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Literature Review

WEED MANAGEMENT AND HERBICIDE SELECTIVITY IN ORNAMENTAL PLANTS

Manejo de Plantas Daninhas e Seletividade de Herbicidas em Plantas Ornamentais

MARTINS, D.[1]*
MARTINS, C.C.[1]
SILVA JR., A.C.[1]

ABSTRACT - Floriculture and landscaping sector has the same problems as other crops regarding weed management. Weeds affect the yield and quality of the harvested product, in which the visual aspect and aesthetics stand out as the most important factors in flower production and landscaping. Weed control in floriculture and landscaping is critical and costly because maintaining the beauty of the product and the use of herbicides is a low-cost management tool compared to manual management. However, it implies knowing herbicide selectivity, as ornamental species may present some injury depending on the active ingredient and the degree of selectivity of the compound. Because the use of this practice in flower production and landscaping both abroad and mainly in Brazil is incipient, aspects of selectivity, chemical weed control, and safe application of different herbicides are addressed in this paper.

Keywords: chemical control, flowers, floriculture, landscaping.

RESUMO - A área de floricultura e paisagismo exibe os mesmos problemas que as culturas agrícolas quando se trata do manejo de plantas daninhas. Nestes cultivos as plantas daninhas afetam o rendimento e a qualidade do produto colhido, destacando-se na produção de flores e no paisagismo o aspecto visual e a estética como os fatores mais importantes. Na floricultura e paisagismo o controle das plantas daninhas torna-se crítico e dispendioso, pois manter a beleza do produto e o uso de herbicidas apresenta-se como uma ferramenta de manejo de baixo custo quando comparado ao manejo manual. Contudo, implica no conhecimento da seletividade dos herbicidas, uma vez que as espécies ornamentais podem apresentar algum tipo de injúria dependendo do ingrediente ativo e do grau de seletividade do composto. Como o uso desta prática na produção de flores e no paisagismo, tanto no exterior como Brasil principalmente, apresenta-se incipiente, pretende-se com este texto abordar aspectos de seletividade, controle químico de plantas daninhas e a aplicação segura de diferentes herbicidas.

Palavras-chave: controle químico, flores, floricultura, paisagismo.

*** Corresponding author:**
<dagoberto.martins@unesp.br>

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INTRODUCTION

Brazilian floriculture is an important economic activity in agribusiness, as it has a social, cultural, and ecological function. As a social function, this activity employs more rural workers than other agricultural activities, as it requires manual labor in the various stages of the production chain. Because it is practiced intensively, the workforce is well paid, and work is usually done

[1] Universidade Estadual Paulista, Unesp, Jaboticabal-SP, Brasil.

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in small areas. The flower market is essential for another segment that has also been gaining ground in Brazil: the landscaping. This activity is no longer seen only as an aesthetic issue, but as a synonym for well-being and quality of life.

In any landscape area, maintenance should be periodic and qualified as specialized care and techniques are required. In this context, one of the most important aspects is weed management, especially in tropical countries. Weeds can occur anywhere there is a possibility of developing a plant species. Therefore, it is not difficult to predict that they occur in areas intended for leisure, landscaping, industries, parks, highways, railways, and urban environments (Deuber, 1997).

According to Schneider (2007), disturbances in the natural environment enhance the dispersal and establishment of weeds, especially after a decrease in natural diversity. These disturbances are closely and widely correlated with anthropic activities such as agriculture, livestock, deforestation, and construction of cities, railways, streets, and roads.

Weed infestation on sidewalks of roads is considered a problem because it changes the aesthetics of paving and, in many cases, makes it difficult for pedestrians to walk, requiring municipalities to periodically invest in control measures using herbicides or even mechanized or manual weeding to prevent its advance. In addition to landscaping, the production of ornamental plants shows weed interference, which reduces production and quality of the final product (flowers, foliage, bulbs or seeds).

Weeds provide several undesirable biotic factors, as they compete for resources for plant growth and development, mainly water, light, and nutrients, release allelopathic substances, and can even host pests and diseases common to cultivated plants, as well as interfere with the aesthetics of gardens (Pitelli, 1985).

The low number of herbicides registered for this purpose, unfavorable architecture of some ornamental plants, and the presence of thorns and aculei are factors that aggravate the difficulty of chemical weed management in landscaping. One of the most commonly used methods for weed control in ornamental beds is weeding, which, in some cases, are unfeasible in large areas due to their high cost and need for specialized labor (Rosa, 2007).

In contrast, chemical weed control is a viable alternative, as it provides fast results and savings in the use of labor that performs the gardening practices necessary to maintain the visual beauty of a garden (Maciel et al., 2005). Herbicides are viable chemicals in the flower production and landscaping (Seixas et al., 2011; Queiroz et al., 2016a), but crops can also have some type of injury depending on the degree of selectivity of each herbicide used, and thus devalue the visual aspect sought in the landscape composition.

