

西南地区梨轻简化栽培品种和树形综合评价

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摘 要:【目的】明确西南地区梨轻简化栽培树形和品种的适配性,实现良种良法配套和省力高效栽培。【方法】以西南地区代表性梨园为研究对象,开展了不同品种在不同树形下新梢长势、萌芽率、成枝力、中短枝比例、早果性、产量等生长结果特性调查,并利用模糊评价法进行系统评价分析。【结果】(1)西南地区梨园树形以开心形为主,其余树形呈零星分布,栽培品种以砂梨品种和特色红皮梨为主。(2)采用开心形树形综合表现较好的品种有黄金、圆黄、爱宕、满天红、美人酥、丰水、翠冠、翠玉8个。采用圆柱形树形的翠玉综合评价值最高,为0.755;彩云红最低,为0.561;总体排名由高到低依次为翠玉、美人酥、满天红、彩云红。采用倒伞形树形后综合评价值由高到低依次为爱宕、丰水、黄冠、圆黄、翠玉、爱甘水。(3)圆黄生产上采用的树形主要包括开心形、倒伞形2种,不同梨园采用开心形的圆黄综合评价值分别为0.763和0.762,均高于倒伞形的0.462。采用不同树形的翠玉生长结果综合评价值由高到低依次为圆柱形、开心形(密植)、倒伞形,分别为0.740、0.690和0.490。美人酥采用不同树形后综合评价值由高到低依次为圆柱形、Y字形、开心形(稀植)。满天红采用圆柱形整体表现优于开心形,采用圆柱形树形的综合评价值为0.828,开心形树形分别为0.604和0.467。采用开心形树形的翠冠适当密植有更好的生长结果表现。【结论】多主枝开心形和圆柱形可作为西南梨产区主推轻简化栽培树形。多主枝开心形可作为黄金、圆黄、爱宕、满天红、美人酥、丰水、翠冠、翠玉的轻简化树形,圆柱形是翠玉、美人酥、满天红、彩云红的适宜轻简化栽培树形。

关键词:梨;西南地区;轻简化;品种;树形;评价

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Comprehensive evaluation on pear varieties and tree shapes used for labor-saving and simplified cultivation in Southwest of China

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Abstract: 【Objective】 The Southwest of China is an important pear production area, with abundant rainfall, long frost-free period, rapid shoot growth, complex terrain and different types of microclimates. If the cultivation techniques are not suitable for varieties, the orchard establishment may be failed, and labor cost may increase, which would seriously restrict the healthy and sustainable development of pear industry. This study aimed at clarifying the tree shapes and variety adaptability with labor-saving and simplified cultivation in Southwest of China, and realized the matching of quality varieties and fine methods for labor-saving and high-efficiency cultivation of pear. 【Methods】 The growth and fruiting characteristics of different varieties and tree shapes were investigated in representative pear orchards in Southwest of China, including new shoot growth vigor, bud break rate, branching ability, proportion of medium shoots and spurs, precocity and yield, and systematic evaluation and analysis were carried out by using fuzzy evaluation method. 【Results】 (1) The common tree shape in Southwest of

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China was open-center system, which was distributed in all production areas, and the other shapes were sporadically distributed. The varieties cultivated were *Pyrus pyrifolia* mainly bred by Japan and South Korea, and red-skinned pear varieties; (2) The growth and fruiting performance of Whangkeumbae pear was the best, and the Cangxi 5-51 was the worst with the open-center system at low planting density. The comprehensive evaluation value of Whangkeumbae, Wonhwang, Atago, Cuiguan and Cuiyu pear were all above 0.70. In high planting density mode, there were 4 varieties' evaluation values above 0.70 with the open-center system, including Cuiguan, Cuiyu, Wonhwang and Housui pear. The pillar shape was mainly distributed in Chongqing city and Yunnan province. The comprehensive evaluation value of Cuiyu pear was the highest, which was 0.755, followed by Meirensu pear, which was 0.632, and Caiyunhong pear was the lowest, which was only 0.561. The overall ranking from high to low order was Cuiyu>Meirensu>Mantianhong>Caiyunhong pear. There were 6 varieties that were adopted the inverted-umbrella shape in Guizhou province. The comprehensive evaluation values from high to low order were Atago>Housui>Huang Guan>Wonhwang>Cuiyu>Aiganshui pear. The inverted-umbrella system was more suitable for the application of *P. pyrifolia* varieties; (3) There were mainly two kinds of tree shapes used in the production of Wonhwang pear, including open-center system and inverted-umbrella system. The comprehensive evaluation values of the open-center system in different orchards were 0.763 and 0.762, respectively, which were higher than the inverted-umbrella system. The comprehensive evaluation values of Cuiyu pear with different shapes from high to low order were the pillar system>the open-center system>inverted-umbrella system, which were 0.740, 0.690 and 0.490, respectively. After adopting different tree shapes, the comprehensive evaluation values from high to low order of Meirensu pear were pillar system>Y-system>open-center system (at low density). The performance of Mantianhong pear using pillar system was better than that of open-center system. The comprehensive evaluation value of the pillar system was 0.828, while the open-center shape was 0.604 and 0.467, respectively. The growth and fruiting performance of Cuiguan pear in appropriate high density planting mode was better than that at low planting density. 【Conclusion】 In conclusion, the pillar system and open-center system with multiple scaffold limbs could be used as the main popularized tree shape in Southwest of China. The open-center system with multiple main scaffold limbs could be used as the labor-saving and simplified cultivation tree shape of Atago, Wonhwang, Housui, Whangkeumbae, Mantianhong, Meirensu, Cuiguan and Cuiyu pear. The pillar system was suitable for the labor-saving and simplified cultivation of Cuiyu, Meirensu, Mantianhong and Caiyunhong pear. It was suggested to adopt the open-center shape with multiple scaffold limbs in steep and irregular mountainous areas or those with little sunshine, and the row space was 2.0 m × 4.0 m, and there were 5-6 scaffold limbs. In areas with gentle terrain and sufficient light, the pillar system was recommended, and the recommended plant row space in production was (1.0-2.0) m × 4.0 m, with 25-30 fruiting branch groups on the central leader.

