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Selective Doses of Mesotrione Applied at Different Post-Emergence Stages of White Oat (*Avena sativa*) Cultivated in Southern Plateau of Brazil

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Abstract

This study aimed to characterize the selectivity of the herbicide mesotrione, applied at three different stages of plant development, by evaluating the injury, yield and quality of grains of white oats. The experimental design was completely randomized with four replicates. The plants of the white oat cultivar URS Corona were sprayed with 4 doses of mesotrione (0, 84, 168 and 336 g a.i. ha^{-1}) applied at 3 vegetative stages (12, 14 and 16 Zadoks code, as early, ideal and late stages, respectively). Leaf injury began at 7 DAA with the symptoms of leaf bleaching (35% and 10% in the 2022/23 and 2023/24 growing season, respectively) and these injuries were reduced at 28 DAA (5 and 2% in the 2022/23 and 2023/24 season, respectively). The mesotrione sprayed at a dose of 168 g a.i. ha^{-1}, did not cause losses of grain yield and grain quality when compared with the control. In conclusion, mesotrione should be applied at post-emergence up to a dose of 168 g a.i. ha^{-1} on white oat plants (cv URS Corona) when it had two to six leaves on the main stem. The results showed flexibility and safety regarding the post-emergence application of time and dose of mesotrione on the white oat plants as the selective herbicide.

Keywords: White oat; Weed management; Phenology; Grain yield; Industrial quality

Introduction

White oat crops may be faced with grain yield losses, harvest difficulties and reduced grain quality due to interference from weeds, such as turnip (*Raphanus sativus* L.) (Xavier *et al*. 2022), ryegrass (*Lolium* sp. Lam.) (Han *et al*. 2021) and black oats (*Avena strigosa* Schreb.) (Pedroso *et al*. 2021). These species are used as green manure or in winter pasture and leave a large seed bank in soil (Galon *et al*. 2023), thereby interfering with subsequent crops. Furthermore, Wildner *et al*. (2023) suggested that turnip and ryegrass, when cultivated as cover crop, should not produce seeds, so as not to become weeds; but when produce seeds, become weeds, a fact already observed in cultivated areas in the state of Santa Catarina, Brazil.

Thus, weeds are predominantly controlled by the chemical method, with post-emergence application of herbicides on the cultivated plant (Castro *et al*. 2011). However, for the white oat crop, there are only five registered active ingredients: 2, 4-D, 2-methyl-4-chlorophenoxyacetic acid dimethylamine salt (MCPA), metsulfuron methyl, bentazone and dicamba (Agrofit 2024). Thus, of these five products, none efficiently controls these three weed species, with post-emergence application of the white oat crop.

There is still a shortage of research to test new herbicides and recommend them for white oats in Brazil, but herbicide selectivity is mandatory for oats, since both oats and weeds emerged in post-emergence applications and there is greater herbicide absorption by the plant shoot, which requires white oat plants to be tolerant to such exposure (Junior and Inoue 2011). In addition, plant growth stage (crop and associated weeds) is important for evaluations of herbicide application efficiency; finally, the herbicide being used must effectively control only the weeds.

Research on the herbicide mesotrione has mostly focused on maize, for example, the response of maize inoculated with *Azospirillum brasilense* under spraying with mesotrione (Bulegon *et al*. 2017), determination of dose curve and weed control (Nurse *et al*. 2010), response of different hybrids to spraying with

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mesotrione (Meyer *et al*. 2010), physiological aspects of maize related to selectivity to mesotrione (Freitas *et al*. 2016). However, there is also research in other species, such as the effect of mesotrione on cassava cultivars (Silveira *et al*. 2012), response of wheat genotypes to mesotrione application (Sudhakar *et al*. 2024), characterization of sorghum genotypes resistant to mesotrione (Pandian *et al*. 2020) and selectivity of sorghum to mesotrione application (Magalhães *et al*. 2023).

As far as white oats are concerned, the study by Soltani *et al*. (2011) evaluated the sensitivity of oats and barley to doses of mesotrione applied at post-emergence. Although mesotrione causes injuries to these plants, it did not reduce the yield of white oats and barley, so it can be concluded that when applied at post-emergence at doses ranging from 50 to 150 g/ha (a.i.), mesotrione can be safely used for these species. Other studies addressed the physiological quality of white oat seeds produced by plants treated with mesotrione (Buba *et al*. 2023a) and the role of mesotrione metabolization and conjugation in white oat tolerance (Buba *et al*. 2023b). However, there are several aspects that have not yet been elucidated and therefore further research should be conducted on the use of mesotrione in white oats.

