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Zilongzhu: A Late-maturing Seedless Grape Cultivar

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Grape (*Vitis* L.) is an economically significant crop in China with a long history of cultivation. Consumers highly value its diverse shape, vibrant colors, and rich nutritional content. According to the International Vine and Wine Organization's 2021 statistics, China's grape cultivation area reached 784,750 ha, making it the world's largest producer and consumer of table grapes (Cheng et al. 2023). Currently, there is a growing demand for high-quality, large, seedless grapes. However, the majority of seedless grapes in China are produced by applying plant growth regulators twice to seeded grape cultivars such as Kyoho and Shine Muscat. This method is both time-consuming and labor-intensive, thus underscoring the need for the breeding and introduction of seedless grape cultivars that reduce labor and time requirements. Recently, triploid breeding has been proposed as an effective method of developing seedless grapes with large berries (Park et al. 2022). Several triploid seedless grape cultivars, such as Honey Seedless, Summer Black, Early Red Seedless, and Magachi Polyploid, have been developed and are currently being promoted for production. To further enhance the breeding efficiency of triploid grape cultivars, embryo rescue technology has been developed, enabling the more efficient identification and production of triploids (Laise and Matthew 2021).

The collection and evaluation of grape germplasm resources began in 2005 at Shijiazhuang Institute of Pomology, Hebei Academy of Agriculture and Forestry Sciences (Shijiazhuang, Hebei Province, China), leading to the preservation of more than 200 germplasm resources to date. In 2010, cross-breeding was initiated between diploid and tetraploid cultivars, with a focus on high yield, disease resistance, and superior fruit quality, including large size, seedlessness, and a sweet and sour taste, as key breeding goals. This effort resulted in the development of the triploid grape cultivar Zilongzhu, which is a late-maturing, seedless cultivar that is well-known for its excellent disease resistance and taste.

Origin

Zilongzhu is a hybrid grape cultivar that was developed in 2010 at Shijiazhuang Institute of Pomology, Hebei Academy of Agriculture and Forestry Sciences, resulting from a cross between the diploid grape cultivar Moldova (*Vitis labrusca* × *Vitis vinifera*) and the tetraploid cultivar Tianyuanqi (*Vitis labrusca* × *Vitis vinifera*) (Fig. 1). Between 2010 and 2020, the average annual temperature in the region ranged from 13.4 to 15.8 °C, with an accumulated temperature of 4561.2 to 4670.3 °C (≥10 °C). The diploid cultivar Moldova derived from a cross between Guzali Kala and SV12375 was introduced from Romania in 1997. Over 10 years of cultivation, it demonstrated high resistance to downy mildew, excellent yield, late ripening, and good storage resistance. Its fruits are oval, have an average weight of 8 to 9 g, have a uniformly purple-black color, and are covered with a deep fruit powder coating. The flesh contains 16% total soluble solids (TSS) and 0.54% titratable acidity (TA). 'Moldova' is suitable for both fresh consumption and wine making, with promising development potential and market prospects. It is now cultivated in Hebei, Shandong, Beijing, and several southern provinces and cities. The tetraploid cultivar Tianyuanqi is a bud mutation of the 'Kyoho' grape. Its fruits are round, have an average weight of 14 g, and have purple-red skin. The flesh is thick, hard, and crispy, with a sweet and sour taste, a soluble solids content of 16% to 18%, and a strong strawberry aroma, thus making it a high-quality cultivar.

One of the main challenges involved in breeding of triploid grape cultivars is seed abortion, which frequently occurs after planned

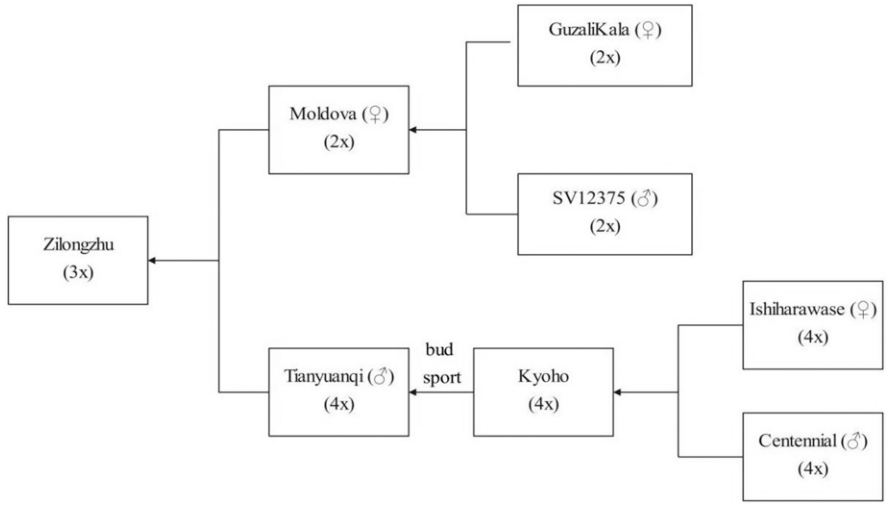

Fig. 1. Pedigree of 'Zilongzhu' seedless table grape.

Fig. 2. Cluster appearance of the 'Zilongzhu' seedless grape.

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crosses. To address this, we used the embryo rescue technique to improve the acquisition rate of hybrid offspring. The young hybrid fruits were collected 40 to 45 d after pollination; following embryo induction and germination, a total of 76 crosses were obtained in the same year. Among these, 'Zilongzhu', initially named W8-1-3, was identified as a triploid selection with superior growth characteristics during its early stages. Then, it was propagated for further evaluation and demonstrated excellent traits such as seedlessness, disease resistance, purple-red skin, and high quality. From 2016 to 2020, W8-1-3 was grafted and tested in various climate regions, including Dingzhou City, Shijiazhuang City, Jinzhou City, and Weixian County, with Moldova and Tianyuanqi serving as control cultivars. After evaluation in 2022, accession W8-1-3 was approved by the Approval Committee for Improved Varieties of Forest Trees of Hebei Province and officially named 'Zilongzhu'.