Key words: Pear; Southwest of China; Labor-saving and simplified; Varieties; Tree shape; Evaluation

西南梨产区是中国重要的梨产区之一,主要包括云、贵、川、渝四地,该产区雨量充沛,无霜期长,果树生长量大,地形复杂,小气候区域较多^[1]。截止到2019年,云南省梨栽培面积约6万hm²,产量达到110多万t;贵州省山地、丘陵面积大,气候特殊,梨栽培面积已达到5万多hm²,品种以砂梨品系为主;四

川和重庆梨产区是中国南方早熟梨优势主产区,梨栽培面积近9万hm²,产量达到120多万t^[2]。其中,云南省特色红梨产区成功入选农业部2009—2015年全国梨重点区域发展规划^[3],西南地区梨产业的快速发展有效带动了果农增收致富,为全面乡村振兴战略的实施提供了有力支撑。省力化、轻简化栽

培是果树产业发展的必然趋势^[4],果树生产属于劳动密集型产业,随着社会老龄化趋势不断加剧,中国果树生产劳动力短缺的问题日益凸显,因此,实现果园栽培管理的轻简化已成为现代果业亟需解决的难题。

品种和树形的选择是轻简化栽培模式的两个关键因素。自20世纪50年代以来,中国科学工作者相继选育了早酥、玉露香、黄冠、翠冠等180余个品种^[5],加上原有的地方品种及国外引进的优新品种,品种资源十分丰富,这为中国梨产业的快速发展奠定了“良种”基础。同时,中国研究人员基于果树产业发展方向,在省力化栽培模式的构建与应用方面也取得了大量科研成果,创建了多种省力化、轻简化的新树形或新模式,如圆柱形树形^[5]、双臂顺行式栽培模式^[6]、Y字形树形^[7]、“3+1”树形^[8]等,为梨产业轻简化栽培发展提供了“良法”。果树种植的区域性较强,同一品种在不同产区的生长结果习性存在差异,不同品种在同一产区不同栽培模式下表现也不尽相同^[9-11]。西南梨产区地形和生态环境复杂多样,生产上由于良种良法不配套,建园效果差或失败的现象频发,这严重制约了该产区梨产业的健康可持续发展。

现有研究对树形评价更多关注光合、果实品质的影响^[12-13],从树体生长结果综合表现的角度来评价树形与品种是否匹配却鲜有报道。隶属函数评价法采用模糊数学原理,是一种通过计算各指标相应的隶属函数值进行加权得到综合评价,进而完成多指标综合评价的方法^[14]。鉴于此,笔者在本研究中利用模糊评价法综合评价不同品种采用不同树形后的生长结果表现,探讨西南梨产区不同品种适宜的轻简化栽培树形,以期为西南梨产区的轻简化栽培和良种良法配套提供理论依据。

1 材料和方法

1.1 调查对象及内容

以西南地区24个肥水管理水平相近的代表性梨园中的17个品种为主要研究对象(表1),对不同梨园的品种、树高、冠幅、树龄、株行距、新梢长度、萌芽率、成枝力、长中短枝比率、早果性、产量指标进行实地调查,调查区域年平均降水量介于900~1100 mm之间,年平均温度14~19℃。

调查树形包括4种:圆柱形、倒伞形、开心形和

Y字形。圆柱形树形利用强壮中心干上直接着生足够数量的小型结果枝(组),枝干级次少,冠幅小,早期产量高;倒伞形树形也称为“3+1”树形,基部三主枝及中心干是其主要的结果部位;棚架栽培通过引缚上架使枝条分布更均匀,位置更合理,光照分布更好,果品质量一致性好;Y字形树形的双主枝上可直接着生结果枝(组),利于控制树势,降低树高,保持高光能利用率。4种树形与传统疏散分层形相比具有结构更简单,整形修剪简化、果品优,且更有利于机械化等优点。

1.2 调查方法

树高、冠幅等用卷尺进行测量记录,每个梨园单株重复,共5次重复;新梢长度利用卷尺测量,选择树冠外围平斜生长的并且已停长的20条新梢进行测量;萌芽率、成枝力、早果性按照《梨种质资源描述规范和数据标准》^[15]进行调查;每个园区随机选取5株树,确定长、中、短枝数量,所有调查数据均取平均值作为最终测定值;产量指标根据单株产量称质量换算得到:产量=平均单株产量×株数;根据主枝数量将开心形分为传统开心形(2~4主枝)和多主枝开心形(5个及以上);将种植密度小于83株·666.7 m²的果园统一划归为稀植栽培进行统计分析。