Mesotrione is a herbicide from the triketone chemical group and its mode of action is to inhibit the enzyme 4-hydroxyphenylpyruvate dioxygenase (HPPD) (Maeda *et al.* 2019). The HPPD enzyme is responsible for catalyzing the conversion of tyrosine into plastoquinone and alpha tocopherol (Buba *et al.* 2023a, b). Without the HPPD enzyme, there is an increase in tyrosine and a depletion of plastoquinone in meristematic tissue. Since plastoquinone is a critical cofactor for the phytoene desaturase enzyme, its decrease leads to a depletion of carotenoids, resulting in bleaching of the plant tissue. This occurs because plastoquinone is responsible for the conversion of phytoene into phytofluene, which is a colorless precursor of carotenoids, which has the function of protecting chlorophyll. The lack of conversion leads to the accumulation of phytoene, leaving the tissues exposed to the occurrence of photooxidation, thus, the plants produce bleaching (colorless) leaf tissues (Soltani *et al*. 2011). However, the application of this herbicide at different stages of development of winter crops has not yet been tested and may present differences in the response of this crop. Information on herbicide application stages in white oats is still scarce.

White oats may respond differently to the application of different doses of mesotrione, based on the capacity of the plant to metabolize the herbicide and depending on its phenological stage of development. Considering the above-mentioned context, this study evaluated the selectivity of mesotrione when applied at the 3 stages of vegetative development (early, ideal and late) of white oats and its effect on grain yield and grain quality.

Materials and Methods

Site of experiment

The field experiment was carried out during the 2022/23 and 2023/24 growing seasons in the experimental farm of the Santa Catarina State University – Agroveterinary Sciences Center (UDESC-CAV), in the municipality of Lages/SC.

The meteorological data of temperatures (maximum, average and minimum) and daily rainfall occurred on experimental farm of Lages during the plant growth in both growing seasons (Fig. 1). Both experiments were done in an aluminum humic Cambisol, with the following characteristics (after liming): pH in water: 6.0; Ca: 7.5 cmolc dm^{-3}; Mg: 4.6 cmolc dm^{-3}; Al: 0.1 cmolc dm^{-3}; K: 95 mg dm^{-3}; $P_{(Mehlich)}$: 61.1 mg dm^{-3}; cation exchange capacity-CEC: 13.8 cmolc dm^{-3}; organic matter-OM: 28 g dm^{-3} and Clay: 500 g dm^{-3}.

Plant material

The experiments were carried out on the white oat cultivar URS Corona. This cultivar was released on March 19, 2012; and is characterized by early cycle, great height (106 cm plant height) moderate lodging resistance and good resistance to leaf rust (Carvalho *et al*. 2023). The cultivar URS Corona stands out for its high grain yield potential (in the 2022 cultivar trial it achieved a yield of up to 8 t ha^{-1}) and is as the main white oat cultivar in Brazil (Carvalho *et al*. 2023; Lucas *et al*. 2023).

Experimental design, treatments and management practices

The soil was prepared with a plow and leveling harrow to incorporate corrective (limestone) and sowing was carried out with an experimental plot seeder, coupled to the tractor for conventional sowing, on July 22, 2022 and July 24, 2023, respectively.

The experimental design was completely randomized, with four replicates, arranged in a 3 x 3 + 1 factorial arrangement, with factor A consisting of three phenological stages: 12, 14 and 16 on the Zadoks *et al*. (1974) codes; Factor B consisted of the following herbicide doses: 84, 168 and 336 g a.i. ha^{-1} of mesotrione (Meristo®) with the addition of mineral oil (Assist®) at a concentration corresponding to 0.2% of the spray volume and as an additional treatment, the control (0 g a.i. ha^{-1}). Each plot consisted of 5 rows of 5.5 m in length and the rows spaced apart (0.2 m). The plant population used was in accordance with the technical indications of the crop, corresponding to 350 viable seeds per square meter. Base fertilization was applied according to the soil analysis obtained, for an expected grain yield of 6 t.ha^{-1}; consisting of 30 kg of N, 108 kg of P_2O_5 and 54 kg of K_2O per hectare.

