PAB
Pesquisa Agropecuária Brasileira

ISSN 1678-3921

Journal homepage: www.embrapa.br/pab

For manuscript submission and journal contents, access: www.scielo.br/pab

Crop Science/ Original Article

Weed control in melon with preemergence herbicides

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Received
November 12, 2020

Accepted
August 31, 2021

How to cite
CARVALHO, D.R. de; LINS, H.A.; SOUZA, M. de F.; SILVA, T.S.; PORTO, M.A.F.; MENDONÇA, V.; SILVA, D.V. Weed control in melon with preemergence herbicides. **Pesquisa Agropecuária Brasileira**, v.57, e02334, 2022. DOI: https://doi.org/10.1590/S1678-3921.pab2022.v57.02334.

Abstract – The objective of this work was to evaluate the effectiveness and selectivity of herbicides applied at preemergence to the melon (*Cucumis melo*) crop. The experiments were carried out from 2017 to 2018, in a randomized complete block design, with four replicates, in the state of Rio Grande do Norte, Brazil. The treatments consisted of the preemergence application of: 35 g ha^{-1} a.i. flumioxazin, 25 g ha^{-1} a.i. flumioxazin, 250 g ha^{-1} a.i. sulfentrazone, 480 g ha^{-1} a.i. metribuzin, 240 g ha^{-1} a.i. oxyfluorfen, 240 g ha^{-1} a.i. oxyfluorfen + 960 g ha^{-1} a.i. S-metolachlor, 360 g ha^{-1} a.i. clomazone, and 360 g ha^{-1} a.i. clomazone + 240 g ha^{-1} a.i. oxyfluorfen; in 2018, metribuzin did not show selectivity and was substituted by 480 g ha^{-1} a.i. ametryn and 1,600 g ha^{-1} a.i. diuron. Fruit yield and quality, as well as weed control and dry mass, were evaluated. The metribuzin, ametryn, and diuron herbicides caused melon plant death. The best efficiency in weed control was obtained with the mixture clomazone + oxyfluorfen, followed by oxyfluorfen, oxyfluorfen + S-metolachlor, and clomazone. The treatments with oxyfluorfen, oxyfluorfen + S-metolachlor, and clomazone + oxyfluorfen were not considered selective. Clomazone was the only selective herbicide in the two years of evaluation and can be an alternative for weed control in melon crops.

Index terms: *Cucumis melo*, herbicide efficiency, herbicide selectivity, phytotoxicity.

Controle de plantas daninhas no melão com herbicidas de pré-emergência

Resumo – O objetivo deste trabalho foi avaliar a eficácia e a seletividade de herbicidas aplicados em pré-emergência no cultivo de melão (*Cucumis melo*). Os experimentos foram conduzidos de 2017 a 2018, no delineamento de blocos ao acaso, com quatro repetições, no estado do Rio Grande do Norte, Brasil. Os tratamentos consistiram na aplicação pré-emergencial de: 35 g ha^{-1} i.a. de flumioxazin, 25 g ha^{-1} i.a. de flumioxazin, 250 g ha^{-1} i.a. de sulfentrazone, 480 g ha^{-1} i.a. de metribuzin, 240 g ha^{-1} i.a. de oxyfluorfen, 240 g ha^{-1} i.a. de oxyfluorfen + 960 g ha^{-1} i.a. de S-metolachlor, 360 g ha^{-1} i.a. de clomazone e 360 g ha^{-1} i.a. de clomazone + 240 g ha^{-1} i.a. de oxyfluorfen; em 2018, o metribuzin não apresentou seletividade e foi substituído por 480 g ha^{-1} i.a. de ametrina and 1.600 g ha^{-1} i.a. de diuron. Foram avaliados a produtividade e a qualidade dos frutos, bem como o nível de controle e a massa seca das plantas daninhas. Os herbicidas metribuzin, ametrina e diuron causaram a morte das plantas de melão. A melhor eficiência no controle das plantas daninhas foi obtida com a mistura e clomazone + oxyfluorfen, seguida de oxyfluorfen, oxyfluorfen + S-metolachlor e clomazone. Os tratamentos com oxyfluorfen, oxyfluorfen + S-metolachlor e clomazone + oxyfluorfen não foram considerados seletivos. O clomazone foi o único herbicida seletivo nos dois anos de avaliação e pode ser alternativa para o controle de plantas daninhas na cultura do melão.

Termos para indexação: *Cucumis melo*, eficácia de herbicidas, seletividade de herbicidas, fitotoxicidade.

Introduction

Brazil is one of the largest producers of melon (*Cucumis melo* L.) worldwide, with a production of 540,000 tons in 2017 (FAO, 2018). The production system used usually involves raised seedbeds covered with plastic mulch, which has been widely adopted in the country because it improves yield, increases water and fertilizer use efficiency, and reduces weeds (Samtani et al., 2017).

One of the main challenges in melon production is weed control (Bairambekov et al., 2016). In mulch production systems, broadleaf and grass weeds emerge in the planting holes and between beds (Boyd, 2016). Although cucurbits are susceptible to herbicides used in other agronomic crops (Abouziena & Haggag, 2016), currently, only herbicide fenoxaprop-P-ethyl and the combination clomazone + carfentrazone-ethyl are registered for the selective control of weeds in melon (Agrofit…, 2020).

Fenoxaprop-P-ethyl is a herbicide inhibitor of the enzyme acetyl-coenzyme, a carboxylase (ACCase inhibitor) that acts in the postemergence control of grasses (Takano et al., 2020). Clomazone is a synthase inhibitor (DOXP inhibitor), which is a pivotal component for plastid isoprenoid synthesis (Cabral et al., 2017), whereas carfentrazone-ethyl causes the inhibition of the protoporphyrinogen oxidase enzyme (PPO inhibitor) (Brusamarello, 2016). The commercial premix of clomazone + carfentrazone-ethyl is registered for the pre- and postemergence control of grass and broadleaf weeds in several crops. However, this premix is not efficient against weeds considered essential and difficult to control in cropping systems in Brazil, such as *Amaranthus* spp. and *Merremia aegyptia* (L.) Urb. (Raimondi et al., 2010).