1.3 数据处理和综合评价分析

所有数据均采用软件Microsoft Excel 2020进行处理。

对10个生长结果指标进行综合评价,包括1/新梢长度、萌芽率、成枝力、1/冠幅(东西)、1/冠幅(南北)、1/树高、中短枝比率、长枝比率、1/早果性、产量,具体分析方法如下^[16-17]。

首先,对原始指标数据进行标准化处理,依据式(1)计算隶属函数值。

$$X_{ij}' = \frac{X_{ij} - \min(X_j)}{\max(X_j) - \min(X_j)} \cdot \alpha + (1 - \alpha) \quad (1)$$

式中: X_{ij}' 为隶属度函数值; i 个处理的第 j 个指标原始数据值; $\min(X_j)$ 为第 j 个指标的最小值; $\max(X_j)$ 为第 j 个指标的最大值; α 为功效系数,为避免隶属函数值出现零, α 的范围选取(0,1)。本文取 $\alpha=0.6$,计算生长结果指标隶属度函数值。

采用熵值法计算各形态指标的权重系数,计算步骤如下:

将试验数据构建 m 个处理 n 个指标的判断矩阵 $X=(X_{ij})_{m \times n}$ ($i=1,2,\dots,m; j=1,2,\dots,n$)。 (2)

表 1 调查梨园的基本信息
Table 1 Information of pear orchard

地点 Site	位置 Location	品种 Variety	树形 Tree shape	株行距 Row space/ (m×m)	树龄 Tree age/ a	主枝数 Shoot number
四川省盐亭县 Yanting county, Sichuan province	E 105°22'51.087" N 31°11'1.032"	翠冠、黄金、丰水、圆黄 Cuiguan, Whangkeumbae, Housui, Wonhwang	开心形 Open-center shape	2.0×3.0	20	2
四川省苍溪县 Cangxi county, Sichuan province	E 105°55'21.180" N 31°44'28.075"	翠冠、黄金 Cuiguan, Whangkeumbae	开心形 Open-center shape	2.5×5.0	10	2
	E 105°55'38.169" N 31°44'43.835"	苍溪雪梨、苍溪 5-51 Cangxi Xue pear, Cangxi 5-51	开心形 Open-center shape	2.5×5.0	25	2
四川省南充市 Nanchong city, Sichuan province	E 106°3'27.132" N 30°44'24.207"	雪青、翠冠、西子绿、黄金 Xueqing, Cuiguan, Xizilü, Whangkeumbae	开心形 Open-center shape	2.0×4.0	17~20	2
四川省广安市 Guang'an city, Sichuan province	E 106°50'19.049" N 30°26'36.102"	黄花 Huanghua	棚架开心形 open-center shape (Shed frame)	2.0×3.0	20	2
		黄金、翠冠 Whangkeumbae, Cuiguan	开心形 Open-center shape	2.0×3.0		
		翠玉 Cuiyu	开心形 Open-center shape	1.5×4.0	5	3~4
重庆市巴南区 Banan, Chongqing	E 106°48'56.720" N 29°28'15.785"	翠冠、黄花 Cuiguan, Huanghua	开心形 Open-center shape	2.0×3.0	10	2
重庆市永川区 Yongchuan, Chongqing	E 105°50'52.704" N 29°14'11.803"	黄花 Huanghua	开心形 Open-center shape	2.0×4.0	17	2
		翠玉 Cuiyu	圆柱形 Cylindrical shape	1.5×4.0	2	19~22
贵州省毕节市 Bijie city, Guizhou province	E 105°18'30.293" N 27°12'6.992"	黄冠、圆黄、爱甘水、翠玉、丰水、爱宕 Huangguan, Wonhwang, Aiganshui, Cuiyu, Housui, Atago	倒伞形 Inverted-umbrella shape	4.0×4.0	5	3
贵州省安顺市 Anshun city, Guizhou province	E 106°19'7.665" N 26°28'37.178"	圆黄、爱宕 Wonhwang, Atago	开心形 Open-center shape	3.0×3.0	8	4~6
		晚秀 Mansoo	开心形 Open-center shape	2.0×3.0	4	6~8
云南省安宁市 Anning city, Yunnan province	E 102°26'37.990" N 24°58'12.147"	满天红、美人酥、彩云红 Mantianhong, Meirensu, Caiyunhong	圆柱形 Cylindrical shape	(1.0~1.5)× (3.0~3.5)	3~6	20~40
		满天红 Mantianhong	棚架开心形 Open-center shape (Shed frame)	3.0×5.0	12	2
	E 102°21'45.977" N 24°40'3.697"	满天红、美人酥 Mantianhong, Meirensu	开心形 Open-center shape	4.0×5.0	14	3~4

然后根据隶属函数法式(1)计算出隶属度函数值,计算出隶属度矩阵 $X'=(X_{ij}')_{m \times n}$;再计算第j项指标第i个处理指标值所占的比例[式(3)],建立数据的比例矩阵 $F=(f_{ij})_{m \times n}$ 。

$$f_{ij} = \frac{X_{ij}'}{\sum_{i=1}^m X_{ij}'}, (i=1,2,...,m; j=1,2,...,n); \quad (3)$$

