

Ammonia thiosulfate in Japanese plum tree thinning

Ricardo Antonio Ayub¹, Iohann Metzger Bauchrowitz², Clandio Medeiros da Silva³
Isabela Leticia Pessenti⁴, Fernanda Grimaldi⁵, André Belmont Pereira⁶

Abstract- In order to test the use of ammonia thiosulfate (ATS) in the chemical thinning of the Japanese plum tree, a field experiment was conducted throughout the 2015/2016 and 2016/2017 crop growing seasons at Ponta Grossa, PR, Brazil. The experimental design adopted herein was a randomized block design (RBD). During the 2015/2016 season, the trial was comprised of two accesses and six treatments, such as T1 (control); T2 (ATS 4%); T3 (ATS 5%); T4 (ATS 6%); T5 (ATS 7%) and T6 (manual thinning) with four replications. During the 2016/2017 season, solely one plum tree access was taken into account along with six treatments, such as T1 (control); T2 (ATS 6%); T3 (ATS 7%); T4 (ATS 8%); T5 (ATS 9%) and T6 (manual thinning) and four replications. The evaluations were performed seven days before the application of ATS and 30 days before harvest to establish the percentage of fruit drop. The following response variables were assessed: diameter (D), fresh mass (MF), firmness (N), soluble solids (SS), titratable acidity (AT), ratio, pH and plant production (PP). Experimental data were compared by means of the Tukey test at 5% probability. The concentration of 8 % ATS was efficient in the chemical thinning of the Japanese plum fruits, having a diameter and productivity similar to the manual thinning, evidencing that such a product was amenable to enhance commercial fruit quality.

Index terms: *Prunus salicina*, flowering, chemical.

Tiossulfato de amônia no raleio de ameixa japonesa

Resumo- O manejo da cultura da ameixeira apresenta grandes problemas no Brasil devido à falta de produtos químicos registrados para o uso na cultura. Com o objetivo de testar o emprego do Tiossulfato de amônio (ATS) no raleio químico da ameixa japonesa implantou-se e conduziu-se um experimento durante as safras de 2015/2016 e 2016/2017 em Ponta-Grossa, PR, Brasil. O delineamento experimental utilizado foi em DBC (delineamento em blocos casualizados). Na safra 2015/2016 o experimento foi composto por dois acessos e seis tratamentos, T1 (controle), T2 (ATS 4%), T3 (ATS 5%), T4 (ATS 6%), T5 (ATS 7%), T6 (raleio manual) com quatro repetições. Durante a safra de 2016/2017, o estudo foi composto por um acesso de ameixeira com seis tratamento, T1 (controle), T2 (ATS 6%), T3 (ATS 7%), T4 (ATS 8%), T5 (ATS 9%), T6 (raleio manual) e quatro repetições. As avaliações foram realizadas sete dias antes da aplicação do ATS e 30 dias antes da colheita para estabelecer a porcentagem de queda de frutos da planta. Foram analisados o diâmetro, massa fresca (MF), firmeza (N), sólidos solúveis (SS), acidez titulável (AT), ratio, pH dos frutos e produção por planta (PP). Os dados foram analisados através do teste de Tukey a 5% de probabilidade. A concentração de 8% de ATS foi eficiente no raleio químico para a ameixa japonesa, tendo diâmetro e produtividade similar ao raleio manual, sendo um bom produto para melhorar a qualidade comercial da fruta.

Termos para indexação: *Prunus salicina*, floração, químico.

Corresponding author:
rayub@uepg.br

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¹PhD Professor in Crop Science Department, State University of Ponta Grossa (UEPG), Ponta Grossa-PR, Brazil. E-mail: rayub@uepg.br (ORCID 0000-0003-3240-8417)

²Master in Agronomy, State University of Ponta Grossa (UEPG), Ponta Grossa-PR, Brazil. E-mail: iohannbauchrowitz@gmail.com (ORCID 0000-0002-7582-0594)

³PhD in Agronomy. Paraná Agronomic Institute, Londrina-PR, Brazil. E-mail: claudio@iapar.br (ORCID 000-0002-0569-4836)

⁴PhD Student in Agronomy, State University of Ponta Grossa (UEPG), Ponta Grossa-PR, Brazil. E-mail: isabelaleticiapessenti@gmail.com (ORCID 0000-0002-5176-3134)

⁵PhD in Vegetal Production, State University of Santa Catarina (UDESC), Lages-SC, Brazil. E-mail: fernandagrimaldi@outlook.com (ORCID 0000-0002-2632-9328)

