EFFICACY OF CHEMICAL AGENTS IN REDUCING FRUIT SET OF 'LETICIA' JAPANESE PLUMS

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ABSTRACT

Looking for improving 'Leticia' Japanese plums fruit quality and size, thinning of flowers and fruits have to be done early in the spring. Although, there are very few studies showing the effectiveness of chemical compounds that effectively promote thinning of stone fruits, especially for the Southern Brazilian conditions. Thus, the objective of this study was to investigate the effectiveness of several agents with potential to promote thinning at blooming or post blooming in 'Leticia' Japanese plums. To do so, in the cropping season of 2014/2015 the treatments abscisic acid, benzyladenine, benzyladenine + gibberellic acid$_{4+7}$, ethephon, metamitron, vegetal oil, and calcium chloride were sprayed in 'Leticia' plums looking for evaluating the effects on the fruit set. The treatments ABA, benzyladenine, metamitron, benzyladenine + gibberellic acid$_{4+7}$, calcium chloride, and vegetal oil are effective to reduce fruit set of 'Leticia' plums in Southern Brazil.
KEYWORDS: thinning, flowering, *Prunus salicina* Lindl, abscission

EFICÁCIA DE AGENTES QUÍMICOS NA REDUÇÃO DA FRUTIFICAÇÃO EFETIVA DE AMEIXEIRA 'LETICIA'

RESUMO

Buscando melhorar a qualidade e o peso de frutos de ameixeira japonesa 'Leticia', o raleio de flores e frutos deve ocorrer no início da primavera. Entretanto, há muito poucos estudos demonstrando a eficácia de agentes químicos que efetivamente

promovam raleio de frutos de caroço, especialmente nas condições climáticas da região sul do Brasil. Dessa forma, o objetivo desse estudo foi investigar a efetividade de diversos compostos com potencial de promover raleio de flores ou de frutos de ameixeira 'Leticia'. Para tal, na safra de 2014/2015, os tratamentos ácido abscísico, benziladenina, benziladenina + ácido giberélico$_{4+7}$, etefom, metamitron, óleo vegetal, e cloreto de cálcio foram aplicados em ameixeiras 'Leticia' para avaliação dos efeitos dos tratamentos sobre a frutificação efetiva. Os tratamentos ácido abscísico, benziladenina, benziladenina + ácido giberélico$_{4+7}$, metamitron, óleo vegetal e cloreto de cálcio reduziram a frutificação efetiva de ameixeira japonesa 'Leticia', no sul do Brasil.
PALAVRAS-CHAVE: raleio, floração, *Prunus salicina* Lindl, abscisão

INTRODUCTION

The size at harvest of temperate zone fruits, depends on the number of fruits that are growing simultaneously in the trees. For instance, in the apple crop it is necessary that up to 90% of the flowers abscise, so the fruits that are left can reach marketable size (LAKSO; GOFFINET, 2013). In addition, these authors reported that during early flowering the fruits have intense cell division rate along with intense shoot growth, creating a powerful competition between the shoots and fruits for assimilates; therefore, if the competition is eliminated early in the season there is a high potential for fruit growth. Another benefit from thinning early in the season is the removal of excess endogenous gibberellin from the growing fruitlets, which negatively interferes the flower bud induction, decreasing the amount of flowers and fruits in the following year (WEBSTER; SPENCER, 2000; EROGUL; SEN, 2015).

Usually, blossom thinners are composed of caustic substances (i.e. ammonium thiosulfate, urea, lime sulphur) that burns the stigmatic surface and inhibits pollen tube germination and consequently the fecundation, or an oily substance, which impedes the pollen grain adherence on the stigma or even blocks the pollen tube growth (FALLAHI; WILLEMSEN, 2002; FALLAHI; GREENE, 2010; McARTNEY et al., 2006; MARCHIORETTO et al., 2018; MARCHIORETTO et al., 2019). Although, both caustic compounds of oily compounds may have an indirect effect on the fruit abscission, as they damage the leaf tissue or create a barrier on the stomatas, decreasing leaf gas exchange rate and consequently the rate of assimilates production (LENAHAN; WHITING, 2006; McARTNEY et al., 2006). The main advantage of these agents is that they are not susceptible to weather conditions, as their effect are more direct (GREENE, COSTA, 2013).

