

# 枣幼胚培养后代新品种晚脆蜜的选育

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**摘要:**晚脆蜜是六月鲜枣品种的控制杂交后代经幼胚培养技术选育而成的鲜食枣新品种。该品种树体矮化, 树冠紧凑, 枣头枝节间短, 适宜密植栽培。果实长椭圆形, 果型较大, 平均单果质量为14.7 g。果实硬度大, 肉质致密, 耐贮性较强。鲜枣可食率95.20%, 可溶性固形物含量(w, 后同)为28.4%, 总糖含量27.5%, 酸含量0.383%, 维生素C含量3580 mg·kg<sup>-1</sup>。在山西太谷地区, 4月中旬开始萌芽, 6月上旬进入盛花期, 9月下旬果实成熟, 果实生育期110 d左右, 属于晚熟类型。早果丰产性能较强, 2~3年生枝的枣吊平均结果1.0个, 3~5年生树产量6250 kg·hm<sup>-2</sup>。果实抗裂果能力强, 裂果率仅为3.8%。该品种是一个树体矮化、早果丰产、抗裂耐贮、晚熟优质的鲜食品种, 具有良好的产业发展前景。

**关键词:**枣; 新品种; 晚脆蜜; 幼胚培养后代; 抗裂果

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## Breeding report of a new variety of Chinese jujube Wancuimi via embryo culture

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**Abstract:** *Ziziphus jujuba* Mill. is one of the important fruit trees native to China. With the continuous changes in the market, fresh jujube variety has high economic benefit and great development potential. There is an urgent demand to breed new varieties of fresh jujube with both crack resistance and high fruit quality. The problem of jujube embryo abortion seriously restricts the process of jujube hybrid breeding. Embryo culture technology provides the possibility to solve the problem of early embryo abortion and offers a new way for breeding new variety. Breeders have attempted to use embryo culture to obtain jujube hybrid offspring, but so far there have been no reports on obtaining new varieties. Wancuimi is a new cracking resistant and late maturing jujube variety obtained through immature embryo culture technology after controlled hybridization of fresh jujube variety Liuyuexian with Mifengguan. The growth vigor of this variety was moderate and robust. The main trunk was longitudinally cracked, the branches were purple-red, the internodes were short, and the thorns were undeveloped. The leaf blade was ovate-lanceolate, slightly curled inward, with blunt apex, wedge-shaped base, and blunt teeth on the margin. The flowering amount was moderate, with diurnal opening. Compared with the maternal variety Liuyuexian, the internodes of this variety were shorter. This variety exhibited strong early yield performance, with an average of 1.0 fruit per hanging branch of 2-3 year-old branches. The grafted

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trees began to bear fruit in the second year. The fruits of this variety were relatively large, oblong. The average single fruit weight was 14.7 g. The fruit shoulder was flat, the top was slightly protruding, and the fruit dots were small and dense. The flesh was dense, showing significantly higher fruit strength, flesh hardness, flesh thickness, and flesh compactness than Liuyuexian. The fruit color was red, with a sweet and sour taste, and good freshness. The edible rate of the fresh jujube was 95.2%, the soluble solid content was 28.4%, the soluble sugar content was 27.5%, the acidity was 0.383%, and the vitamin C content was  $3580 \text{ mg} \cdot \text{kg}^{-1}$ . The fruit core was middle-large, long-spindle-shaped, with plump kernels and a high kernel rate. The seeds were spindle-shaped and reddish-brown. This variety had strong crack resistance, with a low cracking rate of 3.8%, far lower than the cracking rate of 38.8% of the Liuyuexian. In the Taigu county of Shanxi, bud burst was in mid-April, initial flowering in late May, peak flowering in early June, fruit coloring in mid-September, and fruit maturation in late September. The fruit development period was about 110 days, belonging to the late-maturing variety type. This variety was a fresh eating variety with compact tree body.