An alternative for weed control in melon crops is applying residual herbicides during the pre-transplantation of melon seedlings. Herbicide application would be carried out after the formation of beds and before the addition of mulch, allowing weed control in the first seven weeks when the crop is more sensitive to the presence of weeds (Monteiro et al., 2021). It is essential to highlight that the efficiency of residual herbicides depends on the physical and chemical properties of the molecule used, the rate applied, the edaphoclimatic conditions of the region, and the weed species present in the cultivation area (Carneiro et al., 2020; Lins et al., 2021). Some herbicides – such as fomesafen and flumioxazin (protoporphyrinogen oxidase inhibitors), clomazone (carotenoid biosynthesis inhibitor), S-metolachor (cell-division inhibitor), and fomesafen + S-metolachlor chlorine or dimethenamid-P – have potential to be applied to cucurbits (Lins et al., 2018). However, it is important to evaluate the efficiency and selectivity of these herbicides in different cropping systems. For a sustainable melon production, it is key to identify selective herbicides with an acceptable weed control effectiveness.

The objective of this work was to evaluate the effectiveness and selectivity of herbicides applied at pre-emergence to the melon crop.

Materials and Methods

The experiments were conducted from October to December, in 2017 and 2018, at the experimental farm of Universidade Federal Rural do Semi-Árido, located in the municipality of Mossoró, in the state of Rio Grande do Norte, Brazil (5º3'39.8"S, 37°23'44.6"W, at 78 m altitude).

The climate of the region, according to Köppen's classification, is of the BSwh type, hot and dry, with an average rainfall of 674 mm (Alvares et al., 2013). The average data on temperature, humidity, and precipitation during the melon growing seasons were obtained at the automatic meteorological station of Instituto Nacional de Meteorologia, located in the state of Rio Grande do Norte (Figure 1). There was no precipitation during the entire study period in both years.

The soil at the experimental field was classified as a Latossolo Vermelho distrófico (Santos et al., 2018), i.e., an Oxisol (Soil Survey Staff, 2014), with 130 g kg^{-1} clay, 840 g kg^{-1} sand, and 30 g kg^{-1} silt. The soil was prepared with plowing and harrowing, using a rotary hoe to form the seedbeds. According to the crop's needs, soil fertilization was carried out based on the soil analysis (Table 1) (Cavalcanti, 2008).

Each year, two separate experiments were conducted to determine the effectiveness of weed control and the selectivity of the herbicides applied before melon transplantation. The experimental design used was randomized complete blocks with three replicates. In 2017, ten herbicide treatments were selected for application (Table 2). In 2018, the treatment with metribuzin was withdrawn from the trial due to its lack of selectivity for melon plants and was substituted by two other herbicides (ametryn and diuron), totaling 11 treatments in this year. The herbicides were applied one day before the melon seedlings were transplanted. Two controls were included: weedy (no wedding) and weed-free (wedding) plots; the weed-free plots were weeded manually at weekly intervals for the entire growing season.

At planting, 180 kg ha^{-1} P_2O_5 (simple superphosphate) were applied and manually incorporated, as well as 3.0 kg ha^{-1} zinc (zinc sulfate) and 1.1 kg ha^{-1} boric acid. The applications of nitrogen (165 kg ha^{-1} N) and potassium (30 kg ha^{-1} K_2O) were divided weekly, throughout fertigation, between 15 and 60 days after melon was transplanted (Cavalcanti, 2008).

Pests and diseases were controlled using the pesticides recommended for the crop (Agrofit…, 2020). The drip irrigation system was adopted, with emitters presenting a flow of 1.7 L h^{-1} and spaced at 0.3 m. Irrigations were performed daily according to the estimated evapotranspiration (ETc) of the crop (ETc = reference evapotranspiration x Kc), where Kc corresponds to the melon development stages; the reference evapotranspiration was obtained by the Penman-Monteith equation (Allen et al., 1998). The total water depth applied during the crop cycle was 552 mm.

The herbicides were applied to the planting lines using the CO_2 pressurized research sprayer Pulverizador Pesquisa (Herbicat, Catanduva, SP, Brazil) equipped with a bar with two XR11002 spray nozzle tips (TeeJet, Aabybro, Denmark), spaced 0.5 m apart, at the height of 0.5 m from the soil. The used sprayer pump pressure of 3.0 MPa and velocity of 3.6 km h^{-1} allowed an application volume of 200 L ha^{-1}

