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中国果树志

苹果卷

陆秋农 贾定贤 主编



中国农业科技出版社
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序

《中国果树志》是1979年全国果树科技规划会议提出的一项科研计划，由中国农业科学院果树研究所负责主持实施。1981年3月27日至4月3日，中国农业科学院在重庆召开《中国果树志》编写工作座谈会。来自12个省、市、自治区科研、院校与出版单位的专家、教授及专业人员共27人出席了会议，讨论和成立了《中国果树志》总编委会并推举了顾问，同时落实了29个专志的主编单位，制定了编写提纲和编写体例（草稿）。总编委会编辑部设于辽宁兴城中国农业科学院果树研究所，负责修订编写体例、提纲，统筹经费等具体编辑出版事宜。

计划中的专志将包括：苹果、梨、柑橘、葡萄、桃、李、杏、梅、樱桃、核桃、板栗、柿、枣、山楂、榛子、猕猴桃、醋栗及穗醋栗、草莓、荔枝、龙眼、枇杷、香蕉及长山核桃、杨梅、石榴、菠萝、香蕉、芒果及杨桃、银杏、稀少落叶果树等29个专志。《中国果树志》不仅包括栽培品种，而且也包括半栽培品种和野生果树的种、变种及类型，这些都属于种质资源。所谓“种质”，是指细胞核内有生命的物质，它决定生物体的遗传性质，并把这些性质从亲本传递给后代。广义地说，种质是生物体总的遗传构造。

《中国果树志》的任务是反映中国果树种质资源的面貌及有关的科学研究成果，为科研、生产、教学服务。由于多年来特别是中华人民共和国成立以来全国各地已进行了大量的调查和研究，积累了大量宝贵的资料，又由于中国果树种质异常丰富，还须继续长期地发掘勘探，因此本志是全国果树种质研究的阶段性总结，同时也是中国前所未有的第一部较全面、系统的果树种质研究的科学论著。

作为一部果树志，不言而喻，重点放在种、变种和品种的描述，尤其是可供生产参考的经济特性的介绍，如果实的外观及品质，成熟时期，耐贮运力，对气候土壤的适应性，对病虫害、旱、涝、盐碱的抗性等。栽培管理技术仅限于叙述各该树种不同于其它树种的特点及重要的沿革。

在中国古农书的宝库中，有不少记载和描述果树品种的专著，其中最突出的是北宋蔡襄的《荔枝谱》（成书于1059年）和南宋韩彦直的《橘录》（1178年）。两书都是全世界关于这两种果树最早的专著。元代柳贯的《打枣谱》（1300年）记述了枣的73个品种；清代褚华的《水蜜桃谱》（1813年）记述了上海水蜜桃的历史、栽培、病虫害防治等。散见于其它古农书中有关果树品种的记述，多不胜数，主要有《齐民要术》《种艺必用》《农桑辑要》《王桢农书》《农桑衣食撮要》《种树书》《群芳谱》《广群芳谱》《农政全书》《花镜》《授时通考》以及其它如《本草纲目》《植物名实图考》等。这些浩瀚的文献，说明了我们的祖先对果树种质资源的重视，为后人留下了宝贵的资料。

全国性的果树种质的调查、收集和利用，始于20世纪50年代。经过各地果树科技工作者长期的努力，发掘出了大量过去未受注意但却具有某些优良特性的品种，例如：新疆库尔勒香梨，喀什的黄肉蟠桃；新疆阿克苏及陕西扶风的隔年核桃，太白的串子核桃；陕西紫阳的三季栗；眉县的怀胎柿；陕西秦岭山区及河南的冬桃，山东昌邑的冻桃和泰安大石榴，河北的雪桃；福建莆田的解放钟枇杷；广东惠东的四季荔，广州的红荔；广西的无核黄皮等。