WEEDS AND CHEMICAL MANAGEMENT

Since the dawn of agriculture and livestock, plants that spontaneously infested human-made areas that were not for food were considered undesirable and called weeds. Botanically, these plants are considered pioneer plants, which occupy areas where the original vegetation has been profoundly altered and have the function of creating suitable habitats for the beginning of a succession of populations that culminates in the restoration of the original vegetation (Pitelli and Pitelli, 2004).

Weeds are a large group of plants that grow spontaneously in anthropized areas and almost always behave as undesirable. The high aggressiveness associated with high yield, ease of dispersal, and longevity of seeds are attributes that enable high survival and perpetuation of these species (Baker, 1965; Hill, 1977; Lorenzi, 2007). These plants directly affect crop growth and yield by competing for essential growth resources and/or releasing allelopathic substances (Pereira et al., 2011).

The use of herbicides stands out among the different control systems adopted in relation to weeds. Its success, despite the higher control efficiency and ease of application, depends on a series of technical principles adopted, among them the identification of the weeds to be controlled. It is due to the choice of the active ingredient of the product to be used, which will depend on the weed species existing in the site, as weed communities may vary their floristic composition depending on the type and intensity of the imposed management practices. Recognizing the species is essential, mainly considering the financial and environmental costs of using chemicals.

The choice of an herbicide should consider technical and economic aspects, such as efficiency, crop selectivity, residual effect, time to application, control spectrum, and cost. Cultivation mode, application time (wet or dry), and climate and soil characteristics of the area should also be taken into account (Christoffoleti et al., 2008). However, studies on herbicide selectivity are essential to decide on chemical control. Selectivity is the ability of an herbicide to eliminate weeds in the area to be worked without reducing any desirable phytotechnical or economic aspects such as development and visual beauty of plants (Queiroz et al., 2016a).

The effectiveness and selectivity of herbicides depend on several factors, among them are the physicochemical characteristics and dose, species to be controlled, stage of development and biology of weeds and crops, application techniques, environmental factors at the time and after the application of herbicides, as well as soil physicochemical characteristics for pre-emergence herbicides. These factors continuously interact, leading to differences in the observed results. In addition, soil moisture conditions, precipitation, and temperature affect the residual period of the herbicide, which should range from 60 to 150 days, varying according to cultivation mode and application time (Christoffoleti et al., 2008).

USE OF HERBICIDES IN FLOWERS, SHRUB PLANTS, AND LAWNS

Studies on the use of herbicides in ornamental plants are scarce. However, there is a growing interest in this area. Despite the difficulty due to the scarcity of scientific information, it is possible to discuss the use of herbicides in the species groups that make up a garden, ranging from lawns to annual and perennial species.

According to Barbosa et al. (1997), the scarcity of technical information resides in the fact that ornamental plants and lawns have little-recognized importance by research centers in Brazil, eagerly sought by potential users, resulting in their importation and/or generalization of solutions and recommendations without scientific basis. However, like any crop, ornamental species are subject to weed interference, which may affect flower production and especially the visual quality of flowers.

Most commercially produced ornamental plant species have a slow growth rate in their early development when compared to some weed species, making them vulnerable to competition for water, light, and nutrients (Freitas et al., 2007). Because there is little information on the use of herbicides in ornamental plants, studies on the selectivity of chemical control in these plants are required. Selectivity is an essential characteristic of the herbicide because it allows weed control without affecting the crop (Silva and Silva, 2007).

Cut or potted flowers

Gladiolus

Yadav and Bose (1987) observed that the herbicides atrazine (3.0 kg ha^{-1}) and oxyfluorfen (0.5 kg ha^{-1}) were selective for *Gladiolus* spp., also providing good control of some weeds occurring in pots: [*Eragrostis tenella* (L.) P. Beaux. ex Roem. & Schult.], *Echinochloa crus-galli* L., *Ageratum conyzoides* L., *Chenopodium album* L., *Euphorbia hirta* (L.) Millsp, and *Indigofera glabra* L.

Richardson and Zandstra (2006) carried out a study in which the selectivity of 18 herbicides (clomazone, flumioxazin, halosulfuron, imazamox, imazapic, linuron, mesotrione, oryzalin, oxyfluorfen, pendimethalin, prometryn, rimsulfuron, S-metolachlor, sulfentrazone, trifloxysulfuron, flumioxazin + S-metolachlor, flumioxazin + oryzalin, and isoxaben + oryzalin) were tested in gladiolus plants and observed acceptable injuries (lower than 6%) with the use of the herbicides flumioxazin, linuron, oryzalin, pendimethalin, prometryn, S-metolachlor, sulfentrazone, flumioxazin + S-metolachlor, flumioxazin + oryzalin, and isoxaben + oryzalin. These results are different from those of Yadav and Bose (1987) regarding the selective use of oxyfluorfen, which may be related to the type of gladiolus hybrid used by the researchers. Thus, verification of selectivity is required when using distinct hybrids.

