Comunicata Scientiae 3(4): 255-262, 2012

Original Article

Selectivity of nicosulfuron and atrazine on different corn hybrids

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Abstract

Nicosulfuron and atrazine are herbicides widely used for weed control on corn crops. However, its selectivity is often fairly questionable due to genotypic variability of hybrids in the market. In this context, this study aims to assess both nicosulfuron selectivity and atrazine mixture in 34 corn hybrids. Treatment was arranged in a completely randomized block design, in a split-plot scheme (34x5) with four replicates, in which corn hybrids constituted the plots and herbicides the subplots. 34 corn hybrids were submitted to four herbicide treatments: nicosulfuron (rates of 50 and 60 g ha^{-1}) and nicosulfuron + atrazine (20 + 1500 and 40 + 3000 g ha^{-1}) as well as a non treated check for each hybrid. Application was performed at 19 days (V4/V5) after corn emergence. Phytointoxication symptoms were assessed at 7; 14 and 21 days after treatment application. One thousand grain weight and hybrid yield were also determined. Based on the results, it was observed that the phytotoxic effects of nicosulfuron+atrazine (40+3000 g ha^{-1}) were enough to reduce the weight of 1000 seeds in hybrids BMX61, BMX750, and NB7405. Nevertheless, herbicide treatments, either alone or associated with atrazine, were selective to the 34 genotypes studied.

Keywords: Atrazine, post-emergence, ALS inhibitors, *Zea mays*

Seletividade de nicosulfuron e atrazine em diferentes híbridos de milho

Resumo

Nicosulfuron e atrazine são herbicidas de dupla aptidão mais utilizados no manejo de plantas daninhas na cultura do milho. No entanto, sua seletividade é bastante questionada em função da variabilidade genotípica dos híbridos presentes no mercado. Neste contexto, objetivou-se com este trabalho avaliar a seletividade do herbicida nicosulfuron e da mistura com atrazine em 34 híbridos de milho. O ensaio foi implantado em delineamento de blocos casualizados em esquema de parcelas subdivididas 34 x 5, com quatros repetições, adotando-se os híbridos na parcela e herbicidas na subparcelas. Os 34 híbridos de milho foram submetidos a quatro tratamentos herbicidas, sendo eles: nicosulfuron nas doses de 50 e 60 g ha^{-1} e nicosulfuron + atrazine nas doses 20 + 1500 e 40 + 3000 g ha^{-1}, além de uma testemunha sem herbicida para cada híbrido. A aplicação foi realizada 19 dias (V4/V5) após a emergência do milho. Foram avaliados os sintomas de fitointoxicação aos 7, 14 e 21 dias após a aplicação dos tratamentos. Determinou-se, ainda, a massa de mil grãos e a produtividade dos híbridos. Com base nos resultados, constatou-se que os efeitos fitotóxicos da mistura nicosulfuron+atrazine (40+3000 g ha^{-1}) foi suficiente para reduzir a massa de mil grãos nos híbridos BMX61, BMX750 e NB7405. Entretanto, os tratamentos herbicidas, sejam eles na forma isolada ou associada ao atrazine foram seletivos aos 34 genótipos estudados.

Palavras chave: Atrazine, pós-emergência, inibidores de ALS, *Zea mays*

Received: 27 July 2012
Accepted: 16 October 2012

Introduction

Due to its productive potential, chemical composition and nutritive value corn (*Zea mays* L.) is one of the most important sources of energy consumed in the world. Because of its wide variety of applications, which includes not only food, it has an important socioeconomic role, besides being indispensable raw material boosting diversified agro-industrial complexes (Dourado Neto & Fancelli, 2004).

Weed interference is particularly noteworthy because it may affect the crop genetic potential expression. It is estimated that the infesting weeds on corn plants during the first four weeks after emergence promote reductions ranging from 40 to 97% of grain yield (Galon et al., 2008). These reductions occur due to the competition for resources such as water, light and nutrients. According to Gimenes et al. (2011), the intensity of weed interference in corn crops is variable because of several factors such as the occurrence period, population density and species present in the environment, so that the adoption of control measures is essential to ensure maximum productivity.