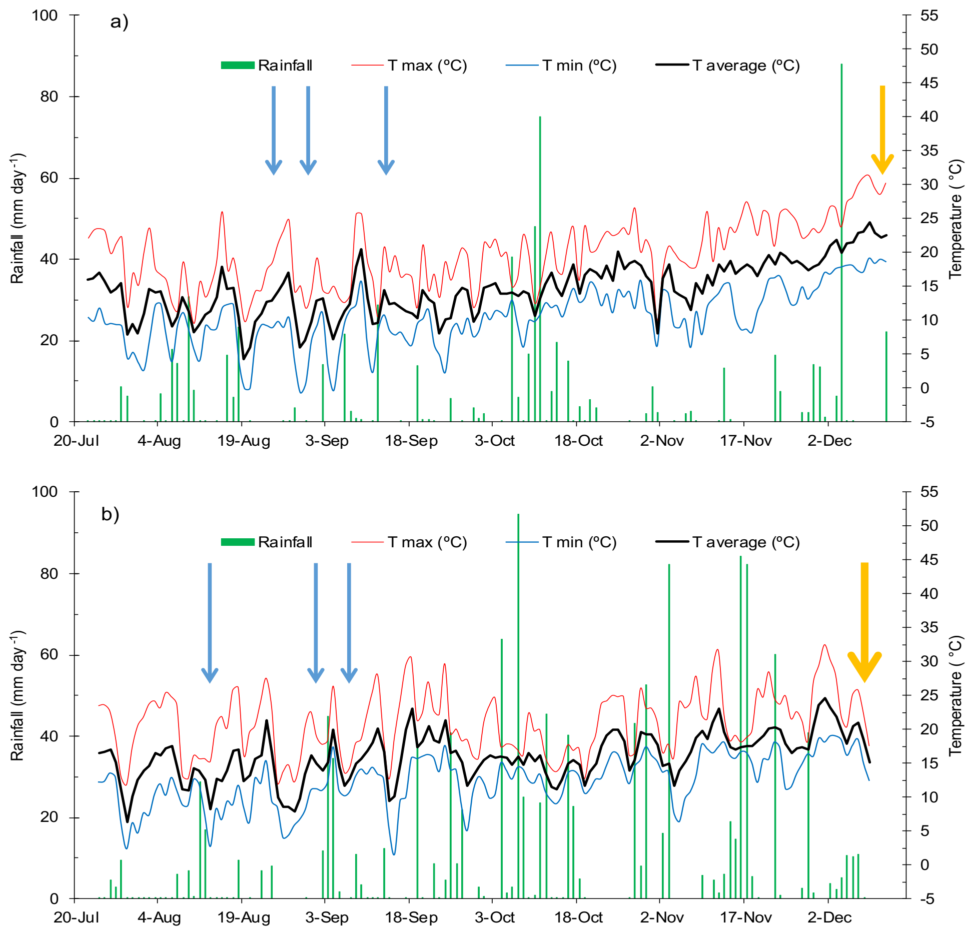

Fig. 1: Daily rainfall and temperatures (minimum, average and maximum) during (**a**) 2022/23 and (**b**) 2023/24 white oat growing season, Lages-SC, Brazil. The blue arrows show mesotrione applications dates at 12 (early), 14 (ideal) and 16 (late) plant development stages and orange arrows show harvest date

The topdressing N fertilization was performed with 78 kg of N (as urea) spliced in two times, when plant reach first tiller visible per plant and second at early stem elongation.

In the two crop seasons, white oats URS Corona were sown in an area of soybean/white oats succession. Phytosanitary management was carried out according to technical recommendations (Brazilian white oats guide) (Danielowski *et al*. 2021). Furthermore, management was directed towards controlling weeds, foliar diseases and insect pests. For management of magnoliopsid weeds (dicots), metsulfurom-methyl [Ally®, 5 g c.p. (commercial product) ha^{-1}] was sprayed in post-emergence. For diseases caused by *Puccinia coronata* var. *avenae*, spraying was carried out with the fungicides epoxiconazol + fluxapyroxad + pyraclostrobin (Ativum®, 1.2 l c.p. ha^{-1}), azoxystrobin + cyproconazol (Priori Xtra®, 0.3 l c.p. ha^{-1}) and pyraclostrobin (Comet®, 0.8 l c.p. ha^{-1}). To control *Bipolaris sorokiniana*, the fungicide trifloxystrobin + tebuconazol (Nativo®, 0.75 l c.p. ha^{-1}) was sprayed and for *Blumeria graminis*, propiconazol + difenoconazol (Score Flex®, 0.5 l c.p. ha^{-1}) was sprayed. To control insects such as *Pseudaletia sequax*, the insecticide teflubenzuron (Nomolt®, 0.2 l c.p. ha^{-1}) was sprayed and for *Diabrotica speciosa*, *Dichelops melacanthus* and *Colaria scenica*, profenofos+petroleum naphtha (Curyon®, 0.75 l c.p. ha^{-1}) was sprayed. Such insecticides like thiodicarb (Larvin WG), beta-cypermethrin (Mustang®) and thiamethoxam + lambda-cyhalothrin (Engeo Pleno®) were applied alternately between one application and another.

The identification of specific plant stages: 12 (early), 14 (ideal) and 16 (late) was based on the appearance of the 2nd, 4th and 6th leaves on the main shoot and were considered early, ideal and late stages, respectively. When the plants reached these stages, they were sprayed with different doses of mesotrione using a backpack sprayer pressurized with CO_2, with a pressure of 30 psi, equipped with six 80.04 VS cone jet nozzles (TeeJet®, ConeJet, USA), calibrated for a spray volume of 200 L ha^{-1}.