Calla lily

Freitas et al. (2007) evaluated the selectivity of the herbicide oxyfluorfen in calla lily [*Zantedeschia aethiopica* (L.) Sprengel] production under pot conditions and found that doses of 300 to 340 g ha^{-1} of oxyfluorfen were selective to calla lily plants, with few visual and transient injuries.

Carnation and geranium

Talbert et al. (1999), in a study on the selectivity of *Dianthus* spp. (carnation) and *Geranium* spp. (geranium) to different herbicides, found that a ready mixture of oryzalin + oxyfluorfen (13.46 kg ha^{-1}) caused significant injuries for both species at 10 days after treatment (DAT), but plants were recovered and without symptoms of phytointoxication from 28 DAT. Moreover, the herbicide oryzalin applied at doses of 4.49 and 8.98 kg ha^{-1} caused injuries initially at 10 DAT in both species, but plants were recovered in the other evaluated periods, showing that symptoms of injuries were transient.

Chrysanthemum and gaillardia

Deer (1993) evaluated the selectivity of some herbicides (isoxaben, metolachlor, oxadiazon, and simazine) in plants of chrysanthemum (*Chrysanthemum leucanthemum* L.) and gaillardia (*Gaillardia aristata* Pursh.) and observed that only metolachlor (4.5 kg ha^{-1}) was selective to these species, with acceptable and transient injuries. The herbicides isoxaben, oxadiazon, and simazine in association with metolachlor provided high and unacceptable visual injuries to the plants of both species.

Moreover, Porter (1996) analyzed the selectivity of some herbicides in plants of another chrysanthemum species (*C. coccineum* Wild) and found that trifluralin (3.36 kg ha^{-1}), oryzalin (3.36 kg ha^{-1}), isoxaben (0.56, 0.84, and 1.12 kg ha^{-1}), isoxaben + oryzalin (5.6 kg ha^{-1}), and isoxaben + trifluralin (2.8, 4.2, and 5.6 kg ha^{-1}) were selective to this species.

Dahlia, lance-leaved coreopsis, and baby's-breath

Staats and Klett (1993) evaluated the selectivity of some pre-emergence herbicides [(metolachlor (4.6 and 9.1 kg ha^{-1}), isoxaben (1.1 and 2.3 kg ha^{-1}), oxadiazon (4.5 and 9.0 kg ha^{-1}), oryzalin (2.3 and 4.6 kg ha^{-1}), trifluralin (4.5 and 9.0 kg ha^{-1}), and oxyfluorfen + oryzalin (3.4 and 6.8 kg ha^{-1})] on dahlia (*Dahlia* Cav. X hybrida), lance-leaved coreopsis (*Coreopsis lanceolata* L.), and baby's-breath (*Gypsophila pacifica* Kom.) and found that oryzalin was non-selective for dahlia and baby's-breath, while the other herbicides were selective at all tested doses.

Orchids

Studies with orchids are very restricted, which demands a wider range of scientific researches. There are several mentions in electronic media of herbicide use but without scientific connotation.

Freitas et al. (2007) worked with two species of orchids (*Epidendrum ibaguense* and *Dendrobium* sp.) aiming at controlling rockweed [*Pilea microphylla* (L.) Liebm.] with different doses of the herbicide oxyfluorfen applied in full area and directed jet. They observed that no tested treatment provided any type of injury to both orchid species, and herbicide doses higher than 0.250 g ha^{-1} were efficient to control this weed.

Battistus et al. (2014) also studied the control of rockweed in orchids with the herbicide oxyfluorfen, but on cattleya (*Cattleya tenebrosa* x *Cattleya leopady*) seedlings with the herbicides nicosulfuron, mesotrione, clethodim, flumioxazin, and metsulfuron-methyl. The researchers reported that all herbicides were selective for this cattleya hybrid, but the herbicides flumioxazin, metsulfuron-methyl, and oxyfluorfen were also efficient for weed control, corroborating the results of oxyfluorfen obtained by Freitas et al. (2007).

Klein et al. (2015) studied *P. microphylla* infesting orchid seedlings of the genus *Rhynchostylis* [(*R. gigantea* Alba x *R. gigantea*) x *R. gigantea* Semi-Alba] and reported that the herbicides flumioxazin and oxyfluorfen were efficient in controlling rockweed plants, confirming the results already found for oxyfluorfen in the literature. In addition, they verified that nicosulfuron and mesotrione were inefficient to control this weed, being all the tested herbicides selective to seedlings of this orchid hybrid (*Rhynchostylis*).