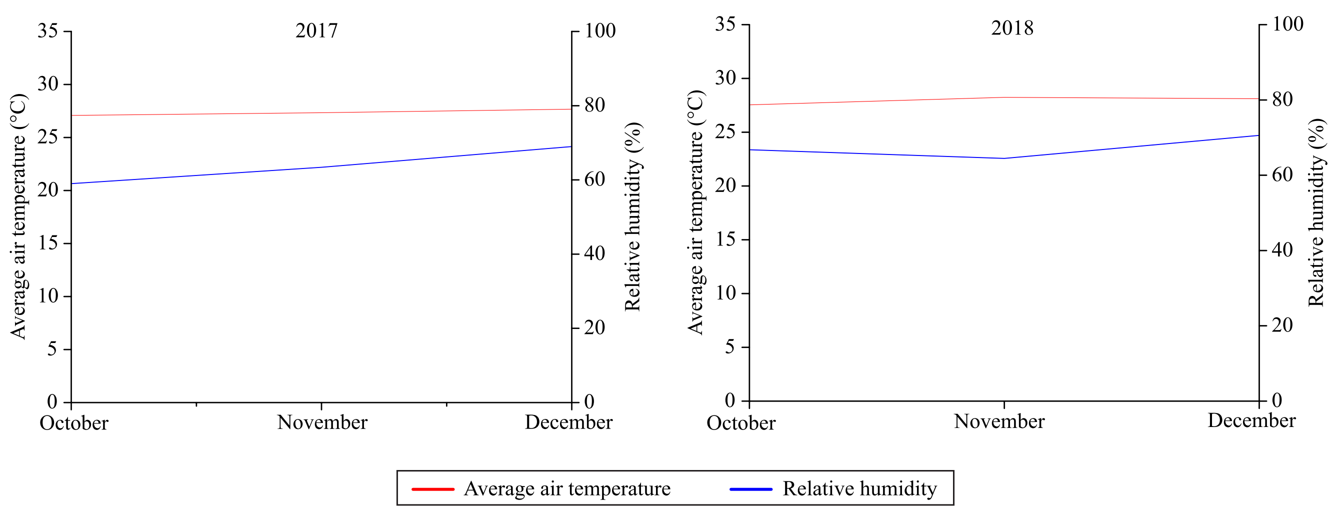

Figure 1. Average temperature and air relative humidity in the two years of melon (*Cucumis melo*) cultivation. Data obtained at the automatic meteorological station of Instituto Nacional de Meteorologia and using a rain gauge installed at the experimental farm, in the state of Rio Grande do Norte, Brazil.

Table 1. Chemical characterization of the soil in the yellow melon (*Cucumis melo*) cultivation area[(1)].

Year	pH	SOM	K	P	Na	Ca	Mg	Al^{3+}	$H+Al^{3+}$	CEC
	H_2O	(g kg^{-1})	(mg dm^{-3})			(cmol$_c$ dm^{-3})				
2017	6.6	2.6	33.8	25.5	6.9	0.5	0.7	0.0	0.0	1.3
2018	6.9	2.3	39.1	14.1	7.3	1.1	0.4	0.0	0.2	1.8

[(1)]SOM, soil organic matter; H+Al, potential acidity; and CEC, cation exchange capacity.

DOI: 10.1590/S1678-3921.pab2022.v57.02334

syrup. At the moment of herbicide application, the environmental conditions were: air temperature of 22.4°C, air relative humidity of 80%, and wind speed of 2.8 km h^{-1}.

To avoid drift, the herbicides were applied during higher relative humidity, lower temperatures, and slower wind speed. Before herbicide application, the planting lines were irrigated until the soil reached field capacity. After the herbicides were applied, black and white mulch film (Negreira, Arujá, SP, Brazil) was placed on the beds, with the white side facing up and black one facing down. The holes for planting seedlings in the mulch had a 5 cm diameter and were spaced at 0.4 m.

Seedlings of the Goldex yellow melon (Topseed, Agristar, São Paulo, SP, Brazil) were planted in 200 cell polyethylene trays, with 20 cm^3 substrate per cell, in a greenhouse, being transplanted 12 days after sowing when the first true leaf appeared and their height was approximately 5 cm. The melon seedlings were transplanted 24 hours after the application of the herbicides, at a 0.4 m spacing between plants and 2.0 m between lines, with one line corresponding to one bed. Each experimental plot had three beds that were 2.8 m long and 0.8 m wide, with 21 plants. The two external beds and the two external plants of the central bed were used as a border, and only the three plants of the effective area of each experimental plot were used for fruit harvesting.

Melon plant injury (phytotoxicity) and weed control (efficiency) were evaluated visually at 7, 14, and 21 days after herbicide application (DAA). Phytotoxicity and herbicide effectiveness were assessed visually for each plot and rated on a scale from 0% (no injury or growth reduction compared with the untreated plot) to 100% (complete plant death). Yellow melon fruits were harvested from the plants in the central bed of each plot (central area) at 65 days after transplanting. During the harvest period, the aboveground biomass of the weeds was collected in the central area of each plot; all weeds that grew during the crop cycle were collected and identified and, then, taken to a forced-air circulation oven, at 65ºC, until reaching a constant weight for later weighing and dry matter determination.

After harvest, the fruits were weighed to determine yield (kg ha^{-1}). The following fruit postharvest characteristics were evaluated based on a sampling of two fruits per plot: fruit longitudinal and transverse diameters, pulp thickness and firmness, pH, soluble solids content, and titratable acidity.

The dimensions of the fruits (cm) were obtained by measuring longitudinal and transverse diameters and pulp thickness with the aid of a digital caliper. To determine pulp firmness (Newton), the fruits were divided longitudinally into two parts – median region and basal region opposite of the peduncle –, and two readings were performed in each one of them using the PTR-300 fruit hardness tester (SoilControl

Table 2. Herbicide treatments applied before yellow melon (*Cucumis melo*) transplanting in 2017 and 2018, as well as their mechanisms of action, application rates, and chemical groups.

Treatment[1]	Mechanism of action	Rate (g ha^{-1} a.i.)	Chemical group
Weeding (control)	-	-	-
No weeding (control)	-	-	-
Flumioxazin 35	Protox	35	N-phenylphthalimide
Flumioxazin 25	Protox	25	N-phenylphthalimide
Sulfentrazone	Protox	250	Aryl triazolinone
Metribuzin	PSII	480	Aryl triazolinone
Oxyfluorfen	Protox	240	Diphenylether
Oxyfluorfen + S-metolachlor	Protox + cell division	240 + 960	Diphenyl ether + chloroacetanilide
Clomazone	Carotenoids	360	Isoxazolidinone
Clomazone + oxyfluorfen	Carotenoids + cell division	360 + 240	Isoxazolidinone + chloroacetanilide
Ametryn	PSII	480	Triazines
Diuron	PSII	1,600	Urea

[1]Flumioxazin 35, 35 g ha^{-1} a.i.; and flumioxazin 25, 25 g ha^{-1} a.i.

