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DECIDUOUS FRUIT PRODUCTION IN ASIA AND THE PACIFIC

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
REGIONAL OFFICE FOR ASIA AND THE PACIFIC
BANGKOK, THAILAND, 1999

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Edited
by
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This publication brings together edited manuscripts of papers presented at the Expert Consultation on "Deciduous Fruit Development in Asia", held in Bangkok, Thailand, 2-4 June, 1998. The Consultation was organized and sponsored by the FAO Regional Office for Asia and the Pacific. The Report of the Consultation was brought out in June 1998 (FAO/RAP Publication: 1998/10).

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FOREWORD

The hilly and mountainous eco-system of the Asia-Pacific region is the home of some of the most economically disadvantaged communities, who are mainly hill-tribes in origin. Their system of shifting cultivation and subsistence agriculture, which they have practiced for generations, contributed much towards the environmental degradation of the watershed areas in most countries. Besides, this agricultural system was found to be no longer sufficiently productive and remunerative to attract the people who live in those areas.

To encourage these disadvantaged communities, crop diversification was introduced to bring about a more settled form of agriculture. Growing deciduous fruits as cash crops, in place of their traditional crops, appealed to them. The cool climatic conditions in this eco-system favour the cultivation of many deciduous fruits that found ready markets within the region. Using available technologies, farmers have been able to grow these fruits and make substantial profits.

Many technical problems, however, are yet to be solved in order to provide answers to farmers who produce deciduous fruits. On the other hand, technologies that have already been developed in the various countries of the region have to be disseminated to farming communities that are less developed and need more technological support.

Against this background, FAO organized a Regional Expert Consultation on "Deciduous Fruit Crop Development" at the FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, from 2-4 June 1998. Experts from concerned countries participated in the workshop. They were able to identify critical issues that needed more attention. The report of the Consultation was published by FAO (RAP Publication: 1998/10) highlighting the major recommendations. The current publication collates further useful information in the form of Proceedings.

I greatly appreciate the efforts made by Mr. M.K. Papademetriou and Dr. E. Herath in compiling and editing this valuable document.

Dr. Prem Nath
Assistant Director-General
and FAO Regional Representative
for Asia and the Pacific

INTRODUCTORY REMARKS

Minas K. Papademetriou [*]

Allow me to welcome you to the FAO Regional Office and to this Expert Consultation. The Consultation has been organized and sponsored by the FAO Regional Office for Asia and the Pacific. I am grateful to all of you for coming here to contribute to this Meeting.

When we talk about development of deciduous fruits in Asia our mind goes immediately to the cooler highlands (hill and mountainous areas) of Asia. Those are the areas where the poorest of the poor and the most marginal of the marginal farmers live. The problems of agriculture in those areas are many and complex ones, and they are of concern to every government. They are also of concern to FAO and other International Organizations.

The poor agriculture with its low level of diversification is no longer sufficiently interesting as an economic activity to attract the people who live in those areas. Consequently, many of them abandon the hill and mountainous areas, migrating to the towns with the hope for a better living. This leads to a deterioration of the status of agriculture, not to mention the damage to the natural environment resulting from neglect.

By developing deciduous fruit trees in the highlands the farmers' income can be substantially improved and erosion problems can be reduced. Deciduous fruits tend to be high value crops and in the tropics are highly marketable. However, on the one hand many technical problems related to the development of deciduous fruits such as apple, pear, peach, plum, apricot, persimmon etc., need to be solved. On the other hand the results already obtained in India, Indonesia, Pakistan, Nepal, Bhutan, China and of course Thailand merit dissemination.

Strengthening cooperation among countries and institutions in production development is very important. A forum like this will allow us to learn from each other. We must explore the possibilities of sharing our experiences for mutual benefit. It is in this context that this Consultation has been convened. Briefly its objectives are the following:

a) To review the status of deciduous fruit production in Asia, discuss the problems faced as well as strategies required to overcome existing problems.

b) Elaborate on the Potential and Opportunities for deciduous fruit development in Asia.

c) Discuss ways and means of strengthening collaboration on deciduous fruit research and development.

I wish you all productive discussions and good contacts among one another for the exchange of information and experience.

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WELCOME ADDRESS

Soetatwo Hadiwigeno [*]

It gives me great pleasure to welcome you to the Expert Consultation on Deciduous Fruit Development in Asia. I wish to take this opportunity to convey to all of you warm greetings and good wishes from the Director-General of FAO, from my colleagues in the regional office and from myself.

I am glad to see the keen interest shown by the fruit experts in Asia on a subject which is of high economic significance to many less endowed communities living in relative isolation, where social structures need help to build up and improve their agricultural base. Since production problems in this unique agro-ecological niche are common to all countries, we have decided to host this consultation in order to provide a forum to discuss and deliberate on common problems in a spirit of inter-country cooperation. It is my hope that this meeting will be a valuable and rewarding experience for all of you.

Many countries in Asia have physiographic features and climatic conditions that could be effectively exploited for the production of deciduous fruits. However, the production systems that are already in place and which have been developed by farmers themselves are comparatively inefficient and less competitive. These traditional systems are no longer economically viable. Whilst many farmers in the highlands have held on to these traditional systems as a means of survival, others have abandoned these areas and moved in search of better prospects. Vast areas that have been abandoned have been subject to environmental degradation through neglect. Many governments have resorted to interventions such as re-afforestation to stabilize these areas. Whilst these attempts have helped to restore the ecological balance, the problem of de-population has not been arrested and most countries are grappling with the problem of re-settling people in these areas and improving the conditions for farmers to develop agriculture on a settled basis.

In searching for viable alternatives for the hilly and mountainous areas, we may attempt to promote a transformation of existing traditional systems in favour of commercialized and more remunerative production systems. Most countries today have active researchers working on the adaptation of new crops and better varieties which have high marketability. A multitude of such crops and cultivars are available. I must take this opportunity to commend the work of those scientists who have successfully introduced several deciduous fruit crops into many countries of the region through these programs that have been meticulously engineered by these scientists to blend into the framework of highland agriculture strategies.

This kind of approach which doubtless, has considerable merit, may not be the overall solution for a full-scale agricultural development strategy. Since farm holdings are relatively small and the terrain is difficult to manage, a highly specialized crop

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diversification plan is needed to intensify agriculture to the extent that farmers derive greater benefits for their efforts.

Deciduous fruits such as apples, pears, peaches, plums apricots, nectarines, persimmons etc., seem to adapt well to the highland areas. These crops also help to stabilize hill slopes and arrest environmental degradation, even without resorting to expensive bench terracing, which has been the traditional system in the hill and mountainous areas.

Transport is often difficult from some of the inaccessible areas, but these fruits tend to have better shelf-life and storability than most tropical fruits and are also more amenable to drying. Other possibilities for the producer are simple fruit preservation techniques in order to help better utilization and marketing. Once these fruits reach urban markets, there is ready acceptance as they are non-traditional commodities much sought after by consumers.

As mentioned earlier, highland areas of the tropics are characterized by steep slopes and highly indented valleys that have poor road accessibility and communications. Most areas support populations that have few avenues for development, which often results in abandoning the land and migrating to lower elevations and urban areas which offer alternate avenues for survival. There is also a lack of programs for such regions as they are not well patronized by governments or by the private sector. A well-organized development plan for the production of deciduous fruits would help generate more income through the supply of these non-traditional commodities to markets within each country and can even substitute expensive imports.

It must be borne in mind, however, that there are many production technology gaps for the successful cultivation of deciduous fruits in tropical highlands. This is a challenge for the production specialists who are called upon to cater to the needs of every crop and variety.

The first step in the process of deciduous fruit development would be to identify superior cultivars of quality fruit which are market demanded, and suitable for different growing areas in each country. These varieties should be vegetatively propagated using appropriate rootstocks. Availability of high quality planting material is of paramount importance in the whole process. Similarly, appropriate crop management practices such as training and pruning of the plants, fertilizer application, weeding, mulching, supplementary irrigation, pest and disease control etc. can play a very important role in increasing the production and productivity of these crops. It should be noted that plant protection is an important component of the crop management program. However, in order to develop an eco-friendly package, it will be necessary to reduce dependence on chemical control methods and to switch over to integrated pest management practices. Processing and marketing issues are equally important and need to be given due attention. There is also a need to strengthen advisory services to guide the agricultural communities in the proper adoption of new innovations.

Countries in the region have highland areas with similar climates. It must not be ignored that many agricultural communities have developed several useful technologies on their own. These useful technologies that have evolved over a period of many years should also be given due recognition. What is now needed is to assimilate this information, refine the technologies where and when necessary, and share such information among countries. This will help expansion of deciduous fruit culture to other areas where diversification and development are needed.

In conclusion, I wish to state that we need to plan out strategies to collect available information, develop new technologies and seriously consider the sharing of our knowledge through dialogue and discussion at meetings of this type, and establish regional mechanisms for inter-government cooperation. I would also like to take this opportunity to thank you all on behalf of FAO for accepting our invitation to participate at this meeting. I also wish that your deliberations will be successful and I can assure you of FAO's full support to further your country programs on deciduous fruit development.

DECIDUOUS FRUIT PRODUCTION IN AUSTRALIA

Alan P. George [*]

1. INTRODUCTION

Apples and peaches were first introduced into Australia by both European and Chinese settlers at the end of the 1890s. Fruit quality and productivity of temperate fruits grown have been gradually improved through introduction and selection of better quality varieties, mainly from the USA. Over a period of time, the most suitable regions to grow these fruits have been selected. About 90% of Australia's production is consumed domestically. Australia was a major exporter of apple to the UK in the 1970s. However, with the UK entering the European community our exports to this market collapsed. Since then, a major restructuring of most temperate fruit industries has occurred and now Australia has repositioned its exports to Japan and South-east Asia.

