ATLANTIS PRESS

Advances in Engineering Research, volume 170

7th International Conference on Energy and Environmental Protection (ICEEP 2018)

Study of GA_3 on Breaking Forced Dormancy of *Ziziphus jujuba* 'Zhanshanmizao' Bud and the Effect on Fruit Quality

Haiyan Wang[1,a] , Jie Zhou[1,b] , Yan Zhou[1,c] and Huifen Zhang[1,d]*

[1]College of Horticulture, Sichuan Agricultural University, Chengdu, Sichuan, China

[a]m13990140661@163.com, [b]493137598@qq.com, [c]zhouyan6213500@qq.com, [d]1042335395@qq.com

*Corresponding author.

Keywords: GA_3; *Ziziphus jujuba* 'Zhanshanmizao'; forced dormancy; organic nutrients; fruit quality

Abstract. The 7-year-old *Ziziphus jujuba* 'Zhanshanmizao' as experimental material was used to measure the water content and organic nutrients (starch, soluble sugar, soluble protein, and free amino acid) in jujube branches and analyze the fruit quality after spraying jujube trees with different concentrations of gibberellin (GA_3) on January 30th, 2017. The effects of different concentrations GA_3 on breaking forced dormancy of jujube trees were compared. The results showed that in the forced dormancy period 200 mg/L GA_3 can significantly increase the ratio of free water to bound water in jujube buds, rapidly affect the composition changes of organic nutrients and activate antioxidant system. This concentration of GA_3 breaking the forced dormancy of jujube buds is better than other concentration treatments. 50 mg/L GA_3 is basically ineffective and even inhibits the breaking of forced dormancy. Combined with the analysis of fruit quality at later stage, the experiment is found that 200 mg/L GA_3 is the most effective concentration to break forced dormancy of jujube.

Introduction

Ziziphus jujuba 'Zhanshanmizao' as deciduous fruit trees has a long history of cultivation and is rich in a variety of nutritious substances [1]. *Z. jujuba* 'Zhanshanmizao' is excellent fresh jujube with local characteristics that is quite popular in the market [2]. The dormancy of deciduous fruit trees is divided into correlative dormancy, endodormancy and forced dormancy [3]. Forced dormancy is the dormancy caused by external environment such as low temperature, drought and other stress factors. When plants break away from this adversity, the dormancy of buds will naturally be relieved. In recent years, the study of using chemicals instead of low-temperature chilling requirement to break the forced dormancy of deciduous fruit trees is relatively more [4]. However, study on the physiology of breaking the jujube's forced dormancy has rarely been reported so far. Gibberellin (GA_3) is currently used as dormancy-breaking chemicals in the dormancy study of deciduous fruit trees in China. Therefore, in this study, 7-year-old *Z. jujuba* 'Zhanshanmizao' trees were used as materials to study the changes of water content and organic nutrients in jujube branches treated by different concentrations of GA_3. And the fruit quality which was sprayed with the dormancy-breaking chemicals was analyzed. The aim of this study is to find the most effective concentration of GA_3 to break the forced dormancy of jujube, advance the maturity period of jujube, and increase the income of jujube farmers. It can provide some guidance for the regulation of the ripening period of the regulatory.

Materials and Methods

Materials and Treatments. The experimental base was located in Yongxin Zhen Yonglian Village, Santai County, Mianyang City. The tested materials were 7-year-old *Z. jujuba* 'Zhanshanmizao' trees (tiller propagation seedlings). Plants were treated by four concentrations (0, 50, 100 and 200 mg/L) of GA_3 on January 30th, 2017, taking 0 mg/L GA_3 as the control (CK). Each plot was repeated 3 times, with a total of 12 plants in random plot. First samples were collected on the second day after treatment,

and then sampled at intervals of 7 d. At each sampling, two or three representative secondary branches in the middle and upper part of the crown of jujube trees were removed. The samples were wrapped in plastic wrap and placed in ice box to the comprehensive laboratory of Horticulture Department, Sichuan Agricultural University. The buds of branches was taken by the knife, then placed in the refrigerator at -10 °C for determination. When the fruits were ripe, 30 fruits were harvested per treatment for fruit quality analysis.

