioxazin, em pré-semeadura da soja, diminuiu o vigor e germinação das sementes. A aplicação de herbicidas inibidores da ACCase em associação com latifolicidas, em pré-semeadura, não teve impacto sobre a qualidade das sementes. A aplicação de s-metolachlor (até 2.880 g de ingrediente ativo [ia] ha^{-1}) ou de clomazone (até 1.800 g ia ha^{-1}) foi segura para a germinação das sementes, mesmo para a aplicação em pós-emergência da cultura.

Palavras-chave: *Glycine max.* Auxinas sintéticas. Inibidores da acetil-CoA carboxilase. S-metolachlor. Clomazone.

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***Corresponding author:**
<afmoreirasilva@alumni.usp.br>

INTRODUCTION

In grain farming, herbicides are often used in the off-season, primarily to manage difficult-to-control weeds, combining burndown with pre-emergent herbicides applied before planting (ALBRECHT et al., 2021). Dicotyledonous (dicot or broadleaf) weeds can be controlled using synthetic auxins, such as 2,4-D and dicamba (ASKEW et al., 2021; CANTU et al., 2021), among other broadleaf herbicides, including protoporphyrinogen oxidase (PPO) (COPES et al., 2021) or acetolactate synthase (ALS) inhibitors (KASPARY et al., 2021).

The most common herbicides used to control grass weeds are acetyl-CoA carboxylase (ACCase) inhibitors, often combined with herbicides that have other mechanisms of action either to improve efficacy or due to the presence of dicots (BAUER et al., 2021; AGOSTINETTO et al., 2022). Post-emergent and/or residual herbicides can be used, the latter persisting in the soil until vegetative development of the subsequent crop.

Pre-emergent herbicides with a residual effect until soybean vegetative development are essential in managing difficult-to-control weeds. In this respect, the postemergence application of residual herbicides such as s-metolachlor and clomazone (SARANGI; JHALA, 2019; HARRE et al., 2021) has been investigated in soybean in order to achieve a longer residual effect within the crop cycle.

However, the selectivity of these herbicides for soybean is a key factor in agronomic efficiency. Selectivity describes the different responses of crops to herbicide application, whereby the plants may be injured or not. The severity of this damage varies according to the application conditions, physiological status, plants' ability to recover after herbicide application by molecule inactivation/metabolization and plant morphology (NANDULA et al., 2019).

Seed quality is a set of traits that determine the value of seeds for planting and involves interaction between genetic, physical, physiological and health attributes (MARCOS FILHO, 2015). Stressors that cause physiological changes in soybean can affect seed quality parameters such as viability and vigor (ALBRECHT et al., 2012). Although studies have identified negative effects of herbicides on seed quality, most involve postemergence application (SILVA et al., 2018a; GARCIA et al., 2020) or preharvest desiccants (ZUFFO et al., 2020).

For pre-emergent herbicides, studies have evaluated their effectiveness in weed control (DE SANCTIS et al., 2021; PATEL et al., 2023) and/or selectivity for soybean, as well as their effect on initial growth, yield and other agronomic performance parameters (FORNAZZA et al., 2018; ARSENIJEVIC et al., 2021). Research on the quality of the seeds produced is scarce; however, Marchi et al. (2021) found that flumioxazin applied preemergence had a minimal effect on the electrical conductivity of soybean seeds.

It is believed that pre-emergent herbicides applied postemergence and combined with burndown herbicides used pre-planting may negatively affect the quality of soybean seeds. As such, the present study aimed to assess the effect of pre- and post-emergent herbicide application on soybean seed quality.

MATERIAL AND METHODS

Five field experiments were conducted in Paraná state, Brazil, in the 2018/2019 and 2019/2020 growing seasons. Climate in the region is Cfa (humid subtropical), according to the Koppen-Geiger classification, with average annual temperature and rainfall of approximately 15 to 37 ºC and 1,650 mm. The geographic coordinates and location of the experimental areas as well as the soybean cultivars used and results of soil physical analysis and organic matter content are presented in Table 1. All the experiments used a no-till system, with 12 soybean seeds m^{-1} and 0.45 m between rows.

