Mulberry Cultivation and Utilization in China

Yongkang Huo

Regional Sericulture Training Centre for Asia and Pacific
South China Agricultural University
Guangzhou, China

I. Area cultivated with mulberry

China is the largest producer of mulberry and silk in the world. In 1998, fresh cocoon production was 432,820 ton from 626,000 ha of mulberry. Mulberry is distributed all over the country (Figure 1). The main provinces and autonomous region cultivated with mulberry are described here:

1. Xinjiang Uygur Autonomous Region

Geographical position: Situated in northwest China.

Climatic features: Continental, dry and sunny. In south Xinjiang, the effective accumulated temperature is higher than 3,500° and the frostless season is longer than 150d, but the annual rainfall is less than 100 mm.

Main mulberry variety cultivated: He Tian Bai Sang.

2. Shandong and Hebei Provinces

Geographical position: Situated in the lower end of the Yellow River, they are the main sericulture provinces in north China,

Climatic features: Average daily temperature 8 ~ 15°, frostless season 170 ~ 250d, annual rainfall 400 ~ 1,000 mm.

Main mulberry varieties cultivated: Da Ji Guan, Hei Lu Cai Sang, Xuan 792 and Niu Gen Sang.

3. Shanxi and Shaanxi Provinces

Geographical position: Situated in the middle of the Yellow River.

Climatic features: Average temperature 10 ~ 14°, frostless season 150 ~ 200d, annual rainfall 400 ~ 700 mm.

Main mulberry variety cultivated: Hei Ge Lu

4. Zhejiang and Jiangsu Provinces

Geographical position: The main sericulture area in China, situated in the end of the Yangtze River.

Climatic features: Average temperature 15 ~ 18°, frostless season 250 ~ 275d, annual rainfall 1,000 ~ 1,500 mm.

Main mulberry varieties cultivated: Tong Xiang Qing, Hong Cang Sang, Hu Sang 197, Hu Sang 199, Huo Sang, Nong Sang 8, Yu 2 and Zhong Sang 5801.

5. Anhui, Hubei and Hunan Provinces

Geographical position: Situated in the middle of the Yangtze River.

Climatic features: Average temperature 15 ~ 20°, frostless season 250 ~ 300d, annual rainfall 1,000 ~ 1,500 mm.

Main mulberry variety cultivated: Hong Pi Wa Sang.

6. Sichuan Province

Geographical position: Province with the largest area with mulberry in China, situated in the upper Yangtze River.

Climatic features: Average temperature 16 ~18°, frostless season 240 ~ 330d, annual rainfall 1,000 ~ 1,250 mm.

Main mulberry varieties cultivated: Hei You Sang, Da Hua Sang, Xiao Guan Sang and Jia Ling 16.

7. Guangdong and Guangxi Provinces

Geographical position: Situated by the Pearl River of south China, the most sub-tropical zone.

Climatic features: Average temperature 22°, frostless season 340d, annual rainfall 1,500 ~ 2,000 mm.

Main mulberry varieties cultivated: Guangdong Jing Sang, Lun 40, Lun 109, Sha 2, Da 10 and Kang Qing 10.

8. Yunnan and Guizhou Provinces

Geographical position: Situated in Yun-gui High Plateau of south-west China.

Climatic features: The effective accumulated temperature is higher than 3,500°, frostless season longer than 200d and the annual rainfall more than 600 mm.

Main mulberry varieties cultivated: Yun Sang 2 and Dao Zhen Sang.

II. Taxonomy

In China, the scientists classify the genus *Morus* into 14 species and 1 variety. The key for identification is the following:

Mulberry identification key

1.1 Pistils with distinct long styles

2.1 Protuberance within the stigma

3.1 Denticle pick of leaf margin with long prickle

4.1 Upper surface of leaf smooth, without hair; lower surface green, with some pubescence, usually non-incised:

Mongolian Mulberry (*M. mongolica* Schneid)

4.2 Upper surface of leaf rough; lower surface grayish-white, with dense pubescence, usually incised:

Gui Mulberry (*M. mongolica var. diabolica* Koidz)

3.2 Denticle pick of leaf margin without prickle

5.1 Upper surface of leaf smooth

6.1 Upper surface of leaf non-shriveled; denticle pick of leaf margin with short protuberance; style as long as stigma; sorosis globular:

Tang-gui Mulberry (*M. nigriformis* Koidz)

6.2 Upper surface of leaf shriveled; denticle pick of leaf margin without protuberance; style shorter than stigma; sorosis elliptical

Rui-sui Mulberry (*M. mizuho* Hotta)

5.2 Upper surface of leaf coarse

7.1 Leaf round or broad-ovate, lower surface without pubescence; sorosis cylindrical, 3 ~ 3.5 cm long, jade-white in colour when mature

Chuan Mulberry (*M. notabilis* Schneid)

2.2 Hair within the stigma

7.2 Leaf cordate or ovate, lower surface with scarce pubescence; sorosis elliptical, 2 cm long, purplish-black when mature:

Mountain Mulberry (*M. bombycis* Koidz)

8.1 Leaf ovate or slant-ovate, usually incised, margin serrated small and dense; style longer than stigma; sorosis 1 ~2 cm long, dark purple when mature:

Ji Mulberry (*M. australis* Poir.)

8.2 Leaf codate or broad codate, usually non-incised, margin serrated triangular with short pick; style shorter than stigma; sorosis 4 ~ 6 cm long, red when mature:

Tian Mulberry (*M. yunnanensis* Koidz)

1.2 Pistils without distinct long styles

9.1 Protuberance within the stigma

10.1 Leaf without hair or with pubescence in young stage; sorosis narrow-cylindrical, 4 ~ 16 cm long

11.1 Leaf long elliptical, entire leaf margin or with shallow serrates in the upper margin; 3 ~ 4 pairs of side veins; mature sorosis purplish-red:

Chang-sui Mulberry (*M. wittiorum* Hand -Mazz.)

11.2 Leaf broad ovate, margin with small serrates; 4 ~ 6 pairs of side veins; mature sorosis yellowish-green or purplish-red:

Chang-guo Mulberry (*M. laevigata* Wall.)

10.2 Leaf veins of lower surface with pubescence; sorosis elliptical, 1 ~2.5 cm long.

12.1 Big leaf, usually non-incised, with water-bubble appearance or shriveled; mature sorosis purplish-black

Lu Mulberry (*M. multicaulis* Perr.)