2. PRESENT SITUATION OF DECIDUOUS FRUIT CROP CULTIVATION

Australia grows a wide range of deciduous fruits including apple, pear, grape, nashi, peach, nectarine, plum, apricot, cherry and to a lesser extent persimmon, kiwifruit and blueberries. About 70% of the current production occurs in temperate regions. However, temperate fruit production in subtropical regions of Australia has increased rapidly during the past 10 years due to the ready availability of high-quality stonefruit germplasm from the University of Florida breeding programs (Sherman, et al., 1978; Sherman et al., 1984; Sherman, 1987) and the introduction of high quality non-astringent persimmon cultivars from Japan. Suitable agro-climatological conditions exist within many regions of Australia to grow these temperate fruits, and new industries are being developed in regions where none previously existed. Production statistics for different temperate fruits are presented in Table 1. Major production areas, varieties and rootstocks used are presented in Tables 2 and 3.

Table 1. Production Statistics for Temperate Fruits in Australia

Deciduous Fruit Crop	Production (tons)	Area (hectares)	Estimated % Grown in Subtropical Regions
Peach	20,182	3,200	30
Nectarine	16,552	1,720	25
Apricot	18,134	1,200	0
Plums/prunes	10,714		5
Cherries	5,043	1,400	0
Apple	327,877	9,200	2
Pear	161,354	5,378	0
Nashi	7,450	950	0
Dried Vine fruits	46,162	1,500	0
Table grapes	50,000	3,000	15
Kiwifruit	5,000	250	60
Persimmon	800	285	80
Blueberry	1,200	356	60

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Table 2. Major Deciduous Fruit Production Regions and Cultivars Grown

Deciduous Fruit Crop	Temperate Region	Major Cultivars	Subtropical Regions	Major Cultivars
Peach	Stanthorpe, Batlow, Orange, Huon Valley, Tamar Valley, Tatura, Shepparton, Goulburn Valley, Perth Hills	Cal Red, Rich Lady, Elegant lady, Crown Princess, O'Henry	Atherton Tablelands, Nambour, Gatton, Kumbia, Northern NSW, Hills District, Sydney, Perth, Gin Gin	Flordaprince, Flordagold, Tropic Beauty
Nectarine	Stanthorpe, Batlow, Huon Valley, Tamar Valley, Goulburn Valley, Perth Hills	Fantasia, Fairlane, Maygrand, SpringRed, Red Diamond, Rose Diamond, August Red	Nambour, Gatton, Kumbia, Northern NSW, Hills District, Sydney, Perth, Gin Gin	Sunwright, Sunripe, Sundowner, Sunracyer
Apricot	Stanthorpe, Batlow, Huon Valley, Tamar Valley, Goulburn Valley, Perth Hills	Early Divinity, Castlelin, Castlebrite, Glengarry,		
Plums/Prunes	Stanthorpe, Batlow, Huon Valley, Tamar Valley, Goulburn Valley, Perth Hills	Red Ace, Black Amber, President, Red Beaut, Autumn Giant, Friar, Amber Jewel, Radiance	Nambour, Gatton, Kumbia, Northern NSW, Hills District, Sydney, Perth, Gin Gin	Gulf Ruby, Fla 87-7, Fla 85-1, Fla 8-1, Gulfgold
Cherries	Young, Orange, Batlow	Burgsdorf, Early Burlat, Royal Eagle, Bing, Van, Stella, Lambert, Black Douglas	none grown in low-chill regions	
Apple	Stanthorpe, Batlow, Huon Valley, Tamar Valley, Goulburn Valley, Perth Hills,	Granny Smith, Red Delicious, Lady Williams, Fuji, Pink Lady, Sundowner, Royal Gala	Gin Gin	Anna, Sundowner, Fla 65-39
Pear	Stanthorpe, Batlow, Huon Valley, Tamar Valley, Goulburn Valley, Perth Hills	Williams, Packam's Triumph, Beurre Bosc, Winter Cole	Gin Gin	Sunshine, Princessa, Centenaria, Flordahome, Hood
Nashi	Goulburn Valley, Perth, Adelaide Hills	Nijisseiki, Hosui, Kosui	mid North Coast NSW	Nijisseiki
Dried Vine Fruits	Sunraysia, Riverlands			
Table grapes	Stanthorpe, MIA, Sunraysia, Riverlands, Perth,	Flame Seedless, Red Globe, Menindee Seedless, Sultana	Emerald, Mundubbera, Carnarvon	Red Globe, Menindee Seedless
Kiwifruit	Goulburn Valley, Adelaide Hills	Bruno, Monty, Abbott, Hayward, Tomuri, Matua	Mt Tamborine, far North Coast NSW, Mid North Coast NSW,	Dexter, Abbott, Bruno, Tomuri *, Matua *
Persimmon	Sunraysia, Riverlands	Fuyu, Izu, Jiro, Suruga, Gailey *	far North Coast NSW, Mid North Coast NSW, , Kumbia, Nambour	Fuyu, Izu, Jiro, Suruga, Gailey *
Blueberry	Melbourne, Gosford	Brigitta Blue, Blue Rose, Dnise Rose, Bluecrop, Earliblue, Premier, Tifblue	North Coast NSW	Misty, Sharpeblue

* pollinator

Table 3. Rootstocks Used for Different Deciduous Fruits Species in Australia

Deciduous Fruit Species	Rootstock	
	Temperate Regions	**Subtropical Regions**
Peach	Nemaguard, Fort Valley, Elberta, Golden Queen	Okinawa, Flordaguard, Coastal, Nemasun
Nectarine	Nemaguard, Fort Valley, Elberta, Golden Queen	Okinawa, Flordaguard, Coastal, Nemasun
Apricot	Nemaguard, Fort Valley, Elberta, Golden Queen	Okinawa, Flordaguard, Coastal, Nemasun
Plums/Prunes	Myrobolan, Marianna, Nemaguard, Fort Valley, Citation	Okinawa, Flordaguard, Coastal, Nemasun
Cherries	Mazzard, Mahaleb	
Apple	MM106, Northern Spy, MM102, Merton 778, 779, M9, M26	MM106
Pear	*Pyrus calleryana* D6< Quince A with Beurre Hardy interstock	*Pyrus calleryana* D6, Sunshine<
Nashi	*Pyrus calleryana* D6< Quince A	*Pyrus calleryana* D6, Pyrus betulaefolia
Dried Vine Fruits	Ramsey, Teleki, Dog Ridge, 101-14	Ramsey, Rugeri 140
Table Grapes	Ramsey, Teleki, Dog Ridge, 101-14	Ramsey, Rugeri 140
Kiwifruit	Seedling	Seedling
Persimmon	*Diospyrus kaki* (various selections)	*Diospyrus kaki*

Major Harvest Periods

Peaches : available from mid September to April
Nectarines : available from late September to March
Apricots : available from Late October to January
Plums : available from October to April
Cherries : available from October to January
Apple : available all year

3. PRODUCTION OF PLANTING MATERIAL

The production of grafted or budded planting material is undertaken by a number of large private nurseries. Only selected cultivars of known performance are propagated commercially and all have been through a process of virus testing before release. The main methods of grafting are the approach grafting and cleft grafting. Propagated trees are normally containerised. A small number of high density orchards of stonefruit are using trees propagated from either softwood or hardwood cuttings. Seedlings are not used due to their genetic variability. Grafted trees are no longer produced by Government State Departments. A number of private organisations are now buying the rights for overseas varieties and collect royalties on the sale of trees (usually between $1-2 per tree). Breeding

of new varieties is being conducted by State Government Research Centers and Universities. New varieties released by these agencies are normally patented.

4. ESTABLISHMENT OF ORCHARDS

Land Preparation

Planning the orchard is a complex procedure. A brief overview of land preparation procedures is presented. A map of the intended orchard site with existing features (roadways, standing timber, gullies, slope direction etc) is made. Slopes of up to 15% are preferred as these are less susceptible to soil erosion, allow flexibility with row layout, and enable tractors and machinery to be operated safely across the slope. Slopes greater than 15% are avoided, but if used, require specialised design advice for terracing. Windbreaks and drains are normally installed before planting. Rows are run in a North-South direction where possible, and are normally deep-ripped prior to planting to improve drainage. Where possible, green manure crops are grown before planting. The main species used are hybrid forage sorghum for spring or summer plantings, and oats in autumn or winter.

Planting Season

In general, container grown trees can be planted at any time of the year, provided frost is not a problem, and adequate water is available and tree guards are used.

Spacing

Tree training system, row and tree spacing also need to be determined before planting. A soil analysis is done prior to planting to determine nutrient problems. Suggested row and tree spacing for temperate fruits are contained in Table 4.

Table 4. Spacing Options for Most Temperate Fruits

Training System	Spacing	Trees/ha
Open vase	5.0 - 6.0 m between rows 4.5 - 5.0 m between trees	333 - 445
Palmette	4.0 m between rows 2.5 - 3.0 m between trees	833 - 1,000

Planting Procedure

Thorough pre-plant preparation is necessary to obtain good tree establishment and so that trees rapidly fill their allotted space. If soil amendments such as lime or dolomite or phosphorus are required, these are applied before planting because lime takes several years to move through the profile from surface applications. The surface soil is dug where the tree is to be planted with holes of about 1 m in diameter. About 300 g of lime if soil pH is low (<4.5), 300 g of superphosphate or rock phosphate, and 1 bucket of poultry manure (dried for 3 months) are incorporated into the top 20 cm of soil. Trees should be mulched after planting. No fertiliser will generally be necessary for the first few months or until trees start to put on new growth. Small amounts (about 80 kg of a 13:6:12 N:P:K mixed fertiliser per hectare) are applied every six to eight weeks during the first year. This may be stopped during the winter months.