Table 1. Geographic coordinates, location, growing seasons and soybean cultivars used in the experiments.

Experiment	Coordinates	Location	Growing Season	Cultivar	Maturity group	Planting date
1	24°28'28''S 53°51'40''W	Assis Chateaubriand	2018/2019	M5917 IPRO	5.9	09/17/2018
2	24°23'27''S 53°84'51''W	Palotina	2018/2019	BS2606 IPRO	6.0	09/11/2018
3	24°20'52"S 53°51'42"W	Palotina	2019/2020	M5947 IPRO	5.9	11/22/2019
4	24°20'52"S 53°51'42"W	Palotina	2019/2020	M5947 IPRO	5.9	11/22/2019
5	24°20'36"S 53°51'58"W	Palotina	2019/2020	M5947 IPRO	5.9	10/23/2019

Results of soil physical analysis and organic matter content					
Experiment	Clay	Silt	Sand	Texture	Organic matter
	%				
1	61	19	20	Very clayey	2.2%
2	63	18	19	Very clayey	2.6%
3	65	17	18	Very clayey	2.7%
4	66	16	18	Very clayey	2.5%
5	62	19	19	Very clayey	2.5%

The field experiments were carried out in a randomized block design with four repetitions and the experimental units consisted of plots containing six 5-meter-long rows. The treatments in experiments 1, 2, 3 and 4 are described in Tables 2, 3 and 4. In experiment 5, the treatments involved applying 6 doses (0; 360; 720; 1,080; 1,440; 1,800 g ai ha^{-1}) of the herbicide clomazone (Reator® 360 CS) after soybean emergence.

Table 2. Treatments involving individual or combined pre-planting application of synthetic auxins and pre-emergent herbicides. Assis Chateaubriand, PR, Brazil, 2018/2019 (experiment 1).

Treatment	Commercial product	Dose[1]
		g ae or ai ha^{-1}
Control with no herbicide	-	-
Saflufenacil	Heat®	35
2,4-D	DMA® 806 BR	1,340
Dicamba	Atectra®	480
Saflufenacil + diclosulam	Heat® + Spider® 840 WG	35 + 35.3
Dicamba + saflufenacil	Atectra® + Heat®	480 + 35
Dicamba + chlorimuron	Atectra® + Classic®	480 + 20
Dicamba + diclosulam	Atectra® + Spider® 840 WG	480 + 35.3
Dicamba + sulfentrazone/diuron	Atectra® + Stone®	480 + 245/490
Dicamba + imazethapyr/flumioxazin	Atectra® + Zethamaxx®	480 + 120/60

[1]Doses in g of acid equivalent (ae) ha^{-1} for 2,4-D, dicamba and imazethapyr, and in g of active ingredient (ai) ha^{-1} for the remaining herbicides.

Table 3. Treatments involving individual or combined preemergence application of ACCase inhibitors and broadleaf herbicides. Palotina, PR, Brazil, 2018/2019 (experiment 2).

Treatment	Commercial product	Dose[1]
		g ae or ai ha^{-1}
Control with no herbicide	-	-
Clethodim	Select® 240 EC	192
Haloxyfop	Verdict® R	120
Clethodim + 2,4-D	Select® 240 EC + DMA® 806 BR	192 + 1,005
Haloxyfop + 2,4-D	Verdict® R + DMA® 806 BR	120 + 1,005
Clethodim + triclopyr	Select® 240 EC + Triclon®	192 + 960
Haloxyfop + triclopyr	Verdict® R + Triclon®	120 + 960
Clethodim + dicamba	Select® 240 EC + Atectra®	192 + 480
Haloxyfop + dicamba	Verdict® R + Atectra®	120 + 480
Clethodim + carfentrazone	Select® 240 EC + Aurora® 400 EC	192 + 30
Haloxyfop + carfentrazone	Verdict® R + Aurora® 400 EC	120 + 30
Clethodim + saflufenacil	Select® 240 EC + Heat®	192 + 49
Haloxyfop + saflufenacil	Verdict® R + Heat®	120 + 49
Clethodim + chlorimuron	Select® 240 EC + Classic®	192 + 20
Haloxyfop + chlorimuron	Verdict® R + Classic®	120 + 20

