SIMULATED DRIFT OF DICAMBA AND 2,4-D ON SOYBEANS: EFFECTS OF APPLICATION DOSE AND TIME

DERIVA SIMULADA DE DICAMBA E 2,4-D EM SOJA: EFEITO DE DOSES E ÉPOCAS DE APLICAÇÃO

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ABSTRACT: The use of soybean varieties resistant to the herbicides dicamba and 2,4-D may lead to drifts towards areas grown with non-resistant varieties. The aim of this study was to evaluate the effects of dicamba and 2,4-D underdoses applied at the phenological stages V_4 and R_2 of soybeans. Two experiments were conducted with dicamba or 2,4-D in a randomized block design with four replications. The $4 \times 2 + 1$ factorial scheme was composed of four doses (0.028, 0.28, 2.8, and 28 g ae ha^{-1}) of dicamba or 2,4-D applied at two phenological stages (V_4 and R_2) + a control treatment (without herbicide application). Dicamba underdoses caused damage to soybean crop affecting its vegetative growth and yield; the injuries caused by 2,4-D were neither enough to damage crop nor affect yield components. Dicamba underdoses applied at V_4 caused injuries of up to 41%, while in R_2 they reached 70%. Plant height decreased by up to 61% when treated with dicamba. Soybean yield was reduced by 29 and 76% when the simulated drift occurred at V_4 and R_2, respectively, and at a dose of 28 g ae ha^{-1} of dicamba. For the tested underdoses, only 2,4-D had no effect in soybean crop yield.

KEYWORDS: *Glycine max* (L.) Merrill. Auxin herbicides. Soybean-resistant herbicides.

INTRODUCTION

The emergence of glyphosate-resistant eudicotyledonous weed species led to the need to seek alternative control measures such as the insertion of varieties resistant to the herbicides dicamba (BEHRENS et al., 2007) and 2,4-D (WRIGHT et al., 2010), which may be part of a management program for herbicide-resistant plants commonly used. However, the drift of these herbicides on non-resistant soybean plants can cause damage to the vegetative and reproductive development of the crop, reducing its yield.

Underdoses of auxin herbicides can cause abnormalities in sensitive eudicotyledonous plants (SILVA et al., 2018). Thus, the contamination of the spraying equipment, spraying drift, and volatilization of dicamba can cause phytotoxicity and reduce soybean yield (GROWE, 2017).

Drift is the deviation of the trajectory of particles released during the application, which do not reach the target and cause product losses (SOUZA; CUNHA; PAVANIN, 2011) and economic and environmental damages in nearby areas. Even after the herbicides reach the target, there is still a risk of drift due to their volatilization (JONES, 2018), as well as contamination of sprayer tanks by them.

Studies carried out by Wax, Knuth and Slife (1969), Auch and Arnold (1978), Solomon and Bradley (2014), Jones (2018), and Silva et al. (2018) showed the damages caused by underdoses of auxin herbicides can cause on the soybean crop. Robinson et al. (2013a) observed yield losses of 10% when exposed to dicamba at a dose of 22.7 g ae ha^{-1}. Johnson et al. (2012) observed yield losses of up to 85% with dicamba application at a dose of 41 g ae ha^{-1}. In addition, Andersen et al. (2004) observed that 5.6 g ae ha^{-1} of dicamba, which corresponds to 1% of the use rate in corn crop, reduced soybean yield by up to 34%, while 112 g ae ha^{-1} of 2,4-D was necessary to reduce productivity within a range of 25 to 32%.

Crop development stage at the time of exposure of soybean plants to auxin herbicides is a factor that significantly influences the formation of injuries and yield reduction. Soybean at the R_1 stage is 2.5 times more sensitive to dicamba when compared to soybean plants at the V_3 stage (GRIFFIN et al., 2013). Recently, commercial release of 2,4-D- and dicamba-tolerant soybeans has attracted attention and encouraged research to understand impacts on non-target crops. Thus, the aim of this study was to evaluate the effects of a simulated drift of dicamba and 2,4-D applied at two phenological stages of soybeans.

