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Effects of GA_3, NAA and PCPA on the Fruit Drop Rate and Quality of *Ziziphus jujuba* 'Zhanshanmizao'

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Abstract: This experiment studied the effects of different concentrations of gibberellius (GA_3), naphthalene acetic acid (NAA), and 4-chlorophenoxyacetic acid (PCPA) on the fruit drop rate and quality of *Ziziphus jujuba* 'Zhanshanmizao'. The results showed that spraying NAA reduced the fruit drop rate of *Z. jujuba* 'Zhanshanmizao', and 10 mg/L NAA increased the fruit's intrinsic quality. With the exception of 10 mg/L GA_3, the other concentrations of GA_3 all increased the fruit drop rate of *Z. jujuba* 'Zhanshanmizao', and the four concentrations of GA_3 all decreased the appearance quality of the fruit. Spraying PCPA reduced the fruit drop rate of *Z. jujuba* 'Zhanshanmizao', but it also reduced the appearance and intrinsic quality of the fruit.

Introduction

Jujube (*Ziziphus jujuba* Mill.) is a native and specific tree of China [1], with beautiful fruit shape, bright color and rich nutrition [2, 3]. Due to its strong adaptability and good economic and ecological benefits, jujube trees have developed rapidly after Chinese Economic Reform and open up [4]. *Z. jujuba* 'Zhanshanmizao' is a good variety of fresh food of jujube, which has been cultivated in santai county for more than 200 years .In recent years, many scholars have applied plant growth regulators to fruit production to explore the effects on fruit drop rate and quality. Zhao [5] found that the length of grape spike treated with gibberellius (GA_3) increased, and the fruit setting rate, fruit quality and morbidity were all significantly reduced. Chen [6] found 50 mg/L naphthalene acetic acid (NAA) can obviously improve the fruit vitamin C, soluble solid, the content of sugar, organic acid, and fruit weight. 50 mg/L GA_3 can increase fruit weight and organic acids, but reduced sugar and vitamin C. Shi [7] found that the 4-chlorophenoxyacetic acid (PCPA) of 25 mg/L and 50 mg/L could significantly increase the fruit setting rate, yield of sweet orange, increase the vitamin C, and sugar content of fruit. The production of *Z. jujuba* 'Zhanshanmizao' is serious and the quality is uneven. However, there are few studies on the related issues of *Z. jujuba* 'Zhanshanmizao'. In this experiment, different concentrations of GA_3, NAA, and PCPA were sprayed during the expansion of *Z. jujuba* 'Zhanshanmizao' young fruit, in order to be able to screen out suitable growth regulator types and concentrations that can both reduce the fruit drop rate of *Z. jujuba* 'Zhanshanmizao' and maintain its good quality, which will provide a scientific basis for sounding *Z. jujuba* 'Zhanshanmizao' production.

Materials and Methods

Materials. The test site is located at *Z. jujuba* 'Zhanshanmizao' Experimental Park in Yongxin Town, Santai County, Mianyang City. The soil in the park is loamy and well managed. The test material were 10-year-old jujube trees with spacing of 2 m × 3 m.

Different concentrations of GA_3, NAA, and PCPA were sprayed at 9:00 am on sunny days during the puffing period (June 17 th, 2017). The concentration of GA_3, NAA, and PCPA was 0 mg/L (clear water), 10 mg/L, 20 mg/L, 30 mg/L, and 40 mg/L. All the fruiting groups of each tree were selected and listed. Each treatment was repeated 3 times. The other management measures are consistent with the local cultivation management of *Z. jujuba* 'Zhanshanmizao'. After separating the adjacent plants

with plastic film, it is recommended to use hand-operated knapsack compression spray to hang the branches and spray them evenly on the leaves and fruits of jujube trees.

