

SELECTIVITY OF THE HERBICIDE DICAMBA (XTENDICAM) APPLIED AT THE TILLERING STAGE OF WHEAT

SELETIVIDADE DO HERBICIDA DICAMBA (XTENDICAM) APLICADO NO PERFILHAMENTO DA CULTURA DO TRIGO

SELECTIVIDAD DEL HERBICIDA DICAMBA (XTENDICAM) APLICADO DURANTE LA ETAPA DE AHIJAMIENTO DEL TRIGO



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ABSTRACT

The use of hormonal herbicides in wheat requires evaluation regarding selectivity, especially for molecules without registered recommendations for this crop. This study aimed to evaluate the effect of different doses of dicamba (Xtendicam) applied at the tillering stage of wheat on phytotoxicity and yield components. The experiment was conducted under field conditions in Verê, Paraná, Brazil, using a randomized complete block design with four replications and five treatments (0; 0.4; 0.6; 0.8; and 1 L ha⁻¹). The evaluated variables included phytotoxicity, plant height, number of tillers, number of grains per spike, thousand-grain weight, dry biomass, and yield. Increasing doses resulted in higher phytotoxicity, reaching 15.5% at 42 days after application at the highest dose, which was considered low and reversible. Reductions were observed in plant height, number of tillers, and number of grains per spike at higher doses. Grain yield was reduced at all doses, with a significant difference at 0.8 L ha⁻¹, showing a reduction of up to 34.9% compared to the control. The number of plants per linear meter, dry biomass, and thousand-grain weight were not affected. The results indicate that, although visual phytotoxicity was low, dicamba negatively affects wheat yield components. The dose of 0.4 L ha⁻¹ showed the lowest impact on the crop and was

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considered the safest under the evaluated conditions.

Keywords: Tillering. Phytotoxicity. Chemical Management. Weeds.

RESUMO

O uso de herbicidas hormonais na cultura do trigo requer avaliação quanto à seletividade, especialmente para moléculas sem recomendação registrada para a cultura. O presente estudo teve como objetivo avaliar o efeito de diferentes doses de dicamba (Xtendicam) aplicadas no perfilhamento do trigo sobre a fitotoxicidade e componentes de rendimento. O experimento foi conduzido a campo no município de Verê-PR, em delineamento de blocos casualizados, com quatro repetições e cinco tratamentos (0; 0,4; 0,6; 0,8 e 1 L ha⁻¹). Foram avaliadas fitotoxicidade, altura de plantas, número de perfilhos, número de grãos por espiga, peso de mil grãos, matéria seca e produtividade. O aumento das doses promoveu elevação da fitotoxicidade, atingindo 15,5% aos 42 dias após aplicação na maior dose, sendo considerada baixa e reversível. Houve redução na altura das plantas, número de perfilhos e número de grãos por espiga nas maiores doses. A produtividade foi reduzida em todas as doses, com diferença significativa na dose de 0,8 L ha⁻¹, apresentando redução de até 34,9% em relação à testemunha. O número de plantas por metro linear, matéria seca e peso de mil grãos não foram afetados. Os resultados indicam que, embora a fitotoxicidade visual seja baixa, o dicamba compromete componentes produtivos do trigo. A dose de 0,4 L ha⁻¹ apresentou menor impacto sobre a cultura, sendo considerada a mais segura nas condições avaliadas.

Palavras-chave: Perfilhamento. Fitotoxicidade. Manejo Químico. Daninhas.

RESUMEN

El uso de herbicidas hormonales en el cultivo de trigo requiere una evaluación de su selectividad, especialmente para moléculas sin recomendaciones registradas para este cultivo. Este estudio tuvo como objetivo evaluar el efecto de diferentes dosis de dicamba (Xtendicam) aplicadas durante el ahijamiento del trigo sobre la fitotoxicidad y los componentes del rendimiento. El experimento se realizó en campo en el municipio de Verê-PR, en un diseño de bloques aleatorizados, con cuatro repeticiones y cinco tratamientos (0; 0.4; 0.6; 0.8 y 1 L ha⁻¹). Se evaluaron la fitotoxicidad, la altura de la planta, el número de tallos, el número de granos por espiga, el peso de mil granos, la materia seca y la productividad. El aumento de las dosis promovió un incremento en la fitotoxicidad, alcanzando el 15.5% 42 días después de la aplicación con la dosis más alta, lo cual se consideró bajo y reversible. Se observó una reducción en la altura de la planta, el número de tallos y el número de granos por espiga con las dosis más altas. La productividad se redujo en todas las dosis, observándose una diferencia significativa con la dosis de 0,8 L ha⁻¹, que mostró una reducción de hasta el 34,9 % respecto al control. El número de plantas por metro lineal, la materia seca y el peso de mil granos no se vieron afectados. Los resultados indican que, si bien la fitotoxicidad visual es baja, el dicamba compromete los componentes productivos del trigo. La dosis de 0,4 L ha⁻¹ presentó el menor impacto en el cultivo, considerándose la más segura en las condiciones evaluadas.