Although corn crop is regarded as extremely important for grain yield in the Cerrado region, there are few studies dedicated to herbicide selectivity, mainly those applied at post-emergence. In accordance with Moraes et al. (2009), one of the most utilized and registered graminicide herbicides for corn crop is nicosulfuron. It is a systemic herbicide belonging to the sulphonyl urea group, whose activity inhibits ALS enzyme activity. It is recommended for weed post-emergence control and it has been shown to be effective for a number of weed crops (Rodrigues & Almeida, 2001). It is believed that the selectivity of this herbicide occurs due to its fast metabolism, which might also be related to its absorption speed, slower for corn crops, in this case (Silva et al., 2007).

Nicosulfuron has always been an open question and a reason of distrust for most corn farmers. This is due to the presence of phytointoxication symptoms linked to this herbicide use. Recent studies have shown that some hybrids present different levels of tolerance to nicosulfuron. By assessing yield of five corn hybrids submitted to increasing rates of the herbicide, Cavalieri et al. (2008) have observed a reduction of 17.4% in grain yield for only one of the hybrids tested, to which the highest rate of the herbicide was used (60 ha^{-1}). In another study, Cavalieri et al. (2010) have observed contrasts performed at rates of 30 and 60 ha^{-1} of nicosulfuron, verifying that the hybrids Ballu and Coodetec were more effective than nicosulfuron when compared to the other 33 herbicides studied.

On the other hand, studies on selectivity highlight the need to observe some factors such as hybrid used, period when cover nitrogen fertilization will be performed, and crop's phenological stage at application time. Once these factors are neglected, crop selectivity to these herbicides may be reduced, thus leading to the appearance of phytotoxic effects on corn plants (Nicolai et al., 2006).

Another aspect that should be mentioned is the use of tank mixture, since the association with other herbicides such as atrazine is used to maximize the action of spectrum. However, few studies take tank mixture utilization into consideration, therefore, making it crucial to ensure further research on this issue.

In order to enable the expansion of corn cropping in Brazil, further studies on differential tolerance of corn hybrids to nicosulfuron is of fundamental importance because of its relevance to weed control on this crop. In this context, this study aims to evaluate nicosulfuron alone and/or mixed with atrazine in different corn hybrids.

Material and Methods

The experiment was carried out in the city of Rio Verde, GO, latitude 17°47'29" S, longitude 50°56'41" W, and altitude of 691 meters. Regional climate, classified in accordance with Koppen International System, is humid CWA type with dry winter, average annual rainfall of 1,500 mm and average annual temperature of 25 ^{o}C.

Soil at the experimental area is classified as eutroferric red oxisol (460 g kg^{-1} clay; 60 g kg^{-1} silt; 480 g kg^{-1} sand, and 64% base saturation). Sowing was accomplished in November, 2008. Prior to sowing (10 days), the experimental area was managed using glyphosate (1.440 a.e.g ha^{-1}).

Treatment was arranged in a completely randomized block design, in a split-plot scheme (5x34) with four replicates, in which corn hybrids constituted the plots and herbicides treatments the subplots (Table 1). Each subplot consisted of 7 m long, 4 m wide (8 rows of corn) area, adding up to a total of 28 m^2. The useful floor area used for assessment were 4.5 m^2 (2 central rows of corn).

Sensitivity trial was carried out for the following hybrids: ASE9623, AS 1579, ASE9619, AS1572, AS1577, ASE9731, 20A55, BM 207, BM502, BMX61, BMX790, BMX743, BMX750, DKB245, DKB175, DKB399, 2B655, BRS 3035, BRS 2022, BRS3025, BRS4103, BRS1630, BX1255, BX993, BX1200, X6B296, B67049, X6A252, X7B415, NB7316, NB7376, NB7405, NB4306, NB7205.

Corn hybrids were sown mechanically in 0.50 m spaced rows and density of 3.5 seeds per linear meter under a no-till system. Corn seeds were previously treated using [tiodicarbe + *imidaclopid]* based insecticide (0.23 L/100 kg of seeds). A base fertilization of 350 kg ha^{-1} (8-20-18) was performed at sowing time. Cover fertilization was performed at 10 and 26 days after crop emergence applying 200 kg ha^{-1} of the fertilizer N-P-K (36-00-12).