中国西南的山岳地带是世界上一个重要的柑桔种质中心。在云南红河发现了大翼橙的一个新种，红河大翼橙 (*Citrus honghoensis* YLDL.)。在云南宾川发现了柑桔属枸橼的一个新变种，云南香橼 (*C. medica* L. var. *yunnanensis* S. Q. Ding)。在四川木里发现了枸橼的另一个新变种，木里香阳果 (*C. medica* L. var. *muliensis* W. D. et Y.)。在四川秀山发现了柚的一个自然杂交种，柚香橼 (*C. grandis-junos*)。在四川的小金、马尔康、理县，发现了苹果属的一个新种，小金海棠 (*Malus xiaojinensis* Cheng et Jiang)。

不少地区存在着大面积的野生果树，如新疆天山山区巩留、新源、霍城、伊宁等地的塞威氏苹果林 (*Malus sieversii* Ledeb.)，湖南道县的野桔，海南的野生荔枝和香蕉。

长期以来，对西藏的果树种质资源缺乏了解，现在，这个空白点已基本消除了。根据中国农业科学院组织的西藏农作物品种资源考察队果树组的报告，在山南和昌都两个地区的栽培和野生果树，分属18科、33属、106个种或变种。值得注意的是分布最广的野生果树之一西藏桃 [又称光核桃，*Prunus mira* (Koehne) Kov. et Kost.]，年逾千年的古老植株，仍然生长旺盛，结果正常，树高达21米，干周10米。核桃树分布很广，丰产，病虫害少，果仁含油量高，有高达30多米、占地1亩以上的大树，最老的估计树龄超过千年。

中华猕猴桃原产中国，其果实营养价值很高，中国组织了全国猕猴桃资源普查，在各地野生的中华猕猴桃和美味猕猴桃中，选得了大量的具有优良性状的单株，或果形大，或维生素C含量高，或果实成熟时果皮无毛。据报道，中国已发现61个种，44个变种，其中不乏有很大生产潜力的种质，因此，除中华猕猴桃和美味猕猴桃外，其它的种如软枣猕猴桃、狗枣猕猴桃、黑芯猕猴桃、金花猕猴桃等也正在列入研究项目之中。

原产中国的山楂，果实中含有丰富的矿质营养、维生素C、果酸和黄酮类，在医药和食品中占一定的地位，被誉为“疗效食品”。中国组织了全国性的调查组，经多年的努力，基本上查明了各地山楂的种、变种和品种，其中有很多表现了独特的性状。

1979年，中国农业科学院在重庆召开的全国果树科研规划会议上，根据区域适应性、交通等社会条件和原有的果树种质保存的基础，提出了在全国建立15处国家果树种质圃的计划，并得到了农业部的支持。目前，这15处种质圃已在不同程度上分别进行收集、鉴定、观察记载经济性状的研究工作等。各处种质圃收集、研究的果树种类各有侧重，如兴城为梨和苹果，郑州为葡萄和桃，重庆北碚为柑橘，北京为草莓和桃，泰安为核桃和板栗，福州为龙眼和荔枝，等等。国家种质圃的建立，为保存和研究果树种质提供了保证。

中国对世界各国的果树生产有巨大的贡献，许多具有重要经济价值的果树均原产于中国。例如，甜橙在15世纪初叶由热那亚贸易路线上的商人从中国带到欧洲，其后由葡萄牙人传播到欧洲各地，再扩散到许多国家，成为今日全世界最重要的果树。桃的英名 (Peach) 和学名 [*Prunus persica* (L.) Batsch.] 都是由“Persia” (波斯) 推演而来，因此，使许多人对桃的原产地发生误解，以为桃原产于波斯，实际上在这种果树引入欧洲以前2000余年中国早就有桃的栽培，是原产地。德康多尔 (de Candolle) 认定，波斯从来没有野生的桃。桃的主要品

种之一,‘埃尔伯塔’(Elberta)是美国在1870年从中国的一粒白肉粘核桃的种子获得的。另一粒中国的粘核桃种子产生了又一个主要的品种——‘Belle of Georgina’。这2个品种不仅本身有重要的经济价值,而且也是杂交育种工作中优良的亲本。从记录上推测,这2粒白肉粘核桃的种子很可能是上海水蜜桃。

20世纪初,英国和美国先后引种中国猕猴桃作为观赏植物。1906年,新西兰从湖北宜昌地区引种栽培,经过多年的努力,培育出果大质优的一些新品种,成为果中珍品,曾独霸世界市场。