第j项指标的熵值 H_j 计算如下:

$$H_j = \frac{-1}{\ln m} \sum_{i=1}^m f_{ij} \ln f_{ij}; \quad (4)$$

第j项指标的权重 W_j 计算如下:

$$W_j = \frac{1 - H_j}{n - \sum_{j=1}^n H_j}; \quad (5)$$

根据加权求和公式计算第i个处理的综合评价值 R_i ,公式如下:

$$R_i = \sum_{j=1}^n X_{ij}' W_j. \quad (6)$$

2 结果与分析

2.1 不同树形适宜品种评价与筛选

2.1.1 开心形树形 开心形树形在西南产区应用广泛,共有14个品种采用开心形(表2,表3)。

由表2可知,乔砧稀植栽培模式下不同品种新梢长度介于53.5~115.8 cm之间,其中10年生翠冠的新梢长度最长,为115.8 cm,水平棚架下开心形的满天红新梢长度最小,为53.5 cm;除圆黄、丰水外,各品种中短枝比率均高于70%;不同品种萌芽率均在70%以上;成枝力方面黄金最低,均值为1.35,其余品种均在2.0以上。不同品种产量差异较大,爱宕产量最高,达到4 500 kg·666.7 m²,黄金最低,仅为1 250 kg·666.7 m²。由综合评价结果可知,黄金表现最好,综合评价值为0.784,苍溪5-

表 2 不同品种采用开心形树形(稀植)生长结果状况及综合评价

Table 2 Growth and fruiting status and comprehensive evaluation of different varieties with the open-center tree shape (low density)

品种 Variety	新梢长度 Shoot length/ cm	萌芽率 Germina- tion rate/%	成枝力 Branching ability	冠幅 Crown width/ (m/m)	树高 Tree height/ m	中短枝比率 Medium and short branch ratio/%	长枝比率 Long branch ratio/ %	早果性 Early fruiting	产量 Yield/ (kg·666.7 m ⁻²)	综合评价 Comprehen- sive evalua- tion value	排名 Rank
满天红 Mantianhong	64.6	77	2.0	4.9/5.0	3.5	87.4	12.6	3	2400	0.658	8
美人酥 Meirensu	66.2	63	3.0	5.2/5.3	2.5	85.6	14.4	3	2400	0.703	6
圆黄 Wonhwang	76.5	86	2.0	2.8/2.6	3.5	59.7	40.3	3	3600	0.791	2
爱宕 Atago	72.0	69	2.0	3.1/3.5	3.0	86.4	13.6	3	4500	0.753	3
满天红(棚架) Mantianhong (Shed frame)	53.5	86	2.0	4.7/6.5	2.5	92.4	7.6	3	3000	0.723	5
翠冠 Cuiguan	115.8	86	3.0	2.9/4.0	2.1	70.1	29.9	4	1500	0.684	7
黄金 Whangkeumbae	102.0	85	1.0	3.5/2.4	2.1	84.7	15.3	3	1500	0.750	4
苍溪雪梨 Cangxi Xue pear	78.8	78	2.0	3.8/3.5	2.3	79.3	20.7	4	2750	0.650	9
苍溪 5-51 Cangxi 5-51	58.3	71	1.0	3.6/3.6	2.4	85.7	14.3	4	2500	0.619	10
黄金 Whangkeumbae	73.0	100	1.7	2.6/2.7	2.4	88.0	12.0	3	1250	0.792	1

表 3 不同品种采用开心形树形(密植)生长结果状况及综合评价

Table 3 Growth and fruiting status and comprehensive evaluation of different varieties with the open-center tree shape (high density)

品种 Variety	新梢长度 Shoot length/ cm	萌芽率 Germina- tion rate/%	成枝力 Branch- ing ability	冠幅 Crown width/ (m/m)	树高 Tree height/ m	中短枝比率 Medium and short branch ratio/%	长枝比率 Long branch ratio/%	早果性 Early fruiting	产量 Yield/ (kg·666.7 m ⁻²)	综合评价 Comprehen- sive evalua- tion value	排名 Rank
晚秀 Mansoo	72.33	67	2.7	2.0/2.0	4.0	75.8	24.2	3	2650	0.682	6
翠玉 Cuiyu	67.0	100	3.7	2.6/1.9	2.0	78.1	21.9	3	1200	0.736	2
翠冠 Cuiguan	62.7	83	2.8	2.6/1.3	1.8	80.9	19.1	3	2000	0.764	1
黄金 Whangkeumbae	79.5	81	1.0	2.1/1.7	2.6	84.3	15.7	3	2000	0.668	8
丰水 Housui	77.8	74	4.0	2.3/2.0	2.5	60.2	39.8	3	2000	0.708	4
圆黄 Wonhwang	100.0	75	3.3	2.2/1.2	2.8	82.6	17.4	3	2000	0.716	3
雪青 Xueqing	43.5	83	1.8	3.3/2.8	2.0	79.8	20.2	3	2250	0.678	9
西子绿 Xizilü	71.0	100	1.7	3.9/3.1	2.3	42.9	57.1	3	2250	0.666	10
黄花 Huanghua	86.0	81	2.0	4.0/3.4	2.3	70.6	29.4	3	2000	0.600	11
翠冠 Cuiguan	79.0	80	2.3	2.5/2.7	2.3	51.1	48.9	3	2000	0.664	7
黄花(棚架) Huanghua (Shed frame)	47.0	82	1.7	2.6/2.0	2.3	75	25.0	3	1500	0.687	5