Shrub plants

Crown of thorns

Maciel et al. (2005) evaluated the selectivity of different herbicide groups applied in post-emergence in crown of thorns (*Euphorbia splendens* Hook.) plants and observed that the herbicide metsulfuron-methyl (0.0024 kg ha^{-1}) was selective for this ornamental species, as it did not present any injury on its leaves, maintaining the visual quality and chlorophyll content and, mainly, vigorous development of inflorescences. The herbicides fluazifop-b-butyl (0.25 kg ha^{-1}), sethoxydim (1.25 kg ha^{-1}), and propaquizafop (0.125 kg ha^{-1}) caused injuries to flowers of crown of thorns plants, which depreciated the visual quality of plants, not allowing to recommend these herbicides for this ornamental plant.

Jungle flame

Neel (1977) worked with jungle flame (*Ixora coccinea* L.) plants to evaluate the selectivity of the herbicide oxadiazon applied at doses of 2.4, 4.8, and 8.96 kg ha^{-1} in pre-emergence and pot conditions. This researcher found that all tested doses were selective for this species.

The association of herbicide with mulch was studied by Seixas et al. (2011), who evaluated the effect of the herbicide pendimethalin (1.5 kg ha^{-1}) applied alone and in association with rice husk and sawdust (10, 15, and 20 t ha^{-1}) for weed control (*Alternanthera tenella* Colla, *Blainvillea rhomboidea* Cass, *Cenchrus echinatus* L., and *Commelina benghalensis* L.) in *Ixora chinensis* Lam. Both pre-emergence spraying and herbicide soaking into mulch were used.

The use of mulch soaking with herbicides was more efficient in weed control than spraying it on mulch. The higher the amount of dry matter placed as cover, the more effective was the control. Pendimethalin application directly on the soil provided good control of the weed community, being selective at all doses with or without association with mulches. In contrast, direct spraying of herbicide on Chinese ixora plants was not viable, causing strong phytointoxication (Seixas et al., 2011).

Sage

In a study on weed control and selectivity of the herbicide oxyfluorfen under field conditions, Rosa (2007) applied 240 and 480 g ha^{-1} oxyfluorfen to plants of salvia (*Salvia splendens* Sellow ex J.A. Schulles) associated with rice husk (4, 6, and 8 t ha^{-1}). This association provided acceptable visual injuries to sage plants regardless of the dose, and the dose of 480 g ha^{-1} oxyfluorfen associated with 4 t ha^{-1} of rice husk provided good control of weeds present in the area (*Brachiaria decumbens* Stapf, *Digitaria horizontalis* Wild, *Amaranthus viridis* L., and *Cyperus esculentus* L.).

Oxyfluorfen application directly on the soil was not selective to sage plants, and the use of rice husk without herbicide did not provide adequate weed suppression, being necessary the association with the herbicide.

Hibiscus

Porter (1996) evaluated the effect of herbicides on hibiscus (*Hibiscus moscheutos* L.) plants and reported that isoxaben (0.56, 0.84, and 1.12 kg ha^{-1}) and oryzalin (3.36 kg ha^{-1}) and their associations were selective to this species.

Azalea

Beste and Frank (1985) studied the effect of the herbicides oxyfluorfen (2.2 kg ha^{-1}), oxadiazon (4.5 kg ha^{-1}), and napropamide (4.5 kg ha^{-1}) on weed control [*Portulaca oleracea* L., *Euphorbia maculata* L., *Oxalis stricta* L., *Senecio vulgaris* L., *Stellaria media* L., and *Digitaria sanguinalis* (L.) Scop.] on azalea plants (*Rhododendron obtusum* Planck). They found that all the tested herbicides were selective to azalea plants and that oxadiazon efficiently controlled plants of *P. oleracea*, *E. maculata*, *O. stricta*, and *S. media*. On the other hand, napropamide provided satisfactory control of *S. media* plants, and oxyfluorfen controlled *D. sanguinalis* plants.

Grasses

The use of grasses in landscape composition is present in many types of projects, both indoors and outdoors. The use of grasses in outdoor projects in larger areas next to lawns usually requires more intense weed control and, consequently, the use of herbicides.

Neel and Senesac (1991) evaluated the selectivity of different ornamental grasses under pot conditions to various herbicides applied to the soil as granules and sprayed liquid. The studied species were American beachgrass (*Ammophila breviligulata* Fern.), Uruguayan pampas grass [*Cortaderia selloana* (Schult. & Schult. f.) Asch. & Graebn.], fescue [*Festuca ovina* var. *glauca* (Lam.) W.D.J. Koch], crimson fountaingrass [*Pennisetum setaceum* (Forssk.) Chiov.], and reed canarygrass (*Phalaris arundinacea* var. *picta* L.).