12.2 Small leaf, usually incised, surface smooth; mature sorosis purplish-black or jade-white, occasionally pink:

White Mulberry (*M. alba* Linn.)

9.2 Hairs within the stigma.

13.1 Lower surface of leaf with pubescence; short petiole; mature sorosis purplish-black or purplish-red.

14.1 Upper surface of leaf rough; petiole without groove; sorosis elliptical, 1.5 ~ 3 cm long, purplish-black when mature:

Black Mulberry (*M. nigra* Linn.)

14.2 Upper surface of leaf with pubescence; petiole with shallow groove; sorosis cylindrical, 2 ~ 3 cm long, purplish-black or purplish-red when mature:

Hua Mulberry (*M. cathayana* Hemsl.)

13.2 Lower surface of leaf without hair; upper surface usually smooth, less luster; sorosis narrow-circular cone with round tip, 2 ~ 4 cm long, purplish-black when mature:

Guangdong Mulberry (M. *atropurpurea* Roxb)

Mulberry Varieties

There are more than 1,000 cultivated varieties of mulberry in China. Most of them originate from the 4 main species: Lu Mulberry (M. multicaulis Perr.), White Mulberry (M. alba L.), Mountain Mulberry (M. bombycis Koidz.) and Guangdong Mulberry (M. atropurpurea Roxb.).

The main cultivated varieties of mulberry in China are introduced as the following:

1. Tong Xiang Qing

Indigenous and widely distributed in Zhejiang Province. It belongs to the species of Lu Mulberry (*M. multicaulis* P.). Chromosome number is 2n = 2x = 28.

Climatic requirement: Bud sprouting in Hangzhou is from 28 March to 6 April. Leaf-opening stage is in the middle of April. Bud sprouting ratio is 61.5% and the bud-growing ratio is 11.1%. Leaves mature in early May, belonging to the medium sprouting and mid-mature variety. Autumn leaves harden in mid-September.

Average yield per ha: This variety has medium shooting ability and the side branches are few. From 1m shoot, 139g leaves can be produced in spring and 151 g produced in autumn. Spring leaf is 260 pieces /kg and autumn leaf 200 pieces/kg. Leaf weight occupies 45.4% of the total weight of twigs, shoots, leaves and fruits. Annual leaf yield is 34,500 kg/ha.

Fruiting habits: Few sorosis (fruits), medium-large size and purplish-black.

Leaf chemical composition: Leaf quality is good. Dry matter of leaf contains 22.0 ~ 24.5 % crude protein (CP) and 15.1% soluble carbohydrates (SC).

Fertilization recommendations: Sufficient water supply and fertilization in summer and autumn are needed for preventing leaves from early hardening.

2. Hong Cang Sang

Selected from the varieties of Tong Xiang Qing, belonging to the species of Lu Mulberry (*M. multicaulis* P.). Chromosomes number is 2n = 2x = 28. Widely distributed in Zhejiang and Jiangsu Provinces.

Climatic requirement: Bud sprouting in Hangzhou is from 30 March to 6 April. Leaf-opening stage is from 7 April to 18 April. Bud sprouting ratio is 55% and the bud-growing ratio is 19.8%. Leaves mature in early May, belonging to the medium sprouting and mid-mature variety. Autumn leaves harden in mid-September.

Average yield per ha: This variety has medium shooting ability and the side branches are less. From 1m shoot, 135g leaves can be produced in spring and 137 g produced in autumn. Spring leaf is 263 pieces/kg and autumn leaf 137 pieces/kg. Leaf weight occupies 46% of the total weight of twigs, shoots, leaves and fruits. Annual leaf yield is 33,900 kg/ha.

Fruiting habits: Few sorosis, large size, purplish-black in colour.

Leaf chemical composition: The leaf quality is good. Dry matter of leaf contains crude protein 20.6 ~ 23.8 % and soluble carbohydrate 16.9%.

3. Hu Sang 197

Selected from Zhejiang province, belonging to the species of Lu Mulberry (*M. multicaulis* P.). Chromosome number is 2n = 2x = 28.

Climatic requirement: Bud sprouting is from 30 March to 6 April. Leaf-opening stage is from 8 April to 19 April. Bud sprouting ratio is 70% and the bud-growing ratio is 14.3%. Leaves mature in early May, belonging to the late-sprouting and mid-mature variety. Autumn leaves harden in late September.

Average yield per ha: This variety has strong shooting ability and the side branches are less. From 1m shoot, 128g leaves can be produced in spring and 170 g produced in autumn.

Spring leaf is 375 pieces/kg and autumn leaf 224 pieces/kg. Leaf weight occupies 47.7% of the total weight of twigs, shoots, leaves and fruits. Annual leaf yield is 33,750 kg/ha.

Fruiting habits: Sorosis is less and smaller, purplish-black in colour.

Leaf chemical composition: The leaf quality is good. Dry matter of leaf contains crude protein 18.7 ~ 27.1 % and soluble carbohydrate 13.1%.

4. Hu Sang 199

A resistant variety selected from Zhejiang, belonging to the large-leaf variety of species of White Mulberry (*M. alba* L.). Chromosome number is 2n = 2x = 28. Widely cultivated in Zhejiang and Jiangsu Provinces.

Climatic requirement: Bud sprouting is from 30 March to 6 April. Leaf-opening stage is from 8 April to 18 April. Bud sprouting ratio is 75% and the bud-growing ratio is 13.4%. Leaves mature from 6 May t0 15 May, belonging to the late-sprouting and late mature variety. Autumn leaves harden in early October.

Average yield per ha: This variety has strong shooting ability. From 1m shoot, 151g leaves can be produced in spring and 119 g produced in autumn. Spring leaf is 400 pieces/kg and autumn leaf 239 pieces/kg. Leaf weight occupies 44% of the total weight of twigs, shoots, leaves and fruits. Annual leaf yield is 29,250 kg/ha.

Fruiting habits: Sorosis is less but bigger, purplish-black in colour.

Leaf chemical composition: The leaf quality is comparatively poor. Dry matter of leaf contains crude protein 19.8 ~ 21.0 % and soluble carbohydrate 15.3 ~16.2%.