51 综合表现最差,综合评价值为0.619。综合评价值在0.70 以上的品种有5 个:黄金、圆黄、爱宕、满天红、美人酥。

由表3 可知,乔砧密植栽培模式开心形树形新梢长度介于43.5~100.0 cm 之间,其中雪青新梢长度最小,为43.5 cm,圆黄新梢长度最大,为100.0 cm;除晚秀外,其余品种萌芽率均大于70%,晚秀萌芽率为67%;成枝力方面,黄金最小,值为1.0,其余品种均接近或大于2.0;除西子绿、丰水和部分翠冠园外,其余品种中短枝比例均大于70%。综合分析表明,密植模式下采用开心形树形综合评价值在0.70 以上有4 个品种,评分由高到低依次为翠冠、翠玉、

圆黄、丰水。

2.1.2 圆柱形树形 采用圆柱形树形果园主要分布于云南和重庆两地,采用该树形的品种有4 个(表4),新梢长度分布在23.1~51.8 cm 之间,2 年生翠玉新梢长度仅为23.1 cm,主干着生结果枝或枝组个数分布在20~40 个之间;除2 年生翠玉外,其余品种中短枝比率均在80%以上;4 个品种的萌芽率介于64%~83% 之间,成枝力在2.0~2.5 之间;翠玉由于树龄较小,产量最低,仅为50 kg·666.7 m⁻²。由综合评价结果可知,不同品种综合评价值由高到低依次为翠玉、美人酥、满天红、彩云红,翠玉的综合评价值最高,为0.755,彩云红综合评价值最低,为0.561。

表 4 不同品种采用圆柱形树形生长结果状况及综合评价

Table 4 Growth and fruiting status and comprehensive evaluation of different varieties with cylindrical tree shape											
品种 Variety	新梢长度 Shoot length/cm	萌芽率 Germination rate/%	成枝力 Branching ability	冠幅 Crown width/ (m/m)	树高 Tree height/ m	中短枝比率 Medium and short branch ratio/%	长枝比率 Long branch ratio/%	早果性 Early fruiting	产量 Yield/ (kg·666.7 m ⁻²)	综合评价值 Comprehensive evaluation value	排名 Rank
满天红 Mantianhong	43.0	77	2.3	1.8/2.2	4.0	81.4	18.6	2	5700	0.614	3
美人酥 Meirensu	51.8	83	2.5	2.1/2.4	4.5	89.6	10.4	2	6000	0.632	2
彩云红 Caiyunhong	51.8	68	2.0	1.5/1.9	2.5	82.6	17.4	2	2300	0.561	4
翠玉 Cuiyu	23.1	64	2.0	0.5/0.5	2.8	41.0	59.0	2	50	0.755	1

2.1.3 倒伞形树形 倒伞形树形主要在贵州省,采用倒伞形的品种有6 个(表5),新梢长度介于67.0~100.2 cm 之间,其中爱甘水新梢长度最小,为67.0 cm,圆黄的最大,为100.2 cm;中短枝比率在70%以上有3 个品种:翠玉、黄冠、爱宕;成枝力均在1.5 以上,翠

玉萌芽率最低,仅为64%,圆黄萌芽率最高,为80%;不同梨品种平均产量在1550~2050 kg·666.7 m⁻² 之间。综合评价值在0.70 以上的品种有2 个:爱宕、丰水。不同品种综合评价值由高到低依次为爱宕、丰水、黄冠、圆黄、翠玉、爱甘水。

表 5 不同品种采用倒伞形树形生长结果状况及综合评价

Table 5 Growth and fruiting status and comprehensive evaluation of different varieties with inverted-umbrella tree shape											
品种 Variety	新梢长度 Shoot length/ cm	萌芽率 Germination rate/%	成枝力 Branching ability	冠幅 Crown width/ (m/m)	树高 Tree height/ m	中短枝比率 Medium and short branch ratio/%	长枝比率 Long branch ratio/%	早果性 Early fruiting	产量 Yield/ (kg·666.7 m ⁻²)	综合评价值 Comprehensive evaluation value	排名 Rank
丰水 Housui	98.5	68	1.7	2.4/2.3	4.0	50.3	49.7	3	2000	0.779	2
爱宕 Atago	76.67	79	3.0	2.9/2.3	4.0	79.9	20.1	3	2000	0.870	1
黄冠 Huangguan	91.8	76	1.7	2.7/2.4	4.0	86.4	13.6	3	1550	0.694	3
圆黄 Wonhwang	100.2	80	1.5	3.4/3.5	4.5	62.8	37.2	3	2050	0.639	4
爱甘水 Aiganshui	67.0	71	2.0	3.7/3.5	4.5	44.1	55.9	3	1550	0.575	6
翠玉 Cuiyu	80.0	64	2.0	3.4/3.1	4.0	88.4	11.6	3	1550	0.626	5

2.2 梨优良品种适宜轻简化栽培树形的评价

2.2.1 圆黄 圆黄采用的树形包括2种:开心形和倒伞形(表6)。稀植模式开心形新梢长度最小,测定值为76.5 cm;成枝力方面开心形>倒伞形;开心形(稀植)与倒伞形中短枝比例相近,密植开心形树