Table 1. Fruit characteristics of Zilongzhu, Moldova, and Tianyuanqi grape cultivars grown in Shijiazhuang, Hebei, China.

Characteristics	Zilongzhu	Moldova	Tianyuanqi
Maturing date	9 Sep	10 Sep	15 Aug
Cluster shape	Cylindrical	Conical	Conical
Berry shape	Round	Ovate	Round
Berry skin color	Purple-red	Purple-black	Purple-red
Cluster weight (g)	823.6 ± 66.4	425.4 ± 24.7	842.5 ± 54.9
Berry weight (g)	9.8 ± 0.66	7.8 ± 0.46	11.2 ± 0.56
Seed status (no.)	No	Yes (3–4)	Yes (3–4)
TSS (Brix)	19.9 ± 0.70	16.9 ± 0.52	18.4 ± 0.21
TA (%)	0.62 ± 0.05	0.64 ± 0.04	0.54 ± 0.02
TSS/TA ratio	32.1	26.4	34.1
Aroma	Strawberry	No	Strawberry
Fruit firmness (kg/cm^2)	0.45 ± 0.01	0.36 ± 0.01	0.48 ± 0.02

Data source: All values represent means investigated in Shijiazhuang, China, from 2018 to 2020.
Sampling method: Ten clusters from gibberellic acid-treated (25 ppm) vines were sampled randomly from five vines at the optimal harvest period for calculation.
Berry weight calculation: Average berry weight was calculated by dividing the total fruit weight by the number of berries.
Soluble solids and acidity measurements: Ten berries were randomly sampled from each cluster. Total soluble solids was measured using juice extracted from the berry with a digital refractometer (PR-101; Atago, Tokyo, Japan). Titratable acidity was measured with an automatic titrator (TitroLine alpha; Schott, Mainz, Germany).
TA = titratable acidity; TSS = total soluble solids.

Description

Growth and fruiting habits. 'Zilongzhu' has a budburst rate of 91.7% and a fruiting branch rate of 91.5%, with an average of 1.86 flower clusters per fruiting branch; almost every new branch develops two or more flower clusters. In Shijiazhuang, the bud sprouting date is in early April, with full bloom occurring in mid-May. The flowering period lasts 7 to 10 d. The optimal harvest date for Zilongzhu is in mid-September, with approximately 160 d from germination to berry ripening, thus classifying it as a late-maturing cultivar.

Flower and cluster. The flowers of 'Zilongzhu' are hermaphroditic. Similar to other triploid grape cultivars, its fruit set is poor without gibberellic (GA_3) treatment (Heo and Park 2015). However, a single application of GA_3 at a concentration of 25 ppm during full bloom significantly improves the fruit set. The clusters are uniformly shaped, cylindrical, have medium density, and are challenging to separate from the stems, with an average weight of 823.6 g. The fruit of 'Zilongzhu' is juicy, with a crispy texture.

Berry characteristics. The fruit of 'Zilongzhu' is round and seedless, with an average weight of 9.8 g; however, its weight reaches up to 12.8 g after GA_3 treatment. The skin is purple-red with a medium-thick fruit powder coating (Fig. 2). The berry's skin is medium-thick and relatively resistant to cracking. The flesh is crisp, juicy, and has a sweet and sour taste with a hint of strawberry fragrance. At harvest, the average TSS concentration is 19.9%, the TA is 0.62%, and the TSS/TA is 32.1 (Table 1). A TSS greater than 18% and a TSS/TA ratio exceeding 30 ensures a good taste (Sonego et al. 2002). These characteristics establish Zilongzhu as a high-quality, outstanding cultivar, with strong potential to become an important late-maturing seedless grape cultivar in China.

Vine characteristics. 'Zilongzhu' vines display relatively vigorous growth, thus necessitating proper canopy management during the growing season. To maintain berry quality, it is better to limit each shoot to one cluster because each shoot typically bears more than two clusters.

'Zilongzhu' also demonstrates enhanced resistance to major fungal diseases compared with that of other cultivars. Long-term evaluations have shown its high resistance to downy mildew (*Plasmopara viticola*) and powdery mildew (*Erysiphe necator*), and it has near-immunity or rare occurrences during special years. This makes 'Zilongzhu' a valuable resource for breeding new grape cultivars with high tolerance to biotic stresses.

Cultivation

'Zilongzhu' is well-suited for cultivation in Hebei Province and other regions with similar climates. It can thrive in plains and in mountainous and hilly regions with good drainage. It is adaptable to open ground and facility plantings using single-arm hedge or V-shaped frame systems. The recommended plant spacing is 1.0–1.5 m × 2.0–3.0 m. To improve fruit quality, timely thinning of the flower and fruit is essential. Organic fertilizer should be applied early, immediately after harvest, at a rate exceeding 100% of the annual yield. Because of the cultivar's extended fruit development period, it is crucial to provide adequate nutrition throughout all growth stages. Additionally, irrigation should follow fertilization to ensure optimal growth conditions.

Availability

'Zilongzhu' has been approved by the Approval Committee for Improved Varieties of Forest Tree of Hebei Province (Hebei S-SV-VV-009-2021) (Supplemental Fig. 1). Limited quantities of bud wood are available upon request for trial, research, and commercial propagation. For research purposes, requests for cuttings can be directed to Lili Yang (yanglili0311@163.com).

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