[1]Doses in g of acid equivalent (ae) ha^{-1} for haloxyfop, 2,4-D, triclopyr and dicamba, and in g of active ingredient (ai) ha^{-1} for the remaining herbicides. Except for the control, 1,080 g ae ha^{-1} + 192 g ai ha^{-1} of glyphosate (Roundup® Original) + clethodim (Select® 240 EC) were applied in all the treatments in soybean stage R_1.

Table 4. Treatments consisting of s-metolachlor or clomazone doses applied at three intervals after soybean planting. Palotina, PR, Brazil, 2018/2019 (experiments 3 and 4). Commercial products: Dual Gold® (s-metolachlor), Reator® 360 CS (clomazone).

Herbicide dose		Application time
Experiment 3 (s-metolachlor)	Experiment 4 (clomazone)	
g of active ingredient (ai) ha^{-1}		Days after planting (DAP)
960	360	0
1,920	720	14
2,880	1,080	28

In experiment 1, the herbicides were applied 37 days before soybean planting. In experiments 1 and 2, all the herbicides were added with glyphosate (1,080 g acid equivalent [ae] ha^{-1} - Roundup® Original), since the treatments simulate pre-planting herbicide application for weed control; however, this was not considered in the analyses because glyphosate has no effect when used pre-emergence (in the soil). For experiment 2, the herbicides were applied on the day of soybean planting immediately after, and except for the control without application at the R_1 soybean stage, glyphosate + clethodim (Select® 240 EC) (1,080 g ae ha^{-1} + 192 g ai ha^{-1}), in simulation of herbicide application to control post-emergence weed grass escapes in soybean.

Experiments 3 and 4 were arranged in a ([3x3]+1) factorial scheme, consisting of three herbicide doses at three applications times, in addition to the control treatment (no herbicide). The herbicides were applied at 14 and 28 days after planting (DAP), when the soybean crops were at stages V_C-V_1 and V_2-V_3, respectively. Treatment application in experiment 5 occurred in stage V_4-V_5. All the treatments were applied using a CO_2 pressurized backpack sprayer equipped with six AIXR 110.015 nozzles, operating at a pressure of 2.0 kgf cm^{-2}, flow rate of 3.6 km h^{-1} and application volume of 150 L ha^{-1}.

In all the experiments, seeds were collected along 4 m of the four center rows of each plot to assess seed quality. The samples were stored in paper bags under controlled temperature and moisture conditions and sent to the laboratory for subsequent testing. The following were assessed to determine seed quality: vigor, germination and electrical conductivity in experiments 1 and 2, and germination in experiments 3, 4 and 5 (BRASIL, 2009).

Germination tests were performed using four repetitions per field plot, with four sub-samples of 50 seeds in each field repetition per treatment, placed between three sheets of filter paper moistened with demineralized water at 2.5 times the weight of the dry paper. The sheets were rolled up and placed in a germination chamber at a constant temperature of 25 ºC. The first count (indicating vigor) was performed at 5 days, when all normal and abnormal germinated seeds were removed from the rolls and the remainder returned to the germination chamber until the second count, carried out 8 days after the test began. The germination percentage was calculated by adding the results of the two counts.

To determine electrical conductivity, two sub-samples of 50 seeds per field plot were weighed and placed in plastic cups added with 75 mL of deionized water. The cups were placed in a germination chamber at 25 ºC for 24 h under a 12-h photoperiod and electrical conductivity was determined using a conductivity meter. The result was divided by the weight of the seeds to obtain a value in $\mu.cm^{-1}.g^{-1}$ (LOEFFLER; TEKRONY; EGLI, 1988).