**Key words:** Chinese jujube; New variety; Wancuimi; Immature embryo culture offspring; Crack resistance

枣(*Ziziphus jujuba* Mill.)是原产中国的重要果树之一。随着市场的不断变化,以制干枣品种为主的现状难以满足消费者多样化的需求,而且发展鲜食枣的经济效益高、发展潜力大<sup>[1]</sup>。但在生产中鲜食枣优质不抗裂或抗裂不优质的问题较为突出,严重制约着鲜食枣产业的健康和高质量发展。因此,亟须选育抗裂果兼具优质的鲜食枣新品种。

枣栽培历史悠久,但育种技术进展缓慢,长期以来枣树育种一直以芽变选种、株系选优和实生选种为主,杂交育种十分困难<sup>[2]</sup>。主要原因是枣胚发育不良或中途败育现象普遍存在,致使许多拥有优良性状的枣种质,因无法获得后代而难以被利用,从而限制了亲本的选择,加大了杂交育种的局限性。胚培养技术为解决枣胚败育问题提供了可能,以期为加快品种选育进程开辟一条新途径<sup>[3]</sup>。有研究者<sup>[4-8]</sup>试图采用幼胚培养技术获得枣杂种后代,但迄今未见获得新品种的报道。笔者自2001年以来致力于枣胚培养技术研究,先后建立了枣胚培养体系<sup>[9]</sup>、幼胚经愈伤组织培养的技术体系<sup>[10-12]</sup>,成功获得了一批胚培苗,为利用幼胚培养选育枣优良品种提供了技术支持。

六月鲜枣是山东省原产的中熟、质优的鲜食地方良种<sup>[13]</sup>。晚脆蜜枣是笔者于2010年开始利用六月鲜为母本的控制杂交后代经幼胚培养技术获得,是国内首次通过幼胚培养技术选育而成的鲜食良种,具有丰产、抗裂果、耐贮、优质、晚熟等特性。该品种的选育成功为枣育种技术和种质创新开辟了新

途径。

## 1 选育过程

2010年5月在山西农业大学(山西省农业科学院)果树研究所选取生长发育正常的6株10年生六月鲜枣品种,在树体上部各方位高接蜂蜜罐枣品种开展控制杂交授粉试验。因六月鲜后代的种仁发育不饱满,播种后很难获得后代。而幼胚培养技术可以使许多具有特异性状优良枣种质的幼胚得以挽救而获得后代。2012年7月采集经控制杂交后代的幼胚(胚龄30 d,小球形胚阶段),在无菌条件下进行胚乳看护培养,在培养基MS、水解乳蛋白 $0.5 \text{ mg} \cdot \text{L}^{-1}$ 、糖浓度7%,温度 $(24 \pm 2) \text{ }^{\circ}\text{C}$ 和光照(时间 $14 \text{ h} \cdot \text{d}^{-1}$ ,光照度 $3000 \text{ lx}$ )条件下添加适宜的激素配比( $0.5 \text{ mg} \cdot \text{L}^{-1}$  IBA +  $1.5 \text{ mg} \cdot \text{L}^{-1}$  ZT +  $3.0 \text{ mg} \cdot \text{L}^{-1}$  GA<sub>3</sub> +  $0.2 \text{ mg} \cdot \text{L}^{-1}$  NAA),成胚率达52.53%。幼胚经胚乳看护培养后形成球状体,将其完整剥离,放入 $2.0 \text{ mg} \cdot \text{L}^{-1}$  BA的培养基中进行愈伤组织诱导。将诱导形成的愈伤组织转接到添加 $0.5 \text{ mg} \cdot \text{L}^{-1}$  TDZ培养基中,在30 d后愈伤明显增多且质地良好,并有绿色芽点出现,分化率达70.06%。将已获得的胚培苗剪成留3~4片叶的茎段,接入MS +  $2.0 \text{ mg} \cdot \text{L}^{-1}$  BA +  $0.5 \text{ mg} \cdot \text{L}^{-1}$  IBA +  $0.06 \text{ mg} \cdot \text{L}^{-1}$  NAA的培养基上进行扩繁增殖。经扩繁后的胚培苗进行生根培养,生根率达90%。炼苗后,于2013年春移栽到大田栽培观察。2016年从50个胚培养品系中筛选出编号为6-6的优良品系。该品系不仅表现果实成熟期较晚、抗裂果、鲜食品质优