Palabras clave: Ahijamiento. Fitotoxicidad. Manejo Químico. Malezas.

1 INTRODUCTION

According to data from the National Supply Company (2024), for the 2024/2025 harvest, the estimated wheat planted area in the world was 222.2 million hectares, representing a decrease of 0.27% compared to the 2023/2024 harvest.

Weeds represent an important factor of competition in wheat crops. According to Cunha and Caierão (2023), species such as oats (*Avena* spp.), picão-preto (*Bidens* spp.), parsley grass (*Bowlesia incana*), marmalade grass (*Brachiaria plantaginea*), crabgrass (*Digitaria horizontalis*), purpleflower (*Echium plantagineum*), false milkweed (*Emilia sonchifolia*), milkweed (*Sonchus oleraceus*), Viola Tree (*Ipomoea* spp.), ryegrass (*Lolium multiflorum*), turnip (*Raphanus* spp.), white poaia (*Richardia brasiliensis*), as well as volunteer plants of corn (*Zea mays*) and soybean (*Glycine max*). Horseweed (*Conyza* sp.) is also noteworthy, which has generated concern due to the difficulty of control with the herbicide 2,4-D.

Weed management involves cultural practices such as choosing the appropriate sowing time, crop rotation, reducing row spacing, and increasing plant density. Mechanical management, such as weeding and uprooting, is mainly used in small areas. However, the use of selective and non-selective herbicides is common. Among the main selective herbicides, the following stand out: 2,4-D (aryloxyalkanoic acid), applied in post-emergence and with an auxin-mimicking mechanism of action; metribuzin (triazinone), protox inhibitor; metsulfuron-methyl and iodosulfuron-methyl (sulfonylureas), ALS inhibitors; pyroxsulam (triazolopyrimidine sulfonamide), also an ALS inhibitor; bentazone (benzothiadiazinone), an FSII inhibitor; and pendimethalin (dinitroaniline), used in pre-emergence, acting on cell division. In addition, glyphosate, belonging to the group of substituted glycines, is widely used as a non-selective herbicide (EPSPS inhibitor) (CUNHA; CAIERÃO, 2023).

Among the herbicides used in weed management, dicamba also stands out, belonging to the chemical group of benzoic acids. This herbicide is absorbed by leaves, stems and roots, presenting systemic action and acting as an auxin mimimic. It is efficient in controlling dicotyledonous weeds and has recommendations similar to 2,4-D, promoting dysregulation of cell division and growth by acting as a plant hormone (SENSIX, 2022).

According to Brochado et al. (2021), the formulation with DGA (diglycolamine) salt has lower volatility compared to DMA (dimethylamine) salt, due to modifications in the formulation.

However, studies on the use of dicamba in wheat crops are still limited, with a lack of information in the literature. Thus, it becomes relevant to evaluate their behavior in this culture. Thus, the present study aimed to test different doses of dicamba, in order to evaluate

its selectivity for wheat. The experiment was conducted in the Southwest region of Paraná, in the municipality of Verê.

2 MATERIAL AND METHODS

2.1 PLACE OF REALIZATION

The experiment was carried out in the field on the property of Voldinei Luis Cagnini, located in the municipality of Verê, Paraná (approximate coordinates of $\phi = -25.87135$ and $\lambda = -52.87458$), in the community of União da Barra, belonging to the southwestern region of the state.

The climate of the region is classified, according to Köppen, as Cfa (humid subtropical), characterized by an average temperature of the coldest month between 18 and -3 °C, well-distributed rainfall throughout the year and hot summers, with an average temperature of the hottest month above 22 °C (ALVARES et al., 2013).