5. Huo Sang (Fire Mulberry)

Native variety of Zhejiang, belonging to the species of Rui-sui Mulberry (*M. mizuho* Hotta.). It is a natural triploid, with chromosome number 2n = 3x = 42. Widely distributed in Zhejiang province.

Climatic requirement: Bud sprouting in Hangzhou is from 22 March to 25 March. Leaf-opening stage is from 1 April to 13 April. Bud sprouting ratio is 70% and the bud-growing ratio is 6%. Leaves mature from 16 April to 26 April, belonging to the early sprouting and early mature variety. Autumn leaves harden in early and middle September.

Average yield per ha: This variety has strong shooting ability. From 1m shoot, 131g spring leaves or 138 g autumn leaves can be produced. Spring leaf is 231 pieces/kg and autumn leaf 139 pieces/kg. Leaf weight occupies 46.85% of the total weight of twigs, shoots, leaves and fruits. Annual leaf yield is 34,050 kg/ha.

Fruiting habits: Purplish-black sorosis is found occasionally. The seeds are not germinated.

Leaf chemical composition: The leaf quality is medium. Dry matter of leaf contains crude protein 21.82 ~ 23.68% and soluble carbohydrate 15.18 ~ 16.28%.

6. Nong Sang 8

Selected from Zhejiang province, belonging to the species of White Mulberry (*M. alba* L.). It is a diploid, with chromosome number 2n = 2x = 28.

Climatic requirement: Bud sprouting in Hangzhou is from 17 March to 22 March. Leaf-opening stage is from 20 March to 11 April. Bud sprouting ratio is 88.4% and the bud-growing ratio is 14.0%. Leaves mature from 16 April to 21 April,

belonging to the early sprouting and early mature variety. Autumn leaves harden from middle October to late October.

Average yield per ha: This variety has strong shooting ability and the side twigs are less. From 1m shoot, 130g spring leaves or 163.5 g autumn leaves can be produced. Spring leaf is 444 pieces/kg and autumn leaf 250 pieces/kg. Leaf weight occupies 49.68% of the total weight of twigs, shoots, leaves and fruits. Annual leaf yield is 45,000 kg/ha.

Fruiting habits: Sorosis is more, medium-big size, purplish-red in colour.

Leaf chemical composition: The leaf quality is good. Dry matter of leaf contains crude protein 23.45 ~ 26.13% and soluble carbohydrate 14.13 ~ 18.28%.

7. Yu 2

Selected from the hybridization of "Hu-sang 39 ×Guangdong Jing-sang", belonging to the species of White Mulberry (*M. alba* L.). It is a diploid, with chromosome number 2n = 2x = 28.

Climatic requirement: Bud sprouting in Jiangsu is from 30 March to 8 April. Leaf-opening stage is from 10 April to 20 April. Bud sprouting ratio is 78% and the bud-growing ratio is 20%. Leaves mature from 10 May to 15 May, belonging to the early sprouting and mid-mature variety. Autumn leaves harden in early September.

Average yield per ha: This variety has strong shooting ability and the side twigs are less. From 1 m shoot, 130g spring leaves or 84g autumn leaves can be produced. Spring leaf is 692 pieces/kg and autumn leaf 278 pieces/kg. Leaf weight occupies 42% of the total weight of twigs, shoots, leaves and fruits. Annual leaf yield is 31,200 kg/ha.

Fruiting habits: Sorosis is less, medium-big size, purplish-black in colour.

Leaf chemical composition: The leaf quality is medium. Dry matter of leaf contains crude protein 22.8 ~ 26.2% and soluble carbohydrate 12.7 ~ 14.5%.

Fertilization recommendations: Higher production of leaf can be achieved by sufficient fertilization. The recommended training is low or medium trunk. Higher density planting is suitable for shoot harvesting.

8. Zhong Sang 5801

Selected from the hybridization of "Hu-sang 38 ×Guangdong Jing-sang", belonging to the species of Guangdong Mulberry (*M. atropurpurea* Roxb.). It is a diploid, with chromosome number 2n = 2x = 28.

Climatic requirement: Bud sprouting in Jiangsu starts from early April. Leaf-opening stage is from 13 April to 21 April. Bud sprouting ratio is 84% and the bud-growing ratio is 15%. Leaves mature from 3 May to 9 May, belonging to the medium sprouting and mid-mature variety. Autumn leaves harden in the middle of September.

Average yield per ha: This variety has strong shooting ability and the side twigs are less. From 1m shoot, 134g spring leaves or 96 g autumn leaves can be produced. Spring leaf is 734 pieces/kg and autumn leaf 266 pieces/kg. Leaf weight occupies 41% of the total weight of twigs, shoots, leaves and fruits. Annual leaf yield is 23,400 kg/ha.

Fruiting habits: Sorosis is more, medium-big size, purplish-black in colour.

Leaf chemical composition: The leaf quality is medium. Dry matter of leaf contains crude protein 22.3 ~ 23.6% and soluble carbohydrate 11.3 ~ 13.3%.

9. Hei You Sang

Indigenous to Sichuan, China. Natural triploid (2n=3x=42), belonging to the species of White Mulberry (*M. alba* L.). Mainly cultivated in south Sichuan.

Climatic requirement: Bud sprouting in Sichuan is from 17 March to 22 March. Leaf-opening stage is from 28 March to 9 April. Bud sprouting ratio is 86% and the bud-growing ratio is 25%. Leaves mature from 20 April 30 April, belonging to the medium sprouting and mid-mature variety. Autumn leaves harden in early October.

Average yield per ha: This variety has medium shooting ability and the side twigs are less. From 1m shoot, 251g spring leaves or 137 g autumn leaves can be produced. Spring leaf is 362 pieces/kg and autumn leaf 175 pieces/kg. Leaf weight occupies 48% of the total weight of twigs, shoots, leaves and fruits. Annual leaf yield is 20,700 kg/ha.

Fruiting habits: Sorosis is less and smaller, with low ability of fruit bearing, purplish-black in colour.

Leaf chemical composition: The leaf quality is good. Dry matter of leaf contains crude protein 22.54 ~ 30.98% and soluble carbohydrate 11.23 ~ 16.88%.

Fertilization recommendations: This variety can be propagated by cutting, layering or bud-grafting. The recommended training is low or medium trunk.

10. Da Hua Sang

Indigenous to Sichuan. Natural triploid (2n=3x=42), belonging to the species of White Mulberry (*M. alba* L.). Mainly cultivated in south Sichuan.