利用中国的果树改良原有品种,以增加对病虫害、寒、旱和其它不良环境因子的抵抗力的例子,在世界果树栽培史中,屡见不鲜。1904年,美国的栗树(*Castanea dentata* Borkh.)发生胴枯病[病原菌为*Endothia parasitica* (Murr.) A. et A.],病情严重,在短短五、六年內蔓延全国,几乎把原有的栗树一扫而尽。是中国的板栗,提供了抗病的种质,因为板栗表现了对此病强大的抗性。洋梨的火疫病是许多国家梨生产中最严重的一种病害,原产中国的梨属的一些种,对此病有一定的抗性,因而这些种成为他们梨抗病育种中的重要亲本。

米丘林在培育果树抗寒品种的工作中,曾大量用中国的种质作为亲本,许多苹果品种名都带有“Kitaika”一词,如‘Bellefleur-Kitaika’、‘Borsdorf-Kitaika’、‘Kandil-Kitaika’、‘Kitaika-Anisovaya’、‘Kitaika Zolotaya Rannaya’等,“Kitaika”是俄语的“中国”。此外,他还利用中国的山樱桃、毛桃、山桃、郁李、山定子、花盖梨、核桃楸、小榛树等作为亲本。

野生的和栽培的、半栽培的果树种质构成了自然界和我们的祖先赋予我们的遗传变异的源泉,它们有些可能对目前的生产不起作用,但是,从长远的发展来看,它们是宝贵的财富。在山林中,在原野上,在果园里,在住家的庭院里,它们默默无闻地存在着,有些是成片的,有些是零星分散的,有些是少数几株或甚至只有一二株。长期以来,由于人们的无知,在开垦荒地、滥伐林木、建筑水库、建设工厂、扩展铁路和公路等活动中,没有注意对果树种质的保护,使这丰富的资源迅速缩小,这是一个无法挽回的损失。

威尔森(Ernest Henry Wilson)在湖北、四川一带经过历时10年、先后四次的采集之后,深感中国植物蕴藏之富,把他1929年出版的书名定为“中国,园林之母”。该书在关于这一地区内栽培和野生果树的记载中,列举了为数极多的种类,仅悬钩子一属的植物,野生于山林中的就有一百余种,其中大部分的果实可供食用,而且有几种风味特佳。茶藨子属和草莓属的植物也普遍地生长在林野里。时至今日,这些种质还有多少依然存在,难于断言。

果树种质的流失,是一个世界性问题,只是各国的严重程度不同而已。发掘、保存、利用这些资源的工作的优劣,是一国文化水平高低的一个标志。50年代以来,这项工作一直受到中国政府的重视,列为重点研究课题,取得了令人瞩目的成绩。

1945年,E. H. M. Cox在他的《在中国猎取植物》这本书的最后一段写道:“在中国还可以找到更多的植物材料,从中国还可以学到更多的东西。本书叙述了外国人在这个巨大的国家所进行的植物勘探。让我们希望下一卷与本题有关的书,将叙述中国人自己在—一个崛起的和平、繁荣的新中国所取得的成就。”

今天,在该书发表近半个世纪之后,中国全体果树科技工作者几十年来辛勤劳动的成果——《中国果树志》各卷专志,将陆续问世。它们将对对中国果树科研、教学和生产的发展起到重要的作用;同时,对世界各国的果树工作者,也将是一份宝贵的参考文献。

正如前述,《中国果树志》是一份中国果树种质资源研究的阶段性总结,因为,可以肯定,

在今后的岁月里，还会有许多栽培的、半栽培的和野生的种质被发掘出来，这将有待于中国果树工作者的继续努力。

《中国果树志》的编写，只是果树种质研究整个计划的一部分，这项计划的最终目标是利用种质为人类福利服务。要达到这个目标，首先需了解它们的各种特性。在科学技术日新月异的今天，我们完全有可能从形态学、细胞学、生态学、营养学、土壤学、遗传学、分类学、生理生化学、植物病理学、昆虫学等方面进行深入的研究。这就意味着，必须有多学科的密切协作，才能取得对人类有利的成果。