形下中短枝比率最高,倒伞形比开心形(密植)长枝比例低7.69%;倒伞形冠幅最大,树高方面表现为倒伞形>开心形。采用模糊评价法可知,不同圆黄梨园采用开心形综合评价值分别为0.763和0.762,均高于倒伞形,表明开心形更适合圆黄梨的轻简化

表 6 不同树形圆黄梨生长结果状况及综合评价

Table 6 Growth and fruiting status and comprehensive evaluation of Wonhwang pear with different tree shapes

树形 Tree shape	新梢长度 Shoot length/ cm	萌芽率 Germina- tion rate/%	成枝力 Branching ability	冠幅 Crown width/ (m/m)	树高 Tree height/ m	中短枝比率 Medium and short branch ratio/%	长枝比率 Long branch ratio/%	早果性 Early fruiting	产量 Yield/ (kg·666.7 m ⁻²)	综合评价值 Comprehensive evaluation value	排名 Rank
倒伞形 Inverted- umbrella shape	100.2	80	1.5	3.4/3.5	4.5	62.8	37.2	3	2050	0.462	3
开心形(密植) Open-center shape (High density)	100.0	85	3.3	2.2/1.2	2.8	82.6	17.4	3	2000	0.763	1
开心形(稀植) Open-center shape (Low density)	76.5	86	2.0	2.8/2.6	3.5	59.7	40.3	3	3250	0.762	2

栽培。

2.2.2 翠玉 翠玉分布在贵州、重庆产区,共采用3种树形:开心形(密植)、倒伞形、圆柱形(表7)。新梢长度总体表现为:倒伞形>开心形(密植)>圆柱形,均在80 cm以内;萌芽率、成枝力开心形(密植)最高,圆柱形和倒伞形相同;圆柱形翠玉由于树龄较小,前期刻芽促分枝后导致长枝比例较高,为

59.0%,倒伞形的长枝比例最小,比相同树龄的开心形树形低47.03%;产量方面圆柱形处于始果期,仅为50 kg·666.7 m⁻²,倒伞形比密植开心形产量高25%。不同树形下翠玉综合评价值由高到低依次为圆柱形、开心形(密植)、倒伞形,综合评价值分别为0.740、0.690和0.490。综上,开心形和圆柱形均可作为翠玉的轻简化栽培树形。

表 7 不同树形翠玉梨生长结果状况及综合评价

Table 7 Growth and fruiting status and comprehensive evaluation of Cuiyu pear with different tree shapes

树形 Tree shape	新梢长度 Shoot length/ cm	萌芽率 Germina- tion rate/ %	成枝力 Branch- ing ability	冠幅 Crown width/ (m/m)	树高 Tree height/m	中短枝比率 Medium and short branch ratio/%	长枝比率 Long branch ratio/%	早果性 Early fruiting	产量 Yield/ (kg·666.7 m ⁻²)	综合评价值 Comprehensive evaluation value	排名 Rank
倒伞形 Inverted-umbrella shape	80.0	64	2.0	3.4/3.1	4.0	88.4	11.6	3	1500	0.490	3
圆柱形 Cylindrical shape	23.1	64	2.0	0.5/0.5	2.75	41	59.0	2	50	0.740	1
开心形(密植) Open-center shape (High density)	67.0	100	3.7	2.6/1.9	2.0	78.1	21.9	3	1200	0.690	2

2.2.3 美人酥 美人酥主要分布在云南产区,采用3种树形:Y字形、圆柱形、开心形(稀植)(表8)。3种树形下新梢长势相近,圆柱形树形的萌芽率高于Y字形和开心形树形,3种树形的中短枝比率均在80%以上,圆柱形长枝比例最低,3种树形的成枝力均在2.0以上。与Y字形、开心形树形相比,圆柱形树形早果性更好,树冠较小,且进入盛果期后产量更高。经综合评价可知,美人酥采用不同树形后生长

结果综合评价值由高到低依次为:圆柱形、Y字形、开心形(稀植)。

2.2.4 满天红 满天红主要分布在云南产区,采用2种树形:圆柱形、开心形(稀植)(表9),采用圆柱形树体长势较弱,新梢长度仅为43.0 cm,比棚架结构和普通开心形树形分别低了24.5%和50.2%,萌芽率和成枝力相近,但圆柱形树形6年生树体产量高达5700 kg·666.7 m⁻²,显著高于开心形和棚架开心形。满天

表 8 不同树形美人酥梨生长结果状况及综合评价											
Table 8 Growth and fruiting status and comprehensive evaluation of Meirensu pear with different tree shapes											
树形 Tree shape	新梢长度 Shoot length/ cm	萌芽率 Germina- tion rate/ %	成枝力 Branching ability	冠幅 Crown width/ (m/m)	树高 Tree height/ m	中短枝比率 Medium and short branch ratio/%	长枝比率 Long branch ratio/%	早果性 Early fruiting	产量 Yield/ (kg·666.7 m ⁻²)	综合评价价值 Comprehensive evaluation value	排名 Rank
Y 字形 Y-shape	58.8	63	3.0	3.1/6.0	2.5	88.0	12.0	3	2000	0.586	3
圆柱形 Cylindrical shape	51.8	83	2.5	2.1/2.4	4.5	89.6	10.4	2	6000	0.833	1
圆柱形 Cylindrical shape	51.8	68	2.0	1.5/1.9	2.5	82.6	17.4	2	2300	0.780	2
开心形(稀植) Open-center shape (Low density)	66.2	63	3.0	5.2/5.3	2.5	85.6	14.4	3	2400	0.562	4