异,而且还具有树体生长势中庸、节间短等特性。2016年采集优良品系6-6的接穗,经嫁接繁殖、性状观察和区域试验,表现性状稳定一致。经与母本品

种六月鲜比较,表现果实成熟期晚、果肉质致密及枝条节间短等特异性,经SSR分子检测,DNA多态性高度相似,将其定名为晚脆蜜(图1,图2)。于

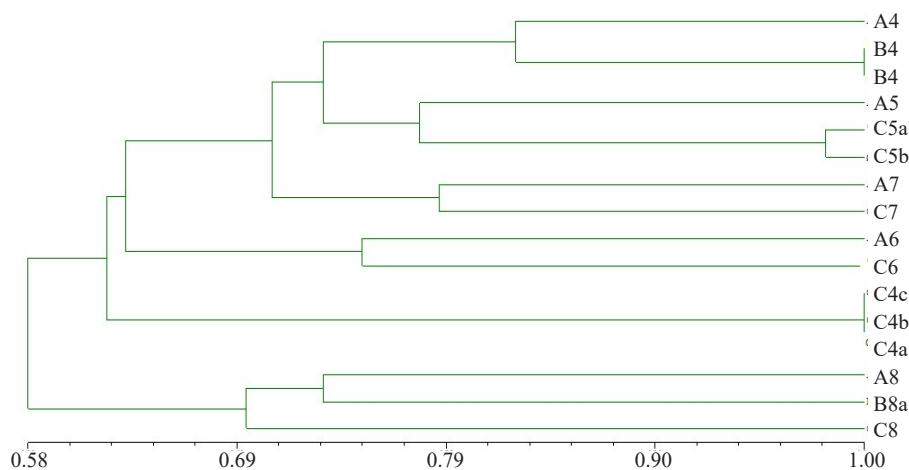


A. 丰产状;B. 节间对比;C. 晚脆蜜果实。

A. Fertility; B. Inter node comparison; C. Wancuimi fruit.

图1 晚脆蜜品种性状特征

Fig. 1 A new late-ripening, crack resistance *Ziziphus jujuba* variety Wancuimi



A4. 冷白玉;B4. 冷白玉胚培养后代;A5. 襄汾圆枣;C5a, C5b. 襄汾圆枣胚培养后代;A7. 山东梨枣;C7. 山东梨枣胚培养后代;A6. 六月鲜;C6. 晚脆蜜;A8. 迎秋红;B8、C8. 迎秋红胚培养后代。

A4. Lengbaiyu; B4. Embryo culture offspring of Lengbaiyu; A5. Xiangfenyuanzao; C5a, C5b. Embryo culture offspring of Xiangfenyuanzao; A7. Shandonglizao; C7. Embryo culture offspring of Shandonglizao; A6. Liuyuexian; C6. Wancuimi; A8. Yingqiu hong; B8, C8. Embryo culture offspring of Yingqiu hong.

图2 晚脆蜜与六月鲜品种的聚类分析

Fig. 2 The cluster analysis of Wancuimi and Liuyuexian

2023年12月通过山西省林木品种审定委员会审定(良种编号:晋S-SV-ZJ-014-2023)。

## 2 主要性状

### 2.1 植物学特征

晚脆蜜树体较小,树姿较开张。主干条状皮裂,枣头枝为紫红色,节间短,节间长度7.5 cm,二次枝节间长度4.6 cm,弯曲度中等,针刺不发达。2~3年生枝每枣股枣吊数5.5个,枣吊长度22 cm,叶片数13枚。叶片中大,叶长6.2 cm,宽3.1 cm,叶片卵状