2.2 EXPERIMENTAL DESIGN

The experimental design was in randomized blocks, with four replications. Five treatments were evaluated (four different herbicide doses + control). The dicamba doses used were 0.4; 0.6; 0.8 and 1 L ha⁻¹ of the commercial product Xtendicam, in addition to the control, as shown in Table 1.

The experiment consisted of 20 plots, with dimensions of 3 x 1 m, totaling 3 m² per plot and a total area of 60 m².

2.3 IMPLEMENTATION AND CONDUCTION

Wheat sowing was carried out on June 23, using the Senna cultivar, which has a hyper-early cycle of approximately 100 days. This cultivar has a small size and weight of a thousand seeds of approximately 44 g (SEMENTEC AGRONEGÓCIOS, c2025).

Sowing was carried out with a Kuhn seeder of 21 rows, spaced at 0.17 m, regulated for seed deposition between 3 and 4 cm in depth and density of 430 plants m⁻².

2.4 CULTURAL MANAGEMENT

The cultural management was carried out according to the practices adopted by the producer, since the experiment was inserted in a commercial area. The insecticide Connect and the fungicides Fox and Nativo were used. In addition, fertilizer with a formulation of 30-00-20 was applied at the full tillering stage, at a dose of 205 kg ha⁻¹.

2.4.1 Application of dicamba (Xtendicam)

Considering reports in the literature about possible damage to the crop when the herbicide is applied in very early or late stages, the application was carried out at the tillering stage, considered the most appropriate.

As the objective of the study was to evaluate different doses, the Xtendicam recommendation for corn was adopted as a reference, also belonging to the grass group, since the product does not have a recommendation for wheat.

The doses were defined based on the product leaflet, which recommends 1 L ha⁻¹ for corn, with a volume of 200 L ha⁻¹. The recommendation of 2,4-D for wheat (0.4 to 0.7 L ha⁻¹) was also considered. Based on these parameters, doses of 0.4; 0.6; 0.8 and 1 L ha⁻¹ of Xtendicam.

The application was carried out on July 30, using a knapsack sprayer with a capacity of 20 L. The equipment was calibrated so that the flow rate of the AD-IA/D type spray tip (anti-drift, air induction, double fan) was 5 mL s⁻¹. The displacement speed was adjusted so that the application resulted in 40 mL per plot, corresponding to a spray volume of 133 L ha⁻¹.

For each treatment, a volume of 2 L spray was prepared. The application was carried out from the lowest to the highest dose, avoiding the need to wash the tank between treatments. The adjuvant XTEND PROTECT was used at a concentration of 1% v/v (20 mL for 2 L of mixture), with the objective of reducing evaporation and drift.

At the time of application, carried out in the morning, the wind speed was 7 km h⁻¹ and the temperature was 21 °C, with cloudy sky conditions, and these parameters were monitored with the aid of an anemometer.

2.5 PARAMETERS EVALUATED

Phytotoxicity in wheat was evaluated at 7, 14, 21, 28, 35 and 42 days after application (DAA), using the scale of the Brazilian Society of Weed Science (SBCPD, 1995).

The height of the plants was evaluated before application and at 42 DAA, by means of a ruler graduated in centimeters, and the values were compared with the control.

The number of tillers was determined at 42 DAA, based on the average of five plants per plot. The density of plants per linear meter was also evaluated, by counting in one meter of row in each plot.

To determine the dry matter of the shoot, after the evaluation of the other parameters, the plants were cut close to the ground in an area of 0.50 x 0.50 m. The ears were separated

from the stalks to evaluate the yield. After threshing the grains, the residues were gathered and packed in bags, which were later taken to the greenhouse for drying.

The number of grains per ear was determined by the average of five ears per plot. The weight of one thousand grains was obtained from four replicates of 100 seeds per plot, and the average values were multiplied by ten.

To determine the yield, the grain moisture content was adjusted to 13%, using the formula $PF = P_i \times (100 - i_u) / (100 - 13)$. Subsequently, the values obtained were extrapolated to bags per hectare.

2.6 STATISTICAL ANALYSIS

The collected data were analyzed using The SAS System, version 9 (SAS Inst., Cary, United States, 2002), and submitted to analysis of variance at 5% probability. When significant, the means were compared using Tukey's test, followed by regression analysis in the Rbio application (BHERING, 2017).