They found that the herbicides metolachlor (sprayed or applied as granules) and oryzalin (sprayed) were not selective to these species, except for American beachgrass, which was not affected by metolachlor formulated as granules. Napropamide (sprayed and granules) was selective only for American beachgrass and reed canarygrass. The herbicides pendimethalin (sprayed), prodiamine (granules and sprayed), trifluralin (granules), isoxaben (sprayed), oxyfluorfen + pendimethalin (granules), and benefin + trifluralin were selective for all studied species (Neel and Senesac, 1991).

Hubbard and Whitwell (1991) also evaluated under pot conditions the selectivity of fenoxaprop-ethyl, fluazifop-p, and sethoxydim on several ornamental grass species: feather reed grass [*Calamagrostis arundinacea* (L.) Roth cv. Karl Foerster], weeping lovegrass [*Eragrostis curvula* (Schrad.) Nees], ravennagrass [*Erianthus ravennae* (L.) Beauv.], Chinese silvergrass (*Miscanthus sinensis* Andress var. *variegatus*), switchgrass (*Panicum virgatum* L. cv. Haense Herms), Chinese fountaingrass [*Pennisetum alopecuroides* (L.) Spreng], Indiangrass [*Sorghastrum nutans* (L.) Nash], cordgrass (*Spartina pectinata* Link cv. Aureomarginata), and Uruguayan pampas grass (*C. selloana*). The researchers found that only fenoxaprop-ethyl provided selectivity and only to feather reed grass, and all other species were affected by the three herbicides tested.

Gardenia and orange jessamine

In a study under pot conditions, Neel (1977) tested several doses of oxadiazon (2.4, 4.8, and 8.96 kg ha^{-1}) for its selectivity to gardenia (*Gardenia jasminoides* Ellis) and orange jessamine (*Murraya paniculata* Jack). None of the oxadiazon doses affected the growth of orange jessamine plants. However, gardenia showed severe phytointoxication symptoms with the use of the two highest doses of this herbicide.

Crane flower, red ginger, and parakeetflower

Freitas et al. (2007) evaluated the selectivity and effectiveness of the herbicide oxyfluorfen to control *P. microphylla* in the production of crane flower (*Strelitzia reginae* Banks) and found that weed control was higher than 90% from doses of 300 g ha^{-1} of oxyfluorfen and that the herbicide was selective for this species at all tested doses (300, 320, and 340 g ha^{-1}), with few visual and transient injuries.

Queiroz et al. (2016a) worked with plants of crane flower (*S. reginae*), red ginger (*Alpinea purpurata* K. Schum.), and parakeetflower (*Heliconia psittacorum* L.) to study the selectivity of some post-emergence herbicides. In general, all herbicides (fluazifop-p-butyl, quizalofop-p-ethyl, sethoxydim, quinclorac, chlorimuron-ethyl, clethodim + fenoxaprop-p-ethyl, bentazon, and fomesafen) were selective for these three species. In addition, red ginger and parakeetflower plants presented initial visual phytointoxication symptoms that dissipated over time and presented a satisfactory visual aspect at the end of the study. However, reductions in plant dry matter accumulation were verified in crane flower plants when the herbicides sethoxydim (184 g ha^{-1}) and quizalofop-p-ethyl (75 g ha^{-1}) were applied, being non-selective to these ornamental species.

Lawns

According to Paiva and Gavilanes (2004), lawns need to be well implemented and cared for to exercise its aesthetic landscaping purpose. The following factors should be considered for their implantation: contamination of the plates by weeds, delay in planting, use of irregular plates, which are removed with a hoe at the production site, and delay in its closing, making it more susceptible to infestation (Demattê, 1988; Paiva, 2001).

In turn, weeds cause loss of aesthetic quality, seriously compromising it (Freitas et al., 2003). Thus, chemical control with the use of herbicides stands out as an alternative for weed management, as it contributes to reducing maintenance costs and extending lawn life. Importantly, the use of non-selective herbicides can cause lawn injuries and make it difficult to be established in the area, resulting in more weed problems (Fagerness et al., 2002).

In Brazil, only the herbicide 2,4-D has been registered in the past for use in lawns (Rodrigues and Almeida, 2005), but currently, there is no registered herbicide. Thus, the identification of selective herbicides that have different mechanisms of action becomes essential for the development of weed management programs in Brazilian lawns, besides avoiding the selection of herbicide-resistant species.

In other countries, several researchers have highlighted the feasibility of using pre- and post-emergence herbicides, such as atrazine, oxadiazon, quinclorac, sethoxydim, among others, on various types of lawns, as well as the possibility of using these products in a tank to maximize the effects of different mechanisms of action on weed control (Johnson and Carrow, 1999; Fagerness et al., 2002).

Due to the existence of a specific bibliographic review on this subject (McElroy and Martins, 2013), only the literature on the subject after this period produced in Brazil is mentioned.