⁶PhD Professor in Soil Department, State University of Ponta Grossa (UEPG), Ponta Grossa-PR, Brazil. E-mail: abelmont@uepg.br (ORCID 0000-0002-1673-9841)

Introduction

The plum is a temperate fruit tree that has a great potential for growth in Brazil (FACHINELLO et al., 2011). However, the producers have been facing problems, such as high cost of labor, shortages for handling and harvest (PAVANELLO; AYUB, 2014). Manual thinning is a very costly practice and hard to execute in large fields, making it a non-viable option for producers (SCHRÖDER, 2013), increasing the production cost (AHRENS et al., 2014). Due to lack of skilled labor, thinning has been replaced by chemicals (MCARTNEY; OBERMILLER, 2012).

Nowadays, products such as Ethephon (PAVANELLO, AYUB, 2012), ATS and hydrogen cyanamide (ANZANELLO; TEDESCO, 2017; PAVANELLO; ZOTH; AYUB, 2018) are used for crops such as the European plum (WEBSTER; SPENCER, 2000; PAVANELLO; AYUB, 2014) and apple trees (HAMPSON; BEDFORD, 2011; BOUND; WILSON, 2007). These products are employed mainly in the European continent, where the need for manual thinning is minimal owing to chemicals usage (SEEHUBER; DAMEROW; BLANKE, 2011).

ATS decreased the rate of pollen germination, pollen tube length, due to its high sulfur concentration (BOUND; WILSON, 2007), which struggles the ovule fertilization (MARCHIORETTO et al., 2018), the desiccation of flowers and damage to the base of the flower peduncle (MELAND; MAAS, 2017). Since it is a leaf fertilizer, it does not present risk to the environment (BALKHOVEN-BAART; WERTHEIM, 1998). In the United States and Europe, ATS use is consolidated and there are plenty of research on this theme. In Brazil, however, little is known about the thinning properties and its effects on fruit quality parameters and chemical blossom thinner (MARCHIORETTO et al., 2018). Thus, the aim of the current research was to assess the effect of ATS different concentrations as a chemical thinning process throughout two crop growing seasons in distinct accesses of Japanese plum.

Material and methods

The experiment was carried out in Ponta Grossa, Paraná, 25° 9'47" S and 50°9'47" W, with an altitude of approximately 838m. The climate of the region according to the Köppen classification is of type Cfb, subtropical humid, with an annual mean temperature of 18 °C plus an overall annual precipitation of roughly 1.550 mm (CAVIGLIONE et al., 2000).

During the 2015/2016 season, the experiment was conducted in RBD, comprised by G52 precocious and G7 later-on plum selections and six treatments with four replications, with five plants each. The treatments were T1

(control), T2 (ATS 4%), T3 (ATS 5%), T4 (ATS 6%), T5 (ATS 7%), T6 (manual thinning). ATS (25% S and 11% N, 1040 L ha⁻¹) was applied with 50% open flowers in the morning in mid-July, at 15 °C by means of a manual costal spray. During the 2016/2017 season, G53 one later-on access was taken into account and the experiment was conducted in RBD in light of six treatments T1 (control), T2 (ATS 6%), T3 (ATS 7%), T4 (ATS 8%), T5 (ATS 9%), T6 (manual thinning), with four replications, composed by five plants.

In each cycle, 200 flowers/plant were marked seven days before the ATS application, and were counted 30 days before fruit harvest to define the percentage of flower drop. After harvest, 120 fruits were taken to the laboratory where the physical chemical analyses were performed. The fruit harvesting point was between 25 and 50% of red color.

The physical analysis of diameter (mm), fruit fresh mass (FM) (g), firmness (N), soluble solids (SS) (°Brix), titratable acidity (AT) (% malic acid), ratio (SS/AT), pH and plant production (PP) were based upon the methodology proposed by Pavanello and Ayub (2012). The experimental data were submitted to a polynomial regression analysis (data not shown herein) and the treatment means were compared by the Tukey test at 5% reliability by means of SISVAR 5.6 program (FERREIRA, 2014).

Results and discussion

Manual thinning was equivalent to 7% ATS with 60% flower drop, 50% more than control (Fig. 1a) during 2015/16 season. This allowed to reach 48 mm of fruit diameter for the concentrations 6 and 7% in the accesses G52 and G7 (Fig. 1b) throughout this season. Thus, it resulted in fruits with a mean of fruit fresh mass of 60g for G7 access, which led to values of 10g up above those related to control treatment, although not revealing statistical differences (Fig. 1c). For G52 access, fresh mass was lower when compared to G7 among ATS concentrations (Fig. 1c).