3 RESULTS AND DISCUSSIONS

The increase in the doses of Xtendicam provided an increase in the levels of phytotoxicity in wheat, with a gradual increase over time, as observed in the evaluations carried out, reaching 15.5% at the highest dose (1 L ha^{-1}) at 42 days after application (DAA) (Table 1 and Figure 1). Although there was a statistical difference between the doses, even at the highest dose of Xtendicam the visual phytotoxicity was considered low, non-permanent and recoverable throughout the crop cycle. The coefficient of variation (CV) indicated moderate variation, conferring reliability to the averages obtained.

In a study conducted by Velloso and Dal'Piaz (1982), evaluating the application of dicamba and other chemical compounds at 30 days after emergence, at the tillering stage of wheat, barley and rye crops, phytotoxicity was analyzed at 15 days after application by means of the ALAM scale (1: total plant death; 2: very severe; 3: severe damage; 4: moderate damage; 5: slight damage; 6: absence of injury). The authors observed that dicamba, at a dose of 392 g ha^{-1} , was the compound that presented the greatest phytotoxic effect in the three crops, being classified as moderate damage (note 4) for wheat.

Considering the acid equivalent of Xtendicam (480 g L^{-1}), the dose of 392 g ha^{-1} corresponds to approximately 0.8 L ha^{-1} . At this dose, in the present study, symptoms classified as mild to moderate were observed, according to the phytotoxicity scale of the Brazilian Society of Weed Science (SBCPD, 1995), evidencing the presence of visual injuries

in the crop. Thus, the results obtained in this experiment are in agreement with those reported in the literature.

Table 1

Toxicity (%) of doses of Xtendicam applied to tillering of wheat over 42 days after application (DAA)

Xtendicam	7th DAA	14 DAA	21 DAA	28 DAA	35 DAA	42 DAA
0.4 L/ha	4.75 b	6.25 b	6.5 b	7.5 b	8 b	8 b
0.6L/ha	6 b	8.25 b	9.5 abs	10.75 abs	12 b	12 abs
0.8 L/ha	6 b	9.25 b	10 to	12.35 abs	13 abs	13.5 to
1 L/ha	9.25 to	14 to	12.75 to	14 to	15.25 to	15.5 to
0 L/ha	0 c	0 c	0 c	0 c	0 c	0 c
CV (%)	20,6	19,8	19	21,4	23,7	20,4

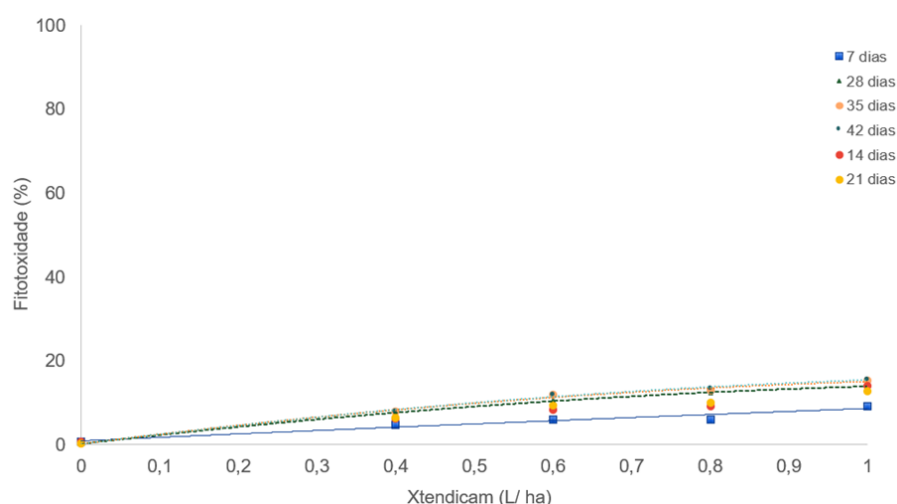
Means followed by the same letter, in the same column, do not differ from each other by Tukey's test at 5%.

CV= coefficient of variation

Source: Authors.

Figure 1

Phytotoxicity (%) of Xtendicam doses applied to wheat tillering over 42 days after application (DAA)



Source: Authors.

It can be observed that in the curves for the herbicide in all the evaluations carried out, the values of R^2 (coefficient of determination) were above 0.90, that is, they were significant (≥ 0.7) and explain in more than 90% the behavior of the data collected in the field evaluations (Table 2).