Maciel et al. (2013) evaluated the selectivity of the herbicides imazapyr (in three formulations: Kapina®, Kapina Plus®, and Contain®), imazapic, and halosulfuron on the species Korean lawngrass (*Zoysia japonica*) and Bermudagrass [*Cynodon dactylon* (L.) Pers.], as well as the control efficiency of these herbicides on *Cyperus flavus* (Vahl) Kük ex Herter and *C. rotundus* L, and found that all herbicides and formulations were selective for Korean lawngrass. The herbicides imazapyr (Contain® formulation), imazapic, and halosulfuron were not selective for Bermudagrass, causing serious visual injuries to the plants. The researchers also report that all chemical treatments were effective for weed control.

Marques et al. (2016) evaluated the selectivity of the herbicide bentazon (720 g ha^{-1}), nicosulfuron (50 g ha^{-1}), halosulfuron (112.5 g ha^{-1}), oxadiazon (875 g ha^{-1}), and 2,4-D (698 g ha^{-1}) on Korean lawngrass plants and found that none of them reduced plant height, but reduced dry matter. Visually, only the herbicides nicosulfuron and oxadiazon provided injuries, which dissipated within 21 days after herbicide application. Thus, all tested herbicides were selective to the plants of this grass species.

In another study, Marques et al. (2017) evaluated the same herbicides and doses of the previous research on bahiagrass and also observed acceptable selectivity of the herbicides halosulfuron (112.5 g ha^{-1}), 2,4-D (875 g ha^{-1}), and bentazon (720 g ha^{-1}) to this species and lower selectivity of the herbicides nicosulfuron (50 g ha^{-1}) and oxadiazon (875 g ha^{-1}), with more severe injuries only with nicosulfuron application, which led to being considered as non-selective. Thus, most results corroborate those found by Marques et al. (2016) for Korean lawngrass.

Moreover, several herbicide molecules in the literature are recommended for weed control in lawns (McElroy and Martins, 2013), but herbicide companies need to register them to provide legal protection for their use.

HERBICIDE USE IN PERENNIAL PLANTS

Palm trees

Many palm trees have various purposes, such as food, rope making, and household items, being also an ornamental plant option in the landscape composition due to their visual aspect.

Neel (1977) evaluated the herbicide oxadiazon at different doses (2 to 8.96 kg ha^{-1}) on the palm trees fountain palm (*Livistona chinensis* R.Br. ex Mart.) and butterfly palm (*Chrysalidocarpus lutescens* H. Wendl.) and found no symptoms of intoxication in butterfly palm plants, being considered selective at all doses. However, this herbicide was non-selective for fountain palm, regardless of the tested dose.

In another study, Freitas et al. (2007) evaluated the control of *P. microphylla* and selectivity of the herbicide oxyfluorfen applied in full area and directed jet on Bangalow palm (*Archontophoenix cunninghamii* H. Wendl. & Drude) plants maintained in pots. The researchers observed its seedlings had evident symptoms of intoxication when spraying was carried out in full area, regardless of the dose (24, 72, 144, 288, and 360 g ha^{-1}). However, the herbicide was selective to seedlings when the directed jet was used, and weed control was efficient (above 90%) when using the oxyfluorfen dose of 360 g ha^{-1}.

Queiroz et al. (2016b) evaluated the effect of some post-emergence herbicides on the early growth of Alexandra palm (*Archontophoenix alexandrae* (F. Mueller) H. Wendl. & Drude) and peach palm (*Bactris gasipaes* Kunth). The herbicides fluazifop-p-butyl (93.8 g ha^{-1}), quizalofop-p-ethyl (75 g ha^{-1}), and lactofen (168 g ha^{-1}) were selective and nicosulfuron (50 g ha^{-1}), sethoxydim (184 g ha^{-1}), and clethodim + fenoxaprop-p-ethyl (50 + 50 g ha^{-1}) were non-selective for Alexandra palm, causing severe visual injuries to both plants. On the other hand, all the tested herbicides were selective to peach palm, with only light and momentary injuries on the leaves.

Moreover, Queiroz et al. (2016c) tested the same herbicides of the previous study, but with monosodium methanearsonate (MSMA) on assai palm (*Euterpe oleracea* Mart.) and jussara palm (*E. edulis* Mart.), also in the early development stages (40-50 cm). In this case, all herbicides and tested doses (fluazifop-p-butyl, quizalofop-p-ethyl, lactofen, fomesafen, sethoxydim, nicosulfuron, clethodim + fenoxaprop-p-ethyl, and MSMA) were selective for assai palm. However, only sethoxydim (184 g ha^{-1}), nicosulfuron (50 g ha^{-1}), and clethodim + fenoxaprop-p-ethyl (50 + 50 g ha^{-1}) were selective for jussara palm.

Ornamental trees

Some tree species are used in the floristic composition of landscape design, mainly those that have specific shapes or abundant flowering.