It was observed that PP decreased 10 to 7.5 kg in comparison to manual thinning, but not bringing about significant discrepancies among ATS concentrations (Fig. 1d) during 2015/16 season. However, the commercial yield improved by increasing the caliber of the fruit. Throughout 2016/2017 season, G53 access flower drop reached approximately 60% in manual thinning with 9% ATS concentration, despite of not being statistically different from 8% concentration (Fig. 2a) during 2016/17 season and statistically superior than natural drop, which resulted in 15% flower drop under control treatment conditions.

Nevertheless, there was an increase in diameter, achieving 46 and 47 mm for both manual and 8 - 9% ATS concentrations (Fig. 2b) during 2016/17, not differing from ATS concentrations of 6 and 7% with a diameter of 44 mm (Fig. 2b). The fruit FM increased with manual thinning, but with effects not statistically different from the higher concentrations of ATS, leading to weight of fruits above 50 g (Fig. 2c) during such a crop growing season, that was superior to the control and 6% ATS treatment. This is due to the fact that ATS is a foliar fertilizer, which helps fruit development within an optimum of physiological efficiency. The yield per plant is lower in manual thinning, even though there are no significant differences among the highest doses of ATS, with production ranging between 20 and 26 kg / plant (Fig. 2d) during the 2016/17 season.

Sulfur-based products may influence flowers drop and fruits on different fruit plants (BANGERTH, 2004). Owing to ATS composition possessing great amount of sulfur when applied to blossoming, such a product causes flower burning and consequently the abscission of the flowers. This reduces the plum number (PAVANELLO; ZOTH; AYUB, 2018) and increases apple diameter (ROBINSON; LAKSO, 2008). In apple cv. Fuji, which received three applications of ATS with 12 kg i.a./ha during flowering, there was a flower reduction corresponding to 82% (MAAS, 2007). According to Petri et al. (2016), the concentration of 1.5 to 2% of ATS is sufficient to thin apple trees, which is a very low concentration for the Europe plum tree (PAVANELLO; ZOTH; AYUB, 2018), corroborating the outcomes obtained in our current study on Japanese plum.

For the variables SS, AT, ratio, pH and firmness for G52 and G3 accesses there were not significant differences among treatments (data not shown). However, for the G7 access there were chemical and physical discrepancies among treatments not solely attributed to the influence of ATS application, but rather to a likely sample variation inherent to the trial (Table 1).

The G52 and G7 approaches treated with concentrations of 6 and 7% of ATS and with manual thinning resulted in a fruit diameter greater than 46 mm. Such a fruit diameter is considered to be higher than the 40-mm obtained for cultivar Irati, which was treated with ethephon (PAVANELLO, AYUB, 2012), as well as thresholds of 45.80 and 45.90 mm for cultivar Polirosa subjected to green pruning (CARVALHO et al., 2015). Fruits of the G53 access thinned under concentrations of 8 - 9% of ATS presented fruits with a diameter of 46.95 mm, being superior to the manual thinning of this access (Fig. 2b). Fruits with a diameter greater than 44 mm are accepted for commercialization (PAVANELLO; AYUB, 2012; AHRENS et al., 2014). The increase in the plum diameter was proportional to the increase of ATS concentrations, due to the reduction of the excess fruit produced in the accesses, as observed under the

mechanical (HEHNEN et al., 2012) and chemical thinning (PAVANELLO, AYUB, 2012, PAVANELLO; ZOTH; AYUB, 2018). The composition of the ATS has a fertilizing effect, mainly having nutrients such as sulfur and nitrogen (FERNANDES, 2010), which when applied to flowering causes an increase in apple diameter of 10 to 12 mm (MAAS, 2007).

The FM increased with raises in ATS concentration, reaching 52.25 and 58.79 g at G52 and G7 accesses respectively, whereas at G53 access the best fresh mass results were obtained under a concentration of 8% leading to a weight of fruits equivalent to 64.67 g. Fruits of cultivars Reubennel and Irati have shown a fresh mass of 64 and 40g per fruit (PAVANELLO; AYUB 2014).

This is the first report dealing with ATS use on Japanese plum in Brazil. Previous studies carried out with European plums under the influence of 3% ATS concentrations during full blooming did not culminate to thinning satisfactory results (Pavanello et al., 2018). Recent research taking into consideration ethephon on physiological responsiveness of fruit plants have had a consistent impact on thinning (PAVANELLO & AYUB, 2012, 2014), however such a product did not evidence permission of application in plum orchards at commercial scales. For Maxi Gala apple Marchioretto et al. (2018) observed that ATS at 2.5% is effective to reduce crop load and improve fruit quality. The aforementioned authors reported that ATS thinning effect is not dependent on weather conditions throughout the crop growing season, an assumption that opposes the findings of Fallahi & Greene (2010) in conjunction with our personal information.