Another group of chemical thinners are the plant growth regulators that are applied usually at post bloom aiming to fruitlet thinning. Growth regulators like benzyladenine, ethylene, and abscisic acid are the most commonly commercially available for perennial fruit trees (FALLAHI; GREENE, 2010; GIOVANAZ et al., 2015). Although, these compounds have a downside, which is the interference of weather conditions leading to unstable results. For instance, during spring, if the night and daytime temperatures are warmer and there is little solar radiation incidence (clouds), the trees will have a lower reserves status, making them more susceptible to thinning by these growth regulators; whereas, if the mean temperatures are cooler, and the solar radiation is more intense, then the trees will produce a greater amount of assimilates, making the effect of the growth regulators more difficult (GREENE, COSTA 2013).

Stone fruit manual thinning may be quite expensive (FALLAHI; WILLEMSEN, 2002; MEITEI et al., 2013; PAVANELLO et al., 2018), especially because most producers are smallholder farmers with limited availability of resources. Although, pome fruits have the inconvenient of having a non-uniform flowering, with flowers at different phenological stages at blooming (FALLAHI, WILLENSEN, 2002). Therefore, new alternatives of thinners to be used at both bloom or post bloom have to be tested in conditions of southern Brazil. Thus, the objective of this study was to investigate the effectiveness of several agents with potential to promote thinning at blooming or post blooming in 'Leticia' Japanese plums.

MATERIAL E METHODS

The experiment was carried out in a commercial plum orchard located in the municipality of Jaquirana-RS, in the cropping season of 2014/2015. The orchard was trained in quad V system with four main branches. The rootstock used was from peach seedlings, and the tree spacing was 2 m between trees and 6 m between rows. The orchard was cultivated with the Japanese plums of the cultivars Leticia and Santa Rosa, as pollinator. The treatments and the moment of application were performed as indicated in table 1. The experiment was conducted in a randomized complete block design with five replications of one tree for each treatment. The application of the treatments occurred on Sept. 5, 2014 with a motorized backpack sprayer. In the same day, four lateral branches in each plant were tagged with the total number of flowers. When the fruitlets had around 20 mm of diameter, they were counted again to calculate fruit set as the ratio of initial number of flowers by the final number of fruits multiplied per 100 to express the data as percentage. The data were subjected to analysis of variance (ANOVA) at 5% of probability, and in case of significance, the means were compared through the Scott-Knott test at 5% of probability using the software Sisvar v. 5.3 (FERREIRA, 2010).

TABLE 1. Commercial name, active ingredient, doses, and moment of application of the treatments in 'Leticia' plums.

Treatments	Dose of commercial product	Moment of application
Untreated Control	-	-
ABA	500 mg/L	FB
ABA + Vegetal Oil	500 mg/L+3%	FB
BA+GA_{4+7}	1 ml/L	FB
BA+GA_{4+7}	2 ml/L	FB
Calcium Chloride	2%	FB
Vegetal Oil	3 %	FB
ABA	250 mg/L	15 DAFB
ABA	500 mg/L	15 DAFB
ABA + Metamitron	150 mg/L+300 mg/L	15 DAFB
Benzyladenine	15 L/ha	15 DAFB
Ethephon	2 ml/L	15 DAFB
Metamitron	600 mg/L	15 DAFB
Metamitron	500 mg/L	15 DAFB

Note: FB = Full Bloom; DAFB = Days After Full Bloom.