《中国果树志》编写过程中，得到国家自然科学基金委员会、中国农业科学院的经费资助和其它有关方面的支持与协作，以及中国林业出版社的重视，谨致衷心感谢。

在《中国果树志》出版之际，我们感到欣喜庆慰，同时也应认识到，我们要走的路还很长很长，要付出的劳动还很多很多。

《中国果树志》总编辑委员会



1991年12月于北京

前言

《中国果树志·苹果卷》(以下简称《苹果卷》)是在中国果树志总编委会的指导下,由中国农业科学院果树研究所和山东省果树研究所共同主持,组织全国 30 多位专家撰编而成。

《中国果树志》的编写是中国农业科学院根据“1979~1985 年全国果树科技发展规划(草案)”而确定的,并于 1981 年 3 月在重庆召开了《中国果树志》编写工作会议。经协商讨论《苹果卷》编撰工作由河北省农林科学院昌黎果树研究所主持,同年 7 月在昌黎召开了第一次《苹果卷》编写工作会议。会后,组成了《苹果卷》编委会,制定编写提纲和分工,但由于经费及其他原因,编写工作未能顺利开展。1992 年初,《中国果树志》总编委会、编辑部鉴于 10 年来人员变迁较大,《苹果卷》原编委中不少已退(离)休或去世,实在难以为继,经与中国林业出版社等有关单位反复磋商,并征得原主编单位和主编的同意,确定《苹果卷》编撰工作改由中国农业科学院果树研究所和山东省果树研究所共同主持,并于同年 10 月在北京召开会议,重新组建了编委会,修订了编写提纲,落实了分工,规划了编审程序和进度安排。1994 年部分初稿完成,即请有关编委审阅;是年底,按总论、各论分别寄交主编初审;1995 年底由主编、副主编集中复审后,再次进行修改、补充和章节调整;1996 年底在总编委会常务副主任蒲富慎的指导下由编辑部邀请王汝谦、朱扬虎、束怀瑞、陈景新和景士西(依姓氏笔画为序),会同编辑部董启凤研究员和中国林业出版社陈利副总编等进行终审。会后,责成陆秋农、贾定贤两主编按终审会的要求和专家们的意见,再次进行修改和补充,并于 1998 年经《中国果树志》编辑部审定,送交中国林业出版社。

《苹果卷》总论部分分为 8 章,即绪言、苹果的起源和演化、栽培历史、分类和种的描述、栽培产区分述、特征和特性、栽培技术和其他科技成就、砧木;各论为第 9 章即品种资源部分,总论、各论文字比重约为 2:8。

关于苹果的起源和栽培历史,中国苹果和西洋苹果虽都源自新疆野苹果(即塞威士苹果),但演化路线不同,两者不仅在形态和经济性状上有一定差异,在染色体倍性和酶学方面既有相似处,又有差异性。《苹果卷》对中国苹果和花红的起源、栽培历史、传播与消长;西洋苹果的引种历史、途径和发展分别进行了记述。

中国苹果属植物的种质资源十分丰富,原产中国的约 23 个种,占全世界已知种的 65.7%。此外,80 年代以来还不断有新种发现。与此同时,在苹果属植物的实验分类研究,如细胞学、孢粉学、酶学、遗传学等方面也取得了长足的进展,为苹果属植物的分类方法提供了新的依据。因此,《苹果卷》在记述分类沿革时,重点反映了国内苹果属植物分类的进展;种和亚种、变种、变型的确立和归属。

中国栽培苹果分布面广,从西藏河谷、云贵川高地到吉林、黑龙江、内蒙古;从东海之

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滨到西北边区都有生产栽培，其生态条件有明显的差异，生产水平也互有高低，主栽品种也不尽相同，分区记述有助于苹果区域化的逐步实施。

由于中国的国情，苹果栽培的立地条件以山区、丘陵、沙荒为主，经过长期生产实践，摸索出一系列与之相适应的栽培技术和经验。随着生产的发展，有关科技研究也较为集中和深入。客观地反映这些经验和技术的积累过程，特别是早期的、与生产密切相关的科技成就，对进一步发展和深入研究将会有一定的借鉴作用。