In stone fruits blossoms thinners should be sprayed whenever some, but not all blossoms are fertilized (FALLAHI and WILLEMSSEN, 2002). In peaches ATS concentration at 5% caused excessive thinning and reduced crop value whereas 3.5% ATS provided less thinning and resulted in the highest crop value (OSBORNE; ROBINSON; PARRA-QUEZADA; 2006). Trials conducted in Britain on the plum cultivar Victoria demonstrated that ATS applied at 1.5% active ingredient at high volume sprays (1000 l ha⁻¹) was very effective for flower thinning. At such a concentration little or no damage at all was noticed on the leaves and/or wood of the cultivar under scrutiny (WEBSTER e SPENCER, 2000). However, the flowers of Victoria develop quite well in advance of the spur leaves and whenever sprays to those cultivars whose spur leaves happen to develop at the same time of flower opening damage is more conspicuous leading to financial losses. In this way, the current work shows labor and production cost reductions in plum cultivation, as described by AHRENS, ET AL. (2014).

Table 1 - Soluble solids, titratable acidity, ratio, pH and firmness in the G7 access of Japanese plum trees treated with ammonium thiosulfate at full blooming during the 2015/2016 season. (Ponta Grossa, 2018).

	SS (°brix)	AT (% malic acid)	Ratio (SS/AT)	pH	Firmness (N)
Control	11,18 ab	0,81 ab	13,81 bc	3,42 ab	8,78 b
4%	12,13 ab	0,83 ab	14,57 bc	3,11 ab	14,20 a
5%	8,53 b	1,31 a	12,31 c	2,65 b	14,92 a
6%	11,66 ab	0,68 ab	17,20 bc	3,14 ab	9,34 b
7%	12,75 a	0,67 ab	19,14 b	3,47 ab	8,47 b
Hand Thinning	12,36 a	0,48 b	25,91 a	4,00 a	8,41 b
CV (%)	14,79	45,58	16,84	13,59	16,31

* Means followed by the same letters in the column do not differ from one another by Tukey test ($p \leq 0.05$).

