

Cultivation and evaluation of series yellow and green apple varieties in Yantai, China

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Abstract

Apple is the main fruit cultivated in Yantai, but mainly red varieties, excellent yellow and green varieties are lacking. In order to enrich the variety structure of apples in Yantai area and increase the diversity of yellow-green varieties, the team selected 15 yellow and green apple varieties through introduction and cross-breeding methods to conduct planting experiments in Yantai area. The botanical characters, fruit quality and phenology of the varieties were evaluated. The results show that 15 varieties have different characteristics in botany characters, fruit quality and maturity period. From mid-July to early November, each variety has unique varieties characteristics and can be used as a characteristic yellow and green apple variety to promote cultivation in Yantai area.

Keywords: Yantai area; yellow-green varieties; botany traits, fruit quality

Apple is the main fruit species in Yantai area with the largest cultivated plantations and the highest yield. At present, the city's Apple orchards are 174 666 ha, and the output is 4.85 million tons, accounting for 66.6 % and 82.6 % of the city's total fruit production and total output. It plays a pivotal role in promoting agricultural efficiency, increasing farmers' income and rural economic development in the city. However, the main apples varieties in Yantai, such as Fuji, Gala, and Red General, are all red varieties. The cultivated area of yellow and green varieties is less than 1%, which is difficult to meet the diversified fruit demand of consumers. In order to enrich apple variety structure in Yantai area and increase the diversity of yellow-green varieties, Yantai Academy of Agricultural Sciences Apple breeding team had introduced a series of new varieties of yellow and green apples from domestic and foreign scientific research institutes, and con-

ducted experimental trials Yantai area; In order to screen out new varieties of yellow and green apples suitable for promotion in Yantai apple producing areas, some varieties were used as parents to carry out hybrid breeding of yellow-green varieties.

MATERIALS AND METHODS

In order to meet the needs of selecting yellow and green apple varieties, 15 yellow and green apple varieties were conducted. The source of each variety is shown in Table 1. The apple variety garden is located in Fushan District, Yantai City, with an area of 0.5 hm², an average annual temperature of 12.6°C, an average frost-free period of 215 days, average annual sunshine hours of 2658 h, and a precipitation of 735 mm. The garden is flat, with deep soil layers, sandy loam, and uniform soil quality.

Table 1. Test variety materials

Variety	Parents	Breeding units or country
Zaocuilv	Liaofu×Dailv	Shandong Pomology Research Institute
Yanxiangyu	Honglu - open pollination	Yantai Academy of Agricultural Sciences
Lvshuai	Golden Delicious -open pollination	Liaoning Pomology Research Institute
Qingxiang	Golden Delicious×White winter pearmain	Qingdao Academy of Agricultural Science
Yanjin No.1	Golden Delicious×Qianqiu	Yantai Academy of Agricultural Sciences
Huajin	Spur Golden Delicious×Spur Earli Blase	Pomology Institute of Chinese Academy of Agricultural Sciences
Yanjin No.2	Honglu×Senshu	Yantai Academy of Agricultural Sciences
Mingyue	Akagi×Fuji	Japan
Orin	Golden Delicious×Indo	Japan
Jinfu	Golden Delicious - open pollination	Gansu Academy of Agricultural Sciences
Mutsu	Golden Delicious×Indo	Japan
Huayue	Golden Delicious×Huafu	Pomology Institute of Chinese Academy of Agricultural Sciences
Ruixue	Qin fuji 1×Pink Lady	Northwest Agricultural and Forestry University
Harlikar	Golden Delicious - open pollination	Japan
Gr. Smith	unknown	Australia

In 2012, M9 was used as rootstock to graft different varieties. In the spring of 2013, the garden was built and micro-spraying irrigation facilities were installed throughout the garden. The distance between the plants and rows is 2.0×4.0 m, and the tree shape is freed spindle-shaped.