5. CARE AND MAINTENANCE OF ORCHARDS

Tree Training

In Australia, due to increasing labour costs for thinning, pruning and harvesting, alternative methods of management and training of excessively vigorous temperate fruits are being developed. Currently orchardists have a choice of using a wide range of management systems. However, only 3 systems are currently used commercially; standard vase, palmette, and Tatura. Of these systems the palmette is the most widely used because of its ease of management and low labour costs compared with other systems. With stonefruit, excessive tree growth is controlled with several very low dosages of paclobutrazol applied 12-18 months after planting (George et al., 1993; George et al., 1996, unpublished data). The aim in the early stages of tree development is to prevent excessive shading and loss of fruiting wood.

Application of Manures and Fertilisers

Nitrogen appears to be the key element affecting fruit size of temperate fruits. Excessive N application increases vegetative growth and shading and results in a reduction in fruit size and quality. However, when paclobutrazol and N are applied together, fruit size may be increased by as much as 39% (George and Nissen, 1992). The improvement in fruit size may be attributed to 3 factors; increased photosynthetic capacity of leaves higher in nitrogen, delayed leaf abscission, and control of excessive vegetative growth (George et al., 1992). Potassium is the other major element affecting fruit quality. Potash may increase fruit size by as much as 8% (George et al.., 1988a). In high rainfall regions, deficiencies of minor nutrients like B, Cu and Zn are common. These can be corrected through either foliar applications during the flowering and early fruit set period or through soil application. Late summer applications of minor elements may also be important to ensure availability within the tree for the next season's flowering and early fruit development. The most commonly used fertilisers are straight inorganics. Very few organic fertilisers are used except for young trees at planting. Fertiliser rates are normally based on crop removal rates and an allowance is made for leaching and fixation losses.

Pruning

Most temperate fruits are normally winter dormant pruned. Time of dormant pruning varies with cultivar. With low-chill cultivars, earlier pruning often gives earlier flowering; however, the reverse is true for high-chill cultivars. Summer pruning of stonefruit several times during the fruit development period has also been shown to increase fruit size by about 20%.

Weeding

Newly planted trees find it difficult to compete with weeds for water and nutrients. Therefore, weed control in the immediate vicinity of the young trees is vital. This is achieved by mulching and spot spraying under and around the trees. Where weeds grow through the mulch they are either hand-weeded or spot-sprayed with herbicides. With young trees the most commonly used herbicide is paraquat. With older trees glyphosate is commonly used during the summer months in combination with paraquat.

Mulching

The most commonly used mulches are coarse hay or straw such as sorghum stubble. The grassed inter-row area is also a valuable source of on-site mulch. Mulches are normally applied in spring. The mulched/sprayed area extends to just beyond the dripline of the trees, making it roughly two metres wide. Besides reducing weeds, mulching increases soil organic matter, improves soil structure and reduces root temperature fluctuations. It also increases water retention and may reduce irrigation requirements.

Irrigation

In Australia, all temperate fruits are irrigated. The preferred system is mini-sprinklers. Irrigation is scheduled according to either soil moisture content or tension as measured by tensiometers or gypsum blocks, respectively. More sophisticated methods of monitoring e.g. Environscan are being used in larger orchards. With high-chill stonefruit regulated deficit irrigation is used to control growth (up to 75%) without loss of yield or fruit size (Chalmers *et al*., 1981, 1984, 1985).

Control of Pests and Diseases

The most serious pests for the major temperate fruit species are: Queensland and Mediterranean fruit fly, fruit spotting bug, white peach scale, and oriental fruit moth, for stonefruits; codling moth, light brown apple moth, San Jose scale, two spotted mite, mealybug, Monolepta and dried fruit beetles for pomefruits; and bunch mite for grape. The most serious diseases for the major temperate fruit species are: shot-hole, rust, bacterial spot, leaf curl, brown rot, and transit rot for stonefruits; apple scab and *Phytophthora* for pomefruits; downy mildew, powdery mildew, anthracnose, and botrytis rot for grape. IPM programs are being implemented for most pests, the most being used to control scales, mealybugs and mites. Regular spraying for diseases during the active growth season of spring, summer and autumn is essential. A wide range of fungicides are used.

6. INTERCROPPING

Intercropping is not practised in commercial temperate fruit orchards in Australia.

7. HARVESTING OF FRUITS AND YIELDS

The highest yields for temperate fruits have been recorded for apples on Tatura trellis (high-chill cultivars 40 - 60 MT/ha - Chalmers and van den Ende, 1975a, Van den Ende and Chalmers, 1982; McDermott et al*.,* 1987, George et al*.,* 1992a). High-chill stonefruits tend to be less productive with maximum yield of 40-50 MT per hectare. Due to their short development period, low-chill cultivars when planted at standard densities often yield only one third of the maximum yields recorded for later maturing, higher-chill cultivars planted at similar densities (low-chill cultivars 15 - 25 MT/ha). The maximum yields recorded for a range of temperate fruits in Australia are shown in Table 5. Yield benchmarking is a useful tool to evaluate if management inputs are achieving their target potential.

Table 5. Maximum Yield Potential Recorded from Temperate Fruits Grown under Different Production Systems

Training System	Species	Number of Trees per Hectare	Maximum Yield Recorded (MT/hectare)
Vase	Low-chill Stonefruit	660	24
Palmette	Low-chill Stonefruit	800	28
Vase	High-chill Peach	800	51
Tatura	Apple	800	80

In terms of consumer acceptance of temperate fruits, fruit size, shape and colour are the most important fruit quality characteristics readily identified with and often these characteristics are culturally conditioned. With stonefruit, there is a preference for yellow-fleshed, very large size fruit. Small fruit size is the major quality defect of stonefruit in Australia. Fruit size is adversely affected by the short fruit development period (70 -110 days), heavy crop loads (George et al., 1988a), excessive vegetative growth (Allan et al., 1993), low temperatures during the fruit development (Topp and Sherman, 1989b), and stress during the early post-budbreak period at the time of cell division (Hieke and George, 1995, unpublished data). Crop load can be adjusted by thinning, and excessive vegetative growth controlled by the use of growth retardants, pruning and cincturing.

Another major problem with temperate fruit early-maturing cultivars grown under higher rainfall in subtropical regions is their poor sugar content and flavor. Generally, late cultivars do not exhibit this problem. Fruit with better flavor and sugar levels are produced in drier regions and on sandy loam soil types. George et al. (1988a) have shown that heavy rainfall prior to harvest can cause fruit sugar levels to drop as much as 1.5° Brix. Besides environmental factors, many cultural practises have been shown to affect fruit sugar levels including crop load (George et al., 1988), cincturing (Allan *et al.,* 1992; George et al*.,* 1991), spring and summer pruning (George et al., 1988) and enclosing trees under cloches during the fruit development period. With stonefruit, non-melting fleshy cultivars may also be able to be left longer on the tree to develop higher sugar levels, without a corresponding softening of the flesh.

8. MARKETING

Most temperate fruit producers pack and market their own fruit, either directly to retail chains, or through the wholesale domestic market system. The main markets that temperate fruits are sent to include Brisbane, Sydney, Melbourne and Adelaide. Smaller quantities are sent to Tasmania, Western Australia, Northern Territory and Newcastle. Approximately 90% of all temperate fruit grown is marketed on the domestic market. Increasingly, temperate fruit is being purchased through retail chains with their market share increasing from 34% in 1990 to 47% in 1994.

Stone fruit imports to Australia in 1995/96 consisted of 1,193 tons of apricots (US$3.2m), 593 tons of peaches (US$1.5m) and 5 tons of plums (US$22,480). Imports were mostly from New Zealand. The USA is currently seeking access to the Australian market,

and some interest has also been shown by Chile. These are not a major threat to Australian stonefruit growers as they are grown in the Northern Hemisphere and are out-of-season with Australian stonefruit. Australian stonefruit would generally be of higher quality and fresher which is important to the consumer.

Less than 10% of Australian temperate fruit is exported, with the major markets being Singapore and Hong Kong. However, this proportion is likely to increase to 20-25% (conservative estimate) over the next 5 years. In 1994, Australia exported 39,000 tons of apple mainly to South East Asia and Japan. Australian stone fruit exports are primarily of plums, with a major component being from Western Australia. Total Australian exports in 1995/96 were 6,331 tons, comprising 4,977 tons of plum, 592 tons of peach, 524 tons of nectarine, and 238 tons of apricot. Exports to Taiwan were given a boost in 1996/97 through a 1,000 tons quota for peach and plum to Taiwan. While plums account for 70% of all stonefruit exported to Asia the national association has reported that there is also a definite market niche for peaches and nectarines from mid-September to December. This is a time when there are no peaches and nectarines available from the USA who is the traditional supplier of the Asian markets.

Currently Australia's export of stone fruit is limited; however, with rising production there is increased industry interest in exports. Exporters are either larger producers, or networks of producers, or buyers operating from the domestic wholesale markets. Export marketing of stonefruit needs to be better organised and planned in the future to make a serious impact on the target markets as the USA has developed. The Australian Fresh Stone Fruit Growers Association (AFSGA) is represented on the Horticultural Market Access Committee, and is closely monitoring opportunities for export to new markets particularly Korea, China and Japan.

Asian economies are generally becoming more affluent and western in their tastes. This means that the more traditional, well-known fruits, such as stonefruits, are increasing in popularity. The Singapore age group between 25 and 35 are developing more western tastes due to the fact that many are being educated in Australia and the USA. This western education has also changed the way they shop, with a preference for supermarkets compared with the traditional wet markets. This has triggered an increase in western supermarket chains moving into Singapore and the development of central warehousing facilities. This, allows for better handling of perishable products such as stonefruit and hence better quality products sold to the consumers.

9. PROCESSING

Australia is the world's second largest producer of golden style dried sultana, producing about 70,000 tons. Apart from dried grape products, few other temperate fruits are dried. High quality dried fruit products are becoming very popular in Asian markets, particularly in the new supermarket chains which have entire display areas for dried fruit only. Consequently, some R&D effort should be put into developing dried fruit products for export.

10. POTENTIAL FOR DECIDUOUS FRUIT DEVELOPMENT

The main strengths and weaknesses in deciduous fruit production are presented in Table 6.