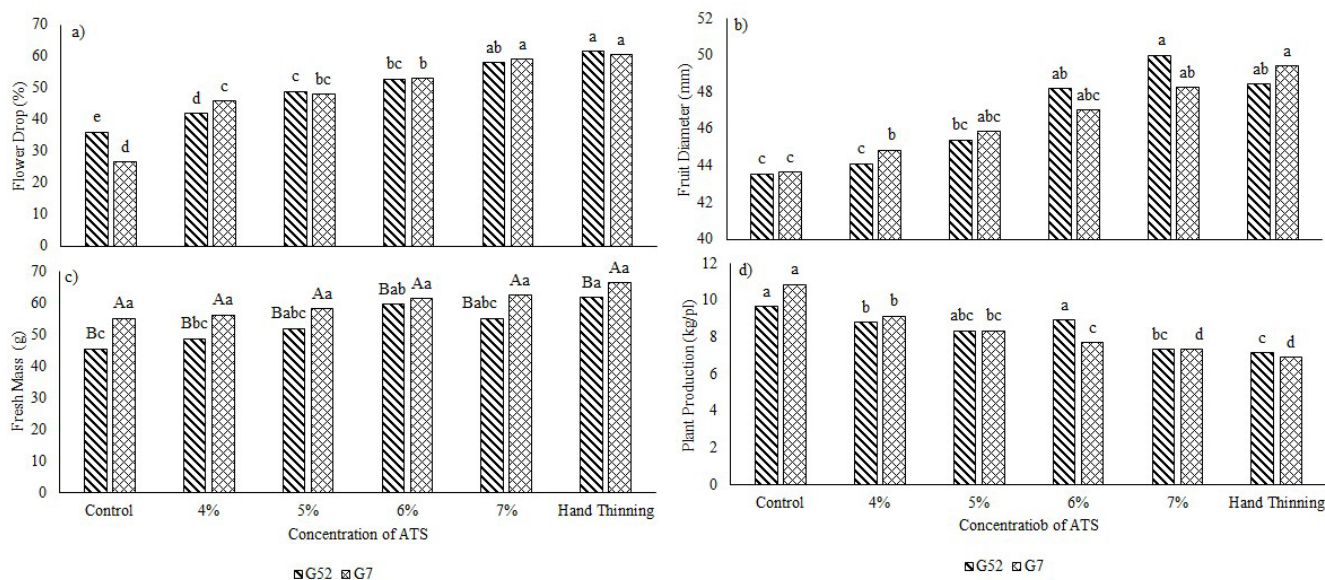


Figure 1 - Flower drop (%) (a), fruit diameter (mm) (b), fresh mass (g) (c) and plant production (kg / pl) of Japanese plum accesses G52 and G7 submitted to different concentrations of ATS during the 2015/2016 season. Means followed by the same letters do not differ statistically from one another; capital letters between accessions and small letters between concentrations by the Tukey test ($p \leq 0.05$). Figures 1a, b and c do not differ statically between treatments of access. Ponta Grossa (2018).

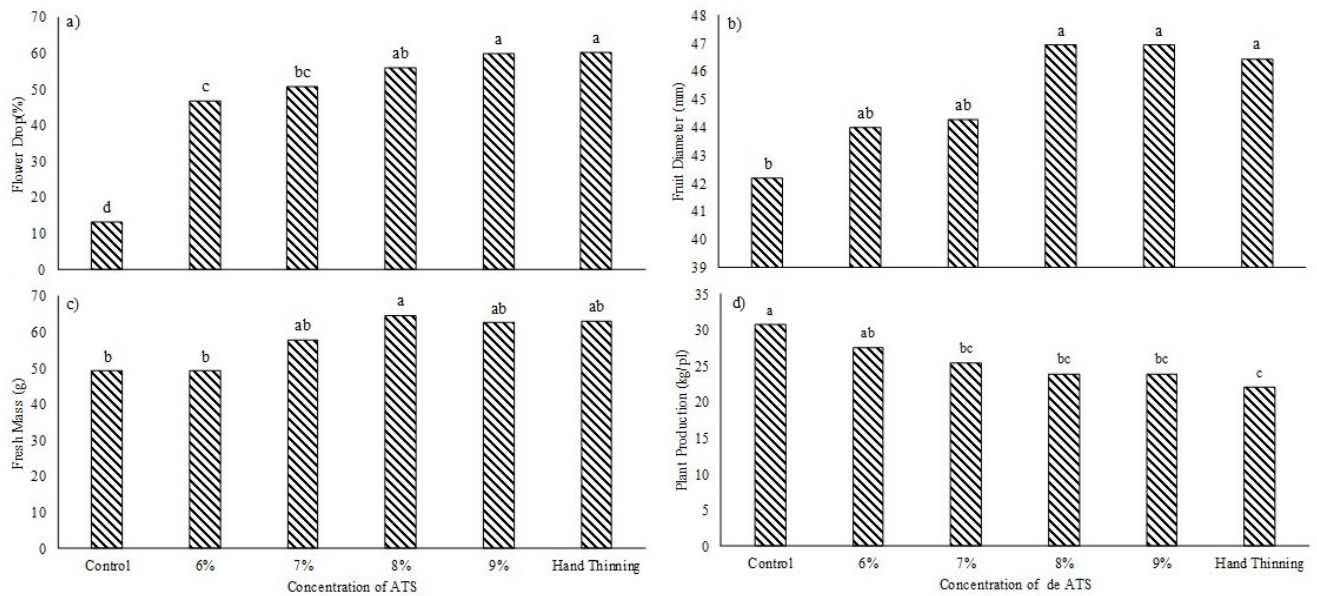


Figure 2 - Flower drop (%) (a), fruit diameter (mm) (b), fresh mass (g) (c) and plant production (kg / pl) of Japanese plum access G53 submitted to different concentrations of ATS during the 2016/2017 season. Means followed by the same letter do not differ statistically by the Tukey test ($p \leq 0.05$). Ponta Grossa (2018).

Conclusions

The accesses under scrutiny have a large potential to meet expectations of the market because by the adoption of a good management of the orchards they reach both fresh weight and caliber at a commercial scale.

It is pivotal to consider that the concentration of 7% ATS during the first season did not reach the maximum point of thinning. However, throughout the second season the concentration of 8% ATS was proved to be efficient to trigger chemical thinning on Japanese plums, causing the fruit to enhance diameter and fresh mass, as well as to achieve potential yield equivalent to that one obtained by means of manual thinning procedure. ATS was found to be a good product amenable to assure economical returns, improve commercial fruit quality and reduce labor costs in the field.

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André Belmont Perira

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André Belmont Pereira