Methods. The water content was determined by Li's method [5]. The content of starch and soluble sugar was determined by anthrone colorimetry [5]. The content of soluble protein was determined by Coomassie brilliant blue dye binding method [6]. The free amino acid content was determined by ninhydrin colorimetry [6].The titratable acid content was determined by acid-base neutralization titration, and the ascorbic acid was determined by 2,6-dichlorophenol phenol titration [7].

Statistical Analyses. The dates were processed using SPSS 20.0 and Excel 2010.

Results and Discussion

Changes of Water Content during Forced Dormancy of Jujube Buds. The total water content of jujube bud had been relatively stable since the beginning of experiment, and had a small upward trend (Fig. 1). The change range of total water content and free water content treated by dormancy-breaking chemicals was always higher than that of CK. The change trend of total water content and free water content at different concentrations of GA_3 was basically the same within 15 days after treatment. From 15 day to 29 day, the total water content treated by 200 mg/L GA_3 was significantly higher than that in CK and other treatments. However, the free water content treated by 200 mg/L GA_3 was significantly higher than that of CK and other treatments at all times. The difference between the 50 mg/L GA_3 and CK was not significant. During the period of forced dormancy, bound water content in the jujube bark was decreasing, which was just opposite to that of free water. Since 15 days after experiment, the variation trend of various water contents in the bark of all jujubes treated by GA_3 was significantly better than that of CK, which might be related to the enhancement of the metabolic activity of the trees. The decrease of bound water content and the ratio of bound water to free water indicated the end of the jujube tree's forced dormancy.

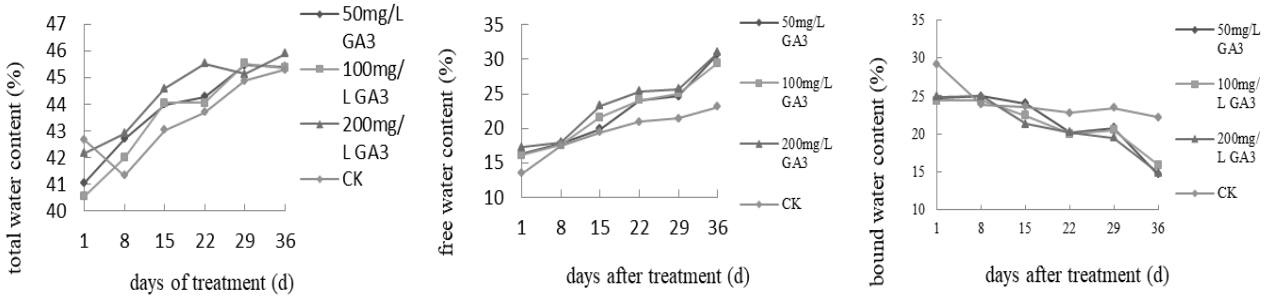

Fig. 1 Effects of GA_3 on water content of jujube in dormancy period

Changes of Organic Nutrients during Forced Dormancy of Jujube Buds. The soluble sugar content decreased first and then increased, and that in the experimental group was higher than that in CK (Fig.2). The soluble sugar content reached the lowest value on the 15 day after treatment, which meant that the forced dormancy was ended at that time. The soluble sugar content of the experimental group treated by 200 mg/L GA_3 was always at a high level, and was significantly higher than that of other treatments on the fifteenth day. The increasing of soluble sugar content may be related to the gradual enhancement of respiration. Soluble sugar acts as an energetic material.

The change trend of starch was opposite to that of soluble sugar. It reached the peak value on the 15 day after treatment. The starch content of each treatment was always lower than that of CK (Fig.2). Among them, starch content in branches treated by 200 mg/L GA_3 was always lower than that in other concentrations.