Table 2

Parameters of the quadratic polynomial equation and R² value for the phytotoxicity variable (%) of Xtendicam on wheat crop

DAA	Mediums	X	X ²	R ²
7	0,9422	8,42	0,7143	0,9397
14	0,9786	10,87	14,682	0,9687
21	0,3186	17,532	-54,483	0,9875
28	0,2323	21,862	-8,160	0,9982
35	0,2216	23,86	-8,988	0,9933
42	0,194	23,918	-8,652	0,9962

Polynomial quadratic equation $Y=X^2+X+Mean$.

Source: Authors.

In the present experiment, plant lodging was observed when in the presence of dicamba herbicide and when compared to the controls in the absence of dicamba, there was a delay in the emergence of ears or even no ears emission.

This was also reported by Oliveira and Greidanus (1991), who highlight the occurrence of lodging when 2,4-D and dicamba were applied in late stages of the crop, in addition to reducing the size of wheat, demonstrating that applications at the end of tillering had a more impactful effect on the crop, and also greater lodging, reporting that dicamba has greater aggressiveness.

As already mentioned by Roman et al. (2005), when the plant absorbs auxins they move with the flow of sugar and amino acids towards the growing points, thus, ruining the growth of the plants, which can cause epinasty, curling of branches, leaves and petioles, chlorosis and necrosis can also occur at the growing points. Also, Galon et al. (2010), report that symptoms such as the retention of ears in the stem after elongation, causing the ears to become crooked, also observed in this experiment, may occur.

Regarding plant height, before application (in tillering) there was no significant difference between the treatments, since the application was after the establishment of the crop, conferring uniformity in the plots that received the treatments (Table 3 and Figure 2). Regarding the height after herbicide application (evaluated at 42 DAA), only the height of 0.4 L/ha was not affected by dicamba, not differing significantly from the dose of 0 L/ha. The doses of 0.6, 0.8 and 1 L/ha were statistically lower than the dose of 0 L/ha, presenting an average reduction of 13% in plant height. Therefore, the herbicide reduced plant growth at

the highest doses when compared to the treatment in the absence of the herbicide. The low coefficient of variation indicates that a high accuracy of the results was obtained.

Table 3

Height of wheat plants (cm) before and after dicamba application

Xtendicam	Before application	After application
0.4 L/ha	34.25 to	67.6 abs
0.6 L/ha	34.2 to	62.8 b
0.8 L/ha	35, 28 to	63.1 b
1 L/ha	35.32 to	62.6 b
0 L/ha	34,325 to	71.8 to
CV (%)	5,12	5,25

Means followed by the same letter, in the same column, do not differ from each other by Tukey's test at 5%.

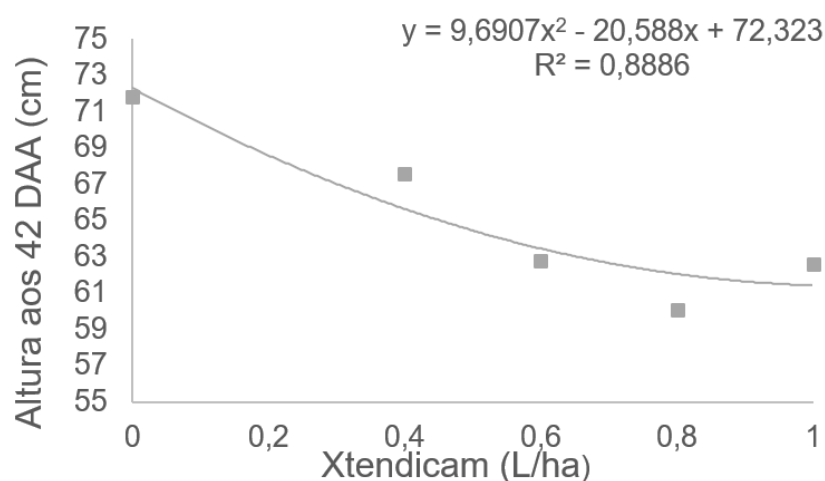
CV = coefficient of variation

Source: Authors.

According to Fleck et al. (1995), when hormonal herbicides are applied to wheat in the pre-tillering stage, they adversely affect crop height, being linked to a reduction in grain yield. Also as previously mentioned by Nunes et al. (2007), when applied high doses can cause complications to the wheat crop such as reduced seedling emergence, high degree of phytotoxicity and growth arrest.

Figure 2

Plant height 42 days after application of the herbicide Xtendicam on wheat crop during tillering



Source: Authors.