At 19 days after corn emergence (Stage V3/V4), herbicide treatment applications were performed using a precision costal sprayer pressurized with CO_2, equipped with six nozzles type AI-110.02, calibrated for a 150 L ha^{-1} spray volume. Applications were accomplished from 8:30 to 10:05 a.m. Climatic conditions within this time were: Min. T = 23.3; Average T = 24.1°; Max. T = 26.4°; Min. RH = 78%; Average RH = 83%; Max. RH = 91%; Minimum Wind Speed = 3.1 km h^{-1}; Medium Wind Speed = 6 km h^{-1}. The moisture in the soil superficial layer was appropriate at the time of treatment application. All experimental plots were kept free of weed interference during the development of the crop.

Phytointoxication assessments were performed at 7, 15, and 21 days after treatment applications (DAT) by using a percentage scale from 0 (zero) to 100%, in which 0 (zero) represents symptoms absence and 100% represents plant death (SBCPD, 1995).

Grain yield was determined by manually harvesting corn ears present in the plots' useful floor area (4.5 m^2). Right after harvesting, the material was threshed and weighed. Grain moisture was corrected to 13% and then one thousand grain weight was determined.

Results on phytointoxication levels were transformed into $\sqrt{x+1}$ in order to create the requirements for variance analysis (*p≥0.05*). Means of significant variables were compared by the Scott-Knott test at 5% significance.

Table 1. List of herbicide treatments used in the experiment.

Treatments	Registered trade name	Rate g i.a. ha^{-1}	Rate L p.c. ha^{-1}
Non treated	-	-	-
nicosulfuron	Sanson 40 SC	50.00	1.25
nicosulfuron	Sanson 40 SC	60.00	1.50
nicosulfuron + atrazine[1]	Sanson 40 SC + Gesaprim 500	20.00 + 1,500.00	0.50 + 3.00
nicosulfuron + atrazine[1]	Sanson 40 SC + Gesaprim 500	40.00 + 3,000.00	1.00 + 6.00

[1]Mineral oil addition 0.75 v/v

Results and Discussion

Treatments in this study have shown good selectivity for different corn hybrids grown in the Cerrado region. During the first evaluation performed at 7 days after herbicide application (DAT) (Table 2), slight chlorosis was observed on young and new-born leaves. Similar effects were reported by Lópes-Ovejero et al. (2003). In contrast, Cavalieri et al. (2008) have even mentioned strong chlorosis, stained leaves and corn leaf curling in hybrids considered sensitive to nicosulfuron, findings which have not been encountered in the present study. According to Silva (2007), these effects are due to the inhibition of branched amino acid synthesis (leucine, isoleucine, and valine) via Aceto Lactate Synthase (ALS) enzyme inhibition. This effect interrupts protein synthesis, what interferes in DNA synthesis and cell growth.

Again at 7 DAT (Table 2), isolate-used nicosulfuron (60 g ha^{-1}) provided visual symptoms only for genotypes BX 993 and NB 7316. On the other hand, when used in tank mixture (nicosulfuron+atrazine at a rate of 40+3000 g ha^{-1}), the number of hybrids showing symptoms increased, especially for AS 1579, ASE9619, AS1572, AS1577, BM 207, BM502, BX1200. Despite visual effects, phytointoxication percentage was no higher than 8.0%, level considered low according to SBCPD (1995).

Table 2. Phytointoxication in several corn hybrids, 7 days after herbicide application (DAT), Rio Verde, GO, 2008-09 harvest.