Climatic requirement: Bud sprouting in Sichuan is from 16 March to 26 March. Leaf-opening stage is from 1 April to 8 April. Bud sprouting ratio is 70.4% and the bud-growing ratio is 22%. Leaves mature in mid-May, belonging to the medium sprouting and late-mature variety. Autumn leaves harden in early October.

Average yield per ha: This variety has medium shooting ability and the side twigs are less. From 1m shoot, 168g spring leaves or 163 g autumn leaves can be produced. Spring leaf is 408 pieces/kg and autumn leaf 202 pieces/kg. Leaf weight occupies 46.21% of the total weight of twigs, shoots, leaves and fruits. Annual leaf yield is 18,000 kg/ha.

Leaf chemical composition: The leaf quality is good. Dry matter of leaf contains crude protein 27.7 ~ 29.4% and soluble carbohydrate 11.25 ~ 12.63%.

Fertilization recommendations: This variety is suitable to plant in the good soil condition so as to achieve high productivity. The recommended training is medium or high trunk.

11. Xiao Guan Sang

Native variety of Sichuan, China. Diploid (2n=2x=28), belonging to the species of White Mulberry (*M. alba* L.). Widely distributed in the east and north of Sichuan.

Climatic requirement: Bud sprouting in Sichuan is from 12 March to 15 March. Leaf-opening stage is from 17 March to 20 April. Bud sprouting ratio is 80% and the bud-growing ratio is 27%. Leaves mature in early May, belonging to the early sprouting and early mature variety. Autumn leaves harden in early October.

Average yield per ha: This variety has less side twigs. From 1m shoot, 226g spring leaves or 92 g autumn leaves can be produced. Spring leaf is 456 pieces/kg and autumn leaf 225 pieces/kg. Leaf weight occupies 66.66% of the total weight of twigs, shoots, leaves and fruits. Annual leaf yield is 18,750 kg/ha.

Fruiting habits: Sorosis is less and smaller, purplish-black in colour.

Leaf chemical composition: The leaf quality is medium. Dry matter of leaf contains crude protein 18.83 ~ 21.97% and soluble carbohydrate 14.5%.

Fertilization recommendations: This variety has broad adaptability to various soil and climatic conditions. It is suitable to plant in the scattered land of hilly area, train into low or medium trunk.

12. Jia Ling 16

A triploid bred by crossing “Xiqing” (tetraploid) with “Yu 2”(diploid). Since 1992, it has been widely cultivated in all Sichuan and introduced to other provinces, such as Xinjiang, Guizhou, Henan, Shaanxi, etc.

Climatic requirement: Bud sprouting in Sichuan is in the middle of March, belonging to early-sprouting and mid-mature variety. Bud sprouting ratio is above 80%.

Average yield per ha: This variety has high productivity.

Fruiting habits: Sterile.

Leaf chemical composition: The leaf quality is good. Dry matter of leaf contains crude protein 28.05% in average of spring and autumn.

Fertilization recommendations: Good fertilization and management for this variety can lead to high productivity. It is suitable to cultivate this variety in the hilly and mountainous area with high density or inter-cropping.

13. Guangdong Jing Sang

A highly heterogeneous variety originated from the Pearl River Delta of Guangdong, widely distributed in south China. Diploid (2n=2x=28), belonging to the species of Guangdong Mulberry (*M. atrpurpurea* Roxb.).

Climatic requirement: Bud sprouting in Guangzhou is from 18 January to 21 January. Leaf-opening stage is from 2 February to 21 February. Bud sprouting ratio is 85% and the bud-growing ratio is 20%. First crop leaves mature from 27 February to 17 March. Growing period is 25 ~ 30 days for whole leaf and 40 ~ 45 days for the leaf-shoot respectively, belonging to the early sprouting and early mature variety.

Average yield per ha: This variety has very strong shooting ability, with more side twigs, uniform growing. From 1m shoot, 85g spring leaves or 65g autumn leaves can be produced. Leaf in the main branch is 441 pieces/kg and in the side twig 945 pieces/kg. Annual leaf yield can reach 33,750 kg/ha.

Fruiting habits: Sorosis is more and bigger, purplish-black in colour.

Leaf chemical composition: The leaf quality is medium. Dry matter of leaf contains crude protein 21.24% and soluble carbohydrate 8.38%.

Fertilization recommendations: This variety can be propagated by seedlings and planted in a very high density (90,000 ~ 120,000 plants/ha). High yielding can be achieved by providing sufficient fertilization each crop.

14. Lun 40

A high yielding variety selected from Guangdong Jing Sang. Natural triploid (2n=3x=42), belonging to the species of Guangdong Mulberry (*M. atrpurpurea* Roxb.), widely distributed in south China.

Climatic requirement: Bud sprouting in Guangzhou is from 16 January to 28 January. Leaf-opening stage is from 2 February to 15 February. Bud sprouting ratio is 80% and the bud-growing ratio is 17%. First crop leaves mature from 18 February to 10 March. Growing period is 25 ~ 30 days for whole leaf and 40 ~ 45 days for the leaf-shoot respectively, belonging to the early sprouting and early mature variety.

Average yield per ha: This variety has medium shooting ability, with less side twigs. From 1m shoot, 175g spring leaves or 120 g autumn leaves can be produced. Leaf in the main branch is 178 pieces/kg and in the side twig 475 pieces/kg. Annual leaf yield can reach 46,500 kg/ha.

Fruiting habits: Sorosis is more and bigger, purplish-black in colour, but the fertility is very low.

Leaf chemical composition: The leaf quality is medium. Dry matter of leaf contains crude protein 21.06% ~ 25.01 and soluble carbohydrate 7 ~ 7.9 %.

Fertilization recommendations: This variety can be planted in high density (90,000 plants/ha). Additional applying of phosphoric and potassium fertilizer is needed for the newly planted garden.

15. Lun 109

Selected from Pearl River Delta of Guangdong. Diploid (2n=2x=28), belonging to the species of Guangdong Mulberry (*M. atrpurpurea* Roxb.).