MATERIAL AND METHODS

Two experiments were conducted simultaneously, one with dicamba (Atectra®, 480 g L^{-1}) and one with 2,4-D (Nortox®, 806 g L^{-1}). These were installed in adjacent areas in Rio Verde-GO, Brazil, which is located at 17º48'55" S and 50º56'28" W, and 758-m mean altitude. According to Köppen-Geiger classification, the regional climate is Aw (tropical), with precipitation in the summer (October to April) and a well-defined dry period in the winter (May to September). During the experimental period, the recorded precipitation was 147, 244, 267, 136, and 20 mm and the average temperature was 25.0, 24.4, 24.8, 24.9, and 26.3 °C from November 2017 to March 2018, respectively. The soil of the site has a clayey texture, pH ($CaCl_2$) of 5.4, organic matter content of 3.9%, and base saturation of 71%.

The experiments 1 (dicamba) and 2 (2,4-D) were carried out in a randomized block design, with four replications. The treatments were arranged in a 4 × 2 + 1 factorial scheme of four underdoses (0.028, 0.28, 2.8, and 28 g ae ha^{-1}) applied at two soybean phenological stages (V_4 and R_2), plus an additional treatment without herbicide application. Doses were about 0.0058, 0.058, 0.58, and 5.8% of the commercial dose of dicamba, and about 0.0035, 0.035, 0.35, and 3.5% of the commercial dose of 2.4-D.

The soybean variety ADV 4672 IPRO, non-dicamba-tolerant, was mechanically sown in a no-tillage system with a 0.45 m interrow spacing and 18 seeds per meter. Fertilization and disease and pest management were carried out with the application of phytosanitary products according to the need and technical recommendations for the soybean crop (EMBRAPA, 2013). Weed control was performed with pre-planting glyphosate applications the day before sowing at a dose of 2150 g ae ha^{-1} and post-planting applications at 25 and 35 days after sowing at a dose of 960 g ae ha^{-1}.

The experimental plots had 25.2 m^2, being considered as the useful area the 5 central meters of the 5 rows of each plot. Drift simulation was carried out with a CO_2-pressurized backpack sprayer adjusted to obtain a constant pressure of 150 KPa and a spray solution volume of 170 L ha^{-1}. The spray tips used were flat fan type model XR Teejet 8002VB. Weather conditions during V4 stage applications were: wind speed, 1 m/s; temperature, 29.7 °C; relative humidity, 61.3%. Yet, during R2 stage, conditions were: wind speed, 1 m/s; temperature 24.5 °C; relative humidity, 79%.

At 7, 14, and 28 days after treatment application (DAA), plant height evaluations were carried out at 5 random points of each plot, taking as a reference the soil surface and the canopy. On the same dates, the phytointoxication caused by drift simulation was evaluated by means of the visual evaluation and assignment of scores varying from 0 to 100%, where 0% represents no injury and 100% represents plant death, according to the SBCPD (1995).

The useful area was harvested manually at the R8 stage (full maturation, with 95% of pods with mature coloration), followed by threshing in a mechanized thresher. At harvest time, the number of plants and seed yield in the useful area of each plot were evaluated to determine the yield (expressed at 13% of water content). Ten plants were taken to evaluate the final height, the number of branches, and the number of pods per plant, as well as the number of grains per pod in one hundred pods taken at random. The evaluation of one thousand-seed weight was carried out with eight replications of one hundred seeds for each plot on a precision analytical balance (0.01 g) (BRASIL, 2009).

Data were submitted to normality and homogeneity tests, analysis of variance ($p \leq 0.05$), and Dunnett and Tukey tests ($p \leq 0.05$), using the software Assistat in order to detect differences between treatments and the control and between treatments without presence of the control. For plant injury and height at 7, 14, and 28 DAA, only the doses were compared. The data of the variable injury at 7, 14, and 28 DAA for both experiments were transformed using the equation $(X + 1)^{0.5}$ by using the software SISVAR version 5.6.

RESULTS AND DISCUSSION

The induced injuries varied according to the herbicide, doses, and soybean phenological stage at application time (Table 1). At the dose of 0.028 g ae ha-1, dicamba drift during V4 caused no injury compared to the control in all evaluations. An opposite effect was observed at higher doses. A higher phytotoxicity was observed between 7 and 14 DAA, with symptoms reducing after 14 DAA. This shows that toxic effects of dicamba take longer to manifest, and that soybean plants have mechanisms allowing them to recover, at least partly, the drift damages. Solomon and Bradley (2014) observed that plants treated with dicamba sub-doses at V3 recovered, but those treated in R2, showed no signs of injury recovery.

