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Regulated effects of exogenous salicylic acid on flower dropping and fruit setting of *Citrus unshiu*

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ABSTRACT

The study was to research the effects of exogenous salicylic acid (SA; 10, 20, and 40 mg/L) on flower dropping and fruit setting of *Citrus unshiu* and NO₃-N, soluble sugar, soluble protein, soluble starch, and non-structural carbohydrate concentrations in leaves and ovary. The present results showed that all the SA applications significantly decreased the flower dropping percentage but significantly increased the fruit setting percentage, which were related to improvement of nutrition and carbohydrates in the ovary caused by exogenous SA. Meanwhile, 20 mg/L SA displayed the best regulated effects. © 2014 Trade Science Inc. - INDIA

KEYWORDS

Carbohydrate;
Citrus;
Flower dropping;
Fruit setting;
Salicylic acid

INTRODUCTION

Citrus is one of the important fruit trees all around the world, including in southern regions of China. In the field, the flower dropping of citrus is rather serious, and the fruit setting percentage often ranges from 1% to ~5%, which extremely restricts production of citrus fruits. The reasons are the two explains: (i) a great deal of semideveloped thin and misshapen flowers during florescence, and (ii) bad environments, such as lack illumination, high temperature, drought, waterlogging, serious diseases, insect pests, etc. As a result, increase of flowering is important and urgent in citrus trees.

Salicylic acid (SA) has been regarded as a plant hormone because of its role in regulating metabolized process, such as growth, development, ripeness, senescence, etc.^[1]. Many studies showed that SA can

induce flowering of plants^[2], affect sex differentiation^[3], and enhance fruit setting^[4]. Exogenous SA treatment with 100 mg/L concentration significantly increased fruit setting of almond varieties “Luotuhuang” and “Huaxiangjiexing” during primary flowering^[4]. Application of 2.5–10 mg/L SA significantly increased *in vitro* pollen vigor and fruit setting in field of apple variety “Dangxia”^[5]. These results suggest that SA represents regulated effects on almond and apple trees. However, we do not know whether the SA effects occurred in *Citrus unshiu*. In addition, screening an efficient SA concentration will be urgent to apply to regulate flower dropping and fruit setting of *C. unshiu*.

The aim of the present study was to research the effects of exogenous SA treatments on flower dropping and fruit setting during flower of citrus. The analysis of nutritional status of leaves and ovary was to clarify the physical mechanism.

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MATERIALS AND METHODS

Plant material

Plant materials selected the 22-year-old *Citrus unshiu* cv. Guoqing No. 1 grafted on *Poncirus trifoliata* L. Raf., which were planted in citrus orchard of Yangtze University (30°36' N, 112°14' E), Jingzhou, China. The area has the North subtropical humid monsoon climate, with four distinct seasons, plenty of rain, suitable light, and a long frost-free period. The annual total radiation is 4367–4576 MJ/m, the annual sunshine hour 1823–1987 h, the average annual temperature 16.2–16.6°C, and the annual precipitation 1100–1300 mm. The citrus orchard carried out the no-tillage soil management practice of natural grass cover. These trees are basically same growth.

Experimental design

The experiment designed as one factor, which included 10, 20, and 40 mg/L SA treatments. The control was 0 mg/L SA. There were four treatments in the study, each replicating four times, resulting in 16 trees. At April 8, 2010, these citrus trees were weekly applied with exogenous SA treatments, a total of three times.

Parameter determinations

At May 8, 2010, flower and basal leaves from the watters of each tree were selected. Meanwhile, the ovaries were separated from the flowers. The leaves and ovaries were stored at -70°C.

The flowers were mounted at April 29 and May 8, and flower dropping percentage was expressed as $1 - (\text{Flower number at May 8} / \text{Flower number at April 29})$. The fruit setting percentage was expressed as the ratio of fruit number at May 24 and fruit number at May 16.

Soluble sugar and soluble starch of leaves and ovaries were determined by the anthrone colorimetric^[6]. Non-structural carbohydrate concentration was the sum of soluble sugar and soluble starch concentrations. Soluble protein was measured using the method of Bradford^[7] using bovine serum albumin as the standard. NO₃-N concentration was evaluated by the method of Zou^[6].

Statistical analysis

The data were statistically analyzed by one-way

variance (ANOVA) with SAS software. The significant differences were compared with the Least Significant Differences (LSD) at the 5% level.