Climatic requirement: Bud sprouting in Guangzhou is from 16 January to 31 January. Leaf-opening stage is from 5 February to 21 February. Bud sprouting ratio is 68% and the bud-growing ratio is 27%. First crop leaves mature from 24 February to 10 March. Growing period is 25 ~ 30 days for whole leaf and 40 ~ 45 days for the leaf-shoot respectively, belonging to the early sprouting and mid-mature variety.

Average yield per ha: This variety has strong shooting ability. It grows fast, with early sprouting and sturdy side twigs from 1m shoot, 147g spring leaves or 110 g autumn leaves can be produced. Leaf in the main branch is 192 pieces/kg and in the side twig 583 pieces/kg. Annual leaf yield can reach 39,450 kg/ha.

Leaf chemical composition: The leaf quality is medium. Dry matter of leaf contains crude protein 29.47% and soluble carbohydrate 7.61%.

Fertilization recommendations: This variety can be planted in high density (90,000 plants/ha). Apply nitrogen fertilizer after each harvesting and apply additional phosphoric and potassium fertilizer after the second harvest.

16. Sha 2

Selected from Pearl River Delta of Guangdong. Diploid (2n=2x=28), belonging to the species of Guangdong Mulberry (*M. atrpurpurea* Roxb.).

Climatic requirement: Bud sprouting in Guangzhou is from 20 January to 31 January. Leaf-opening stage is from 3 February to 23 February. Bud sprouting ratio is 62.9% and the bud-growing ratio is 37.1%. First crop leaves mature from 20 February to 10 March. Growing period is 25 ~ 30 days for whole leaf and 40 ~ 45 days for the leaf-shoot respectively, belonging to the early sprouting and early mature variety.

Average yield per ha: This variety has medium shooting ability, with early sprouting and more side-twigs. From 1m shoot, 109g spring leaves or 81 g autumn leaves can be produced. Leaf in the main branch is 154 pieces/kg and in the side twig 294 pieces/kg. Annual leaf yield can reach 39,000 kg/ha.

Fruiting habits: Sorosis is more and bigger, purplish-black in colour.

Leaf chemical composition: The leaf quality is medium. Dry matter of leaf contains crude protein 22.88% and soluble carbohydrate 10.88%.

Fertilization recommendations: For seed production purpose, more quantity of phosphoric and potassium fertilizer is needed. When sorosis appears red colour, slightly apply nitrogen fertilizer to promote fruiting.

17. Da 10

A natural triploid (2n=3x=42) Selected from Pearl River Delta of Guangdong, belonging to the species of Guangdong Mulberry (*M. atrpurpurea* Roxb.).

Climatic requirement: Bud sprouting in Guangzhou is from 16 January to 28 January. Leaf-opening stage is from 31 January to 16 February. Bud sprouting ratio is 85% and the bud-growing ratio is 10%. First crop leaves mature from 20 February to 10 March. Growing period is 25 ~ 30 days for whole leaf and 40 ~ 45 days for the leaf-shoot respectively, belonging to the early sprouting and early mature variety.

Average yield per ha: This variety has medium shooting ability, with less side twigs. Annual leaf yield is 30,000 kg/ha. For fruit production purpose, the annual output of berry can reach 15,000 kg/ha.

Fruiting habits: Sorosis is more and bigger, purplish-black in colour. The fruit contains total carbohydrate 2.78 ~ 3.8%, reducing sugar 2.28 ~ 3.57%, amino acid 0.813% (16 kinds). Vitamin C content of the berry reaches 1.02 mg/100g, so it is a good material for fruit and beverage production

Fertilization recommendations: For fruit production purpose, more quantity of phosphoric and potassium fertilizer is needed. Two times of pruning can be done, one in April another in July or August. Apply nitrogen fertilizer in between tow pruning.

18. Kang Qing 10

A resistant variety selected from the west of Guangdong. Diploid (2n=2x=28), belonging to the species of Guangdong Mulberry (*M. atrpurpurea* Roxb.).

Climatic requirement: Bud sprouting in Guangzhou is from 26 January to 5 February. Leaf-opening stage is from 11 February to 24 February. Bud sprouting ratio is 80% and the bud-growing ratio is 15%. First crop leaves mature from 16 February to 5 March. Growing period is 20 ~ 25 days for whole leaf and 35 ~ 40 days for the leaf-shoot respectively, belonging to the early sprouting and early mature variety.

Average yield per ha: This variety has strong shooting ability, growing fast, with more side twigs. From 1m shoot, 130g spring leaves or 100 g autumn leaves can be produced. Leaf in the main branch is 206 pieces/kg and in the side twig 311 pieces/kg. Annual leaf yield can reach 37,050 kg/ha.

Leaf chemical composition: The leaf quality is medium. Dry matter of leaf contains crude protein 22.4% and soluble carbohydrate 5.26%.

19. Hei Lu Cai Sang

Indigenous to Shandong China, belonging to the species of Lu Mulberry (*M. multicaulis* P.). Chromosome number is 2n = 2x = 28.

Climatic requirement: Bud sprouting in Shandong is from 22 April to 25 April. Leaf-opening stage is from 28 April to 8 May. Bud sprouting ratio is 75% and the bud-growing ratio is 15%. Leaves mature on 14 May, belonging to the medium sprouting and mid-mature variety. Autumn leaves harden in early September.

Average yield per ha: This variety has strong shooting ability and the side branches are more. From 1m shoot 98 g leaves can be produced in spring and 116 g produced in autumn. Spring leaf is 670 pieces /kg and autumn leaf, 275 pieces/kg. Leaf weight occupies 49.3% of the total weight of twigs, shoots, leaves and fruits. Annual leaf yield is 19,500 kg/ha.

Fruiting habits: Sorosis is less and small, purplish-black in colour.

Leaf chemical composition: The leaf quality is good. Dry matter of leaf contains crude protein 23.8 ~ 24.1 % and soluble carbohydrate 13.2 ~ 18.3%.

20. Da Ji Guan Sang

Indigenous to Shandong, belonging to the species of Lu Mulberry (*M. multicaulis* P.). Chromosome number is 2n = 2x = 28.

Climatic requirement: Bud sprouting in Shandong is from 22 April to 26 April. Leaf-opening stage is from 29 April to 7 May. Bud sprouting ratio is 85% and the bud-growing ratio is 25%. Leaves mature on 16 May, belonging to the medium sprouting and mid-mature variety. Autumn leaves harden in mid-August.

