Anthocyanin-rich Fruit Radish 'Sheng Cui 745'

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Abstract Fruit radish 'Sheng Cui 745', rich in anthocyanins, is a first-generation hybrid developed by crossing sterile line HSR2063A as the female parent and inbred line HSR1876 as the male parent. The plants exhibit moderate growth vigor, with a slightly flat leaf cluster. The leaves are dark green, pinnately lobed. There are approximately 14 leaves per plant, 30 cm in length. The fleshy roots are 18 cm in length and 8.5 cm in diameter, presenting a cylindrical shape with purple-red skin and flesh. The flesh is fine-textured, crisp, and slightly spicy. The fleshy roots have a anthocyanin content of 708.7 mg/L and exhibit excellent toughness. The yield of the variety can reach up to 56 700 kg/hm^2. It is suitable for open-field autumn cultivation in Shandong, Tianjin, Hebei, and other regions.

Key words Anthocyanin; Fruit radish; Sterile line

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Radish (*Raphanus sativus* L.), a representative root vegetable of the Brassicaceae family, has been cultivated in China for over 2 700 years. According to data from China Agricultural Statistics Yearbook, its cultivation spans all 31 provincial-level regions, making it one of the country's important cash crops[1]. Modern pharmacological studies confirm that radish is not only rich in glucosinolates, vitamin C, and dietary fiber, but also contains unique isothiocyanate metabolites (such as sulforaphane), which have demonstrated significant anticancer activity and antibacterial properties (exhibiting an inhibition zone diameter of 15.3 mm against Staphylococcus aureus)[2-3]. Anthocyanins, a core subclass of flavonoids, are vital water-soluble pigments in plant secondary metabolism, widely distributed in fruits and vegetables such as blueberries and purple cabbage[4]. Their chemical structure consists of two aromatic rings (A and B) connected by a heterocyclic C ring, with hydroxyl and methoxyl substitution patterns (such as cyanidin and delphinidin) directly determining their color properties and biological activities[5]. Studies have shown that the antioxidant capacity of anthocyanins is significantly higher than that of conventional antioxidants, with a median inhibition concentration (IC_{50}) for free radical scavenging being only 1/50 that of vitamin E[6], and their superoxide anion-scavenging efficiency reaching up to 20 times that of vitamin C[7]. This potent antioxidant property enables anthocyanins to exert multiple health benefits. In specific, they slow the progression of atherosclerosis by inhibiting low-density lipoprotein (LDL) oxidation (reducing oxidative susceptibility by 38%)[3]. They down-regulate the expression of inflammatory factors such as TNF-α (inhibition rate exceeding 60%) via regulation of the NF-κB signaling pathway[8]. And they activate collagen-synthesizing enzymes (LOX, P4H) in skin fibroblasts, significantly mitigating UV-induced skin photoaging (collagen degradation reduced by 45%)[9]. Although the health benefits of anthocyanins are widely recognized, their natural enrichment in Brassicaceae vegetables remains challenging. Current mainstream radish varieties generally exhibit low anthocyanin content, significantly lower than that of berry crops such as blueberries. This situation presents a notable contradiction with the increasing demand of consumers for functional vegetables[10-11]. In recent years, advancements in molecular breeding technologies have provided new pathways for crop biofortification, enabling the effective integration of superior agronomic traits with the synthesis capacity of highly-bioactive compounds. Based on this, in view of the lack of varieties with special colors and functions in the current fruit radish market, our research group developed a new fruit radish variety with high anthocyanin content and marketability using the male sterility three-line breeding technique combined with high-efficiency breeding techniques, contributing to the upgrading of functional vegetable industry.

Breeding Process

For the development of female parent HSR2063A, a stable inbred line was first obtained through multiple generations of single-plant systematic selection using Beijing 'Xin Li Mei' radish from 2011 to 2018. From 2016 to 2020, a sterile plant from Korean 'Cheongsu' radish was used as the sterility source for six generations of continuous generation-adding transfer breeding, resulting in a male sterile line with 100% sterility degree and sterile plant ratio. It shows 14 pinnatisect leaves with flat leaf arrangement in the field. The fleshy roots are spherical, 9 – 13 cm in length and 5 – 7 cm in diameter, and has an average weight of 0.2 – 0.3 kg. It has fine texture, and features green skin and purple flesh. The variety demonstrates good resistance to viral diseases and downy mildew.

The male parent HSR1876 is a superior inbred line developed through seven consecutive generations of selfing using the Japanese red-skinned red-fleshed radish cultivar 'Zi Dan'. It exhibits 13 pinnately-lobed leaves forming a flat leaf cluster. The roots are

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short-cylindrical and have red skin and red flesh. They are 15 – 18 cm in length and 7 – 8 cm in diameter, each weighing at 0.4 – 0.5 kg. The variety demonstrates high resistance to viral diseases.

In spring 2021, a hybrid combination was developed, and combining ability tests and variety comparison trials were conducted from 2022 to 2023 in Qingzhou (Shandong) and Xiaoshawo Village (Tianjin), where the hybrid demonstrated outstanding performance. In fruit radish variety comparison trials, the yield reached 56 700 kg/hm^2, representing a 17.93% average increase over the control variety Beijing ‘Xin Li Mei’. Since 2024, trial cultivation and demonstration have been carried out in Shandong, Tianjin, Hebei and other regions, and the variety was officially named ‘Sheng Cui 745’. It was declared for plant variety protection in May 2024.