Table 1. Injury in soybean plants in response to the application of dicamba (experiment 1) and 2,4-D (experiment 2) doses at phenological stages V_4 and R_2 and evaluated at 7, 14, and 28 days after application (DAA)

Herbicide	Dose (g ae ha^{-1})	Phenological stage					
		V_4			R_2		
		7 DAA	14 DAA	28 DAA	7 DAA	14 DAA	28 DAA
		Injury[1]					
Dicamba	0.028	4 a[2]	5 a	1 a	9 a (+)	22 a (+)	11 a
	0.28	9 ab	30 ab (+)	1 a	15 a (+)	26 a (+)	24 ab (+)
	2.8	24 bc (+)	31 ab (+)	16 b (+)	18 a (+)	31 a (+)	35 b (+)
	28	38 c (+)	41 b (+)	24 b (+)	38 b (+)	33 a (+)	70 c (+)
	Control	0	0	0	0	0	0
CV (%)		26.65	38.82	24.95	11.24	9.87	15.54
2,4-D	0.028	0.3 ab	0.0	0.0	0.0	1.3	3.0
	0.28	0.0 a	0.0	0.0	0.0	0.0	0.3
	2.8	1.4 b (+)	0.0	0.0	0.0	0.0	0.3
	28	0.6 ab	1.3	0.0	0.0	1.0	3.3
	Control	0	0	0	0	0	0
CV (%)		13.97	0.00	0.00	0.00	26.38	50.65

Means followed by different letters within a row differ significantly from each other by the Tukey's test ($p<0.05$). Means followed by (+) were higher when compared to those of control treatment by the Dunnett's test ($p<0.05$). [1]Injury scoring according to Frans (1972). [2]Data transformed to $(X + 1)^{0.5}$ for analysis.

Other authors also have reported higher injuries caused by dicamba at 14 DAA when compared to 7 DAA (AL-KHATIB; PETERSON, 1999; GRIFFIN et al., 2013; GROWE, 2017). Injuries caused by dicamba in soybean plants are observed in newly formed tissues, as it is translocated to meristematic tissues (SENSEMAN, 2007). Varieties of indeterminate growth habit present the formation of injuries in newly formed leaves since there is the formation of vegetative organs even after flowering (HEATHERLY; ELMORE, 2004).

The effects of dicamba applied at R_2 differed in relation to those of application at V_4 since no reduction in injury intensity was observed as a function of time, therefore, plants could not recover, except at the lowest dose (0.028 g ae ha^{-1}). At the lowest dicamba dose, the highest injury levels were 4.8 and 22.3% for V_4 and R_2, respectively, whereas for the highest dose it was 41.3 and 69.8% for V_4 and R_2, respectively. These results are supported by those observed by Silva et al. (2018), who observed increased levels of injury in soybean plants with increasing dicamba doses.

A higher percentage of injuries was observed at a dose of 2.8 g ae ha^{-1} of 2,4-D at 14 DAA (Table 1). The other doses, evaluated at 7, 14, and 28 DAA, were unable to compromise soybean development, being classified as very light injuries according to the scale described by SBCPD (1995). Solomon and Bradley (2014) evaluated underdose of eight synthetic auxin herbicides, including dicamba and 2,4-D, applied at two phenological stages (V_3 and R_2) on soybeans and observed that all herbicides caused injury and reduced crop yield, except for 2,4-D.

The tested herbicides reduced the height of soybean plants evaluated at 7, 14, and 28 DAA, but more intense reductions were observed for the application of dicamba underdoses in relation to 2,4-D (Table 2). At 28 DAA, plant height reduction reached approximately 35 and 50% for doses of 2.8 and 28 g ae ha^{-1} of dicamba applied at V_4, respectively (Table 2). Solomon and Bradley (2014) observed that dicamba reduced the height of soybean plants at 28 DAA for doses of 2.8 and 28 g ae ha^{-1} applied at V_3 and R_2. Silva et al. (2018) observed a 60% reduction in plant height under dicamba drift at a dose of 42 g ae ha^{-1} at V_5.

Similarly, the height of soybean plants evaluated at 7, 14, and 28 DAA was lower when exposed to higher dicamba underdoses applied in R_2, as well as in 2,4-D applications at a dose of 28 g ae ha^{-1} in R_2. The application of 28 g ae ha^{-1} of dicamba at R_2 reduced plant height by 53% at 28 DAA (Table 2). On the other hand, the application of 0.028 g ae ha^{-1} of dicamba promoted a reduction in the height of soybean plants (109.9 cm) in relation to the control (116 cm).

