EFFECT OF FLOWER THINNING ON YIELD AND QUALITY OF '`STANLEY`' PLUM (*PRUNUS DOMESTICA* L.)

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Abstract

Plum is the most important fruit crop for cultivation in Serbia. However, a small amount of plum fruit is sold as fresh fruit due to its poor quality. In order to improve fruit quality and obtain regular and high yield chemical blossom thinning agents were applied. The experiment was conducted on seven-year-old plum trees of cultivar `Stanley` which were planted on distance 5x5 m. Ammonium thiosulphate and ethephon were applied in the next treatments: 1) ammonium thiosulphate 1.5% (ATS); 2) ethephon 0.015% (E); 3) ammonium thiosulphate 1.5% + ethephon 0.015% (ATS + E); 4) hand thinning (HT); 5) untreated control treatment (UTC). Chemical thinning treatments were performed once during the phase of full bloom, while hand thinning treatment was performed after the fall of unfertilized fruitlets at the end of May. Parameters analyzed were yield, fruit size, fruit weight, pit weight, fruit firmness, fruit shape index, soluble solids content, total acid content and the amount of harvested fruits per time unit. The obtained results have shown that ATS + E, ATS and HT treatments significantly reduced the number of fruits on the trees compared to the control treatment. However, yield per tree was reduced significantly only in the ATS + E treatment. Other treatments compensated for the smaller number of fruits per tree with a significantly larger fruit size. Since the fruit size was larger on treated trees, the amount of harvested fruits per time unit was significant compared to control treatment. There were no significant differences among the applied treatments in terms of fruit firmness, soluble solids and total acid content.

***Key words**: ammonium thiosulphate, ethephon, fruit quality, plum, yield*

INTRODUCTION

The European plum (*Prunus domestica* L.) is very important fruit species in Serbia. It has been traditionally cultivated for a very long time. Even today, the extensive way of growing plums, with low annual yields, is quite widespread. According to FAOSTAT, the average annual production of plums in Serbia from 2016 to 2020 was 474,740 tons. `Stanley` cultivar is a variety that is quite widespread today and represents one of the most grown cultivar. This variety tends to produce many fruits that are small and do not meet market requirements and cannot be sold as stone fruit. The fruit size is a good parameter for fruit quality: when a given size is not achieved no balanced sugar-acid relationship and taste are achieved. In addition it must be taken into account that fruits under 34 mm size are unmarketable (Weber, 2013). Also, scaffolds may be break due to an excessive amount of fruit. In addition, excessive fruit numbers often reduce the numbers and quality of flower buds for the subsequent season and may lead to the establishment of biennial pattern of cropping (Webster & Spencer, 2000). In order to reduce excessive fruit set, and thereby alleviate these effects, some chemical agents could be used for flower of fruitlets thinning. Blossom thinning in stone fruits, particularly peaches [*Prunus persica* (L.) Batsch] and plums [*Prunus domestica* (L.)] and [*Prunus salicina* (Lindl.)] is more important because of the high cost of hand thinning and lack of appropriate post bloom thinning agents. Since stages of blossom development are not as distinct as in pome fruit, it is difficult to chemically thin stone fruit blossoms (Fallahi & Willemsen, 2002). Thinning can often be less rigorous where fruits are grown for one of the many processing markets (e.g. for jams, canning, and alcoholic beverages) (Webster & Spencer, 2000).

Today, products such as ammonium thiosulphate and ethephon are used for crops such as European and Japanese plum (Meland, 2007; Seehuber et al., 2011; Pavanello et al., 2018) peaches and nectarines (Rasouli et. al., 2010), sweet cherries (Schoedl et al., 2007; Milić et al., 2015) and apples (Fallahi et al., 2004; Basak, 2006; Stopar, 2007).

Chemical thinning response depends on many factors. Variables such as light interception, ambient temperatures, water availability and nutrition influence the optimal crop load, as may management factors such as the rootstock used, the tree spacing and the pruning/training system employed (Webster & Spencer, 2000; Meland, 2007). It is extremely difficult therefore, to propose meaningful general guidelines for optimal crop loads (Webster & Spencer, 2000). Thus, an experiment was conducted to examine the effect of two chemical thinning agents on yield and fruit quality of `Stanley` plum.