品种和砧木资源是生产的基础。根据生产的实际需要，砧木是以实生砧、营养系砧木和新选育砧木分别概述其主要类型的生产性能和应用前景。品种则根据历史情况和现状，按中国原产的品种、中国选育的品种、引入国外的品种分为三部分。分别对其起源分布、果实经济性状、生物学特性和植物学特征进行描述，记述见于生产栽培或研究单位保存的品种 660 个，列表记载品种 210 余个。

由于编著者水平和掌握的资料所限，难免有遗漏和不当之处，敬希读者指正，以便今后补充和修订。

《中国果树志·苹果卷》

编辑委员会

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SUMMARY

Chapter 1 Introduction

Chinese apple (*Malus domestica* Borkh. subsp. *chinesis* Li Y. N.), which was named Nai in ancient time, had been cultivated in China for about 2000 years. It was gradually substituted since the introduction of European apple (*M. domestica* Borkh.) cultivars in 1871. A lot of new cultivars developed by China breeding program had been extended in the production area since 1950's. The genetic resources in *Malus* is very rich in China, which has 23 species, especially 12 species in the Palaeo Continent between Sichuan and Yunnan Province.

The policy of apple cultivation in China was to plant them in impoverished soil and not to scramble for the land of grains and cotton. Apple production was becoming a key industry for the economic development in the vast area of mountains, hills and infertile sand beaches. The income from apple occupied about 30%~50% in the agricultural gross revenue in some part of main apple production area. In the same time, apple production also had promoted the development of relative industry, such as food processing, package, storage and handing. So, planting apple was to be one of main method that local government help peasants shake off poverty and build up a fortune. In 1995, the apple total yield in China reached 14010t.

Since 1949, apple production in China had experienced three phases:

1. *Three-year restoration* Chinese government took a policy of resting and building up with strength-exemption from income tax, providing means of production, and protection and control of plant diseases and pests. This made tree grow vigorously and fruit farmer full of production confidence.

2. *During first high tides of apple production* (1950~1960) The old apple production bases, such as South of Liaoning, Peninsula of Shandong and North of Hebei, were strengthened and improved. During the same stage, the government did his best to support the construction of a new base, such as the Old Course of the Yellow River, Northern Foot of Qinling Mountains and Border Region of Northwest. The total apple production in China was up to 2.975×10^5 t. From 1959 to 1961, apple cultivation area and production went down quickly. But from 1962 apple production continued to develop, and in 1972, cultivation area and production arrived individually to 4.58×10^5 hm² and 8.603×10^5 t.

3. *The construction of commodity base and change of cultivars* Consumer began to pay more attention to fruit quality along with the development of market. In 1973, the production bases of high quality apple were set up in the area of the Bohai Bay, Northwest Plateau

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and Southwest Highland, which was suitable to product high quality apple. Selection of good strains from sport mutation and introduction of fine cultivars from outside into the nation were launched. All the cultivars in production were completely changed. In 1990, the fine apple cultivars occupied about 75% in the production area of Shandong, Hebei, Shanxi, Henan, Liaoning and Shaanxi Province.

Chapter 2 Origins and evolution of *Malus*

The cultivated apple in China was classified to two kinds: Chinese apple and European apple from Europe, North America or Japan. Both of them differ from each other not only in the economic traits but also in the physiology and biochemistry.

Chinese apple originated from *M. sieversii* (Ledeb.) Roem. in the Autonomous Region of Xinjiang of China. *M. sieversii* distribute all over vast Yili valley and Huocheng basin of China, and Alamutu Mountains of Kazakhstan 20×10^6 years ago. There was a lot of wild forestry in the Yili of Xinjiang up to now. It was investigated that there were 16 ecotypes in Xingyan County and 28 in Gongliu County. The biggest fruit was five to six centimeters in diameter among more than 40 ecotypes, which were the base of artificial.

The scientific basis that Chinese apple originated from *M. sieversii* was identical to the same center of geological distribution, likeness of morphology, same chromosome number ($2n=2x=34$), globular shape of pollen and consistence of peroxidase isozymers.