Regarding the number of tillers, the doses of 0.4 L/ha, 0.6 L/ha, 0.8 L/ha and 1 L/ha did not differ significantly from each other and were statistically lower than the number of tillers presented at the dose of 0 L/ha (1.3 tillers), negatively affecting this variable (Table 4).

The herbicide dicamba did not influence the number of plants per linear meter, as this variable had already been defined before its application. Similarly, dicamba doses did not significantly affect dry matter and the weight of one thousand grains.

The number of grains per ear was not negatively affected for the doses of 0.4 (28.9) and 0.8 L/ha (28.85), when compared to the dose of 0 L/ha(33.5), but at the doses of 0.6 (25.25) and 1 L/ha (27.85) there was a significant reduction, however, they were not different from the doses of 0.4 and 0.8 L/ha.

The wheat grain yield at the effective dicamba rates evaluated were lower than those observed at the 0 L/ha rate (85.86 bags/ha), however, there was only a significant difference between the 0.8 (55.87 bags/ha) and 0 L/ha rates.

Therefore, a significant reduction in grain yield can be observed in relation to the dose of 0 L/ha, being 15.2, 20.1, 34.9 and 30.8%, respectively, for the doses of 0.4, 0.6, 0.8 and 1 L/ha of Xtendicam. This represents about 13.0, 17.3, 30.0 and 26.5 bags/ha and considering the quotation of Coopertradição, Pato Branco-PR, on 01.07.2025 at 73 reais/bag, it is equivalent to 949, 1,262, 2,190 and 1,934 reais, respectively.

The coefficient of variation of 18.16% obtained for wheat grain yield is considered average, because according to Gomes (1990) for agricultural trials to evaluate grain yield the average CV class is represented by the CV interval of 10-20%, conferring average experimental precision, contributing to explain the considerable amplitude between the yield averages (possibly due to the influences of environmental factors) and the absence of significant difference between some effective doses and the control (0 L/ha). The VC for the other variables was less than 15%, showing that good precision and homogeneity of the results were obtained.

Table 4

Number of tillers per plant, plants per linear meter, dry matter, weight of one thousand grains, number of grains per ear and wheat yield

Dose Xtendicam	Number of tillers (Average of 5)	m/linear floor plans	MS (g)	Weight thousand grains (g)	No. of grains/cob	Productivity (sc/ha)
0.4 L/ha	0.95 b	58 to	156.88 to	39.2 to	28.9 ab	72.84 abs
0.6 L/ha	0.95 b	58 to	170.75 to	38.9 to	25.25 b	68.6 abs
0.8 L/ha	0.95 b	54 to	156.55 to	38.48 to	28.85 abs	55.87 b
1 L/ha	0.90 b	50 to	159.85 to	38.58 to	27.85 b	59.4 abs
0 L/ha	1.3 to	51 to	158.43 to	40.04 to	33.5 to	85.86 to
CV (%)	14,7	12,53	14,29	2,16	8,64	18,16

Means followed by the same letter, in the same column, do not differ from each other by Tukey's test at 5%.