The description of botanical traits and fruit economic traits of varieties refers to Wang Kun “Apple Germplasm Resource Description Specification and Data Standard” was carried out; 30 mature leaves in the middle of the shoots were collected for every cultivars and the length, width and petiole length were measured using scale. When the fruit matures, 100 fruits are selected randomly, and each index is determined. Each variety randomly took 30 fruits to measure fruit longitudinal diameter, horizontal diameter, hardness, soluble solids content and single fruit weight. Fruit longitudinal diameter, horizontal diameter and fruit handle length were measured by electronic vernier caliper. The fruit shape index is calculated according to the longitudinal diameter and horizontal diameter. The fruit hardness was determined by GY-1 hardness tester. The contents of fruit soluble solids were measured by LB50T hand-held sugar meter. The determination of soluble sug-

ar was referred to GB6194-86 and was determined by Filin reagent method. The titratable acid content is determined by NaOH titration with reference to GB12293-90.

RESULTS AND DISCUSSION

The results of botany traits survey showed that there were significant differences in leaf size, internode length, inflorescence fruit rate and flower fruit rate among 15 apple varieties (Table 2). The leaves of the four varieties of Lvshuai, Qingxiang, Huajin and Orin are larger, and the average length of the leaves is 10.0 cm or more. The leaves of the three varieties of Yanjin No.1, Huayue, and Granny Smith are small. In terms of internode length, the average internode length of Ruixue varieties is 1.8 cm, which has obvious short branch characteristics. The length of the remaining 14 varieties is above 2.0 cm, which are ordinary long-branch varieties. From the perspective of inflorescence sitting rate and flower sitting rate, the 15 varieties had good sitting rate. Under the conditions of normal bee pollination, they all could meet the needs of tree sitting fruit,

and the Huayue species had the highest sitting rate. The fruit-sitting rate of Zaocuilv and Yanjin No. 1 was 12.6% and 31.5%. Each inflorescence sat 1-2 fruits, basically without artificial fruits thinning, and had good cultivation characteristics.

A comprehensive fruit quality evaluation of 15 yellow and green apples was conducted (Table 3). The average single fruit weight of Yanxiangyu was 120.2 g, the soluble solids content was 15.5%, and the mature period was in mid-August. It was a crisp, sweet and yellow apple variety. The average single fruit weight of Zaocuilv is 195.0 g, ripens in mid-July and is the earliest green apple variety in all the varieties.

Huajin, Lvshuai, Orin, Yanjin No. 2, Ruixue and Harlikar are the species with larger fruit, with an average single fruit weight of more than 220 g. The acidity of the three varieties of Huajin, Mutsu, and Granny Smith is relatively large, with titratable acid content of more than 0.5 %, and Granny Smith even reaches 1.22 %. It is a good fresh and processing variety. Huayue with an average single fruit weight of 191.5 g, is a small fruit, yellow coloured and late ripening variety. Harlikar and Ruixue are two yellow late-ripening varieties, with an average single

fruit weight of about 230 g. Compared with the two varieties, Ruixue variety have a slightly larger acid content, greater hardness, and a slightly larger sweetness of Harlikar variety. The proportion of fruit rust is larger for Harlikar apple variety.

There are many factors to determine the adaptability of Apple varieties, including the resistance to disease, abundance, quality and storage of fruit, and the ability of varieties to pollinate with existing cultivars. Zaocuilv is a precocious green apple variety selected by Shandong Provincial Fruit Tree Research Institute (Li Linguang et al., 2004). The skin is green, the meat is thin and crisp, the taste is sweet and the aroma is strong. It has a good cultivation performance in Shandong Province and Henan province (Sun Ang et al., 2017). The results of this experiment show that Zaocuilv also has a good cultivation performance in Yantai area, and it is not necessary to artificial fruits thinning and save labor. Lvshuai is a green variety selected by Liaoning Pomology Research Institute (Yi Kai et al., 2005). It has strong resistance to apple rot disease. The results show that the variety is large in fruit, green in color. It has sour and sweet delicious taste.