RESULTS AND DISCUSSION

Effects of exogenous SA on flower dropping percentage and fruit setting percentage

Figure 1 indicated that all the SA treatments significantly decreased the flower dropping percentage but significantly increased the fruit setting percentage. Meanwhile, the 20 mg/L SA treatment represented the highest effects. The result is in agreement with the reports of pawpaw^[8], cucumber^[9], tomato^[9], almond^[4], and apple^[5]. However, the highest effects on almond and apple trees were 100 and 10 mg/L SA treatments, respectively. The result implies that the effects of SA treatments on fruit setting percentage were strongly dependent on SA concentrations.

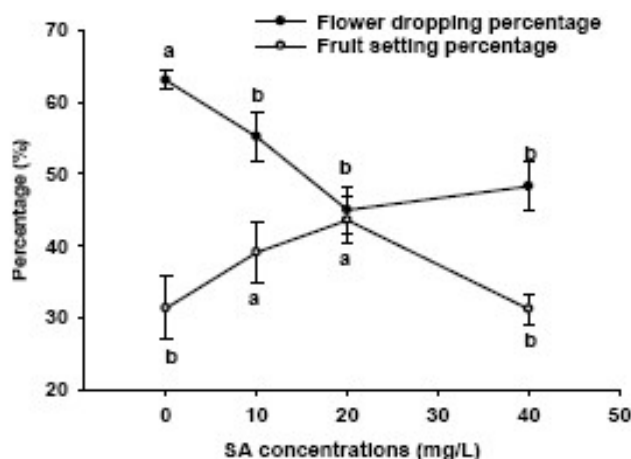


Figure 1: Effects of exogenous SA treatments on flower dropping percentage and fruit setting percentage of *Citrus unshiu*

Effects of exogenous SA on leaf NO₃-N concentration

Figure 2 showed that among the treatments, 10 mg/L SA treatment did not affect the NO₃-N concentration of ovary, 20 mg/L SA treatment significantly increased leaf NO₃-N concentration of ovary, and 40 mg/L SA treatment significantly decreased leaf NO₃-N concentration of the ovary. In leaf, all the SA treatments significantly increased the NO₃-N concentration. The result is in agreement with the findings of Cao et al.^[10], who reported the positive effect on nitrate accumulation in leaf of Chinese chive. Meanwhile, 20 mg/L SA

treatment showed the highest effect.

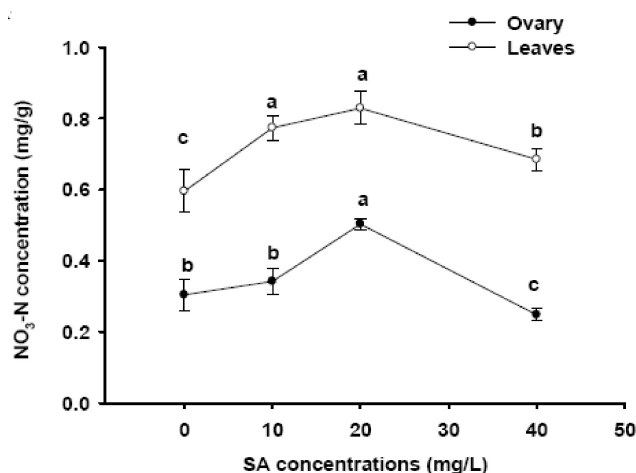


Figure 2 : Effect of exogenous SA treatments on leaf NO₃-N concentration in leaf and ovary of *Citrus unshiu*

Effect of exogenous SA on soluble protein concentration of leaf and ovary

Compared with the control, 10 and 20 mg/L SA treatments significantly increased soluble protein concentration of leaf (Figure 3). In ovary, 20 and 40 mg/L SA treatments significantly increased soluble protein concentration, but 10 mg/L SA application did not alter the effect on soluble protein concentration. Liu et al.^[11] also reported the increased effect of exogenous SA treatments especially 15 mg/L on peony at green bud. The role of SA in soluble protein of leek increased with the increased concentration from 0.5 to 3.0 mmol/L^[10]. In the present study, we found that the SA effect on soluble protein increased with the SA concentration at 10–20 mg/L, but the effect decreased over 20 mg/L.

