Effect of Gibberellin Treatment on Dormancy-breaking and Germination of Cherry Seeds

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Abstract. Cherry (Cerasus Mill.) species are important agricultural crops with high economic and ornamental values. The seeds of stone fruits have a long dormancy period after harvest, which cannot germinate and grow until the dormancy has been broken. In order to break the dormancy and speed up the germination of cherry seeds, we studied the effect of GA3 treatment on the dormancy-breaking and germination rate of Chinese cherry and sweet cherry seeds without cold stratification. The results showed that GA3 treatment significantly increased the germination rates of cherry seeds, reaching the maximum value of 64%, 24% and 40% at the concentration of 100 mg•L⁻¹ of GA3 for cultivated and wild Chinese cherry, and sweet cherry. In addition, GA3 treatment obviously speed up the germination index of cherry seeds, reaching the maximum value when immersing seeds with 100 mg•L⁻¹ of GA3. Therefore, it is necessary to cultivate cherry seedlings by GA3 treatment.

1. Introduction

Cherry species belongs to the genus Cerasus Mill. of the subfamily Prunoideae, family Rosaceae, including significant agricultural crops with high economic and ornamental values [1]. There are four economically important cultivated cherry species: Chinese cherry [C. pseudocerasus (Lindl.) G. Don], sweet cherry (C. avium L.), sour cherry (C. vulgaris L.), and downy cherry (C. tomentosa Thunb.) [2, 3]. Among of them, sweet cherry has relatively large fruit size with the weight per fruit ranging from 4.0 to 15.0 g, and resistance to fruit crack [4, 5], widely cultivated in China. Chinese cherry originates from Southwest China, whose domestication and cultivation history can be traced back to over 3000 years [1, 6, 7]. As a traditional fresh fruit with fabulous flavor, the drupes contain rich nutritional ingredients and trace elements such as vitamins, minerals, fiber and antioxidant compounds for healthy diets [2, 8]. It also has distinct advantages in adaption, resistance to pests, productivity and flavor traits [9]. Nowadays, Chinese cherry has played an important role in the rural tourist industry in China, which is booming throughout its distribution areas.

The seeds of stone fruits have a long dormancy period after harvest, which cannot germinate and grow until the dormancy has been broken. Previous studies suggested that cold stratification and GA3 treatments could break the physiological dormancy, which significantly promoted overall germination percentage and germination index [10, 11]. However, it is a long time to experience cold stratification, such as 60 to 90 days for sweet cherry [10]. This will obviously hinder the process of cherry breeding.
Therefore, we explored the effect of GA3 treatment on the dormancy-breaking and speeding up germination of cherry seeds without cold stratification. Our objectives are to select the approximate GA3 concentration to break the physiology dormancy, and to improve the seedlings growth in the cherry production.

2. Materials and methods

2.1. Plant materials
In this study, cultivated and wild Chinese cherry, and sweet cherry accessions were collected from Pujiang, Yingjing Sichuan and Zibo Shandong, respectively. The seeds were used for next experiment after excluding fruit flesh. The testa of fresh seeds, the hard-dry protective covering of a seed, formed from the integuments of the ovule, was excluded before GA3 treatment.

2.2. Seed germination rate detection
We set three gradient GA3 concentration of 0, 50, 100 and 150 mg•L⁻¹. Fifty seeds were immersed in GA3 solution for 24 h in each treatment with three replicates per treatment. And then the seeds were put on the culture dish at 25°C to germinate. After several days, we summarized the date for germination and the number of germinated seeds. The germinating seed is formed when the length of the seed coat is half the length of the seed. Germination index and rate were calculated by \((\text{the number of germinated seeds within the allotted period} / \text{total number of seeds}) \times 100\%\), and \(\text{total number of germinated seeds} / \text{total number of seeds}) \times 100\%\).

2.3. Data analysis
Significant differences between the means of the treatments were determined with 95% confidence (p < 0.05) limit by Duncan multiple range test using SPSS18.0 (IBM, USA). Data are shown as the means of three replicates.

3. Results

3.1. Germination rate of cherry seeds by GA3 treatment
Compared with the CK, GA3 treatment significantly increased the germination rates of cherry seeds, reaching the maximum value of 64%, 24% and 40% at the concentration of 100 mg•L⁻¹ of GA3 for cultivated and wild Chinese cherry, and sweet cherry (Table 1). By comparison, there were significant differences of germination rates among different GA3 concentrations (Table 2).

| Material             | Number of germinated seeds / germination rate |
|----------------------|---------------------------------------------|
|                      | CK  | 50 mg•L⁻¹ of GA3 | 100 mg•L⁻¹ of GA3 | 150 mg•L⁻¹ of GA3 | Average |
| Cultivated Chinese cherry | 10 / 20% | 19 / 38% | 32 / 64% | 14 / 28% | 18.75 / 37.5% |
| Wild Chinese cherry   | 5 / 10% | 7 / 14% | 12 / 24% | 6 / 12% | 7.5 / 15% |
| Sweet cherry          | 11 / 22% | 13 / 26% | 20 / 40% | 11 / 22% | 13.75 / 27.5% |
| Average              | 8.67 / 17.3% | 13 / 26% | 21.33 / 42.7% | 10.33 / 20.7% |

Table 2. Variance analysis based on the Table 1 using SPSS method

| Origin of variance | SS    | df | MS   | F value |
|--------------------|-------|----|------|---------|
| Material           | 254.1667 | 2 | 127.0833 | 1.3416 |
| GA3 concentration  | 284.1667 | 3 | 94.7222 | 7.6974 |
| Error              | 73.8333 | 6 | 12.3056 |
| Total              | 612.6667 | 11 | |
3.2. Germination index of cherry seeds
We also observed the germination trend of cherry seeds by GA$_3$ treatment. The all cherry seeds started to germinate at two days after treatments, which reached the maximum germination speed from three to five days for the seeds by 100 mg•L$^{-1}$ of GA$_3$ treatment, significant higher than the CK (Table 3). The results indicated that different concentration GA$_3$ treatment all speed up the germination process, germination percentage and germination vigour.