Methods. (1) The fruit drop rate of *Z. jujuba* 'Zhanshanmizao': The total number of jujube was counted at 9:00 am at the beginning of the expansion of *Z. jujuba* 'Zhanshanmizao' (June 17 th, 2017). The fruiting statistics of the fruiting date of *Z. jujuba* 'Zhanshanmizao' (August 17 th, 2017). (2) Fruit appearance quality: Randomly selected 30 mature fruits from each of the treated *Z. jujuba* 'Zhanshanmizao' and the vertical and horizontal diameters of the fruit were measured with a vernier caliper. The fresh fruit weight were weighed with an electronic balance. (3) Intrinsic quality of fruit: Soluble sugar content was determined with reference to anthrone colorimetry [8]. Titratable acid content was reference to acid base titration [9]. Vitamin C content was referenced in "Agrochemical Analysis" [10].

Statistical Analyses. The data were analyzed using SPSS 22.0 (IBM, Chicago, IL, USA) for variance analysis (Duncan). Data were analyzed by analysis of variance with least significant difference at the 5% confidence level. Drop rate = number of fruit drop / total number of young fruits before harvesting. Fruit Shape index = fruit longitudinal diameter / fruit transverse diameter. The ratio of sugar to acid = soluble sugar content/titration acid content.

Results and Discussion

Effect of GA_3 on fruit drop rate and quality of *Z. jujuba* 'Zhanshanmizao'. Compared with the control (table 1), the fruit drop rate of the 10 mg/L GA_3-treated *Z. jujuba* 'Zhanshanmizao' decreased the most, which was 18.79% ($p < 0.05$), while the 40 mg/L GA_3 increased the *Z. jujuba* 'Zhanshanmizao' fruit drop rate, which was 17.95% ($p < 0.05$). The results showed that the low concentration of GA_3 helps to reduce the fruit drop rate of *Z. jujuba* 'Zhanshanmizao', while the high concentration of GA_3 promotes the shedding of *Z. jujuba* 'Zhanshanmizao'. Compared with no application of GA_3, 4 concentrations of GA_3 had no significant effect on the longitudinal diameter, transverse diameter and fruit shape index of *Z. jujuba* 'Zhanshanmizao'. With the increase of GA_3 concentration, the single fruit weight of *Z. jujuba* 'Zhanshanmizao' declined gradually, among which the 40 mg/L GA_3 decreased by a maximum of 14.88 ($p < 0.05$). With the increase of GA_3 concentration, the vitamin C content, soluble protein content, titratable acid content, and sugar-acid ratio of *Z. jujuba* 'Zhanshanmizao' all decreased, but the difference was not significant.

Table 1 Fruit drop rate and quality of *Z. jujuba* 'Zhanshanmizao'

GA_3 concentration (mg/L)	Drop rate (%)	Fruit appearance quality				Fruit intrinsic quality			
		Single fruit weight (g)	Longitudinal diameter (cm)	Transverse diameter (cm)	Fruit shape index	Vitamin C content (mg/100 g)	Soluble sugar content (%)	Titratable acid content (%)	Sugar acid ratio
0	28.47±2.54 b	4.30±0.34 a	2.22±0.02 a	1.82±0.03 a	1.22	352.44±6.33 a	21.06±2.12 a	0.28±0.03 a	75.21
10	23.35±2.67 c	4.19±0.12 a	2.23±0.04 a	1.84±0.06 a	1.21	347.68±5.78 a	20.36±3.12 a	0.28±0.02 a	72.14
20	28.78±2.81 b	4.17±0.22 a	2.32±0.10 a	1.98±0.06 a	1.17	341.24±6.33 a	18.78±4.21 a	0.26±0.00 a	72.08
30	31.15±3.63 ab	4.02± 0.18 ab	2.31±0.03 a	1.89±0.02 a	1.22	338.13±8.18 a	17.26±3.27 ab	0.26±0.01 a	66.38
40	33.58±3.82 a	3.66±0.23 b	2.39±0.07 a	1.92±0.05 a	1.24	336.76±7.23 a	16.88±4.72 b	0.26±0.01 a	64.92

Note: The data are mean ±standard error.The English lowercase letters after the same column of data indicate significant difference between different treatments ($p < 0.05$).The following is the same.