Average yield per ha: This variety has medium shooting ability and the side branches are more. From 1m shoot 212 g leaves can be produced in spring and 184 g produced in autumn. Spring leaf is 660 pieces /kg and autumn leaf, 240 pieces/kg. Leaf weight occupies 59.3% of the total weight of twigs, shoots, leaves and fruits. Annual leaf yield is 20000 kg/ha.

Fruiting habits: Sorosis is less and small, purplish-black in colour.

Leaf chemical composition: The leaf quality is good. Dry matter of leaf contains crude protein 23.1 ~ 27.2 % and soluble carbohydrate 12 ~ 17.1%.

21. Xuan 792

Selected from the variants of native mulberry in Shandong, belonging to the species of Lu Mulberry (*M. multicaulis* P.). Chromosome number is 2n = 2x = 28. Widely distributed in Shandong and the provinces in North China.

Climatic requirement: Bud sprouting in Shandong is from 24 April to 28 April. Leaf-opening stage is from 1 May to 10 May. Bud sprouting ratio is 73% and the bud-growing ratio is 15%. Leaves mature on 16 May, belonging to the late sprouting and mid-mature variety. Autumn leaves harden in early September.

Average yield per ha: This variety has strong shooting ability and the side branches are less. From 1m shoot 112g leaves can be produced in spring and 138g produced in autumn. Spring leaf is 410 pieces /kg and autumn leaf, 190 pieces/kg. Leaf weight occupies 49.79% of the total weight of twigs, shoots, leaves and fruits. Annual leaf yield is 30,000 kg/ha.

Fruiting habits: Sorosis is less, medium size, purplish-black in colour.

Leaf chemical composition: The leaf quality is good. Dry matter of leaf contains crude protein 25.2 ~ 27.5 % and soluble carbohydrate 11.3 ~ 15.3%.

Fertilizing recommendation: This variety is suitable to plant in the north China and train into low or medium trunk. Higher planting density and application of fertilizer in autumn can lead to the higher production.

22. Niu Gen Sang

Native variety of Hebei China, belonging to the species of Lu Mulberry (*M. multicaulis* P.). Chromosome number is 2n = 2x = 28. Widely distributed in Hebei province.

Climatic requirement: Bud sprouting in Hebei is from 6 May to 12 May. Leaf-opening stage is from 14 May to 20 May. Bud sprouting ratio is 72% and the bud-growing ratio is 20%. Leaves mature from 25 May to 1 June, belonging to the medium sprouting and mid-mature variety. Autumn leaves harden from 10 September to 15 September.

Average yield per ha: This variety has medium shooting ability and the side branches are less. From 1m shoot 155g leaves can be produced in spring and 140g produced in autumn. Spring leaf is 400 pieces /kg and autumn leaf, 160 pieces/kg. Leaf weight occupies 50% of the total weight of twigs, shoots, leaves and fruits. Annual leaf yield is 15,000 kg/ha.

Fruiting habits: Sorosis is less, medium size, purplish-black in colour.

Leaf chemical composition: The leaf quality is medium. Dry matter of leaf contains crude protein 16.25% and soluble carbohydrate 13.41%.

Fertilizing recommendation: This variety is suitable to plant in the north China and train into medium trunk, high trunk or tree type. Properly higher planting density is recommended.

23. Hong Pi Wa Sang

Native variety of Hubei China, belonging to the species of Lu Mulberry (*M. multicaulis* P.). Chromosome number is 2n = 2x = 28.

Climatic requirement: Bud sprouting in Zhenjiang is from 13 April to 17 April. Leaf-opening stage is from 18 April to 23 April. Bud sprouting ratio is 56% and the bud-growing ratio is 15%. Leaves mature from 15 May to 20 May, belonging to the late sprouting and late mature variety. Autumn leaves harden in the middle of September.

Average yield per ha: This variety has weak shooting ability, but grows fast and the side branches are less. From 1m shoot 119g leaves can be produced in spring and 120g produced in autumn. Spring leaf is 548 pieces /kg and autumn leaf, 165 pieces/kg. Leaf weight occupies 54% of the total weight of twigs, shoots, leaves and fruits. Annual leaf yield is 18,000 kg/ha.

Fruiting habits: Sorosis is smaller and less, purplish-black in colour.

Leaf chemical composition: The leaf quality is medium. Dry matter of leaf contains crude protein 23.6 ~ 26.4% and soluble carbohydrate 10.8 ~ 11.5%.

24. Hei Ge Lu

Native variety of Shanxi China, belonging to the species of White Mulberry (*M. alba* L.). Chromosome number is 2n = 2x = 28.

Climatic requirement: Bud sprouting in Shanxi is from 18 April to 25 April. Leaf-opening stage is from 27 April to 4 May. Bud sprouting ratio is 80% and the bud-growing ratio is 27%. Leaves mature from 20 May to 26 May, belonging to the medium sprouting and medium mature variety. Autumn leaves harden in 20 September.

Average yield per ha: This variety has strong shooting ability and the side branches are less. From 1m shoot 125g leaves can be produced in spring and 140g produced in autumn. Spring leaf is 428 pieces /kg and autumn leaf, 256 pieces/kg. Leaf weight occupies 41% of the total weight of twigs, shoots, leaves and fruits. Annual leaf yield is 20,250 kg/ha.

Fruiting habits: Sorosis is smaller and less, purplish-black in colour.

Leaf chemical composition: The leaf quality is medium. Dry matter of leaf contains crude protein 23.4% and soluble carbohydrate 13.2%.

Fertilizing recommendation: This variety is suitable to plant in the road side and river side, train into medium or high trunk type.

25. He Tian Bai Sang

A triploid variety (2n = 3x = 42) selected from south Xinjiang, belonging to the species of White Mulberry (*M. alba* L.).

Climatic requirement: Bud sprouting in south Xinjiang is from 13 April to 16 April. Leaf-opening stage is from 17 April to 22 April. Bud sprouting ratio is 82% and the bud-growing ratio is 21%. Leaves mature from 10 May to 15 May, belonging to the medium sprouting and medium mature variety. Autumn leaves harden in early September.

Average yield per ha: This variety has strong shooting ability and the side branches are more. From 1m shoot 166g leaves can be produced in spring and 45g produced in autumn. Spring leaf is 476 pieces /kg and autumn leaf, 348 pieces/kg. Leaf weight occupies 46.9% of the total weight of twigs, shoots, leaves and fruits. Annual leaf yield is 17,700 kg/ha.