Table 2. Analysis of apple varieties botany traits

Variety	Length of leaf, cm	Width of leaf, cm	Petiole length, cm	Internode length, cm	Inflorescence seating rate, %	Flower sitting rate, %
Zaocuilv	9.8±0.3	6.4±0.2	2.6±0.1	2.3±0.2	57.3±2.3	12.6±1.2
Yanxiangyu	9.7±0.4	7.3±0.3	3.2±0.2	2.5±0.1	85.4±1.8	65.3±2.1
Lvshuai	10.9±0.2	6.7±0.1	2.8±0.1	2.2±0.1	89.2±2.3	67.8±1.9
Qingxiang	10.3±0.4	6.0±0.2	2.2±0.1	2.2±0.2	81.0±3.1	62.0±1.6
Yanjin No.1	8.6±0.2	5.6±0.1	3.2±0.2	2.8±0.2	84.0±2.9	31.5±1.5
Huajin	10.6±0.3	7.3±0.1	2.9±0.1	2.1±0.1	93.0±4.3	55.0±2.3
Yanjin No.2	9.4±0.2	6.7±0.2	2.8±0.2	2.4±1.2	68.5±2.1	52.3±1.8
Mingyue	9.8±0.3	6.2±0.2	3.1±0.2	2.4±0.1	88.2±2.7	67.3±2.1
Orin	11.5±0.2	7.8±0.2	3.2±0.2	2.5±0.2	87.5±3.1	56.2±1.5
Jinfu	9.8±0.2	6.5±0.1	2.7±0.1	2.2±0.1	80.0±2.1	55.0±1.9
Mutsu	9.7±0.3	6.6±0.2	3.0±0.1	2.8±0.2	94.0±2.3	41.2±1.5
Huayue	8.6±0.3	5.4±0.1	2.5±0.2	2.3±0.1	96.5±3.5	84.4±2.1
Ruixue	9.7±0.2	6.4±0.2	3.1±0.1	1.8±0.1	85.2±2.2	67.8±1.9
Harlikar	9.3±0.3	6.7±0.3	2.8±0.2	2.7±0.2	89.5±2.5	76.5±1.5
G. Smith	8.9±0.2	5.7±0.2	2.4±0.1	2.6±0.1	74.1±2.3	63.2±1.9

Table 3. Fruit economic traits of different apple varieties

Variety	Fruit weight, g	Fruit index	Soluble solids content%	Fruit hardness kg/cm ²	Vitamin C, mg/100 g	Soluble sugar, %	Titratable acid, %	Fruit mature period
Zaocuilv	195.0±2.3	0.92±0.08	12.5±0.2	8.6±0.2	3.56±0.23	5.5±0.3	0.20±0.05	mid-July
Yanxiangyu	120.2±4.8	0.95±0.07	15.5±0.3	9.2±0.3	2.53±0.21	11.3±0.2	0.32±0.02	mid-August
Lvshuai	235.7±5.2	0.86±0.09	12.8±0.2	9.2±0.2	2.86±0.23	10.9±0.2	0.34±0.04	late August
Qingxiang	207.3±3.5	0.89±0.04	13.5±0.5	9.6±0.3	2.47±0.19	8.9±0.2	0.23±0.03	mid-September
Yanjin 1	226.5±3.6	0.85±0.07	14.2±0.4	8.6±0.2	2.89±0.27	10.8±0.3	0.36±0.02	end of August
Huajin	241.2±5.2	0.84±0.05	14.4±0.2	8.2±0.2	3.31±0.21	8.9±0.2	0.50±0.04	mid-September
Yanjin 2	235.2±4.2	0.87±0.04	14.8±0.3	8.8±0.2	2.57±0.32	10.5±0.2	0.33±0.02	late September
Mingyue	205.5±2.3	0.89±0.02	14.3±0.1	8.6±0.3	2.83±0.27	10.2±0.3	0.31±0.03	late September
Orin	260.0±5.1	0.85±0.03	12.5±0.4	9.3±0.3	5.31±0.21	9.3±0.2	0.58±0.04	mid-October
Jinfu	285.2±6.4	0.84±0.07	14.5±0.3	9.0±0.3	3.27±0.18	10.8±0.3	0.29±0.02	mid-October
Mutsu	220.0±4.3	0.83±0.02	14.2±0.1	10.2±0.2	3.52±0.23	8.6±0.2	0.34±0.02	mid-October
Huayue	191.5±4.2	0.84±0.05	14.3±0.3	8.2±0.1	4.23±0.19	9.3±0.1	0.47±0.04	mid-October
Ruixue	235.8±3.9	0.91±0.04	13.5±0.2	8.8±0.2	3.31±0.22	9.3±0.3	0.32±0.02	late October
Harlikar	238.6±3.5	0.94±0.03	15.2±0.2	8.3±0.2	3.65±0.20	10.3±0.2	0.25±0.03	late October
Gr. Smith	215.5±2.1	0.96±0.04	13.2±0.2	12.1±0.2	5.16±0.15	10.2±0.2	1.22±0.15	early Novem.