Table 6. Main Strengths and Weaknesses of Temperate Fruit Production in Australia

Strengths	Weaknesses	Opportunities	Threats
• seasonal fruit • associated with summer • fills a market niche • long production period (September to April) • good export potential • traditional fruit with good consumer acceptance • can be grown in frosty areas where other fruit cannot • the industry is organised and has R&D and marketing levies in place. It also makes it easier to implement programs through the well organised industry.	• inconsistent quality • poor eating quality of many early season, low chill peach, nectarine and plum varieties • lack of coordination and training of growers in marketing and market development • no outlets for second grade fresh fruit (some of which is sent to market) • few alternatives to fresh fruit marketing in Australia (canning, drying, juice, conserves)	• high demand in Asia in October to January • increase production through increased plantings in diverse climatic areas to meet export and domestic market demand from September to January • Produce low-chill, early cherries, plumcots and apricots from current breeding programs • Develop high sugar varieties specifically tailored for Asian tastes	• other seasonal competing fruits (e.g. - Mango) • imports from other southern hemisphere countries • move towards 'convenience' foods

11. CONSTRAINTS IN DECIDUOUS FRUIT PRODUCTION AND DEVELOPMENT

Both the Australian apple and stonefruit industry are well organised under the Australian Apple and Pear Association and Australian Fresh Stonefruit Growers Association (AFSFGA). These associations have implemented statutory R&D and Marketing levies. These are currently under review and are being pushed to be increased in 1998. The actual growers within the industry vary between highly entrepreneurial businesses to small family farms. Generally, it can be said that the growers are quite cohesive in their approach to further developing and improving their overall industry. The major constraints to further development are to improve the export marketing skills of growers/grower groups and to integrate current knowledge into marketing and production decision support systems.

12. GOVERNMENT POLICIES AND PLANS FOR RESEARCH AND DEVELOPMENT OF DECIDUOUS FRUITS

Research and Development

The associations impose compulsory levies on the sale of their products. About 60% of the levy is used for market development activities coordinated by the Australian Horticultural Corporation (AHC), and about 40% is used for Research & Development activities, coordinated by the Horticultural Research & Development Corporation (HRDC). Both the AHC and HRDC are Australian Government funded agencies. The Australian Center for International Research (ACIAR) which funds international R&D projects between Australia and developing countries has provided financial support for a major project on developing temperate fruits in Thailand. The benefits of this project should flow on to other Asian countries with similar climatic conditions. It could be used as a model for similar development in other countries as it integrates all components of production and marketing and emphasises training of researchers and growers. A list of some of the major research programs being funded by the Australian Government is presented in Table 7.

Table 7. Some Major Temperate Fruit Projects Funded by Australian Government and Grower Levies

Project Title	Funding Agency	Project Leader	External Funds
Temperate Zone Fruit Development in Australia and Thailand	Australian Center for International Agricultural Research (ACIAR)	Alan George	$680000
Stonefruit Cultivar Database	HRDC	Dougal Russell	$40000
National Plum Breeding	HRDC	Bruce Topp	$120000

Temperate fruit grower associations are now working on the following strategic priority areas:

- Domestic market development programs aimed at increasing consumer confidence in selecting, storing and using stone fruit leading to more frequent purchasing at higher threshold prices. The success of this program will be enhanced by improved consistency in product handling, product performance, and product description - Short Term.
- Product promotion, based on market research to position the product – Ongoing.
- Implementing information & technology transfer programs – Ongoing.
- Crop forecasting & statistics to assist marketing programs – Ongoing.
- Improving the handling and presentation of stone fruit, through the adoption of an industry best practice - post harvest model, including implementation of Quality Improvement programs along the distribution channel “cool chain” from grower to retailer, demonstrating improved profitability to all industry sectors - Short Term.
- Implementing retailer education programs, to achieve a trained fresh produce work force, knowledgeable in stone fruit - Short Term.
- Reviewing and conducting further consumer market research where necessary and, developing consumer education programs, to increase consumer confidence in fresh stone fruit - Short Term.
- Wholesaler education & training programs - Short Term.

- Export market maintenance & development programs - identifying new markets, to meet the projected increase in stone fruit - Medium Term.
- Developing a stone fruit breeding and evaluation program, to provide better information on varietal performance on a region by region basis - Medium Term.

Plans for Production Development and New Opportunities for R &D and Export

- The development of new breeding lines to improve quality and timing of temperate fruits in Australia will boost exports to Asia.
- The development of decision support systems to help grow and make informed growing decisions to ensure they can produce a product to meet market demands.
- Market research and development including the development of group/co-operative marketing to meet new market needs.
- Investigation and development of high-value value-added temperate fruit products.
- Research and development of better handling and packaging protocols, particularly for low-chill varieties, to better meet export and domestic market quality requirements.

Education and Training Opportunities

Further training and development is required in the following key areas:

- Quality assurance development and implementation.
- Marketing and market management.
- Use of information in decision making for growing a product to meet market needs.

13. CONCLUDING REMARKS

A considerable amount of information exists on all aspects of production and marketing of temperate fruits. However, due to the complexity of the whole system and poor communication lines there is often little interaction between the grower, the market place and the needs of the consumer. Substantial gains in orchard profitability could be made through using a systems approach to management and marketing of horticultural products and the use of electronic data transfer systems.

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DECIDUOUS FRUIT PRODUCTION IN BHUTAN

Pema Dorji *

1. INTRODUCTION

Bhutan is a small and extremely mountainous country with a surface area of 46,000 sq. km, located in the eastern Himalayas. It is bordered to the north by the Autonomous Region of China (Tibet) and to the east, west and south by India. The population is about 700,000, and more than 90% of the population live in rural communities comprising of a little over 67,000 households.

Bhutan has extremely diverse agro-climatic conditions due to major differences in altitude and rainfall as well as in slope characteristics. Roughly, the country could be divided into four physiographic zones - the southern foothills, the middle river valleys, the mountain slopes and the high Himalayas. Based on temperature and rainfall the country could be further sub-divided into six agro-climatic zones - wet sub-tropical, humid sub-tropical, dry sub-tropical, warm temperate, cool temperate and alpine zones as shown in Table 1.

Little is known about the history of deciduous fruit cultivation in Bhutan, as there is no documented evidence to draw information. The fact that traditionally fruits always occupied a prominent place on the altar of offering in all religious ceremonies lends support to the assumption that fruit cultivation must have been part of Bhutanese history, which could be traced as far back as the 7th century. Even now there are some existing orchards whose age could be more than 100 years. These orchards have all types of deciduous fruits like apricot, peach, pear, persimmon, walnut and chestnut and are found near almost all monasteries and district administration buildings in Bhutan.

Modern fruit cultivation however began in the reign of the third king Jigme Dorji Wangchuck, who is widely regarded in Bhutan as the Father of The Nation. It was his vision, which, as clearly stated in the foreword of his book on Planting an Orchard (1968) "Our country, the Kingdom of Bhutan, land of Buddhism, is a wonderful place. The variations in altitude and climatic conditions in different regions of Bhutan provide great scope for the growing of different fruits." In the absence of means of transport, however, fruits were grown in the past for domestic consumption only.

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Table 1. Description of the Six Major Agro-ecological Zones.

Agro-Ecological Zone	Altitude (meters)	Temperature ^{o}C			Rainfall (mm)
		Monthly Max.	Monthly Min.	Mean Annual	
Alpine	3600-4600	12.0	-0.9	5.5	<650
Cool Temperate	2600-3600	22.3	0.1	9.9	650-850
Warm Temperate	1800-2600	26.3	0.1	12.5	650-850
Dry Sub-tropical	1200-1800	28.7	3.0	17.2	850-1200
Humid Sub-tropical	600-1200	33.0	4.6	19.5	1200-2500
Wet Sub-tropical	150-600	34.6	11.6	23.6	2500-5500

Source: Bhutan Research Strategy and Plan, the RNR Sector, May 1992.

But now, with the construction of roads, surplus fruits can be exported to the neighboring parts of India, which have a tropical climate but an insatiable market for temperate fruits. We should avail ourselves of this excellent opportunity. Not only is this vision the beginning of modern fruit cultivation in Bhutan but also his personal interest which enabled him to collect different fruits from various nurseries in northern India during his frequent visits in the 1960s.

Prior to the inception of the Five-Year-Development Plan (1962-67), fruit cultivation was limited to backyard cultivations only, meant solely for family consumption. With the beginning of the First Five-Year-Development Plan, fruit cultivation was identified as a potential source of cash income for the farmers and thus the first few commercial plantations were established. Apple was then the most important deciduous fruit crop introduced from India and grown on a commercial scale. Other deciduous fruits like apricot, peach, plum, pear and persimmon were still cultivated at subsistence level and were not of much economic significance.

Commercial cultivation of apple took some time to have significant economic impact owing to a relatively undeveloped road network and marketing systems. It was only in the late eighties that apple production had risen to the level of major commercial importance as a result of a better road network and the development of an export market to Bangladesh.

2. PRESENT SITUATION OF DECIDUOUS FRUIT CULTIVATION

Deciduous fruits grown in the backyards include Asian pear, peach, apricot, persimmon and walnut. Almost all of these have their indigenous species in the wild. The exotic and commercially cultivated deciduous fruits include apple, peach, plum, apricot, Bartlett pear, Nashi, and cherry. There is now a growing tendency to replace the old monastery orchards also with improved cultivars that are now available. By and large, the most extensive orchards at the moment are the apple orchards followed by peach and walnut as shown in Table 2.

Table 2. Type and Number of Deciduous Fruits Grown in Bhutan.

Species	Number of Trees ('000)	Area in Hectares
Apple	565.0	2000
Walnut	9.5	45
Peach	6.4	20
Pear	4.8	15
Plum	3.0	11
Apricot	0.8	3
Others	1.2	7

Source: Baseline Survey Report (1997), RNR-RC, Western Region, Yusipang.