表 9 不同树形满天红梨生长结果状况及综合评价											
Table 9 Growth and fruiting status and comprehensive evaluation of Mantianhong pear with different tree shapes											
树形 Tree shape	新梢长度 Shoot length/cm	萌芽率 Germina- tion rate/%	成枝力 Branching ability	冠幅 Crown width/ (m/m)	树高 Tree height/ m	中短枝比率 Medium and short branch ratio/%	长枝比率 Long branch ratio/%	早果性 Early fruiting	产量 Yield/ (kg·666.7 m ⁻²)	综合评价价值 Comprehensive evaluation value	排名 Rank
圆柱形 Cylindrical shape	43.0	77	2.3	1.8/2.2	4.0	81.4	18.6	2	5700	0.828	1
开心形(棚架) Open-center shape (Shed frame)	53.5	86	2.0	4.7/6.5	2.5	92.4	7.6	3	3000	0.604	2
开心形(稀植) Open-center shape (Low density)	64.6	77	2.0	4.9/5.0	3.5	87.4	12.6	3	2400	0.467	3

红梨采用圆柱形综合评价值为0.828,棚架开心形和普通开心形树形分别为0.604和0.467,因此,采用圆柱形树形的满天红梨综合表现优于开心形。

2.2.5 翠冠 翠冠主要分布在四川、重庆产区,均采用开心形树形(表 10),不同梨园新梢长度分布在 62.7~115.8 cm 之间;萌芽率相近,均在 80.0%以上;成枝力差异较大,最高为 3.0,最低为 1.3;所调查梨园产量在 1500~2250 kg·666.7 m⁻²之间。经综合评价可知,2 个密植开心形梨园综合评价价值均高于稀植栽培。

表 10 不同树形翠冠梨生长结果状况及综合评价											
Table 10 Growth and fruiting status and comprehensive evaluation of Cuiguan pear with different tree shapes											
树形 Tree shape	新梢长度 Shoot length/ cm	萌芽率 Germina- tion rate/%	成枝力 Branch- ing ability	冠幅 Crown width/ (m/m)	树高 Tree height/ m	中短枝比率 Medium and short branch ratio/%	长枝比率 Long branch ratio/%	早果性 Early fruiting	产量 Yield/ (kg·666.7 m ⁻²)	综合评价价值 Comprehensive evaluation value	排名 Rank
开心形(密植) Open-center shape (high density)	62.7	83	2.8	2.6/1.3	1.8	80.9	19.1	3	2000	0.858	1
开心形(稀植) Open-center shape (Low density)	115.8	86	3.0	4.0/2.9	2.1	70.1	29.9	4	1500	0.575	3
开心形(密植) Open-center shape (High density)	73.0	85	1.3	3.8/2.6	2.0	83.0	17.0	3	2250	0.667	2

3 讨 论

研究表明,翠玉和翠冠采用顺行 Y 字双主干

树形比细长纺锤形投入的劳动力更少^[18],李刚波等^[19]认为苏翠 1 号采用宽行密植主干形栽培,利于前期丰产和进行机械化作业,简便省工。由此可见,良种良

法配套是实现梨产业的省力、节本、增效的重要途径。由本研究结果可知,不同品种采用不同树形后的新梢长度、成枝力、树高、长中短枝比率、早果性等指标差异明显,新梢长度是树体长势的直接体现,与树冠大小紧密相关,新梢长势过旺会增加控冠的难度;萌芽率、成枝力直接影响枝组的更新,进而影响冠幅的大小;早果性是决定果树早期产量的重要指标,与果园早期产量、效益息息相关,生产中易受树形、管理技术、苗木质量等多方面因素的影响;树高、冠幅会对日常管理人工投入有重要影响,树高过高或冠幅过大会直接增加田间管理的用工量;长中短枝比率与产量、连续结果能力关联度较高,是果园稳产、丰产的基础,长枝比率过高也会增加树冠调控的人工投入。综上,不同生长结果指标间是互相联系互相影响的,通过单一指标并不能有效评价树形与品种的适配性,需要对多指标进行综合评价。近年来隶属函数法已在抗逆性评价^[20-21]、品质性状^[22]评价等方面得到广泛应用,笔者利用该方法较为全面、客观地评价了不同梨品种在不同树形下的生长结果表现,与实际生产表现较符合,这为树形评价提供了一种可借鉴的思路和方法。

开心形是西南产区应用最广泛的树形,整形简单,树冠通风透光效果良好。开心形树形有更好的冠层结构,冠层内的光分布会直接影响叶片的光合作用,进而影响果实发育与品质形成^[23-24],在多雨寡照地区,该树形优势更加明显。稀植模式下开心形树形主要是几大主枝结果,冠幅要求足够大才能保证产量,老龄果园尤其如此,从省力化、轻简化角度是要逐步淘汰或改造的模式。研究表明,产量与种植密度呈正相关,但并不会呈比例增加^[25-26],适当密植栽培在提高单产方面尤其是早期产量方面潜力较大^[27-28]。调查中发现西南产区开心形密植梨园问题较多,由于年生长量大,修剪过程中短截手法应用较多,导致部分果园出现轻度郁蔽现象。从树形和品种选配来看,开心形树形品种的适配性较为广泛,调查品种综合表现虽然存在差异,但并没有表现出明显的缺陷,笔者还发现多主枝开心形较传统开心形综合评价价值更高,因此,在地形复杂的西南梨产区多主枝开心形有更广阔的推广应用前景。本研究中不同管理水平下黄金采用开心形树形后均表现良好,表明开心形是黄金的适宜轻简化树形之一;在不同树形适宜品种的评价中,丰水、爱宕采用开心形和倒