Fruiting habits: Sorosis is more, medium size, jade-white in colour. The fruit is sweet, containing 18.9% sugar.

Leaf chemical composition: The leaf quality is good. Dry matter of leaf contains crude protein 22.1 ~ 23.3% and soluble carbohydrate 11.0 ~ 14.2%.

Fertilizing recommendation: The recommended training type is low or medium trunk. Higher production can be achieved by providing good fertilization and irrigation. If for both fruit and leaf production, high trunk type or tree type is preferable.

26. Yun Sang 2

A diploid variety (2n = 2x = 28) selected from Yunnan, belonging to the species of White Mulberry (*M. alba* L.).

Climatic requirement: Bud sprouting in Yunnan is from 1 February to 21 February. Leaf-opening stage is from 16 February to 21 February. Bud sprouting ratio is 78% and the bud-growing ratio is 20%. Leaves mature from 15 March to 20 March, belonging to the medium sprouting and medium mature variety. Autumn leaves harden in early October.

Average yield per ha: This variety has strong shooting ability and the side branches are less. From 1m shoot 154g leaves can be produced in spring and 132g produced in autumn. Spring leaf is 600 pieces /kg and autumn leaf, 250 pieces/kg. Leaf weight occupies 36% of the total weight of twigs, shoots, leaves and fruits. Annual leaf yield is 27,000 kg/ha.

Fruiting habits: Sorosis is more, medium size, purplish-black in colour.

Leaf chemical composition: The leaf quality is medium. Dry matter of leaf contains crude protein 21.5% and soluble carbohydrate 12%.

Fertilizing recommendation: The recommended training type is low or medium trunk.

27. Dao Zhen Sang

A native variety selected from Guizhou, diploid (2n = 2x = 28), belonging to the species of White Mulberry (*M. alba* L.).

Climatic requirement: Bud sprouting in Jiangsu is from 3 April to 9 April. Leaf-opening stage is from 12 April to 17 April. Bud sprouting ratio is 75% and the bud-growing ratio is 28%. Leaves mature from 1 May to 5 May, belonging to the early sprouting and early mature variety. Autumn leaves harden in early September.

Average yield per ha: This variety has strong shooting ability and the side branches are less. From 1m shoot 137g leaves can be produced in spring and 90g produced in autumn. Spring leaf is 968 pieces /kg and autumn leaf, 376 pieces/kg. Leaf weight occupies 50% of the total weight of twigs, shoots, leaves and fruits. Annual leaf yield is 22,500 kg/ha.

Leaf chemical composition: The leaf quality is medium. Dry matter of leaf contains crude protein 22.01 ~ 24.58% and soluble carbohydrate 13.8 ~ 13.58%.

Fertilizing recommendation: This variety is recommended to plant in the roadside and field side, train into medium or high trunk.

III. Cultivation Methods

1. Propagation

Sexual method (Seedling) and asexual method (grafting, cutting, layering etc.) are used for mulberry propagation. The good characteristics of the parent plants can be assured by asexual propagation. In order to establish a fast growing and high yielding mulberry plantation, the seedling propagation of improved F_1 hybrids is recommended.

In the tropical and subtropical areas, the mulberry can grow very fast and harvested many times. Seedlings of local Jing mulberry are traditionally used in south China. During 1970s, the technique of breeding and propagating of improved F_1 hybrids was developed in Guangdong. In 1977, the good combinations "Sha 2 ×Lun 109" and "Tang 10 ×Lun 109" were selected. Their leaf yield increased by 20% than Jing variety. These F_1 hybrids were popularized in south China very rapidly. Later they were extended to some areas in the east and north China with success.

The key techniques for propagation of seedling of hybrids are as follows:

Seed harvesting: The seeds are harvest in April. Number of seeds is 450,000 to 500,000 per kg.

Sowing: The land selected as nursery must be fertile, convenient for irrigation and drainage and without diseases and insect pests. The seeds can be sown by broadcasting. The temperature required for germination is above 13°. The germination rate of seeds is 80 ~ 85% and survival rate 40 ~ 50%. By sowing 15kg seeds per ha, 180,000 to 200,000 seedlings can be produced.

Nursery management: After sowing, cover the nursery with rice straw and sprinkle with water to keep moisture. When the young seedling comes out with 2 true leaves about 10 days

later, part of the covered straw can be taken off. Weeding and thinning are needed. When the seedling grows with 4 ~ 5 leaves, sprinkle 0.3 ~ 0.5 % urea solution with an interval of 5 ~ 7 days. The seedlings can grow up to 30cm height 90 days after sowing in spring. They can reach 60 ~ 100 cm within 120 ~ 150d in the nursery.

Transplanting: Seedlings sown in spring can be transplanted in autumn or winter of the same year, while those sown in autumn can be transplanted in the following spring. If the mulberry is newly planted in January, the first crop of leaf can be harvest in May and the leaf yield of the first year can reach 26,250 kg/ha. If the mulberry is planted in early August, the normal harvest is started in mid-April of next year, and the annual leaf yielding can reach 37,500 ~ 52,500 kg/ha.

2. Planting

The main planting methods include exclusive mulberry garden, scattered planting, inter-cropping, and "mulberry dike and fish pond" system etc.

Exclusive mulberry garden: Mulberry trees are exclusively planted in a certain area of cultivated or newly reclaimed land with a proper density for the main purpose of leaf production. This method can achieve higher land productivity and labour productivity by scientific measures and management. Proper planting density is one of the important measures to increase the production. Planting density depends on the variety of mulberry, soil and climatic conditions, fertilization and irrigation etc. In Zhejiang, east China, in order to harvest leaf 26,250 kg/ha, the recommended planting density is 10,500 ~ 15,000 plants/ha, with the trunk height 0.5 ~ 0.8 m, effective shoots 90,000 ~ 105,000, total length of shoots 120,000 m. In

Guangdong, south China, by planting in high density of 90,000 ~ 120,000 plants/ha and training into low trunk or trunkless type, the annual leaf production can reach 37,500 ~ 52,500 kg/ha.

Scattered planting: In order to fully utilize the odd pieces of land, mulberry trees can be planted in the field-side, road-side, surrounding of house and along the irrigation canal and so on. In Sichuan, the biggest sericulture province in China, millions of mulberry trees are scattered planted in the hilly and mountainous areas. By this method, mulberry does not compete with the other crops in the cultivated land.