In addition, the harvest was carried out with a self-propelled harvester in experimental plots (Wintersteiger) on

December 12, 2022 and December 9, 2023, immediately after which post-harvest evaluations were carried out.

Traits evaluated

The variables evaluated were injury, yield and industrial quality of the grains (hectoliter weight, thousand grain weight, hulling index and moisture content). Injury was assessed at 7, 14, 21 and 28 days after application (DAA) of mesotrione, using the system proposed by the SBCPD (1995), in which 0% means absence of symptoms and 100% corresponds to complete dead plants.

When plants reach the harvest maturity point, the seed plot harvester was used. After harvest, the grain samples were cleaned and following traits were evaluated on basis in previously ours works according Uarrota *et al.* (2017): The grain sieve (grains greater than 2 mm – G > 2) was performed with weighted 100 g of grains, after which the sample was sieved for one minute into 2 mm × 20 mm sieve (hole) and newly weighed according to Brazilian Agricultural Agency (Brazil/MAPA 2009); the hectoliter weight (HW) was assessed, which was estimated from a weight (kg) equivalent to 100 L (Brazil/MAPA 2009), using the Dalle Molle scale equipment with a standard volume of 0.25 L. For the thousand grains weight (TGW), the grains from the hectoliter weight assessment were subjected to an electronic counter, reaching 1000 grains greater than 2 mm, which were weighed on a semi-analytical balance (precision of 0.01 g) as proposed by MAPA (Brazil/MAPA 2009). The hulling index was determined with one sample of 5 g of hulled grains that was dehulled and weighed again; the value was expressed in percentage, according to a previous study (Uarrota *et al.* 2017). The grains moisture content was performed with 10 g of grains, following the sample was dried into oven to 105°C for 24 h and newly weighed as according to MAPA (Brazil/MAPA 2009).

Statistical analysis

The data obtained were subjected to normality and homogeneity tests and analysis of variance using the F test ($P < 0.05$). The injury data at 7, 14, 21 and 28 DAA did not meet the assumptions and were transformed into $(X+1)^{0.5}$. When significant, the qualitative factors were subjected to the Tukey test ($P < 0.05$) and the quantitative factors were subjected to regression using the Sisvar software.

Results

In 2022/23 season, there was a significant effect ($P < 0.05$) between application stage and dose of mestrione for the variable injury after application of mesotrione at 7, 14 and 28 DAA and a significant effect ($P < 0.05$) only for dose (in the average of the three stages) in the evaluation of injury at 21 DAA. Differently, in the 2023/24 season, there was a significant effect ($P < 0.05$) between stage and dose for injury at 7, 14, 21 and 28 DAA of mesotrione.

In the 2022/23 and 2023/24 seasons, there was injury after the application of mesotrione in the post-emergence of white oats at all doses and stages tested (Fig. 2). Regardless of the stage of mesotrione application, increasing the dose causes increased the level of injury to white oat plants (Fig. 2).

Symptoms whitening, yellowing and purpling color started from 7 DAA and reduced to 28 DAA (Fig. 2). However, depending on the stage and growing season, the highest level of injury occurred at 7 DAA (early stage in the 2022/23 season, ideal and late stage in the 2023/24 season) at 14 DAA (initial stage in the 2023/24 season, ideal in the 2022/23 and 2023/24 season). However, the magnitude of injuries was different, due to the different climatic conditions between seasons (Fig. 1). In Fig. 2a, injuries were greater than 20% at doses 168 and 336 g a.i. ha^{-1} in all stages at 7 DAA, on the other hand (Fig. 2b), only in the late stage, doses 168 and 336 g a.i. ha^{-1} showed injury greater than 20% at 7 DAA. Likewise, at 28 DAA in the 2022/23 season, injuries were less than 20% compared to the 2023/24 season, which were less than 10% (Fig. 2a–b).

For grain yield, there was a significant effect ($P < 0.05$) of doses. In the 2022/23 season, the control and doses 84 and 168 g a.i. ha^{-1} of mesotrione obtained the highest grain yield. In the 2023/24 season, the grain yield from control was like the mesotrione doses (Fig. 3a–b). It is worth mentioning that there was a large discrepancy in the grain yields of white oat when comparing seasons (2022/23 and 2024/23 seasons), but into each growing season, the herbicide doses and plant development stages had a low impact on grain yield (Fig. 3). In the 2022/23 seasons, the grain yield obtained was 5889, 5953 and 5684 $kg.ha^{-1}$ in the early, ideal and late plant stages, respectively (Fig. 3a). Nonetheless, in the 2023/24 season the yield was lowest with values of 2855, 3018 and 2863 $kg.ha^{-1}$ in the initial, ideal and late stages of mesotrione application, respectively (Fig. 3b). The differences in the grain yield were probably a reflection of the climatic conditions that occurred in each oat growing season, as in the first season (2022/23) it rained 692 mm with an average temperature of 14.6°C. However, in the second season (2023/24) it rained practically twice as much (1256 mm) and with the average temperature was 16°C; therefore, it was 2°C higher (Fig. 1). In addition to grain yield, the quality of the produced grains was also of fundamental importance, especially for commercialization and consumption as food. In white oats, grain quality is determined by hectoliter weight, percentage of caryopsis/hull or hulling index (%), proportion between thick and thin grains and grain weight.