Vavilov (1935) Ponomarenko (1991) and Li (1988) studied the origins of European apple (*M. domestica*) and reported that it originated from *M. sieversii*, which grew in the Mountains of Middle Asia. They believed that it hybridized with *M. orientalis* and *M. sylvestris* when it disseminated to the Western, got some germplasma from them and finally formed the secondary center of Western Europe. So, its germplasma was more complicated than Chinese apple. Its varieties had polyploid in chromosome ($2n=2x, 3x, 4x$), and characteristics of pollen morphology of *M. sylvestris* and *M. orientalis*.

Chapter 3 The history of apple cultivation.

"Nai" was the general name of *Malus* plant grown in China in ancient time, but originally meant big beautiful fruit one of Chinese apple (Mian apple). The written character was first seen in the book of *SHANG LIN FU* (125~118B. C., by Sima Xiangru, A rhymed prose of Shangli garden). The remaining trace of Chinese apple, found from the soil in the site of Niya, Minfeng County, Autonomous Region of Xinjiang, demonstrated that it had been widely cultivated in this area. Hereafter, the book of *QIMIN YAOSHU* (533~544 A. C., by Jiasi Xie, Fruit tree culture and fruit process were recorded in Vol. 4) further described the characteristics, culture technology, and processing of different cultivars. In the same time, it also reflected that cultivation area of Chinese apple gradually moved from the West to the East. At the end of 1500 A. C., large fruit type of "Nai" was first called apple in the book of *XUEPU ZASHU* (1587 A. C., by Wang Shimao, culture technique of melon and fruit was

recorded in Vol. 2).

The cultivars or species of cultivated apple varied a lot day by day as the culture area was enlarged and hybridization naturally occurred between species of *Malus*. From 1600, the name of "Nai" became the joint name of small fruit type of *Malus*. After that, it also became the general term of other small round fruits.

"Shaguo" (*M. asiatica*) was recorded later than "Nai", named "Linquin" in ancient time. It was original in north China. Its fruit was sweeter and smaller than Chinese apple. It was recorded after 300 A. C. and had been widely cultured in China. There were two types of the cultivars of "Shaguo", one was called "Huahong" or "Miguo" and its fruit was sweet in flavor, oblate in shape, vertical in stem; other was "Suanguozi" or "Waibasuan", and its fruit was sour in flavor, a little bit leaning in shape and aslant in stem. Moreover, there were some types locally called "Binzi", "Hulabin". Its fruit was sour and puckery in flavor, oblong in shape, and dark red in colour. The flesh was yellow.

"Haitang" was one of flowering crabapples in old Chinese agriculture books. There were little amount of cultivation of *M. spectabilis* and *M. halliana*. It was in 1871 that European crab apple was introduced into China, the commercial production of crab apple began to work.

NEVIUS J. L. first introduced thirteen apple cultivars from USA to Yantai in 1871. After that, some was from Germany to Qingdao in 1897, some from Britain to Weihai, and some from Russia and Japan to Dalian and Lushun. Peninsula of Shandong and South of Liaoning became the birthplace of production of European apple in China until the first half of 20th century. Moreover, at the first of this century, Xingjiang got some Ukraine and Russia's cultivars from Kazakhstan; some apple seedlings were introduced into Batang in Sichuan by American missionary and some cultivars was introduced into Chengdu and Maowei in Sichuan by Canadian.

Small scale of apple cultivar production was formed in the basin of Chengdu. Some European and American cultivars were introduced into Kunming and Lasa by France and Britain, but they failed. Some colleges in Jiangsu had introduced American and Japan's cultivars but only did experiments with them. In summary, During more than half century from 1871 to 1949 there were almost European apple cultivars introduced into our country, but only 20 cultivars were used in the industry. Besides Liaoning and Shandong had a large scale of production, Xinjiang, Hebei and Beijing only had a little amount cultivation.