During the experiment, soluble protein content in branches increased first and then decreased. When the forced dormancy was breaking on the fifteenth day after treatment, the maximum was

reached. The soluble protein content of each experimental group was always lower than that of CK, which may have been caused by the treatment of dormancy-breaking chemicals which inhibited the synthesis of proteins or accelerated the hydrolysis of proteins.

The content of free amino acids decreased first and then increased. The minimum value was reached on the 15 day after treatment. The content of free amino acids in the experimental group was always higher than that in CK. The high free amino acid content showed that the metabolic activity of the cells was vigorous at this time, and the free amino acids could be used as the basis for the synthesis of macromolecular substances, which promoted the germination of jujube buds.

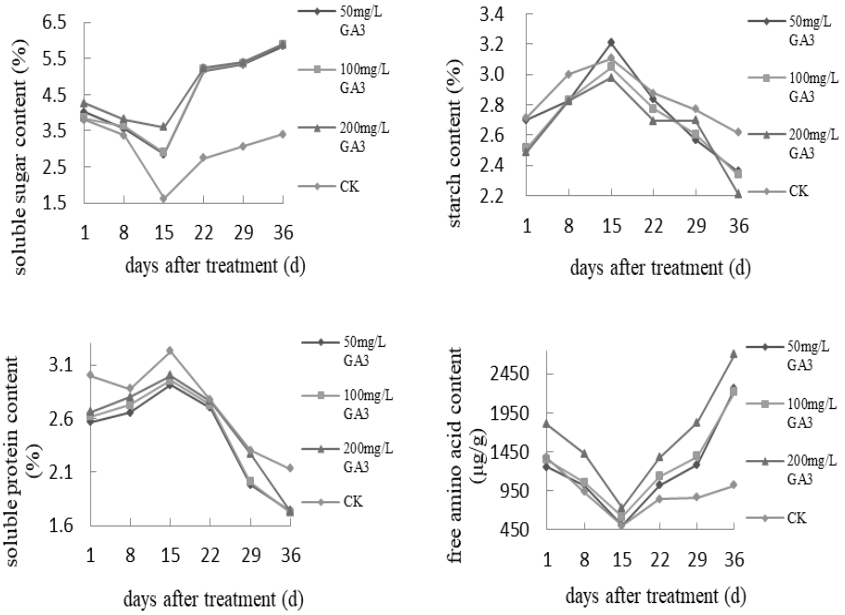

Fig. 2 Effects of GA_3 on organic nutrients content of jujube in dormancy period

Effect of Different Concentrations of GA_3 on Fruit Quality of Jujube. The Vc content of fruits treated by 100 mg/L and 200 mg/L GA_3 was 97.7% of CK, while that of other treatments had no significant effect on Vc content. The soluble solids (TSS) content of fruit treated by 200 mg/L GA_3 was slightly lower than that of CK. The soluble sugar content of all fruits treated by dormancy-breaking chemicals was slightly higher than that of CK. Among them, the soluble sugar content of fruit treated by 50 mg/L GA_3 was the highest, higher than that of CK 36.6%. Only one concentration had an increasing of the titratable acid content of the fruit. The single fruit weight of the branches treated by 100 mg/L GA_3 was slightly lower than that of CK, but the difference was not significant. In all treatments, the single fruit weight of the branches treated by 200 mg/L GA_3 was the largest. However, because the single fruit weight of fruit is greatly influenced by tree vigor and loading capacity, it is difficult to evaluate the effect of treatment.