Qingxiang and Huajin are green apple varieties selected by the Qingdao Academy of Agricultural Sciences (Si Qing et al., 1991) and Pomology Institute of Chinese Academy of Agricultural Sciences (Cheng Cungang et al., 2004). The maturing period is in mid-September, the fruit is smooth and rust-free. It is a good green and late ripening apple variety which could be moderately promoted in Yantai area. Mingyue and Mutsu are late-ripening yellow-green varieties introduced from Japan. The maturing period is in late September. Mingyue is closely related to Fuji, and Mutsu is a triploid species. The two varieties can be promoted in Yantai, but they are not easy to make Fuji variety pollination variety. Orin and Jinfu are late-ripening yellow apple varieties, fruit are large and the quality is excellent. They can be promoted in Yantai area.

Huayue is a yellow apple variety cultivated by Pomology Institute of Chinese Academy of Agricultural Sciences (Yang Zhenying et al., 2010). The tree is highly resistant to disease and has excellent fruit quality. It can be used as a medium-sized yellow variety for promotion in Yantai area. Harlikar is a late-ripening yellow variety cultivated in Japan

(Wang Shubo, 2015). The fruit is crisp and sweet, good storage resistance, and has good early fruit, high quality, and abundant production characteristics. It can be widely promoted in Yantai area. Ruixue is a late-ripening yellow apple variety cultivated by Northwest Agricultural and Forestry University (Wang Leicun et al., 2016). After years of continuous observation, the variety has a good fruit shape and beautiful appearance. It can be used as a late-ripening yellow variety in Yantai area. Granny Smith is a traditional green apple variety. The fruit maturation period is late in Yantai area, and the fruit flavor is acidic, and it is mostly grown as a processed variety or a tempered acid variety.

Yanxiangyu, Yanjin No. 1 and Yanjin No. 2 are yellow apple varieties independently bred by Yantai Academy of Agricultural Sciences. The average single fruit weight of Yanxiangyu is 120.2 g with the mature period in mid-August. It is a crisp-sweet-yellow-small apple variety. The Yanjin No. 1 maturing period is end of August and it is a green apple variety that saves labor. Yanjin No. 2 maturing period is late September and is a medium-late ripening yellow variety. These three varieties can also be tested and promoted in Yantai.

CONCLUSIONS

Yellow and green varieties are important types of apple varieties. Differently colored apple varieties have different health values. Red apple could reduce blood fat, soften blood vessels, improve memory, and maintain the health of the urinary system; Green apple has the effect of liver detoxification, fight depression, promote tooth and bone growth, prevent gum bleeding; Yellow apples could enhance the body's immune system, protect vision and prevent certain cancers. The yellow-green apple varieties do not need consider the color, they can conform to the demand for labor-saving. Therefore, all parts of the world are constantly committed to the cultivation and development of yellow-green varieties. 15 yellow and green varieties were evaluated. Different varieties showed certain differences in maturity and fruit quality. They all could be promoted as specialty varieties in Yantai area. Next step should be to promote widespread consumer recognition of yellow and green varieties; at the same time, the characteristics of yellow and green varieties, cultivation management technology and post-harvest storage preservation technology will be strengthened to further improve the yield and storage performance of varieties.

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