Saidak and Nelon (1960) studied the effect of the herbicides diuron and simazine under field conditions on several two- and five-year-old ornamental trees: hedge maple (*Acer campestre* L.), Siberian peashrub (*Caragana arborescens* L.), arborvitae (*Thuja occidentalis* L.), and sawara-cypress [*Chamaecyparis pisifera* (Siebold & Zucc.) Endl] and observed that only sawara-cypress plants were affected by simazine application at the first stage, but it was not observed when applied to more mature plants. Moreover, both herbicides were selective to the other species when applied at both growth stages.

Neel (1977) evaluated the effect of several doses of the herbicide oxadiazon (2.4, 4.8, and 8.96 kg ha^{-1}) applied in pre-emergence under pot conditions on the ornamental tree species

Norfolk Island pine (*Araucaria heterophylla* Salisb, Franco), weeping fig (*Ficus benjamina* L.), yew plum pine (*Podocarpus macrophyllus* D. Don), Japanese privet (*Ligustrum japonicum* Thunb.), and octopus tree (*Schefflera actinophylla* Endl. Harms) and found that all oxadiazon doses were selective for these species, except for yew plum pine, which presented severe injuries regardless of the used dose.

As in any crop, ornamental plants are also subject to interference by weeds, with losses in production (flowers, foliage, and seeds) and aesthetics (visual quality standards), requiring higher care in the maintenance of green areas and leading to a depreciation of their value. Therefore, studies aiming at chemical control and herbicide selectivity is an essential tool in the management of the weed community, mainly because ornamental plants have aesthetic quality as their main value, and the use of weeding becomes costly in many cases.

REFERENCES

Baker HG. Characteristics and mode of origin of weeds. In: Baker HG, Stebbins GL, editors. The genetics of colonizing species. New York: Academic Press; 1965. p.147-72.

Barbosa JG, *Barbosa LS, Lopes LC, Grossi JAS.* Plantio de gramados de *Paspalum notatum* Flügge "batatais": tipos de mudas e doses de fertilizantes. Rev Bras Hortic Ornam. 1997;3:50-4.

Battistus AG, Klein J, Costa NV, Guimarães VF, Hoffmann V. Chemical control of *Pileamicrophulla* in cattleya seedlings (Cattleuatenebrosa x Cattleyaleopldy). Planta Daninha. 2014;32(4):801-7.

Beste CE, Frank JR. Weed control in newly planted azaleas. J Environ Hort. 1985;3:12-4.

Christoffoleti PJ, Galli AJB, Carvalho SJP, Moreira MS, Nicolai M, Foloni LL, et al. Glyphosate sustainability in South American cropping systems. Pest Manag Sci. 2008;64:422-7.

Demattê MESP. Implantação e manutenção de jardins. In: Graziano TT, editor. Jardinagem. Jaboticabal: FCAV; 1988. p.71-95.

Deer JF. Wildflower tolerance to metolachlor and metolachlor conbined with other boradleaf herbicides. Hortscience. 1993;10:1023-6.

Deuber R. Ciência das plantas infestantes: manejo. Campinas: [s.n.]; 1997. v.2.

Fagerness MJ, Yelverton FH, Cooper RJ. Bermudagrass [*Cynodon dactylon* (L.) Pers.] and Zoysiagrass (*Zoysia japonica*) establishment after preemergente herbicide applications. Weed Technol. 2002;16:597-602.

Freitas FCL, Ferreira LR, Silva AA, Barbosa JG, Miranda GVE, Machado AFL. Eficiência do triclopyr no controle de plantas daninhas em gramados (*Paspalum notatum*). Planta Daninha. 2003;21:159-64.

Freitas FCL, Grossi JAS, Barros AF, Mesquita ER, Ferreira FA. Weed control in ornamental plant seedling production. Planta Daninha. 2007;25(3):595-601.

Hill TA. The biology of weeds. Southamption: Camelot Press; 1977. 64p.

Hubbard J, Whitwell T. Ornamental grass tolerance to postemergence grass herbicides. Hortscience. 1991;26:1507-9.

Johnson BJ, Carrow RN. Tolerance of zoysiagrass (*Zoysia* spp.) cultivars to preemergence herbicides. Weed Technol. 1999;13:706-12.

Klein J, Battistus A, Hoffmann V, Costa N, Kestring D, Bulegon L, et al. Chemical management of *Pilea microphylla* in orchid seedlings. Rev Bras Herb. 2015;14:15-20.

Lorenzi H. Plantas daninhas do Brasil: terrestres, aquáticas, parasitas, tóxicas e medicinais. 4ª ed. Nova Odessa: Plantarum; 2007.