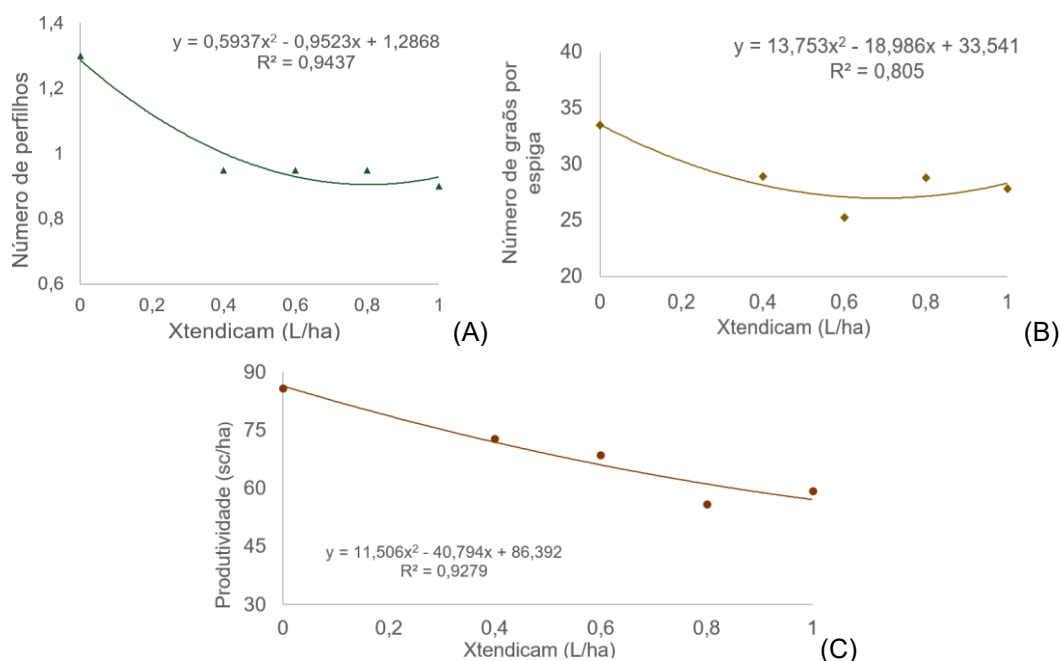
CV= coefficient of variation

Source: Authors.

The regressions indicate that the increase in Xtendicam doses reduced the number of tillers per plant, number of grains per ear and grain yield. In addition, it is possible to observe that the R^2 values were above 0.8, explaining in more than 80% the behavior of the data observed in the field (Figure 3).

Figure 3

Number of tillers (A), number of grains per ear (B) and yield (bags/ha) of wheat submitted to Xtendicam doses in tillering



Source: Authors.

According to Velloso et al. (1982), where diclofop, dicamba, 2,4 D + dicamba and the mixture diclofop + (2,4 D + dicamba) were analyzed, where the applications were carried out at 30 days after crop emergence, at the tillering stage, reported the absence of statistical differences between the treatments, for the variable reduction of the population of rye, wheat and barley plants. Thus, these herbicides did not affect the plant density of these crops, these same authors also report that dicamba caused a reduction in the grain yield of the three crops, showing little selective.

Rodrigues et al. (2006) did not observe effects in relation to the weight of a thousand grains when the hormonal herbicide dicamba was applied and its application reduced the number of full grains per ear, causing a loss of up to 60% in wheat grain yield when applied after the terminal spikelet period (end of tillering), and applications prior to the double-ring stage (beginning of tillering) can cause deformations in the ear and flag leaf.

Similarly, it was also verified by Fleck et al. (1995) that the greatest yield reductions, with applications of 2,4-D in wheat, occurred due to the reduction in the number of grains per

ear. Dicamba presents phytotoxicity to wheat causing foliar symptoms and a drop in grain yield. Also according to the same author, MCPA, 2,4-D (amine and ester) and 2,4-D amine + dicamba decreases the number of ears per area, for this reason having a decrease in grain yield. As already mentioned by Roman et al. (2006), the late application of hormones (after the beginning of elongation) causes a reduction in grain yield due to sporogenesis, causing sterility of the flowers and impairing ear formation if it is applied in late stages (Dercheid, 1951; Pinthus & Natowitz, 1967).

For these reasons, in order to have less negative impact of the crop on grain yield, the ideal would be to use the lowest dosage (0.4L/ha), which can take into account the lowest dosage of 2,4-D for wheat, in addition to applying where horseweed seedlings and other broad leaves are at an early stage to ensure a high level of control.

4 CONCLUSION

The application of dicamba herbicide in wheat crops, at the tillering stage, promoted an increase in phytotoxicity with the increase in doses, but the levels observed were low (<20%), non-permanent and with recovery capacity throughout the crop cycle.

Despite the low visual phytotoxicity, there was a negative impact on important yield components, such as number of tillers, number of grains per ear and plant height, especially at the highest doses. These effects directly reflected on grain yield, showing that the selectivity of dicamba for wheat is limited, especially at higher doses.

The variables number of plants per linear meter, shoot dry matter and weight per thousand grains were not influenced by the doses applied, indicating that the herbicide mainly affected the formation and development of the productive components, without compromising the quality of the grains.

The dose of 0.4 L ha⁻¹ of Xtendicam presented the lowest negative impact on the crop, being considered the safest under the conditions evaluated. However, even at this dose, a reduction in yield was observed in relation to the control, indicating the need for caution in the use of this herbicide in wheat crops.

The results obtained demonstrate the potential of dicamba for use in weed management in wheat, but reinforce the need for further studies to validate safe doses, efficiency in the control of target species and evaluation under different edaphoclimatic conditions, cultivars and management systems.

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