披针形,微内卷,叶尖钝尖,叶基圆楔形,叶缘钝齿。花量中等,花序着花4~9朵,蜜盘乳黄色,花径6.43 mm,昼开型。该品种与六月鲜枣相比表现枝条节间较短(表1)。

### 2.2 生长结果习性

晚脆蜜树体矮化,生长势中庸健壮,幼龄枝结果能力强。经多年调查,果吊率较高,2~3年生枝的枣吊平均结果1.0个,对照品种六月鲜为0.9个。嫁接树第2年开始结果,第3~5年平均产量6750 kg·hm<sup>-2</sup>,早果丰产性能较强。晚脆蜜品种与对照品种六月鲜相比

表1 晚脆蜜与六月鲜枣品种的主要生长和结果性能

Table 1 The main growth and fruiting performance of Wancuimi and Liuyuexian

品种 Variety	生长势 Growth vigor	节间长度 Internode length/cm	股吊率(吊·股 <sup>-1</sup> ) Bearing branches per spur/Bearing branches		果吊率(果·吊 <sup>-1</sup> ) Fruits per bearing branch/Fruits		平均产量 Yield/(kg·hm <sup>-2</sup> ) 3~5 a
			1 a	2~3 a	1 a	2~3 a	
晚脆蜜 Wancuimi	中庸 Medium	7.5	1.4	5.5	0.83	1.0	6750
六月鲜 Liuyuexian	强 Strong	9.5	1.0	3.5	0.62	0.9	6600

表现树体生长势中庸健壮(表1)。

### 2.3 物候期

在山西太谷地区,晚脆蜜4月中旬开始萌芽,5月下旬为初花期,6月上旬进入盛花期,9月中旬果实开始着色,9月下旬果实成熟进入脆熟期。果实

生育期110 d左右,为晚熟品种类型。与六月鲜品种相比,成熟期晚10 d以上(表2)。

### 2.4 果实经济性状

晚脆蜜果实较大,长椭圆形,纵径3.37 cm,横径2.56 cm,平均单果质量14.7 g。果肩平,果顶稍突出,果

表2 晚脆蜜与六月鲜品种的主要物候期(山西太谷)

Table 2 The main phenological characteristics of Wancuimi and Liuyuexian

品种 Variety	萌芽期 Sprout date	盛花期 Full flowering date	脆熟期 Crisp ripening date	果实生育期 Fruit growth period/d	成熟期评价 Ripening evaluation
晚脆蜜 Wancuimi	4月中旬 Middle April	6月上旬 Early June	9月下旬 Late September	110	晚熟 Late ripening
六月鲜 Liuyuexian	4月中旬 Middle April	6月上旬 Early June	9月中旬 Middle September	100	中熟 Middle ripening

点小而密。果实硬度大,肉质致密。采用英国 Stable Micro Systems 公司生产的 TA.XT plus 质构仪测定,在果皮强度、果肉硬度、果肉粗细、果肉内聚性等果肉质相关指标显著高于六月鲜。果实色泽红色,风味酸甜,鲜食口感好。鲜枣可食率95.2%,可溶性固形物含量28.4%,可溶性糖含量27.5%,酸含量0.383%,维

生素C含量3580 mg·kg<sup>-1</sup>。果核中大,长纺锤形,种仁饱满,含仁率较高。种子倒纺锤形,红褐色。晚脆蜜与对照品种六月鲜相比,果肉质表现致密(表3)。