The data from experiments 1 and 2 were submitted to analysis of variance (ANOVA) via the F test ($p \leq 0.05$) and the means of the treatments grouped by the Scott-Knott test ($p \leq 0.05$). The data obtained in experiments 3 and 4 were analyzed by ANOVA using the F test ($p \leq 0.05$) and the levels of the factors compared by Tukey's test ($p \leq 0.05$). For experiment 5, the clomazone doses were submitted to regression analysis ($p \leq 0.05$). Sisvar software version 5.6 was used for all the analyses (FERREIRA, 2011).

RESULTS AND DISCUSSION

ANOVA found no significant effect for synthetic auxins and pre-emergent herbicides ($p > 0.05$) on electrical conductivity. A significant effect was observed for vigor and germination ($p \leq 0.05$). The lowest seed vigor (62.3%) and germination (63%) were recorded for dicamba + imazethapyr/ flumioxazin application, including in relation to the control. The remaining herbicide treatments had no negative effect on seed quality for any of the variables analyzed. Although differences in electrical conductivity were observed, no treatment obtained higher values than the control (no herbicide), with high electrical conductivity indicating greater seed deterioration (Table 5).

For ACCase inhibitors and broadleaf herbicides, ANOVA demonstrated no significant effect ($p > 0.05$) on the vigor, germination and electrical conductivity of the seeds produced. Even glyphosate + clethodim application in R_1 had no significant effect on these variables in relation to the control (no herbicide) (Table 6).

Table 5. Quality of soybean seeds produced under individual or combined pre-planting application of synthetic auxins or pre-emergent herbicides. Assis Chateaubriand, PR, Brazil, 2018/2019 (experiment 1).

Treatment	Dose[1]	Vigor	G[2]	EC[3]
	g ea or ai ha^{-1}	%		$\mu S\ cm^{-1}g^{-1}$
Control with no herbicide	-	85.0 a	86.4 a	117.6 b
Saflufenacil	35	83.3 a	84.8 a	144.6 b
2,4-D	1,340	87.0 a	88.3 a	78.1 a
Dicamba	480	86.0 a	90.5 a	96.1 a
Saflufenacil + diclosulam	35 + 35.3	78.3 a	82.0 a	131.7 b
Dicamba + saflufenacil	480 + 35	82.0 a	84.8 a	133.2 b
Dicamba + chlorimuron	480 + 20	88.3 a	90.3 a	115.0 b
Dicamba + diclosulam	480 + 35.3	77.5 a	78.0 a	122.3 b
Dicamba + sulfentrazone/diuron	480 + 245/490	77.8 a	78.8 a	152.6 b
Dicamba + imazethapyr/flumioxazin	480 + 120/60	62.3 b	63.0 b	119.8 b
	Mean	80.8	82.6	121.1
	CV (%)	8.7	7.2	20.3
	F	4.6*	7.5*	3.2^{ns}

[1]Doses in g of acid equivalent (ae) ha^{-1} for 2,4-D, dicamba and imazethapyr, and in g of active ingredient (ai) ha^{-1} for the remaining herbicides. [2]Germination. [3]Electrical conductivity.
*Means followed by the same letter in the row do not differ according to the Scott-Knott test at 5%. [ns] Not-significant, means did not differ according to the F test at 5% probability.

Table 6. Quality of soybean seeds produced under individual or combined pre-planting application of ACCase inhibitors or broadleaf herbicides. Palotina, PR, Brazil, 2018/2019 (experiment 2).