– Instrumentos Medição & Pesquisa, São Paulo, SP, Brazil) with a 8.0 mm diameter tip.

To determine pH, soluble solids, and titratable acidity, the fruits were crushed in a blender and filtered on filter paper to obtain the juice used for analyses performed in triplicate. Soluble solids (ºBrix) were determined using the Pallete-series PR-100 digital refractometer (Atago CO., LTD., Tokyo, Japan), with automatic temperature correction, according to the methodology proposed by Zenebon et al. (2008). Titratable acidity was obtained by titrating a 10 g aliquot of juice, adding 50 mL distilled water, and titrating with a NaOH (0.1 N) solution. The end of titration was determined with the aid of a digital potentiometer (pH = 8.1), and the results were expressed as percentage of citric acid, also following the methodology of Zenebon et al. (2008). pH was measured in the fruit juice using a pH meter (Horwitz, 2005).

The weed dry matter data from the experiments in 2017 and 2018 were evaluated by the descriptive analysis and plotted using the Origin Pro, version 8.0, statistical software (OriginLab Corporation, Northampton, MA, USA). Phytotoxicity and weed control were compared at 5% probability. The crop years were assessed separately, as the ametryn and diuron herbicides were not tested in 2017.

Homogeneity of variances was assessed by Bartlett's test, and normal distribution of residues, by Shapiro-Wilk's test. The analysis of variance was performed for phytotoxicity and postharvest characteristics (fruit longitudinal and transverse diameters, pulp thickness and firmness, pH, soluble solids, and titratable acidity), with means being compared by Scott-Knott' test at 5% probability.

Results and Discussion

The main weeds that occurred in the cultivation area were: *Trianthema portulacastrum* L., *Amaranthus spinosus* L., *Senna obtusifolia* (L.) H.S.Irwin & Barneby, *Macroptilium lathyroides* (L.) Urb., *Merremia aegyptia* (L.) Urb., *Jacquemontia tamnifolia* Griseb., *Mollugo verticillate* L., *Urochloa plantaginea* (Link) R.D.Webster, *Mimosa pudica* L., *Digitaria horizontalis* Willd., *Waltheria americana* L., and *Ipomoea triloba* L.

Weed control in the two crop years was dependent on herbicide used (Figure 2). Weed biomass was reduced by 100% in both years when 35 g ha^{-1} a.i. flumioxazin and the clomazone + oxyfluorfen mixture were applied. In 2017, plots treated with metribuzin and oxyfluorfen

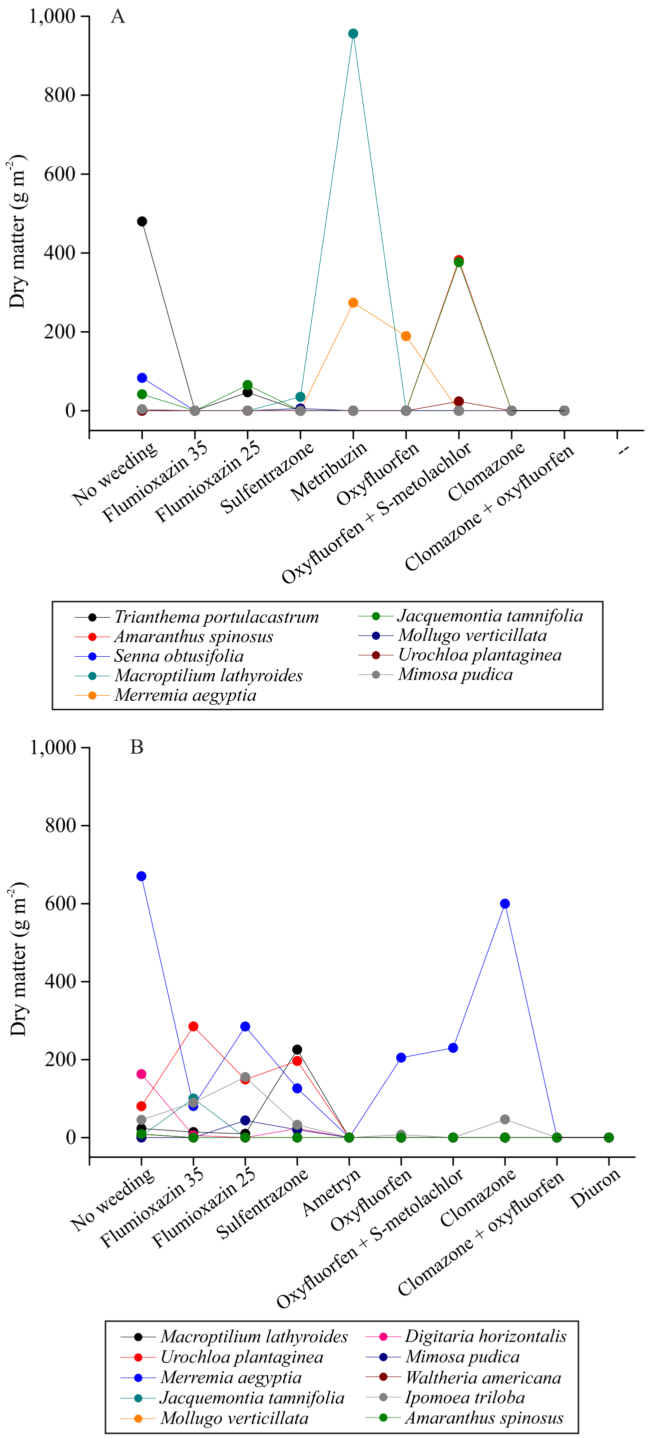

Figure 2. Weed dry matter depending on the application of herbicides to the melon (*Cucumis melo*) crop in 2017 (A) and 2018 (B). Flumioxazin 35, 35 g ha^{-1} a.i.; and flumioxazin 25, 25 g ha^{-1} a.i.