Maciel CDG, Poletine JP, Constantin J. Seletividade de coroa-de-cristo (*Euphorbia splendens*) a diferentes classes de herbicidas para manejo de plantas daninhas em jardinagem. Rev Bras Hortic Ornam. 2005;11:132-40.

Maciel CDG, Sapia JG, Kondo PNY, Benites WLS, Pereira JAA, Wesz VEB, et al. Seletividade e eficácia dos herbicidas Kapina e Kapina Plus no controle de tiririca em gramas bermuda e esmeralda. Rev Bras Herb. 2013;12:39-46.

Marques RP, Martins D, Rodella RA, Saulo Ítalo AC, Vitorino HS. Leaf anatomy of esmerald grass submitted to quantitative application of herbicides. Semina Cienc Agrar. 2016;37:1767-78.

Marques RP, Dagoberto M, Rodella RA, Costa SÍA. Seletividade de herbicidas à grama batatais e sua relação com as características anatômicas foliares. Colloq Agra. 2017;13:67-75.

Mcelroy JS, Martins D. Use of herbicides on turfgrass. Planta Daninha. 2013;31:455-67.

Neel PL. Effects of oxadiazon preemergence herbicide on weed control and growth of sixteen species of containerized ornamental plants. Proc State Hort Soc. 1977;90:353-5.

Neel PL, Senesac AF. Preemergent hercicid safety in container-grown ornamental grasses. Hortscience. 1991;26:157-9.

Paiva PDO. Implantação e manutenção de jardins. Lavras: UFLA/FAEPE; 2001. 88p.

Paiva PDO, Gavilanes ML. Plantas ornamentais: classificação e usos em paisagismo. Lavras: UFLA/FAEPE; 2004. 127p.

Pereira MRR, Teixeira RN, Souza GSF, Silva JIC, Martins D. Inibição do desenvolvimento inicial de plantas de girassol, milho e triticale por palhada de capim-colchão. Planta Daninha. 2011;39(2):305-10.

Pitelli RA. Interferências de plantas daninhas em culturas agrícolas. Inf Agropec. 1985;11:16-27.

Pitelli RA, Pitelli RLCM. Biologia e ecofisiologia das plantas daninhas. In: Vargas L, Roman ES, editores. Manual de manejo e controle de plantas daninhas. Bento Gonçalves: Embrapa Uva e Vinho; 2004. p.29-56.

Porter WC. Isoxaben and isoxben continations for weed control in container-grown herbaceous flowering perennials. J Environ Hort. 1996;14-27-30.

Queiroz JRG, Silva Jr AC, Martins D. Herbicide selectivity in tropical ornamental species. Planta Daninha. 2016a;34:795-802.

Queiroz JRG, Silva Jr AC, Pereira MRR, Martins D. Herbicide selectivity in the early devolpment of Alexander palm and Peach palm. Semina Cienc Agrar. 2016b;37:2891-900.

Queiroz JRG, Silva Jr AC, Pereira MRR, Martins D. Desenvolvimento inicial de mudas de Euterpe ssp após a aplicação de herbicidas. Rev Bras Frutic. 2016c;38:72-80.

Richardson RJ, Zandstra BH. Evaluation of flumioxazin and other herbicides for weed control in gladiolus. Weed Technol. 2006;20:394-8.

Rodrigues BN, Almeida FS. Guia de herbicidas. 5ª ed. Londrina: Au; 2005.

Rosa CS. Seletividade de sálvia (*Salvia splendens*) ao herbicida oxyfluorfen veiculado à palha de arroz [dissertação]. Jaboticabal: Faculdade de Ciências Agrárias e Veterinárias; 2007.

Saidak WJ, Nelson SH. Weed control in ornamental Nurseries. Weeds. 1960;10:311-15.

Schneider AAA. flora naturalizada no Estado do Rio Grande do Sul, Brasil: herbáceas subespontâneas. Biociências. 2007;15:257-68.

Seixas AL, Alves PLCA, Carvalho LB. Pendimentalin aplicado à casca de arroz e serragem para o controle de plantas daninhas em *Ixora chinensis* Lam. Cienc Agrotec. 2011;35:718-27.

Silva AA, Silva JF. Tópicos em manejo de plantas daninhas. Viçosa, MG: Universidade Federal de Viçosa; 2007.

Staats D, Klett JE. Evalualtion of weed control and phytotoxicity of preemergence herbicides applied to container-grown herbaceous and wood plants. J Envrion Hortic. 1993;11:78-80.

Talbert RE, Schmidt LA, Burgos NR, Johnson JA, Curless JK, Norsworthy JK. Field evaluation of herbicides on small fruit, vegetable and ornamental crops. Arkansas Agricultural Experiment Station, Division of Agriculture, University of Arkansas; 1999. (Research series, 461)

Yadav LP, Bose TK. Chemical weed control in tuberose and gladiolus. Acta Hortic. 1987;205:177-85.