For grain sieve (G > 2), only the early stage in the 2022/23 season showed a significant effect ($P < 0.05$), with control being superior to the mesotrione doses tested. The dose of 336 g a.i. ha^{-1} of mesotrione caused a reduction in grain thickness, indicating that high dose negatively affected the size of oat grains, making them thinner/narrower. In the

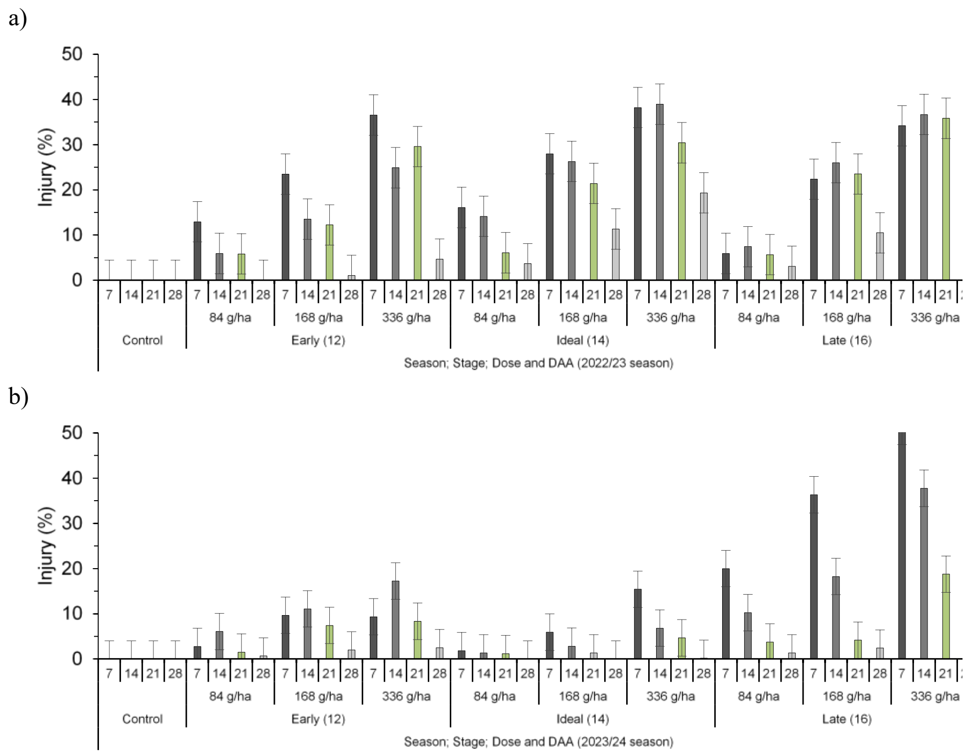

Fig. 2: Injuries in white oats cv. URS Corona (%) at 7, 14, 21 and 28 DAA as function of doses of mesotrione, at the early, ideal and late plant growth stages, in the (**a**) 2022/23 and (**b**) 2023/24 growing seasons, Lages-SC

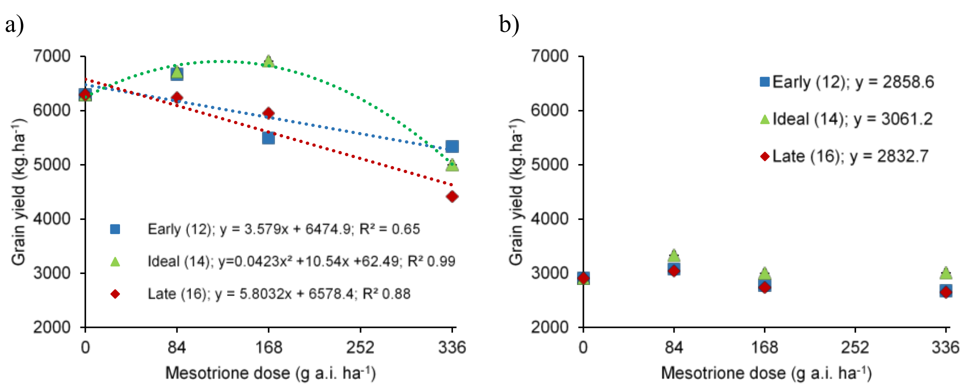

Fig. 3: Grain yield of white oats cv. URS Corona as function of mesotrione doses applied at three plant growth stages, in the (**a**) 2022/23 and (**b**) 2023/24 growing seasons, Lages-SC. Vertical bars represent the standard error of the mean of each treatment

2022/23 season, most grain sieves were around 90% and in the 2023/24 season, it was close to 95%, in both seasons, the grain sieve were within and above the suggested standard regardless of the stages and mesotrione doses (Fig. 4a–b).