伞形后综合排名均较靠前,表明开心形和倒伞形均可作为两个品种的适宜轻简化树形。棚架栽培是中国重要的栽培模式之一,尤其是沿海地区,可以有效减轻台风等恶劣天气的危害,采用该模式后冠层结构良好,叶片表现出较好的光合性能,更好的果实品质^[29-30],笔者在本研究中也发现采用水平棚架栽培的满天红综合表现要优于传统开心形。

采用圆柱形的果园主要分布在云南和重庆,且多以新建果园为主,树龄较小。Lordan等^[31]研究发现与圆柱形相近的高纺锤树形虽然比V形树形光能截获量低,但有较好的产能转化比例,赵明新等^[32]发现早酥梨采用圆柱形与纺锤形相比,可更好地提升梨的果实品质,因为中下部冠层有更好的光照条件,王鑫等^[33]研究发现早酥产量为 $4\,830.4\sim 4\,837.9\text{ kg}\cdot 666.7\text{ m}^{-2}$,黄冠为 $5\,441.3\sim 5\,693.1\text{ kg}\cdot 666.7\text{ m}^{-2}$ 时仍能保证果实品质和第二年的成花情况,均充分体现了圆柱形树形在早产、丰产方面的优势。笔者得到相似的研究结果,6年生的美人酥产量高达 $6000\text{ kg}\cdot 666.7\text{ m}^{-2}$,同时冠幅明显减小。Y字形树形在国内外产区均有分布^[34-35],在西南梨产区生产上很少见到,调查中只有美人酥采用该树形且综合表现良好,生产上建议株行距为 $(2.0\sim 3.0)\text{ m}\times 5.0\text{ m}$,主枝与水平夹角 $30^\circ\sim 45^\circ$,主枝上直接配备结果枝组,树高控制在2.5 m左右。倒伞形树形仅在贵州省毕节市有示范应用,由于生长季高温多雨,树体生长量大抽生旺条较多,树高为4.0~4.5 m,会在一定程度上影响树冠的通风透光性。徐金涛等^[36]研究表明倒伞形树形并不是黄冠梨的最适宜的省力化树形,笔者在本研究中也发现多个品种采用倒伞形后的综合评价价值不是最高,但陈霞等^[37]发现彩云红梨采用圆柱形和倒伞形均表现良好,是适宜彩云红梨种植的树形,结论差异原因可能与评价指标、品种特性等有关。

多主枝开心形、倒伞形、圆柱形3个现代轻简化树形与传统大冠分层树形相比优势较明显,多主枝开心形一般有更好的光照条件和更低的树高,在传统三主枝或四主枝开心形基础上增加2~3个主枝,可起到分散树体营养平衡树势的作用,结合长枝修剪技术,有效缩小冠幅,结合密植栽培可显著提升早期产量;与普通三主枝开心形比,倒伞形多一个中心干作为结果部位,对树势有一定程度的缓和作用,但基部三主枝是倒伞形树形的主要结果部位,为保证产量,冠幅和树高会适当加大,从一定程度影响行间

作业,增加了田间管理工作量,与传统大冠分层形树形相比,该树形冠层内有更好的光照条件,同时能够保证已有产量,因此,倒伞形树形在传统老果园改造方面具有明显的优势;采用圆柱形树形的树体一般具有更小的冠幅和更高的早期产量,但部分品种采用该树形后树体过高会增加日常管理难度,建议在缺乏机械操作平台的情况下,稳产后适当降低树高。综上,在西南产区多主枝开心形和圆柱形树形在新建果园更具优势,建议在地势陡峭、不规整的山地或寡照地区优先选用多主枝开心形树形,栽植株行距为2.0 m×4.0 m,主枝个数5~6个,主枝上直接着生小型结果枝(组),树高控制在2.5 m左右;在地势平缓、光照充足的地区,可优先选择圆柱形树形,株行距(1.0~2.0) m×4.0 m,中心干上配备25~30个结果枝(组),树高控制在3.0~3.5 m。除选择合适的树形和品种外,配套的整形修剪技术应引起重视,避免“新树形”采用“老技术”,影响轻简化树形的应用效果。目前,中国梨果生产总体呈现总产量大但优质果供给不足的状况,笔者仅对不同树形的生长结果习性进行了综合评价,不同树形的梨果实品质评价研究尚有待于进一步探究。

4 结 论

多主枝开心形和圆柱形可作为西南梨产区主推的轻简化栽培树形。多主枝开心形可作为黄金、圆黄、爱宕、满天红、美人酥、丰水、翠冠、翠玉的轻简化树形,圆柱形是美人酥、翠玉、满天红、彩云红梨的适宜轻简化树形。

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