The reduction in plant height promoted by dicamba may decrease crop yield (JONES, 2018). Solomon and Bradley (2014) also observed that reductions in plant height reduced yield, but less strongly than plant injuries. The reduction of plant height by auxin herbicides is caused by an increase in abscisic acid, which may limit plant growth over a period until it overcomes these effects (ROBINSON et al., 2013a). The reduction of plant height decreases leaf area and photoassimilate production, resulting in lower yields (ROBINSON; SIMPSON; JOHNSON, 2013b).

Table 2. Plant height in response to the application of dicamba (experiment 1) and 2,4-D (experiment 2) at V_4 and R_2 stages and evaluated at 7, 14, and 28 days after application (DAA)

Herbicide	Dose (g ae ha^{-1})	Phenological stage V_4 7 DAA	14 DAA	28 DAA	R_2 7 DAA	14 DAA	28 DAA
		Plant height (cm)					
Dicamba	0.028	41 a	58 a	88 a	74 a	93 a	109 a (-)
	0.28	35 ab	50 b (-)	83 a	65 b	86 a	99 b (-)
	2.8	30 bc (-)	38 c (-)	56 b (-)	54 c (-)	74 b (-)	73 c (-)
	28	27 c (-)	33 c (-)	44 c (-)	47 d (-)	60 c (-)	55 d (-)
	Control	40	56	86	68	88	116
CV (%)		7.60	5.56	4.55	5.48	5.33	2.55
2,4-D	0.028	38 a	60 a	91 a	73 ab	95 a	114 ab
	0.28	39 a	59 a	92 a	75 ab	93 a	115 ab
	2.8	37 a	56 ab	88 a	83 a (+)	98 a	119 a
	28	38 a	54 b (-)	89 a	65 b (-)	83 b (-)	105 b (-)
	Control	39	59	89	74	94	115
CV (%)		3.14	3.83	3.25	5.37	2.72	3.91

Means followed by different letters within a row differ significantly from each other by the Tukey's test ($p<0.05$). Means followed by (−) were higher when compared to those of control treatment by the Dunnett's test ($p<0.05$).

Plant height at soybean harvest presented an effect of the interaction between dicamba doses and stages of application, with a reduction at a dose of 28 g ae ha^{-1} applied in R_2 (Table 3). Dicamba applied at a dose of 28 g ae ha^{-1} at V_4 and R_2 resulted in plants 30 and 61% lower when compared to those observed in control treatment, whereas the dose of 0.028 g ae ha^{-1} applied at V_2 and R_2 had no significant difference from the control (Table 3). Auch and Arnold (1978) observed higher reductions in the height of soybean plants under applications performed at the beginning of flowering when compared to vegetative stages. However, Silva et al. (2018) observed a higher reduction in plant height when applications of dicamba underdoses were performed at vegetative stages.

Table 3. Plant height (PH) at harvest time, number of lateral branches (NLB), and number of pods per plant (NPP) of soybeans treated with four doses of dicamba (experiment 1) and 2,4- D (experiment 2) at two development stages

Herbicide	Dose (g ae ha^{-1})	Phenological stage PH (cm) V_4	PH (cm) R_2	NLB V_4	NLB R_2	NPP V_4	NPP R_2
Dicamba	0.028	102 aA	100 aA	3.8 aA	4.3 aA	68 aA (+)	60 aA
	0.28	100 aA	89 bB (-)	3.6 aA	5.1 aA	54 bB	64 aA
	2.8	85 bA (-)	69 cB (-)	5.1 aA	5.8 aA	65 abA	62 aA
	28	73 cA (-)	40 dB (-)	4.5 aA	0.9 bB (-)	67 aA	27 bB (-)
	Control	103.8		4.6		54	
CV (%)		4.48		24.21		11.36	
2.4-D	0.028	111 aA	110 aA	4.2 aA	4.2 aA	55 abB	68 aA
	0.28	109 abA	106 abA	4.3 aA	4.1 aA	52 bA	59 abA
	2.8	103 bB	113 aA	3.9 aA	3.1 aA	64 aA	601 abA
	28	105 abA	103 bA	3.3 aA	5.1 aA	65 aA	55 bB
	Control	109.1		4.73		64.33	
CV (%)		3.50		23.79		10.22	

Means followed by different lowercase letters within a row and uppercase letters within a column differ significantly from each other by the Tukey's test ($p<0.05$). Means followed by (−) were lower when compared to those of control treatment by the Dunnett's test ($p<0.05$).