The main cultivars of apple are Red Delicious, Royal Delicious and Golden Delicious, which account for over 80% of the apple area. These cultivars were first introduced in the 1960s from the northern Indian States of Jammu & Kashmir and Himachal Pradesh. By the 1980s a host of new improved cultivars were brought in from Japan, which now constitute about 15% of the apple areas (see Appendix 1 for species, cultivar and rootstock details).

Apple is generally grown in temperate areas from about 1800m to 3000m. According to the preliminary survey carried out by the Integrated Horticulture Development Project in 1992, there were about 365,000 apple trees in the country, covering roughly about 1400 ha. The present apple population is estimated to be around 565,000 based on the average annual sale of 50,000 plants from the Druk Seed Corporation in the last five years. Of this total, about 90% are found in the western part of the country covering the three Dzongkhags (districts) - Paro, Thimphu and Haa. The other 10% are found in the central district of Bumthang.

Unlike the beginning during the First Five Year Plan, 1962, apple growing has now become a major commercial venture. This is brought about vastly by the improved network of roads and marketing system from the late 1980s. Between 1960 and 1990 there has been a marked increase in the area under apple and other deciduous fruits. The opening of the export market to Bangladesh in the late 80s has created awareness among the farmers of the three western Dzongkhags, who are the primary producers of apple. As a result, the cash income and the nutritional status of the farming communities of these three Dzongkhags has greatly improved. The three Dzongkhags together exported about 11,000 MT from estimated production of about 15,000 MT in 1997, for a value of Nu.169.6 million equivalent to US$ 4.24 million (Table 3). The production is expected to increase to 23,000 MT in the next few years as the vast number of trees planted in the last decade come into bearing.

Table 3. Apple Production During the Years 1995, 1996 and 1997

Year	Production (MT)	Export (MT)	Value in Nu. million
1995	6000	4600	52.25
1996	8000	5600	67.20
1997	15000	11000	132.00

Source: Trade Statistics, Food Corporation of Bhutan, 1997.

3. PRODUCTION OF PLANTING MATERIAL

Traditional orchards found near the monasteries comprise of all seedling trees. The knowledge of clonal propagation of deciduous fruits came along only with the plants introduced from India. However, the country took some time to establish its own nursery industry and it was only in the last eight years or so that it could produce its own requirements of fruit plants. Between 1960 and 1990, the annual fruit plant requirements were met by importing from nurseries in Himachal Pradesh and Uttar Pradesh, India. From 1991, the government nursery under the umbrella of the National Seed and Plant Production Program (NASEPP) was able to meet the national requirement of fruit plants. Initially this nursery used to produce and distribute its own plants but now it has limited its role to selling plants produced by its registered private growers.

Right from the start the technique of vegetative propagation was practiced. The rootstocks were propagated through stooling and hardwood cuttings while the scions were collected from mother trees. The most common form of grafting carried out was the whip and tongue grafting method and the most common budding method was the chip budding technique. All species except walnut were propagated through grafting and budding. Until 1994, walnut was propagated through raising seedlings from seeds collected from bearing trees. From the winter of 1994 however, the first batch of walnut grafts were distributed to the farmers. These grafts were propagated through the Hot Callusing Device developed by H.B. Lagerstedt, USDA, Agricultural Research Service, Corvallis, Oregon, U.S.A.

4. ESTABLISHMENT OF ORCHARDS

Commercial deciduous fruit orchards are established in highlands which are not suitable for paddy cultivation. This again is the policy formulated at the time of the late King Jigme Dorji Wangchuck, and which again falls in line with the noble ideas found in his book **"When Planting an Orchard"** he postulates "Our twin objective in agricultural development should be to achieve self-sufficiency in food production and to maximize wealth by growing cash crops in the rest of the available land. I would strongly advise that paddy land should not be utilized for growing horticultural crops. Lands which have been abandoned, and other pieces of fertile land which can be brought under cultivation should only be utilized for raising fruit and vegetable crops". Following these guidelines, orchards have been established located mostly on mountain slopes in between the cultivated fields and the forest cover. They are also found in the drylands

in the valley bottoms. Orchards on the steep mountain slopes are terraced while the gentle slopes are planted with deciduous fruits along the contour.

The orchard establishment activities start with the fall season, when site clearing is done. Layout and pit digging is carried out in winter when the farmers have less field activities, as well as to allow sufficient time for the organic materials to decompose and the pit soil to settle. The recommended pit size is 3x3ft, and the most common layout followed is the triangular planting method. The standard spacing for the plants grafted on the semi-dwarfing clonal rootstocks is 3x3m, and for those on seedling rootstocks is 6x6m.

Planting is done in late winter/early spring. Enough organic materials in the form of leaf mould and FYM mixed with recommended NPK fertilizer are added to the top soil set aside when digging each pit.

5. CARE AND MANAGEMENT OF ORCHARDS

The newly planted trees are trained immediately after planting by heading back at 24 - 36 cm above ground. Subsequent annual pruning is carried out from the second year to build a good tree frame. The old orchards, however, did not receive good training and pruning as compared to the more recent plantings, owing to lack of technical backup support in the past. These orchards are now being gradually rejuvenated by top-working with improved varieties acceptable to the present export market needs.

Annual application of manures and fertilizers is done in winter with leaf mould, FYM and recommended NPK at the time of basin preparation. Mulching is done immediately after, to preserve moisture and control weed growth in the growing season. Supplementary irrigation is carried out only in the research stations and a few demonstration orchards under a feasibility study program.

With the increasing number of orchards the problem of pests and diseases has also been increasing. This is a serious factor that affects the productivity of the orchards.

Diseases

The most serious disease which destroyed many orchards in the central district of Bumthang in mid 1980s is the Apple Scab (*Venturia inaequalis*). In the past, the control measures taken were severely hampered by the poor access to plant protection chemicals. The situation has improved with the establishment of the National Plant Protection Center(NPPC) in 1983 funded by the EEC. The NPPC has now developed a Captan spray schedule to control scab.

The Powdery Mildew (*Podosphaera leucotricha*) is more damaging in young orchards as it affects the young shoots which if not treated in time leads to total destruction of the growing tips. Preventive measures are usually taken by spraying with Bavistin and Calyxin fungicides. Curative measures are taken by pruning-off the infected shoots and spraying with fungicides.

Collar Rot (*Phytophthora cactorum*) is associated with orchards with heavy and inadequately drained soil. It is also more pronounced in plants on MM106 rootstocks. Its incidence is controlled by adopting proper management practices of good drainage, proper planting method and good weed control.

Brown Rot (*Sclerotinia fructigena*) causes serious damage to fruits both on the trees as well as in storage. Infection usually starts with wounds caused by insects and mechanical injuries. Control involves spraying with Benzimidazole.

Peach Leaf Curl (*Taphrina deformans*) causes severe deformation of entire leaves on a peach plant. According to plant pathologists from the NPPC, the primary cause is aphid attacks followed by secondary infection by the fungus. Recommended control is spraying with copper oxychloride.

Apricot Brown Rot (*Monilinia fruticola*) causes severe losses to apricot production and is the single most damaging disease to the crop. It is controlled to a certain extent by benzimidazole.

Pests

The most serious pest which affects apple orchards is the Woolly Aphid (*Eriosoma lanigerum*). The control recommended for this pest is winter spraying with Lime Sulphur Liquid and Chlorpyriphos in the growing season.

Another serious pest which destroys the apple trees is the Stem and Twig Borer (*Oberea posticata*). This problem is pronounced in poorly managed and older orchards. Control is done by close observation and pruning the affected parts.

The adult of the Leaf and Fruit Feeding Beetles (*Popilla sp, Hyperstylus sp,Microserica sp.*) can seriously damage the foliage and fruit of most fruit trees. Complete defoliation may occur in young plants. The control spray should be timed to coincide with the feeding time of these beetles. Spraying with chlorpyriphos controls the infestation.

Trunk Borer (*Anoplophora sp.*) is the most damaging pest to the walnut trees, killing the plant outright if not detected early and controlled in time.

The use of plant protection chemicals is still very limited, owing to limited supply and strict regulations set by the National Plant Protection Center. Instead the center is carrying out studies at numerous sites to develop a sustainable Integrated Pest Management program.

6. INTERCROPPING

The extent of intercropping varies from orchard to orchard. In some orchards with good soil farmers intercrop soya beans, potato and chili, while orchards with steep slopes and poor soil are left fallow. However, intercropping in general is not widely practiced at present.

7. HARVESTING AND YIELDS

Harvesting of fruit starts with the early variety of cherry (Seneka) by the end of May. Next are the early varieties of peach in June, followed by the Japanese pear variety Hosui. The earliest variety of apple to be harvested is the Japanese variety Hana-iwai in July followed by Nebuta. The main apple harvest season starts from August and extends up to October. The last varieties of apple to be harvested are the Japanese varieties Mutsu and Fuji.

At present, apple dominates deciduous fruit production in Bhutan, followed by peach. The average yield of apple is relatively low owing to low plant density (250 trees/hectare), low level of management and less inputs. As a result, the average yield is reported at 45kg/tree or 11 MT per hectare. Further, the quality of fruit is also variable owing to low level of management. The advantage associated with the Bhutanese apple, however, is the low usage of pesticides compared to the world's major apple growing countries.

8. MARKETING

The production of apple on a commercial scale is a relatively recent development, primarily due to the development of roads and the export market. The export market is the single most important factor that resulted in the recent dramatic increase in the number of plantations; and it could absorb almost 100% of the apple produced, if not for the variable quality of the produce. Of the total annual production, about 30% of the produce does not meet the export requirements and hence is sold in the local market.

The Food Corporation of Bhutan (FCB) operates auction yards in three border towns close to the border with India, where the farmers take their horticultural produce including vegetables, and get good prices. The Agro-Food Processing Factory in Thimphu, established with the help of DANIDA, and located within the apple growing areas, constitutes a major local outlet not only for apples but also for other deciduous fruits. The regular Sunday market is the only form of wholesale market which is also a good retail outlet. At the moment, there are very few retail shops selling fruits primarily because of lack of good storage and packaging facilities.