+ S-metholachlor did not control *M. lathyroides*, *J. tamnifolia*, and *A. spinosus*, whereas oxyfluorfen and metribuzin did not control *M. aegyptia*.

In 2018, *A. spinosus*, *W. americana*, *M. pudica*, *J. tamnifolia*, and *M. verticillata* were unimportant, presenting little dry matter under all herbicide treatments and the control (no weeds). Clomazone + oxyfluorfen, ametryn, and diuron controlled all weeds in the experimental area. In all plots treated with herbicides, the dry matter of *M. aegyptia* was reduced in comparison with that of the plots with no weeding; clomazone was the least effective herbicide in controlling this species, reducing only 10% of its dry matter when compared with the control.

The association of the oxyfluorfen + S-metholachlor herbicides reduced the dry matter of *M. aegyptia* by 70% in comparison with the plots with no weeding, showing a control efficiency similar to that of oxyfluorfen applied alone. However, the clomazone + oxyfluorfen mixture reduced the dry matter of *M. aegyptia* by 100%. This highlights the existence of a combined effect of clomazone + oxyfluorfen that broadened the spectrum of weed control, effectively limiting the broadleaf and grass weeds present in the study area. This observation is supported by another research in which there was an increased control of weeds with the application of tank-mixed herbicides, some of which with several modes of action and residual activity in the soil (Boyd, 2016).

Flumioxazin, at both applied rates, and sulfentrazone reduced the dry matter of *M. aegyptia* by 88, 58, and 82%, respectively, compared with the plots under no weeding. However, these herbicides were ineffective in controlling *I. triloba*, whose dry matter increased in the treatments with 35 and 25 g ha^{-1} a.i. flumioxazin, in comparison with the plots in the untreated area. Therefore, the control of annual grasses was not satisfactory in the treatments with both rates of flumioxazin and with sulfentrazone, herbicides which were not effective in controlling *U. plantaginea*.

The weed species that predominated in the cultivation area were *T. portulacastrum*, *M. lathyroides*, *M. aegyptia*, and *J. tamnifolia*, which are herbaceous with indeterminate growth and prostate size (Fahad et al., 2014). In addition, *M. lathyroides*, *M. aegyptia*, and *J. tamnifolia* are climbing plants that rapidly intertwine with other ones for their growth (Moreira et al., 2018). In crops with prostrate growth habits, such as melon, the interference caused by these weeds can be even more serious (Chaney & Baucom, 2012); however, the cultivation system used in the present study, with beds covered with polyethylene (mulch), provides a mechanical barrier to weed infestation (Johnson & Mullinix, 2002). Therefore, the integration of this practice with the application of preemergent herbicides at pre-transplantation offers melon producers more effective options for weed management, as observed here.

All herbicides effectively controlled weeds at 7 and 14 DAA in 2017 (Figure 3). At 21 DAA, there was a reduction in control effectiveness, which was of 65, 70, 58, and 63% for 25 g ha^{-1} a.i. flumioxazin, sulfentrazone, oxyfluorfen, and oxyfluorfen + S-metolachlor, respectively. In 2018, weed control at 7 DAA was 76% with 35 g ha^{-1} a.i. flumioxazin, higher than that of 66% with 25 g ha^{-1} a.i. flumioxazin and with sulfentrazone; however, these values reduced to 43, 43, and 46%, respectively, at 21 DAA. Clomazone reduced weed control from 83% at 7 DAA to 63% at 21 DAA. Ametryn, oxyfluorfen, clomazone + oxyfluorfen, oxyfluorfen + S-metolachlor, and diuron showed a control greater than 90%.

The greater effectiveness in weed control by ametryn, oxyfluorfen, diuron, clomazone + oxyfluorfen, and oxyfluorfen + S-metolachlor over the days after their application is probably related to their residual control effect. These herbicides have moderate to high persistence in soils (University of Hertfordshire, 2019), allowing weed control for a long time after being applied (Cahoon et al., 2015). The half-life of oxyfluorfen in the soil, for example, has been reported to be between 10 and 31 days (Alister et al., 2009), and it has been observed that the mixture of oxyfluorfen with herbicides of other modes of action and residual activity in the soil improves the effectiveness of weed control (Boyd, 2016). Sulfentrazone shows a very high persistence in soils, with a half-life of 541 days (University of Hertfordshire, 2019); however, this herbicide was not effective in controlling weeds – 46% control at 21 DAA –, which explains the decrease found in the percentage of control.

In 2017, a low phytotoxicity of less than 12% was recorded up to 21 DAA: 6% for 25 g ha^{-1} a.i. flumioxazin, 2% for oxyfluorfen, 10% for clomazone, and 12% for clomazone + oxyfluorfen (Figure 4). Metribuzin caused 100% injury, leading to the death of the plants. At 21 DAA, phytotoxicity was greater than 25% when 35 g ha^{-1} a.i. flumioxazin, sulfentrazone, and oxyfluorfen + S-metolachlor were applied.