Chapter 4 Description of species

A COLLECTION OF PLANT PICTURE, edited by Wu Jijun and *TAXONOMY OF CHINESE TREES* edited by Chen Yong (1939) were earlier book of Chinese scientific classification of *Malus*. They belonged to the category of natural botany classification. Yu Dejun (1956) using the framework of Rehder A. advanced that *Malus* in China had 23 species, 5 subsection and 3 section in his book of *CLASSIFICATION SYSTEM OF CHINESE*

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Malus. He also formulated the classification retrieval system. The great progress had been made for the classification of *Malus* in the field of enzymology cytology. Pollen-morphogenesis since 1970's. Li Yunong et al put forward a new theory of botany classification of *Malus* in China; (1) Some "species" differed greatly in traits or morphology and should be referred as the original species of multi-type and called subspecies, varieties or forma. (2) According to ecology, some species, which had no model sample and wildly dispersed region, should be classified individually with wild species. The former should be classified by Pomology and the later by nature. The wild species were divided into 13 species, 7 subsection, 3 section; the cultivated had 7 subspecies, 7 species, and had no subsection and section. *Malus* in China included 26 species, such as apple, Chinese apple, crabapple etc. were recapitulated. The list of 16 species introduced and 6 new species was included.

Chapter 5 Area of cultivated apple in China

Historically, apple production area was divided into three part; old region of small apple, Chinese apple and crabapple in Xingjiang and Gansu; the region of small apple resistant to cold in Heilongjiang, Jilin, the North of Liaoning and Inner Mongolia; the region of European apple in the Peninsula of Shandong and Liaoning Province. The area of European apple increased quickly from 1950's. Now the apple production of China could be divided into 6-production region according to its production level and condition.

1. *Northeast small fruit region* It was mainly composed of Heilongjiang and Jilin Province, also included the north of Liaoning, Inner Mongolia and Xinjiang. The mean annual temperature was $6\sim 8^{\circ}\text{C}$, the mean temperature in the coldest month was less than -12°C and the effective accumulated annual temperature was $2200\sim 3200^{\circ}\text{C}$. In the same place, reptant was needed even for the apple most resistant to cold. The main cultivars were Jinhong, Beiguang, Qiuhong, Huangtaiping, Daqiuguo and et al. It occupied 2.5% of apple cultivation area and less than 1% of all the production in China.

2. *Northwest production region* It mainly included the high latitude of Yellow River. It was mostly $8\sim 10^{\circ}\text{C}$ of mean annual temperature and less than -10°C of mean month temperature in January. It was mild in summer and most more than 3000°C of annual effective accumulated temperature. It rained a little and was about $250\sim 400\text{ mm}$ of precipitation. Apple had low production per unit area, but high quality in fruit. There were some Chinese apple and *M. asiatica*. At the first when European apple was introduced it often suffered from cold and shoot damage, but it increased rapidly in mild climate area (Shanxi) and Shaanxi became the second apple production region of china, which occupied 12.5% of cultivation area and 27.3% of production in all China.

3. *Bohai Bay production region* It mainly consisted of Shandong and South of Liaoning, including Hebei, Beijing and Tianjing. Its climate was more mild with $8\sim 12^{\circ}\text{C}$ of mean annual temperature. In the north part of this region, winter was cold and cold damage sometimes occurred in apple. The accumulated effective temperature was high and rainfall was

medium. In the south or coastal area, late-in-summer and autumn cultivars coloured difficultly. Cultivars had been renewed several times but now the leading cultivars were Red Fuji, Starkrimson and Redchief. Farmers in this region have rich experience and advanced technology in apple production. Production was high and sometimes arrived to 20~25 t/hm². It occupied 45.8% of the area and 55.3% of production in all China.

4. *Middle China production area* It was from 35° of north latitude to the Huai River and Qinling Mountains, from the east Lianyungang, Jiangsu to the west Baoji, Shaanxi, which belonged to the barren area of "Old Yellow River". It has high air temperature, full of rain, high effective accumulated temperature and minor sunlight. Apple tree grew fast, formed shape quickly and bumpered easily in the early stage. After 1970's, Fuji became top one cultivar. It occupied 16.5% of gross area, 14.8% of gross production and was third region of apple production.