RESULTS AND DISCUSSION

There was significant effect of the treatments on the thinning response of 'Leticia' plums (Table 2). Except abscisic acid (ABA) + metamitron and ethephon, both applied 15 days after full bloom (DAFB), all other treatments promoted flower/fruitlet abscission. The treatments calcium chloride at FB, benzyladenine at 15 DAFB, and vegetal oil at FB were the strongest thinners of this experiment, reducing 56, 54 and 49%, respectively, the numbers of fruits that set. The treatments ABA 500 mg/L at full bloom (FB), ABA 500 mg/L at 15 DAFB, metamitron 500 mg/L at 15 DAFB, and benzyladenine + gibberellic $acid_{4+7}$ at FB were less effective to reduce fruit set than the latter treatments, but they presented a satisfactory response, reducing fruit set at a level of 45, 39, 32 and 41%, respectively. The treatments ABA 250 mg/L at 15 DAFB, ABA 500 mg/L + vegetal oil at FB, metamitron at 600 mg/L at 15 DAFB, and benzyladenine + gibberellic $acid_{4+7}$ 2 ml/L at FB had a milder response, reducing 22, 25, and 24%, respectively the amount of fruits that set.

As the objective of chemical thinning is to reduce fruit set the most as possible to facilitate and reduce the costs of manual fruitlet thinning, the treatments that achieved this aim were the treatments calcium chloride and vegetal oil at FB, which have direct effect on preventing pollination, and the growth regulator benzyladenine sprayed at 15 DAFB. In addition, the treatments ABA 500 mg/L at FB, ABA 500 mg/L at 15 DAFB, metamitron 500 mg/L at 15 DAFB, and benzyladenine + gibberellic $acid_{4+7}$ 1ml/L at FB can be considered as effective, based on the results they presented.

TABLE 2. Effect of different treatments of the fruit set of 'Leticia' plums.

Treatments	Dose of commercial product	Moment of application	Fruit set (%)
Untreated Control	-	-	5.9 a
ABA	500 mg/L	FB	3.3 c
ABA + Vegetal Oil	500 mg/L+3%	FB	4.4 b
Benzyladenine + gibberellic $acid_{4+7}$	1 ml/L	FB	3.5 c
Benzyladenine + gibberellic $acid_{4+7}$	2 ml/L	FB	4.5 b
Calcium Chloride	2%	FB	2.6 d
Vegetal Oil	3 %	FB	3.0 d
ABA	250 mg/L	15 DAFB	4.6 b
ABA	500 mg/L	15 DAFB	3.6 c
ABA + Metamitron	150 + 300 mg/L	15 DAFB	5.8 a
Benzyladenine	15 L/ha	15 DAFB	2.7 d
Ethephon	2 ml/L	15 DAFB	5.3 a
Metamitron	600 mg/L	15 DAFB	4.4 b
Metamitron	500 mg/L	15 DAFB	4.0 c
C.V. (%)	-	-	15.81

Note: Means followed by the same letters in a column are not significantly different according to the Scott-Knott test ($p<0.05$). FB: Full Bloom; DAFB: Days After Full Bloom; ABA: Abscisic Acid.

Vegetal oil or any compound that once is in the stigmatic surface, and blocks the pollen tube development is classified as a "coating" (MYRA et al., 2007; MARCHIORETTO et al., 2019). In addition, these compounds have no effect on the pollen grain germination. For stone and pome fruits, vegetal oil at rates from 3 to 5% v/v are effective in preventing pollination, and promote flower thinning, although when

applied at the proper moment, with the best results obtained when sprayed at 50% FB (JU et al., 2001). On the other hand, caustic compounds act on burning the stigmas and/or halting pollen grain germination, thus, avoiding fecundation (MYRA et al., 2007; MARCHIORETTO et al., 2018; MARCHIORETTO et al., 2019).