The herbicide 2,4-D caused no reduction in the height of soybean plants at harvest time (Table 3). Similar results were observed by Solomon and Bradley (2014), who also noted no reductions in the height of soybean plants treated with 2,4-D at the highest tested dose (28 g ae ha^{-1}). However, Silva et al. (2018) observed a linear reduction in the height of soybean plants treated with 2,4-D, reaching 18% for the dose of 42 g ae ha^{-1}.

The number of lateral branches was affected by the interaction between dose and stage of application. In this sense, dicamba reduced by 81% the number of lateral branches when applied at a dose of 28 g ae ha^{-1} at R_2, with no differences between other treatments and control (Table 3). In this treatment, the apical meristem died, but plants were not able to resume their vegetative development (Table 3). The death of the apical meristem of soybean plants can be compensated for by an increase in the number of branches, which produce flowers and pods that supply a possible yield reduction due to dicamba exposure (WEIDENHAMER; TRIPLETT; SOBOTKA, 1989). Injuries resulting from herbicide drift at vegetative stages do not always compromise crop yield (AL-KHATIB; PETERSON, 1999).

The number of pods, number of grains, and yield were affected by dicamba drift (Tables 3 and 4). The interaction between dose and stage of application for the number of pods per plant was significant, with an increase of 27% in the treatment with 0.028 g ae ha^{-1} of dicamba applied at V_4 but a reduction of 50% for the application of 28 g ae ha^{-1} carried out in R_2. Dicamba drift at reproductive stages may reduce crop yield due to the lower number of pods and grains produced. Solomon and Bradley (2014) observed a reduction of approximately 80% in the number of pods per plant for the treatment with 28 g ae ha^{-1} of dicamba applied in R_2. Kelley et al. (2005) reported that a dose of 5.6 g ae ha^{-1} of dicamba applied at V_3 and V_7 on soybeans caused no reduction in the number of pods per plant, however, the application at R_2 led to a decline of such variable.

Table 4. Number of grains per pod (NGP), one thousand-seed weight (TSW), and grain yield (GY) of soybean treated with four doses of dicamba (experiment 1) and 2.4-D (experiment 2) applied at two development stages

Herbicide	Dose (g ae ha^{-1})	Phenological stage					
		V_4	R_2	V_4	R_2	V_4	R_2
		NGP		TSW (g)		GY (kg ha^{-1})	
Dicamba	0.028	2.3 aB	2.5 Aa	169 aA	174 aA	3221 abA	3194 abA
	0.28	2.4 aA	2.3 Aa	174 aA	174 aA	3597 aA	3471 aA
	2.8	2.4 aA	2.4 aA	170 aA	179 aA	2831 bcA	2811 bA
	28	2.4 aA	1.9 bB (-)	171 aA	176 aA	2365 cA (-)	812 cB (-)
	Control	2.34		180		3337	
CV (%)		5.11		4.21		10.67	
2.4-D	0.028	2.5 aA	2.3 Ab	186 aA	187 aA	3650 aA	3355 aA
	0.28	2.5 aA	2.4 aA	185 aA	184 aA	3672 aA	3417 aA
	2.8	2.4 aA	2.5 aA	181 aA	183 aA	3305 aA	3268 aA
	28	2.6 aA	2.3 aB	179 aA	186 aA	3260 aA	3231 aA
	Control	2.5		185		3607	
CV (%)		4.61		3.91		6.74	

Means followed by different lowercase letters within a row and uppercase letters within a column differ significantly from each other by the Tukey's test ($p<0.05$). Means followed by (−) were lower when compared to those of control treatment by the Dunnett's test ($p<0.05$).

The interaction between doses and growth stages of herbicide application was significant for the number of grains per pod for both herbicides, especially the highest dose of dicamba and 0.028 and 28 g ae ha^{-1} of 2,4-D when applied in R_2, leading to a lower number of grains per pod (Table 4). Solomon and Bradley (2014) observed a reduction in the number of grains per pod in a simulated drift of dicamba, but not for 2,4-D, concluding that applications of auxin herbicides carried out at R_2 with higher doses affect the number of grains per pod in a more expressive way than applications carried out at vegetative stage. The weight of soybean seeds was not affected by treatments (Table 4).