Inter-cropping: In Liaoning province of northeast China, some mulberry trees are inter-cropped with grain crops. In Zhejiang province of southeast China, farmers get very high profit by inter-cropping white chrysanthemum in the mulberry garden. In Guangdong province of south China, winter vegetables are planted in between the rows of mulberry.

"Mulberry dyke and fish pond" system: This ecosystem has been developed in the Pearl River Delta of Guangdong for several hundred years. The proportion of pond area to dyke area is 6 : 4 or 7 : 3 according to the condition. Mulberry trees are planted on the dykes. After feeding the silkworm, the feces of the larvae and the wasted leaf are used as the feed of fish in the pond. The pond silt is used to fertilize the mulberry trees.

3. Field management

Fertilization: For leaf production the proper proportion of N:P:K is 10:4:6. Generally speaking it needs 1.5 ~ 2 kg nitrogen (equivalent to 3.26 ~ 4.35 kg urea) to produce 100 kg leaf. Now the composed fertilizer containing proper NPK and trace elements are wildly used for mulberry.

Irrigation: During the growing seasons of summer and autumn, 8 ~ 9 kg water will evaporate every day from 1 kg mulberry leaf. If the quantity of leaf is 7,500 kg/ha, the water transpiration will reach 72 tons. This does not include the evaporation from the land. In the dry season, the irrigation of water is 30 mm for an interval of 5 days.

Pruning and harvesting: In order to produce quality leaf for silkworm, various training, pruning and harvesting method are adapted according to the different climatic and geographic conditions. In tropical and subtropical areas, the main techniques include high planting density, low trunk or trunk-less training type, and shoot harvesting for the whole year. In the case of animal feed production, the grass-type mulberry plantation is recommended. Mulberry seeds can directly sow in lines with much higher density than that of silkworm feed production. The shoots together with leaves can be cut several times a year by knife or machinery, so a lot of labour can be saved.

IV. Animal Feeding Practices

In China nearly 100% of the mulberry cultivated is used for silkworm feeding only. The litter, containing silkworm feces and wasted leaf, is used to feed fish in the pond or as the supplementary feed for cattle.

V. Other Traditional Uses

1. Silkworm feed

Mulberry contains all the necessary nutrients for the growth and development of silkworm *Bombyx mori*. For more than 5000 years, mulberry leaf is served as the only feed of mulberry silkworm. Even today, this condition is not changed in China,

although the utilization of artificial diet has gained inspiring result in the laboratory level. Fresh mulberry leaf contains 70 ~ 80% water, 20 ~ 30% dry matter. In the dry matter, crude protein is about 25%, soluble carbohydrate 25% and ash 10%, the others are the nitrogen-free substances dissolved in ethyl ether.

The leaf-silk inversion rate, or the feed efficiency of mulberry leaf for cocoon shell production, is the main index to evaluate the leaf quality. In China, it takes 15 to 18kg fresh leaves to produce 1kg fresh cocoon at the farmer's level. The researchers investigated 251 silkworm varieties maintained in Sericulture Research Institute of Chinese Agricultural Academy and the result showed that the leaf-silk (dry matter) inversion rate is 10.11% in average.

2. Fruit

The main content of fresh mulberry fruit (sorosis) is water 85%, crude protein 0.36%, free acid 1.86%, invert sugar 9.19%, crude fibre 0.91%, ash 0.66%. The fruit is also rich in carotene, Vitamin B_1, B_2, C, nicotinic acid, fatty oil etc. The main sugar content is glucose, and the main free acid is malic acid. The fresh sorosis is traditional fruit. Recent years, mulberry fruit juice has been commercially produced as a healthy beverage, and become very popular in China. Without adding antiseptics, the original juice of mulberry fruit can keep fresh under cold storage for 3 months, while the beverage can keep fresh under the natural temperature for 12 months.

3. Mulberry tea

Dry matter of mulberry leaf contains rich γ - aminobutyric acid, which is as high as 266 mg/100g dry matter in average of 119 mulberry varieties investigated, about 10 times higher than

that of green tea. The main function of γ - aminobutyric acid is to lower the blood pressure and help the nerve transmission. In China certain amount of leaves are wasted by the end of rearing circles. In the end of autumn crop, the unused leaf per hectare reaches 1500 kg even more. In order to exploit this valuable resource, the technique of preparing mulberry tea is developed. The processing of mulberry tea is similar to that of green tea, which includes the procedures of leaf harvesting and washing, chopping, steaming, rubbing, baking, cooling, sieving and storage. The preparation of drinking of mulberry tea is the same with that of green tea.

The baked or fried mulberry tea powder is rich in protein and carbohydrate, and with a distinct fragment smell. It can be used as food additive to prepare steam bun, bread, cake and biscuit etc.

4. Edible fungi production

Dry stem of mulberry contains cellulose 50%, semi-cellulose 20%, lignin 20% and crude protein 5%. The proportion of carbon to nitrogen is 86 : 1, which is suitable for edible fungi production. By using the stem powder of mulberry as medium, mushrooms, Jew's ear (*Auricularia auriculajudae*) and medicinal fungi (*Ganoderma lucidum*) have been popularly produced in China.

5. Medicinal uses

Chinese has a long history to us mulberry as a traditional herb medicine. The medicinal function of different part of mulberry is as follows:

Leaf: It is used against hyperlipemia and diabetes.

Fruit (sorosis): It is good for liver and kidney, used against nephritis, thirsty, constipation etc.

Root: It has the function to lower the blood pressure. The bark of root is used against pneumonia and hemoptysis.

VI. References

1. China: Sericulture, 1980 (E*), The FAO Agricultural Services Bulletin.

2. Mulberry Cultivation, Zheng. T. *et al*, 1988 (E*), The FAO Agricultural Services Bulletin.

3. Survey of Mulberry Species in China, Shi Bing-kun *et al*, 1993 (C*), China Agricultural Publish Agent.

4. Mulberry Cultivation and Breeding, Ke Yi-fu *et al*, 1997 (C*), China Agricultural Publish Agent.

5. Progress and Prospect of Sericulture in Guangdong, Y. K. Huo *et al*, 1997 (E*), Indian Silk.

(E: English; C: Chinese)