In general, phytotoxicity rates were higher in 2018. The reason for this effect is not apparent, as the climatic and soil conditions were similar to that of the previous year (Figure 1). In 2018, at 7 DAA, a higher rate of plant injuries was observed in the plots treated with herbicides: 53% for oxyfluorfen, 61% for oxyfluorfen + S-metolachlor, and 53% for clomazone

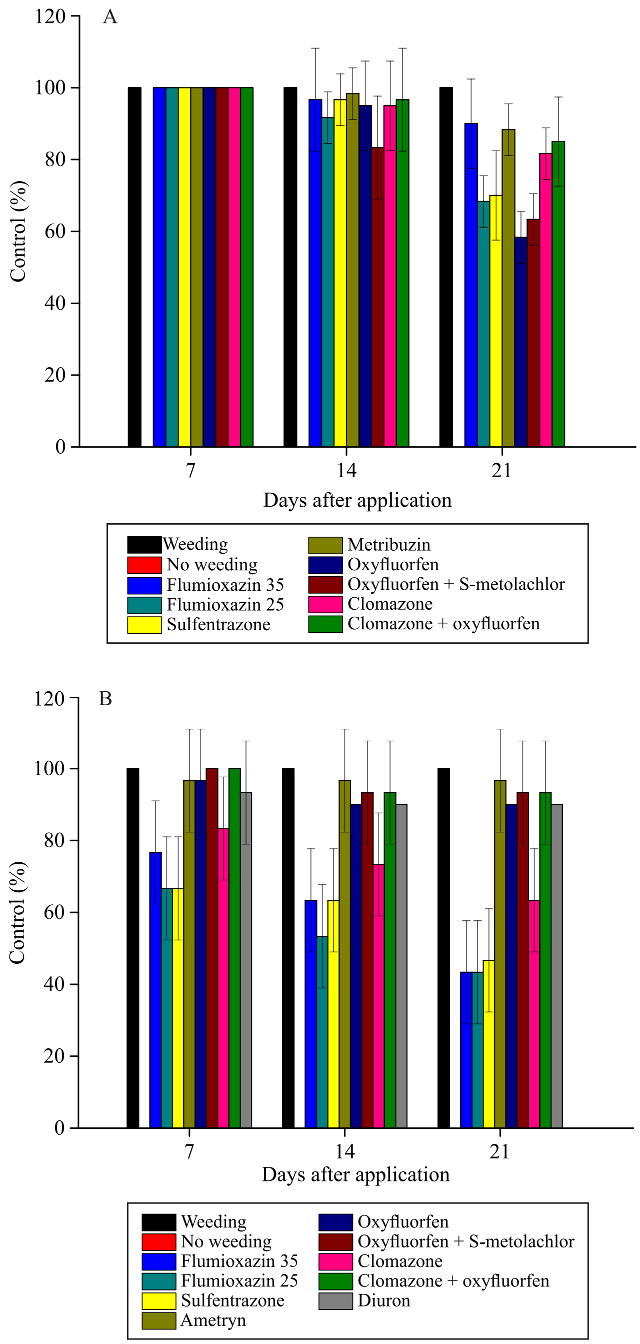

Figure 3. Weed control by the herbicide treatments tested at 7, 14, and 21 days after their application in 2017 (A) and 2018 (B). Error bars indicate 95% confidence intervals. Flumioxazin 35, 35 g ha^{-1} a.i.; and flumioxazin 25, 25 g ha^{-1} a.i.

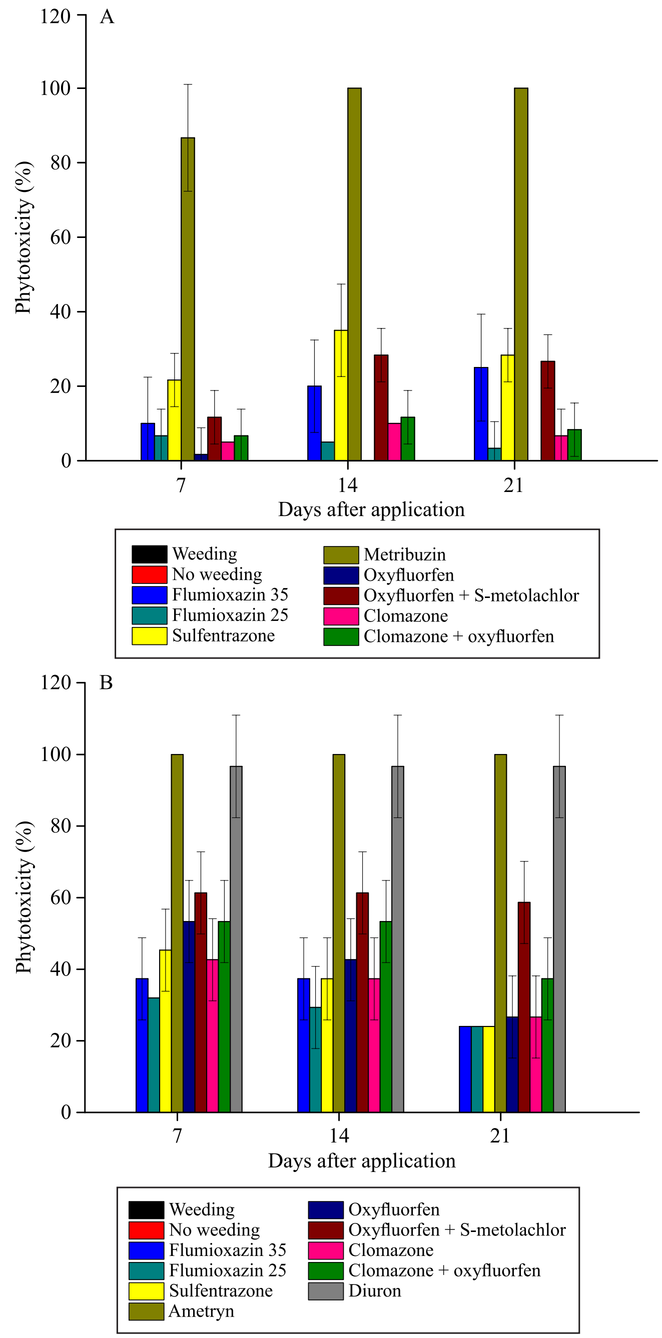

Figure 4. Phytotoxicity of the herbicide treatments tested at 7, 14, and 21 days after their application in 2017 (A) and 2018 (B). Error bars indicate 95% confidence intervals. Flumioxazin 35, 35 g ha^{-1} a.i.; and 25 flumioxazin, 25 g ha^{-1} a.i.