Treatment	Dose[1]	Vigor	G[2]	EC[3]
	g ae or ai ha^{-1}	%		$\mu S\ cm^{-1}g^{-1}$
Control with no herbicide	-	92.0	93.3	61.4
Clethodim	192	87.8	92.0	50.4
Haloxyfop	120	91.0	93.3	54.3
Clethodim + 2,4-D	192 + 1.005	89.5	92.8	54.2
Haloxyfop + 2,4-D	120 + 1.005	88.3	92.8	64.2
Clethodim + triclopyr	192 + 960	93.0	93.8	60.5
Haloxyfop + triclopyr	120 + 960	87.8	90.8	64.6
Clethodim + dicamba	192 + 480	85.3	89.5	57.9
Haloxyfop + dicamba	120 + 480	89.5	93.5	53.7
Clethodim + carfentrazone	192 + 30	87.5	92.5	56.2
Haloxyfop + carfentrazone	120 + 30	89.0	95.0	64.3
Clethodim + saflufenacil	192 + 49	89.8	92.3	60.8
Haloxyfop + saflufenacil	120 + 49	87.5	91.5	59.8
Clethodim + chlorimuron	192 + 20	90.6	94.3	58.6
Haloxyfop + chlorimuron	120 + 20	89.3	92.8	66.4
	Mean	89.2	92.7	59.1
	CV (%)	4.7	3.8	15.0
	F	15.5^{ns}	7.5^{ns}	87.8^{ns}

[1]Doses in g of acid equivalent (ae) ha^{-1} for haloxyfop, 2,4-D, triclopyr and dicamba, and in g of active ingredient (ai) ha^{-1} for the remaining herbicides. [2]Germination. [3]Electrical conductivity. 1,080 g ae ha^{-1} + 192 g ai ha^{-1} of glyphosate (Roundup® Original) + clethodim (Select® 240 EC) were applied in all the treatments in soybean stage R_1, except for the control with no herbicide.
[ns] Non-significant, means did not differ according to the F test at 5% probability.

ANOVA revealed no effect for s-metolachlor or clomazone ($p > 0.05$) or for time between planting and application ($p > 0.05$), and there was no significant interaction ($p > 0.05$) between herbicide doses and time between planting and application (Table 7). In experiment 5, clomazone doses could not be adjusted ($p > 0.05$) for seed germination in postemergence soybean application (V_5-V_6) (Table 8).

Table 7. Seed germination of soybean cultivars grown under s-metolachlor or clomazone application. Palotina, PR, Brazil, 2018/2019 (experiments 3 and 4).

S-metolachlor		Clomazone	
Dose	Germination	Dose	Germination
g i.a. ha^{-1}	%	g ai ha^{-1}	%
960	89.4	360	90.3
1.920	88.1	720	90.3
2.880	89.6	1,080	85.7
Application		Application	
DAP[1]		DAP[1]	
0	89.4	0	88.8
14	89.9	14	89.8
28	87.8	28	87.9
Control	90.5	Control	89.5
F Dose (D)	0.7^{ns}	F Dose (D)	2.2^{ns}
F Application (A)	0.3^{ns}	F Application (A)	0.2^{ns}
F D x A	0.1^{ns}	F D x A	0.3^{ns}
Mean	89.2	Mean	88.9
CV (%)	5.4	CV (%)	6.9

[1]Days after planting.
[ns] Non-significant, means did not differ according to the F test at 5% probability.

Table 8. Quality of soybean seeds produced under postemergence clomazone application. Palotina, PR, Brazil, 2019/2020 (experiment 5).

Doses	Germination
g ai ha^{-1}	%
0	96.3
360	97.8
720	97.5
1,080	98.3
1,440	95.5
1,800	97.8
Mean	97.2
CV (%)	2.5
F regression	0.1^{ns}

[ns] Non-significant at 5% probability.

Analysis of preemergence synthetic auxin, ACCase inhibitor and broadleaf herbicide application showed that only the dicamba + imazethapyr/flumioxazin treatment had a negative effect on seed quality parameters, namely vigor and germination. In this case, the effect may be due to the pre-emergent herbicide, since dicamba alone did not influence seed quality.

Among the pre-emergent herbicides, an effect was observed for the imazethapyr/flumioxazin premix. Marchi et al. (2021) observed higher electrical conductivity in M6210 IPRO soybean seeds, indicating greater deterioration for preemergence application of flumioxazin (60 g ai ha^{-1}), with worse performance in relation to the control (no herbicide), chlorimuron and sulfentrazone. However, flumioxazin did not influence germination, vigor or other parameters for this cultivar and none of the parameters for TMG7062 IPRO. Research on the seed quality of soybean exposed to imazethapyr is rare, especially when applied preemergence. In postemergence application, imazethapyr can negatively affect soybean performance, causing visible damage or even yield loss (BOHM et al., 2014).