There was a significant effect ($P < 0.05$) of mesotrione doses on hectoliter weight at early and late stages in the 2023/24 season; but in the 2022/23 season, no differences were found in hectoliter weight resulting from mesotrione treatments (doses and stages) (Fig. 4c–d). The application of mesotrione doses caused a reduction in hectoliter weight in the 2023/24 season.

Grain moisture content was affected by mesotrione doses in a manner dependent on the development stages of white oats, where the early stage, in the 2022/23 season, increased grain moisture with increasing mesotrione doses, unlike the late stage of the 2023/24 season, which reduced grain moisture with increasing mesotrione doses. In the early stage of the 2023/24 season, moisture was reduced only at the dose of 168 g a.i. ha^{-1} (Fig. 5a–b).

Fig. 5c–d shows that, in the 2023/24 season, the dehulling index was higher than in the 2022/23 season. This is explained by the relationship of the industrial quality

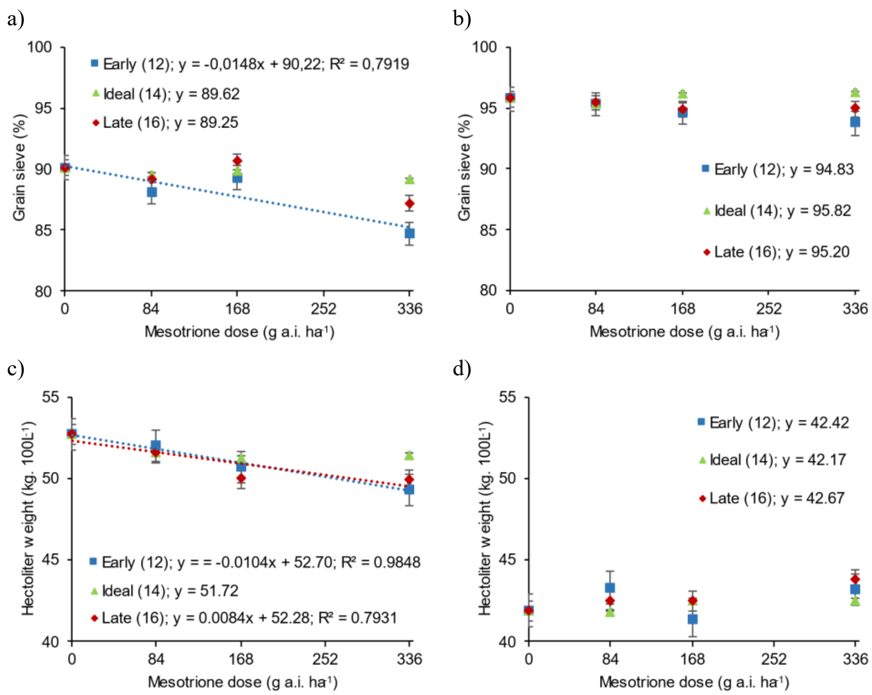

Fig. 4: Industrial quality of white oat grains URS Corona: (**a**, **b**) grain sieve (grain thickness greater than 2 mm) and (**c**, **d**) hectoliter weight, as function of mesotrione doses applied at three plant growth stages, in the 2022/23 and 2023/24 seasons, Lages-SC