MATERIALS AND METHODS

The experiment was conducted during 2022 on seven-year-old plum trees of cultivar `Stanley` in orchard located in the municipality of Blace. The trees were planted at 5 x 5 m (400 trees ha^{-1}), grafted on *Prunus cerasifera* rootstock propagated from the seed and trained as a vase. Two chemical thinning agents were applied: 1) Ammonium thiosulphate (nitrogen 12% and sulfur 58%) and 2) Ethrel (ethephon 480 g l^{-1}). The experiment was carried out as a randomized design with three replications of one tree each. Pest control and other orchard management practices were the same for all the trees in the study. Chemical thinning treatments were performed once during the phase of full bloom, while hand thinning treatment was performed after the fall of unfertilized fruitlets at the end of May. The following treatments were applied:

1) Ammonium thiosulphate 1.5% (ATS);
2) Ethephon 0.015% (E);
3) Ammonium thiosulphate 1.5% + Ethephon 0.015% (ATS + E);
4) Hand thinning (HT);
5) Untreated control treatment (UTC).

Spraying was carried out with a hand sprayer. The amount of water used in the experiment was 1,000 L ha^{-1}. No surfactant was used.

The effect on the yield, fruit quality, quantity of fruit harvested per unit of time and participation of extra and the I fruit class were recorded and evaluated according to the following measurements: (1) yield per tree (kg); (2) number of fruit per tree; (3) fruit weight (g); (4) pit weight (g); (5) fruit size (height, diameter and thickness); (6) fruit shape index (7) fruit firmness (kg cm^{-2}); (8) soluble solids (%); (9) total acid content (%); (10) harvesting efficiency [amount of harvested fruit per time unit (kg h^{-1})]; (11) participation of extra and the I fruit class (%).

At harvest fruits were counted and samples of 30 fruits per repetition were taken for analysis in laboratory. Fruit weight was measured with table scale. Yield was calculated as the product of the number of fruits per tree and the average weight of the fruit. Fruit dimensions were measured with digital caliper. The fruit firmness of selected fruits was determined by a Digital pressure tester which recorded the pressure necessary for the plunger (diameter of the needle was 8 mm) to penetrate the flesh of fruits. Total soluble solids of fresh fruits were determined at room temperature using digital refractometer by putting a drop of juice on the screen and recording the readings. Every use of juice for readings was calibrated with distilled water. Data were analyzed using analysis of variance. The significance of the differences between the mean values was determined by the LSD test at the level of significance $p \leq 0.05$

RESULTS AND DISCUSSION

All thinning treatments reduced crop load. ATS + E, ATS and HT treatments significantly reduced the number of fruits on the trees compared to the control treatment, whereby ATS + E thinning treatment was the strongest, and it reduced number of fruit per tree 78% and yield 66% compared to control treatment (table 1).

Table 1. Effect of flower thinning on Number of fruit and yield per tree of `Stanley` plum

Treatment	Number of fruit per tree	Yield (kg $tree^{-1}$)
UTC	1637a	53.8a
ATS	883bc	38.6ab
Ethephon	1207ab	45.9ab
ATS + E	367c	18.2b
HT	996b	37.1ab
Significance	**	*

Means in a column followed by the same letter are not statistically different at $P \leq 0.05$*.*, ** significant at* $P \leq 0.05$ *or 0.01 respectively*

Maximum values of yield were noted in control trees (53.8 kg) where no thinning was performed. Webster & Holands (1993) reported that single spray of ammonium thiosulphate, irrespective of timing, had very little effect upon yields in plum cultivar `Victoria`. In the `Alberta` peaches, as well as `Sun King` nectarines, ATS (2 and 2.5%) treatment applied once at full bloom showed good results on fruit weight and fruit size, however, double treatment with ATS (2%) at 30% and 80% of full bloom showed even better results considering fruit weight and fruit size in the same cultivars (Rasouli et al., 2020). According to Yoon et al. (2011) double application of 1.5 %

ATS resulted in higher reduction in crop load in `Redhaven` peaches,

Table 2. Effect of flower thinning on fruit and pit weight, fruit shape index, harvesting efficiency and yield of extra and I class of fruit of `Stanley` plum

Treatment	Fruit weight (g)	Pit weight (g)	Fruit shape index	Harvesting efficiency (kg h^{-1})	Extra and I fruit class (%)
UTC	32,2d	1.89c	1.42a	39.6c	44.7b
ATS	44,2ab	2.19b	1.43a	80.9a	100.0a
Ethephon	38,9bc	2.04bc	1.41a	65.7b	85.3a
ATS + E	49,6a	2.50a	1.42a	92.9a	100.0a
HT	37,4cd	2.07b	1.37b	56.5b	76.7ab
Significance	***	***	*	***	*