For the remaining pre-emergent herbicides, there was no decline in seed vigor or germination. Marchi et al. (2021) also reported no negative effects on the quality of seeds produced under diclosulam (33.6 g ai ha^{-1}) applied preemergence. As previously mentioned, the effect of diclosulam and other pre-emergent herbicides on seed quality is little investigated. Nevertheless, some studies have reported negative effects on soybean with diclosulam or sulfentrazone application, such as injury, stunted plant growth and even yield loss in certain situations (FORNAZZA et al., 2018; DALAZEN et al., 2020; GAZOLA et al., 2021).

Given the lack of research on the topic, investigating the possible effects of pre-emergent herbicides is essential. Ribeiro et al. (2021) observed a decrease in plant height (in stage V_C) for sulfentrazone applied to soybean preemergence, but no further reductions were noted from V_2 onwards. In addition to sulfentrazone, the herbicides imazethapyr, chlorimuron, cloransulam, metribuzin, flumioxazin, saflufenacil, acetochlor, s-metolachlor, dimethenamid-P and pyroxasulfone showed no effect on the growth, development and biological nitrogen fixation of soybean plants.

Application of ACCase inhibitors in association with the broadleaf herbicides 2,4-D, triclopyr, dicamba, carfentrazone, saflufenacil and chlorimuron had no effect on soybean seed quality. Some studies reported negative effects for post-emergent chlorimuron application in soybean, especially visible injuries (FORNAZZA et al., 2018; SILVA et al., 2018b), but without altering seed quality (SILVA et al., 2018b), as observed in the present study. Although synthetic auxins can compromise emergence in the subsequent soybean crop (FRANCISCHINI et al., 2020; PERES-OLIVEIRA et al., 2020), there are generally no negative effects when the label-recommended time between application and planting is followed, as evident in seed quality in the present study.

Also in relation to ACCase inhibitors, even clethodim + glyphosate applied in R_1 had no effect on seed quality, since even the control with no herbicide did not differ from the remaining treatments. In glyphosate-tolerant soybeans, this herbicide compromises seed quality, particularly when applied in the reproductive stage (ALBRECHT et al., 2012). However, Silva et al. (2018b) reported no negative effects on soybean seed quality or other parameters for ACCase, clethodim or fluazifop combined with post-emergent glyphosate.

Our study also presents important findings on s-metolachlor and clomazone application in soybean. These herbicides are used for pre-emergent weed control before soybean planting or at least preemergence. Their application postemergence has been investigated with a view to prolonging the residual effect during the crop cycle. Selectivity is generally observed, with visible injury but minimal if any yield loss, and more consolidated results for s-metolachlor (LAWRENCE et al., 2020; PRIESS et al., 2020). The present study demonstrated that applying s-metolachlor (up to 2,880 g ai ha^{-1}) or clomazone (up to 1,800 g ai ha^{-1}) does not compromise seed germination, even when used postemergence.

It should be noted that all these herbicide application strategies can contribute to weed management, whether in pre -planting control or the via residual effect before crop emergence. The results of this study demonstrate that only imazethapyr/flumioxazin associated with dicamba reduced the vigor and germination of the resulting seeds. Nevertheless, it is important to investigate the effect of pre-emergent herbicides on seed quality, since reduced quality has been observed depending on the product used and because research on the topic is scarce.

CONCLUSIONS

Dicamba application combined with the pre-emergent herbicides imazethapyr/flumioxazin before soybean planting reduced seed vigor and germination.

ACCase inhibitors in association with broadleaf herbicides before planting had no effect on seed quality.

Applying s-metolachlor (up to 2,880 g ai ha^{-1}) or clomazone (up to 1,800 g ai ha^{-1}) did not compromise seed germination, even when used postemergence.

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