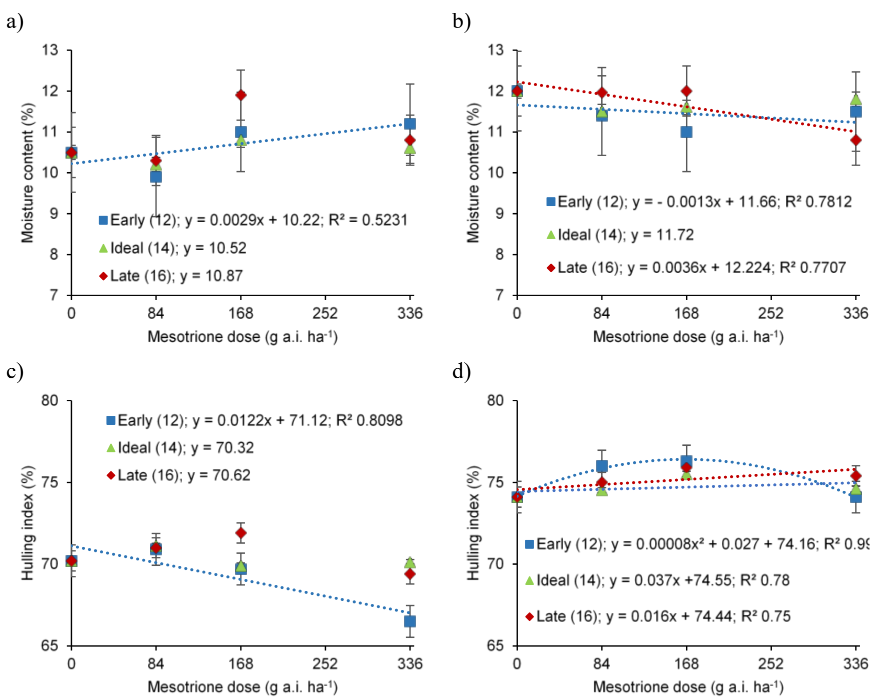

Fig. 5: Industrial quality of white oat grains URS Corona: (**a**, **b**) moisture content and (**c**, **d**) hulling index as function of mesotrione doses applied at three plant growth stages, in the 2022/23 and 2023/24 seasons, Lages-SC

parameters mentioned above. Thus, the grains obtained in the 2023/24 season were thicker. However, hectoliter weight was lower owing to a low transfer of reserves to the grains as a result of the application of mesotrione doses. This fact was similar at the three plant development stages in which the herbicide was applied; empty spaces were generated within the grain, which increased the efficiency of the dehulling index and moisture content was decreased (Fig. 5a–b). This is also due to the fact that grain yield in the second season (2023/24) was much lower than in the first season (2022/23).

Discussion

The plant injury in both seasons was observed after the application of mesotrione in the post-emergence of white oats at all doses and stages tested (Fig. 1). The symptoms observed on the white oat leaves were whitening, yellowing and purpling. These symptoms are evident even in tolerant crops and occur due to the photo-oxidation of chlorophyll molecules, which leads to a reduction in photosynthesis, which can cause the death of plant tissue in less tolerant plants (Bulegon *et al.* 2017). Similar results were found by Buba (2022) in white oats after application of mesotrione but only on plants with four leaves (stage 14).

Regardless of the stage of mesotrione application, increasing the doses may increase the injury magnitude to white oat plants. This fact was also reported by Dan *et al*. (2011) when evaluating Brachiaria brizantha intercropped with maize after spraying with mesotrione.

Alterations of magnitude of the symptoms of injury are possible to occur due to climatic differences among seasons. This is because environmental factors, such as temperature, relative humidity, solar radiation and rainfall, affect the behavior of the herbicide in the plant (Xavier 2018). Soltani *et al*. (2014) in oats and wheat and Dan *et al.* (2011) in maize found that the greatest injury occurred at 7 DAA of mesotrione, Bulegon *et al.* (2017) in maize occurred between 6 and 9 DAA of mesotrione; but to Soltani *et al*. (2014) in wheat and Maia *et al.* (2019) in sweet popcorn, the highest injuries were generated later at 14 DAA of mesotrione. However, the magnitude of injuries was different, due to the different climatic conditions between seasons (Fig. 1).

For grain yield, there was a significant effect ($p<0.05$) of doses. In the 2022/23 season, the control and doses 84 and 168 g a.i. ha^{-1} of mesotrione obtained the highest grain yield. In the 2023/24 season, the GY from control was like the mesotrione doses (Fig. 3). Mesotrione applied post-emergence in oats and barley had no harmful effect in studies by Soltani *et al*. (2014) while for Maia *et al.* (2019), the application of mesotrione in popcorn did not cause differences in yield. For Dias *et al.* (2023), the grain yield of sorghum did not demonstrate a significant difference after the application of mesotrione. The grain yield showed a large difference between the two oat cultivation seasons (vis 2022/23 and 2024/23 seasons) because of the differences in white oat grain yield between seasons reflect the crop's sensitivity to climatic conditions. According to research by Castro *et al*. (2012), the factors that affect grain yield are temperature, air humidity, rainfall, photoperiod, solar radiation, water availability and winds. According to Rispail *et al.* (2018) the main ones being (as the key factors) are rainfall and maximum post-heading temperature. Thus, when environmental conditions are adverse, crop failures may occur, proportional to the duration and intensity of climate variations (Castro *et al*. 2012). This is because tillering is considered the main factor in grain yield and this is dependent on the climatic conditions in which the crop develops and thus influences the number of panicles per area and consequently the number of grains per area (Jat *et al*. 2022). Thus, the grain yield in the second harvest (2023/24) was lower than in the first harvest (2022/23) because less photoassimilates were allocated to the grains, producing lighter grains and consequently reducing yield and causing lower performance in characteristics related to grain quality. These results agree with those obtained by Doehlert *et al.* (2010).