Breeding Results

Yielding ability

Variety comparison trials From 2022 to 2023, variety comparison trials were conducted at the South Farm of Huasheng Agricultural Group Co., Ltd. The seeds were sown on August 28, with Beijing ‘Xin Li Mei’ as the control. The plant spacing and row spacing were 20 and 50 cm, respectively, and the plot area was 12 m^2. The trials followed a randomized block design, with each treatment replicated three times. In 2022, ‘Sheng Cui 745’ achieved an average yield of 56 745 kg/hm^2, representing a 19.03% increase over the control Beijing ‘Xin Li Mei’. In 2023, the average yield of ‘Sheng Cui 745’ reached 57 780 kg/hm^2, showing a 20.69% increase compared with the control.

Table 1 Yield results of ‘Sheng Cui 745’ in variety comparison trials

Year	Yield//kg/hm^2		Increasing rate//%
	Sheng Cui 745	Xin Li Mei (CK)	
2022	56 745	47 670	19.03
2023	57 780	48 975	20.69

Regional trials In 2022, regional trials were conducted at the following locations with Beijing ‘Xin Li Mei’ as the control: South Farm of Huasheng Agricultural Group Co., Ltd. (seeding on August 26), Hanting District of Weifang City (seeding on August 28), Xiaoshawo Village of Tianjin City (seeding on August 28). The trials followed a randomized block design with three replicates per treatment. The plant spacing and row spacing were 20 and 50 cm, respectively, and each plot had an area of 12 m^2. The results showed that ‘Sheng Cui 745’ achieved an average yield of 56 955 kg/hm^2, representing a 17.66% increase over the control (Table 2).

Table 2 Yield results of ‘Sheng Cui 745’ in regional trials

Location	Yield//kg/hm^2		Increasing rate//%
	Sheng Cui 745	Xin Li Mei (CK)	
South Farm of Huasheng Agricultural Group Co., Ltd.	55 935	47 385	18.04
Hanting District, Weifang City	58 185	50 205	15.89
Xiaoshawo Village, Tianjin	56 775	47 625	19.21

Production demonstration trials were conducted in 2023 at the South Farm of Huasheng Agricultural Group Co., Ltd. (seeding on August 29), Hanting District of Weifang City (seeding on August 25), and Xiaoshawo Village of Tianjin City (seeding on August 28). The plant spacing and row spacing were 20 and 50 cm, respectively, and the area was 667 m^2 at each location. The yield was measured by the five-point sampling method. The results showed that ‘Sheng Cui 745’ achieved an average yield of 56 700 kg/hm^2, representing a 17.93% increase over the control variety Beijing ‘Xin Li Mei’.

Disease resistance

Field disease investigations conducted during multi-site trials in 2022 demonstrated strong resistance to TMV (disease index 13.5) and CMV (disease index 16.7), moderate resistance to soft rot (37.7), indicating strong comprehensive disease resistance.

Commercial quality

Quality analysis conducted on mature radish roots in October 2023 showed: crude fiber content 0.5%, soluble sugar content 3.03%, vitamin C content 20 mg/kg, protein content 0.72%, moisture content 92.8%, and anthocyanin content 708.7 mg/L, and the peel contained anthocyanins at a particularly high level reaching 1 197.6 mg/L. Table 3 shows that in the regional trials of fruit radish varieties in 2023, under the condition of sowing on August 26, ‘Sheng Cui 745’ was more in line with the overall market demand compared with Beijing ‘Xin Li Mei’ in terms of flesh color (deep purple) and taste (crisp and sweet), better uniformity, and higher commodity rate.

Table 3 Field commercial quality evaluation results of ‘Sheng Cui 745’

Variety	Leaf trait	Leaf number	Fleshy root shape	Flesh color	Taste
‘Sheng Cui 745’	Pinnately divided	16	Long cylindrical	Deep purple	Crisp and sweet
Beijing ‘Xin Li Mei’	Pinnately divided	13	High round	Deep red	Hard

Variety characteristics

‘Sheng Cui 745’ is an early-maturing F_1 hybrid variety. The plants show moderate growth vigor with flat-spreading leaf clusters. The leaves are dark green, pinnately lobed. There are approximately 14 leaves per plant, 30 cm in length. The fleshy roots are 18 cm in length and 8.5 cm in diameter, presenting a cylindrical shape with purple-red skin and flesh. The flesh is fine-textured, and crisp. The fleshy roots are rich in anthocyanins, and slightly pungency under high temperatures, and have excellent toughness. The variety exhibits high commodity rate and outstanding uniformity.

Fig. 1 A new fruit radish variety 'Sheng Cui 745'

Key cultivation techniques

This variety is suitable for open-field autumn cultivation in Shandong, Tianjin, Hebei and similar regions. The optimal sowing period falls between late August and early September. Generally, 2 seeds are sown per hole, and the seeding rate is 1 500 – 2 250 g/hm^2. After sowing, the seeds are covered with 0.5 cm of fine soil. When seedlings develop 5 – 6 true leaves, and the fleshy roots begin to expand (known as 'root breaking' stage), final singling is performed according to specified plant spacing, and intertillage weeding and thinning are performed simultaneously. During the peak expansion period of fleshy roots, the water demand reaches its maximum, and thorough and even irrigation is required while maintaining soil available water content above 70% – 80% to prevent hollowness and root cracking simultaneously. The optimal harvest period occurs 65 – 70 d after sowing when the roots reach full expansion but before frost exposure, as premature harvesting affects yield. Timely harvest after complete root expansion ensures maximum yield, and the roots should be washed for sales or cold storage.

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