+ oxyfluorfen (Figure 4). However, a phytotoxicity below 45% was found for 35 g ha^{-1} a.i. flumioxazin, 25 g ha^{-1} a.i. flumioxazin, sulfentrazone, and clomazone. Moreover, ametryn and diuron caused plant death.

In the two years of cultivation, there was a reduction in the injuries caused by the herbicides in the third phytotoxicity assessment at 21 DAA, with melon plants showing a recovery behavior. This result suggests that melons can metabolize herbicides to fewer toxic metabolites as they grow (El-Nahhal & Hamdona, 2017). The metabolization of herbicides by plants reduces the amount of these xenobiotics that reaches their sites of action (Bakkali et al., 2007), decreasing the damage caused. According to Qi et al. (2015), oxidative damage caused to plants by herbicides can inhibit the activity of antioxidant enzymes that play an essential role in the elimination of reactive oxygen species. Therefore, the lower the inhibition of these enzymes, the greater the metabolism and recovery of plants from the oxidative stress caused by herbicides.

The highest yield (kg ha^{-1}) was registered in the weeded plots (free of weeds) in 2017 and 2018, with values of 29,333 and 25,383 kg ha^{-1}, respectively (Figure 5). In this year, the plots treated with clomazone did not differ statistically from the weeded plots and the plots treated with oxyfluorfen, oxyfluorfen + S-metolachlor, and clomazone + oxyfluorfen. The treatments with 35 g ha^{-1} a.i. flumioxazin, 25 g ha^{-1} a.i. flumioxazin, and sulfentrazone, as well as the untreated plots (no weeding, i.e., with natural weed infestation), showed a significantly reduced yield when compared with the weedy plots. The lightest fruits (12,200 kg ha^{-1}) were harvested in the plots treated with 35 g ha^{-1} a.i. flumioxazin. Flumioxazin, at both rates, and sulfentrazone caused a decrease in yield above 45%. Oxyfluorfen, oxyfluorfen + S-metolachlor, clomazone, and clomazone + oxyfluorfen reduced the yield of yellow melon by up to 24% when compared with the weeded plots. In the case of metribuzin, which caused plant death, there was no fruit production.

In 2018, the weight of the fruits in the plots without weed control was approximately 30% lower than that of the weeded plots. The oxyfluorfen, oxyfluorfen + S-metolachlor, clomazone, and clomazone + oxyfluorfen treatments did not reduce the yield of yellow melon, when compared with the weeded control plots. The weight of the fruits harvested in the plots treated with 35 g ha^{-1} a.i. flumioxazin, 25 g ha^{-1} a.i. flumioxazin, and sulfentrazone was of 18,800, 16,050, and 15,475 kg ha^{-1}, respectively, similar to or lower than that of 17,783 kg ha^{-1} of the fruits grown in competition with weeds. It should be noted that ametryn and diuron caused the death of melon plants, which led to a 100% reduction in yield.

In 2018, the application of oxyfluorfen, oxyfluorfen + S-metolachlor, clomazone, and clomazone + oxyfluorfen caused phytotoxicity in the melon plants, which, however, recovered, without having their yield affected. The loss of yield caused by 25

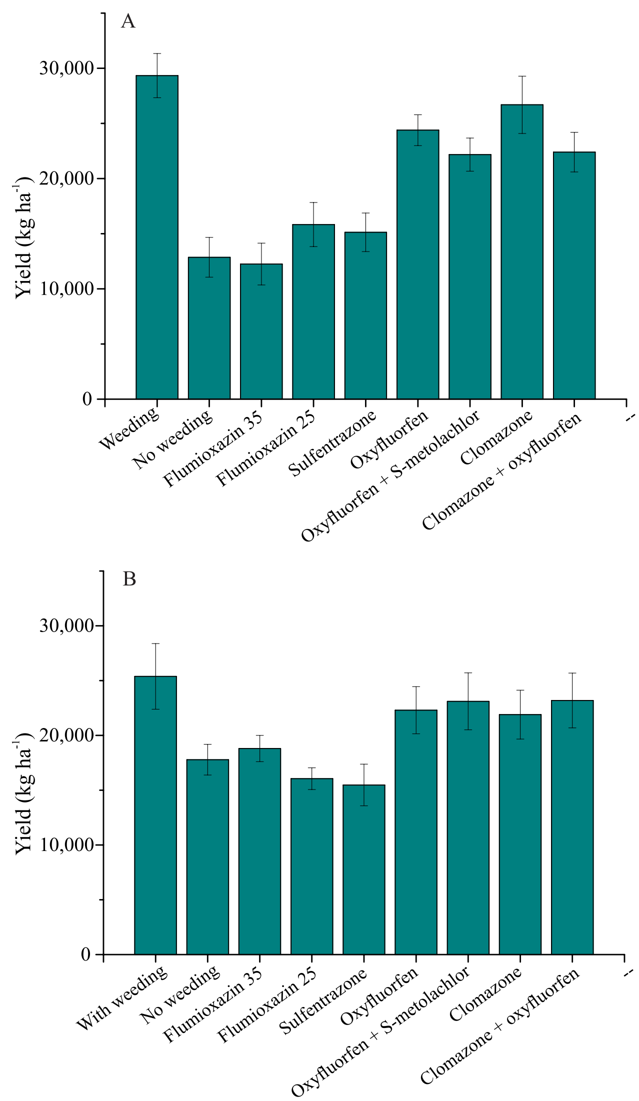

Figure 5. Melon (*Cucumis melo*) yield after the application of herbicides in 2017 (A) and 2018 (B). Error bars indicate 95% confidence intervals. Flumioxazin 35, 35 g ha^{-1} a.i.; and flumioxazin 25, 25 g ha^{-1} a.i.