The effects of treatments on the evaluated variables in dicamba-treated soybean resulted in a 29% and 76% reduction in yield at a dose of 28 g ae ha^{-1}, when applications were carried out at V_4 and R_2, respectively. Griffin et al. (2013) verified that

17.5 g ae ha^{-1} of dicamba applied at V_4 and R_1 reduced soybean yield by 15% and 36%, respectively. Auch and Arnold (1978) found that dicamba drift at flowering is more damaging than in more advanced reproductive stages. Soybean yield was reduced with increasing doses of auxin herbicides, with a higher loss for dicamba when compared to 2,4-D (SILVA et al., 2018).

Damages promoted by herbicides applied in V_4 were lower when compared to those applied in R_2 due to the longer time interval to repair the damage caused by dicamba between the applications and the end of the cycle (ROBINSON; SIMPSON; JOHNSON, 2013b). Wax, Knuth and Slife (1969) observed a reduction of 23% in soybean yield with the application of 4.4 g ha^{-1} of dicamba at flowering, whereas 35 g ha^{-1} was required to reduce the yield by 20% when its application was carried out at the vegetative stage.

One of the factors that reduced soybean yield due to dicamba drift (Table 4) is attributed to non-recovery of height and architecture of plants, leading to a lower vegetative development, lower leaf area, and fewer nodes available for the formation of inflorescences, pods, and grains. Herbicides of the synthetic auxin group activate auxin response genes (ABEL; THEOLOGIS, 1996; KELLEY et al., 2004; ROBINSON et al., 2013a), leading to an overproduction of ethylene and then abscisic acid (GROSSMANN, 2003, 2010; ROBINSON et al.; 2013a). The increased concentration of abscisic acid causes the closure of the stomata, limiting CO_2 assimilation (GROSSMANN, 2010; ROBINSON et al., 2013a).

The herbicide 2,4-D applied under different underdoses and phenological stages promoted no reduction in soybean yield (Table 4). Solomon and Bradley (2014) obtained similar results with a maximum dose of 28 g ae ha^{-1}. However, Silva et al. (2018) observed a reduction of 34 and 17 kg ha^{-1} in the yield for each gram of 2,4-D applied at V_5 and R_2, respectively.

CONCLUSION

Dicamba underdoses reduced plant height, caused leaf injuries, and reduced crop yield. However, 2,4-D underdoses promoted less damage to soybeans. Therefore, affordable precautions must be taken to avoid damage by herbicides, as these can damage non-tolerant crops.

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RESUMO: Com a inserção de variedades de soja resistentes aos herbicidas dicamba e 2,4-D os eventos de deriva destes herbicidas para áreas com variedades não resistentes será passível de ocorrência. Objetivou-se neste trabalho avaliar os efeitos de subdoses de dicamba e 2,4-D aplicados nos estádios fenológicos V_4 e R_2 da cultura da soja. Dois experimentos foram conduzidos com dicamba ou 2,4-D em delineamento experimental de blocos casualizados, com quatro repetições. Adotou-se o esquema fatorial de 4 x 2 + 1 composto por quatro doses (0,028, 0,28, 2,8 e 28 g ea ha^{-1}) de dicamba ou de 2,4-D, aplicados em dois estádios fenológicos (V_4 e R_2) + um tratamento testemunha (sem aplicação de herbicida). As subdoses de dicamba provocaram danos na cultura da soja, afetando o desenvolvimento vegetativo e a produtividade, enquanto o 2,4-D não provocou injúrias suficientes para provocar danos que comprometessem a cultura, e desta forma, não afetou os componentes de produção. As subdoses de dicamba aplicadas no estádio V_4 provocou injúrias de até 41%, enquanto em R_2 chegaram a 70%. A altura das plantas reduziu em até 61% quando tratadas com dicamba. A produtividade da soja foi reduzida em 29 e 76%, quando a deriva simulada ocorreu nos estádios V_4 e R_2, respectivamente, e na dose de 28 g ea ha^{-1} de dicamba. Nas subdoses testadas somente o 2,4-D não afetou a produtividade da cultura da soja.

PALAVRAS-CHAVE: *Glycine max* (L.) Merrill. Herbicidas auxínicos. Soja resistente a herbicidas.

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