Hybrids	Check		Treatments							
			nicosulfuron				nicosulfuron + atrazine			
			Rate (g ha^{-1})							
			50		60		20 + 1500		40 + 3000	
	Phytointoxication (%)									
1. ASE9623	0.00	aA	2.22	aA	3.00	aA	3.66	bA	4.33	aA
2. AS 1579	0.00	aA	2.33	aA	1.66	aA	3.00	bA	6.00	bB
3. ASE9619	0.00	aA	3.33	aA	4.33	bA	4.33	bA	3.66	aB
4. AS1572	0.00	aA	2.33	aA	1.00	aA	2.33	aA	5.66	bB
5. AS1577	0.00	aA	2.33	aA	1.66	aA	4.33	bA	6.66	bB
6. ASE9731	0.00	aA	2.33	aA	1.66	aA	2.33	aA	3.66	aA
7. 20A55	0.00	aA	1.00	aA	2.33	aA	0.00	aA	1.66	aA
8. BM 207	0.00	aA	1.00	aA	3.00	aA	1.66	aA	6.66	bB
9. BM502	0.00	aA	6.33	aB	5.66	bB	7.66	bB	7.00	bB
10.BMX61	0.00	aA	4.66	aA	3.66	aA	3.66	bA	4.33	aA
11. BMX790	0.00	aA	2.33	aA	1.00	aA	2.33	aA	3.66	aA
12. BMX743	0.00	aA	2.33	aA	3.00	aA	3.00	bA	3.66	aA
13. BMX750	0.00	aA	2.33	aA	5.00	bA	5.00	bA	3.66	aA
14. DKB245	0.00	aA	3.00	aA	4.33	bA	4.33	bA	4.66	aA
15. DKB175	0.00	aA	2.33	aA	1.00	aA	0.00	aA	0.00	aA
16. DKB399	0.00	aA	1.00	aA	1.00	aA	1.66	aA	1.66	aA
17. 2B655	0.00	aA	2.33	aA	1.00	aA	0.00	aA	3.66	aA
18. BRS 3035	0.00	aA	4.33	aA	5.00	bA	1.66	aA	2.33	aA
19. BRS 2022	0.00	aA	2.33	aA	2.33	aA	1.66	aA	2.33	aA
20. BRS3025	0.00	aA	1.00	aA	1.00	aA	0.00	aA	2.33	aA
21. BRS4103	0.00	aA	2.33	aA	2.33	aA	3.66	bA	2.33	aA
22. BRS1630	0.00	aA	1.00	aA	2.66	aA	3.00	bA	3.00	aA
23. BX1255	0.00	aA	1.00	aA	5.66	bA	0.00	aA	4.33	aA
24. BX993	0.00	aA	1.00	aA	7.66	bB	3.00	bA	3.66	aA
25. BX1200	0.00	aA	7.00	aA	5.66	bA	3.66	bA	8.00	bB
26. X6B296	0.00	aA	1.00	aA	1.00	aA	1.66	aA	2.33	aA
27. B67049	0.00	aA	2.33	aA	3.66	aA	2.33	aA	2.33	aA
28. X6A252	0.00	aA	1.00	aA	2.33	aA	5.00	bA	2.33	aA
29. X7B415	0.00	aA	1.00	aA	1.66	aA	1.66	aA	2.33	aA
30. NB7316	0.00	aA	1.00	aA	7.56	bB	3.66	bA	3.66	aA
31. NB7376	0.00	aA	2.33	aA	1.00	aA	0.00	aA	2.33	aA
32. NB7405	0.00	aA	1.66	aA	5.66	bA	4.33	bA	5.66	bA
33. NB4306	0.00	aA	3.00	aA	2.33	aA	0.00	aA	4.33	aA
34. NB7205	0.00	aA	1.00	aA	3.00	aA	3.66	bA	4.33	aA
CV% Herb.					23.12					
CV% Hybr.					18.43					

*Means of treatments followed by the same letter (lower case letter in the column and capital letters in the line) do not differ by the Scott-Knott test at (p> 0.05) probability.

Phytointoxiation results at 14 DAT have followed the same tendency of values presented at 7 DAT and phytointoxication levels have oscillated between 0.0 to 5.3% and therefore considered low (data not shown). During this period, symptoms of slight chlorosis remained and no abnormalities in both leaves and plant development were observed. According to Dan et al. (2012), this is a remarkable feature in corn plants intoxicated with ALS-inhibiting herbicides.

In addition to that, there is a reduction of visual effects caused by herbicide treatments at 21 DAT (Table 3) with maximum values of 3.7% for the hybrid 1200 for both rates mixed with atrazine. Within this assessment period, symptoms practically disappeared, indicating great recovery capacity of the hybrids evaluated. It was observed that the association with atrazine had no antagonistic influence on this herbicide selectivity, which is an important tool on weed control for corn crops. Data obtained in this study corroborate those observed by Nicolai et al. (2006), who have reported that atrazine did not provide negative effects when applied in the presence of nicosulfuron. According to these authors, this association, although prohibited by legislation, presented low intoxication levels in corn plants, showing that it is selective for a number of hybrids.