Effects of exogenous SA on carbohydrate concentrations of leaf and ovary

Previous studies showed that when the cucumber

plants were treated by 1, 2, and 3 mmol/L SA, the soluble sugar was significantly increased^[12]. The soluble starch concentration of lily was accumulated by the 5 mmol/L SA treatment^[13]. Our study showed that all the SA treatments significantly increased soluble sugar and non-structural carbohydrate concentrations of ovary but did not affect soluble starch concentration of ovary (except a decrease by 40 mg/L SA treatment) (Figure 4). In leaves, 10 mg/L SA treatment significantly decreased soluble sugar concentration and 20 mg/L SA treatment significantly increased soluble sugar concentration (Fig. 4a), 10–40 mg/L SA treatments significantly increased soluble starch concentration of leaves (Figure 4b), and 20–40 mg/L SA treatments notably increased non-structural carbohydrate concentration of leaves (Figure 4c), as compared with the control. These results indicate that SA treatments could induce a positive effect on accumulation of carbohydrates in leaves and ovary of citrus. It is well known that during the period of physiological fruit drop, the fruitlets remaining must obtain

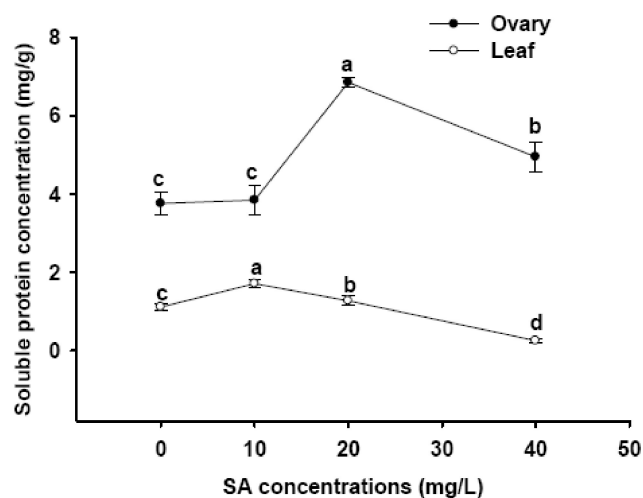


Figure 3 : Effect of exogenous SA treatments on soluble protein concentration in leaf and ovary of *Citrus unshiu*

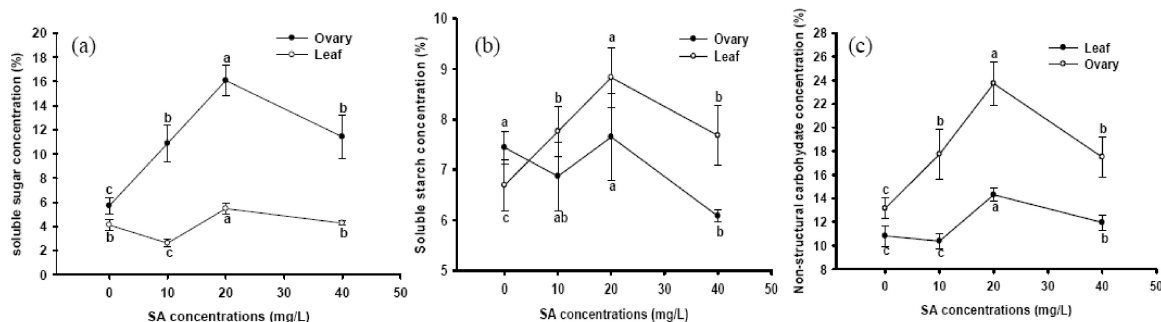


Figure 4 : Effect of exogenous SA treatments on soluble sugar (a), soluble starch (b), and non-structural carbohydrate (c) concentrations in leaf and ovary of *Citrus unshiu*

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more carbohydrates from the leaves for itself development, in order to complete with the other fruitlets dropping^[14]. Higher concentrations of soluble sugar, soluble starch, and non-structural carbohydrates in the citrus trees applied by exogenous SA would result in lower abscission level in leaf and ovary and be in the position of the leading during competition between growing fruitlets^[15]. Therefore, higher fruit-setting caused by exogenous SA might increase the demand for carbohydrates, thereby, inducing the carbohydrates more from leaf to ovary or fruitlet. A beneficial cycle in carbohydrates among fruit-setting, flower-dropping, and fruitlet development would be established with exogenous SA application.

CONCLUSIONS

Our study showed that applications of exogenous SA in a range of 10–40 mg/L obviously accelerated the accumulation of nutrition (such as N) and carbohydrates (soluble sugar and non-structural carbohydrate), thereby resulting in the increase of fruit setting and the decrease of fruit dropping. Meanwhile, 20 mg/L SA treatment displayed the best regulated effects and can be used to field.

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