### 2.5 耐贮性、抗裂果性

晚脆蜜品种耐贮性较强,在冷库常规管理条件下,贮存2个月后,好果率仍可超过90%。该品种具

表3 晚脆蜜与六月鲜品种的果实特性

Table 3 The fruit characteristics of Wancuimi and Liuyuexian

品种 Variety	单果质量 Single fruit mass/g	果实形状 Fruit shape	果肉质地 Flesh texture/g	果皮强度 Preicarp strength	果肉硬度 Flesh firmness/g	果肉粗细 Flesh thickness	果肉内聚性 Fruit cohesion/(g·mm <sup>-1</sup> )	可食率 Fresh fruit edible rate/%	w(可溶性固形物) Soluble solid content/%	w(可溶性糖) Soluble sugar content/%	w(可滴定酸) titratable acid/%	w(维生素C) Vitamin C content/(mg·kg <sup>-1</sup> )
晚脆蜜 Wancuimi	14.7	长椭圆形 Oblong	致密 Dense	1 017.58 A	639.53 A	6.02 A	59.64 A	95.2	28.4	27.5	0.383	3580
六月鲜 Liuyuexian	15.0	卵圆形 Oval	松脆 Crisp	801.31 B	400.55 B	4.89 B	37.64 B	93.5	28.6	28.0	0.335	3130

注:邓肯氏新复极差检验, $\alpha=0.01$ ,不同字母表示差异极显著。

Note: Mean separation was conducted using Duncan's new multiple range test at  $\alpha=0.01$ , and the different letters within the same cocolumn represent significant difference.

有较强的抗裂果能力。裂果率较低,平均仅为3.8%,远低于六月鲜品种裂果率38.8%。

## 3 栽培技术要点

### 3.1 栽植密度和建园技术

适宜密植栽培,株行距(2.0~2.5)m×(3.0~4.0)m,

每666.7 m<sup>2</sup>栽65~110株。根据立地条件、树形及栽培模式等决定适宜的密度。可通过定植嫁接苗、坐地酸枣苗嫁接和高接换优等途径建园。

### 3.2 树形和整形修剪技术

树形采用小冠疏层形或纺锤形等。小冠疏层形树高控制在1.8~2.0 m,干高30~50 cm,全树有5~7

个骨干枝,分二层着生在中央领导干上。纺锤形树高控制在 1.8~2.0 m,干高 40~50 cm,自主干距离地面 40 cm 以上螺旋状排列 15~17 个二次枝。该品种树冠紧凑、生长势中庸健壮且枝条节间短,夏季修剪较为省工。夏剪主要采用抹芽、摘心、拉枝和环剥等措施,促进早果丰产。冬剪以疏枝为主。

### 3.3 花果管理技术

晚脆蜜具有较强的早果丰产性能,但花期采用环剥、环割、摘心、拉枝以及喷赤霉素、硼酸、磷酸钾肥等措施可显著提高产量。对设施栽培、肥水条件较好、树势偏旺的骨干枝在盛花期采取 1 次环割措施,可达到控势增产的效果。该品种的结果能力强,为实现其丰产稳产,除加强修剪、肥水管理外,还要注意合理负载。一般 2~3 年生的初果期树应控制在 4500~5250 kg·hm<sup>-2</sup>,5 年后盛果期不应超过 15 000 kg·hm<sup>-2</sup>。

### 3.4 土肥水管理技术

适宜土层深厚、土壤肥力较高、有机质含量高的壤砂土。萌芽期、枣头枝旺长期和果实膨大期对肥水需求较大,分别浇水 1 次,果实膨大期追施磷酸钾肥 300 kg·hm<sup>-2</sup>,秋季施有机肥 45 000~75 000 kg·hm<sup>-2</sup>,并灌封冻水。

### 3.5 病虫害防控技术

遵循“预防为主、综合防治”的原则,注意绿盲蝽象、食芽象甲、枣锈病等病虫害的防治。

## 4 市场前景展望

晚脆蜜是国内首次通过枣幼胚培养技术选育而成的鲜食枣新品种,具有树体矮化、早果丰产、抗裂果、耐贮、晚熟优质的特性。该品种解决了枣产业中抗裂果且优质鲜食枣品种稀缺的问题,据该品种的特性、用途及各区试点的表现,可在全国枣主要产区发展推广,在国内市场上有巨大的潜力和广阔的前景。

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