Effect of NAA on fruit drop rate and quality of *Z. jujuba* 'Zhanshanmizao'. It can be seen that with the increase of NAA concentration (table 2), the fruit drop rate of *Z. jujuba* 'Zhanshanmizao' is gradually reduced, indicating that spraying NAA can help prevent the falling fruit of *Z. jujuba* 'Zhanshanmizao'. After the 40 mg/L NAA treatment, the drop rate of the fruit drop rate was 18.92% ($p < 0.05$). The highest fruit weight was found in the application of 40 mg/L NAA, which was 8.12% higher than that of non-sprayed NAA. Different concentrations of NAA increased the longitudinal diameter and transverse diameter of *Z. jujuba* 'Zhanshanmizao', but reduced the fruit shape index.

For the intrinsic quality of *Z. jujuba* ‘ Zhanshanmizao’, spraying NAA had no significant effect on the content of vitamin C and titratable acid in fruits. Compared with non-sprayed NAA, the ratio of soluble sugar and acidity of NAA increased by 10 mg/L, which was 9.19% ($p > 0.05$) and 13.22% ($p > 0.05$), respectively.

Table 2 Fruit drop rate and quality of *Z. jujuba* ‘Zhanshanmizao’

NAA concentration (mg/L)	Drop rate (%)	Fruit appearance quality				Fruit intrinsic quality			
		Single fruit weight (g)	Longitudinal diameter (cm)	Transverse diameter (cm)	Fruit Shape index	Vitamin C content (mg/100 g)	Soluble Sugar content (%)	Titratable acid content (%)	Sugar acid ratio
0	28.33±2.87 a	4.31± 0.27 ab	2.35±0.87 a	1.74±0.42 b	1.23±0.12a	352.30±7.34 a	21.22±1.22 ab	0.28± 0.01 a	75.79
10	26.24±3.12 a	4.32±0.27 ab	2.55±0.52 a	2.11±0.62 a	1.21±0.23 a	352.77±9.27 a	23.17±2.83 a	0.27±0.04 a	85.81
20	25.75±2.98 b	4.32± 0.92 ab	2.47±0.12 a	2.10±0.14 a	1.17±0.42 a	355.48±5.26 a	20.26±2.76 b	0.28±0.02 a	72.35
30	23.66±3.16 b	4.21±0.75 b	2.40±0.65 a	1.97±0.24 ab	1.22±0.22 a	351.16±6.42 a	19.68±3.11 b	0.29±0.03 a	67.86
40	22.97±3.31 b	4.66±0.56 a	2.41±0.56 a	1.98±0.19 a	1.22±0.15 a	348.86±7.49 a	19.88±1.98 b	0.28±0.01 a	71.00

Effect of PCPA on Fruit Drop and Fruit Quality of *Z. jujuba* ‘Zhanshanmizao’. It can be seen that as the concentration of PCPA increases (table 3), the fruit drop rate of *Z. jujuba* ‘Zhanshanmizao’decreases gradually. Compared with spraying 0 mg/L PCPA, the fruit drop rate of *Z. jujuba* ‘Zhanshanmizao’ sprayed with 40 mg/L PCPA was the highest, which was 22.42% ($P<0.05$). Both 30 mg/L PCPA and 40 mg/L PCPA promoted the increase of single fruit weight, but the difference was not significant. Compared with the non-sprayed PCPA, spraying PCPA increased the longitudinal diameter and transverse diameter of *Z. jujuba* ‘Zhanshanmizao’, and reduced its fruit shape index. For the intrinsic quality of the fruit of *Z. jujuba* ‘Zhanshanmizao’, with the increase of PCPA concentration, the content of vitamin C, soluble sugar content and titratable acid content of *Z. jujuba* ‘Zhanshanmizao’ gradually decreased, but the difference was not significant.