Means in a column followed by the same letter are not statistically different at $P \leq 0.05$*.*, **, *** significant at* $P \leq 0.05$*, 0.01 or 0.001 respectively*

while 4.5% ATS over thinned the trees. On the other hand, `Babygold 5` showed less sensitivity to bloom thinners than `Redhaven` resulting in good results with 4.5% ATS applied once at full bloom or double application of 1.5% (50 and 80% of full bloom) considering both yield and fruit size. Milić et al. (2015) reported that application of ATS at lower rates (1 and 2%) did not consistently reduce fruit set, while at higher rates (3%) it produces visible phytotoxicity on the leaves of sweet cherry.

Ethephon was less aggressive, with a similar number of fruits per tree as in the hand thinned-treatment (1207 and 996, respectively). All treatments increased the percentage of marketable fruits (extra and I fruit class) compared to the control treatment. Ethephon application at a rate of 375 mg l^{-1} applied at full bloom thinned `Jubileum` plums successfully to a target of about 10-15% fruit set, which is required in order to fulfill the market requirements for fruit quality (Meland & Birken, 2010). Also, ethephon application at a rate of 200 mg l^{-1} applied at full bloom significantly increased fruit size in `Katinka` plum compared with the control (Pavanello et al., 2018).

Fruit shape index was slightly different with hand thinning treatment, presenting fruits that are more round than the other treatments.

The fresh fruit weight was positively influenced with the application of all chemical thinning agents (table 2). Significant increase in fruit weight was recorded in all treatments, with the highest value recorded with treatment ATS + E, and followed by ATS treatment. However, treatment ATS + E significantly reduced total yield under this treatment compared to control treatment.

Meland (2007) reported that fruit weight from the thinned trees was slightly increased in plum cultivar `Victoria`, but not significantly. Also, pit weight showed significant difference in all treatments compared with control treatment. The highest value of pit weight was in ATS + E treatment (2.5 g), due to a significant reduction in the number of fruits and increased fruit size.

There were no significant difference among the applied treatments in terms of fruit firmness, soluble solids and total acid content (table 3). However Meland (2007) noticed that fruit firmness was decreased when ATS was applied at full bloom.

Table 3. Effect of flower thinning on fruit firmness and chemical properties of `Stanley` plum

Treatments	Fruit firmness (kg cm^{-2})	Soluble solids (%)	Total acids (%)
UTC	3.79	19.5	0.56
ATS	4.34	19.9	0.57
Ethephon	4.14	19.8	0.58
ATS + E	4.68	19.8	0.55
HT	4.00	19.7	0.52
Significance	ns	ns	ns

Ns- nonsignificant *at P ≤ 0.05*

Meland & Birken (2010) found effective thinning of 'Victoria' plums after application of Ethephon at 250, 375 and 500 μl l^{-1}, with no clear response in acid content. Also, Rajput & Bhatia (2017) reported increased soluble solids in chemical thinning treatment in Japanise plum, but decreased total acid content. In `Redhaven` and `Babygold 5` application of ATS with different concentration did not show any significant difference considering soluble solids (Yoon et al., 2011).

Since the fruit size was larger on treated trees, the amount of harvested fruits per unit of time was significantly increased compared to control treatment.

CONCLUSION

Demand for large and high quality fruits will be maintained or will increase in the future. The requirements for reducing of crop load will be necessary in order to obtain good quality of stone fruits.

The obtained results have shown that ATS + E, ATS and HT treatments significantly reduced the number of fruits on the trees compared to the control treatment. However, yield per tree was reduced significantly only in the ATS + E treatment. Other treatments compensated for the smaller number of fruits per tree with a significantly larger fruit size. Since the fruit size was larger on treated trees, the amount of harvested fruits per unit of time was significantly higher compared to control treatment. There were no significant differences among the applied treatments in terms of fruit firmness, soluble solids and total acid content.

Hand thinning of plum fruit has proven to be a good and reliable method. However, since the labor cost of manual thinning continues to rise faster than the value of the crop, this method is unacceptable in a commercial plum orchard.

ACKNOWLEDGEMENTS

This work was carried out with the support between the Faculty of Agriculture in Belgrade and the Ministry of Education, Science and Technological Development of the Republic of Serbia, contract registration number: 451-03-68/2022-14/200116.

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