5. *Southwest highland production region* It consisted of the plateau of Yunnan-Guizhou-Sichuan and the valley of Xizang. The apple production was carried out at the latitude of 1500~3500 m by using vertical change of climate in the high mountains. The mean annual temperature was 8~17°C, mostly 10~12°C. The low temperature in January was enough for the dormance of apple. Rainfall was abundant. It was best place for the production of high quality apple. Golden Delicious, Red Delicious and Ralls were its main cultivars. The production and area were a little bit more than Northeast region.

6. *Warm zone production region* It consisted of some parts of provinces along the low-middle reaches of the Yangtze River. The mean annual air temperature was higher than 15°C and rainfall was more than 1000 mm. The accumulated temperature was high but the sunlight was minor. The apple production in this region had experienced various vicissitudes. There were only a little production in Sichuan basin and the mountains of Fujian, Zhejiang and Hubei (the latitude was more than 600~800 m). The main cultivars were earlier one, such as Liaofu, Tongmu-1, and Anna.

Chapter 6 Characteristics of cultivated apple

The height of cultivated apple trees was about 3~6 m. Flower bud mostly on the top of shoot and axillary flower bud formed on the shoot of vigorous tree or just starting-fruiting tree. Polymorphism existed widely in fruit size, shape, colour, flavor and et al. The ripe time of fruit was from June to November.

The characteristics and adaptability of apple roots depended on the factors of soils, root-stocks etc. The roots were distributed over soil in the depth of 80~300 cm, pH 5~7.5 of soil was suitable to root growth. There were two to three growing peaks of roots in one year and some difference in the time gap existed between top and deep soil. The more the growing roots, the more vigorous the tree grew. When fibrous roots occupied a dominant position, the tree grew in the golden mean stage.

The beginning of initiation of flower bud had a close relationship with the slow stage of

vegetative growth in the same year. Although the initiation of flower buds started early or late, the most of them arrived to the stage of initiation of primordial pistil when dormancy began in December. The nutrient level of flower bud was effected by the length of differentiation progress. The flower, which first formed and was in the middle, had high quality and good fruit-setting. Only minor of cultivars, such as Anna, Qiguan and Danxia, had a ability of self-fertility; some, such as Ralls, Indo and White Winter Banana, had a ability of mutually-crossing between plants. All others need to suitable pollinators.

Apple phenophase was from south to north, from east to west in China and was controlled by local effective accumulated temperature. The fruit maturity started at 10°C of efficient accumulated day temperature. The mean annual temperature at 7~14°C was suitable for apple growth and development. If mean month temperature in January was less than -12°C, it was north boundary. If the mean day temperature was more than 26°C in the warm production region, it was no good to the initiation of flower bud. If the night temperature was more than 18°C and sunshine time in a month was less than 150h., it did not benefit to the formation of red colour.

Chapter 7 Apple culture technology and other scientific achievements

Propagation of apple via the methods of mound layering or division of suckers was adapted in the first stage. But now grafting was mainly method of apple propagation. Budding was the usual methods of propagating trees in the nursery. Among them, budding with xylem was more efficient and could carried on for a long time during seasons. Clonal root-stocks still were propagated with layering. The methods getting rid of virus were employed to obtain the nursery stocks with no latent virus and improve the stock quality. According government policy saving the grain field, the orchards were most established in the land of hills, mountains and infertile sand. It occupied more than 60% of total land. The method of soil and water maintenance in the region of mountains and hills was to build the terrace field, dig fish-scale pits and trench, and plant tree on the contour. The density was 4~5m×5~6m in the region of mountains, 5m×6m in the sand soil of river bank. For the clonal root-stocks or spur-type varieties, It was mainly about 2~3m×3~4m.

In the past, clean tillage and planting other crops between rows in the young orchard was widely used as method of soil management. Since 1980, in the most orchards, especially for young trees, the methods such as "covering with plastic film, storing water with dens had been inforced to save water. For bearing orchard, mulching (a depth of at least 20 cm of straw, hay, sawdust) had been used beneath the trees. It benefited for the orchard to increase the moisture-holding capacity and prevent soil from erosion. The system planting green manure crop in the row was used in sandy orchard to improve the soil structure and conserve moisture.

The base manure mainly consisted of organic fertilizer, a little bit nitrogen and phosphorus. It took up the half of fertilizer used in all year. The proportion of N: P₂O₅: K₂O was