Table 3 Fruit drop rate and quality of *Z. jujuba* ‘Zhanshanmizao’

PCPA concentration (mg/L)	Drop rate (%)	Fruit appearance quality				Fruit intrinsic quality			
		Single fruit weight (g)	Longitudinal diameter (cm)	Transverse diameter (cm)	Fruit shape index	Vitamin C content (mg/100g)	Soluble sugar content (%)	Titratable acid content (%)	Sugar acid ratio
0	29.22±2.76 a	4.29±0.34 a	2.12±0.12 a	1.77±0.15 b	1.28	351.17±6.12 a	20.88±3.12 a	0.28±0.00 a	74.57
10	28.11±3.11 a	4.18±0.55 a	2.34±0.23 a	1.91±0.21 ab	1.23	344.12±7.82 a	20.14±2.77 a	0.27±0.02 a	74.59
20	24.34±2.97 b	4.21±0.23 a	2.41±0.31 a	2.02±0.06 a	1.19	343.66±7.11 a	19.84±2.41 a	0.26±0.01 a	76.31
30	23.55±2.88 b	4.32±0.21 a	2.46±0.12 a	2.10±0.27 a	1.17	341.31±8.12 a	19.12±1.93 a	0.26±0.03 a	73.54
40	22.67±1.39 c	4.30±0.43 a	2.41±0.09 a	2.00±0.23 a	1.20	340.12±6.92 a	19.04±2.64 a	0.26±0.01 a	73.23

Conclusions

To sum up, different concentrations of NAA were reduced come *Z. jujuba* ‘Zhanshanmizao’ abscission rate, 40 mg/L NAA increased helps promote unfolding *Z. jujuba* ‘Zhanshanmizao’ fruit weight increase, 10 mg/L NAA helps to promote the inner quality of unfolding *Z. jujuba* ‘Zhanshanmizao’. Except GA_3 at 10mg/L, GA_3 at the other concentration increased the fruit drop rate of *Z. jujuba* ‘Zhanshanmizao’, and GA_3 at the four concentrations reduced the fruit and appearance quality. PCPA reduced the fruit drop rate of *Z. jujuba* ‘Zhanshanmizao’, but also reduced the appearance and inner quality of the fruit.

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References

[1] Z.Z. Qu and Y.H. Wang: *Chinese journal of fruit trees, jujube rolls* (China Forestry Press, 1993 Beijing).

[2] A.L. Zhang, D.K. Li, Y.K. Wang, C.L. Sui and Y.Q. Cao: Journal of Plant Genetic Resources Vol.11 (2010), p. 811.

[3] M.S. Miao and L.M. Sun: HENAN TRADITIONAL CHINESE MEDICINE Vol. 23 (2003), p. 59.

[4] M.J. Liu: Chinese Fruit Tree Vol. 1 (2018), p. 1.

[5] Y.M. Zhao, D.D. Liu, P. Liu, X.F. Le and Z.W. Zhang: Northern Horticulture Vol. 5 (2018), p. 64.

[6] J.Y. Chen, K.Y. Liu, H. Cao, S.B. Wang, J.H. Xie and Y.W. Xie: CHINESE JOURNAL OF TROPICAL CROPS Vol. 29 (2008), p. 460.

[7] J.K. Shi, Y.L. Hu and Z.X. Zhou: Journal of Mountain Agricultural and Biology Vol.18 (1999), p. 21.

[8] Q.E. Xiong: *Experimental course on plant physiology* (Sichuan Science and Technology Press, Chengdu 2010).

[9] Y.S. Han: *Experimental guidance on food chemistry* (Beijing Agricultural University Press, Beijing 1992).

[10] C.S. Liu and S.X. Yang: *Agricultural chemical analysis* (China Agricultural University press, Beijing 1996).