DOI: 10.1590/S1678-3921.pab2022.v57.02334

g ha^{-1} a.i. flumioxazin, 35 g ha^{-1} a.i. flumioxazin, and sulfentrazone was more significant than that in untreated plots due to phytotoxicity and mainly the ineffective control of weeds.

In 2017, herbicide treatments influenced the quality of soluble solids in melon fruits (Table 3). However, pH, titratable acidity, pulp thickness, transverse and longitudinal diameters, and pulp firmness were not significantly different between treatments and controls (weeded and not weeded). The soluble solids content of the fruits harvested in the plots treated with 25 g ha^{-1} a.i. flumioxazin and with sulfentrazone was lower than that of the fruits grown in the weeded plots. Furthermore, the plots treated with oxyfluorfen were statistically equal to those in competition with weeds.

In 2018, herbicide treatments significantly influenced the content of soluble solids and the firmness of the fruits (Table 3). However, the other postharvest characteristics were not affected. Since the treatments with the application of ametryn and diuron caused plant death, there were no fruits for evaluation in this year. The firmness of the fruits was significantly lower in the plots treated with 35 g ha^{-1} a.i. flumioxazin, sulfentrazone, oxyfluorfen, and clomazone + oxyfluorfen in comparison with the weeded plots. The soluble solids content was of 8.03 and 8.64 °Brix, respectively, for the fruits harvested in the plots treated with clomazone and oxyfluorfen + S-metolachlor, statistically lower than that of 11.12 °Brix found for the fruits grown in the weeded plots, but close to that of 7.73 °Brix for the fruits of the plots in competition with weeds. Despite this reduction in the soluble solids content of the fruits, the values obtained in the plots treated with herbicides and in the controls (weeding and no weeding) are within the standard of 8 °Brix set for yellow melon by the United Nations Economic Commission for Europe (Unece, 2017). The high content of soluble solids in melon is considered one of the most important factors for consumer acceptance.

Table 3. Effect of herbicides on the postharvest characteristics of yellow melon (*Cucumis melo*) fruits in 2017 and 2018[(1)].

Treatment[(2)]	Soluble solids (°Brix)	pH	Titratable acidity (%)	Pulp thickness (cm)	Transverse diameter (cm)	Longitudinal diameter (cm)	Fruit firmness (N)
				2017			
Weeding	11.47a	6.05a	0.17a	4.31a	14.41a	18.34a	28.62a
No weeding	8.75b	5.91a	0.17a	3.74a	13.62a	17.14a	32.27a
Flumioxazin 35	10.57a	5.98a	0.16a	4.13a	15.21a	17.76a	26.12a
Flumioxazin 25	9.03b	5.98a	0.20a	3.70a	13.37a	15.51a	30.88a
Sulfentrazone	8.87b	5.92a	0.17a	3.53a	13.47a	16.21a	28.97a
Oxyfluorfen	11.40a	5.96a	0.17a	4.11a	15.33a	18.27a	32.91a
Oxyfluorfen + S-metolachlor	10.59a	5.90a	0.17a	4.26a	14.22a	16.05a	28.99a
Clomazone	10.30a	5.96a	0.15a	3.47a	13.84a	16.07a	29.58a
Clomazone + oxyfluorfen	11.03a	5.92a	0.16a	4.03a	15.27a	17.30a	27.43a
				2018			
Weeding	11.12a	4.88a	0.25a	5.31a	15.27a	18.85a	38.25a
No weeding	7.73b	4.72a	0.21b	4.55a	13.99a	17.84a	33.78b
Flumioxazin 35	9.93a	4.81a	0.25a	5.35a	14.52a	18.27a	34.35b
Flumioxazin 25	8.89b	5.21a	0.26a	4.85a	14.99a	18.62a	36.56a
Sulfentrazone	10.20a	4.23a	0.24a	4.93a	14.32a	17.90a	32.67b
Oxyfluorfen	10.63a	4.50a	0.21b	5.21a	14.55a	18.36a	31.56b
Oxyfluorfen + S-metolachlor	8.64b	4.83a	0.22b	5.25a	15.00a	17.71a	37.15a
Clomazone	8.03b	5.02a	0.24a	4.70a	14.12a	17.28a	35.18a
Clomazone + oxyfluorfen	10.24a	4.90a	0.19b	5.09a	14.55a	17.50a	33.06b

[(1)]Means followed by equal letters, in the columns, do not differ by Scott-Knott's test, at 5% probability. [(2)]Flumioxazin 35, 35 g ha^{-1} a.i.; and flumioxazin 25, 25 g ha^{-1}a.i.

Conclusions

1. The preemergence application of clomazone is selective for the melon (*Cucumis melo*) plant, since the herbicide is the safest to apply, as it did not affect yield in the two experimental years.

2. The oxyfluorfen + clomazone mixture is the most effective in controlling weeds during melon cultivation.

3. The ametryn, metribuzin, and diuron herbicides cause melon death when applied pre-transplant.

4. Regarding the quality of melon fruits, soluble solids are reduced by the treatment with 25 g ha^{-1} a.i. flumioxazin or with sulfentrazone, whereas pH, titratable acidity, pulp thickness, transverse and longitudinal diameters, and pulp firmness are not affected by the evaluated herbicides.

Acknowledgments

To Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (Capes), for financial support (Finance Code 001).

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