At present, Bangladesh is the largest importer of Bhutanese fruits, importing about 70% of the total produce. The drawback with the Bangladesh market is that it demands apples of small to medium size only, which not only results in huge rejects of the common varieties like the Delicious group. At present, there are no markets for the large size fruit of improved Japanese varieties like Fuji, Sekaiichii and Mutsu. Therefore, there is a growing concern among the growers of the large sized apples, and demand on the government to explore means and ways to market those fruits to other markets in the region. Hopefully, the on-going UNDP assisted Integrated Horticulture Development Program may help ease this situation in the near future.

9. PROCESSING

Processing of fruit products in Bhutan is constrained by the lack of small-scale processing units to suit low volume productions in areas far away from the road points, the shortage of labor and difficulties in transportation. The main fruit processing facilities in Bhutan at the moment are the Agro-Industries Ltd. in Thimphu, and the Bhutan Fruit Products Ltd. in

Samchi. These two factories produce a wide range of fruit juices, jams, jelly, fruit cocktails, peach and apricot halves, cordials and similar products. The products are of high quality and are mainly marketed to major cities in India and Bangladesh.

10. POTENTIAL AND CONSTRAINTS FOR DECIDUOUS FRUIT PRODUCTION DEVELOPMENT

Bhutan has a huge potential to produce several deciduous fruit crops due to a wide range of agro-climatic conditions. Apart from growing apples and other deciduous fruits in the temperate zones, it could also grow peach, pear, apricot and grapes in its warm temperate zones, where there exists ample land resources to be exploited for this purpose.

If production is increased and quality improved, it could enjoy the benefits of close markets in India, Bangladesh and other countries in the region. Bhutan has the potential for the production of high quality produce in a clean environment; and the production seasons are different from most countries in the region. The other important factor is that the farmers are now aware of the benefits of growing fruit crops and are willing to cooperate in production development programs. Horticultural produce has provided the best opportunities for the farmers to earn cash income, which is expected to provide further impetus to develop fruit crops like peach, pear, apricot, plums, cherries and grapes.

The major physical constraints to fruit production development are primarily due to the mountainous nature of the country. The narrow valleys with steep slopes restrict large-scale production of fruits by limiting mechanization. The road network is still not well-developed, restricting transport of goods and produce from the farm to the market. In addition to the inadequate road network, horticultural production is constrained by limited infrastructure and facilities in terms of marketing, grading and packaging, storage and processing. As a result, there is limited access to the export markets outside India and Bangladesh.

Another limiting factor is at the institutional level, where fruit cultivation received only recent emphasis owing to late exploration of markets and also because the priority in the past was more on the production of grains to meet the national goal of food self-sufficiency. This has resulted in a shortage of trained personnel in the horticulture sector, less research activities and poor extension services.

In addition, information on horticultural production, markets and trade is limited and not reliable, leading to uncertainties as to the real commercial potential of different crops, and making effective policy and strategic planning difficult.

At the field level, yields are often low due to such problems as lack of knowledge among farmers in fruit production, poor varieties, low quality planting material, poor orchard management practices, and pest and disease problems.

In summary, the exploitation of the full potential of deciduous fruit cultivation in the country has not been possible due to the following constraints:

- Lack of clear-cut horticulture development policy and strategy in the past.
- Inadequate transportation network, including lack of feeder roads to potential production areas.

- A weak horticulture research and extension system.
- Limited farmer knowledge of fruit production systems.
- Insufficient market information and market facilities.
- Low yields and poor quality fruits due to low level of management practices.
- Poor post-harvest practices and lack of storage facilities.
- Lack of small-scale processing facilities.

11. GOVERNMENT POLICIES AND PLANS FOR RESEARCH AND DEVELOPMENT

As mentioned earlier, the horticulture development policy is based on the wisdom and the vision of the third King. This national commitment is the key to long-term success in horticultural development, and is particularly relevant in the attainment of the national development goal in the horticulture sector. Its aim is to increase production of horticultural crops both for domestic and export markets, leading to higher nutrition intake, higher farm incomes, and greater economic growth and export revenues.

The long term and short term objectives of horticultural development are:

Long Term Objective: "To optimize the contribution of the horticulture industry to the welfare of present and future generation of Bhutanese farmers and consumers with emphasis on improved cash income, food security, higher nutritional standards and export earnings".

Short Term Objective: "To improve the existing management practices and to increase production and quality of those horticultural commodities with a comparative advantage in a sustainable manner in all production environments through interdisciplinary research, extension and marketing".

To meet the objectives the following strategies are being adopted:

- Production based on market requirements.
- Production of high quality commodities.
- Production of high value produce with low perishability.
- Extension of supply periods through use of different varieties growing environments.
- Introduction and development of improved varieties.
- Intensification of production systems.
- Development of small-scale agro-industries.
- Development of kitchen gardens.
- Improvement of institutional capabilities.

To achieve the objectives and strategies, the following activities are being carried out:

- Applied and adaptive research.
- Strengthening extension services.
- Development of market information services and infrastructure.
- Human resources development.
- Improving the input supply system.
- Supporting private sector activities in the fruit industry.

Integrated Horticulture Development Program

Until the initiation of the first Integrated Horticultural Development Project (IHDP-I), funded by the UNDP and executed by FAO from 1990-1994, there was no systematic research in deciduous fruit cultivation. This project however, assisted in establishing a basic infrastructure and an action program for horticulture research and development by studying production and market prospects, and strengthening the national capacity through training, germplasm introduction and technical assistance. The main output of the project has been the preparation of a comprehensive long-term masterplan which has culminated into the on-going UNDP assisted Integrated Horticultural Development Program (IHDP-II). This program is geared towards an all-round development of horticulture covering all aspects such as production, research, extension, post-harvest activities and marketing. Its implementation commenced in July 1997. The program is aimed at establishing a viable and vibrant horticultural industry in the long run.

The Integrated Horticulture Development Program (IHDP-II) consists of six sub-programs – a) Coordination sub-program; b) Technology generation sub-program; c) Extension sub-program; d) Post-harvest sub-program; e) Marketing sub-program; and f) Aromatic and Medicinal Plants sub-program.

- The Coordination sub-program has the overall responsibility to ensure smooth functioning of the other sub-programs.

- The Technology generation sub-program looks after the research activities of horticulture in terms of introduction of germplasm, establishment of adaptive trials and generation of appropriate technologies.

- The Extension sub-program works towards strengthening the horticulture extension activities.

- The Post-harvest sub-program introduces post-harvest practices like grading, proper packaging and storage facilities.

- The Marketing sub-program collects information on markets, explores new markets and develops markets for the horticultural products.

- The Aromatics and Medicinal sub-program looks after the development of indigenous aromatic and medicinal plants and their uses.

National Horticultural Research

The national research program in agriculture consists of research in forestry, livestock, field crops and horticulture. Horticultural research has received equal footing with research in field crops, livestock and forestry which are the main sub-sectors in the Renewable Natural Resources (RNR) Sector. The National Horticultural Research Center is based at Khangma in eastern Bhutan. This center has horticulture research as its main mandate apart from carrying out research in other fields. Horticulture research is also being carried out in other RNR research centers although their mandates are in livestock, forestry and field crops, based on the agro-ecological regions of the centers.

12. CONCLUSION

Commercial deciduous fruit production in Bhutan is as old as the process of planned development. Yet the progress in this area is still not comparable to the progress made in such fields as hydro-electricity, telecommunication, education and health.

Horticulture is potentially the most important sub-sector in the RNR sector for providing cash income, as well as in improving the nutritional intake of the rural population. Because of its geographical situation, Bhutan has a considerable comparative advantage in the production of horticultural crops for which agro-climatic conditions are more favorable than in the neighboring countries. A large range of different fruits, from temperate to tropical, can be produced due to the existence of varied agro-climatic conditions. It is close to large and developing markets of India and Bangladesh, as well as to other regional south-east Asian markets, and can produce a range of different products in different seasons than most other competitors. It is expected that the long term development of the horticulture industry will be firmly rooted with the implementation of the Integrated Horticulture Development Program.

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APPENDIX 1

Details of Species, Cultivars and Rootstocks of Deciduous Fruits Grown in Bhutan.

Species	Cultivar	Rootstock
Apple	1. Red delicious	1.Apple seedling
	2. Royal delicious	2.Wild pear seedling
	3. Golden delicious	3. MM 106
	4. New Jonagold	4. MM 111
	5. Gala	5. Bitter felder
	6. Akane	
	7. Nebuta	
	8. Kogetsu	
	9. Fuji	
	10. Mutsu	
	11. Sekaiichi	
	12. Shuko	
	13. Tsugaru	
	14. Kitanosachii	
	15. Haniwaii	
	16. Starking	
	17. Grannysmith	
	18. Jonathan	
Peach	1. July Elberta	1. Local peach seedling
	2. Floradsun	2. GF 677
	3. Nonome wase	
	4. Shimizu Hakuto	
	5. Redhaven	
Plum	1. Stanley	1. Local peach seedling
	2. Santarosa	2. St. Julian "A"
		3. GF677
Apricot	1. Kagzi	1. Local peach seedling
	2. New castle	2. GF 677
	3. Kaisha	
Cherry	1. Seneka	1. Colt
	2. Jabouley	2. Mahaleb
	3. Royal Ann	
Pear	1. William Bartlett	1.Wild pear seedling
	2. Commice	2. Kirchensaller
Persimmon	1. Local Aanday	1. Local seedling
	2. Hana Fuju	
	3. Jiro	

DECIDUOUS FRUIT PRODUCTION IN CHINA

Li Zai-Long*

1. INTRODUCTION

China is one of the earliest and most important centers of origin of cultivated plants in the world. Many deciduous fruits such as peach, Asian pear, apricot, plum, jujube, chestnut and filbert that are grown today are native to China. From the fossil remains of filbert and chestnut dug up from Banpo village, Xian, Shaanxi province and peach stones discovered in archeological investigations in Wu County in Jiansu province, it is evident that pomology is an agricultural science that started in China nearly 6000 years ago. Manuscripts mentioning 17 different fruits, mostly deciduous, can be found in Shi Jing, an ancient record of songs written about 1000 BC. Cultivar differences of winter peach and stoneless jujube were recognized by Chinese ancestors at least as early as the early part of second century B.C. Due to this long history of fruit cultivation, an abundance of fruit growing experience and production practices has been accumulated in cultivar selection, grafting, fruit thinning, pest control and storage technologies. A great number of valuable varieties were developed, some of which are recognized even today in fruit production programs.