The grain quality plays an important role for commercialization and consumption as food. The industry has increasingly demanded grains of high technological standards, with a high percentage of caryopsis, high hectoliter weight, well-formed, thicker (large), heavy and uniform grains (Alves and Kist 2010), that is, a high percentage of grains with a thickness greater than 2 mm (Gatto 2005). The factors that influence the size of white oat grains are the type of grain (primary, secondary and tertiary) into spikelet, position of spikelet in the panicle, genotype and environmental conditions. If the environment is favorable during spikelets formation, this can result in the complete flower fertilization, generating a greater number of effective and heavier grains. On the other hand, unfavorable environments generate spikelets with fewer and lighter grains. In addition, the uniformity of size and the proportion of the three types of grains, if primary, secondary or tertiary, indicate their potential for industrial quality (Antonow 2013). Thus, white oat grain classification is done by evaluating grains with thickness greater than 2 mm (grain sieve; G > 2 mm), because there are 2 classification levels suggested by the Brazilian Oat Research Committee: type 1 with at least 75% of G > 2 mm, type 2 and 3 with less than 75% of G > 2 mm (Gatto 2005). In general, the G>2 mm were above the suggested standard (regardless of the stages and mesotrione doses) (Fig. 4a–b).

Overall, there was no consistent trend (of increase or decrease in hectoliter weight) due to the application of mesotrione on oat plants, as there was an interaction between the plant's development stage and the dose of the product applied. This fact was also observed in other crops and in other research with the herbicide mesotrione. For example, Karpinski *et al.* (2018) observed in wheat cv. BRS Campeiro that the control treatment obtained a higher hectoliter weight than that submitted to herbicide application; however, the hectoliter weight of barley cv. URS Brau treated with herbicide did not differ to the control (without herbicide). This is because hectoliter weight indirectly indicates the amount of reserves that the grain has (Gatto 2005), since the grains are stored in a certain volume and considering that the grain does not have its caryopsis filled completely inside the husk (palea and lemma), there are empty spaces inside the grain, which contributes to reducing the hectoliter weight of oats (Antonow 2013). However, in Brazilian Ministerial Ordinance #191 of April 14, 1975, *A. sativa* has standardization, classification and marketing specifications, one of which is in relation to the hectoliter weight value. Thus, considering that the hectoliter weight found in this work was around 50 kg.100 L^{-1}, which fits into standardization group 1. This corresponds to a hectoliter weight equal to or greater than 50 kg.100 L^{-1} and is considered to be of excellent quality for commercialization. Despite the reduction found, the mesotrione doses did not affect the quality of the grains of white oats cultivar URS-Corona.

Oat grain moisture content in this study was lower (12%) than the value established by the Brazilian Ministerial Ordinance #191 of April 14, 1975, which is 14%, for moisture in *A. sativa* grains (Brasil 1975).

The white oat grain is composed of caryopsis and hull and the hull is composed of structures called palea and lemma. For human consumption, the hull must be removed from the grain, that is, the grains must be peeled; the hull accounts for 25 to 35% of the grain's weight and peeling efficiency depends on a series of factors related to the grain, its genetics, its hull and the environment; its genetics, the genotype/cultivar; the grain, its morphology, size and moisture content; the hull, its content and thickness; the environment and environmental conditions during the plant growth (Antonow 2013).

Conclusion

Injury to white oat leaves resulting from post-emergence application of mesotrione on plants at the stages 12 (early), 14 (ideal), or 16 (late) recovered up to 28 DAA. This outcome points to the selectivity of this herbicide to the crop, thus allowing greater safety in the time interval for mesotrione application. Grain yield was not affected by mesotrione when applied up to the dose of 168 g/ha (a.i.) in the early, ideal and late stages. Furthermore, grain quality was not impaired after the application in a manner dependent on the herbicide at different plant growth stages. This allows flexibility and safety for the mesotrione doses and the time of application at post-emergence of white oat plants. Mesotrione should be applied at post-emergence up to a dose of 168 g/ha (a.i.) on white oat plants (cv. URS Corona) when it has two to six leaves on the main stem.

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Author Contributions

DCB and CAS planned the experiments; DCB, CAS, FFF and ROS interpreted the results; DCB, CAS and FFF made the write up; DCB and CAS statistically analyzed the data and made illustrations.

Conflict of Interest

All authors declare no conflict of interest.

Data Availability

Data presented in this study will be available on a fair request to the corresponding author.

Ethics Approval

Not applicable to this paper.

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