In this experiment, calcium chloride showed promising results for this purpose, even though no other literature is available to corroborate with our results. Similarly, for 'Golden Delicious' apples, Myra et al. (2007) found that sodium chloride indeed reduced pollen grain germination on an *in vitro* experiment, but in field conditions it had a mild performance in reducing fruit set, although the caustic compounds lime sulphur and ammonium thiosulfate were effective in reducing pollen grain germination, pollen tube development and on reducing fruit set. In contrast, for European plums, Pavanello et al. (2018) found no effect of ammonium thiosulfate on reducing fruit set. Although, for peaches, El-Boray et al. (2013) reported that ammonium thiosulfate at 3% v/v and soybean oil at 9% v/v reduced fruit set, and increased leaf area, indicating that somehow these treatments also stimulate vegetative growth, and maybe it causes restriction of assimilates for the flowers.

Plant growth regulators are widely used for apple fruitlet thinning, and the mechanism of action of these compounds are related in promoting fruitlet abscission (WEBSTER; SPPENCER, 2000). In general, for stone fruits, growth regulators have unreliable response when used for chemical fruitlet thinning, as they are affected by environmental factors, as well as the phenology of the tree. The stone fruits have a double-sigmoid fruitlet growth pattern, with the second peak occurring when the fruits have around 10 mm until the harvest. At the beginning of this phase the fruitlets are more susceptible to be abscised by the growth regulators (WEBSTER; SPENCER, 2000; GREENE, COSTA, 2013). Although, Giovanaz et al. (2015) reported that ABA was effective in promoting fruitlet thinning of 'Chirripá' peaches when sprayed at 40 DAFB in similar rates of this experiment, although, not satisfactory results were found when applied at 24 or 52 DAFB. The authors attributed the effectiveness in promoting fruitlet abscission to the ethylene buildup in the floral tissues. In this experiment, both doses of ABA were effective at FB and 15 DAFB.

The growth regulator benzyladenine and in the commercial available product, Promalin, which is associated with gibberellic acid, acts on stimulating whole tree growth at the apical meristems, creating a temporary shortage of assimilates to the fruitlets, and then inducing the abscission of part of them (YUAN; GREENE, 2000). Theron et al. (2016) found no response of benzyladenine at 100 and 300 ml/L to reduce fruit set of peaches, when the chemical was sprayed in fruitlets with 10 mm of diameter. In addition, Bhatt et al. (2017) found that benzyladenine at 250 or 500 ml/L had no results in decreasing blossom density in 'Kala Amritsari' Japanese plums, contrasting this experiment.

The herbicide metamitron acts inhibiting the photosynthetic rate of the plants, and ultimately it has been used in apple orchards, when the fruitlets are with 8 to 15 mm (GREENE; COSTA, 2013). In Israel, metamitron effectively promoted thinning of 'Gala' apples when sprayed at 6 or 10 mm fruitlet diameter (STERN, 2016). On the other hand, in Brazil, metamitron at 350 mg/L was effective to reduce 'Fuji' apple fruit set only when associated with benzyladenine (GABARDO et al., 2017). Although, in 'Redhaven' peaches, Turk et al. (2014) found no response of metamitron at 500mg/L sprayed when the fruitlets had 8 mm of diameter. In this study, metamitron seemed to be a potential fruitlet thinner for 'Leticia' plums. Ethephon had no effect on fruit set in this experiment. This result is corroborated by Pavanello et al. (2018) where

ethephon did not promote flower thinning and had little effect on fruit set. This growth regulator has variable results and the weather conditions have a huge influence on the performance, as when sprayed later in the season, it tends to be more effective than when used at early spring, due to the colder temperatures in the beginning of the season (WEBSTER; SPENSER, 2000).

CONCLUSION

'Leticia' Japanese plums are thinned by calcium chloride, vegetal oil, ABA, and benzyladenine + gibberellic acid $_{4+7}$ when sprayed at full bloom.

Benzyladenine, ABA, and metamitron promote fruitlet thinning of 'Leticia' plums when sprayed at 15 days after full bloom.

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