After the establishment of the People's Republic of China in 1949, the fruit industry passed through its recovery and stable development stage which led to a period of rapid development. In 1997, the total production of fruits in China was 50.89 million tons, out of which 17.22 million tons were apples and 6.42 million tons were pears. They accounted for 11.2, 31.8 and 44.4 percent of the world production respectively. Fruit production in total or individually for apple and pear assumed the first place in the world.

The fruit industry ranks third in the country after grains and vegetables and exceeds that of cotton, forestry, oil and sugarcane. Per capita availability of fruits per annum increased 6-fold from 6.8 kg in 1978 to 41.2 kg in 1997.

It has been the policy of the Government to encourage the development of the fruit industry in the mountains and hilly areas, leaving the fertile lowlands for the production of grains and cotton. Under this policy the loess plateau in the Northwest, highlands of the Southwest, other hilly regions and mountainous areas have become bases of commercial fruit production.

Development of fruit growing on the highlands has several advantages. Firstly, due to more exposure to sun light and greater variation in daily temperatures, fruit trees growing in the highlands are likely to produce quality fruit with good color and higher sugar content. Secondly, by growing fruits the farmers can obtain much higher returns than from field crops. An added benefit of cropping the highlands is the improvement of socio-economic conditions of

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undeveloped highland communities. Furthermore, as commercial fruit orchards got established in these areas, contour terraces, water conservation projects, roads and storage facilities were established. Other services related to fruit production were also improved. These, accelerated the economic development of the rural highland areas and the fruit industry was often referred to as a green revolution with fruit trees acting as environment cleaning agents.

2. PRESENT SITUATION OF DECIDUOUS FRUIT CULTIVATION IN CHINA

Among deciduous fruit crops grown in China, apple is far ahead in acreage and production, while pears, peach and grapes are also leading crops. Apricot, plum, mume, jujube, persimmon, walnut, chestnut and kiwifruit are next in importance. Other deciduous fruits such as cherry, almond, pomegranate, fig, filbert and ginkgo are also cultivated but to a limited extent. Hawthorn (*Crataegus pinnatifida* Bgc), Roxburgh Rose (*Rose roxburghii* Tartt.) and Seabuckthorn (*Hippophae* spp.) are new fruit crops that have been recently domesticated. In China, a large portion of the deciduous fruits are produced in the North along the Yellow river valley. However, the Yangtze river basin areas are also important for the production of sand pear, honey peach and mume. Table 1 shows the development of major deciduous fruits in acreage and production. Table 2 shows the major rootstocks in use, and Table 3 indicates the most important pests and diseases.

Table 1. Development Statistics of Major Fruit Crops in China (1952-1997)

Year	Total (Fruits)		Apple		Pear		Grapes	
	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.
1952	68.4	244.3	3.1	11.8	-	34.6	-	4.8
1872	117.1	444.2	-	85.0	-	104.8	-	10.1
1975	148.3	538.1	-	158.4	-	108.7	-	12.3
1980	178.3	679.3	74.3	236.3	29.9	146.6	3.16	11.0
1985	273.6	1163.9	86.5	361.4	33.8	213.7	8.7	36.1
1990	517.9	1874.4	163.3	431.9	48.1	235.3	12.3	85.9
1995	809.8	4214.6	295.3	1401.1	-	494.3	-	174.2
1996	855.3	4652.8	298.7	1705.2	93.3	580.7	15.3	188.3
1997	868.5	5089.3	283.8	1721.9	92.4	641.5	15.8	198.5

Units: Area in 10,000 ha
Production in 10,000 tons

Table 2. Major Rootstocks Used for Deciduous Fruits in China

Fruit Crop	Rootstock	Remarks
Apple	M. baccata Brokn. M. prunifolia Maxim M. micromalus Makino M. hepehensis Rehd M. sieversii Ldb.	Northeast China Northern China Northern China Many different types Northwest China
Pear	P. betulaefolia Bge P. calleryana Dune P. xeropila Yu.	Northern China Southern China Northwest China
Peach	P. davidiana Franch P. persica Stoke	Northern China Southern China
Mume	P. mume	The same species
Plum	P. davidiana Franch P. persica Stoke. P. salicina	North China South China The same species
Apricot	P. armeniaca L. P. siberica L.	The same species North China
Cherry	P. serrulata Lindl. P. mahaleb L.	Widely used The same species
Persimmon	D. lotus L. D. kaki L.	Widely used The same species

Table 3. Important Pests and Diseases of Deciduous Fruits in China

Fruit Crop	Pest	Disease
Apple	Peach fruit borer Lesser apple fruit borer Leaf roller Mites Apple aphids	Apple tree canker Brown spot of apple Anthracnose Apple ring rot Powdery mildew
Pears	Mites White peach scale San Jose scale	Pear scab Black rot of pear Black spot Pear blight
Stone Fruits	Peach aphids Peach fruit borer Peach pyralid moth Peach longicorn beetle	Brown rot Bacterial spot Anthracnose Peach canker Leaf curl

The apple crop is grown on 32.66 percent of the total area under fruit cultivation and it contributes 33.8 percent to the total fruit production. This makes apple the most important fruit

crop among deciduous fruits in China. There has been a 4.2-fold increase in acreage and 7.5-fold increase in production of this crop during the last two decades. The major fruit producing areas are along the Bohai Sea, the Yellow river lowlands, Northern foot of the Qing-ling mountains, the Loess plateau in the Northwest and the highlands of the Southwest. The major producing provinces are Shangdong, Lianing, Hebei, Henan, Shaanxii and Shanxi, while minor production is undertaken in Gansu Xijiang and Jiangsu. During the 1980's more than 20 cultivars were under cultivation. Nearly 60 percent of the apples produced were of cultivars such as Ralls Janet, Golden Delicious, Red Delicious and Jonathan. At the present time, however, over 70 percent of plantings are of Red Fuji, Starkrimson, Jonagold, Golden Delicious and Gala apple cultivars.

The second major crop among deciduous fruits is pear, which covers an area of 924,000 ha with a production of 6,415 million tons a year. Its share in total deciduous fruit crop area is 10.6 percent and production is 12.6 percent. Cultivated pear in China is classified into four groups. White pear (*Pyrus bretschneiderie*) is mainly grown in Northern China, Hebei, Shandong, Liaoning provinces and accounts for 60 percent of pear production in the country. A great number of cultivars exist in this group; some of these cultivars, notably Ya-Li, Xue-hua-li, Lai-yang-ci-li and Dong-guo-li produce fruits of excellent quality with crispy, juicy and sweet flesh and relatively few stone cells. Sand Pears (*P. pyrifolia*) grow almost wild in the Yangtze river valley. They adapt well to wet and high summer temperatures and the popular cultivars Cang-xi-li and Bao-zhu-li are locally important cultivars. Huang-hai-li and Jin-shu 2 are newly developed cultivars and are extensively used in new plantings. The Japanese cultivars also belong to the sand pear category. Some Japanese cultivars such as New century, Kosui and Shin sui are also important cultivars in this area. Fruits of white pear and sand pear are juicy, crisp and sweet. They do not require a ripening after harvest and could be used as a dessert fruit immediately after picking. The Ussurian pear (*P. ussuriensis*) is the most hardy of all Pyrus species and is grown in the areas North of the Great Wall, especially in Northeast China. In general, fruit quality of the cultivars derived from this species are very much inferior to those of the white pear and sand pear. The fruits are usually smaller and require a period of post-harvest ripening to become edible. After proper ripening they become soft with a strong aroma and acceptable quality. Representative cultivars of this group are An-li, Da-xiang-shui-li, Nan-guo-li and Jing-bei-li. European pear is not commonly found in China and it is only grown to a limited extent in a few localities.

Peach is native to China. There are two major groups of cultivars and ecotypes. The Mitao cultivars are generally cultivated in North China. They tend to bear larger fruits with firmer flesh. The principal producing areas are located in Feicheng and Yidou in Shandong province, Shenzhou of Hebei province, Liquan and Fuping of Shaanxi province, Zhenging and Zhangye in Gansu province. Leading cultivars include Feicheng Tao, Shenzhou Mitao and Yidou Mitao. Shumitao peach, also known as Honey peach, is mostly grown in Southern parts of China and it is well adapted to wet and high summer temperatures in the Yangtze river basin. Fruit of this peach is tender-fleshed, melting and juicy with high sugar content. The important areas of peach production are close to the cities of Nanjing, Wuxi, Shanghai, Hangzhou, Ninbo and Fenghuo. Fenghua yulu and Baihua shuimi are the best known cultivars in these production areas. Peach fruits grown for fresh markets in China are almost all characterized by white flesh, melting and juicy clingstone types, while non-melting and yellow-fleshed types are mainly used for canning. These canning types thrived best during the period between 1970 to 1980's, but

decreased in the 1990's. On the other hand, early peach and nectarine cultivars and their area of production have increased recently.