| Material               | Average number of germinated seeds / Increment to CK |
|------------------------|-----------------------------------------------------|
|                        | CK 50 mg•L$^{-1}$ of GA$_3$ 100 mg•L$^{-1}$ of GA$_3$ 150 mg•L$^{-1}$ of GA$_3$ |
| Cultivated Chinese cherry | 10 18 / 80% 32 / 220% 12 / 20% |
| Wild Chinese cherry     | 5 6 / 20% 11 / 120% 6 / 20% |
| Sweet cherry            | 10 12 / 20% 46 / 360% 10 / 0 |

4. Discussion
Based on the results, the hard shell is one of the barriers for the young seedlings. Thus, appropriate and effective measures should be taken to break the shells of seedlings in the production. Previous studies suggested that the seed dormancy was resulted from mechanical block of testa, inclusive repressor and immature embryo [12-15]. Zou [15] suggested that physiological ripening and the existence of inhibitors are the main reasons for the dormancy of C. maximowiczii seeds. In addition, we found that the seeds were abortive due to the hypogenetic cotyledons.

GA$_3$, as a plant hormone, can break the seed dormancy and improve the germination of seeds. This study indicated that appropriate concentration GA3 could improve the germination percentage and speed up the germination process. There was certain difference among different concentrations, and the best treatment was 100 mg•L$^{-1}$ of GA$_3$. This was consistent with the results by Yin and Song [13]. Zou [15] suggested that the dormancy of C. maximowiczii seeds can be effectively broken by warm-temperature stratification 90 days later and cold-temperature stratification 120 days later. In this study, the fresh seeds could germinate without cold-temperature stratification or GA$_3$ treatment. This indicated that the dormancy of cherry seeds was not strict.

Acknowledgments
This work was financially supported by the National Natural Science Foundation of China (31672114), Sichuan Science and Technology Program (2019JDTD0010) and Key Fund Project of Sichuan Provincial Department of Education (18ZA0385).

References
[1] Yü, D.J. (1979) Taxonomy of Fruit Trees in China. Agricultural Press, Beijing.
[2] Yü, D.J., Li, C.L. (1986) Flora of China. Science Press, Beijing.
[3] Lu, L.D., Gu, C.Z., Li, C.L., Jiang, S.Y., Crinan, A., Bruce, B., Anthony, R.B., David, E.B., Hiroshi, I., Hideaki, O., Kenneth, R.R., Steven, A.S. (2003) Flora of China, revised. Missouri Botanical Garden Press and Science Press, St. Louis, Beijing.
[4] Jia, H.H., Zhang, X.Y., Chen, X.S., Chen, X.L., Zhao, C.Z. (2007) Survey of partial physiological index of cherry different cultivars. J. Shandong Agri. Univ. 38(2): 193–195.
[5] Chen, Q.F., Tian, J.B., Wang, M., Wang, G.P. (2009) A new late-maturing and crack resistance sweet cherry cultivar 'Jingling'. Acta Hortic. Sinica 36(12): 1839–1840.
[6] Liu, C., Liu, M. (1993) The seed relics identification of HouMa Shaanxi Copper Casting sites. Cultural Relic Press, Beijing.
[7] Liu, C.J., Jin, G.Y., Kong, Z.C. (2008). Archaeobotany-Research on Seeds and Fruits. Science Press, Beijing.
[8] Huang, X.J., Wang, X.R., Chen, T., Chen, J., Tang, H.R. (2013). Research progress of germplasm diversity in Chinese cherry (Cerasus pseudocerasus). J. Fruit Sci. 30(3): 470–479.
[9] Chen, T., Li, L., Zhang, J., Huang, Z.L., Zhang, H.W., Liu, Y., Chen, Q., Tang, H.R., Wang, X.R. (2016) Investigation, collection and preliminary evaluation of genetic resources of Chinese cherry \([Cerasus\ pseudocerasus\ (Lindl.)\ G.\ Don]\). J. Fruit. Sci. 33(8): 917–933.
[10] Ai, C.X., Liu, Q.Z., Li, G.T., Zhang, L.S., Zhang, Y.Y. (2011) The effect of cold stratification and GA\(_3\) treatment on seed germination of sweet cherry. Deciduous Fruits 2: 4–5.
[11] Yang, X.F., Si, H.Z., Zhou, L., Li, H.H. (2013) Research on the germination characteristics of four kinds of stone fruit seeds. Chinese Hortic. Abstract 7: 14–1542.
[12] Han, M.Y., Zhang, M.R., Tian, Y.M., Zhang, W.B., Zhang, J.K. (2002) Effect of plant hormones on seed dormancy and seeding growth of stone fruits. Acta Bot. Boreal. -Occident. Sci. 22(6): 1348–1354.
[13] Yin, Z.W., Song, J.W. (2008) The effect of different concentration gibberellin treatment on the germinate of cherry seeds. North Hortic. 12: 52–54.
[14] Peng, N., Zhou, L., Wang, C., Zhang, X. (2015) Study on germination characteristics of seeds in \([Cerasus\ tianschanica]\). Nonwood Forest Res. 33(3): 145–149.
[15] Zou, W., Tao, S.Y., Wang, Q.B. (2019) Study on dormancy mechanism and removal method of \([Cerasus\ maximowiczii]\) seeds. Forestry Sci. Technol. 44(4): 33–36.