Table 3. Phytointoxication in several corn hybrids, 21 days after herbicide application (DAT), Rio Verde, GO, 2008-09 harvest.

Hybrids	Check		nicosulfuron 50		nicosulfuron 60		nicosulfuron + atrazine 20 + 1500		nicosulfuron + atrazine 40 + 3000	
	Phytointoxication (%)									
1. ASE9623	0.00	aA	0.00	aA	0.00	aA	0.00	aA	2.34	bB
2. AS 1579	0.00	aA	1.66	aA	0.00	aA	0.00	aA	1.64	aA
3. ASE9619	0.00	aA	1.88	aA	1.66	aA	1.63	aA	1.64	aA
4. AS1572	0.00	aA	1.66	aA	1.66	aA	0.00	aA	1.64	aA
5. AS1577	0.00	aA	0.00	aA	1.66	aA	0.00	aA	1.64	aA
6. ASE9731	0.00	aA	1.66	aA	0.00	aA	1.66	aA	2.34	bB
7. 20A55	0.00	aA	0.00	aA	0.00	aA	0.00	aA	0.00	aA
8. BM 207	0.00	aA	0.00	aA	0.00	aA	1.66	aA	2.34	bB
9. BM502	0.00	aA	1.70	aA	3.00	bB	2.44	aB	2.34	bB
10.BMX61	0.00	aA	1.66	aA	2.33	bB	1.66	aA	1.64	aA
11. BMX790	0.00	aA	1.80	aA	1.66	aA	0.00	aA	2.34	bB
12. BMX743	0.00	aA	1.66	aA	1.66	aA	1.12	aA	1.64	aA
13. BMX750	0.00	aA	1.87	aA	2.33	bB	0.00	aA	0.00	aA
14. DKB245	0.00	aA	0.00	aA	1.66	aA	0.00	aA	1.64	aA
15. DKB175	0.00	aA	2.33	aB	0.00	aA	0.00	aA	0.00	aA
16. DKB399	0.00	aA	0.00	aA	0.00	aA	0.00	aA	0.00	aA
17. 2B655	0.00	aA	1.66	aA	0.00	aA	0.00	aA	0.00	aA
18. BRS 3035	0.00	aA	1.09	aA	1.66	aA	0.00	aA	0.00	aA
19. BRS 2022	0.00	aA	1.67	aA	0.00	aA	0.00	aA	0.00	aA
20. BRS3025	0.00	aA	0.00	aA	0.00	aA	0.00	aA	0.00	aA
21. BRS4103	0.00	aA	0.00	aA	0.00	aA	1.90	aA	1.64	aA
22. BRS1630	0.00	aA	0.00	aA	0.00	aA	1.66	aA	1.64	aA
23. BX1255	0.00	aA	0.00	aA	3.00	bB	0.00	aA	3.02	bB
24. BX993	0.00	aA	0.00	aA	0.00	aA	1.98	aA	1.64	aA
25. BX1200	0.00	aA	2.33	aB	1.66	aA	3.62	aB	3.70	bB
26. X6B296	0.00	aA	0.00	aA	0.00	aA	0.00	aA	1.64	aA
27. B67049	0.00	aA	0.00	aA	1.66	aA	0.00	aA	1.64	aA
28. X6A252	0.00	aA	1.66	aA	0.00	aA	1.66	aA	2.34	bB
29. X7B415	0.00	aA	0.00	aA	0.00	aA	0.00	aA	2.34	bB
30. NB7316	0.00	aA	0.00	aA	2.33	bB	1.66	aA	1.64	aA
31. NB7376	0.00	aA	0.00	aA	0.00	aA	0.00	aA	1.64	aA
32. NB7405	0.00	aA	2.33	aB	3.66	bB	3.30	aB	3.50	cB
33. NB4306	0.00	aA	1.67	aA	0.00	aA	0.00	aA	1.64	aA
34. NB7205	0.00	aA	0.00	aA	0.00	aA	0.00	aA	0.00	aA
CV% Herb.					26.21					
CV% Hybr.					19.92					

Treatments: Check; nicosulfuron; nicosulfuron + atrazine. Rate (g ha^{-1}).