Plum (*Prunus salicina*), apricot, mume, Chinese cherry (*Prunus pseudocerasus*), and persimmon are all native to China. They are grown almost all over the country, except mume which is restricted to the South China. Major producing areas are also located in Hebei, Henan, Shandong, Shanxi and Shaanxi provinces. Oriental plums differ from the European plum and have two categories of cultivars, red colored and yellow skin types. The red types possess either yellow or red colored skins, but the yellow types have exclusively yellow flesh only. There are more than 800 cultivars under cultivation, but Zu-li in Zhejiang, Fu-rong-li and Mi-liin Fujiang are highly preferred by consumers.

Apricots are found mostly in North China, mainly concentrated in the Yellow river valley. The many cultivars under production have different uses. Some are grown for the fresh market (the larger fruited types reaching up to 200 gm in size). Although the Yangtze river valley is not the main producing area for apricots, many important local cultivars exist. Some bear high quality fruits of large size and they are well adapted to humid weather prevalent in the area.

Both European cherry and Chinese cherry are grown in China. Chinese cherry (*Prunus pseudocerasus*) has been grown in China for over 2000 years, and bears more fruits than the European cherry. Chinese cherries also have a wider range of distribution. Taihe in Anhui, Zhuji in Zhejiang, Zhengzhou in Henan, Qingdao, Zaozhuang in Shandong and Lantian in Shaanxi province are the major producing areas. The European cherry cultivars were introduced to China in 1870. Their production is limited to Yantai in Shandong, Luda in Liaoning, and Beidaihe and Changli in Hebei province. Napoleon, Black Tartarian and Bing are major European cultivars grown in China.

About 860 cultivars of persimmon exist in China. They bear fruit varying greatly in shape, size, color and ripening period. Most of the cultivars are astringent in taste at harvest time. Persimmons originated in Southern China, but the largest production is confined to the Yellow river valley. Annual production of persimmon is around one million tons and Shaanxi, Shanxi, Hebei, Henan and Shandong provinces account for 70-80 percent of the production. Fuyu and Jiro are major cultivars of sweet persimmon from Japan.

Mume (*Prunus mume* Sieb et Zucc.) has been cultivated in China for over 3000 years. The wild forms can still be found in mountainous areas between Hubei and Sichuan provinces. Since they bloom in early spring and are sensitive to frost damage, the production areas are limited to Yangtze river valley and its Southern parts. Zhejiang, Jiangsu and Hunan provinces are the major producers of mume fruit.

3. CARE AND MANAGEMENT OF ORCHARDS

Methods in training and pruning of trees vary depending on climatic and soil conditions, fruit species, cultivars, rootstock, spacing and management systems used in orchards. Two basic training systems are, however, commonly adopted in the deciduous orchards in China. They are the modified central leader system for apples and pears, and the open center system for peach trees. Pruning is mainly carried out in the dormant season, but summer pruning is also

practiced, especially in peach orchards. Hand pruning is considered a special art and a skill very much needed in proper tree management. Despite the differences in tree forms or the time of pruning, much concerns are centered around the balance between vegetative and reproductive growth.

Fruit growers in China traditionally use a high amount of organic matter as basic source of nutrients for the trees in the dormant season. Animal manures are used extensively and sometimes oil-pressed cakes and chemical fertilizers are also added. These basic nutrient sources are considered to be important for quality fruit production since they not only provide nutrients for tree growth, but also improve soil structure which promotes better root development. Their application is usually recommended during the dormant season up to autumn, after fruit harvest but usually before leaf fall. This application coincides with the third peak of annual root growth. The fertilizers help trees to recover from the depletion caused by a heavy fruit load and also enhance development of quality fruit buds. Top dressing applications are usually chemical fertilizers which are applied two to four times before bud break, prior to or after blooming and at fruit enlargement stage depending on the requirements of each type of fruit tree.

Since most orchards in China are established in hilly areas, the soils may be low in nutrients and not deep enough for good root development. Therefore, in addition to reclamation work before orchard establishment, soil improvement after planting is also required. As most soils in such areas are around 50 cm in depth (usually with a hardpan), deep tillage is required. Sub-soil tillage is carried out either by enlarging the planting pit up to the tree canopy line or by constructing ditches between tree rows. After removing the sub-soil, pits and ditches are filled with a mixture of top soil and organic manures such as farmyard manure, straw, compost etc. If orchard soils are clayey, 1.5-2.25 tons of lime hydrate is recommended for incorporation during sub-soil tillage to help regulate soil pH. In young orchards, deep tillage can be carried out in spring, summer or autumn, while in older orchards this practice is carried out after harvesting the crop.

Since 1980's, the use of straw or plastic film has become popular in orchards established in hilly areas. If straw mulch is used, the soil is initially tilled after incorporating farm manures and a 10-20 cm layer of straw is used for mulching every year. If clear plastic film is used to mulch under tree canopies, a 10 cm soil layer is used to cover the plastic mulch, especially when temperatures go up to 20-25 ^{0}C.

Although annual rainfall in Northern China is adequate to meet the requirements of fruit tree orchards, the distribution is erratic and most of the rain is received from July to September. Supplementary irrigation is therefore essential during the period from October to June. In Southern China, irrigation is also required during the hot and dry spells in July-August. Surface irrigation systems are mostly used in China, while drip systems are preferred in saline soils. Sprinkler irrigation is also being installed in several areas in recent times.

4. POTENTIAL FOR DECIDUOUS FRUIT CROP DEVELOPMENT

The fruit industry in China has reached a new stage of development with a massive increase in growing area and production. At the same time, however, this rapid development has brought about many problems and the fruit industry is currently facing many challenges. Firstly, with such a rapid increase in production it has brought in its wake deficiencies in post-harvest handling, storage facilities, processing and marketing which are unable to cope with the volume of fruit produced. As a large quantity of fruits reached markets, disposal within a short period could not be achieved, resulting in depressed prices and considerable losses which even forced growers to abandon harvesting the crops. Secondly, due to the rapid expansion in production area, the use of low quality planting material was sometimes difficult to avoid and some of the cultivars grown by farmers are of very poor fruit quality. Another factor was the lack of training given to fruit growers, especially in the new fruit growing areas. Poor management has also resulted in lower yields per unit area in addition to the use of inferior germplasm. This situation will reach catastrophic proportions in the near future when about 40 percent of the young plantings reach bearing age.

It was found that about 66 percent of the total fruit production was contributed by apple, pear and citrus. Many of the cultivars of these fruits have a short harvest season which contributed to unmanageable surpluses. Quality was another factor since nearly 20 percent of fruit produced was of smaller size and unacceptable quality. Looking into these problems, it was also revealed that only about 30 percent of fruits produced were of good quality while the remaining 50 percent reached average quality standards. It was also found that only about 1 percent of the harvest received post-harvest treatments such as fruit cleaning, waxing, grading and packing. Currently available storage facilities can accommodate only 15 percent of production, leaving 85 percent of the harvest to be disposed within a short period. This has resulted in severe post-harvest losses and lowering of prices bringing about economic ruin to farmers. Lack of storage facilities has resulted in about 20-25 percent of the total fruit produced perishing after harvest.

Under these circumstances, new Government policies for the fruit industry are directed towards giving high priority to fruit quality, yield per unit area and better economic returns to fruit producers. Whilst total extent under fruits will remain at the same level, there will be changes in the combination of species and cultivars used. Regulations will be introduced to effect these changes. In order to maintain the proportion of the area under citrus, apple and pear in a ratio of 6:4 with other fruit crops, part of the hectarage of these crops that are grown under sub-optimal agro-ecological situations will be replaced by other fruit crops. It has also been planned to re-plant about 1.6 million ha of old orchards and about 3 million ha of plantings with low quality or low yield potential will be rejuvenated by topworking using newly developed superior cultivars. Cultivar regulation will also include the spreading of the harvest season. A proper mix of early, mid and late cultivars of all fruit crops will be promoted in a ratio of 10, 30 and 60 percent respectively. In apples, the cultivar Anna will be grown for early season harvest, Tsugaru, Gala, Starkrimson and Golden Delicious for mid-season and Red Fuji and Jonagold for late season production.

The current policies will also ensure fruit quality and better economic returns rather than increases in extents or volume of production as earlier encouraged in the 1980's. One of the major goals of the new policies include the increase in the percentage of quality fruit from the

present 30 percent to 40 percent by the year 2000, and a further increase up to 60 percent by the year 2005.

5. CONCLUDING REMARKS

In conclusion, a few salient facts need to be highlighted with respect to deciduous fruit production in China. Firstly, in fruit crop production extents, the Northwest parts of China, including Xingjiang, Gansu, Ningxia and Shaanxi will be exploited for expansion of deciduous fruits, due to the favorable climatic conditions these regions possess. These are relatively dry areas with more sunshine hours and high light intensity, less precipitation and greater diurnal range of temperatures. Deciduous fruits grown in these regions produce fruits of larger size, better color, higher sugar contents and better storage life, and with lesser problems from diseases. However, the economic conditions in these areas are much inferior compared to the Southeast coast of China. The most important consideration in the development of these areas would be the establishment of supplementary irrigation systems if large-scale commercial production is to be attempted since water sources are very limited.

The sand or apple pear that originated in the Yangtze River basin and is a popular crop in this area should also be categorized under the deciduous fruit crop group. It has excellent adaptability under warm and humid conditions. Many of the improved cultivars of sand pear produce high quality fruits. They are crisp, juicy and sweet, especially suitable for eating during the hot summer months. Development of this fruit is of special importance as it reaches markets earlier than other deciduous fruits. The fruit is also very popular in Southeast Asia.

Lastly, considering the entire fruit industry in the country, it should be noted that China is the largest fruit producing country in the world. Despite this, judging by the standard of fruit quality, average yield per unit area and per capita incomes, the Chinese fruit industry is relatively underdeveloped when compared with those of the more advanced countries. Although the fruit industry in some parts of China has started to make changes towards modernization, there is still a long way to go, in terms of improvement of all aspects of the industry. Of the many improvements that are needed, post-harvest handling, storage and marketing are salient aspects that need immediate attention, since there is dynamism in the industry as new areas and cultivars are constantly being developed.