Table 1 Effects of different concentrations of GA_3 on single fruit weight of jujube

Treatment	Vc (mg/100ml)	TSS (%)	Soluble sugar (%)	Single fruit wright(g)	titratable acid (g/100ml)
50 mg/L GA_3	459.94±0.08a	20.7±0.31a	26.91±0.06a	4.71±0.06b	0.66±0.02a
100mg/L GA_3	333.06±0.06c	19.9±0.09b	22.73±0.10b	4.55±0.03d	0.56±0.03a
200 mg/L GA_3	333.06±0.32c	18.5±0.10c	22.44±0.07c	4.87±0.03a	0.57±0.07a
CK	340.99±0.17b	19.7±0.13b	19.70±0.11d	4.63±0.03c	0.61±0.08a

Conclusions

In the process of forced dormancy of *Z. jujuba* 'Zhanshanizao' buds, the change trend of free water and bound water was opposite, and the change trend of soluble sugar and starch was opposite. The increase of free water content might be caused by the transformation of bound water. The hydrolysis of starch might lead to an increase of soluble sugar content. The ratio of free water to bound water increases and the hydrolysis of starch might be related to the release of forced dormancy. During the period of forced dormancy, the soluble protein synthesis ability of *Z. jujuba* 'Zhanshanmizao' buds increased and the content of free amino acids decreased. When forced dormancy was relieved, soluble protein content will be decreased, free amino acid content will be increased, and the metabolic activity of the bud will be enhanced. The research results are similar to those of Simões *et al.* [8]. It could be inferred that the forced dormancy of *Z. jujuba* 'Zhanshanmizao' buds in CK was relieved on the 15 day after the experiment, and the effect of different concentrations of GA_3 to break the dormancy of *Z. jujuba* 'Zhanshanmizao' was different.

During the period of forced dormancy, the application of dormancy-breaking chemicals had little effect on the quality of *Z. jujuba* 'Zhanshanmizao' fruits. The sugar-acid ratio of all the branches and fruits treated by dormancy-breaking chemicals increased to a certain extent, among which the sugar-acid ratio of the branches treated by 50 mg/L GA_3 was slightly higher than that of other concentrations. The single fruit weight and TSS content were not significantly different from those of CK. The Vc content of the branches treated by 100 mg/L and 200 mg/L GA_3 was slightly lower than that of CK, which was 97.7% of Vc content of CK.

In conclusion, 200 mg/L GA_3 could significantly increase the ratio of free water and bound water in the bud of *Z. jujuba* 'Zhanshanmizao', and rapidly influence the composition of organic nutrients and activate the antioxidant system. Therefore, 200 mg/L GA_3 is the most effective dormancy-breaking chemicals in the forced dormancy period of *Z. jujuba* 'Zhanshanmizao'.

Acknowledgements

This work was financially supported by the Double subject construction plan of Sichuan Agricultural University and Special action plan project of science and technology rich people and strong county of Sichuan Province "Integration and demonstration of key Technologies for industrialized Development of *Zizyphus jujuba* 'Zhanshangmizao' of Santai County".

References

[1] L. Wang, A.M. Min, Z.G. Qin, Y. Wang, C.G. Li, H.X. Li and Z. Xiong: Journal of West China Forestry Science Vol. 5(2014), p. 48.

[2] Z.Z. Wang: Modern Agricultural Research Vol. 4 (2008), p. 4.

[3] W.D. Zhao, H.L. Zhao and D.S. Gao: Northern Horticulture Vol. 5 (2008), p. 62.

[4] P.Q. Sun, J. Liu, J.M. Jia, X.H. Wang, Z.A. Shi and X.L. Li: Chinese Agricultural Science Bulletin Vol. 27 (2011), p. 222.

[5] H.S. Li: *The Principle and Technology of Plant Physiology and Biochemistry Experiment* (Higher Education Press, Beijing 2000).

[6] Q.E. Xiong: *An Experimental course in Plant Physiology* (Sichuan Science and Technology Press, Chengdu 2003).

[7] H.R. Gao, J. Zhang, X.L. Chen and M.X. Chen: Journal of Food Safety and Quality Vol. 6 (2015), p. 4142.

[8] F. Simões, F.J. Hawerroth, R.R. Yamamoto and F.G. Herter: Acta Horticulturae Vol. 1058 (2014), p. 305.