*Means of treatments followed by the same letter (lower case letter in the column and capital letters in the line) do not differ by the Scott-Knott test at (p> 0.05) probability.

Low levels of phytointoxication are due to the fact that corn plants are able to metabolize hexogen compounds of both nicosulfuron and atrazine. Tolerant species rapidly detoxicate these herbicides, transforming them into non-phytotoxic compounds. For ALS-inhibiting herbicides, this process occurs due to the action of cytochrome P450 monooxygenase in hydroxylation and glyoxylation reactions (Fonne-Pfister et al., 1990). On the other hand, atrazine presents the action of cysteine and glutathione compounds in the conjugation process of this hexogen compound as well as hydroxylation caused by heme-protein cytochrome P-450 (Maracci et al., 2005). Regarding mixtures, it can be inferred that there is an increase in energy consumption at the peak periods of greatest activity of the herbicide in corn plants. This can explain the increased phytotoxic effects of nicosulfuron mixed with atrazine. However, it is important to highlight the low levels of phytointoxication for all herbicide treatments.

Another variable which did not present any influence from different herbicide treatments was plant height (data not shown). There was no significant interaction for this criterion, which is one of the main components assessing the physiological balance on plant development. On the other hand, significant effects on one thousand grain weight – yield main component – were observed.

BMX61, BMX750, and NB7405, when treated with nicosulfuron+atrazine (40+3000 g ha^{-1}) obtained the lowest grain weight when compared to the non-treated check and the other herbicide treatments (Table 4). Equally important to note is that negative effects were observed for the other hybrids evaluated. This important fact relates hybrid tolerance to nicosulfuron alone or mixed with atrazine, since one of the most evident symptoms of phytointoxication caused by this herbicide is the presence of constricted ears at the rachis diameter, failure of grain formation and a consequent reduction in weight as reported by Spader & Vidal (2001). However, according to literature, such effect is observed only in more sensitive ALS-inhibiting hybrids, often in late applications (V5/V6), when application is performed at the peak of floral differentiation (Dourado Neto & Fancelli, 2004), clearly showing the importance of the stage at which application is accomplished. By assessing nicosulfuron effects in corn hybrids, Dan et al. (2010) have observed negative effects only for the genotype AX-890, which did not affect the main yield component of other hybrids.

Table 4. One thousand grain weight in several corn hybrids submitted to different post-emergence herbicide treatments. Rio Verde-GO, 2008-09 harvest.

Hybrids	Treatments				
	Check	Nicosulfuron		nicosulfuron + atrazine	
		Rate (g ha^{-1})			
		50	60	20 + 1500	40 + 3000
	One thousand grain weight (g)				
1. ASE9623	271.2 aA	281.1 bA	287.8 bA	271.4 bA	291.3 bA
2. AS 1579	282.9 aA	271.5 aA	295.1 bA	303.1 cA	304.1 bA
3. ASE9619	296.0 bA	306.5 cA	303.7 cA	297.3 bA	293.7 bA
4. AS1572	294.5 bA	304.0 cA	302.7 cA	307.6 cA	312.4 bA
5. AS1577	292.3 bB	325.3 cA	284.9 bB	277.0 bB	291.2 bB
6. ASE9731	303.1 bA	243.0 aA	276.1 bA	277.0 bA	255.2 aA
7. 20A55	253.5 aA	293.1 bA	287.5 bA	266.4 aA	276.1 bA
8. BM 207	251.6 aA	272.1 bA	278.0 bA	255.6 aA	267.1 aA
9. BM502	262.1 bA	271.5 bA	296.4 bA	275.2 bA	268.8 bA
10.BMX61	279.0 bA	293.3 aA	274.1 bA	284.1 bA	245.9 aB
11. BMX790	264.2 bA	306.0 cB	272.6 bA	273.4 bA	274.8 bA
12. BMX743	252.4 aA	266.3 aA	274.8 bA	250.5 aA	276.3 bA
13. BMX750	279.9 bA	303.0 cA	277.5 bA	290.1 bA	248.1 bB
14. DKB245	285.0 bA	282.9 bA	278.2 bA	269.1 aA	269.1 bA
15. DKB175	284.0 bA	284.4 bA	300.4 cA	298.2 bA	300.1 bA
16. DKB399	263.9 bA	264.0 aA	281.3 bA	278.7 bA	287.4 bA
17. 2B655	272.1 bA	285.2 bA	283.4 bA	276.8 bA	277.6 bA
18. BRS 3035	274.3 bA	266.4 aA	283.4 bA	276.5 bA	280.1 bA
19. BRS 2022	286.5 bA	296.4 bA	295.0 bA	296.9 bA	297.6 bA
20. BRS3025	277.1 bA	288.1 bA	279.9 bA	284.7 bA	275.5 bA
21. BRS4103	277.1 bA	289.8 bA	295.0 bA	283.0 bA	283.8 bA
22. BRS1630	254.7 aA	269.4 aA	283.5 bA	278.2 bA	264.9 aA
23. BX1255	255.5 aA	289.1 bA	275.6 bA	288.3 bA	277.1 bA
24. BX993	284.7 bA	297.1 bA	307.4 cA	289.5 bA	298.4 bA
25. BX1200	265.3 bA	255.9 aA	279.3 bA	259.8 aA	266.3 aA
26. X6B296	254.9 aA	262.7 aA	268.9 aA	258.1 aA	254.9 aA
27. B67049	275.2 bA	264.1 aA	304.1 cA	278.9 bA	273.5 bA
28. X6A252	302.7 bA	355.1 cA	335.3 cA	318.9 cA	322.8 bA
29. X7B415	288.4 bA	285.0 bA	304.2 cA	291.2 bA	301.3 bA
30. NB7316	262.3 bA	256.4 aA	242.9 aA	257.1 aA	255.6 aA
31. NB7376	272.1 bA	276.1 bA	271.2 bA	276.7 bA	266.9 bA
32. NB7405	285.6 bA	277.4 bA	279.4 aA	278.1 bA	251.1 aB
33. NB4306	267.9 bA	266.3 aA	275.3 bA	276.5 bA	270.4 bA
34. NB7205	277.1 bA	274.0 bA	273.9 bA	277.8 bA	280.9 bA
CV% Herb.			13.29		
CV% Hybr.			9.14		

*Means of treatments followed by the same letter (lower case letter in the column and capital letters in the line) do not differ by the Scott-Knott test at (p> 0.05) probability.

Despite the unwanted effects on one thousand grain weight found in some hybrids (BMX61, BMX750, and NB7405), the same behavior was not confirmed for the grain yield variable. There was no significant interaction between treatments effects within each hybrid studied, that is, herbicide treatments showed similar yield when compared to the non-treated check (Table 5). Nevertheless, when nicosulfuron+atrazine (40+3000 g ha^{-1}) effects were compared to BMX61, BMX750, and NB7405, yield losses of 13.9; 10.6 and 7.6 bags ha^{-1} were obtained, respectively in relation to the non-treated check. Such results indicate that increased caution should be taken when utilizing nicosulfuron+atrazine (40+3000 g ha^{-1}) treatment for these genotypes. Effects of nicosulfuron on crop yield were reported by Cavalieri et al. (2008) on the selectivity of hybrids B 551, Ocepar 705, Penta, B 761, AG 7000 evaluated under field conditions, in which only B-761 showed increased sensitivity to 60 g ha^{-1} nicosulfuron utilization.

Tabela 5. Yield of several corn hybrids submitted to different post-emergence herbicide treatments. Rio Verde-GO, 2008-09 harvest.

Hybrids	Treatments									
	Check		nicosulfuron				nicosulfuron + atrazine			
			Rate (g ha^{-1})							
			50		60		20 + 1500		40 + 3000	
	Yield (Bags ha^{-1})									
1. ASE9623	84.14	bA	81.47	bA	82.42	bA	91.33	bA	88.93	aA
2. AS 1579	73.34	aA	74.08	aA	73.62	aA	71.80	aA	73.43	bA
3. ASE9619	79.25	bA	81.16	bA	89.64	bA	84.85	bA	89.66	bA
4. AS1572	88.17	bA	86.88	bA	81.24	bA	80.05	aA	81.25	aA
5. AS1577	77.46	aA	79.18	bA	79.12	bA	84.02	bA	81.46	aA
6. ASE9731	79.77	bA	85.09	bA	80.29	bA	86.75	bA	91.92	bA
7. 20A55	85.99	aA	85.39	bA	77.86	bA	85.99	bA	91.73	bA
8. BM 207	80.47	bA	79.81	bA	78.68	bA	76.22	aA	93.74	bA
9. BM502	75.96	aA	83.80	bA	81.56	bA	86.06	bA	72.58	aA
10.BMX61	89.77	bA	76.42	aA	79.60	bA	81.77	bA	75.78	bA
11. BMX790	83.51	bA	81.21	cA	81.22	bA	80.88	aA	76.37	aA
12. BMX743	78.09	aA	85.98	bA	82.55	bA	87.39	bA	87.26	bA
13. BMX750	84.88	bA	77.48	aA	83.04	bA	88.68	bA	74.03	bA
14. DKB245	80.16	bA	81.84	bA	86.21	bA	79.00	aA	79.05	aA
15. DKB175	91.22	cA	89.25	bA	88.02	bA	90.05	bA	84.38	aA
16. DKB399	99.41	cA	98.46	cA	91.63	bA	88.33	aA	88.62	bA
17. 2B655	76.77	aA	75.91	aA	75.17	aA	81.83	bA	81.73	bA
18. BRS 3035	65.27	aA	67.04	aA	62.75	aA	71.38	aA	79.17	aA
19. BRS 2022	82.40	bA	76.00	aA	77.19	aA	73.67	aA	70.38	aA
20. BRS3025	72.59	aA	74.51	aA	88.22	bA	83.13	bA	78.68	aA
21. BRS4103	75.76	aA	81.08	bA	70.37	aA	75.59	aA	78.82	aA
22. BRS1630	80.54	bA	70.36	aA	73.58	aA	80.13	aA	75.43	aA
23. BX1255	86.40	bA	70.68	aA	70.68	aA	72.00	aA	76.15	aA
24. BX993	73.37	aA	78.22	aA	81.42	bA	86.99	bA	70.29	aA
25. BX1200	78.20	aA	80.29	bA	76.55	bA	81.89	bA	84.00	bA
26. X6B296	82.19	bA	77.75	aA	79.41	bA	80.42	aA	77.48	aA
27. B67049	97.34	cA	89.31	bA	84.34	bA	87.46	bA	93.33	bA
28. X6A252	92.81	cA	88.77	bA	92.74	bA	92.89	bA	89.45	bA
29. X7B415	80.10	aA	76.17	aA	74.51	aA	79.27	aA	85.91	bA
30. NB7316	82.85	bA	71.49	aA	73.95	aA	82.63	bA	81.10	aA
31. NB7376	82.03	bA	81.42	aA	91.77	bA	79.49	aA	90.56	bA
32. NB7405	73.26	aA	75.51	aA	66.17	aA	73.84	aA	65.59	aA
33. NB4306	66.69	aA	64.78	aA	71.27	aA	78.25	aA	70.80	aA
34. NB7205	80.93	bA	80.86	bA	84.86	bA	82.31	bA	86.28	bA
CV% Herb.					15.11					
CV% Hybr.					11.54					

*Means of treatments followed by the same letter (lower case letter in the column and capital letters in the line) do not differ by the Scott-Knott test at (p> 0.05) probability.

A possible explanation for such results may be found on the form of genotype selection. Some researchers perform nicosulfuron applications in segregating populations, aiming not only at weed control but also at the selection of genotypes which show selectivity to this herbicide. This activity provides greater reliability of the genotypes launched in the market.

Based on these results, it was found that nicosulfuron alone or mixed with atrazine provides low levels of injuries and does not affect the 34 hybrid yield studied. On the other hand, the nicosulfuron+atrazine (40+3000 g ha^{-1}) mixture provides negative effects on one thousand grain weight of hybrids BMX61, BMX750, and NB7405 demanding increased caution in relation to these treatments.

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